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Nanotechnology in Industrial Applications

European and International Forum on Nanotechnology
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EuroNanoForum 2007

Nanotechnology in Industrial Applications

European and International Forum on Nanotechnology

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NANOTECHNOLOGIES AND NANOSCIENCES,
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The future of nanotechnology has already begun. Even today nanotechnological developments influence a world market volume of 100 billion Euro per year. For the coming five to ten years, experts predict an tenfold increase, which would raise the world market volume to one trillion Euro. In order to fully benefit from this potential, we need to swiftly blend good ideas into appropriate products. Only this approach will enable us to make Europe the strongest economic area worldwide.

Europe needs to make use of the opportunities afforded by nanotechnology. The conditions are favourable. In the field of nanotechnology Europe is already in the lead. We have excellent scientists and businesses with an openness to innovation and which are developing and launching new products. The 7th Research Framework Programme of the European Union makes a valuable contribution to this, as do the national measures taken within the member states – such as, in Germany, the Nano-Initiative - Action Plan 2010.

As an enabling technology nanotechnology enters the value-added chain at an early stage. Nanotechnology is in demand for the realisation of smaller-scale, faster, more powerful or more 'intelligent' system components for products with significantly improved or even entirely new functionalities. Nanoparticles targeting tumours with pinpoint accuracy, minuscule data storage devices storing the content of an entire DVD within the space of a one cent coin, self-cleaning surfaces or mechanically reinforced sports equipment are but a few examples.

EuroNanoForum 2007 is a joint initiative by the Federal Ministry of Education and Research and the European Commission. The aim of this year's Forum is to bring together Science and Economy, in order to ensure that current scientific findings in nanotechnology merge into products and applications at an even greater speed, thus creating new sustainable jobs.

EuroNanoForum 2007 will give new impulses for innovations in nanotechnology. These innovations will take Europe forward on the path of becoming the number one business location.

Dr. Annette Schavan, MdB
Federal Minister of Education and Research

Europe recognized the importance of nanosciences and nanotechnologies early on, building on its already established position in material sciences. We must now further consolidate these strengths to maintain the leading position we have reached in the field and to exploit the potential of nanotechnology in a timely way.

Nanosciences and nanotechnologies are highly promising areas for research and industrial innovation, with a potential both to boost the competitiveness of Europe’s industry and to create new products that will make positive changes in the lives of everyone. That is why the development and use of nanotechnology should not be delayed or left to chance. This is also why I wanted to increase the contribution to nanotechnology research and technological development in the EU Framework Programmes. Almost 1.4 billion € has already been granted to nanotechnology projects in FP6 and we expect to double that within FP7 on a year-to-year basis.

Nanotechnology benefits from an interdisciplinary approach and – as for all new technologies – may pose new challenges. Like a prudent car driver, policy makers should be able to press on the accelerator or the brake as a function of the opportunities or potential risks that are met. These must be duly investigated upfront, accompanied by appropriate safety measures.

Following the successful "EuroNanoForum 2003" and "EuroNanoForum 2005" (dedicated to applications in health care), I am glad to present you with this third "EuroNanoForum 2007".

Nanotechnology, even if at its beginning, is no longer in its infancy and impressive progress is being made in many technological fields, from chemistry to electronics, from new sensors to functionalised surfaces and novel fabrics. This EuroNanoForum 2007 event is dedicated to the industrial applications of nanotechnology and also addressing the possible precautions related to nano-particles and safety measures.

The European Commission has defined a wide-ranging strategy for an integrated, safe and responsible approach to nanotechnology, and a matching Action Plan. The European Parliament, the Council of the European Union, the European Economic and Social Committee, the hundreds of members of the public who replied to our open consultations and countless stakeholders welcomed this approach.

Nanotechnology allows new products and services to be created for the benefit of all. It is a promising area for industry and investors, a source of new jobs for our youth and offers many challenges for researchers in natural and social sciences, as well as in engineering. As for all new technologies, it is important that all stakeholders act responsibly and that an open and transparent dialogue is maintained between all stakeholders in Europe and across the world.

To the researchers and to all those engaged in research, development and innovation in nanotechnology I send my best wishes for a successful and fruitful work.

Janez Potočnik
European Commissioner for Science and Research

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Nanotechnology: markets, potential and future applications

Donald Fitzmaurice
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Key drivers for innovation are the needs of aging knowledge workers seeking a sustainable lifestyle. Successful companies will meet these needs by bringing to market products that improve our health, particularly in later life, that enhance our efficiency and creativity as knowledge workers, and that reduce our energy and environmental footprint.

Biotechnology, Information and Communication Technology and Nanotechnology are seen as keen enablers in the short and medium term. However, it is the convergence of these technologies that is seen as the key enabler in the long term.

This presentation will explore how technology convergence will enable human enhancement and life extension; artificial brains and the networked human; and the development of clean energy sources and the factory of the future.

It will also explore the implications for entrepreneurs, investors and policy makers in Europe now and in the future.

Nanotechnology as a platform for innovation areas

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Nanotechnology is widely seen as one of the key technologies in the upcoming century, since it can be generally considered as the synthesis, modification, control, manipulation, and characterization of particles and structures on the scale between 1 and 100 nm at least in one dimension, providing improved or new properties and functions not achievable with macroscopic structures.

Besides of existing and established nanotechnology based approaches new materials and systems enabled by nanoscaled structures offer an enormous broad variety of new properties and functions leading to diverse new emerging applications in material and in life sciences as well. In the most cases elements of nanotechnology cover a widely extended upstream range of the value chain with nanoobjects at the beginning over nanointermediates and finally enabling high value final products or systems at its end.

Because of these common features of nanotechnology it can be commonly recognized as a versatile platform for various innovation areas today and in the future.

Based on general technical future scenarios high market volumes and growth rates are predicted for nanomaterials, nano-enabled intermediates and products by a multitude of market studies. The predictions range between 1.000 and 3.000 billion US $ for 2015 and several studies expect a high double digit annual growth for the near future in special emerging segments. However, a significant market already exists today for established nanotechnology consisting of e.g. polymeric blends, dispersions, and nanosized particles. Based on these economic expectations the public and private investments in research & development regarding nanotechnology have been enormously increased during the past years, up to 12-13 billion US $ in 2006, supporting and accelerating the progress of innovations along the value chain.

Many general broad and versatile features of nanotechnology are already utilized today as a powerful tool to develop innovation areas and accelerate their growth within several diverse commercial segments.

The entire Bayer Group - according to its slogan 'Science for a Better Life' focusing on innovation driven and technology intensive core areas of health care, nutrition and high tech materials - can be seen as a representative for the industrial use of nanotechnology today in terms of a tool and a platform for various innovation and growth areas along the value chain, mentioned above more general.

In life sciences increased bioavailability and controlled release of active ingredients offer new opportunities for Bayer HealthCare and CropScience. The inclusion of active ingredients (a.i.) into nanosized and surface modified liposomes provides an improved control of the release behavior of a.i. and might contribute to the suppression of unintended side effects.

In addition, new surface modified paramagnetic nanoparticles as contrast agents for medical diagnostics in Bayer HealthCare deliver an improved resolution of magnetic resonance imaging of specific organs to identify irregularities or tumors more reliably. The nature of particles, their specific surface modification and the imaging procedure are essential elements of nanotechnology.

Especially for Bayer MaterialScience, intelligent materials and functional surfaces can be approached by the nanotechnology platform today, combining classical chemical synthesis and elements of nanotechnology along different steps of the value chain.

Intelligent flame retardance in combination with superior long lasting mechanical properties of housings for electronic devices (such as TV and computer housings) are improved by the use of appropriate nanoparticles with the right surface modification in polymeric nanocomposites.

Increased scratch resistance and lower sensitivity against the attack by chemicals in coatings are achieved by the use of suitable surface modified nanoparticles in combination with a polymeric binder, tailored cross-linker and the adjusted application procedure.

Beyond this, a significant range of nanotechnology applications can be identified at the interface between life and materials science, such as tailor made nanostructured surfaces in medical technology.

Future businesses and growth are generally driven by the development of new technology options (technology push) in combination with the future market i.e. customer demands (market pull). In several fields of future nanotechnology businesses technology push and market pull has to be adjusted to each other in order to bridgeover the value chain starting at nanoobjects and ending by nano-enabled systems. Very often a significant change of paradigm is needed - by using new approaches, business models and partnerships - to enable or accelerate rather parallel than serial developments, i.e. stronger collaboration with partners - suppliers and customers - along the value chain.

Especially large companies have to use new internal processes to promote the transformation of new projects to attractive emerging businesses. Representatively the 'Greenhouse' of Bayer MaterialScience – as an internal venturing like structure - can be considered as a harbor to incubate and develop promising projects to profitable future businesses. The first nano related internal start up incubated in the 'Greenhouse' is focused on the production, application development and marketing of multi wall carbon nanotubes – Baytubes®.

The commercialization routes of such novel nanoobjects indicate very clearly that traditional serial developments along the value chain will have to be more and more replaced by parallelized and also open innovation approaches in the future. The combination of public and private funding – such as 'Pennsylvania Nanomaterials Commercialization Center' in Pittsburgh, co-funded by Bayer MaterialScience as a public-private-partnership organization - can be helpful to speed up developments, can create new application and technology based networks and can complete existing R&D-chains to support today's new business creation efforts in addition.

The success of nanotechnology in the future will depend on the one hand on disruptive innovations leading to strongly emerging markets for novel products and applications and on the other hand on the level of responsible care taken with that technology along all levels of the value chain. Hence, from the industrial perspective all efforts and actions have to be taken, in order to ensure that the production, handling, transport and use of nano-enabled products are safe.

Again representatively Bayer MaterialScience is committed to an extensive Product Stewardship program to ensure safe handling and care of nanomaterials for human health and environment. The development of nanomaterials is taking place within the framework of the chemicals industry's Responsible Care® Global Charter. In addition, Bayer MaterialScience contributes to nanomaterial health, safety & environment research projects funded by the German Ministry of Education and Research (BMBF), such as NanoCare and TRACER, which focus on the characterization and the development of a broad scientific consensus on measurement methods and testing procedures for nanomaterial safety assessments.

The view back to the history and the comparison with other well developed enabling technologies might show that nanotechnology starts with already existing established applications and markets but finally it will lead to completely new emerging and fast growing markets deeply influencing our daily life in the future.

The future of nanoelectronics in industrial applications

Dr. Alfred J. van Roosmalen
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Semiconductor industry entered the domain of nanoelectronics in the late 1990's by passing the 100-nm pattern size limit. This was the eventual result of relentless following dimensional scaling for digital logic according to Moore's Law, a path existing now for more than four decades. In technological terms, scaling can certainly continue for many more years; much more uncertain is whether doing so can be economically feasible. Systems for future applications will see an increasing content of non-digital More-than-Moore elements, characterized by miniaturization rules much more elaborate than simple patterning dimension only. At the same time, the economic value of the software embedded in these systems will quickly equal and surpass the hardware value. Overall result is that the simple linear value chain of the past semiconductor industry will have to evolve into a complex knowledge ecosystem spanning continents rather than countries.

Targeted nanomedicines

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Many candidate and established drugs have less than ideal properties with consequently unfavourable therapeutic implications. Particulate drug targeting systems can be designed to improve the therapeutic behaviour of such drugs, which are commonly administered orally and parenterally. Nanoparticulate-based drug targeting has come a long way since Paul Ehrlich introduced the concept early in the last century. Progress has been slow, but several products have reached the market. Nanotechnology-inspired approaches to particle design and formulation, an improved understanding of (patho)physiological processes and biological barriers to drug targeting, as well as the lack of new chemical entities in the 'pipeline', are causing large pharmaceutical companies problems in bringing new drug compounds to the market. This indicates that there is a bright future for targeted nanoparticles as pharmaceuticals. It is now well known that a reliable
targeting system is essential for successful drug delivery in many serious disease situations. Targeting systems can target a drug to the intended site of action in the body, thus enhancing its therapeutic efficacy (site-specific delivery), and/or direct a drug away from those body sites that are particularly sensitive to the toxic action of it (site-avoidance delivery). A multidisciplinary research approach, employing the combined forces of many scientific disciplines, is a key factor for success. It is becoming increasingly recognised that a major limitation, impeding the entry of targeted delivery systems into the clinic, is that new concepts and innovative research ideas within academia are not being developed and exploited in collaboration with the pharmaceutical industry. Thus, an integrated 'bench-to-clinic' approach realised within a structural collaboration between industry and academia, is required to safeguard and promote the progression of targeted nanomedicines towards clinical application.
The development of effective, safe, and innovative drug targeting systems, is a complicated multi-step process. There is an increasing need to select and / or identify appropriate matrix materials, surface coatings, and targeting ligands with advanced properties. Therapeutic agents (small molecules, but also macromolecules like proteins and nucleic acids) to be loaded into nanocarriers vary widely in their physicochemical properties and it remains a challenge to balance the nanoscale dimensions of the particulate with the types and amounts of drugs that are clinically required. Proper structural and physicochemical characterisation is required to guarantee reproducible effects in vivo. Advances in particle engineering (e.g. surface modification with 'stealth' polymers, like poly(ethyleneglycol) (PEG) and targeting ligands) have already yielded nanoparticles which can reach major pathological sites in vivo, after intravenous and local routes of injection. Examples of target sites that are accessible in vivo include sites of malignancy and inflammation. Here, the most common method of targeting is passive extravasation through 'leaky' vasculature (the Enhanced Permeability and Retention (EPR) effect) using stealth polymer coated nanoparticles, which circulate in the bloodstream for a sufficiently long period of time ('passive targeting'). Ligand-mediated targeting ('active targeting') to endothelial cells lining blood vessels present within the site of pathology has also been used successfully. Vascular targeting ligands are directed against receptors, which are specifically (over)expressed on the pathological vasculature because of the angiogenesis process. To date, most research in this field has been directed towards solid tumours.
MEDITRANS represents a multidisciplinary Integrated Project (FP6) dealing with targeted nanomedicines. Platform technologies are being developed with broad applicability to disease treatment, as exemplified by the choice for chronic inflammatory disorders (rheumatoid arthritis, Crohn's disease, multiple sclerosis), and cancer as target pathologies. Nanomedicines (based on carrier materials like polymeric and lipidic nanoparticles, nanotubes, and fullerenes) will be endowed with superior targeting and (triggerable) drug release properties. In parallel, MRI imaging probes will be designed that report on the in vivo localization of the targeted nanomedicines, specific biomarkers, the drug release process and therapeutic outcome (imaging-guided drug delivery). The consortium consists of 30 partners from 9 EU member states (including 1 new member state) and 3 associated states, and includes 13 industrial companies, 11 universities and 6 research institutes. The total budget is € 16.1M, with € 11M from the EC and € 5.1M from MEDITRANS' industrial partners.

Needs for and status of standardization for nanotechnologies

Dr Peter Hatto
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Introduction

In a formal sense standards fall into one of two categories – measurement standards, providing the base or fundamental units of a measurement system, and written standards, which provide agreed ways of: naming, describing and specifying things; measuring and testing things; managing things e.g. quality and environmental management, e.g. ISO 9001 and ISO 14000; and reporting things, as in e.g. ISO 26000 (Social Responsibility), which is currently under development.

Such written, consensual, standards, whether formal (national, regional or international) or informal (company, trade association, interest group, etc) can support business and other related activities in one or more of the following ways: they can provide a technical, quality, and/or environmental management basis for procurement; they can provide support to specific user groups against what may be seen as unfair competition; they can provide technical support for appropriate legislation/regulation.

It is true to say that without written standards the complex, technological world in which we live could not possibly operate. However, though standards are essentially ubiquitous, applying to virtually every aspect of our lives – from the highly innovative, e.g. internet protocols, to the mundane, e.g. shoe sizes, and including aspects that even most people involved in the standardization process do not appreciate, e.g. 'Unmanned spacecraft residual propellant mass estimation for disposal manoeuvres', under development by ISO/TC 20/SC14, they are virtually invisible to the general public.

Historically, standards development has followed the commercialisation of a particular technological development, though more recently standardization has been viewed, by some at least, as an instrument that can provide support for commercialisation and market development, particularly in areas that are identified as strategically, economically and/or socially important and technically challenging.

Nanotechnologies are recognised as being all of these and more: they are technically challenging, being dependant on the measurement, manipulation and control of matter at a scale substantially below anything mankind has previously achieved, and well below our conventional ability for visualization; they are viewed as economically important, with a projected market impact of between \$500 billion and \$3,000 billion per annum by 2015 (1), equivalent to something between 6% and more than 30% of the value of world exports in 2005; they will clearly be strategically important, providing both evolutionary and revolutionary (disruptive) displacement of existing products, processes and materials; the growth in global trade means that the products and processes of nanotechnologies will extend across national boundaries and will almost invariably have a global impact; and last, but by no means least, there is increasing public anxiety about the potential negative health and environmental impacts of certain aspects of nanotechnologies. All of these factors mean that early standardization will be important for the successful commercialisation, market development and consumer acceptance of many if not most of the applications of nanotechnologies under development or under consideration.

Standards and standardization

As already indicated, written standards are developed under the auspices of a number of different bodies and, as such, have a different status depending on the status of the responsible organisation. Formal standards are those standards that are adopted by national, regional or international standardization bodies, for example AFNOR (France), BSI (UK) and DIN (Germany), CEN (European Committee for Standardization), CENELEC (European Committee for Electrotechnical Standardization) and ETSI (European Telecommunications Standards Institute), or ISO (International Organisation for Standardization), IEC (International Electrotechnical Commission) and ITU (International Telecommunications Union). All formal standards are developed through a process of consensus, meaning that none of those involved in their development and approval maintains sustained opposition to their contents (not quite the same as unanimity!), and, with very few exceptions, compliance with their requirement is entirely voluntary. Informal standards, whilst also voluntary and based on consensus, are developed by business or professional interest groups, companies, etc.

The process of standards development typically follows a well established pattern, which for international standardization is detailed in the ISO/IEC Directives (2). Development is normally undertaken by a group of experts working together in a Working or Project Group (WG or PG) under the auspices of a Technical Committee (TC) organised to oversee standardization in a particular subject area. Where the need for a specific standard has been identified by a member of the technical committee, or other appropriate organisation, a New Work Item Proposal (NWIP) is developed and submitted to the committee for approval. In the case of ISO, this is accomplished when 5 or more 'P' (participating) members of the committee agree to work on developing the standard and at least 50% of those voting approve the adoption of the new work item. Once the WG has reached consensus on the document's content, the TC is invited to adopt the standard, and having done so, with or without comment and subsequent revision, the document becomes a Committee Draft. At this stage it is submitted to the full membership of the standardization body for approval, again with or without comments, and once approved, possibly following further revision, it either becomes a formal standard or undergoes one further stage of formal approval prior to its final adoption.

In addition to full consensus documents, such as National, Regional or International standards, lower consensus documents can also be published, depending on the identified need, the maturity of the subject matter, and the urgency of the development. Documents such as Publicly Available Specifications (PAS), Technical Specifications (TS), Technical Reports (TR) and Workshop Agreements (WA) all have their place in the standardization arena. Indeed, instruments such as these, whilst not 'full' standards, can have an important role in providing stakeholders with a draft test method, guideline, etc. which they can evaluate and which can be further developed if and when considered necessary. The timescales for publication of such documents is substantially shorter than the 3 year 'maximum' for full International Standards, e.g. a PAS might be developed and published in just a few months.

One important point to note is that although the process of standardization is facilitated and managed by the relevant standardization body, proposals for and the development and approval of standards is the responsibility of the membership of that body. Hence ISO does not develop or approve International Standards – its members do, and therefore statements such as ISO should develop a standard for xxx are quite meaningless.

Similar procedures are normally adopted by developers of informal standards (Standards Development Organisations – SDOs, and other interest groups), and depending on the subject matter, degree of consensus, or standardization need, such standards might eventually be adopted by the National Standards Body (NSB) as a National Standard. This process is typically used in the approval of American National Standards by ANSI, which accredits around 280 SDOs for the preparation of National standards.

Written standards are almost universally voluntary. As a non-governmental organization, ISO has no legal authority to enforce their implementation. A certain percentage of ISO standards - mainly those concerned with health, safety or the environment - has been adopted in some countries as part of their regulatory framework, or is referred to in legislation for which it serves as the technical basis. Such adoptions are sovereign decisions by the regulatory authorities or governments of the countries concerned; ISO itself does not regulate or legislate. However, although ISO standards are voluntary, they may become a market requirement, as has happened in the case of ISO 9000 quality management systems, or of dimensions of freight containers and bank cards.

The need for standardization for nanotechnologies

One of the earliest calls for standardization in the field of nanotechnologies was made at a joint VAMAS – CENSTAR Workshop on Measurement Needs for Nano-scale Materials and Devices, held in June 2002 at the National Physical Laboratory, UK, which concluded that 'there is an overarching need for methods, standards, reference materials and guidelines in mechanical property determinations for the characterisation of nano-scale materials and devices.' (3).

This call has been reiterated numerous times, notably by a workshop entitled 'Mapping out Nano Risks', convened by The

Health and Consumer Protection Directorate General of the European Commission in March 2004 (4); by the UK Royal Society and Royal Academy of Engineering, in their report entitled 'Nanoscience and nanotechnologies: opportunities and uncertainties', published in July 2004 (5); and by the European Commission in their Communication to the Council, the European Parliament and the Economic and Social Committee 'Nanosciences and Nanotechnologies: an Action Plan for Europe 2005-2009', published in July 2005 (6).

One area of very high, perhaps the highest visibility for nanotechnologies, is that of health, safety and environmental effects (HS&E). International concerns about unpredictable health and environmental impacts of nanoparticles and other nanoscale materials has led to calls of varying demand, from the appropriate application of the precautionary principle to an outright ban or moratorium on all work on nanomaterials and nanotechnologies. A number of international fora have emphasized the need for a responsible approach to the research, development and introduction of nanotechnologies, and this is now rapidly becoming a mantra for those with a vested interest in their adoption. However, in most cases it seems that the notion of responsibility is limited to not doing the 'wrong' thing, whilst some, including the author, believe that a more appropriate - and 'responsible' - view would also include 'doing the right thing'. This might include international cooperation in developing those applications of nanotechnologies that could help address the global challenges of sustainability, particularly for energy and water.

This is not to suggest that international action on the issue of health, safety and environmental implications of nanotechnologies is absent. As mentioned above, the Health and Consumer Protection Directorate General of the European Commission convened a workshop in March 2004 entitled 'Mapping out Nano Risks', which gave rise to twelve recommendations from the experts, including the following, which are all strongly related to standardization: 'developing a nomenclature for NPs, developing instruments, developing risk assessment methods, promoting good practices, developing guidelines and standards, and eliminating whenever possible and otherwise minimizing the production and unintentional release of waste nanosized particles'. In the autumn of 2006, and after significant deliberation, the Chemicals Committee of the Organisation for Economic Cooperation and Development (OECD) established a Working Party on Manufactured Nanomaterials (WPMN) to address health and environmental impacts of these potentially important materials. The Working Party has now developed a detailed programme of work divided into six separate projects:

1. Development of an OECD (Nanosafety) Database on Human Health and Environmental Safety (EHS) research
2. EHS Research Strategies on Manufactured Nanomaterials
3. Safety Testing of a Representative Set of Manufactured Nanomaterials
4. Manufactured Nanomaterials and Test Guidelines
5. Co-operation on Voluntary Schemes and Regulatory Programmes
6. Co-operation on Risk Assessments and Exposure Measurements

With a remit to look at the broader area of risk, and considering the risks of both acting and of failing to act in the adoption of nanotechnology applications, the International Risk Governance Council has completed a project and published a white paper on risk governance for nanotechnology (7), work which was funded by the US EPA, the Swiss Government and Swiss Re.

Numerous international conferences, congresses and meetings have now been devoted, either wholly or partially, to the issues of HS&E and have done much to identify the areas requiring effort. They have also helped to highlight the complexity of the issues and to emphasize the need for international collaboration in developing protocols and test methods to both evaluate the health and safety impacts of nanomaterials and to provide robust and relevant characterization methods applicable to them.

National and international standardization for nanotechnologies
The first country to develop and adopt voluntary standards for nanotechnologies was China, which published 7 national standards in December 2004, and implemented them the following April, in accordance with the WTO (World Trade Organisation) Technical Barriers to Trade (TBT) regulations. These 7 standards included a terminology for nanotechnology, 4 material specifications – for nanoparticle nickel, titanium dioxide, zinc oxide and calcium carbonate, and two measurement

techniques – for the determination of particle size distribution of nanometer powders, and for the determination of the specific surface area of solids by gas adsorption (both these latter two are based on existing ISO standards). Since that time China has published and implemented another 5 National standards: three in the area of particle sizing; one providing procedures for dispersing (nano) powders in liquids; and one on nanometer-scale length measurement by Scanning Electron Microscopy (SEM).

The publication by China of the first national nanotechnology standards occurred shortly before the UK submitted a proposal for a new ISO Technical Committee for Nanotechnologies. This proposal was confirm in April 2005, and the new committee – ISO/TC 229 – Nanotechnologies – was formally established in June 2005 with a UK secretariat and chairman. To date the committee has held four meetings - November 05 in London, June 06 in Tokyo, December 06 in Seoul and June 07 in Berlin. The next meeting will be in Singapore in December. The committee currently has 37 members - 29 'P' and 8 'O' – see (8) for details. The work of the TC is governed by its scope statement, agreed at the first meeting:
'Standardization in the field of nanotechnologies that includes either or both of the following:
- Understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometres in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications,
- Utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties

Specific tasks include developing standards for: terminology and nomenclature; metrology and instrumentation, including specifications for reference materials; test methodologies; modelling and simulation; and science-based health, safety, and environmental practices.'

The TC structure consists of 3 Working Groups - Terminology and Nomenclature (WG1, convened by Canada), Measurement and Characterization (WG2, convened by Japan) and Health, Safety and Environment (WG3, convened by the USA). There are currently 3 work items in development: an ISO/TS - terminology and definitions for nanoparticles, which is subject to a ballot as a Committee Draft; an ISO/TR - health and safety practices in occupational settings relevant to nanotechnologies, which should be published later this year; and an ISO/IS (International Standard) - endotoxin test on nanomaterial samples for in vitro systems, which will be ready for publication in late 2009 or early 2010. The committee has recently approved 6 new work items – four in the area of characterization of single walled carbon nanotubes and two associated with toxicological testing of nanoparticle silver, and work will start on these shortly. Three further NWIP – one on characterization of multi-walled carbon nanotubes, one on a further technique for the characterization of single walled carbon nanotubes, and one for a terminological framework and core terms for nanotechnologies – are currently out for ballot.

ISO/TC 229 works closely with the CEN TC in the area (TC 352 – Nanotechnologies, also chaired by the UK), using the Vienna agreement where appropriate, and with IEC/TC 113 – 'Nanotechnology standardization for electrical and electronic products and systems' chaired by the US, with Germany providing the secretariat. ISO/TC 229 and IEC/TC 113 have established two Joint Working Groups (JWG) – in Terminology and Nomenclature (ISO/TC 229 WG1) and in Measurement and Characterization (TC 229/WG2) - both led by ISO. Close contact will be maintained in the area of HS&E (TC 229/WG3), though it is not currently planned to establish a JWG for this. The two Technical Committees plan to hold joint plenary meetings, starting in December 2007.

Given the diversity of the subject it is clear that standardization, as with many aspects of nanotechnologies, will require collaboration between different disciplines – and for disciplines in the standards arena read Technical Committees. A large number of existing committees already work in the area or will be impacted by nanotechnology and can therefore be expected to have an interest in this field of standardization. Indeed some of these committees, e.g. TC 24 (Sieves, sieving and other sizing methods), TC 146 (Air quality) and TC 201 (Surface chemical analysis), have already published standards relevant to nanoscale technology and management. Besides these, a number of other bodies have a specific interest in standardization for nanotechnologies, and in view of these wide interests in the subject, ISO/TC 229 has to date established liaisons with

15 other ISO TC's (8), with the OECD (Working Party on Manufactured Nanomaterials), with the EC Joint Research Centres (IRMM and Institute for Health and Consumer Protection, Ispra), with the Asia Nano Forum and with VAMAS. Despite the elatively high number of existing committees in liaison, it is estimated that some 40 ISO Technical Committees will be directly impacted by nanotechnologies and will therefore wish to establish a liaison sometime in the future, if they have not already done so.

In autumn 2006 the TC undertook a survey of the standardization needs of members, which identified over 100 high priority topics, with 54 being relevant to WG2, 31 relevant to WG3, 5 relevant to a new working group on materials specifications, and 18 relevant to other ISO TCs. The information gathered from the survey is being used to prepare road maps for both the individual working groups and for the TC, though the implementation of these will be subject to effective coordination and cooperation between the various stakeholders, both nationally and internationally. Whilst highlighting the need for standards development in the area of HS&E, and for this work to be supported by parallel developments in the areas of terminology and measurement and characterization, the actual future work of the committee will depend upon the NWIPs it receives from its members, and might also depend on NWIPs made to other, liaison committees. The submission and success of these proposals will, in turn, depend upon the resources available to individual member countries, and on specific national and technical committee interests. In support of international cooperation in the area of HS&E, TC 229 is working closely with the OECD WPMN, particularly within project 3 and 4, and it is to be hoped that this can help focus national efforts whilst also helping to coordinate and harmonize international efforts in this critical area.

Work in Europe on standardization for nanotechnologies has been ongoing since spring 2004, when a CEN Technical Board Working Group, (CEN/BTWG 166) was established to develop a strategy for standardization for Nanotechnologies in Europe. This WG reported in June 2005 with the principal recommendation that CEN should establish a full Technical Committee in the area, the outcome being CEN/TC 352. This TC was formed in November 2005 and has so far met three times. At its most recent meeting, in Brussels in April 2007, it adopted three NWIPs, for projects on:

- Format for reporting the engineered nanomaterials content of products (to be published as a CEN/TS);
- Guide to nanoparticle measurement methods and their limitations (CEN/TR)
- Guide to methods for nanotribology measurements (CEN/TR).

Whilst international standardization provides the ultimate target for much activity, standardization at a national level has an important role to play, either by providing basis documents for NWIPs for ISO or for areas where the subject matter is of largely national, as opposed to international interest. Besides the activities in China, referred to earlier, there has been significant activity in a number of other countries. In June 2005 the UK published a Publicly Available Specification (PAS) 'Vocabulary for Nanoparticles' (PAS 71), which was made freely available on the www (9) and has so far been downloaded around 1000 times. This document was used as the basis document for the first NWIP to ISO/TC 229 for a Technical Specification: Terminology and Definitions for Nanoparticles. It is understood that the UK National Committee, NTI/1, is currently engaged in developing another 6 sector specific terminologies – for the bio-nano interface, carbon nanostructures, medical, health and personal care applications of nanotechnologies, nanofabrication, nanomaterials, and nanoscale measurement terms including instrumentation, which it also plans to make available for free download on the www and will use as basis documents for further NWIPs to ISO/TC 229. In addition it is understood that the UK is working on three other standards – a guide to labelling of engineered nanoparticles and products containing engineered nanoparticles, a guide to specifying nanomaterials, and a guide to handling and disposal of engineered nanoparticles.

In Germany, a guideline 'Guidance for handling and use of nanomaterials at the working place' will be published soon. This is intended to assist the safe manufacture and use of nanomaterials and to offer recommendations reflecting the current state of science and technology.

In Korea, at the end of 2006 there were more than 110 domestic nanomaterial-related standards. This number is expected to increase significantly in the near future considering the increasing importance of nanotechnologies to both the domestic and the global economies as a future engine for industrial growth.

In the USA, the establishment of the ANSI (American National Standards Institute) Nanotechnology Standards Panel in June

2004 provided a coordination body for the advancement of nanotechnology standardization. In 2006 the Institute of Electrical and Electronics Engineers published the first measurement standard for the electrical properties of carbon nanotubes (IEEE 1650) (10) and the American Society for Testing Materials International published its Terminology for Nanotechnology (11). The latter organisation is actively involved in developing standards for nanotechnologies, particularly in the area of physical, chemical and toxicological characterization, where it has 8 projects under development.

The Russian Technical Committee TC 441 'Nanotechnologies and Nanomaterials' has developed 4 National standards in the field:

- Single-crystal silicon nanometer range relief measure. Geometrical shapes, linear size and manufacturing material requirements;
- Nanometer range relief measure with trapezoidal profile of elements. Method for verification
- Atomic-force scanning probe measuring microscopes. Method for verification
- Scanning electron measuring microscopes. Method for verification

The diversity of aspects of nanotechnologies that will be impacted by and benefit from standardization in the area were highlighted in a recent issue of ISO Focus (April 2007). Besides reviewing the activities of the three working groups of ISO/TC 229 – terminology and nomenclature, measurement and characterization, and health, safety and the environment – the special issue contained articles looking at medical opportunities, food and agriculture, insurance, electronics, sustainability and global challenges, ethical, legal and societal issues, economic aspects, etc.

Conclusions

International collaboration in the development and introduction of standards for nanotechnologies, particularly in the areas of terminology and nomenclature, measurement and characterization, and health, safety and the environment, will greatly assist the early commercialisation, market development and consumer acceptance of these new and potentially far reaching technologies.

Note: any views expressed in this paper are those of the author and should not be construed as representing general views of the International Organisation for Standardization, the ISO Technical Committee for Nanotechnologies, ISO/TC 229, or of any of its members.

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(9) See: http://www.bsi-global.com/en/Standards-and-Publications/Industry-Sectors/Nanotechnologies/PAS-71/

(10) 1650-2005 IEEE Standard Test Methods for Measurement of Electrical Properties of Carbon Nanotubes, IEEE, 2005

(11) E2456-06 Standard terminology Relating to Nanotechnology see: http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E2456.htm?E+mystore

Possibilities for a global governance of nanotechnology

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The presentation will focus on the progress made in global governance of nanotechnology and suggest future possibilities. Nanotechnology has characteristics which provide new issues for science, technology and risk governance. It is still in an early phase of development, and is sometimes compared in the literature to information technology in the 1960s and biotechnology in the 1980s. The first international benchmarking in over twenty countries was prepared in 1997-1999 (Siegel et al., 1999). It is expected that convergence of nanotechnology, modern biology, the digital revolution and cognitive sciences integrated with other more traditional technologies will bring about tremendous improvements in transformative tools, generate new products and services, enable human potential, and in time reshape societal relationships. The research and development areas are shifting progressively from passive nanostructures to complex nanosystems as suggested in Figure 1. In 2000, the National Science Foundation (NSF) estimated that $1 trillion worth of products worldwide would incorporate nanotechnology in key functional components by the year 2015. These estimates were based on a broad industry survey and analysis in the Americas, Europe, Asia and Australia, and continue to hold in 2005.

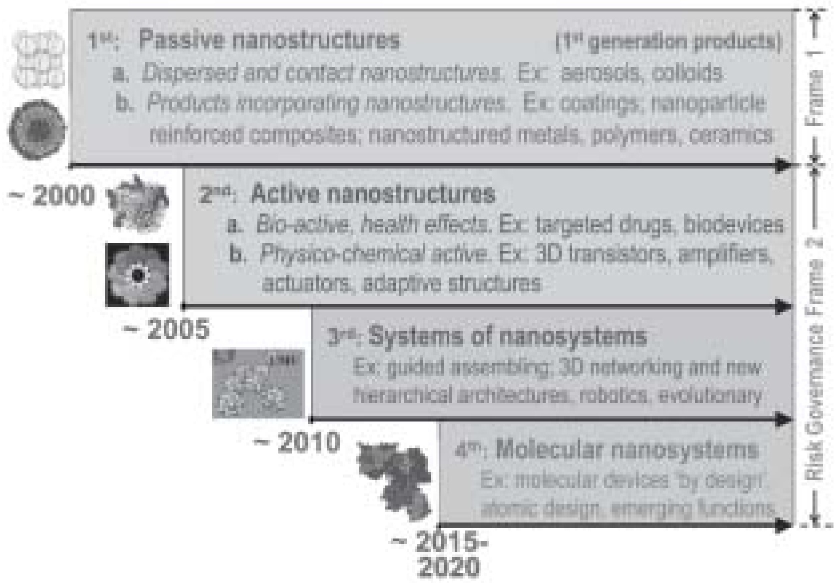


Figure 1.
Timeline for beginning of industrial prototyping and nanotechnology commercialisation: Four overlapping generations of products and processes.

The proposed framework for governance calls for several key functions:
- Supporting the transformative impact, including investment policies and innovation;
- Advancing responsible development, including health, safety and ethical concerns;
- Encouraging national and global partnerships; and
- Commitment to long-term planning with effects on human development.

Principles of good governance include participation of all those involved or affected by the new technology (Figure 2), transparency, participant responsibility, and effective strategic planning. Introduction and management of nanotechnology development must be done with respect for immediate concerns (such as changes in the markets, information privacy, access to medical advancements, and addressing toxicity of new nanomaterials) and longer-term concerns (such as human development and concern for human integrity, dignity and welfare). These assumptions underline the switch from government alone to governance in debates about the modernization of policy systems, implying a transition from constraining to enabling types of policy or regulation.

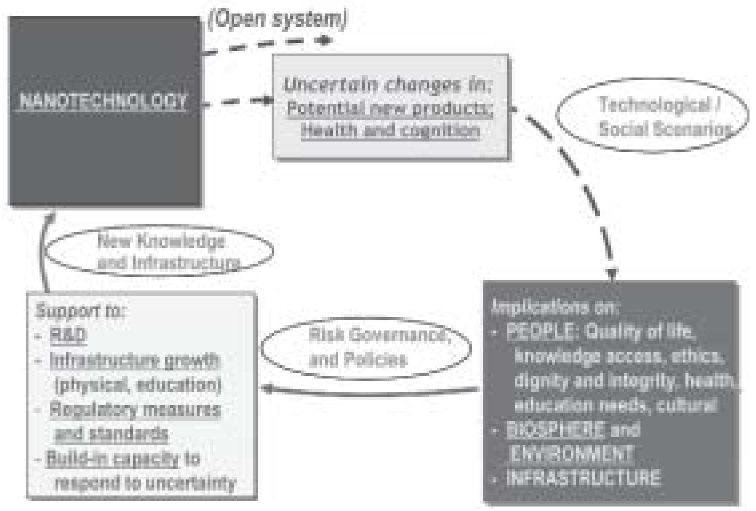
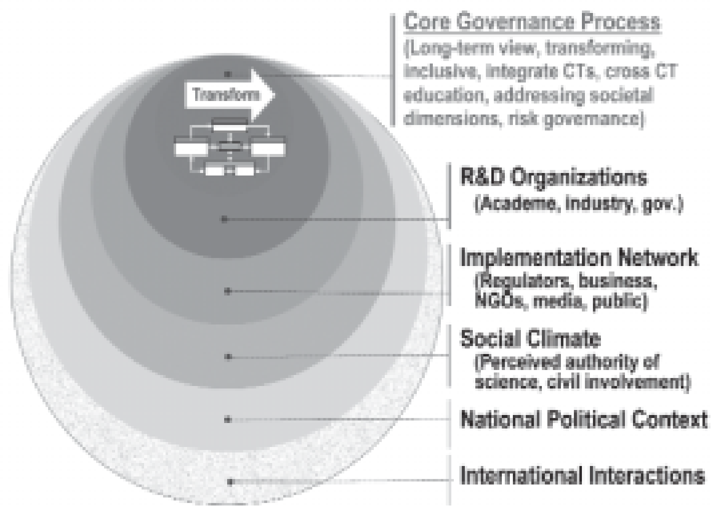


Figure 2.
Open system in nanotechnology governance.

Core governance processes and actors involved or affected by nanotechnology are shown in Figure 3.
Because nanotechnology offers a broad technology platform (for industry, biomedicine, environment and an almost indefinite array of potential applications) and reaches the basic level of organisation of atoms and molecules, where the fundamental properties and functions of all manmade and natural systems are defined, it bring particularities as compared to any single technology. We have identified several core governance strategies: commitment to a long-term view, transformative approaches, and inclusiveness with both the participants and those affected, integration of converging technologies, cross-converging technologies education, addressing societal dimensions, and earlier adopting of risk governance. Governance must deal with societal complexity, address multi-stakeholders, and use methodologies recognized globally for risk assessment and management.

Figure 3. Overview of nanotechnology governance:



Four levels of governance of nanotechnology have been identified in the global ecosystem:
- Adapting existing regulations and organizations;
- Establishing new programs, regulations and organizations specifically to handle converging technologies;
- National policies and institutional capacity building; and
- International agreements and partnerships.

Figure 5 illustrates the steps in the International Risk Governance Council (IRGC) risk assessment and management framework for nanotechnology. The initial framing of risk is important for public perception and decision makers. Government regulations may be dedicated to various areas of application of nanotechnology. In dealing with conflicts in risk management, it is preferable to adopt constructive solutions such as changes in technology than additional regulations.

Figure 4. Multi-level structure of risk governance for nanotechnology:

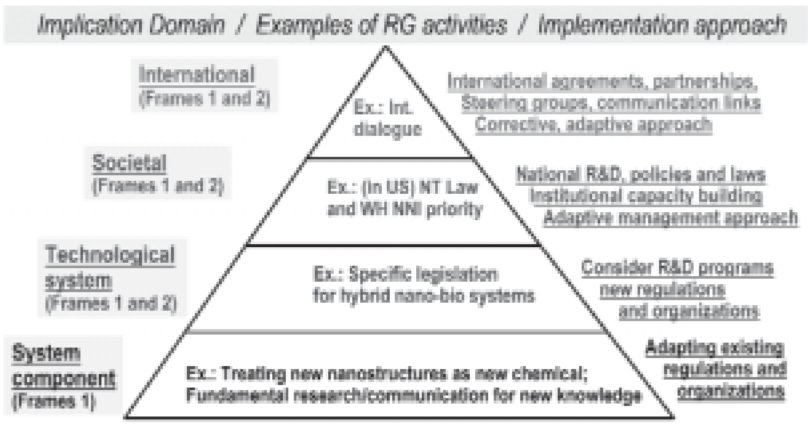
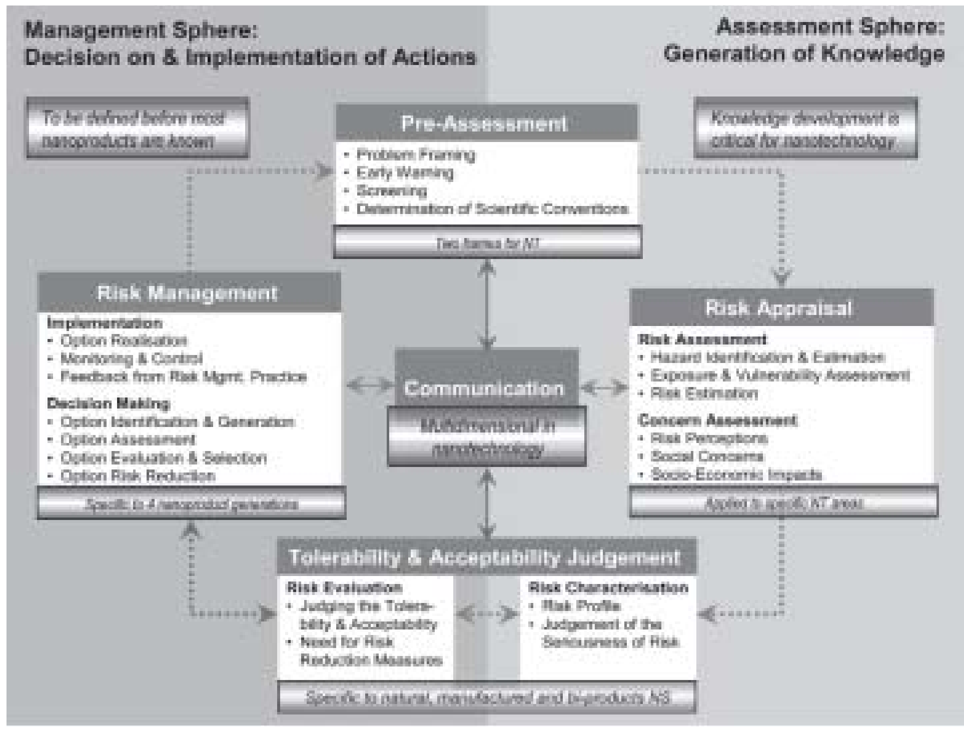


Figure 5. Steps in IRGC risk assessment and management framework for nanotechnology:



The initial ideas about an international governance approach (Roco, 2001) are evolving now in the following key areas: investment policies, science and technology policies, business policies, education and training, economic transformational mechanisms, addressing EHS and ELSI implications, methods of risk management, communication approaches, building national and global capacity, long-term and global view in planning, and support of human development. Several possibilities

for improving governance of nanotechnology in the emerging global ecosystem involving stakeholders from both developed and developing countries are:

- Open-source models of nanotechnology development;
- Supporting databases, specific tool development, knowledge creation and innovation in the international context;
- Supporting partnerships between various stakeholders active in nanotechnology applications and related emerging technologies;
- Long-term planning using global scenarios;
- Involving international organizations to advance multi stakeholder global challenges;
- Applying nanotechnology for improving availability of common resources such as water, food, energy, and sustainable environment;
- Creating better opportunities for development of nanotechnology in developing countries;
- Global communication and information;
- Allocation of development funds for common metrology, standards, patent evaluation, and methodologies including for a predictive toxicology approach for nanomaterials;
- Public involvement with international outreach; and
- Voluntary systems and science-based measures for risk management.

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NanoDialogue: Recommendations to archieve sustainable governance and social acceptance

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Deutsches Museum, Munich (Germany); www.nanodialogue.org

The nanodialogue consortium, coordinated by the Fondazione IDIS – Città della Scienza, based in Naples, Italy, comprised a total of 11 organisations of excellence in different fields (scientific research, social participation, science communication) representing a wide European dimension. These elements ensured that high quality standards were maintained in the communication tools and methodologies and contributed to the widespread diffusion of the project's results.
The participant institutions and their team members included: Fondazione Idis - Città della Scienza (Italy); Associazione MQC2 (Italy); University of Westminster - Centre for Study on; Democracy (United Kingdom); Ecsite - the European Network of Science Centres; and Museums (Belgium); Centre de Culture Scientifique, Technique et Industrielle de Grenoble (France); Flanders Technology International Foundation (Belgium); Deutsches Museum (Germany); Universeum AB (Sweden); Ciência Viva - Agência Nacional para a Cultura; Científica e Tecnológica (Portugal); Ahhaa Science Centre (Estonia) and Fundació Parc Científic de Barcelona (Spain).

The nanoDialogue project: an integrated approach to communication
Engaging citizens in dialogue and discussions about emerging science and technologies has been recognized by the European Commission as a fundamental component to create the knowledge economy at the basis of the European Union's Lisbon Agenda. Science centres and museums are the natural choice of venue to begin such activities, since they offer an opportunity for a wider exchange of ideas, providing information that is generally perceived to be reliable and giving different actors a chance to meet and voice their concerns.
In this framework, Fondazione IDIS - Città della Scienza has coordinated the NanoDialogue project with funding provided by the European Commission, under the Nanotechnologies and Nanoscience program.
The 'pillars' of NanoDialogue were a modular exhibition, designed for display in 8 different countries (Belgium, Estonia, France, Germany, Italy, Portugal, Spain, Sweden), a program of events and participatory activities in each location, and a survey of public perceptions and expectations with 800 questionnaires and 16 focus groups organized at each location. The analysis of these components has lead to a final conference, held in the seat of the European Parliament in Brussels, in order to present the results of the project to the European Commission and Parliament.

The 'Overall Approach'
The main goal of the project was to arise curiosity and stimulate debate on nanotechnologies and nanosciences, both for the general public and for more sophisticated targets. So, the exhibition had to be exciting enough to achieve curiosity for science and research in general, and specifically for nanosciences and nanotechnologies. The debate approach - and the Ethical, Legal and Social Aspects (ELSA) involved – suggested to organise the exhibition module as an ancient 'agorà', a public area to meet, discuss and concentrate, an area where visitors could compare their ideas, opinions and points of view.

NanoDialogue events
To share information about N&N with citizens, the width of reach of the NanoDialogue consortium relied on a multitude of tools and activities, each targeted to specific publics with different information needs. In particular, the consortium carried out and implemented several activities like seminars, demonstrations, lectures, guided tours, shows, workshops, discussions and theatre performances.
In some instances, science centres have been spontaneously contacted by N&N industries in order to conduct public presentations and discussions of their products within the exhibition space. This was mainly achieved through the programs and activities, for which the NanoDialogue exhibition module was a catalyst. Worth noticing is on the one hand the pro-active interest of the industry, as noted before, and the self-declared interest of groups of visitors that came to the science centre on purpose to visit the exhibition and take part in the programs. Although these visitors represent a very small part, in numerical terms, they are at the same time 'engaged citizens' that take advantage of the NanoDialogue exhibition as a platform to understand more and discuss about N&N. It showed that despite the small size of the exhibition, its role as 'attractor' for public debate was considerable. NanoDialogue was also contributing to challenge science centres and museums as 'repositories of truth', and presenting them instead as a place for public debate and dialogue, and to support the development of science rather than just acknowledging it.

Citizens' Feedback Assessment
Citizens' Feedback Assessment involved the preparation, collation and analysis of quantitative and qualitative data derived from visitors' responses to questionnaires and participation in focus groups. The analysis of this feedback highlights visitors' interests in as well as their perceptions and expectations of N&N, which forms the basis of a set of recommendations that are intended to provide inputs into processes of national and European agenda-setting and further public debates.

Summary of Responses

The socio-demographic profile of the NanoDialogue questionnaire respondents
Gender balance of respondents was achieved across the exhibitions. Respondents were predominantly young (15-24) students or highly-educated white collar workers who lived in urban areas. The high proportion of urban-dwellers is possibly influenced by the metropolitan location of the exhibition venues.

Level of understanding of N&N
The general level of understanding of N&N among respondents was low, while a further fifth of the respondents declared no understanding at all.

Sources of information about N&N
Respondents' primary sources of information about N&N included television, school or university, newspapers and magazines. Many respondents indicated that they had never heard or read about N&N.

Effect of N&N on our way of life
The effect of N&N on respondents' way of life over the next 20 years is generally expected to be positive although, in keeping with their levels of awareness, just over a third of respondents were not sure what effect it would have. Focus group participants anticipated a variety of beneficial uses and applications for N&N including medical progress in the detection and treatment of diseases. However, participants were duly concerned about the potentially harmful effects and unexpected consequences of N&N products and nanoparticles to human health and the environment. Furthermore, the majority of participants were of the opinion that N&N will be socially and economically divisive, and may also lead to the encroachment by the state upon the privacy of citizens.

A moratorium on research and commercialisation?
In spite of the relatively positive perceptions of nanotechnologies noted above, the majority of respondents agreed there should be a moratorium on N&N research and commercialisation until there is evidence that they are safe. Nevertheless, focus group participants generally favoured a less rigid approach whereby research and development should proceed with precaution rather than being curtailed by a moratorium. For some the risk of being left behind in the 'nano-race' was considered to be detrimental. Conversely, some participants strongly supported a moratorium on the specific use of nanomaterials for human enhancement or by the military, stating safety concerns.

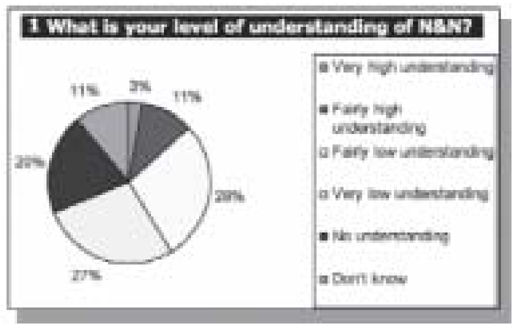
Regulation and control of N&N
Focus group participants were concerned about the possibility of misuse or abuse of the technology, and were particularly fearful of its appropriation for terrorist activities. The creation of an independent ethics body to oversee the equitable regulation of N&N was suggested.

Public engagement on N&N
The inclusion of the public in decision-making processes surrounding N&N was considered highly desirable by the respondents in the context of research and development of N&N, its regulation, and the commercialisation of its products. The related issue of increased public awareness was also raised in focus groups discussions as the majority of participants expressed the desire for more in-depth information.

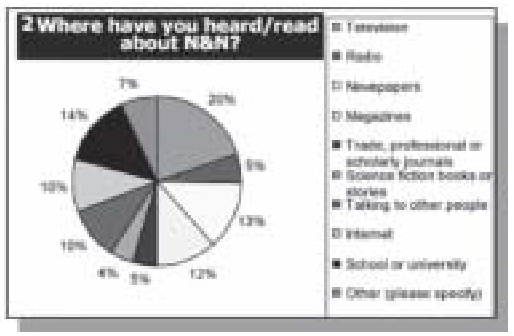
Benefits and risks to society
Across a range of possible N&N scenarios and potential applications, respondents' envisaged more benefits than risks to society. Benefits to human health and environment were the most keenly anticipated while risks to national security and the economy posed the most concern.

Has the NanoDialogue exhibition increased your level of understanding of N&N?
While the vast majority of respondents agreed that the NanoDialogue exhibition had increased their level of understanding of N&N, many expressed a desire for more information. The exhibition prompted several questions from visitors including 'what are the current regulatory systems governing N&N in the European Union?', and 'has nanotechnology already affected the labour market, resulting in redundancies?'. Focus group participants' reflections on their visitor experience varied considerably; the German and Swedish participants were satisfied by the level and objectiveness of the information compared to the majority of French participants whose opinion of the content of the NanoDialogue exhibition was less than complementary.

Questionnaire responses
From March to October 2006, 706 visitors to the exhibitions held in the eight participating countries were invited at random to complete a brief questionnaire to determine: 1) their socio-demographic profile, 2) their perceptions and expectations regarding N&N, and 3) their assessment of the potential benefits and risks posed by N&N, based on the content of the exhibition. Sections 1 and 2 were completed by the visitors before viewing the exhibition while section (iii) was completed following the exhibition.

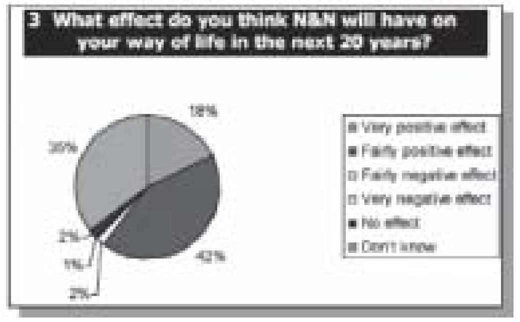


The socio-demographic categories correspond with those used by Eurobarometer to enable comparative analysis where possible. A gender balance of respondents was achieved, young people under the age of 24 were the largest single socio-demographic group to visit the exhibitions (45%), 47 percent of respondents indicated that they were still studying. The exhibitions appeared to attract visitors with a high-level of educational attainment as 35 percent of respondents indicated that they had completed their education above the age of 20. Prior to visiting the exhibition, the majority of respondents rated their level of understanding of N&N as low (55%) compared to just 14 percent who thought their level of understanding was high. A significant proportion (20%) of visitors stated that they had no understanding at all.



Responses to the question where have you heard/read about N&N? varied considerably with 20 percent of respondents indicating their primary source as television followed by school or university (14%), newspapers (13%), and magazines (12%). Surprisingly, the internet (10%) and talking to other people (10%) did not feature as major sources of information about N&N, perhaps indicating a lack of sufficient interest in the topic to actively seek out further information. Even fewer respondents had heard or read about N&N from the radio (5%), from trade, professional or scholarly journals (5%) or from science-fiction books or stories (4%).

Where respondents stated that they have heard or read about N&N from 'other' sources (7%), this included mainly the museums, science centres and public spaces in which the exhibitions were held, however many also indicated that they had never heard of N&N.



When asked what effect do you think N&N will have on your way of life in the next 20 years, 60 percent of respondents believed the effect would be positive while only three percent envisaged negative effects. Of the nine risk/benefit scenarios proposed, respondents perceived more benefits than risks posed by N&N. Benefits to human health and environment were the most keenly anticipated while risks to national security and the economy posed the most concerns.

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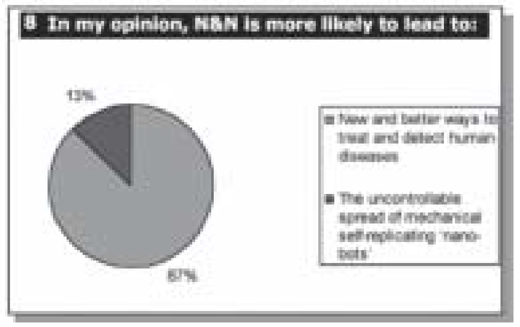

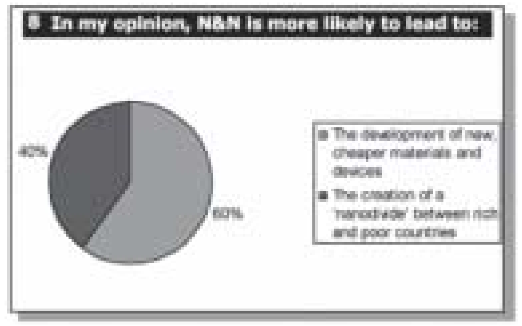

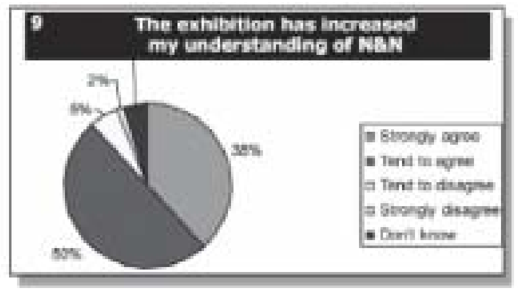

Finally, 88 percent of respondents agreed that the NanoDialogue exhibition had increased their understanding of N&N.

Summary of Focus Groups Discussions and recommendations
Focus group participants' were first asked by moderators to identify their particular interests or concerns regarding nanotechnologies and nanosciences. These can be broadly categorised as follows: (i) science fiction, (ii) research and development, (iii) regulation and control, (iv) current or future uses and applications, (v) human health and the environment, (vi) economic aspects, (vii) information and understanding and (viii) ethical, legal and social aspects. These broad topics/issues were then explored in-depth during discussions to elucidate which aspect/s they felt most positive about, which aspect/s they regarded with precaution, and which aspect/s they felt most negative about. Follows some recommendations coming from the different topics discussed.

Obstacles for industrial use to be overcome Plenary session 2

Science fiction

The metaphorical and imagerial representation of N&N as science fiction was one of the first issues raised by focus group participants. Drexler's vision of mechanical self-replicating nano-robots was regarded positively by an Estonian participant who imagined them as servants for humans. Estonian colleagues were slightly more cautious or even negative in their appraisal of the potential of nano-bots. One was wary of nano-bots' potential to become living organisms that can infiltrate the human body. Others imagined them as killer robots unable to be controlled, especially once inside the body. Indeed, the issue of whether humans were able to control nano-bots or not effected whether they were positively or negatively perceived.

Research and development

Participants' perceptions and expectations regarding N&N research and development highlighted more concerns than reassurances. While many viewed scientific progress generally and medical advancement in particular as positive aspects, the predominant view of research and development was negative in terms of 'who controlled it' and 'what is was used for'. Participants were concerned that research and development would be controlled by private interests rather than utilised for the public good. They perceived that private research was better funded and therefore attracted 'better' scientists. This may account for the lack of trust in scientists and the suspicion surrounding what goes on in laboratories. They were also worried that private research would lead to N&N's application for military or defence purposes, either by their own governments or in the hands of adversaries. Others favouring the middle ground stated that research and development should proceed with precaution rather than being curtailed by a moratorium (DE, EE).

- It is recommended that levels of government funding of N&N research and development be competitive with the private sector to attract leading scientists and technologists (R1).
- It is recommended that both the public and private sectors engage 'upstream' with publics on their research and development activities to ensure openness, participation, and accountability (R2).
- It is recommended that research and development of N&N for military or defence purposes is tightly regulated and subject to public engagement (R3).

Regulation and control

Interestingly, none of the participants noted any positive aspects to regulation and control. This may be because they believe either that N&N is, or will be, adequately regulated and it therefore does not necessitate mentioning or that it currently isn't, or will fail to be, adequately regulated and therefore fails to raise any positives.

However, participants' displayed a predominantly precautionary approach to regulation and control, demonstrating some trust in regulatory processes. While it was generally agreed that regulation performed a valuable monitoring and control function, an Estonian participant thought that an international body to oversee the regulation of N&N was required as the technology crosses international borders. French and Italian participants concluded that regulations should be controlled by a not-for-profit body and informed by an ethics committee to ensure accountability to the public. The prevailing view was that of seeking ways of balancing scientific freedom with risk-averse regulatory parameters. While the possibilities of self-regulation or voluntary regulation were ruled out, it was agreed by French participants that some limits on research and development were needed as short- and long-term risks were unknown.

Among the negative perceptions or expectations was a concern that excessive regulation would lead to a brain drain of researchers to competitors such as the US (DE). Another viewed regulation as a necessity to keep production costs low to ensure affordability (EE). A more sceptical view was that it is too late to apply the brakes to the research juggernaut (DE). There were also fears that the technology would fall into the wrong hands and possibly be used by terrorists (BE, EE).

- It is recommended that an international body be established to oversee the standardisation of regulatory parameters where feasible (R4).
- It is recommended that regulatory bodies regularly communicate across national borders to ensure that any regulatory gaps are identified at an appropriate stage (R5).
- It is recommended that regulatory bodies are advised by ethical committees to ensure public accountability (R6).

Current or future uses and applications

Overwhelmingly positive perceptions of the current or future uses and applications of N&N emerged from the focus groups. Stronger, more durable, lighter, cleaner, 'smarter' nanomaterials which will improve upon, or lead to new, everyday objects are expected to improve our way of life. Likewise, advances in medicine brought about by N&N are expected to lead to the improved detection and treatment of serious illnesses, more effective drug delivery, more successful organ transplants and better prosthetics. Interestingly, the use of nanoparticles in cosmetics to aid absorption and improve the appearance of the skin was viewed positively by some participants (BE, EE, DE).

The development of nanomaterials was welcomed by focus group participants who cautioned that public acceptability would be linked to their practicality and affordability (DE). A French participant was worried that changes to production methods would displace people and jobs while others questioned whether they were really necessary or if our expectations of them were too high (DE, FR). Similar concerns were held about the use of nanomaterials in medical devices and applications. An Italian participant was cautious about their affordability and therefore the availability of nanomedicine for all.

Concerns about national security featured heavily among the negative aspects of current or future uses and applications of N&N. The appropriation of N&N by terrorists or even the military - possibly leading to war - was of major concern (BE, DE, FR, SE). Consequently, some participants supported a moratorium on the use of nanomaterials for human enhancement or by the military stating safety concerns (FR, IT). While for a French participant, the risk of being left behind in the 'nano race' was considered detrimental.

- It is recommended that regulatory bodies and their advisors engage with publics to discuss future uses and applications of N&N to ensure that any regulatory gaps are identified at an appropriate stage (R7).

Human health and the environment

Numerous issues relating to human health and the environment where viewed as both positive and negative or warranting a precautionary approach by focus group participants. The potential of N&N to enable healthier, longer lives was viewed positively (BE, DE). As was the development of cleaner, more efficient and cost-effective (i.e. environmentally-friendly) energy products (BE, DE, IT).

Such issues would, as you'd expect, evoke an air of caution, particularly concerning potential long-term health effects. As mentioned above, the question of how much nanomedicine can achieve or whether it is even desirable remains (ET, SE). Likewise, while N&N may produce numerous benefits to the environment, unexpected consequences may later emerge and these must be made known to the public (DE, ET).

Potential risks to human health sparked the most negative comments in this category. Of particular concern was the possible ingestion, inhalation or absorption of nanoparticles into the body (BE, DE, FR, IT) – a concern echoed by The Royal Society and The Royal Academy of Engineering report. Many agreed there was too little knowledge on the risks to human health and that more research was needed to determine any long-term health effects. One French participant went so far as to label nanotechnology's potential a 'red herring'. Similar concerns were raised when considering the potentially negative effects of nanoparticles on the environment. Altering the building blocks of nature/life (BE, FR) and the inevitable comparisons with the GM controversy (IT) and the Chernobyl disaster (EE) also carried negative connotations for a number of the participants.

- It is recommended that all regulatory bodies review their existing regulations and take any appropriate measures to protect humans and the environment from the risks mentioned in this report (R8).
- It is recommended that the release of nanoparticles into the environment be prevented until more is known about their impact on human health and the environment (R9).

Economic aspects

The potential economic benefits to developing countries were viewed positively by participants even though the prevailing view was that developed countries would reap the benefits first (BE, ET).

The precautionary view questioned the affordability of nanoproducts warning that it is unreasonable to assume that N&N will alleviate poverty; partly as industrial innovation is driven by market demands rather than philanthropic motives (BE, DE, EE, FR).

This notion of N&N as a profit-making exercise rather than as science for science's sake was also among the most negative views (EE, FR, SE). Indeed, the prevailing notion was one of creating a 'nano-divide' thereby perpetuating the gap between the haves and have-nots (BE, EE, FR). Contributing to this dilemma is the negative perception of patents restricting consumer choice and only benefiting a wealthy few (FR, IT). A related concern was that N&N would eventually deplete employment opportunities. As people live longer because of nanotechnologies, there will be fewer opportunities for the young to enter the job market (DE, IT).

- It is recommended that industry and government liaise to control the economic impact of N&N, by ensuring its widespread affordability and availability (R10).
- It is recommended that governments undertake a review of their patent legislation economic impacts of patents law on public access to N&N products (R11).

Information and understanding
No positive perceptions or expectations were documented for this category. It was, however, generally agreed that more information on N&N should be made available to the wider public. The media and the school curriculum were singled out as ideal vehicles for information dissemination (BE, FR, DE, IT). Opportunities for public debate and to engage in dialogue with scientists, technologists, policy-makers and stakeholders at local, national, European and international levels was also seen as important (FR). It was acknowledge that such opportunities would better prepare publics for the inevitable social diffusion of nanotechnologies (DE, EE).
The prevailing negative perception is that there is a dearth of relevant, accessible information available to the public to enable them to develop informed opinions of the benefits and risks posed by N&N (BE, DE, FR). Likewise, there are few opportunities to engage in debate on issues that affect our everyday lives (FR).

- It is recommended that governments' fund and initiate widespread public dialogue on the research and development of N&N to increase public awareness and understanding and to improve decision-making processes (R12).

Ethical, legal and social aspects
The potential of N&N to improve surveillance techniques was considered one of its most positive, and most negative, qualities. The future use of nano-chips was seen as beneficial in tracing missing persons, tracking criminals and even as a means of parental control (EE, IT, SE). Improved communication techniques would encourage cultural exchanges and benefit people living in remote areas (IT).
The ethical, legal and social issues raised by N&N are innumerable. It comes as no surprise, therefore, that the vast majority of focus group participants were in favour of promoting a precautionary approach through regulation and labelling. Questions concerning 'who should control nanotechnologies?' and 'at what stage of the innovation trajectory?' were posed (ET, FR). A level of distrust in scientists and their (perceived) ulterior motives was evident (DE, ET). Like GM food, it was recommended that nanotechnology-based products be labelled to assist consumer choice DE, IT). Common concerns regarding N&N's ability to delay the aging process, it use in cosmetics and its role in human enhancement were raised (BE, DE, IT). Finally, some questioned whether 'profit' and 'ethics' were uncomfortable bedfellows (DE).
The issue of surveillance, as mentioned above, also provoked numerous negative perceptions among focus group participants. They were worried that personal privacy as well as personal safety could be compromised for the sake of national security (DE, IT, FR, SE). The cases of the war in Iraq and of terrorism were cited as examples. While the future use of 'nano-chips' to monitor criminals, terrorists and children was seen as a good thing, it was also considered one of the most negative prospects of the technology (DE, FR, SE). For some, nanotechnology's potential to enhance or extend life was particularly concerning (BE, IT). The possible misappropriation of the technology by influential companies and nations also caused considerable disquiet among the participants (FR, IT).

- It is recommended that government funding programmes support interdisciplinary research into the ethical, legal and social issues surrounding N&N (R13).
- It is recommended that nanoproducts be comprehensibly labelled to inform consumer choice (R14).

The final conference: a discussion on ethical, legal and social aspects of nanotechnologies and nanosciences
The final conference marked the conclusion of the 'NanoDialogue' project. It was held at the European Parliament, on February 5th, 2007 and saw the participation of 11 relevant speakers, coming from different backgrounds, such as nanosciences, social sciences and philosophy, and an audience of 130 people, from industries, policy makers, scientists, science communicators and stakeholders in general. The morning session was devoted to presenting the activities in the project and the related social, ethical and political aspects, from various points of view. In particular, the first session concerned the activities accompanying the exhibition and the results of the social survey. The second session offered the chance to deepen those scientific, ethical and social issues which were not treated by the exhibition, and the third session gave public the opportunity, in a round table debate, to discuss with experts about the issues raised by the project and the topic in general.

Nanosciences and nanotechnologies in the 7th Framework Programme

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Nanotechnology has a many-fold potential, in offering solutions to many current problems and expectations of citizens, in opening up more effective opportunities for sustainable development, in boosting wealth creation, or in defending employment and creating new ones. Both brilliant fundamental research and engineering are indispensable at this stage in order to generate new knowledge and turn it into successful and useful industrial innovation. The European Union (EU) has long supported nanosciences and nanotechnologies (N&N)[1] with attention for the various factors for success, the possible risks and measures to take, and its impact on society.

Support for research and technological development (R&D) came both from the European Commission (EC) and from the EU Member States, with a particular effort of coordination at the level of policies, programmes and projects. Under the Sixth Framework Programme (2002-2006) of the European Community for research, technological development and demonstration activities (FP6), the Commission continued and strengthened its support for R&D in this area. In total, almost 1.4 billion Euro has been committed to more than 550 projects dedicated or directly relevant to N&N. As a comparison, the Community contribution has been about 120 million Euro in FP4 (1994-1998) and 220 million Euro in FP5 (1998-2002). Of this amount, some 75% originated from calls of the third and second thematic priorities of FP6, which had calls specifically addressing N&N, whilst almost 25% originated from 'bottom-up' or other programmes of FP6 which did not make explicit provisions for N&N. Most notable amongst the latter is the programme for Human Resources and Mobility, the Marie Curie actions, in which some 160M€ was committed to projects in N&N. Within the third thematic priority (NMP), the participation of industry was somewhat lower in projects related to N&N than in the other projects within this industry-targeted priority. However, in the course of FP6, the industrial participation in N&N projects has doubled, from 18% in 2003-04, to 37% in 2006. The proportion of SMEs within this industrial participation was in the region 35-40%.

A breakdown amongst FP6 thematic priorities and programmes is shown in the table below:

Research funding in FP6 for N&N

FP6 Thematic priority or activity	*EC funding M€*	*% of total*
NMP[2]	575	41.6
IST[2]	466	33.7
Marie Curie[3]	161	11.7
Health[4]	65	4.7
Infrastructures[5]	40	2.9
NEST[6]	24	1.8
SME[7]	17	1.2
Others	33	2.4
Total	1,382	100.0

At the level of public funding, the comparative European positioning in the last few years has remained essentially the same. The funding in Europe increased, but it did so in line with that outside the EU. During its operational duration, FP6 accounted for almost a third of the overall public expenditures in Europe for N&N. On the basis of an approximate figure for the global expenditure in N&N of $30 billion in the period 2004-06, Europe accounts for more than a quarter of the total, with

Commission funding directly accounting for 5.5%. The relevant figures, for total R&D funding over the years 2004-06, are shown in the table below:

Estimated global spending on R&D in N&N (in M$[8])

	2004	2005	2006
EU	2,425	3,050	3,305
US	2,943	3,700	3,706
Japan	2,290	2,230	2,679
Others	870	1,200	1,722
TOTAL	8,528	10,180	11,412

In terms of private funding Europe is at a significant disadvantage with respect to the US and Japan, and far from the relevant target of the '3% objective' (which requires a two-thirds contribution from private funding). This situation, however, is not specific to nanotechnology. On the other hand, it should be noted that the private sector is making progress in this as part of its activities in the different European Technology Platforms (ETPs) dedicated to themes directly relevant to nanotechnology and its applications, such as Nanoelectronics, Nanomedicine, Sustainable Chemistry and Industrial Safety, which have produced vision papers and strategic research agendas. Other ETPs relevant to N&N include Advanced Engineering Materials and Technologies, and Hydrogen and Fuel Cell Technology. The priorities set out by the ETPs are taken into account in the elaboration of the FP7 calls for proposals, e.g. in the NMP, IST, Health and Energy themes.

Under the Seventh Framework Programme (2007-2013) of the European Community for research, technological development and demonstration activities (FP7),[9] it is expected that the Commission funding will increase significantly, particularly in the specific programme 'Cooperation', and is likely to more than double on a yearly basis. This is thanks to increases in the overall budgets of relevant themes, as well as expected increases in the share of N&N in 'bottom up' programmes, notably the 'Ideas' and 'People' programmes, which are in turn much larger than their FP6 counterparts.

The first calls of FP7 were published on 22 December 2006. The wide coverage of FP6, in terms of subject area and type of funding, is expected to continue. Overall, some 60 calls and topics opened in the first year of FP7, in all specific programmes, are directly relevant to R&D in N&N, with many more being potentially relevant. These cover research and development activities, as well as supporting actions, in nanosciences, technology development, impact assessment, societal issues, nanomaterials, nanoelectronics, nanomedicine, as well as in training and frontier research. Moreover, direct R&D actions in risk assessment of nanomaterials, nanobiotechnology and metrology have been included in the Multi-Annual Work Programme of the Commission Joint Research Centre.

Funding in FP7 has also a strategic relevance. Without neglecting fundamental research, the NMP theme of FP7 aims for research that can lead to useful applications and is relevant to the needs of industry, in accordance to Article 163 of the EU Treaty.[10] This is reflected in the three criteria adopted to evaluate research proposals, quality, impact and usefulness. Moreover, there are many measures in place to increase industrial participation in projects, including that of SMEs, and undertake complementary initiatives, such as the collaboration with the European Patent Office, the introduction of a guarantee fund, and the Competitiveness and Innovation Programme (CIP) which is complementary to FP7.

The FP6 ERA-NET scheme supports the coordination and coherence in the research programmes carried out at national level, such as for NanoSci-ERA, MNT ERA-NET and MATERA. The ERA-NET scheme will be continued and boosted in FP7 with the introduction of the ERA-NET Plus scheme. An additional, valuable contribution to coordination came from COST.

The European Commission's support for these key technologies is not limited to funding of R&D projects. Complementary action to support N&N was already taken in the mid- to late 1990s. As a result Europe is in a leading position in nanotechnology. Now the European industry and society in general should enter the commercialisation phase, to reap the benefits of this knowledge through innovative products and processes. Safety is steadily addressed, as well as other issues that could represent impediments or delays to the successful use of nanotechnology.

To meet the challenges and to ensure Europe's competitiveness in this sector we need to join forces across disciplines, sectors and national borders. We need to increase investment, boost interdisciplinarity, create the necessary infrastructures, expand human resources and develop international co-operation to support research and foster innovation. At the same time, we need to address societal concerns brought about by the development of new applications. We also need to consider potential regulatory issues. These priorities are central to the European integrated, safe and responsible approach to nanotechnology, as proposed by the European Commission in two Communications, the European Strategy and the Action Plan 2005-09.[11]

In general, Europe enjoys a strong position in terms of producing knowledge in nanotechnology (e.g. publications), but is weaker in transferring this knowledge into industrial products and services (e.g. patents and start-ups). With regard to funding, the European Commission has steadily increased the level of its funding for research in nanosciences and nanotechnologies, as described above. On the other hand, the level of private R&D funding is lower in Europe in comparison to some other areas e.g. the USA and Japan. The challenge in funding R&D in this diverse and important field, is to focus on the most promising sciences and technologies, leading to higher-performance products and services on the one hand, and sometimes a 'revolutionary', not only 'evolutionary', industrial innovation.

With regard to regulation, a high level of public health, safety, environmental and consumer protection is aimed at. This requires the identification of safety concerns, the collection of appropriate data for an adequate health and environmental impact assessment of the products data, and action at the earliest possible stage through adjustments, where necessary, of risk assessment procedures for issues of nanotechnology. To address these needs, relevant research projects have already been funded; following an informal collection of information, impact assessment is a major component of the first calls of FP7 and the intention is to continue this support in further calls. In the meantime, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) has adopted an opinion on 'The appropriateness of existing methodologies to assess the potential risks associated with engineered and adventitious products of nanotechnologies'. Briefly, this has recommended addressing various uncertainties with regard to potential hazards and exposure; addressing gaps in knowledge; and further developing guidelines and methods. Another opinion is being drafted, on the appropriateness of the risk assessment methodology in accordance with the Technical Guidance Documents for new and existing substances for assessing the risks of nanomaterials. Apart from research-centred activities, the European Commission is currently looking into the legislative issues of the increasing use of nanotechnologies, i.e. it is currently exploring the already existing European legislation applicable to nanotechnology and assessing its adequacy and appropriateness. Current analysis shows that the current regulatory framework is, in principle, capable of handling nanomaterials. Ethical issues are also constantly addressed, and in January 2007 the European Group on Ethics delivered its opinion on Nanomedicine.

Note that the views expressed in this paper are those of the author, do not necessarily represent those of the European Commission and do not engage the European Commission in any way.

[1] *http://cordis.europa.eu/nanotechnology/*
[2] *Respectively, 'Nanotechnologies and nano-sciences, knowledge-based multifunctional materials and new production processes and devices' (NMP); and 'Information Society Technologies' (IST)*
[3] *Specific programme 'Structuring the European Research Area', 'Marie Curie Actions - Human resources and mobility'*
[4] *Thematic priority 'Life sciences, genomics and biotechnology for health'*
[5] *Specific programme 'Structuring the European Research Area', 'Research Infrastructures'*
[6] *Specific programme 'Integrating and Strengthening the European Research Area', 'New and Emerging Science and Technology'*
[7] *Specific programme 'Integrating and Strengthening the European Research Area', 'Specific SME Activities'*
[8] *For the purposes of an approximate global comparison, figures are given in M$ using 2005 exchange rates. Source: European Commission and Lux Research*
[9] *http://cordis.europa.eu/fp7*
[10] *Article 163 of the EU Treaty states that The Community shall have the objective of strengthening the scientific and technological bases of Community industry and encouraging it to become more competitive at international level, while promoting all the research activities deemed necessary by virtue of other Chapters of this Treaty.*
[11] *http://cordis.europa.eu/nanotechnology/ & http://cordis.europa.eu/nanotechnology/actionplan.htm*

Carbon nanotubes: maturing products based on maturing processes

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From production capacities in grams or kilos at the most a few years ago, carbon nanotubes can now be purchased by the ton. Simultaneously their price has been drastically reduced and their conditioning has evolved and diversified.
Master batches, coated forms, purified and/or functionalised CNTs, solutions, predispersed forms are also available on the market. Further integration into end products has also become a reality and intermediate products are available such as textile spools, conductive films and special paints. This fast maturation from a single to a family of products has been made possible notably by a rapid maturation of the processing tools. A short review of these developments highlight how carbon nanotubes have become a reality and can no longer be considered simply as a potential opportunity. Could this fast development set the trends for broad range of nanoproducts?

Energy balance of carbon nanoparticle applications: a technology assessment of production and use systems

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Abstract
Energy requirements for fullerene and nanotube synthesis are calculated from literature data and presented for a number of important production processes including fluidised bed and floating catalyst CVD, carbon monoxide disproportionation, pyrolysis, laser ablation and electric arc and solar furnace synthesis. Critical issues in energy and scaling production are identified and potentials for improvement in industrial scale processes are discussed including possible interactions with related industrial ecosystems. Carbon nanoparticles (CNPs) are found to be highly energy intensive materials, in the order of 3-100 times more energy intensive than aluminium, even with idealized implementations of production routes. This perspective is used to survey real world applications with newly commercialised or anticipated products enabled by carbon nanotechnology. By examining concepts such as energy payback from dematerialising or increasing the efficiency of technology, insights into the potential lifetime energy profile of carbon nanomaterials is gained. Despite the large energy demand of production, CNP lifecycle energy flows could become neutral or positive in some applications, particularly in energy related systems.

Background and method
The unique material properties and recent successes working with C_{60} and carbon nanotubes have led to a host of realized and anticipated applications. In particular, they have been portrayed as having a potential to provide new technologies for efficient and clean conversion, storage and use of energy and thus be key to climate change mitigation (Baughman et al. 2002, Smalley 2005). As carbon nanotechnology has left the laboratory and begun the process of industrialisation,[1] interest and concerns over the potential environmental impacts of CNPs have also begun to arise. The main objective of this work is to obtain a reasonable set of cumulative energy requirement estimates for current and potential CNP mass production processes in order to enable evaluations of potential net energy balances in CNP applications[2] and to dentify critical issues in production and assess future potential to ameliorate them. Lifecycle inventories of laboratory scale processes have begun to emerge (Isaacs et al 2006). However, such results may not be representative of future large-scale production systems. Therefore, an approach is taken where the cumulative energy requirements (CER) for production at industrial levels are built up by assuming industrial efficiencies in obtaining the observed reaction conditions and using known CERs of creating the precursor materials. Complete sets of lifecycle data on the production of all background inputs into the production system were obtained. For inputs without lifecycle analyses available, an estimate was made from process data.

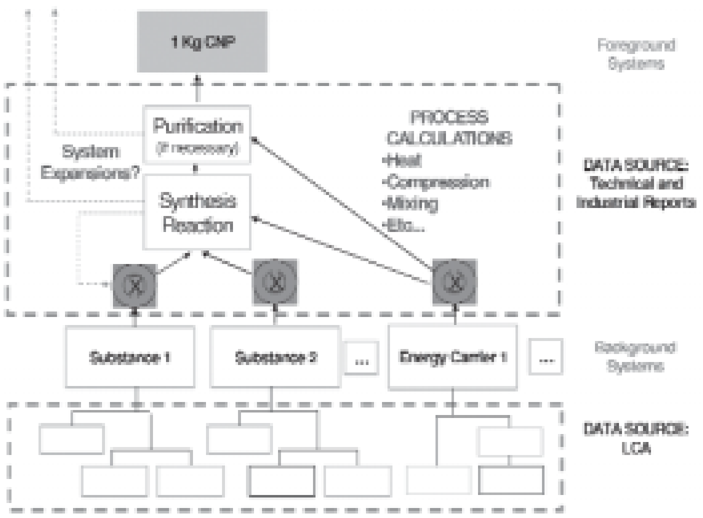

Figure 1: System Methodology for CER calculations

[1] *Some estimates place single wall nanotube production at 5 kilograms globally in 2000, while production of all carbon nanoparticles is estimated to reach 400+ tons in 2007 (Cientifica 2006), and grow rapidly thereafter.*

[2] *See Kushnir and Sandén (2007) for a full paper on energy requirements of CNP production and Kushnir (2007) for energy balances of some CNP applications.*

Various systems for production are discussed along with possible technical improvements suggested by research or by the model results. There are two main cases, or variations of this foreground system, considered for each process: a baseline case and an 'efficient' case. There are several tradeoffs inherent in production systems and yield per unit feedstock versus yield per unit time appears to be one of them. The baseline cases all use stoichiometry data from reports containing the highest yields per unit time found, while the efficient cases take their stoichiometry from process reports detailing very high feedstock yields, with the assumption that such high efficiencies can be obtained at higher throughput.
Additionally, integrating some production processes with compatible existing industries could abate some of the production energy and material costs from a lifecycle perspective, but it is not clear when or if it will be feasible to do so.

Results
The results of the process model calculations are given in Table 1. The figures represent the cumulative electricity and thermal energy requirements for a net production of 1 kg of bulk nanoparticles and indicate that they will remain highly energy intensive materials, even in a close to optimal industrial production setting. With some caveats, it can be said that the values calculated lie somewhat above what is thermodynamically possible, and therefore represent a long term target that could only be achieved with scaling of process and some technical innovation.

Table 1: Cumulative Energy Requirements (CER) of seven CNP production pathways (cradle to gate)

		Baseline Case		Efficient Case	
Process	Product	Thermal (MJ_{th}/kg)	Electrical (MJ_e/kg)	Thermal (MJ_{th}/kg)	Electrical (MJ_e/kg)
Fluidized Bed CVD	SWNT	328	626	93	220
Floating Catalyst CVD	MWNT	295	187	331	74
HiPco	SWNT	47	5769	-	-
Pyrolysis	C60	6341	678	5412	538
Electric Arc	MWNT	295	2170	75	2170
Laser Ablation	SWNT	211	9424	61	1600
Solar Furnace	SWNT	292	(6200)* + 150	72	(6200)* + 150

* *This value is the 'wasted' electric potential of using such a thermal system, and represents an opportunity cost for using the apparatus to produce nanomaterial. An alternative value is zero.*

The manufacturing energy costs of various processes used in CNP application such as melt pressing, dispersion or ball milling are fairly well characterized, but quite small compared to that of the nanotubes themselves. Because of the high production energy requirements, addition of nanotube material increases the energy intensity of virtually any material. However, this does not imply that the overall life cycle energy balance of CNPs in comparison to other materials is always negative; in many applications, there is a definite potential to offset energy and material requirements of CNP production via increased efficiency and dematerialization of the application.
In bulk materials, observed and theoretical increases in material properties suggest that adding small amounts of CNPs to toughen materials is a more energetically efficient way to improve structural materials than creating high-concentration composites. Neither may be effective compared to traditional materials if increases in industrial efficiency are not realized. For instance, Table 2 shows an example demonstrating energy efficiency in stiffness based structural materials; it shows that while aluminium and carbon fibre based composites could represent an improvement in structural material efficiency, SWNT composites, despite potentially superior material properties, represent an increase in energy intensity per unit of service.

Table 2: Stiffness Based Material Replacement Index and Energy Requirement (CER)

Material	Young's Modulus (E) (Gpa)	Density (ρ) (g/cm³)	Material Replacement Index (=E³/ ρ, Steel = 1)	CER* / Material Replacement Index (Steel = 1)
Aluminium 2024-T4	142	2.7	2.5	0.7
CF/Epoxy Composite (Automotive 61%)	100	1.59	3.7	0.5
SWNT/HDPE composite	162	1.35	5.3	1.5

** From Table 7: SWNT baseline. 0.35 thermal to electrical conversion efficiency assumed.*

In energy applications, because effects from their use are leveraged over comparatively large masses of components, dematerialization resulting from increase in lifetime could be a major direct environmental benefit, with benefits an order of magnitude larger than costs. Small increases in device efficiency could additionally result in a large amount of energy savings over the lifetime of a product; potentially as large as or larger than the CER of production (Kushnir 2007).

Realizing actual gains in either category will require energy and material flow improvements from current laboratory production efficiencies. Regardless, it seems possible to regain the high energy cost of carbon nanoparticle production from dematerialization effects and direct results of efficiency increase, particularly in energy applications.

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Nanospider™ technology and its applications

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Nanofiber preparation methods

Electrospinning methods seem to be the only ones exploitable in industrial production process. While the processes working with sets of hollow needles show some difficulties in continuous production and machine throughput, the electrospinning from surface provides reasonable production speed, regular nanofiber layers and acceptable fiber diameter distribution.

Electrospinning from surface (roller) was invented by Technical University in Liberec, Czech Republic, in 2003, and it was patented a year later.

The process in itself is very easy for explanation (Fig.1). The roller as a spinning electrode is sunk into the polymer solution. A very thin layer of the solution is created on the surface of rotating roller. Due to high electric field between rotating roller and upper collector, Taylor cones are created on the surface of the roller and the individual rays of polymer are splitted as long as they fall to the surface of substrate material.

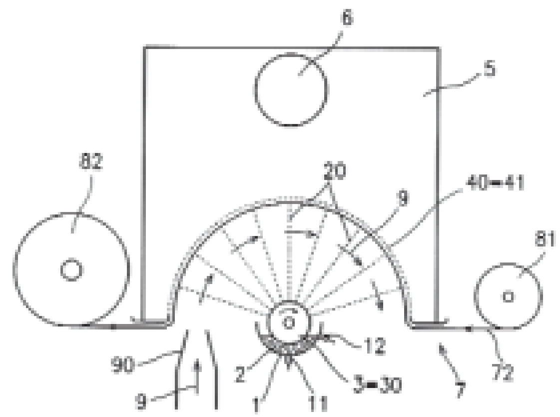


Fig.1. The principle of Nanospider™ electrospinning technology

The technology is very versatile for many polymer solutions.

Some examples of polymers spun by Elmarco are: PA6, PA6/12, PUR, PARA, PVA, PES, GELATINE, CHITOSAN, fluorated polymers, etc.

It is able to prepare nanofibers from precursors of the following inorganic material: TiO_2, SiO_2, Al_2O_3 etc.

The technology is being modified for melt polymers as well.

The Nanospider™ technology has many advantages thanks to its simplicity:
- Very high throughput in comparison with nozzles usage
- Low maintenance, short downtime
- Consistent, homogenous nanofiber layer
- Safety operation

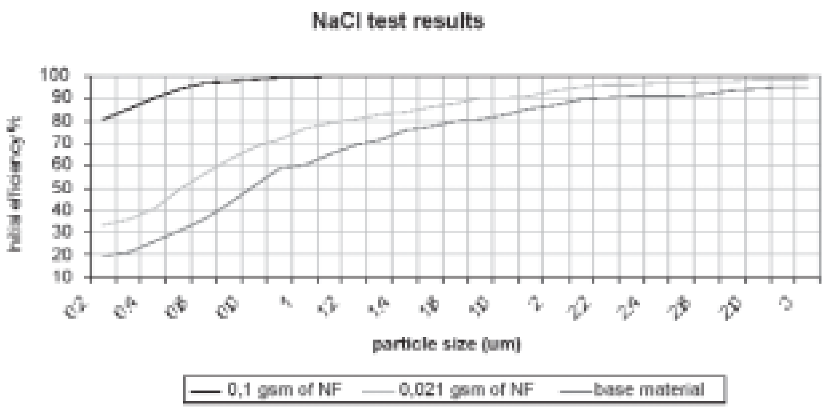
The product portfolio Elmarco company offers in nanofiber technology is very wide: from customized research and development over laboratory machines for production of nanofiber samples to industrial-scale machines.

The technology is very friendly to the environment.

End-uses of nanofibers

The application area of nanofibers is very wide and various.

At this moment, the main application area is air and liquid filtration. Thanks to unique nanofiber properties, as very high specific surface, high porosity, small pore size, ability to dope nanofibers with active agents, the nanofibers enable to remove very small particles. At very low area weight (0.1 gsm), the filtration efficiency is increased while the pressure drop stays at almost the same value.



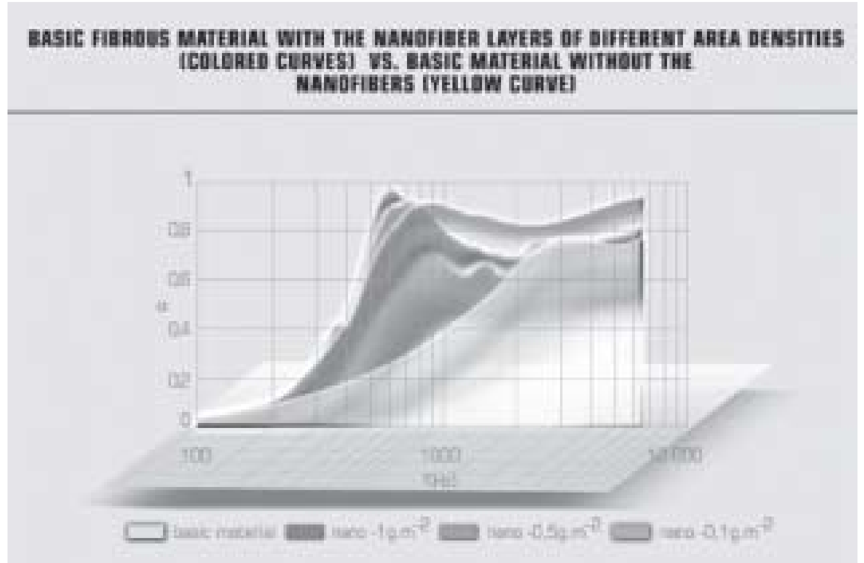
In 2006, Elmarco R&D team developed a new material for elimination of some mechanical and biological impurities from air, called AntimicrobeWeb™. This material consists of support material (viscose) which is coated with two nanofiber layers. One layer contains of at least one microbial additive and therefore is effective in growth inhibition of some microbes. Other layer with smaller pore size is designed as fine filtration component. This material is suitable for face masks, air conditioning filters, filters for clean rooms, etc.

The face masks made by Nanospider technology were tested in Nelson Laboratories (USA) for bacterial and viruses filtration efficiency with very good results. BFE and VFE are higher than 99.9%.

Additional application of nanofiber layers is in HEPA and ULPA filtration. In this area, it enables to use lower area weight of substrate material, which is quite expensive and the charged meltblown has not been used for filtration efficiency increase. In the liquid filtration, we expect the usage in wastewater filtration, oil and fuel filtration and in biotechnology filtration (wine, beer, milk, etc.). Very prospective area is ion exchange membrane as well.

Other area of application is sound absorbing material containing nanofibers.

As sound absorption of lower frequencies is quite problematic with fibrous materials made up of coarser fibers, development of highly efficient sound absorption material is called for. An ordinary fibrous material absorbs sound energy of higher frequencies and a foil absorbs only lower frequencies but nanofibrous layers damped by the porous material absorb the acoustic energy of wide frequency band. It is caused by very low diameter of fibers. The incident sound wave is transferred into the heat after absorption.



The material is called AcousticWeb™ and it is very lightweight with very good heat insulation properties. This material can be used in automotive sector (transportation) as door insulation, headliner, car boot, etc. in home appliance (fridges, dishwashers, washing machines), and in buildings.

In wound coverings applications, Elmarco signed join venture with Irish pharmaceutical company. Wound coverings are materials with some specific functions:

Stop bleeding; allow liquids to get out of wound; allow air to access wound; do not allow access of bacteria; release drugs which help healing process. Some wound coverings are to decompose inside of body in certain time interval. Composite materials containing nanofibers were tested as wound coverings with positive results.

There are many other application of nanofibers, e.g. in photovoltaic cells, new generation of batteries and condensers, fuel cell, wave shielding material, in nanocomposites - development of ground-breaking composites with outstanding properties.

Elmarco with its technology creates the world of 3rd millennium.

Nanolayers and nanostructures for the refinement of polymer products - an overview

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Abstract
All kinds of polymer surfaces in principle can be refined by the application of nanolayers or nanostructures. An overview about the possibilities within the Freudenberg group will be given. Possible substrates are non-wovens for clothing, wipes or elastomer for sealing, damping or household applications.
Relevant material properties are friction coefficient, wear, stick-slip behaviour, wetting, soiling or antibacterial properties. Such layers and structures can be applied by wet coating, plasma coating, laser techniques or sputtering techniques.

Examples
Antibacterial silver-layers deposited by sputtering

As metallic silver-nanostructures exhibit a high surface-to-volume-ratio, the concentration of microbiological effective silver ions at the nanoparticle surface, generated by atmospheric oxygen and humidity from the environment, is significant higher than for macroscopic, respective μ- structures. Applying nanosilver to textiles can improve the smell properties as shown in Figure 1, where a nonwoven was equipped with different loadings of nanosilver. The fact that a moderate concentration of approx. 300 ppm silver is sufficient in order to reduce the bad smell is due to the genuine advantage of the nanotechnology.

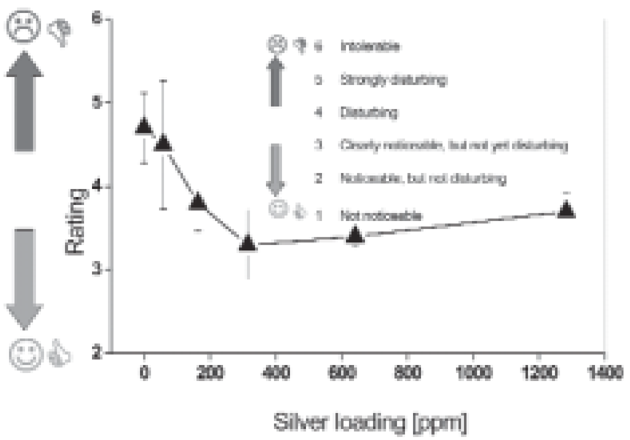

Figure 1:
Rating of the smell of wipes as a function of the silver loading

Wear reduction of rubber lips by deposition of HMDSO plasma-layers
As cleaning products for the professional segment are used frequently and often, their wear can be a critical property. We used a plasma process for the coating of such lips with HMDSO nanolayers. As shown in Figure 2, the wear can be reduced by 2-3 orders of magnitude, depending on the applied plasma parameters. The tests were performed on a pin-on disc apparatus.

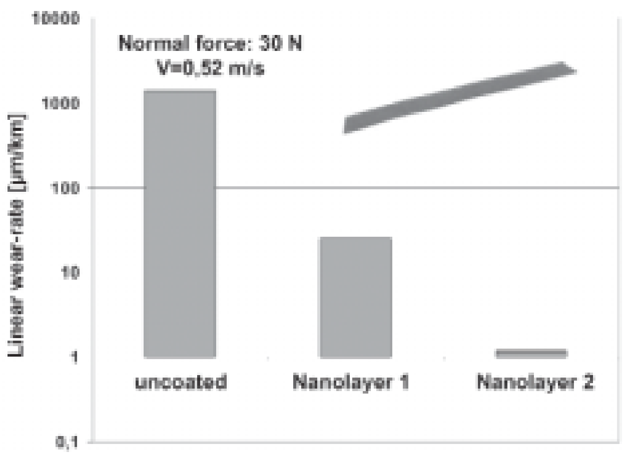

Figure 2:
Linear wear rate of uncoated and coated rubber lips

Dynamic wetting behaviour of household wipes by fluoroform nanolayers
The dynamic wetting behaviour of non-wovens for household wipes can be a critical factor of the cleaning performance. As the wiping process is fast, the relevant time scales are far below one second. For this reason, it is a great challenge to influence the dynamic wetting behaviour within milliseconds. In Figure 3, the water contact angle for different wipes is shown as a function of time. It can be clearly seen, that a successive application of fluoroform nanolayers results in a reduction of the wetting velocity. The wetting behaviour can be influenced very sensitively and within a very small time scale by such layers.

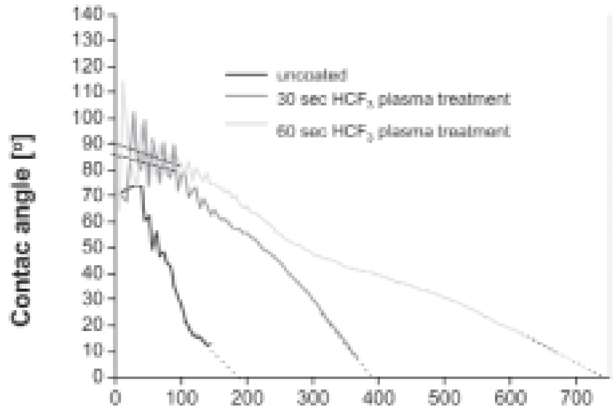

Figure 3:
Dynamic wetting behaviour of wipes coated with fluoroform

Friction reduction of dynamic sealings by plasma-layers or microstructures
As dynamic sealings like the Simmering® are part of tribological systems, it is of great interest to reduce the friction coefficient in order to prolong the lifetime and to reduce energy consumption. In a first step, we applied HMDS plasma layers. As shown in Figure 4, the friction coefficient can be reduced by a factor 6-7.
Another possibility for reducing the friction is the direct structuring by laser techniques or the negative structuring of the tools and therefore the application of a imprinting process. The results of the application of the imprinting technology can be seen in Figure 5. The application of larger structures results in a increase of the friction coefficient, smaller structures decrease the friction coefficient.

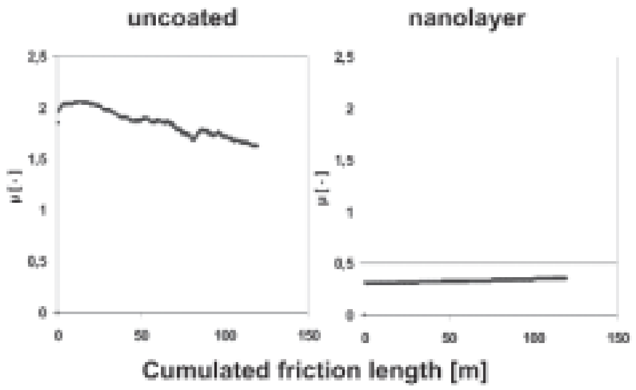

Figure 4:
Friction coefficient for a HNBR material without and with a HMDSO nanolayer

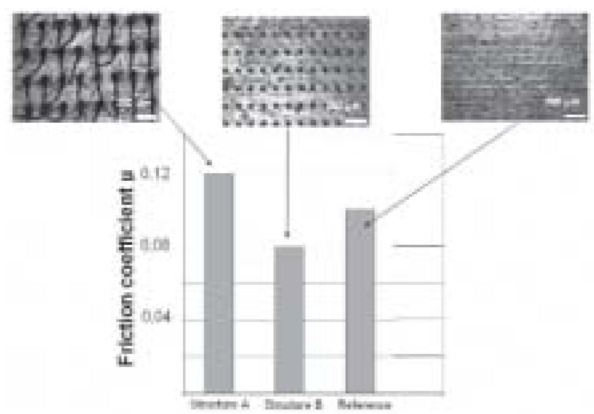

Figure 5:
Friction coefficient for a HNBR material without different surface structures

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Includes
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Deterministic nanofabrication: CVD or PECVD?

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Deterministic synthesis of functional nanoassemblies (NAs) ranging from common nanostructures to intricate nanopatterns and nanodevices is a current demand and ultimate crux of modern nanoscience and nanotechnology. At the macroscopic level, this implies the ability to adequately select and adjust the process parameters to achieve the desired properties of individual NAs, such as their positioning, alignment, shape, elemental composition, crystallinity, etc. [1] At the microscopic level, the determinism implies a certain degree of control over the building blocks that selfassemble into the required nanoassemblies and optimization of elementary processes in the nanofabrication environment. Therefore, the choice of the most favorable environment turns out to be a critical factor to reduce process costs and achieve the long-held goal of deterministic nanofabrication.

Here, from the microscopic-level viewpoint, we argue that partially ionized environments of the plasma-enhanced chemical vapor deposition (PECVD) can offer a better deal of controlling the size, shape, and pattern uniformity in deterministic synthesis of selected nanoassemblies, as compared to charge-neutral thermal CVD. By using an experimental investigation, hybrid Monte Carlo and adatom selforganization simulation [2], we show that the ionized gas environment is decisive in sustaining the growth of tall and sharp carbon nanotip microemitter structures as opposed to short and wide nanotips grown by the CVD under the same conditions.

We also show [3] the advantages of using low-temperature plasma environments for post-processing of dense nanotube arrays. By controlling plasma-extracted ion fluxes and varying the plasma and sheath parameters, one can selectively coat, dope, or functionalize different areas on nanotube surfaces. Conditions of uniform deposition over the nanotube surfaces are obtained for different arrays. The plasma route enables a uniform processing of lateral surfaces in very dense (with a step-to height ratio of 1:4) arrays, impossible via the neutral gas process wherein radical penetration into the inter-nanotube gaps is poor.

The supporting experimental results are also discussed in details.

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Rapid nanocomposite manufacturing - a new way of realizing multifunctional applications

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Abstract
The use of ultrashort pulsed laser ablation enables to generate functional nanoparticle polymer composites. The nanoparticle dispersions can be transfered into homogenous polymer nanomaterial. This method is qualified to rapidly design nanomaterials for customers needs. At the example of a silicone-based implant, we demonstrate the fabrication route to multifunctional custom-tailored polymer composites which is realised with embedded nanoparticles and nanoparticles mixtures of a variety of materials. Overall, we discuss how value can be added to conventional material by transferring nanomaterials into prototypes in order to close the gap between nanomaterials design and manufacturing of products, especially for small series or individual end products.

Introduction
The need to accelerate the transition of nanotechnology into practical use gains increasing importance. A variety of new nanocomposites material formulations do already exist but they often do not correspond to the customers' need. There is still a lack in providing costumers with parts and small series of new designed multifunctional nanocomposites for testing. But the availability of prototypes of end-user parts for material and functionality testing is often the prerequisite for a market launch or mass production. This can be realized with the novel method of rapid nanocomposite prototyping and manufacturing. The aim of this study is to bridge the gap in the value chain with a straight-forward realization of an innovative raw material into a prototype e.g. for medical applications. Engineered nanoparticles are used in nanocomposites and coatings for biomedical applications such as antibacterial implants or catheters, modification of textiles, and refinement of polymers. Very often the desired range of applications is restricted due to a limited availability of nanoparticle materials, their purity, their re-dispersability (e.g. of agglomerated powders) and costs (specially for small amounts like pre-series). Laser ablation has showed itself as an alternative physical nanomaterial fabrication method, which offers novel opportunities to solve the agglomeration and impurity problem inherent to conventional methods like the gas phase hydrolysis/pyrolysis and sol-gel process. The method is based on the ablation of a target by ultrashort-pulsed laser radiation, leading to the ablation of the solid and the formation of nanoparticles/nanostructures which are quenched and stabilised by the confining liquid [1]. In Figure 1, the nanosecond-pulsed and femtosecond-pulsed laser ablation is compared with respect to the different thermal load of the material, giving minimal thermal load in the case of fs-laser ablation [2].

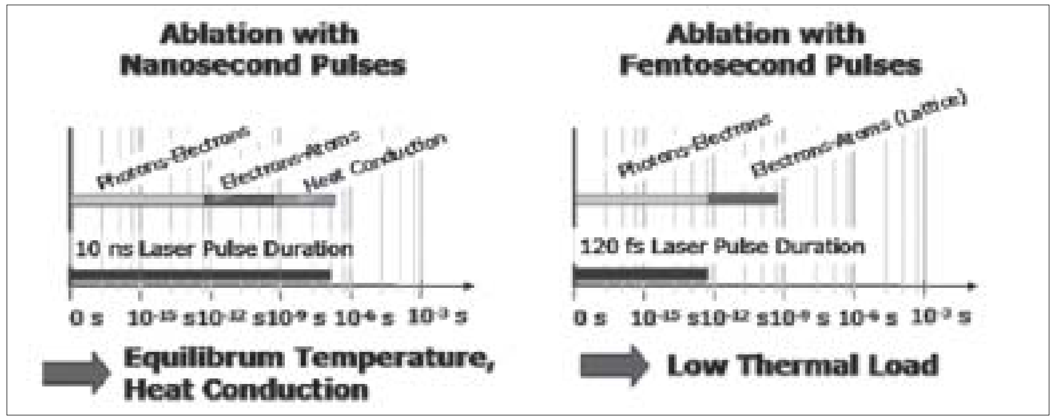

Figure 1: Comparison of nanosecond-pulsed and femtosecond-pulsed laser ablation with respect to the time regime of photon-electron, electron-atom interaction, and heat conduction

This ultrafast ablation process makes it possible to produce very gentle material removal converting a bulk material into nanoparticles in gases and liquids [3,4] without changing its stoichiometry [5]. If the nanoparticle generation is carried out by ablation in an infrared transparent liquid (such as water, ethanol, acetone, ethylacetate, acrylates, ...), an in-situ dispersion of the nanoparticles in these solvents and subsequent polymerisation is possible. Within 30 seconds, a colloid is manufactured ready for testing; in the following minutes, the ultrapure nanocomposite material is available for the manufacturing of the end-part e.g. by moulding.

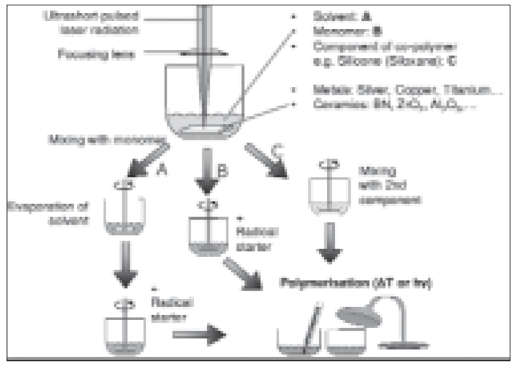

Figure 2:
Workflow of the rapid nanocomposite manufacturing method

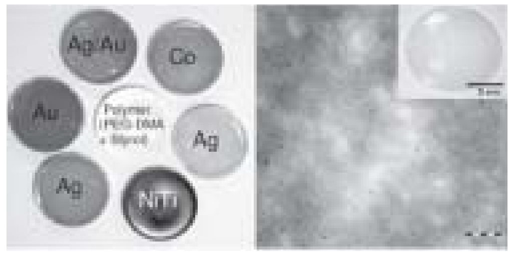

Figure 3:
Examples of manufactured nanocomposites with embedded metallic nanoparticles (left).
TEM image of gold nanoparticles embedded into acrylic polymer (right).
Insert: transparent nanocomposite sample

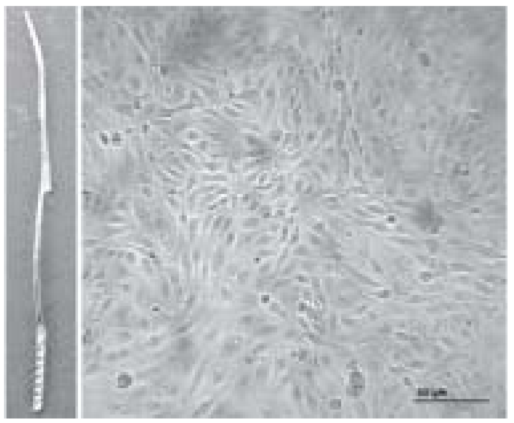

Figure 4:
Endothelian cells grown on silicone-silver-nano-particle composite. Left: Silicone electrode mantle of a cochlea implant

Experimental
The generation of nanoparticles was carried out using a femtosecond laser system by Spectra Physics (Spitfire PRO), emitting 120 fs laser pulses at 800 nm. This laser produces fs pulses with an energy of up to 1 W and works with a repetition rate of 1 kHz. A fourstage positioning unit for laser micromachining by 3D-Micromac was used. Femtosecond laser ablation in liquid media was carried out in an open glass vessel. The material is placed on the bottom of the glass vessel filled with several ml liquid. The laser beam was focused by a lens on the surface of the target.
During the process in liquid media, generated particles are dispersed as colloids. Afterwards, three different routes of polymerisation may be realized depending on the solvents used during the ablation process.
An overview about the principle of the nanocomposite manufacturing with the simple steps i) laser generation within liquid (solvent, monomer or resin component), ii) preparation of mixture for polymerisation, iii) polymerisation by heating or applying UV light is given in Fig. 2. Depending on the liquid (solvent, monomer, resin), three different routes apply as shown in the work flow of Fig. 2.

Results
Experiments have been carried out to manufacture nanocomposites with embedded nanoparticles of a wide range of metallic materials. Some examples of these nanocomposites are shown in the left image of Figure 3. Due to the embedding of the nanoparticles their optical properties are implemented into the composites which are still transparent after embedding. The polymer obtains the element characteristic colour based on the plasmon resonance of the nanoparticle e.g. gold nanoparticles turn red, silver nanoparticles orange to yellow. Additionally to the metallic nanoparticles also nanoparticles of alloys are generated. The right image of Fig. 3 shows a transmission electron microscope image of gold nanoparticles embedded in acrylic polymer. This demonstrates the homogeneous distribution of the nanoparticles in the polymeric matrix.

The functionalisation of these nanomaterials for medical application is demonstrated at the example of silicone used as cochlea implant electrode carrier. Into the silicone matrix, silver nanoparticles are embedded using the above method. It is well-known that silver hydroxide ions are released from water molecule permeable polymers with embedded nanoparticles, causing antibacterial functionality. But care has to be taken in case of implant, in order to avoid anti-proliferative effects on cells which are responsible for the functionality of the implant. In case of the cochlea implant electrode, spiral ganglia cells (SGC) and endothelial cell have to grow towards the silicone surface. In addition, it is aimed that SGC cells (responsible for signal transfer to the central nervous system)

grow more effective than endothelial cells (responsible for fixation of the implant). Therefore, a slight suppression of the endothelial growth is sought. First results of proliferation effects of endothelial cells in the log-phase on the nanocomposite material are shown in figure 4. As wanted, they grow slower than on the pure silicon control, but show sufficient proliferation behaviour.

Conclusion and outlook
Compared to conventional methods, stable nanoparticles are generated in high purity during pulsed laser ablation of solids in liquids without the use of chemical precursors. In-situ dispersions and subsequent embedding of nanoparticles into polymers have been demonstrated. This method allows a design of new functionalities of polymer composites due to nanoparticle derived effects. The use of a variety of materials and liquids underlies almost no restrictions.
As shown at the example of a bioactive product, the novel manufacturing route gives access to rapid nanomaterial generation and variation of properties, e.g. for pre-clinical studies. Since the materials can be used as masterbatch, their integration into conventional processing chains like injection or reaction moulding is the consequent next step towards rapid nanomaterialparts prototyping.

Acknowledgments
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Large-scale synthesis of single-walled carbon nanotubes with a modified arc-discharge technique

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This contribution describes the synthesis of single walled carbon nanotubes (SWCNT) with a modified arc-discharge technique. It will be shown that the synthesis of nanotubes with arc-discharge results in some unique opportunities, one of them being the possibility to easily upscale the SWCNT synthesis – with results suggesting a production volume of tons/year being in reach. This is followed by the presentation of an integrated approach aiming not only at a large-scale synthesis of SWCNT but also at an integrated solution for the direct synthesis of chemically modified nanotubes. This results in both an upscaled and flexible synthesis route for these promising nanomaterials.

Techniques, instruments and special aspects of CEN and CEN-STAR with some views in nanotechnology for measurements and quality insurance

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1. Introduction and definition

What is CEN ?

CEN, the European Committee for Standardization, was founded in 1961 by the national standards bodies in the European Economic Community and European Free Trade Association countries. Today CEN is contributing to the objectives of the European Union and European Economic Area with voluntary technical standards which promote free trade, the safety of workers and consumers, interoperability of networks, environmental protection, exploitation of research and development programmes, and public procurement.

CEN is one of the 3 European Union standardisation official organisations with CENELEC for electro-technical standardisation and ETSI for telecommunication.

CEN technical areas are:

1. Chemistry
2. Building and civil engineering
3. Household goods sport and leisure
4. Environment
5. Food
6. General standards
7. Healthcare
8. Health and safety
9. Heating, cooling, ventilation
10. Information society
11. Materials
12. Mechanical engineering
13. Measurement
14. Services
15. Transport and packaging
16. Utilities and energy

Why develop European Union Standards?

Standardisation facilitates the exchange of goods and services by elimination of the barriers of a technical nature. Consumers and producers alike benefit from standardisation through increased product safety and quality as well as lower prices. With one common standard for 30 European countries, a product or a service can reach a far wider market with much lower development and testing costs (i.e. 500 million people).

Standards are technical references well documented, prepared by experts and adopted following the consensus process. Standards are information to the users and different stakeholders; their diffusion is complement to the scientific publications and to the patents, the two other ways for technical innovation references.

In few words, standards:

- Increase safety and allow interoperability
- Increase understanding and information transfer
- Promote competitiveness of industry and increase competition
- Define agreement on the design, manufacture, performance and testing of products, services, or operations
- Diffuse results from R&D

Standards are transparent and consensus based working forum open to all interested parties, freely agreed, voluntarily applied and verifiable compliance, coherent set of specifications. They are revisited when the state of the art improved and reviewed each 3 or 5 years.

What is CEN-STAR ?

CEN-STAR is a committee in which STAR means Standardisation and Research.

CEN-STAR is Advisory Action Group reporting to CEN Technical Board (since 1992). It promotes closer links between researchers and standardisers, suggests opportunities in EU policies for Research and for Industry. Its Terms of Reference have been revised in 2003 and a Strategic Action Plan is in operation since beginning 2005.

2. Research and standardisation

The relationship between research and standardisation is written in the EU Treaty, it was decided in the Single Act in 1986 when the Research and Technology policy was introduced.

Art 163 states

1. The Community shall have the objective of strenghthening the scientific and technological bases of Community industry and encouraging it to become more competitive at international level, while promoting all the research activities deemed necessary by virtue of other Chapters of this Treaty.

2. For this purpose the Community shall, throughout the Community, encourage undertakings, including small and medium-sized undertakings, research centres and universities in their research and technological development activities of high quality; it shall support their efforts to cooperate with one another, aiming, notably, at enabling undertakings to exploit the internal market potential to the full, in particular through the opening-up of national public contracts, the definition of common standards and the removal of legal and fiscal obstacles to that cooperation.

Moreover, in the Decision of the 7th Framework Programme for Research, Technological Development and Demonstration Activities (2007 to 2013) concerning COOPERATION,

The nine themes determined for EU action are the following:

1. Health
2. Food, agriculture and biotechnology
3. Information and communication technologies
4. Nanosciences, nanotechnologies, materials and new production technologies
5. Energy
6. Environment (including climate change)
7. Transport (including aeronautics)
8. Socio-economics sciences and humanities
9. Security and space

The nine themes also include research needed to underpin the formulation, implementation and assessment of EU policies, such as in the areas of health, safety, consumer protection, energy, the environment, development aid, fisheries, maritime affairs, agriculture, animal welfare, transport, education and training, employment, social affairs, cohesion, and justice and home affairs, along with pre-normative and co-normative research relevant to improving the quality of standards and their implementation…

3. Type of research in the standardisation field:

The Co-Normative Research (CNR) is research and development in direct interaction with ongoing and/or planned standardisation activities, usually proposed by CEN technical committees to progress items in their agreed work programme.

The Pre-Normative Research (PNR) is research and development likely to support future trends in standardisation i.e. work anticipating future standards.

CEN-STAR, twice a year in its plenary meeting evaluate and decide upon proposals of CNR and PNR.

4. CEN-STAR instruments and projects

CEN-STAR scope is to improve the links between standardisation and research. It promotes the diffusion of research results and expertise through standards at European level.

CEN-STAR performs the following tasks:

- Establishes lists of the needs for normative research in support to CEN standardisation
- Organizes Trends Analysis Workshops in selected fields with high relevance of R&D in order to identify important needs for future standardisation and to promote appropriate standardisation activities
- Interfaces with the European Commission as well as with other bodies funding research in Europe to ensure that research is used for the benefit of the standardisation process and that research needed to improve the quality standards is supported from public and private funds.

CEN-STAR has produced a best practice guide 'Exploiting Research Through Standardisation' for researchers and scientists as well as industrialists to develop efforts from research results to standards. This guide is distributed on request and available on *http://www.cen.eu*

The 'Fish bone Analysis' was primarily developed to address the strategies and choices in research and standardisation. It is an integrated approach for reaching ambitious objectives. The whole idea behind the integrated approach Fishbone starts from the fact that large amounts of private but also taxpayer money are spent on various activities, including research, without having actually a large impact. This can generate frustration and disillusion. With the integrated approach, it would most probably end up spending substantially more on some actions, but with much higher chances of getting long lasting improvements i.e; a better return on investment.

The starting point of the proposed methodology comes from a clear identification of 'difficulties', which can be of a commercial nature, or of a societal nature, or a mix, any kind of large and lasting difficulties in fact.

Organisations and groups facing several difficulties can fix priorities. They may of course wish that these difficulties would disappear without effort, but the suppression, or at least the large mitigation, of these difficulties would be considered an objective if they are willing to allocate time and resources to seek mid-term (or in some cases long-term) solutions in a proactive and tenacious way.

Core members of these groups need to spend enough time to analyse the various facets which should lead to the solutions. We live in a complex world and some of the envisaged solutions might be complex indeed. In the Fishbone methodology it is checked whether further research is needed. It needs also to check whether written standards (containing harmonised requirements, possibly backed by testing methods) are requested.

In some cases the objective could not be reached in practice without mandatory new legislation which will need to make it happen. And it is to be as comprehensive as possible in the analysis of all complementary measures (promotion, marketing, education..). A large majority of members should be fully convinced about the feasibility of the approach. Then comes the time to allocate people and resources to the various actions, to be conducted in parallel or in sequence, in a pragmatic way.

CEN-STAR Trend Analysis Workshop

CEN-STAR organised Trends Analysis Workshops :

In 2005 on Sampling and the Environment made under the leadership of Nordic Countries. This results is now ongoing on the standard methods to proper collect sample for soil, air, waste and different living markers. It is of strong interest especially in order to be able to assess the EU Environment Directives.

The Workshop 'MYCAREVENT' - Mobility and collaborative work in European vehicle emergency networks took place in May 2006 and will have a CEN deliverable as one of the follow-up.

In February 2007, CEN/STAR with CENELEC held at the International Energy Agency in Paris, a Trends Analysis Workshop on the issue of the promotion of compact fluorescent lamps, CFL, and the corresponding phasing out of incandescent lamps. Standards (to be elaborated by CENELEC or CEN) could help marketing CFLs. In particular there is a need for objective and repeatable testing methods for the 'lighting quality'.

Several Trend Analysis Workshops are under preparation:

- Biotechnology in 2007 (European Federation of Biotechnology)
- Photocatalysis technologies and novel nanosurfaces materials in 2008 (COST Action 540)
- Standard methods for improving the quality management of research in 2009(IRD IMPACQ).

Reference methods and measurements (with Joint Research Centre - JRC)
JRC mission is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies, independently of private and national interests. Within JRC, the IRMM Institute focuses on technical measurement. This enables uniform implementation of European Directives and Regulations, this strengthens the economy by improving competitiveness, and this enables the functioning of the European internal market and global trade. At IRMM, laboratories are now responsible for providing the certified reference materials and methods needed for the control of heavy metals.

COPRAS
COPRAS, Cooperation Platform for Research and Standards, aimed at stimulating interaction and exchange between FP 6 IST projects and standardisation groups. All research projects have been submitted to analysis about their direct or indirect potential for new standards in the field of Information and Communication Technologies. This proved particularly useful and successful. More challenging was to help initiate new standardisation activities from consortia wishing to better 'implement' their findings.

CEN-STAR at its last meeting recommended to organise a new COPRAS in the field of environment, especially motivate to the revision of EU Directives and using all expertise and results obtained in the research Framework Programmes.

Already, thanks to the EU research efforts in the field of nanosciences and nanotechnologies and the numerous results achieved, could sustain standardisation in CEN TC 352 creating a COPRAS Nano.

Links to European Technological Platforms
Following the request of Commissioner Potocnik CEN STAR is contributing to the promotion of standardisation in the European Technology Platforms ETPs. It is recalled the role of European standardisation in the innovation process as described in the Aho report, as well as the central role of standardisation, including on horizontal coordination, for the success of the strategic research agendas of the ETPs as endorsed at the Vienna Conference a year ago. A particular highlight is the role of ETPs towards SMEs and towards international and globalisation aspects, CEN STAR proposes to CEN/BT to encourage the active participation of the NSBs in the national mirror committees of ETPs in order to promote the role of European standardisation in their strategic research agenda.

European Technology Platforms STAR Members have been reminded to liaise urgently with their NSB to prepare high level contacts with their National Authorities on the following issues:
- increased awareness by these National Authorities on the role and importance of standardisation
- need to ensure adequate possibilities and modalities in FP7 to support research necessary for standardisation activities.

Quality management of research
The project IMPAQT 'Improved Management Practice and Quality Training' highlighted the need to provide guidance to young researchers, in general unaware of management and harmonised quality practices, which could useful be applied in research activities.
The partners of the IMPAQT project are specialized in coaching and management teaching in academia, several standardization bodies and research organisations. They have developed a strong experience with the translation and interpretation of the organisation standards EN ISO 9000 and EN ISO 9001 as they have worked for several years in the training and promotion of quality management in research laboratories, universities and research administration and developed two normative tools: FD X 50 551 and GA 50 552, which translate these standards into the cultural environment of research and which give examples from 'the lab bench' for all important concepts and requirements of EN ISO 9001.

Quality assurance is a main driving element in this respect.

Need of reliable data collections for new standards
CEN STAR has been requested in the beginning of 2007 to prepare a guidance document for CEN Technical Committees on the collection of test data to support standardisation activity.

The problem of Round Robin tests supporting standardisation activity has been raised. In most cases, waiting for definite data makes it impossible to comply with the time frame and therefore adoption of preliminary standards. However, this may be deleted due to shortage of funding to carry out the necessary tests, or a low-content draft may risk being written because the market is not willing to wait.

5. CEN-STAR in the field of nanotechnology
The following particular input from CEN-STAR in the nanoworld:

- promotion of standardisation in several scientific meetings, conference and workshop
- participation in the strategic group of CEN-TC 352
- project advisory committee of NanoStrand
- examples of inputs : - COST 540 in Photocatalysis
  - ESF in EuroNanoPAR

6. Conclusion
The issue of measurements and quality insurance in the field of nanotechnology is related to following fields under the frame of CEN-STAR activities promoting links between researchers and standardisers:

Metrology, measurement methods
Reliable data collection
Quality research management
Risk assessment

Selective detection of SO_2 in air based on carbon nanotubes nanosensors

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In the past decades the interest in the environmental problems caused by atmospheric contamination has increased. The emissions of NO_X, CO_X, organic vapours and SO_2 have reached high levels giving rise, among others, to acid rain and greenhouse effect. One of the most toxic gases among the major ones in atmospheric contamination is sulphur dioxide; it is strong irritant and causes several damages on eyes, mucous membranes, skin and respiratory tract. Moreover, its combination with water vapour in the atmosphere to form sulphuric acid is one of the principal causes of acid rain. There are multiple sources of SO_2, which ones include volcanism, biomass burning, wine industry, smelting of sulphidic ores or burning of fossil fuels for vehicles and energy production. However, the specific detection and determination of SO_2 is often limited to liquid phase. Usually the determination is made by iodometric titration, procedure known as Ripper method (1). For detection in gas phase several devices based on nanostructured metallic oxides have been developed, but these devices have some problems as high working temperatures, lack of selectivity, high response times or low sensitivity (2).

In order to improve the performance parameters of the gas sensors, different nanostructured materials have been studied as sensing part for these devices in the past years. These materials include metallic particles (3, 4), organic polymers (5) and carbon nanotubes (6) among others. The devices made with the new materials have provided lower working temperatures, a decrease in response and recovery times and higher sensitivities than using traditional gas sensing devices. However, they still have very low selectivity since their response to several gaseous analytes. For this reason, several functionalization processes for the sensing materials have been proposed as a possible solution to increase the selectivity. The aim of these processes is to incorporate specific receptors for each target analyte on the surface of sensors.

Carbon nanotubes (CNTs) are one of these new materials, and they have been used as the conducting channel of field effect transistor (FET) devices, which have been successfully used for the detection of NH_3 (7), NO_x (8), CO_x (9), organic vapour (10), etc. CNTs are an interesting material for sensing devices for their semiconducting nature and because they offer many possibilities to be functionalized. Two main strategies can be followed: covalent and non-covalent functionalization. In the covalent functionalization (3), the functional groups are covalently bound to the structure of the CNTs, and each new covalent bond implies a defect on the surface that changes the electronic properties of the CNTs. The non-covalent functionalization (4) consists of coating the CNT surface with a material (e.g. a polymer, protein, metallic films or nanoparticles, among others). In this way, the molecules are adsorbed onto the CNTs and do not break their electronic structure.
These methodologies have shown an increase in the selectivity for some substances, specially for some biosensors like for instance for DNA sequences or proteins (Immunoglobulins E and G) (11-13).

We employ FETs based on networks of CNTs to selectively detect SO_2 in air at room temperature. The selectivity of the device is acquired in a two-steps functionalization process of the CNTs. First, the CNTs are coated with a thin layer of polyethilenimine (PEI). Since PEI coats all the surface of CNTs it avoids any interaction of CNTs with the atmosphere, either interactions with SO_2 or with any interference in the surrounding environment. Then, a specific receptor for SO_2, a platinum (II) complex [PtI(4-E-2,6-{ $CH_2N(CH_3)_2\}_2$-C_6H_2] (14), is covalently bonded to the amino groups of PEI. The complex (sensing material) acts as a selective pincer for SO_2, binding the molecule in a reversible reaction by coordination bonds. The specific detection is improved by the use of a blocking molecule (N-acryloxysuccinimide) which prevents interferences due to the possible response of the remaining free amino-groups of the polymer that have not reacted with the Pt (II) complex, which can have acid-base reactions with gases with acid properties. The response of the device to SO_2 was monitored through changes of the current flowing through the CNTs. The device was selective to SO_2 and the lowest concentration detected was 0.7%.

Experimental

Synthesis of CNT
Single wall CNTs were synthesized by chemical vapour deposition on Si/SiO_2 substrates. The chips were cleaned with acetone and dried with nitrogen. The catalyst, 50mL of a solution of 100 ppm of $Fe(NO_3)_3 \cdot 9H_2O$ in isopropanol, was deposited by spin-coating on the surface of the chips. The catalyst was activated with hydrogen (0,2L/min) and methane was used as carbon source (0,6L/min) at 900°C for 20 min. A flow or argon was used during the heating and cooling of the reactor.

Functionalization process
The chips with CNTs were immersed in an aqueous solution of PEI, 20% p/v, for 5 h at room temperature, rinsed with water and dried with nitrogen. With this process the CNTs are coated with a film of the polymer. For the incorporation of the specific receptor, the chips functionalized with PEI were immersed in a solution of 3mg/mL of the complex in dichloroethane for 3 h at room temperature, rinsed with dichloroethane and dried with nitrogen. Figure 1 shows the scheme of this reaction.

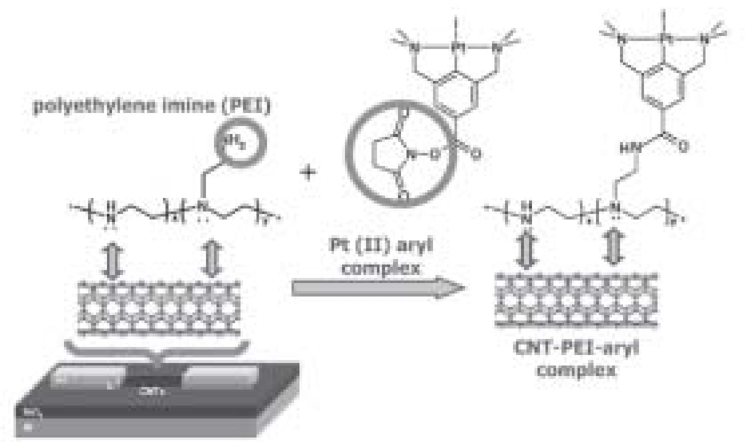
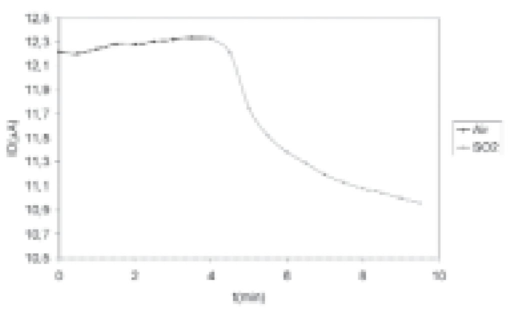


Figure 1. Functionalization process of the CNT with PEI and aryl-complex.

The reaction of the remaining free amino groups of PEI with the blocking molecule was made using a solution of N-acryloxysuccinimide (NAS) of 3mg/mL in water by 2 hours at room temperature. With the use of this blocking molecule each free amino group of PEI is bonded to an acrylic group. This reaction prevents the interaction of the polymer with SO_2 and with any other interference.

Electrical characterization
Screen-printed was used to print the source and drain electrodes and the back Si substrate (coated with aluminium) was used as the gate electrode. The response to SO_2 was measured as the change on the electric current between source and drain electrodes.



Response of the sensor to SO_2 in air
The response of the sensor was evaluated for increasing concentrations of SO_2 ranging from 0 to 26.5%. The measurements were performed in a gas chamber at atmospheric pressure and room temperature. Once the aril complex interacts with SO_2, the electronic current decreases due to the electronegative character of SO_2 (see Figure 2).

Figure 2. Response of the CNTs functionalized with PEI, aril-complex and NAS to 26.5% of SO_2 for a gate voltage of 10V and a bias voltage of 0.5V.

Once we checked that the FET device was sensitive to SO_2, we checked that the change on the current is produced only by the reaction between the receptor and the target analyte (SO_2). In order to know if the blocking molecule (NAS) suppresses the interaction between the free amino groups of the polymer and any gas in the surrounding environment, we evaluated the response of the device coated only with PEI and with PEI and NAS. The results obtained are showed in the Figure 3.

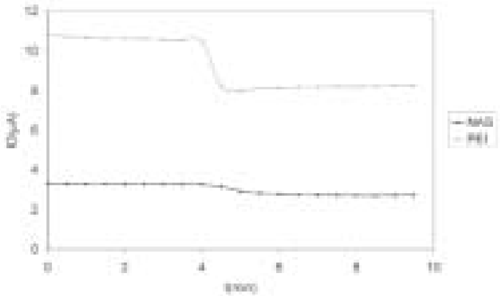


Figure 3.
Current intensity of the CNTs functionalized with PEI and PEI with N-acryloxysuccinimide (NAS) obtained in air and 26.5% of SO_2. The bias voltage was -0.5V and the gate voltage was 10V.

Figure 3 shows that the current for the device functionalized with PEI and N-acryloxysuccinimide does not change significantly with SO_2. Therefore, we can conclude that the blocking molecule suppresses the response of the polymer to SO_2 and that the response of our sensor is only due to the interaction between SO_2 and the complex.
Once the selectivity of the sensor has been showed, the device was exposed to a lower concentration of SO_2. In this case, we used 0.7% of the SO_2 in air (see Figure 4). The change obtained for an increase of 0.7% of SO_2 was approximately -10% of the initial value.

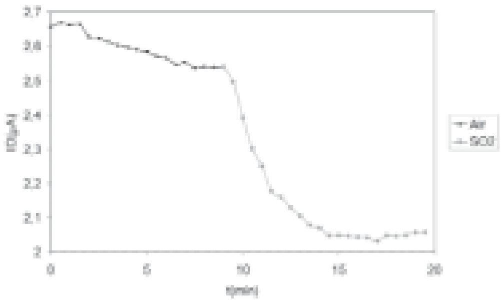


Figure 4. Current intensity of CNTs functionalized with PEI, aril-complex and N-acryloxysuccinimide obtained in air and for 0.7% of SO_2. The gate voltage was 10 V and the bias was 0.5V.

Conclusions
We developed a selective sensor for the detection of SO_2 in air. The response of CNTs and polymer was suppressed with the functionalization process. In this way we ensure that the change of the electric current is only produced by the selective interaction between SO_2 and the aril-complex. We are working on the evaluation and improvement of the detection limit, response, recovery time and sensitivity.

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Measurement in nanotechnology

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Abstract
As many authorities predict that applications of nanotechnologies will pervade all areas of life and will enable dramatic advances to be realized in all areas of communication, health, manu-facturing, materials and knowledge-based technologies, there is an obvious need to provide industry and research with suitable tools to aid the development and application of the tech-nologies. It is also essential that regulators and health and environmental protection agencies have available reliable measurement systems and evaluation protocols supported by well founded and robust standards.

Introduction
Activities in the field of measurement in nanotechnology consist of the development of standards for measurement, characterization and test methods for nanotechnologies, taking into consideration needs for metrology and reference materials. The different facets of nanotech-nology are presented in figures 1 and 2 according to different tasks of measurement – the characterization of an individual engineered particle in figure 1 or the analysis of collected nanoparticles in figure 2 for exposure characterization e.g.

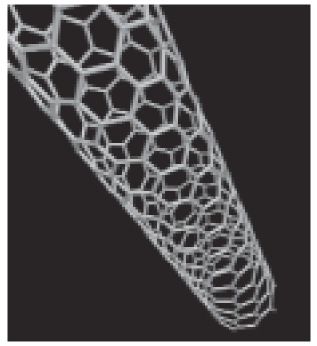

Figure 1

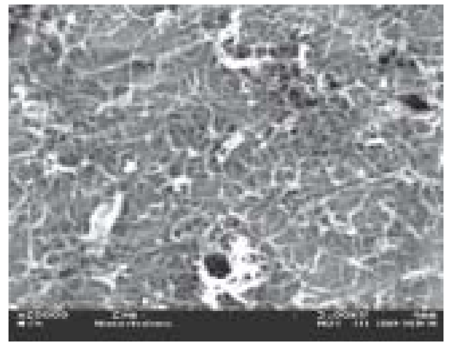

Figure 2

Figure 1: Nanotube – generated by atomistic configuration viewer [1]

Figure 2: Nanotubes – SEM picture Preparation: filtration of suspension and drying

ISO Technical Committee TC 229 will, in accordance with ISO's strategic plan for 2005 to 2010, develop robust standards and other deliverables relevant to nanotechnologies [2]. Where relevant Technical Committees exist in ISO or IEC, TC 229 will cooperate with such committees to develop robust product/application standards, but where no relevant committee exists, such product standards will fall within the remit of ISO TC 229. TC229 has established three Working Groups to progress identified priority areas of standardization [3]:
WG 1: Terminology and nomenclature
WG 2: Measurement and characterization
WG 3: Health, safety and environmental aspects of nanotechnologies.

Liaison and coordination with external standards bodies and research institutes, as well as international organizations, are essential to the successful development of a timely and relevant program of work for TC229 Nanotechnologies.

External liaisons:
- IEC Technical Committee 113 Nanotechnology standardization for electrical and electronics products and systems,
- European Union Joint Research Centre
- Organisation for Economic Co-operation and Development (OECD)
- Asia Pacific Economic Cooperation Forum (APEC)
- Versailles Project on Advanced Materials and Standards (VAMAS)

Measurements and quality assurance in the field of nanotechnology Session A2

WG 1 Terminology and nomenclature
Scope: Define and develop unambiguous and uniform terminology and nomenclature in the field of nanotechnologies to facilitate communication and to promote common understanding. The development of standards for measurement and characterisation and health and safety cannot be completed until consensus on terminology and a controlled vocabulary and nomen-clature is reached. A key part of the strategy for WG1 is to develop a framework and roadmap for a controlled, first vocabulary, based partly on the results of the Strategy Task Group survey. Initial analysis of the survey shows that there is a high priority and high urgency for generic nomenclature standards for nanoparticulates and nanotubes.
An Active Work Item on Nanoparticles-Terminology and Definitions is already underway - AWI TS 27687. To create an unitary standard, this terminology and definitions document will encompass terms used in both nanosciences and nanotechnologies concerning nanoparticles. It will provide an up to date listing of terms and definitions relevant to the area. It will form one part of a projected multi-part terminology and definitions document covering outstanding aspects of nanotechnologies. It is intended to facilitate communications between organizations and individuals in industry and those who interact with them. The plan for the first part of 2007 includes 3 new work items, one on general terminology for nanotechnologies, one to develop a terminology framework for nanotechnologies, and another on terminology for nanomaterials. The latter will include a subset for carbon nanomaterials, and possibly broach the issues of the nano-bio interface as it applies to materials.

Logically, the development of standards flows from WG1: Terminology and nomenclature to WG2: Measurement and characterization and then to WG3: Health, safety and environment. Because of the urgency in developing nanotechnology standards, it has been decided to develop standards in all three areas in parallel.

Actually the main task in the field of particle technology is undertaken by the liaison with ISO/TC 24/SC 4 'Sieves, sieving and other sizing methods'. A new work item of WG1 in TC24/SC4 'Particle characterization of particulate systems – terminology' is developed in coordination with WG 1 of TC229 to guarantee consistency of general particle related terms within ISO. Furthermore the relevance and limitation of standardized particle sizing methods to nanomaterials are evaluated.

WG 2 Measurement and characterization
Scope: The development of standards for measurement, characterization and test methods for nanotechnologies, taking into consideration needs for metrology and reference materials. A key part of the strategy for WG2 is to develop a framework and roadmap, based partly on the results of the Strategy Task Group survey. Initial analysis of the survey shows that a number of the high-priority, high-urgency needs fall within the scopes of other ISO TCs, e.g. TC 24, TC 201 and TC 202. These cover characterization protocols for nanoparticulates and test methods for the use of scanning probe microscopes and analytical electron microscopes. WG2 will work closely with these TCs to ensure that the needs of the nanotechnology community are met. The survey shows that there are high-priority, high-urgency needs for characterization protocols for nanoparticulates (e.g., degree of agglomeration, specific area, and chemical purity), nanotubes (e.g., diameter and length distribution, batch quality, and chemical structure), nanoscale coatings/films (e.g., thickness, composition, structure) and for generic standards for nanostructured materials, particularly nanoporous/mesoporous materials and nanocomposites. The survey also established high-priority, high-urgency needs for standards covering metrological measurement at the nanoscale, particularly for length, mass and surface area and artefacts such as grids, gratings and scales and reference nanopowders.

WG 3 Health, safety and environmental aspects of nanotechnologies
Scope: The development of science-based standards in the areas of health, safety, and envi-ronmental aspects of nanotechnologies. A key part of the strategy for WG3 is to develop a framework and roadmap, based partly on the results of the Strategy Task Group survey. Initial analysis of the survey shows that there are high-priority, high-urgency needs for stan-dard methods for toxicological screening, relative toxicity/hazard potential determination, establishing occupational exposure limits, etc. for nanoparticulates and other nanoscale mate-rials; and protocols for inhalation testing, toxicology testing, safe handling, exposure determi-nation and safe disposal of nanotubes. The development of a Technical Report on Occupational Safe Practices Regarding Nanotechnologies is already an Active Work Item within WG3. The purpose of this technical report is to collect and identify current safe practices in occupa-tional settings relevant to nanotechnologies. This TR recognizes that while the occupational risks associated with working with nanotechnologies have not yet been fully studied or identified, it is important to identify basic safe practices now and make them available to all interested parties. It is expected that the TR will be completed by June 2007.

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Comparison of dynamic light scattering and centrifugal sedimentation for nanoparticle sizing

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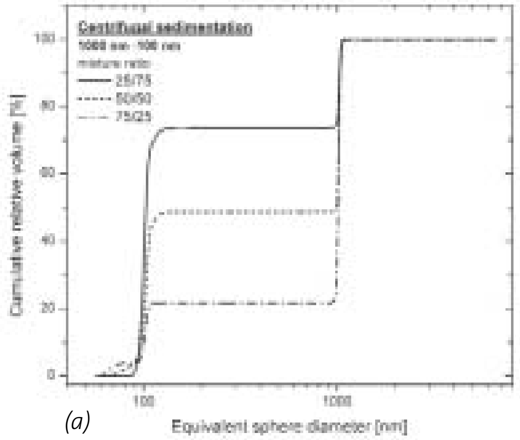
Abstract
To support the efforts of increasing confidence in the comparability of measurements in the field of nanotechnology, the Institute of Reference Materials and Measurements (IRMM) is now producing reference particle materials with particle size in the nanometer range. Several techniques, which are based on different physical principles, have been developed to perform nanoparticle sizing. IRMM is evaluating the differences between results obtained with two of the most commonly used nanoparticle sizing techniques: dynamic light scattering and centrifugal sedimentation. One difference between these techniques is their power to resolve multi-modal particle size distributions. Due to the separation process occurring in the disc centrifuge, centrifugal sedimentation has an excellent resolution and is able to resolve modes with a diameter ratio as low as 1.1. Dynamic light scattering is not able to resolve modes with a diameter ratio lower than 4. On the other hand, dynamic light scattering does not require frequent calibration, as is needed for centrifugal sedimentation, for which the sedimentation velocity must be calibrated. This paper will present experimental results, illustrating advantages and drawbacks associated with each technique.

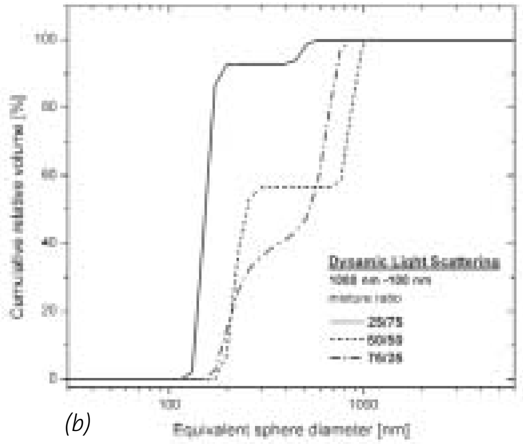
Introduction
Nanoparticles (NPs) are gaining more and more interest in industry and academia due to their potential use in a wide range of applications as catalysis, fuel cells, electronics, ceramics or more recently in medical applications as drug-carriers [1-2]. Due to their extremely small size, concerns about their impact on human health and environmental systems are raised [3]. Well characterized nanoparticle materials are needed to conduct studies to reliably and efficiently assess the potential risks related to NPs. This is one of the reasons why the Institute for Reference Materials and Measurements (IRMM), one of the institutes of the Joint Research Centre of the European Commission, intends to produce reference nanoparticle materials certified for their particle size distribution. To improve the confidence in the certified size distribution, different sizing techniques based on different principles should be used to characterize the reference materials. Nowadays, a wide variety of sizing techniques are commercially available. The most commonly used techniques are based on disc centrifugal sedimentation (DCS) and dynamic light scattering (DLS). The major difference between these two techniques is in their power to resolve multi-modal particle size distributions. DCS has an excellent resolution and is able to resolve modes with a diameter ratio as low as 1.1 whereas DLS is not able to resolve modes with a diameter ratio lower than 4. The techniques also differ in terms of calibration requirements. DLS does not require a calibration of the instrument response for each test series. For DCS, the sedimentation velocity must be calibrated for each new sample analyzed.
In this paper, both techniques will be compared by measuring nanoparticle materials characterized by a bi-modal particle size distribution in order to show how the method-specific limitations could affect the design of the certification process of reference nanoparticle materials.

Experimental details
The reference nanoparticle materials used for the comparison study consist of latex nanoparticles suspended in a water-based solution with a narrow particle size distribution (Duke Scientific Corporation, US). Three different reference materials were chosen with their nominal mean particle diameters at 1000 nm, 100 nm and 50 nm referred thereafter as DS1000, DS100 and DS50 respectively. Two types of mixture were prepared by a gravimetric method: a mixture of DS1000 and DS100 and a mixture of DS100 and DS50 with volume ratios of 25 % / 75 %, 50 % / 50 % and 75 % / 25 % where the first fraction corresponds always to the biggest particle. For the sake of clarity, the symbol % will be omitted in the rest of the paper.
DCS was carried out with a CPS 20'000 disc centrifuge (CPS Instruments, US). The particle suspension is injected at the centre of a spinning disc. Under the effect of the increasing gravitational field, particles with different sizes are separated when travelling to the edge of the disc and their concentration is measured by light absorption [4]. DLS was carried out

with a Horiba LB-550 (Horiba Jobin Yvon, FR). A laser beam is passed through the sample cell and the fluctuations of the backscattered light are analyzed in the frequency domain. Due to the Brownian motion of nanoparticles, the frequencies of the light radiation are Doppler-shifted and the diffusion coefficient of the nanoparticles can be retrieved from the power spectrum function of the radiation [5]. Using the Stokes-Einstein relationship, the distribution in diffusion coefficients can be transformed into a particle size distribution [5].



(a)



(b)

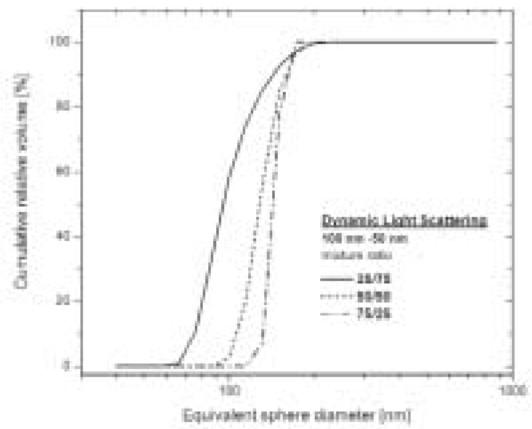


Figure 1: Volume-based particle size distributions as obtained from (a) centrifugal sedimentation and (b) dynamic light scattering for DS1000-100 mixtures corresponding to 25/75, 50/50 and 75/25 volume fractions.

Results
The volume-based particle size distributions obtained by DCS and DLS for the mixtures of DS1000 and DS100 with different mixture ratios are plotted in figure 1. The cumulative relative volume represents the volume fraction of particles in the suspension whose equivalent sphere diameter is below a given diameter. This type of representation was found to be the most effective to compare experimental results from two different techniques since it is less dependent on the size bins used in the analysis of the raw signals. For both techniques, the calculated particle size distributions are bi-modal but only in the case of DCS, both modes exhibited a very narrow particle size distribution and the calculated mode diameters for DS1000 and DS100 agreed well with the diameters provided by the supplier. Results obtained by DLS showed discrepancies in the calculated volume fractions and in the mode diameters.
Mixtures of DS100 and DS50 with different volume fractions of reference materials were measured by DLS. The volume-based particle size distributions of these mixtures are represented in figure 2. As the volume fraction of the biggest particles increases in the mixture, the mean particle diameter increases. But, for none of the mixtures, the results obtained with DLS exhibit a bi-modal particle size distribution. This confirms the limitation in resolution for DLS.

Figure 1: Volume-based particle size distribu-tions as obtained from (a) centrifugal sedimentation and (b) dynamic light scattering for DS1000-100 mixtures corresponding to 25/75, 50/50 and 75/25 volume fractions.

Conclusion
Reference latex particle materials with a narrow particle size distribution were used to prepare bi-modal particle suspensions of known volume fractions. Two types of mixtures were prepared: a mixture of 1000 nm and 100 nm particles and a mixture of 100 nm and 50 nm particles corresponding to mode ratios of 10:1 and 2:1 respectively.
These suspensions were measured by DCS and DLS in order to compare the performance of both techniques. In the case of mixtures of 1000 nm and 100 nm particles, both techniques were able to distinguish between modes but only DCS lead to measured volume fractions that agreed with the values determined by the gravimetric sample preparation. In the case of mixtures of 100 nm and 50 nm particles, both techniques revealed limitations. Due to the small difference between the particle and dispersant densities, the analysis time for DCS experiments was too long and the influence of the Brownian motion of the nanoparticles reduced considerably the resolution of this technique.

For DLS measurements, the calculated particle size distributions were mono-modal. Independently of the volume fractions in the mixture, this technique was not able to distinguish between modes with a 2:1 mode ratio, and did not correctly reveal the fractions of modes with a 10:1 mode ratio.
Bi-modal mixtures of nanoparticle materials seem to be a good example of reference materials that could be useful for the quality or performance control in particle sizing. The comparison of DCS and DLS illustrated the limitations for both techniques that need to be taken into account when characterising this type of materials.

Disclaimer
Certain commercial equipment, instruments, and materials are identified in this paper to specify adequately the experimental procedure. In no case does such identification imply recommendation or endorsement by the European Commission, nor does it imply that the material or equipment is necessarily the best available for the purpose.

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Metrology of nanotubes using novel and 'traditional' nanotools

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Abstract
Quantitative, systematic and reproducible metrology of carbon nanotubes is paramount to the fundamental understanding of these promising nanomaterials. Moreover, development of novel techniques which extend the current suite of available nanotools is also desirable within the nanometrology community. Toward the end of contributing to improved rigor in carbon nanotube metrology, we present here a series of measurements on select sample sets of carbon nanotubes using a novel pyroelectric detection technique currently under development at the National Institute of Standards & Technology, as well as the more 'traditional' technique of Raman spectroscopy. Such testing will ultimately contribute to the standards and protocols now under development for carbon nanotube metrology.

Keywords
Carbon nanotube, metrology, characterization, standards, nanomaterial

Simultaneous sizing of nanoparticles by individually visualizing and separately tracking their Brownian motion within a suspension.

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Abstract
A new nanoparticle tracking analysis system is described which allows nanoscale particles in a suspension to be individually and simultaneously visualized and sized with higher resolution than other light scattering techniques.

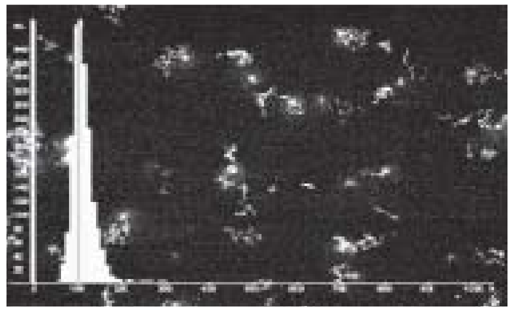

Fig 1: A still from a video of 100nm polystyrene calibration particles showing some (for clarity) of the Brownian motion trajectories analysed and which is overlaid with the corresponding size plot; the unit for re-use, if required.

Introduction
The analysis of nanoparticle size is a ubiquitous requirement in a wide range of applications areas (and increasingly in the drug delivery sector) and is usually carried out by either electron microscopy or dynamic light scattering. Both techniques suffer from disadvantages; the former requiring significant cost and sample preparation, the latter generating only a population average which itself can be heavily weighted towards larger particles within the population. A new method of microscopically visualizing individual nanoparticles in a suspension allows their Brownian motion to be simultaneously analysed and from which the particle size distribution profile (and changes therein in time) can be obtained on a particle-by-particle basis.

Experimental methods
A small (250 µl) sample of liquid containing particles at a concentration in the range 106-10/ml is introduced into the scattering cell through which a finely focused laser beam (approx. 20mW at λ=635nm) is passed. Particles within the path of the beam are observed via a microscope-based system (NanoSight LM10) or dedicated non-microscope optical instrument (NanoSight LM20) onto which is fitted a CCD camera. The motion of the particles in the field of view (approx 100x100µm) is recorded (at 30fps) and the subsequent video analysed. Each and every particle visible in the image is individually but simultaneously tracked from frame to frame and the average mean square displacement determined by the analytical program and from which can be obtained the particle's diffusion coefficient. Results are displayed as a sphere-equivalent, hydrodynamic diameter particle distribution profile (Fig 1). The only information required to be input is the temperature of the liquid under analysis and the viscosity (at that temperature) of the solvent in which the nanoparticles are suspended. Otherwise the technique is one of the few analytical techniques which is absolute and therefore requires no calibration. Results can be obtained in typically 30-60 seconds and displayed in a variety of familiar formats (diameter, surface area or volume on either linear or log scale). The instrument can be programmed to carry out repeat measurements of dynamically changing samples to analyse dissolution, aggregation and particle-particle interactions. Notably, because the instrument isualizes particles on an individual basis, particle number concentration is recoverable. Once analysed, the sample is simply withdrawn from unit for re-use, if required.

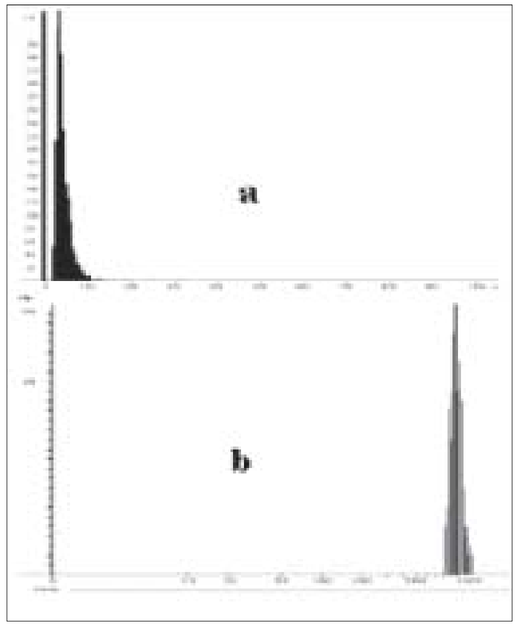

Fig. 2: Size distribution plots of a) 30nm gold colloid (linear scale) and b) 900nm polymeric (log scale) particles.

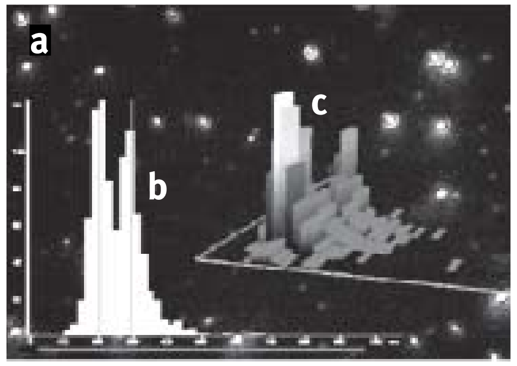

Fig. 3: A mixture of 200nm and 300nm particles; a) still image, overlaid with b) analysis plot and c) 3D number v. relative intensity v. diameter plot.

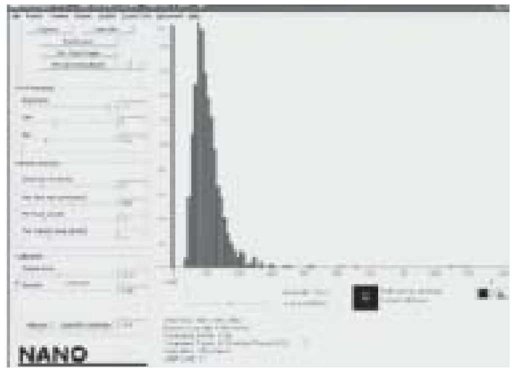

Fig 4: Analysis of a 100nm liposome suspension

Results and discussion
A number of results on calibration microspheres and mixtures there of, colloidal gold and liposomes are shown below which indicate the advantages of the technique. The minimum particle size detectable depends on the particle refractive index but for highly efficient scatterers, such as colloidal silver, 10nm particles can be detected and analysed. For weakly scattering (e.g. biological) particles, the minimum detectable size may only be >50nm. The upper size limit to this technique is defined by the point at which a particle becomes so large (>1000nm) that Brownian motion becomes too limited to be able to track accurately. This will vary with particle type and solvent viscosity but in normal (e.g. aqueous) applications is approximately 800-1000nm. (Fig 2).
All particle types can be measured and in any solvent type providing that the particles scatter sufficient light to be visible (i.e. are not too small or indexed matched).
The results shown in Fig 3 obtained from an analysis of a mixture of 200 and 300nm latex beads (overlaid with the normal particle size distribution plot) show that the two populations can be well resolved from each other. Furthermore, because the technique analyses particles on an individual basis and can collect information on their relative brightness as well as their size (measured dynamically) these two data can be combined to give an intensity v size plot (Fig 3c). This capability shares many features in common with conventional flow cytometry but is unique to method in this deeply sub-micron size range. Finally, the technique has been successfully applied to the analysis of a wide range of viruses and liposomes, vesicles and nano-emulsions. For example, Fig 4 shows an analysis of a liposomal preparation (suitably diluted with a non-perturbing diluent) with a relatively narrow size range centered at approximately 80nm). See [1] for more information and examples of playable videos of a variety of samples.

Conclusion
The technique is robust and low cost representing an attractive alternative or complement to higher cost and more complex methods of nanoparticle analysis such as photon correlation spectroscopy (PCS) or electron microscopy that are currently employed in a wide range of technical and scientific sectors. Finally, the technique uniquely allows the user a simple and direct qualitative view of the sample under analysis (perhaps to validate data obtained from other techniques such as PCS) and from which an independent quantitative estimation of sample size, size distribution and concentration can be immediately obtained.

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[1] www.nanosight.co.uk

LAwave – measurement technology for quality assurance

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Abstract
A laser activated non-destructive testing technique provides access to critical material properties of only a few nanometer thin films such as the Young's modulus and density/porosity of thin films and surface damage layers. By measuring the propagation and in particular the dis-persion of the phase velocity of a laser generated sound wave, it is possible to analyse thin films down to only a few nanometers. As opposed to conventional nano-indentation, this new method is non-destructive and the results do not depend on the particular measurement location and film thickness (substrate influence in nano indentation). The technique has been successfully evaluated for applications such as measuring the Young's modulus of 3 nm thin amorphous carbon films used as top coatings in computer data disks, measuring the thickness of crystallographic damage layers in 12" wafers for semiconductor manufacturing, detecting the native oxide layers on silicon wafers for semiconductor manufacturing, and measuring the stiffness of low-k dielectric materials and photoresist as a function of prior treatments. The laser surface acoustic wave tester (LAwave) can be applied to measure the mentioned material properties in the laboratory providing a wealth useful data for thin film materials as a function of the particular circumstance of their synthesis. But the machine also serves well as a quality control unit for in-line operation since the test is fast (seconds for a data point) and non-destructive.

Introduction
The progress in nanotechnology challenges the test and characterization techniques in manifold way. From the viewpoint of surface technology, nanotechnology means reducing the thickness of films to nanometer range with extreme hardness, stiffness and adhesion, developing films with nanoscopic microstructure and new outstanding properties, and adapting the processes of surface machining to the enhanced requirements.
Apart from chemical and topographic analyses, substantial interest is also focused on the mechanical characterisation of the surface.

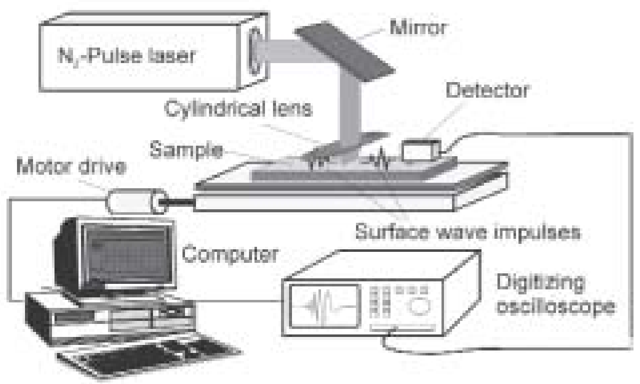

Figure 1: Laser-acoustic test device LAwave

Laser-acoustic technique LAwave
The non-destructive method LAwave (Figure 1) is the laser-acoustic technique based on sur-face acoustic waves [1]. Short laser pulses are used for generating surface acoustic waves with a wide frequency range. Fourier analysis of this waveform yields the dispersion curve, representing the phase velocity of the surface waves depending on frequency. The character of the dispersion curve depends on the combination of film and substrate material, and film thickness as well. Fitting a theo-retical curve enables the elastic constants and density of the film to be determined, if the film thickness is known. On the other hand, the device can also be used for determining the thickness of the film if its elastic properties and density are known. For materials with low ultrasonic attenuation such as coated single crystal silicon, films with thickness down to few nanometers can be tested.

Nanometer top-coats for hard-disks
The increasing memory density of computer hard disks requires reducing the distance between the write-read head and the disk. The surfaces of both must be protected by ultra-thin hard coatings, so-called top-coats. Mechanically testing such nano-meter films is still a challenge. Figure 2 shows the Young's modulus E measured by LAwave for super-hard diamond-like carbon films (DLC) with wide range of thickness, from 100 nm down to 3 nm. For DLC, Young's modulus is an important mechanical parameter increasing with the fraction of sp^3-diamond bonds and, consequently, correlating with hardness H, H = E/10. The films were deposited by a new plasma source consisting of a high current pulsed vacuum arc evaporator (HCA) combined with a sectioned filter unit. The capability of two versions of the HCA-deposition technique have been tested, a laboratory machine (HCA-I) and an industrial version (HCA-II). Additionally, the effect of the deposition temperature T_S has been investigated.

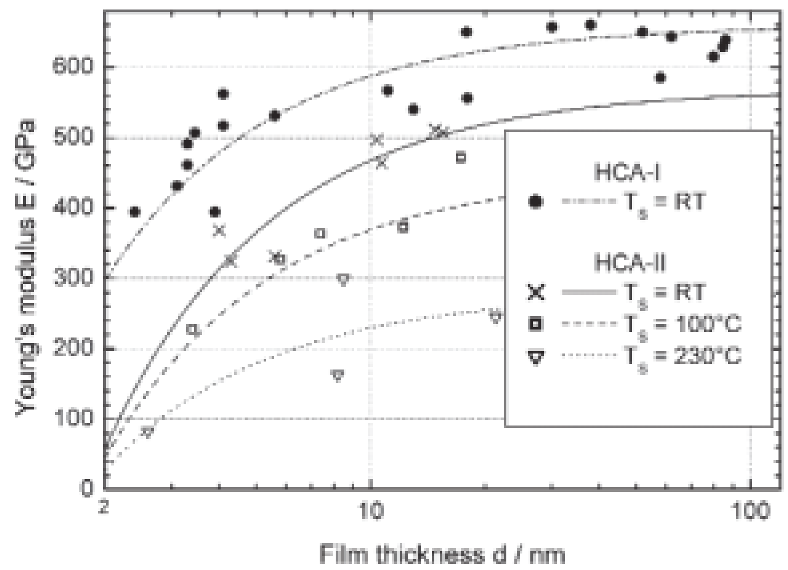

Figure 2: Mechanical stiffness of nanometer super-hard carbon films depending on film thickness

The results confirm that the HCA-technique can deposit excellent films with elastic modulus E higher than 600 GPa [2]. The modulus reduces with reducing film thickness. This can be attri-buted to an increasing effect of a very thin gra-phitic layer assumed to be formed at the surface of the DLC films. The results in Figure 2 reveals that this soft layer can be neglected compared to the sp^3-rich hard coating for films thicker than 20 nm but influence more and more the film quality in the nano-meter range.
Using a multi-layer model enabled a thickness of 1.3 to 2 nm to be estimated for this graphitic layer. Elastic moduli of about 400 GPa were measured for films less than 5 nm thick and de-posited with high current arc (HCA-I), demon-strating that films of high diamond-like quality can be deposited in the nanometer range. It was confirmed that the plastic deformability correlates with the elastic modulus for diamond-like carbon by comparing the non-destructive results with those of an AFM-based nano-scratching technique developed by IBM [3].

Testing nano-porous low-k films
The rapid introduction of new materials to reduce the dielectric permittivity in interconnect systems of integrated circuits creates challenges of integration and materials characterization.
The integration of copper interconnections lines and low-k dielectrica in the Damascene structure enables to reduce both the effective interconnect resistivity and capacitance, required for faster and smaller integrated circuits. Incorporating nano-porosity in siloxane-based films like silica xerogel and silsesquioxane-type materials is a way to make films with low dielectric constants. Although, the dielectric properties (k ‹ 2.2) achieved are promising, introducing the technology still requires adapting their mechanical stability to the subsequent chemo-mechanical polishing (CMP). Nano-porosity up to 50 % causes the mechanical resistance to reduce drastically. According to several investigations a value of more than 2 GPa seems to be required for the elastic modulus quantifying the stiffness of the film material. Efforts are currently undertaken to make high porous low-k films with an elastic modulus as high as possible. This requires the elastic modulus of thin soft films to be measured reliably. LAwave can measure two important parameters of the nano-porous low-k films, the density

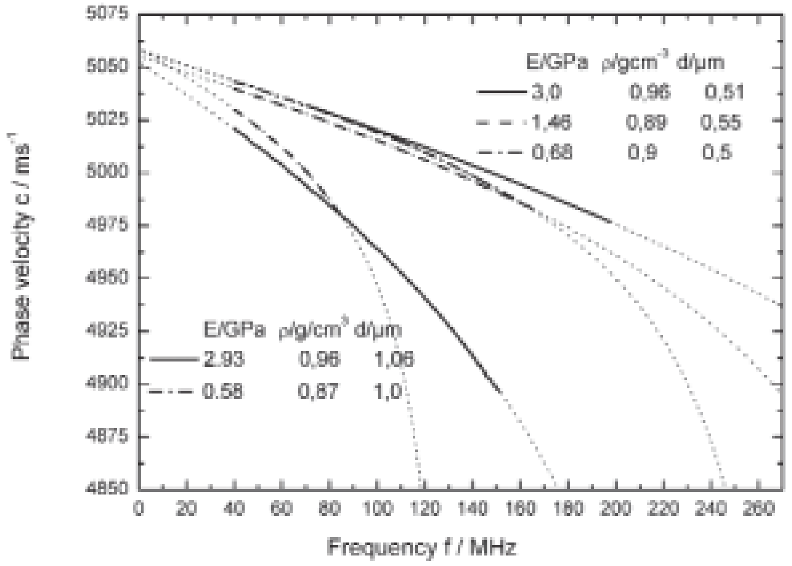

Figure 3: Young's modulus and density of nano-porous low-k films

and the Young's modulus, for films with thikkness down to 150 nm [4].
The density provides a measure for the porosity and Young's modulus characterizes the mechanical strength. Figure 3 shows laser-acoustic results for two test series of low-k films, about 0.5 and 1 μm thick.
The films were deposited by spin-coating on silicon. Figure 3 illustrates that for both test series optimising the deposition process has resulted in a modulus increasing from 0.6 GPa to about 3 GPa. Instead, the density has varied only little. This reveals that the mechanical film properties could be improved for films with similar level of porosity and nearly constant dielectric properties.

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Role of interface engineering in NanoBiotechnologies

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One of the major challenges for the development of analytical devices for biological analysis relies on the ability to design advanced surfaces with controlled interaction with the biological world[1]. Surface functionalization techniques provide those bio-interfaces: appropriate surface physico-chemical properties are able to control the conformation and activity of the immobilized biomolecules. The subsequent technological step is the combination of different bio-functions in micro- and nano-patterns on the surfaces. For instance structuring the surface in adhesive and non adhesive zone in order to preferentially guide the cell growth is one of the most interesting tools for the development of cell chips and for tissue engineering[2,3].The requirement of further integration scales and the study of the special behaviour of the biomolecules interacting with nanostructured materials have been the two main motivations for the development of submicron patterning techniques[4]. For instance an increase of several order of magnitude of analysis capacity in biosensing devices together with lower detection limits are envisaged[5-6].
Plasma assisted techniques are interesting alternatives to produce functionalized surfaces with controlled micro- and nano-patterns: they provide high level functionality surfaces with good stability on different substrates and are compatible with different micro- and nano-patterning techniques.
In this paper we show some examples of micro- and nano-functional surfaces provided by plasma processes in combination with Optical Lithography, Electron Beam Lithography and Colloidal lithography for applications in different biosensing devices.
In particular, micropatterned surfaces were produced by a spatial arrangement of different functional domains by a combination of plasma polymerisation and photolithography: non-fouling patterns were made of poly(ethylene oxide) (PEO)-like polymers obtained by pulsed plasma polymerization of diethylene glycol dimethyl ether while fouling surfaces were composed of PEO coatings with a low concentration of ethylene oxide groups and films containing amino groups (from allylamine monomer) or carboxylic groups (from acrylic acid monomer) obtained by plasma polymerization. Cell adhesion studies (with L929 mouse fibroblasts) on patterned surfaces showed that the fibroblasts only adhere on the patterns, whereas the background stays uncovered (Figure 1).
On the other hand, nano-patterns of fouling-antifouling areas have been produced by combining Electron-beam Lithography and Colloidal Lithography techniques with plasma processes: in particular carboxylic functionalized nano-domes in a PEO-like anti-fouling matrix have been produced. We show that these chemical nano-patterns are able to immobilize proteins selectively in the carboxylic functional nano-domains, leaving the anti-fouling matrix clear (Figure 2). Moreover Enzyme-Linked Immunosorbent Assay experiments were set-up showing that nano-patterned surface constrains the immobilization of the antibodies in a biological reactive configuration, thus significantly improving the device performances as compared to more conventional non-patterned surfaces.

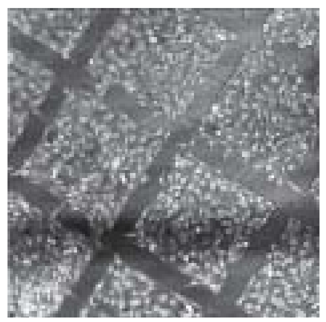

Figure 1. Optical microscope picture of the fibroblasts growing selectively in the fouling areas on a fouling-antifouling surface micropatterned by optical lithography.

Figure 2. Scanning Electron Microscope picture of the proteins selectively absorbed on the polymeric nano-structures. The center of each dome is COOH-functionalized surrounded by anti-fouling matrix with a hexagonal arrangement: the bright objects in the picture (one indicated with a red circle) are the proteins.

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Advances in scanning probe microscopy for biology and nanostructuring

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AFM/SPM (Atomic Force Microscopy/Scanning Probe Microscopy) is widely used to image active protein molecules or living cells in a non-destructive manner. In addition, a variety of molecules can be attached to AFM cantilevers, making them chemically selective sensors for studying individual molecular interactions. Agilent Technologies has developed a variety of different techniques to investigate and manipulate biological matter – from single molecules to live cells. The following topics will be discussed in more detail:

1. High Resolution Imaging of biological species: Several examples of both controlled imaging forces and controlled environment, together with modified cantilevers will be demonstrated. Applications include imaging and probing live cells and viruses, isolated proteins, protein crystals and DNA/RNA.
2. Topography and Recognition (TREC): We will present recent advances in a new AFM technology called TREC, a unique technique that enables measuring real-time, simultaneous topography and specific recognition information. Examples for recognition imaging will be presented on receptor/protein identification on live cells and DNA/protein complexes, as well as applications in medical diagnostics.
3. AFM in combination with inverted optical microscopy: Simultaneous gathering of light, fluorescence, topography and probe data of living cells and/or their components will be introduced. We apply this technique on finding and probing cell membrane proteins where fluorescence microscopy helps us to locate receptors, and AFM imaging and force spectroscopy enables us to study interactions with biologically relevant ligands.

NanoFarma, a Spanish industrial consortium to invest in nanotechnology for drug delivery systems

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Abstract
The NanoFarma consortium was created by 7 pharma and biotech Spanish companies PharmaMar, Rovi, Faes Farma, NeuroPharma, Sylentis, Dendrico and Lipotec. The NanoFarma consortium's research project seeks to develop new drug delivery systems (DDS), both oral and parenteral such as intravenous, intramuscular and subcutaneous. The objective is that the antitumour, anticoagulating and anti-inflammatory molecules developed by the consortium members can be selectively carried to the target organs, tissues or cells, thus enhancing therapeutic efficiency and decreasing toxicity. The consortium is collaborating with more than 30 public-sector research bodies and research and technology centres chosen based on their scientific and technological profile.

Nanopharmaceuticals
In the past 30 years, the explosive growth of nanotechnology has burst into challenging innovations in pharmacology which is in the process of revolutionizing the delivery of biologically active compounds. The main input of today's nanotechnology in pharmacology is that it allows real progress to achieve temporal and spatial site-specific drug delivery.
The long-term objective of drug delivery systems is the ability to target selected cells and/or receptors within the body. At present, the development of new drug delivery techniques is driven by the need on the one hand to more effectively target drugs to the site of disease, to increase patient acceptability and reduce healthcare costs; and on the other hand, to identify novel ways to deliver new classes of pharmaceuticals that cannot be effectively delivered by conventional means. Nanotechnology is critical in reaching these goals. From these technologies, nanopharmaceuticals can be developed either as drug delivery systems or biologically active drug products. This discipline was defined as the science and technology of nanometre size scale complex systems, consisting of at least two components, one of which is the active ingredient. In this field the concept of nanoscale was seen to range from 1 to 1000 nm.
Already now nanoparticle formulations make use of the fact that an enlarged surface/volume ratio results in enhanced activity. Nanoparticles are also useful as drug carriers for the effective transport of poorly soluble therapeutics. When a drug is suitably encapsulated, in nanoparticulate form, it can be delivered to the appropriate site, released in a controlled way and protected from undergoing premature degradation. This results in higher efficacy and dramatically minimises undesirable side effects.

Over the last three decades Europe has been at the forefront of the research and development of nanosized drug carriers including liposomes, nanoparticles, micelles, antibodies and their conjugates, polymer conjugates, etc. The most pressing challenge is application of nanotechnology to design of multifunctional, structured materials able to target specific diseases or containing functionalities to allow transport across biological barriers. To realise the desired clinical benefits rapidly, then importance of focussing the design of technologies on specific target diseases was stressed: cancer, neurodegenerative and cardiovascular diseases were identifies as the first priority areas in view that the these diseases are the highest causes of mortality in Europe.
Although we are still far from the ideal 'magic bullet', proposed by the Nobel laureated Paul Ehrlich, today, nanotechnology has already completed several key achievement to reach this goal. The most straightforward application is in cancer therapy with several marketed compounds (Caely/Doxil®, Abraxane®), and other being currently investigated in clinics. Chemotherapy for cancer treatment is usually applied systemically which leads to severe secondary effects for the patients. The research and investment for therapies in cancer is focusing not only on new therapeutic agents but also on new ways of drug administration to prevent their toxic effects. The creation of drug delivery systems that can act as a vehicle to carry and guide more precisely the active molecule to their desired site of action, is an aspect where nanotechnology has an important role to play. These delivery systems can improve the efficacy of pharmaceutical therapy, reduce side-effects and make drug administration more convenient. These thoughts have been highlight by the EU and US nanotechnology plans

and they are in the strategy plans of the big pharma and biopharma companies working in the sector.

NanoFarma consortium
With this in mind, seven Spanish pharmaceutical companies and start–ups (PharmaMar as leader, Lab Rovi, Faes Farma, Neuropharma, Lipotec, Sylentis and Dendrico) have created an industry-led consortium called NanoFarma in collaboration with more than 30 Spanish basic research groups. The main objective of this consortium is to invest in the development of targeted drug delivery systems coming from nanotechnology and identify target moieties to improve the therapeutics properties of molecules for cancer, Alzheimer, anticoagulant therapy and AIDS.

The drug delivery systems investigated by this consortium include liposomes, polymer nanoparticles, dendrimers, bioconjugates, therapeutics polymers, most of them with multifunctional capabilities; nanoscale devices can contain both targeting agents and therapeutic pay loads at levels that can produce high local levels of a given drug, particularly in areas of the body that are difficult to access. Multifunctional nanoscale devices also offer the opportunity to utilize new approaches to therapy as localized heating or to combine a diagnostic or imaging agent with therapeutic in the same package.
With these projects the consortium pretends to asses potential opportunities for better healthcares as well as to improve the competitively of the Spanish pharmaceutical companies.

Lipid nanostructures as carriers for targeting pharmacological active agents; formulation and in vitro studies

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Abstract
This study focuses on the possible therapeutic utility of liposomal systems containing anti-inflammatory biological agents, such as a glycosaminoglycan, chondroitin sulphate (CS) or lactoferrin (Lf). Their effect on cells (human dermal fibroblasts and human condrocytes) proliferation and morphology was investigated as well as the ability to reduce the proinflammatory cytokines release (TNF-α and IL-6) using *in vitro* model of inflammation (THP-1 cells stimulated with bacterial endotoxins).

Introduction
Lipid nanostructures (liposomes) are known as efficient drug delivery systems that have been demonstrated to protect labile drugs from harsh biological environments, to change pharmacokinetics and biodistribution and to release drugs in a controlled manner (1, 2).
Previous studies have shown that intra-articular administration of anti-inflammatory drugs encapsulated in liposomes have prolonged residence in the joint and reduced the inflammation (2, 3). Lactoferrin (Lf) is an iron-binding glycoprotein of the transferrin family which can modulate the inflammatory response in the course of rheumatoid arthritis (4). Recent data reported the possible effect of CS in the treatment of osteoarthritis but its role is controversial (5). The purpose of this study was to establish the most efficient liposome Lf/CS formulations for cell culture experiments in order to use them in the treatment of rheumatic and inflammatory disorders.

Material and Methods
Reagents. Liposomal lipids, phosphatidylcholine (PC), phosphatidylserine (PS) dioleoyl-phosphatidyl-ethanolamine (DOPE), stearylamine (SA), dipalmitoyl-phosphatidylethanolamine (DPPE), cholesterol (Chol), cholesterylhemisuccinate (CHEMS), human lactoferrin (Lf) and chondroitin suphate (CS) were purchased from Sigma Chemicals (St. Louis, Mo). All other chemicals were of analytical grade.
Liposome preparation. Negatively charged pH-sensitive (DOPE:CHEMS; 6:4 molar ratio), pH-insensitive (PC:Chol:PS; 5:5:1), positive (DPPE:Chol:SA; 5:5:1) and conventional (PC:Chol ; 7:3) liposomes were prepared as previously described (2). Liposomal formulations with the diameter around 200 nm (checked by transmission electron microscopy), were filtered through a 0.22 μM filter (Millipore).
Cells and culture conditions. Human premonocytic THP-1 cells (ATCC TIB 202) were routinely cultured in RPMI-1640 medium (Euroclone) supplemented with 10% fetal calf serum (FCS) and L-glutamine (both from Sigma Chemical Co) and incubated with liposome-Lf systems. Human dermal fibroblasts (HDF) isolated from human dermis and human chondrocytes (HC) obtained from human cartilage by enzyme digestion were grown in Dulbecco's minimum essential medium (DMEM) (GIBCO BRL; UK) supplemented with 10% FCS and incubated with liposomal formulations of Lf/CS.
Cytotoxicity assay. Cell viability was assessed using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay (6).
Cytokine ELISA. The TNFα and IL-6 level in the supernatants of THP-1 cells stimulated with 10 ng/ml LPS (E.coli serotype 055 : B5, Sigma Chemical Co.) for 18 hrs were analysed by capture Duo-ELISA using antibodies pairs and protocols recommended by R&D system.
Statistics. Data were expressed as means ± standard deviation of the mean (SD) Statistical analysis was performed using Student's test. Differences were considered significant at $p<0.05$.

Results and discussions
To investigate the interaction of liposome entrapped anti-inflammatory agents with cells, liposome with different lipid composition and surface charge (neutral, negative and positive) were prepared and characterized. Using THP-1 cells it has been shown that the liposome has no effect on the cell viability at 100 μM lipid final concentration in the medium (data not shown). Liposome-Lf uptake by THP-1 cells is dependent on their surface charge (Fig.1). All liposomal systems were more efficiently in delivery Lf to THP-1 cells than free protein. The highest cytoplasmic level of Lf was achieved by using negative pH-sensitive liposomes.

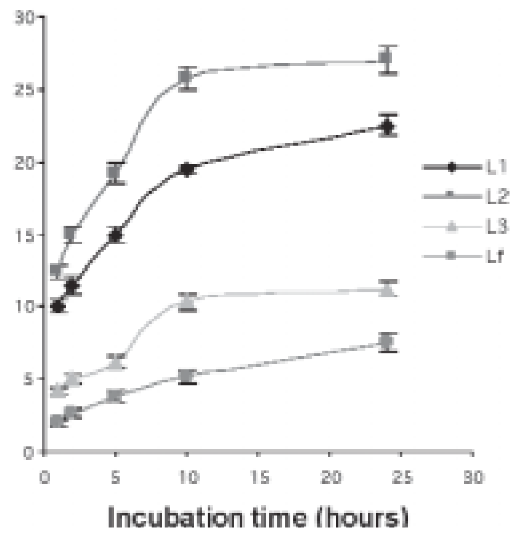

Figure 1. Kinetics of uptake of free and liposome entrapped Lf by THP-1 cells

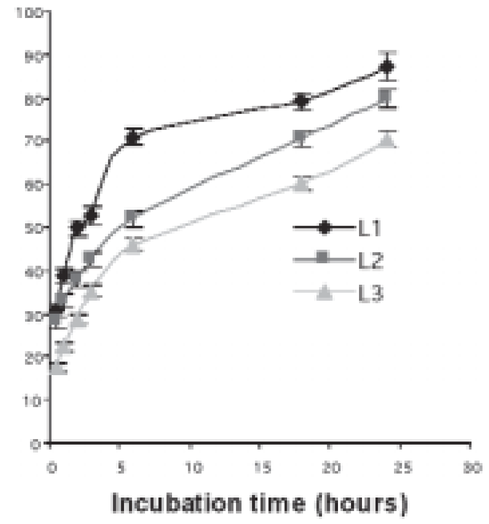

Figure 2. Kinetics of release of Lf entrapped in liposome in the presence of human serum

Lf entrapped in negative pH-insensitive liposomes (PC:Chol:PS; 5:5:1) **(L1)**; Lf entrapped in negative pH-sensitive liposomes (DOPE:CHEMS; 6:4) **(L2)**; Lf entrapped in positive liposomes (DPPE:Chol:SA; 5:5:1) **(L3)**; free Lf **(Lf)**; liposomal lipid concentration 100μM and Lf 20 μg/ml. Each point is represented as the mean ± SD (n=6).

Since the use of liposomes in vivo as carrier involves their interaction with human serum, the effect of this fluid on liposome-Lf stability was investigated by measuring over time (24 hrs), the release of protein. We found that positive liposomes-Lf was more stable than neutral and negative formulation (Fig.2).

The effect of free and liposome entraped CS and Lf on the cell proliferation and morphology of HDF and HC was evaluated by cell viability test and light microscopy. Results from MTT viability assays indicated that liposome systems (Table 1) had no cytotoxic effects on the HDF and HC (Fig. 3).

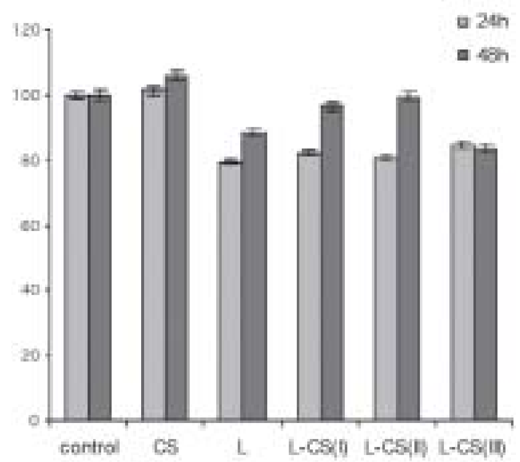

Figure 3 (left) . Chondrocytes proliferation after liposome-CS treatment Results were expressed as percent from the control (100%); values represent the mean ± SD from six experiments.

Formulation code	Lipid concentation *(μM)*	CS concentration *(μg/ml)*
L	200	-
L-CS(I)	100	500
L-CS(II)	200	250
L-CS(III)	200	500

Table 1. Liposome formulationd

Similar data regarding the cell viability were obtained in the presence of liposome-Lf systems (data not shown). Microscopy studies showed that both HDF and HC incubated with liposome included anti-inflammatory agents maintain normal morphology when compared to control cells (data not shown).

We have also investigated liposome system ability to modulate THP-1 response to extracellular inflammatory stimuli such as LPS (Fig. 4).

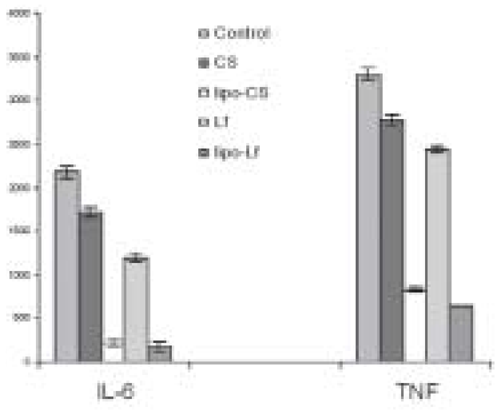

Figure 4. The effect of free Lf/CS and liposome Lf/CS on the proinflammatory cytokines production. Data represent the mean cytokine production ± SD from 5 replicate cultures.

Preliminary results suggested the capacity of liposome based anti-inflammatory agents to reduce the LPS-mediated pro-inflammatory cytokine production (TNF-α and IL-6) in vitro model of inflammation. A significant decreasing of TNF-α and IL-6 level in the presence of liposome containing Lf/CS compared to free biological agents can be seen in Figure 4. Liposome final concentration in the medium was 200 µM, Lf free and entrapped in liposomes 4mg/ml and CS 10mg/ml. In conclusion our studies indicate that liposomes could be used as efficient carriers for controlled delivery of Lf and CS into cells and are encouraging for therapeutic use.

Acknowledgements
This work was supported by MATNANTECH research program, project CEEX 57/2006 (NANOCONTER).

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NANOCYTES-Technology – Biomimetic nanoparticles for life sciences and industrial applications

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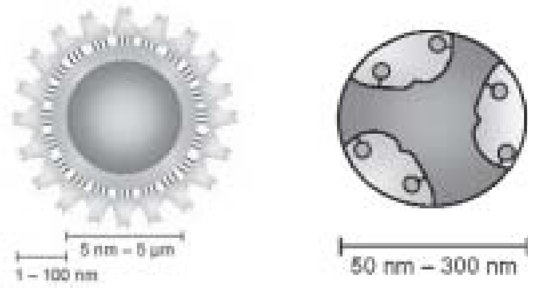
Communication of living systems is done by molecular recognition. This central principle of the living world is performed at the contact sites of different objects such as single macromolecules or highly complex supramolecular assemblies as which living cells may be described. Molecular recognition capabilities are evoked at artificial materials by the NANOCYTES-technology of the Fraunhofer IGB.



(a) (b)

Figure 1: Scheme of core-shell nanoparticles for molecular recognition applications. The shell consists of a supramolecular organic arrangement which either (a) ensures the steric directivity of attached biologically derived receptors and their bioactivity or (b) forms entirely synthetic molecular binding sites. The chemical design and typical applications for both concepts of biomimetic nanoparticles are described throughout the article. The core inside the particles can contain specific physical properties such as a magnetic moment or fluorescent activity.

The biomimetic nanoparticles described here, possess such molecularly recognizing properties. For this purpose they carry molecularly defined binding sites at their surface. These binding sites are either composed from biologically derived macromolecules or fully synthetic receptors. Core-shell nanoparticles are particularly suited for this purpose, e.g. to immobilise a specific protein or a protein complex at their shell surface. Entirely synthetic molecularly recognising nanoparticles can also be prepared by chemical nanotechnology. A cooperative chemical reaction evokes the formation of specific molecular binding sites at the surface of copolymer nanoparticles. A straightforward application is to use the synthetic receptors as specific absorbers e.g. to remove of toxins or contraries from mixtures which may even be of complex nature. Other applications range from specific chromatography or membrane processes to diagnostic purposes and will be highlighted.The talk will highlight the design and application ofbiomimetic nanoparticles based on the structural concepts described above.

Nanoporous aluminium oxide for tissue engineering

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Abstract
Nanoporous aluminum oxide membranes were produced by anodic oxidation and used as cell culture substrates. HepG2 cells were cultured on two different membranes with pore diameters of 54 nm and 207 nm, respectively. Additionally the mem-branes were coated with collagen. The cells adhered to and proliferated on the unmodified nano-porous substrates with a lower extend compared to the collagen-modified membranes and the control culture on polystyrene. The growth behavior was not influenced by the pore diameter of the used membrane. However, SEM investigations reveal different cell morphologies. Cells growing on membranes with larger pore diameters (~210 nm) penetrate into the pores and attached to the pore walls by forming small cell extensions. The presented results are encouraging to further improve the nanoporous aluminum oxide membranes for applications in the field of cell culture.

Introduction
The nanoporous aluminum oxide produced by anodic oxidation is a very unique nanostructured material [1]. Self-supporting nanoporous aluminum oxide membranes are characterized by high porosity, whereas the pores are aligned perpendicular to the membrane surface and arranged in a highly ordered hexagonal manner. Membrane parameters, e.g. pore diameter and membrane thickness, can be adjusted throughout the anodization process [2]. The highly ordered pore structure of nanoporous aluminum oxide is often used as a template for the fabrication of nanotubes and nanowires made of different materials [3,4]. Further, studies are aimed at the optimization of nanoporous aluminum oxide for biomedical applications. A possible field is the surface modification of orthopedic implants, since better cell-ingrowth and con-sequently a stabilization of the endoprosthesis due to the higher porosity of the material is expected [5]. Another approach is the use of self-supporting nanoporous membranes for cell cul-ture applications [6,7]. It was already demonstrated, that the pore diameter of such membranes can affect cellular functions [6]. Compared to conventional porous cell culture inserts made of polymers (PTFE, PC, PET), the porous structure of the used nanoporous aluminum oxide membranes can be well controlled.

Methods and materials
For the investigation of the cellular interactions with self-supporting nanoporous aluminum oxide membranes, we used a hepatoma cell line (HepG2). Due to the production process, the pore diameter of front and back side (facing to the electrolyte or the aluminum plate, respectively, during the anodic oxidation) of the resulting membrane differs [8]. In the experiments described herein, the cells were only cultured on the front sides of the membranes. Two different membrane types were used. Membrane A (thickness 67 µm) was produced in oxalic acid at an anodization voltage of 40 V. Based on scanning elec-tron micrographs (SEM JEOL JSM 6700) and digital imaging analysis, the pore diameter of the resulting membrane on the front side was determined with d = 54±5 nm (porosity 23 %). Membrane B (thickness 46 µm) was anodized in phosphoric acid at 150 V and had a pore diameter of d = 207±24 nm (porosity of 23 %). Prior to cell seeding, the membranes were cut into round pieces (ø=1.2 cm), then cleaned with distilled water and sterilized by ethanol and UV-light. For collagen surface modification, a sterile collagen solution (Collagen R, Serva) was added to the substrates for a final concentration of 8 µg/cm^3. The solvent was evaporated in a laminar flow box overnight. HepG2 cells were cultured in tissue culture flasks until confluence. They were harvested by trypsinization and seeded onto the membranes with a concentration of 1 x 10^5 cells per membrane. The same amount of cells was plated in 24-well culture plates made of PS (TPP) as a control culture. Because of optical transparency of the nanoporous membranes, the cell cultures can be continuously observed by light microscopy. During the experiment, daily cell growth was assessed by using a resazurin-based viability assay (CellTiter-Blue®, Promega). After a culture period of 7 days the cells on the nanoporous substrates were prepared for high resolution scanning electron microscopy (HR-SEM) as described previously [6].

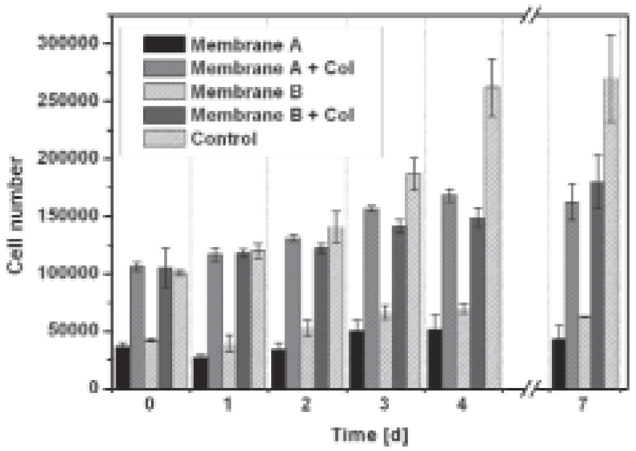

Figure 1: Cell growth of HepG2 on unmodified/collagen-coated nanoporous alumina membranes (A, B) and on control

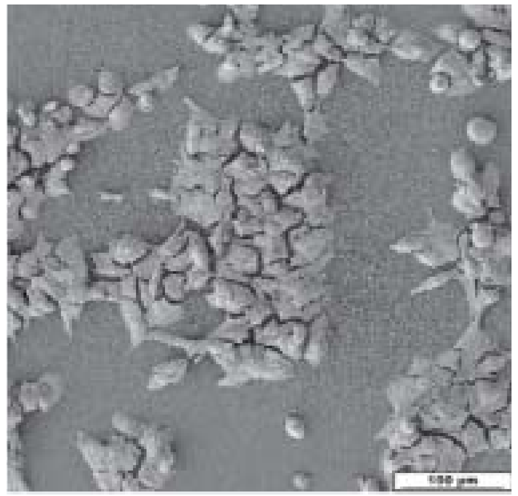

Figure 2: HepG2 cells on nanoporous aluminum oxide membrane B

Results and discussion
Fig. 1 shows cell growth of HepG2 cells on membranes A and B (unmodified and collagen coated) and the control culture during the 7 day culture period. The cell adhesion and growth on the unmodified nanoporous substrates is lower as on the collagen coated membranes as well as the control culture on PS. The modification of the membranes with collagen promotes cell adhesion and growth, resulting in cell numbers comparable to the control group. This can be explained by the fact, that collagen is a main constituent of the extracellular matrix of cells thus providing specific binding sites for cell receptor proteins (e.g. integrins). However, the number of cells in the control group increased more than 2,5fold until day 7, whereas it only increased about 1,7fold on the collagen treated substrates. In this context it has to be noted, that the surface of the normal tissue culture material (PS) is modified to show optimal properties for cell attachment and growth. Nevertheless it was shown, that nanoporous aluminum oxide membranes can be used for cell culturing without significant effects on cell vitality. Additionally, the cell proliferation is not influenced by the pore diameter of the membrane, whether modified or not.
Observations by light microscopy revealed, that the cells spread out over the nanoporous substrates and arrange in larger cell assemblies. This was confirmed by SEM investigations (Fig. 2).
The overall cell morphology was comparable to cells grown in tissue culture plates (PS). They exhibited flat, polygonal cell bodies and possessed microvilli. At higher magnification, the cell-substrate interaction became visible. Fig. 3 shows SEM micrographs of the cell borders of HepG2 cells on the unmodified membranes A and B. It is obvious that the cell extensions could not interact with the small porous structure of membrane A (Fig. 3a, arrows). However, if membrane B with a pore diameter of approximately 210 nm is used, the cells extend into the pores with their filopodia (Fig. 3b, arrows). It seems that the cell uses the pores as anchor points to stabilize the attachment to the underlying nanoporous aluminum oxide. Even after the preparation for the SEM investigation and the accompanied shrinking process, the filopodia stick to the pores. In some cases they are even branched and anchored to two pores simultaneously. This intense cell-substrate interaction is encouraging for further cell culture experiments.

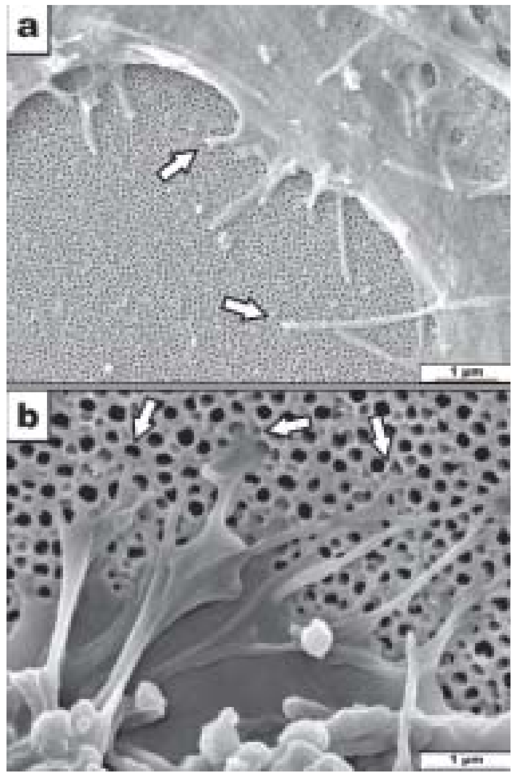

Figure 3: (a) Leading edge of a HepG2 cell on membrane A and (b) membrane B

Conclusions
It was demonstrated that nanoporous aluminum oxide membranes are well suited as substrates for cell culture. Especially collagen-coated membranes provide excellent cell growth conditions and are comparable

to other materials which are optimized for cell cultures. Further investigations are aimed at the development of a co-culture bioreactor set-up with nanoporous aluminum oxide membranes as key elements. Here, the membrane acts as a physical barrier and divides the bioreactor into two compartments. In this way, co-cultures of cells under perfusion conditions can be established, whereas the different cell types are grown on opposite sites of the membrane. Due to the perfusion conditions and the diffusion of cellular metabolites from one side of the membrane to the other, a positive influence on cell behavior and functionality should be possible.

Acknowledgement
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Nanotechnology: health and environmental risks of nanoparticles – research strategy

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As an important future technology, nanotechnology1 provides the opportunity to promote long-term economic development by means of intensive research and the effective transfer of research findings into innovative products. At present, the toxicological and ecotoxicological risks linked to this expanding technology ('emerging technology') cannot be assessed sufficiently. Nanotechnology is increasingly moving into the centre of public attention. However, currently it is not yet linked to any great degree to concerns about health and the environment. Over the next few years this could change, if the media increasingly will point at components linked with nanotechnology which are harmful to health or the environment (cf. also public debate on genetically modified organisms (GMOs). It is expected that the importance of nanotechnology will continue to grow and that workers and consumers will be increasingly exposed to it. Hence, there is a need to monitor the development of this new technology, to weigh up the opportunities and risks in a transparent process and compare them with established technologies. Particularly important is co-ordinated and effective research in order to enable the public agencies BAuA, UBA, BfR (downstream of the Federal Ministry of Labour and Social Affairs, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Food, Agriculture and Consumer Protection) to describe and assess the toxicological and ecotoxicological risks and also to place the resulting recommendations (e.g. classifications, limit values, handling recommendations) on a sound and comprehensive basis.

According to present knowledge, the insoluble and poorly soluble nanoparticles[2] and there agglomerates and aggregates are particularly toxicologically relevant. For that reason and to sensibly define the scope of the subject, this research strategy refers to these nanoparticles (incl. aggregates and agglomerates) and to chemical safety at the workplace and for consumers and the environment. Chemical legislation does not mention nanoparticles to be tested (e.g. toxicological studies) and assessed specifically, nor is there at present a guideline how to measure them. Widespread nanoparticles like for instance titanium dioxide, zinc oxide, iron oxide, silicon dioxide or carbon black involve a nanoscale modification to a HPV[3] existing substance with the same CAS-number. Considering in addition the different modifications of nanoparticles by coatings etc, that might influence the toxicological and ecotoxicological properties, it becomes clear, that a CAS-number-based 'all-in-one-regulation' needs careful consideration of these possible differences. Up to now there has been no specific regulation for nanoparticles in the areas food, consumer goods or cosmetics. For instance, no particle sizes are stipulated in the purity criteria for the approved food additives silicon dioxide (E 551) and titanium dioxide (E 171).

As the exposure of humans and the environment as well as the toxicological and ecotoxicological properties and risks have not yet been characterised sufficiently, there is a general need to conduct further studies and to close the gaps in knowledge through research and assessment activities. Similar to technologically based research, in safety research we also need a shift away from fundamental research and a new direction which facilitates the implementation of results in risk-oriented and comprehensive assessments (or recommended actions) and the covering of the relevant toxicological and ecotoxicological endpoints. Furthermore, the goal is to achieve a balance between *in vitro* and *in vivo* methods which is influenced to a large extent by the validity of the *in vitro* methods.

It should, however, also be taken into account that nanoscale particles are not completely new. For a long time naturally formed and unintentionally produced particles of this size have passed into the environment leading to exposure for humans and the environment.

In order to promote the acceptance of nanotechnology by the public, accompanying social scientific research should be conducted and there should be transparent discussion of the risks with all interested stakeholders in society (cf. for instance http://www.dialog-nanopartikel.de/downloads.html). The establishment of a cross-disciplinary nano discussion platform for Germany is seen as a suitable way of initiating and co-ordinating research and discussion, and using the results for regulatory practice.

On that background BAuA initiated and coordinated a joint draft research strategy of BAuA, BfR and UBA to include human (workers, consumers) as well as environmental safety (for download see[4]). The goal of this research strategy is to structure the research area, to develop the measurement of particles (metrology), to record information on exposure and toxicological/ ecotoxicological effects, to promote the development of a sophisticated risk related test and assessment strategy, to identify the existing elements of a test strategy, to move substances of particular importance centre stage of assessment and, in particular, to ensure the suitability of the data recorded from publicly financed research activities for regulatory questions (e.g. limit values, classifications, handling recommendations). Furthermore, this also encompasses risk communication projects.

The diversity of the projects and research subjects demonstrates the complexity of examining and assessing the risks of a new technology. For occupational safety, consumers and the environment partly similar shortcomings are arising which have led to similar demands (e.g. information on type and scale of exposure). In the fields of occupational safety and consumer protection, ideas of sensible testing are more precise which means that some elements of a test strategy are already available. One major challenge in the near future will be the identification and integration of suitable *in vitro* methods and suitable methods to determine the PC properties in order to predict *in vivo* toxicity. This would justify a renunciation of *in vivo* studies. Up to now, no limit value has been derived from *in vitro* methods as the central database. When it comes to developing a strategically sensible link-up between the projects, it is clear that the determination of type and scale of exposure to nanoparticles is an essential prerequisite for selecting substances for priority testing.

[1] *Nanotechnology describes the manufacture, examination and use of structures, molecular materials, inner interfaces with at least one critical dimension below 100 nm.*

[2] *Nanoparticles are understood as being engineered granular particulates, tubes and fibres with a diameter <100 nm (including their agglomerates and aggregates) for at least one dimension which have been shown to have low solubility in biological systems. Based on knowledge acquired so far these particles are particularly toxicologically relevant.*

[3] *HPV chemicals: chemicals produced in large volumes. Chemicals which are placed on the market in the EU in volumes over 1000 tonnes per year per manufacturer or importer.*

[4] *http://www.baua.de/en/Topics-from-A-to-Z/Hazardous-Substances/Nanotechnology/Nanotechnology.html__nnn=true*

Swiss actionplan 'risk assessment and -management of synthetic nanomaterials'

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1. Background

Today's technological progress enables us to selectively modify materials on the molecular or even atomic level. It allows us to create new, tiny structures of only a few nanometers (1 nm = 10^{-9} m). At this small scale, physical and chemical properties can change. These new and modified characteristics can be used and offer great opportunities.

Nanotechnology is an interdisciplinary technology; it potentially influences a big variety of different products, applications and processes. Novel sunscreens, stain resistant textiles and paintings, self-cleaning windows or scratch-resistant coatings are only a few examples of nanotechnology-enhanced products already on the market. Many other innovations are expected to be available soon in the field of medicine, materials technology, cosmetics, food and packaging, electronics and environment protection.

After a time period in which nanotechnology was almost exclusively linked to 'innovation' and 'benefit', potential environmental and health risks started to emerge as a complementary topic during the last few years. The focus hereby mainly lies on products and applications where the release of synthetic nanoparticles is expected during production, use and disposal. On the one hand, these worries are based on previous experiences with nanoparticles from natural sources (e.g. volcanoes) or technical combustion processes (e.g. diesel soot). On the other hand, several studies about the toxicity of certain synthetic nanoparticles have supported these worries.

However, before any reliable risk assessment can be performed, synthetic nanoparticles have to be further investigated. Therefore, a broad spectrum of research projects is underway worldwide, to close the existing knowledge gaps. Due to the complexity of the field of research and the vast variety of different nanoparticles, it will most probably take many years to provide the necessary data for conclusive risk assessments.

In response to this emerging risk issue, the Federal Office for the Environment (FOEN) and the Federal Office of Public Health (FOPH) have mandated an expert panel under the lead of The Innovation Society to analyse the current scientific knowledge within the scope of an Actionplan called 'Risk assessment and –management of synthetic nanoparticles'.
The project is intended to propose suitable measures to protect employees, consumers and the environment, from advese effects through synthetic nanomaterials. The Swiss Actionplan is supposed to cover a number of topic areas including
- providing a summary of the **uses** of nanoparticles in Switzerland.
- giving an overview on the current knowledge about adverse effects on human health and the environment.
- describing **immediate measures** to protect employees in industry and research.
- devising **scientific principles** for danger and risk assessment.
- drawing up harmonised **definitions, measurement methods** and validated **test guidelines** for the danger and risk assessment in cooperation with the OECD, EU, ISO and UNEP.
- motivating the research and business communities to develop and apply **self-regulation-measures**.
- adapting existing **legislation** if this is needed to guarantee the safety.
- conducting a **dialogue** with the relevant stakeholders (scientists, trade associations, offices, insurers, politicians, investors, general public).

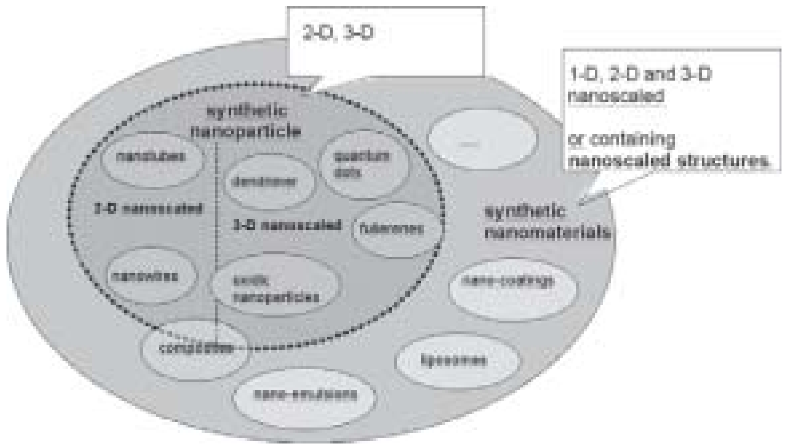

Figure 1: Examples of nanomaterials within the scope of the Swiss Actionplan

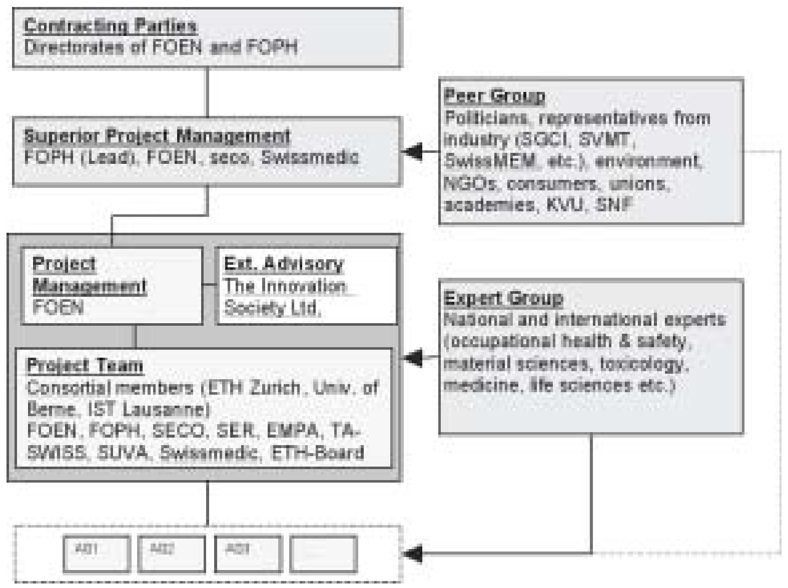

Figure 2: Organisation of the Swiss Actionplan

The focus of the Swiss Actionplan clearly lies on synthetic nanoparticles, while nanomaterials are also considered relevant if nanoparticles can be released during their life cycle (Figure 1). The focus on synthetic nanoparticles is justified by the fact that these small particles are under suspicion to penetrate into the body and through barriers and influence it in an unknown and potentially harmful way.

2. Organisation

Considering the large variety of subject areas involved, the Swiss Actionplan is developed by a panel of experts from different research organisations and governmental institutions (Figure 2). The broad foundation ensures technical excellence and introduces different points of view.

The project is leaded by the FOEN and the FOPH. The scientific fundamentals are developed primarily by a consortium consisting of members of well-known Swiss research facilities (ETH Zurich, University of Berne, IST Lausanne). Besides these consortial partners and the FOEN / FOPH, the project team involves members from the State Secretariat for Economic Affairs (SECO), the State Secretariat for Education and Research (SER), the Center for Technology Assessment (TA-SWISS), the SUVA (Schweizerische Unfallversicherungsanstalt, Swissmedic and the ETH Board. The innovation society Ltd. (St. Gallen) acts as an external consultant and coordinates the parts of the project. All these parties support the development of the scientific basis and the resulting measures.

A so called peer group with members from different branches of the industry, education, politics and NGOs, as well as an expert group periodically evaluate the project and comment on it. This guarantees a broad foundation of the measures developed and increased acceptance within the relevant stakeholders. Furthermore, these partners contribute to the high quality of the resulting documents and actions through the review processes.

In special cases, so called action groups (AG) can be installed to treat specific questions within small expert groups.

3. Process

The Swiss Actionplan was officially launched in June 2006 and started with the collection and development of the scientific knowledge about the risks of synthetic nanomaterials in a **basis report**. This report was created by the project team and commented by the peer group and the expert group. Additional findings, different opinions and comments were included into the basis report in several review rounds. The basis report primarily serves as the foundation to deduce and explain future actions. It was formally accepted and published (online) in June 2007.

With the scientific knowledge about the risks of synthetic nanoparticles (gathered and summarized in the basis report), **research needs** were identified by the experts of the respective subject areas. The need for risk research was compared to projects already running or planned in the country and abroad.

The identification of the research needs as well as other arguments from the basis report lead to the development of the **recommended actions**. Those preliminary masures covered the topics of

- promotion of risk resarch
- standardisation
- voluntary measures of industry and retailers
- legislation
- technology assessment and communication

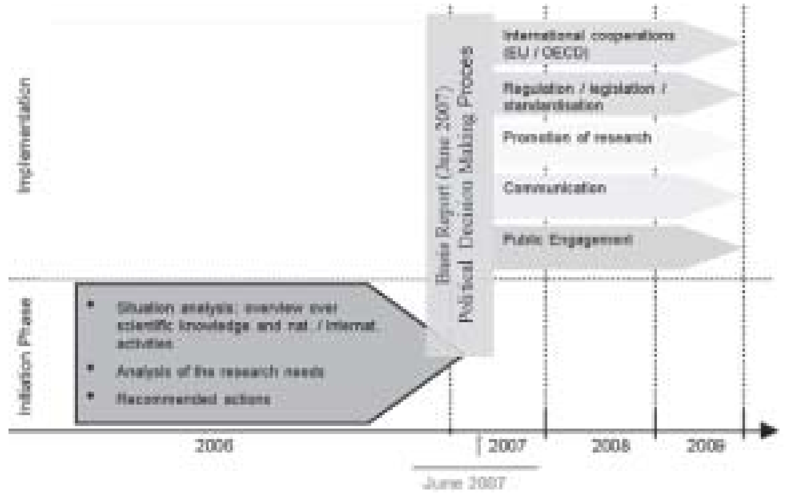

Figure 3: Time schedule of the Swiss Actionplan

The recommended actions represent the interface between the 'scientific layer' of the basis report and any future measures (Figure 3). They were also reviewed by the peer group and the resulting comments have been summarized in a consultation report. The recommended actions were prioritized in the following and finally lead to the implementation plan.

The **implementation plan** consists of a final set of high-priority measures (including information about the necessary ressources and the temporal sequence of the measures) and will be released for the attention of the Swiss Federal Council later in 2007. In the current phase, the recommended actions are worked out in more detail.

4. Results

The Swiss Actionplan follows the goal to develop and provide a series of actions to the Swiss government to ensure the safe manufacture, use and disposal of synthetic nanomaterials.

The first step to the implementation of measures was taken with the development of the **Basis Report**, which summarizes the current knowledge about the risks of synthetic nanoparticles, describes national and international research programmes and deduces research needs. It summarizes the 'status quo' and the scientific knowledge in review chapters about human toxicology, ecotoxicology, physical and chemical hazards and occupational health and safety. Regulatory issues, technology assessment and societal aspects are discussed in a second part. The Basis Report has been published online in June 2007 by FOEN/FOPH.

The Basis Report lead to the identification of **risk research needs**. It turned out that the current scientific knowledge is not sufficient to perform conclusive risk assessments at this early stage. Research needs were identified in the areas of
- **metrology** (instruments, test & assessment methods, etc.)
- **health** (toxicokinetics, effects of nanoparticles on different targets (e.g. organs, cell types), etc.)
- **environment** (distribution, mobility, accumulation, degradation, toxicity, emission sources, etc.)
- **physical and chemical hazards** (fire and explosion behaviour, catalytic activity)
- **occupational health & safety** (screening tools for workplaces, amount & types of nanoparticles used, safety measures, mechanics of particle emission, etc.)
- **technology assessment & communication** (methods of dialogue, risk perception & acceptance, etc.)

These above research needs have been compared with current and planned national and international research projects, primarily to identify important, yet unsufficiently covered and therefore particularly urgent areas of action. However, most of the risk research listed in the basis report correlates well with current or planned risk research projects. Therefore, the EU Framework Programme 7 (EU FP7) represents an opportunity to cover at least one part of the identified research needs. Accordingly, the coordination of the risk research (e.g. via OECD) on an international level turned out to be of particular importance. Another option would be the establishment of a National Research Programme (NRP) 'Risks and Opportunities of Nanotechnology' in Switzerland.

The research needs lead to the development of a series of recommended actions, which also contain details about the implementation and the necessary ressources. During the discussion of the measures and the review phase, it became evident that preliminary risk assessment methods and a strong (temporal) prioritization of the measures have to be developed and implemented in a first step. This represents a precondition to be able to perform precautionary measures at an early stage and to prioritize the research needs and further actions. Standardisation (ISO, SNV, OECD), risk research, and communications were also identified as areas of very high priority.

5. Further procedure
- The recommended actions will lead to the development of an Action- and Implementation Plan. This paper will contain selected actions and will be discussed by the Swiss Federal Council in Summer 2007.
- Later this year, it will be decided whether a Swiss National Research Programme (NSR) on the 'Opportunities and Risks of Nanotechnologies' will be funded. This will influence the way the identified research needs can be covered.
- The implementation of the measures is provided for the time period of the year 2007 to 2010.

The Innovation Society Ltd., St. Gallen (Switzerland)
Innovation Society is an leading Nanotechnology Consulting and Research Firm. The company has strong expertise in safety, risk and regulation issues, providing science based services to international clients from industry, financial and insurance sectors as well as international governmental bodies. The Company developed CENARIOS® the first certifiable Riskmanagement system in cooperation with TÜV SÜD in 2007.

Dr. Christoph Meili
holds a Ph.D in business administration and a Master degree in biotechnology. He is CEO and founder of the Innovation Society and specialized in consulting in the area of nanotechology. He has a long consulting experience risk- and innovationmanagement in the area of emerging technologies.

Workplace safety concepts and measures for nanomaterials – VCI's Guidance for handling and use of nanomaterials at the working place

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Degussa GmbH, Hanau (Germany), German Association of Chemical Industry, Frankfurt (Germany)

The German chemical industry takes the most sensible measures to ensure safety of their workers and employees. To promote this, the German Chemical Industry Association (VCI) conducted so far 2 workshops dedicated to the safe production and handling of nanomaterials at the working place. Further workshops in this series are in preparation, the next one will be devoted to safety data sheets and safety information in the supply chain.
As result of the first workshop of this series VCI and the German Federal Institute for Occupational Safety and Health (BAuA) did agree on conducting a survey on practices for safe production and use of nanomaterials in the German chemical industry. The results of this survey were reviewed and summed up in the document 'Guidance for handling and use of nanomaterials at the working place'.

This Guidance document intends to support the safe production and use of nanomaterials at the workplace. It offers recommendations that reflect the current state of science and technology. It focuses on insoluble nanoscale dusts and aerosols. Content are:
- Background and provisional definition
- Regulations relevant for workplace safety
- Safety concepts
- Recommendations for safe handling and use of nanomaterials at the workplace
- State of the art and developments in exposure measurement
- Checklist for risk evaluation

The key note will explain the state of the art concepts and measures for workplace safety and the 'Checklist for risk evaluation'.

Measurement strategy development towards standardized nanoparticle exposure assessments – Example TiO_2-Workplaces

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Abstract
Nanotechnology opens opportunities for new and improved products and needs tailored pro-duction tools. Nanoparticles are one of the most important building blocks to e.g. develop new or improved materials, allow for higher catalytic efficiencies, or reduce energy and material consumption. In order to assess possible environmental implications of nanoparticles it is necessary to be able to detect and quantify nanoparticles in the corresponding matrix; soil, water, and air in the ambient and/or workplace environment. Different measurement and sampling techniques are necessary as well as task specific strategies to identify and quantitatively determine nanoparticles. The focus of this paper is on measurement strategies for the determination of excess engineered nanoparticles in the environment of workers to avoid data misinterpretation.

Introduction
Exposure to airborne nanoparticles is currently seen as one of the major exposure routes. A recent review on the potential risks of nanomaterials (Borm et al., 2006) gives a good overview of possible environmental and health effects of nanomaterials including nanoparticles.
The term 'nanoparticle' in the present context is used for particles with mobility diameters below 100 nm which are engineered and intentionally produced. They shall be clearly differentiated from ubiquitous ultrafine particles in the size range below 100 nm which can be salt particles such as ammonium sulphate or diesel soot particles of certainly very different toxicological relevance.
Figure 1 gives an example for the information needed with regard to nanoparticle exposure. It exemplifies that particles in the size scale below 100 nm may enter the work area from the ambient atmosphere. For a realistic risk assessment, measurement of this background aerosol is needed to obtain information on possible nanoparticle release and subsequent possible exposure.
This paper focuses on measurement strategies while a companion manuscript deals with toxicological and exposure relevant particle metrics and their possibilities of determination (Fissan et al., 2007).
The use of size distribution measurement data is chosen for demonstration purposes in this paper because those data are the most commonly determined parameters in previous studies (Kuhlbusch et al., 2004 and 2006).

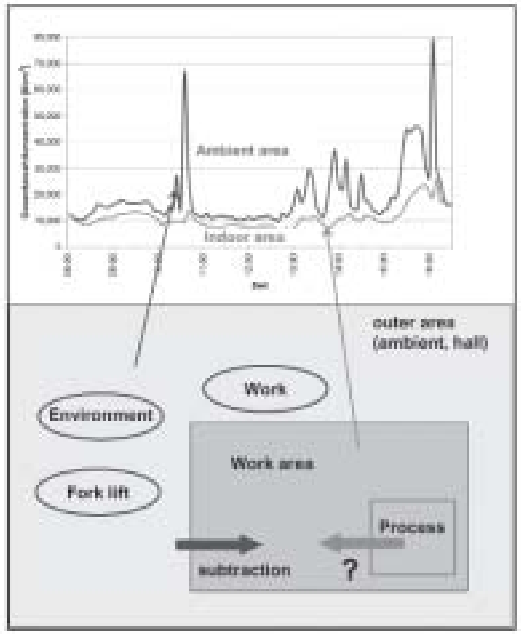

Figure1: Influence of outside ultrafine particles onto workplace atmospheres (Kuhlbusch et al., 2006)

Approaches for the determination of nanoparticles

Most of the current available measurement techniques for the detection of nanoparticles are not personal instruments. Hence, measurements at a fixed location within a work area are currently the most common approach. This certainly leads to the difficulty in the proper placement of the measurement devices in the work area and information on the ventilation of the work area is essential.
Two approaches may be used for the determination of particle concentration fields in specific work areas (a) modelling with realistic data on particle sources (Kuhlbusch et al., 2007) or (b) mapping with e.g. a handheld CPC or an FMPS (Miller, 2006).

Two different approaches may be differentiated to derive information on the possible source strength of processes and/or leaks. The detection of
- single nanoparticles in the work environments
- nanoparticle number concentrations
The evaluation of number concentrations is different whether the concentrations are in a range between approx. 1,000 #/cm^3 and 100,000 #/cm^3, or above 100,000 #/cm^3. This differentia-tion into concentration ranges was made to demonstrate the different needs in nanoparticle measurement techniques as well as measurement strategies. Single particle analysis methods are needed in the first case. Two significantly different methods may be used, (a) sampling of particles on substrates and subsequent analysis by e.g. TEM/SEM – EDX or (b) in some cases aerosol mass spectrometry may be applicable. Generally it can be stated that the available methods for this case are limited and in the case of microscopy quite labour intensive.
Particle detection in the high concentration case may be regarded as the simplest case since (a) particle concentrations › 100,000 #/cm^3 usually only occur in the presence of a strong source and (b) can be attributed to sources near to the measurements. This facilitates an easy identification of the source, because the background concentration can be neglected.
The case of the identification of nanoparticles in the concentration range between 1,000-100,000 #/cm^3 requires the highest attention. Particle concentrations in work areas in this concentration range may come from various internal and external sources of the work area besides the actual product nanoparticles.
Hence we propose the continuous measurements of particle concentrations directly in the vicinity of the working area of interest but at a location not influenced by the work process.
This measurement enables the calculation of ambient particle penetration into the work area based on time periods of no work activities (figure 2).
This calculation is exemplarily shown for the case of measurements of particle size distributions in an ultrafine titanium dioxide bagging area. Overall, particle contributions from the work process of about 522 #/cm^3 (12 % of measured concentration during activity) were calculated. This concentration was determined with concur-rent PM10 concentrations of 1.1 mg/m^3.

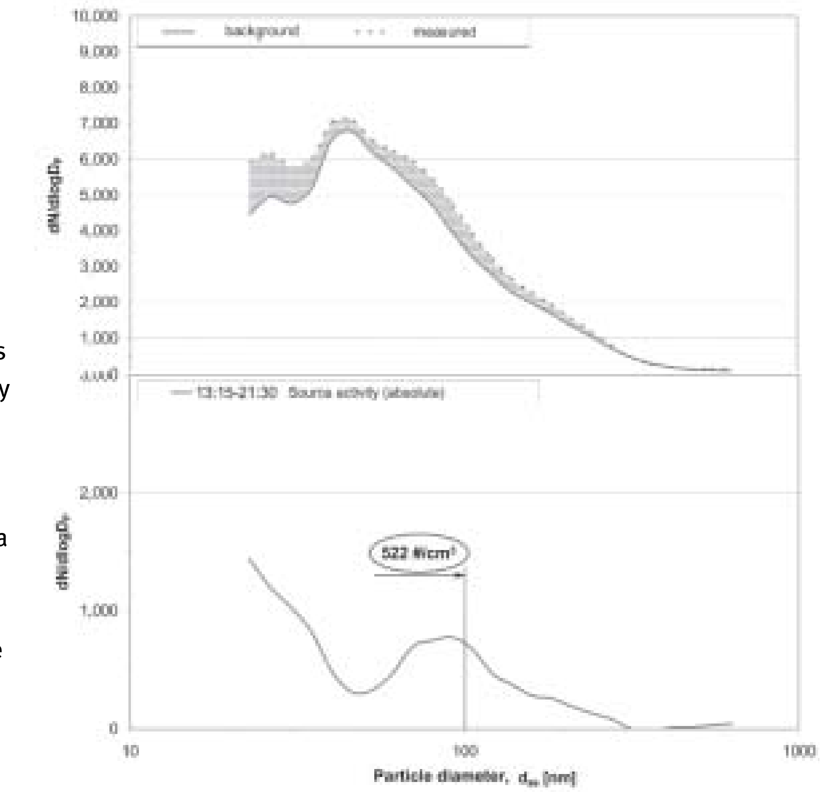

Figure 2: Particle size distribution measurements in the bagging area of ultrafine TiO_2 during bagging; UPPER FIGURE represents the measured values (dashed line) and calculated contribution by ambient particles (solid line), difference contribution by work process; LOWER FIGURE represents the size distribution determined for the work process.

It has to be noted that the detected increase in particle number concentration

- may not be significant taking into account the variability of e.g. the ventilation of the area,
- is concentrated at particles below 20 nm, indicating newly formed particles.

We recommend to perform chemical analysis to proof that the additional particles are from the production source, because their composition is known. In the above case, additional SEM/EDX measurements from this area did not show any significant Titanium concentrations for particles below 100 nm.

This example clearly demonstrates that well defined measurement strategies are necessary

a) to determine engineered nanoparticles at work places
b) to differentiate those from ambient particles of similar size
c) to relate the measured values to potential risks.

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NANOSH – Inflammatory and genotoxic effects of engineered nanomaterials

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Abstract

There are increasing demands by the society for reliable information on the possible effects of engineered nanoparticles (NPs) and the significance of these effects. It is essential that reliable and understandable information will be gathered before wide use of nanoparticles to avoid potential unkonwn health problems.

Some of the identified key-knowledge gaps related to nanoparticles are: 1) lack of suitable reference materials to be used in comparative studies for characterization of different types of NP; 2) lack of understanding of metric's that should be used as the basis for measurement of levels of NP in the environment, or as determinants of dose e.g. in toxicological studies; 3) lack of easy-to-use, portable devices for measurement of nanoparticles in the air and therefore lack of exposure information, especially the working environments; and 4) identification of key-effects in most important target organs of NP; 5) identification the underlying mechanisms of these effects; 6) exploring translocation of NP in man and experimental animals; 7) effects of low exposure levels of nanoparticles to exposed humans, particularly those being exposed in workplaces to nanoparticles; 8) utilization of these data in risk assessment of NP and ultimately in regulation of safety management of NP in their production and in other industrial processes.

Exploring the significance of inflammatory and genotoxic effects of nanomaterials

The NANOSH research aims at exploring some of these identified key-gaps in our knowledge related to NP. The goals of the NANOSH research include: 1) identification of the key-characteristics of the studied NP; 2) characterization of the levels of exposure to specific engineered nanoparticles including carbon nanotubes, nano-sized titanium dioxide and other nanoparticles based on the results of the initial studies with already chosen nanoparticles with a special emphasis on metal and metal oxide NP; 3) pulmonary inflammation induced by exposure to NP in experimental animals and cells; 4) genotoxic effects of NP in experimental animals and cells; and 5) effects of NP on microcirculation and NP-induced disturbances in blood coagulation.

Exposure to various types of NP will be explored in different types of work places in UK, Germany, The Netherlands and Poland. Finnish and UK group will be involved in the characterization of the NP identified in different types of workplaces. In NP characterization, several metrics will be utilized including particle size distribution, particle numbers, particle surface area and mass. NP will mainly be characterized by using electron microscopic techniques.

Health-related studies aim to focus on end point with key-importance in terms of human health significance. Information on the causality between NP exposure and pulmonary inflammation is especially important because of the importance of the lungs as an entry into the body and because of the importance of the lungs as a target organ. The parameters which will evaluate pulmonary inflammation include alterations in the panorama of pulmonary inflammatory cells in vivo as well as expression of biochemical markers of inflammation, i.e. cytokines and chemokines, also in vivo. Parameters of pulmonary inflammation to be studied in vitro include expression of chemokines and cytokines, and markers of cells death.

Genotoxicity as a toxicological endpoint is crucial because remarkable genotoxicity may be an early short-term indicator of potential carcinogenicity or reproductive toxicity. Genotoxicity of the chosen NP will be assessed in pulmonary epithelial cells and mesothelial cells in vitro and pulmonary epithelial cells in vivo by measuring oxidative DNA damage, DNA strand breakage, and chromosomal damage.

NP effects on microcirculation or blood coagulation cascade would implicate that NPs could have a potential to induce wide-spread systemic effects in the body, and hence, this target is of major importance in assessing the potential harmful effects of NP. To assess the effects of nanoparticles on the vasculature, the potential of nanoparticles to induce proinflammatory of prothrombotic effects in the microcirculation in vivo will be explored e.g. by using video microscope in vivo and utilizing fluorescence probes.

This research is a joint undertaking of Dutch, Finnish, German, Polish, and UK research groups to identify key issues related to NP toxicity and characteristics that determine the possible toxic effects of NP.

Acknowledgements
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Sensitive and predictive biological parameters in short-term inhalation test with nanoparticles

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Product safety of nanoparticles
Nanotechnology offers great opportunities in developing innovative solutions by selective modifications of material properties. However, new material properties may also alter the effect of these materials on humans. Therefore, nanomaterials need a thorough risk assessment before marketing. BASF has defined a *Code of Conduct Nanotechnology*[1] encompassing objectives for product safety. As a part of the risk assessment, specific toxicological testing of nanoparticles may be included, depending on exposure scenarios.
Among the possible effects on human health, inhalation of aerosols from nano-scale materials is of the highest concern. We modified short-term inhalation tests to provide fast and reliable data for a realistic assessment of possible health effects.

Aerosols of nanoparticles
An aerosol from nanoscale material is a complex system. Therefore, the first step in studying its health effects is the characterization of the aerosols. We examined aerosols generated from powders of different nanoscale materials (characterized for particle size, specific surface area, zeta potential and morphology) using a brush generator (dry dispersion) and a nebulizer (wet dispersion of suspensions of the powders). Dust concentrations were measured by gravimetry; particle size distributions were determined by an optical particle counter, a scanning mobility particle sizer and a cascade impactor. The examined materials consisted of particles with primary sizes between 10 – 30 nm. In the test atmospheres, however, only small fractions of the materials were actual primary nanoparticles (< 100 nm) and most particles were of larger size (> 1 µm) indicating agglomeration; this was confirmed by electron microscopy.

Table 1: Characterization of atmospheres generated from nanoscale material

Test substance	Total mass concentration *(mg/m³ by gravimetry)*	Number concentration of nanoparticles *(count/cm³)*	Mass fraction of nanoparticles *(%)*
TiO_2	15.2	6420	0.10
Carbon black	8.1	28700	0.48
Amorphous silicate 1	12.1	63420	0.74
Amorphous silicate 2	13.1	12705	0.14
Al_2O_3	15.7	31350	0.42
CuO	35.9	147000	1.53
ZrO_2	16.6	46400	1.02
Amorphous silicate 3	18.4	21600	0.13

Inhalation studies with nanoparticles
Inhalation exposure is the route of most concern for nanoparticles. Various testing methods are currently used to investigate possible effects in the lung, i.e. inhalation, intratracheal instillation, aspiration and various cell and tissue culture systems. Compared to inhalation studies, the other methods are simple models yet the exposure does not reflect the actual situation, considering the complex processes involved in nanoparticle aerosol formation and inhalation. Thus, these test methods will need validation by inhalation studies. Therefore, we performed short-term inhalation studies in rats with exposure to various concentrations of nanoparticles for six hours per day on five consecutive days in comparison with the similar pigment

(micrometer-scaled, non-nano) material. Animals were examined directly at the end of the exposure, and two and fourteen days thereafter.

Deposition of inhaled nanoparticles

Rats were exposed to aerosols generated from nano-scale TiO_2 as well as the pigment (non-nano) material by inhalation; the organ burdens were analyzed in seven tissues and electron microscopy was used to characterize the particles deposited in the tissues.

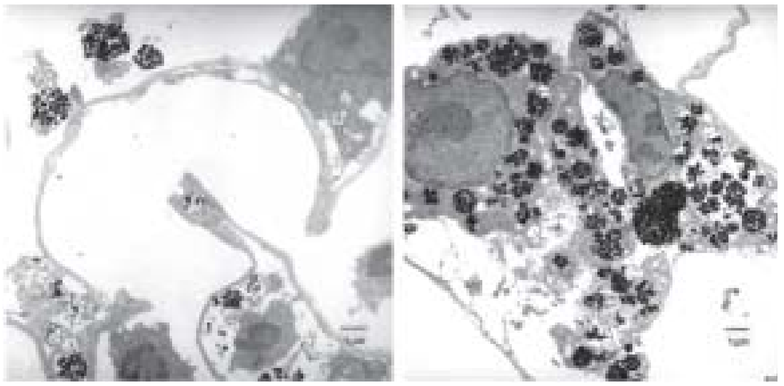


Fig. 1:
Rats exposed to aerosol from nano-scale TiO_2, TEM
left: agglomerates located free in the alveolar space
right: alveolar macrophages with agglomerates in the cytoplasm

The particles from both, the pigment and the nano-scale material were located extracellularly in the lumen of the alveoli and bronchi. Moreover, particles were detected in the cytoplasm of alveolar macrophages. The particles from nano-scale material found in the lung, were agglomerates of about the same size as found in atmosphere; there were no signs of desagglomeration of the inhaled agglomerates.

Table 2: TiO_2 organ distribution after 5-day exposure [in µg TiO_2 per organ by ICP-AES]

	Nano TiO_2 88 mg/m^3		Pigment TiO_2 274 mg/m^3	
	Study day 5	Study day 19	Study day 5	Study day 19
Liver, kidney, spleen, basal brain with olfactory bulb	‹ 0.5*	‹ 0.5*	‹ 0.5*	‹ 0.5*
Lung	2025	1547	9182	7257
Mediastinal lymph nodes	2.2	8.5	8.2	108

* 0.5 µg was the detection limit of the ICP-AES method

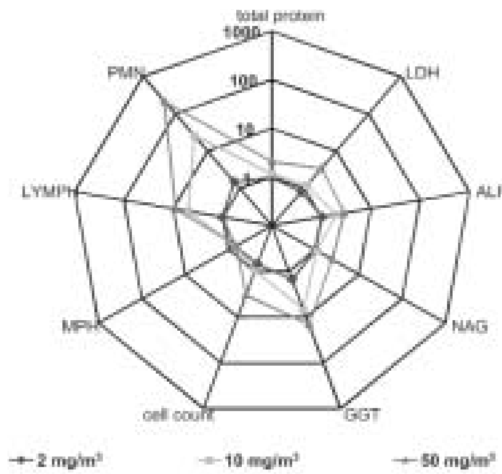
Pigment and nano TiO_2 were deposited nearly exclusively in the lungs, with a similar deposition pattern. A small TiO_2 fraction was detected in the mediastinal lymph nodes. Translocation from the lungs to internal organs was not detected up to two weeks after inhalation exposure.

Biological Effects of Inhaled Nanoparticels

Rats were examined directly and two and fourteen days after the exposure to aerosols of pigment and nano-scale TiO_2 histopathologically. Additionally, a set of over seventy parameters was analyzed in broncho alveolar lavage fluid (BAL) and in serum.

Histopathology	**Cytokines et al.**		
	1. Apolipoprotein A1	24. IL-1á	47. MDC
Proliferation and Apoptosis	2. ß-2 Microglobulin	25. IL-1ß	48. MIP-1á
	3. Calbindin	26. IL-2	49. MIP-1ß
	4. CD40	27. IL-3	50. MIP-1á
Clinical chemistry	5. CD40L	28. IL-4	51. MIP-2
Protein	6. Clusterin	29. IL-5	52. MIP-3ß
lactate dehydrogenase (LDH)	7. C-Reactive Protein	30. IL-6	53. MMP-9
Alkaline phosphatase (ALP)	8. Cystatin	31. IL-7	54. Myoglobulin
γ-Glutamyltransferase (GGT)	9. EGF	32. IL-10	55. OSM
N-acetyl-β-Glucosaminidase (NAG)	10. Emdothelin-1	33. IL-11	56. Osteopontin
total cell count	11. Eotaxin	34. IL-12p70	57. RANTES
cell differential analysis	12. Factor VII	35. IL-17	58. SCF
-macrophage (MPH)	13. FGF-basic	36. Insulin	59. Serum Amyloid P
-polymorph nuclear granulocytes (PMN)	14. FGF-9	37. IP-10	60. SGOT
-lymphocyte (LYMPH)	15. Fibrinogen	38. KC/GROá	61. TIMP-1
	16. GCP-2	39. Leptin	62. Tissue Factor
	17. GM-CSF	40. LIF	63. TNF-á
	18. Growth Hormone	41. Lipocalin-2	64. TPO
Parameters of oxidative stress	19. GST-á	42. MCP-1	65. VCAM-1
Carboxymethyllysin (CML)	20. GST-1 Yb	43. MCP-2	66. VEGF
Malondialdehyd (MDA)	21. Haptoglobin	44. MCP-3	67. von Willebrand Factor
8-OHdG	22. IFN-á	45. MCP-5	
	23. IgA	46. M-CSF	

Table 3:
Parameters examined in lung tissue and/or in broncho alveolar lavage fluid (BAL) and in serum



In this short term study with nano and pigment TiO_2, the overall findings indicated a particle induced local inflammation process in the lung with diffuse alveolar histiocytosis including particle loaded macrophages, and hyperplasia and epithelialization in the region of the terminal bronchioli. The NOAEC of nano TiO_2 was 2 mg/m^3 and the LOAEC was 10 mg/m^3. Based on mass concentration the effects were more pronounced with nano TiO_2 compared to pigment TiO_2, even though the agglomerates of nano TiO_2 and the solid particles of pigment TiO_2 had about the same size. The results of the short-term study were predictive for the long-term effect observed in subchronic and chronic inhalation studies[2,3].

The most sensitive and predictive parameter for long-term effects was the PMN count in BAL two days after the end of the exposure. This work is part of the *NanoSafe2* and the *NanoCare* project, which aims to develop generally accepted test methods to analyze the effects of nanomaterials on human health. NanoCare uses *in vitro* and *in vivo* methods to systematically investigate the effects of nanoparticles and the dependency on their physical and chemical characteristics. The presented data will be crucial to evaluate the data from *in vitro* experiments acquired in the various labs of the project partners. Moreover, the presented inhalation short-term studies - recognizing early markers of inhalation toxicity - may be an appropriate methods in risk assessments for long-term inhalation exposure to aerosols from nanoscale materials.

Acknowledgements

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2 *Heinrich et al. (1995) Inhalation Toxicology, 7: 533-556.*
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Uptake of 1.4 nm versus 18 nm gold nanoparticles in secondary target organs is size dependent in control and pregnant rats after intratracheal or intravenous application

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Introduction

With the advent of nanotechnology the interaction of nanoparticles (NP) and nanostructured surfaces with biological systems including living cells has become one of the most intriguing areas of basic and applied research at the interface to biology. As NP are of the same size scale as typical cellular components and proteins, such particles are suspected to evade the natural defences of the human organism and may lead to permanent cell damages[1]. This includes NP transfer across biological membranes, NP interactions with proteins and cellular constituents as well as NP impact on important biological functions. For a reasonable effect assessment potential target organs and cells need to be known[2]. Target organs may not be restricted to the organ of intake but may include secondary target organs and their cellular constituents depending on the accessibility of NP to these sites. Since gold NP gain continuously increasing interest in nanobiotechnology we selected those for our biokinetic studies[3-5].

Methods

We attempt to investigate the effect of the size of monodisperse NP keeping the NP material and its ionic ligand coating constant. In order to challenge the effect of the size we compare 1.4 nm sized gold NP[6-8] with 18 nm gold NP[9] both stabilized by negatively charged ionic ligands in aqueous solution and radio-labelled with ^{198}Au. Healthy adult WKY rats received either intratracheally (IT) or intravenously (tail vein, IV) radio labeled gold in 50 µl of physiological saline. After NP administration images of the ^{198}Au-NP distribution were taken using a single photon emission computer tomograph gamma camera (SPECT, Prism 2000, Philips) equipped with a pinhole collimator. Rats were killed 24-hours after administration and all organs and tissue samples as well as the remaining carcass and excretion were analyzed quantitatively by gamma-spectrometry achieving a 100% balance. So biokinetics in rats were compared after NP administration to two important organs of intake: lungs and blood.

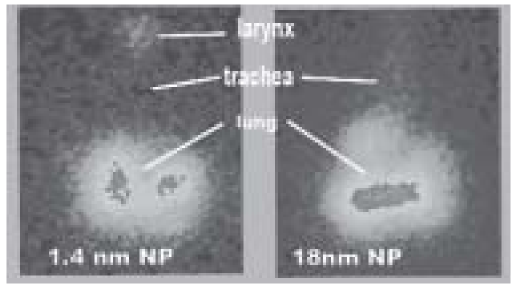

Figure 1: SPECT gamma camera (Prism 2000, Philips) image of ^{198}Au activity distribution in the lungs of animals 1 hour after intratracheal instillation of 1.4 nm (left) and 18 nm NP (right) applying a pinhole collimation geometry.

Results and Discussion

The biokinetics in in-vivo studies were conducted using healthy, adult female Wistar-Kyoto rats (~250g body weight) under German federal guidelines for the use and care of laboratory animals and were approved by the Regierung von Oberbayern (District of Upper Bavaria, Approval No. 211-2531-94/04) and by the GSF Institutional Animal Care and Use Committee.

Twenty-four hours after IT administration lung retention dominated for both NP sizes. After correcting the IT administered NP for fast clearance (part of NP which were deposited in the conducting airways and cleared

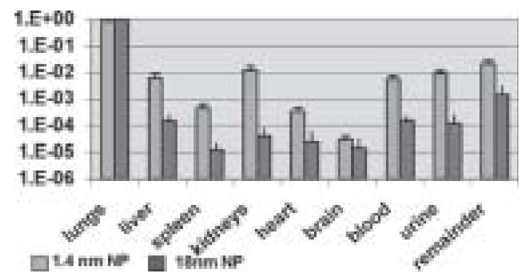

Figure 2: Translocated NP fractions into secondary target organs 24 h after NP instillation into the lungs (data are corrected for fast clearance).

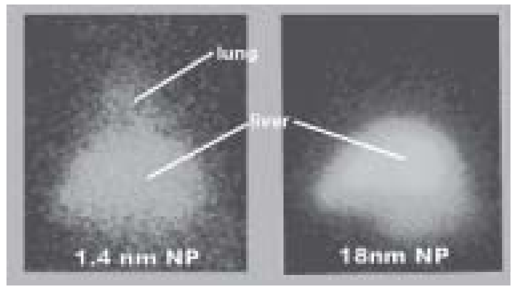

Figure 3: SPECT gamma camera (Prism 2000, Philips) image of ^{198}Au activity distribution 1 hour after intravenously injection of 1.4 nm (left) and 18 nm NP (right) applying a pinhole collimation geometry.

out of them via the mucociliary escalator within 24h) more than 0.9 of the administered particles were still in the lungs (see figure 1 and 2). We found a highly significant inverse size dependency with a more than 20-fold higher accumulation of 1.4 nm NP in secondary target organs versus 18 nm NP ($p<0.001$). The former fraction of the total deposit was 0.039 compared to the latter: 0.0018. After correction for fast clearance the translocated fraction was even higher: 0.07 of 1.4 nm NP translocated into circulation and secondary organs, 18 nm colloids translocated only a 25-fold less. Similarly the 0.006 fraction of 1.4 nm NP circulating in blood 24 hours after administration was 30-fold higher than the 0.0002 fraction of 18 nm NP. In almost all secondary target organs translocated fractions of 1.4 nm NP were up to two orders of magnitude larger than for 18 nm NP (see figure 2).

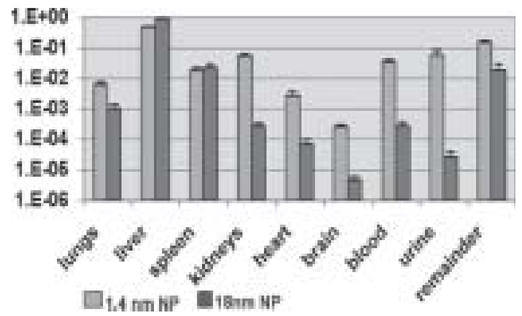

Figure 4: Translocated NP fractions into secondary target organs 24 h after intravenously injection of the NP into the tail vein.

Twenty four hours after intravenous injection the fraction of circulating 1.4 nm NP in blood (0.037) was 130-fold higher than that of 18 nm NP (0.00027). That means more than 0.96 and 0.99, respectively, had been taken up by secondary target organs. However, only 0.49 of the 1.4 nm NP was retained in the liver versus 0.94 of the 18 nm NP. Hence, a much larger fraction of the 1.4 nm NP was distributed and accumulated in the other organs and tissues compared to 18 nm NP (see figure 3 and 4).

In the remaining carcass including muscles and skeleton we found a fraction of 0.16 versus 0.020, respectively. In addition, a remarkable fraction (0.057) of the 1.4 nm NP was excreted into urine – 1000-fold higher than for the 18 nm NP – indicating a much more effective direct passage of 1.4 nm NP from kidneys into urine. Interestingly, a considerable fraction of both NP, 1.4 nm or 18 nm, were found in the gastro-intestinal (GI) tract and faeces 0.051 and 0.014, respectively; in this case the excreted NP fraction was predominantly coming from liver via the bile entering the small intestine; again this indicated a strong inverse size dependence of this clearance mechanism. In the secondary target organs kidneys, heart and brain we found about 100-fold more of the 1.4 nm NP compared to the fractions of the 18 nm NP (see figure 4).

Twenty-four hours after IV-injection of either gold NP we found a rather strong and inversely size-dependent NP uptake in the placenta of pregnant rats in their third trimester (about 0.03 of 1.4 nm NP and about 0.0002 of 18 nm NP) and also in the foetus (0.0006 and 0.00005, respectively).

Conclusion

Featuring the same NP matrix, the size of these gold NP clearly affects translocation kinetics across the alveolar air-blood barrier or vascular endothelium leading to more prolonged circulation and higher accumulation in secondary target organs of the 1.4 nm NP when compared to the 18 nm NP. Both NP accumulate in all organs to a varying but detectable extent; in particular these NP are able to cross all membranes studied: the air-blood-barrier in lungs, the gastro-intestinal-wall, the blood-brain-barrier as well as the placenta of pregnant rats reaching the foetus. Potential adverse health effects in secondary target organs need further investigations.

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Nanostructured materials and coatings through chemistry: from molecules to product applications

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Introduction
Chemical nanosciences enabling controllable manipulation of matter at molecular length scale have become fundamental generators for innovations in materials processing. The successful synthesis, modification and assembly of nanobuilding units such as nanocrystals, -wires and -tubes of different materials have demonstrated the importance of chemical influence in materials synthesis, and have generated great expectations for the future [1-4]. However, the industrial impact of chemical methods for the synthesis of nanomaterials is relatively less explored due to several factors such as, difficulties associated in scaling-up chemical procedures of materials syntheses, expensive nature of the starting materials, safety and health hazard issues related to handling of chemical source materials and the notion that return on investment in chemical nanotechnologies would be rather low, which is outweighed by a large number of spin-offs and start-ups around the globe, who have successfully cut a piece of the pie for themselves [5].

Inorganic nanostructures inherit promises for substantial improvements in materials engineering mainly due to improved physical and mechanical properties resulting from the reduction of microstructural features by two to three orders of magnitude, when compared to current engineering materials. For instance, reduced grain size and slip distance in metals and cermets (composites of ceramics and metals) can enhance the hardness and strength whereas higher hardness and toughness can be accomplished in ceramics through reduced defect size and higher grain boundary stress relaxation. Nanoparticles in powdered form have already found several applications as photocatalysts, conducting paste, drug vectors, bio-imaging and sintering aids. Further, new functionalities such as easy-to-clean coatings, hydrophilic or hydrophobic surfaces, biocompatible, gas sensing, anti-reflective films, can be obtained from nanomaterials-based coatings [6].

2. Synthesis of inorganic materials: traditional and chemical precursor routes
Advanced ceramic materials with nanosized grains have been synthesized using several techniques [1-4]. Conventional methods such as ball milling, severe plastic deformation, combustion and solid-state reactions have been employed successfully in some instances to prepare nanostructured ceramics, however a number of reports indicated limitations in terms of control achieved over stoichiometry and purity [7]. Also, synthesis of metastable compounds has found to be challenging. These intrinsic energy barriers are generally circumvented through thermodynamic forces, for instance, completion of a reaction through several intermittent grinding (mechanical) and heating (thermal) steps. Although successfully applied for bulk materials, the top-down methods have limited applications in the synthesis of nano-sized materials, which demand recipes to synthesize crystalline phases at lower temperatures. In this context, chemical approaches enabling controlled assembly of atoms, ions or molecules are promising alternatives to counterbalance thermodynamic impediments and enable purpose-built creation of nanomaterials [7-9].

We are using discrete chemical precursors as 'molecular seeds' in chemical vapour deposition (CVD), sol-gel and hydrothermal techniques to grow nanomaterials by inducing positional control on phase-building elements [10-13]. The success of chemical routes to nanomaterials is attributed to molecular precursors, which transform into solid phases at much lower temperatures than those required for conventional procedures. Since the elements are chemically linked, diffusion is either not necessary or the distances are too short, which augment the advantages of chemical processing. For instance, perovskite $BaZrO_3$ could be prepared in nanocrystalline and monophasic form at 600°C using $[BaZr(OH)(OPr^i)_5(Pr^iOH)_3]_2$ as the precursor (Fig. 1), whereas higher temperature (1000°C) was required to process the solidsolution of Ba and Zr salts, and final product contained undesired phases (BaO, ZrO_2 and Ba_2ZrO_4) due to different reactivity patterns of the individual precursors [13].

3. Synthesis of nanopowders

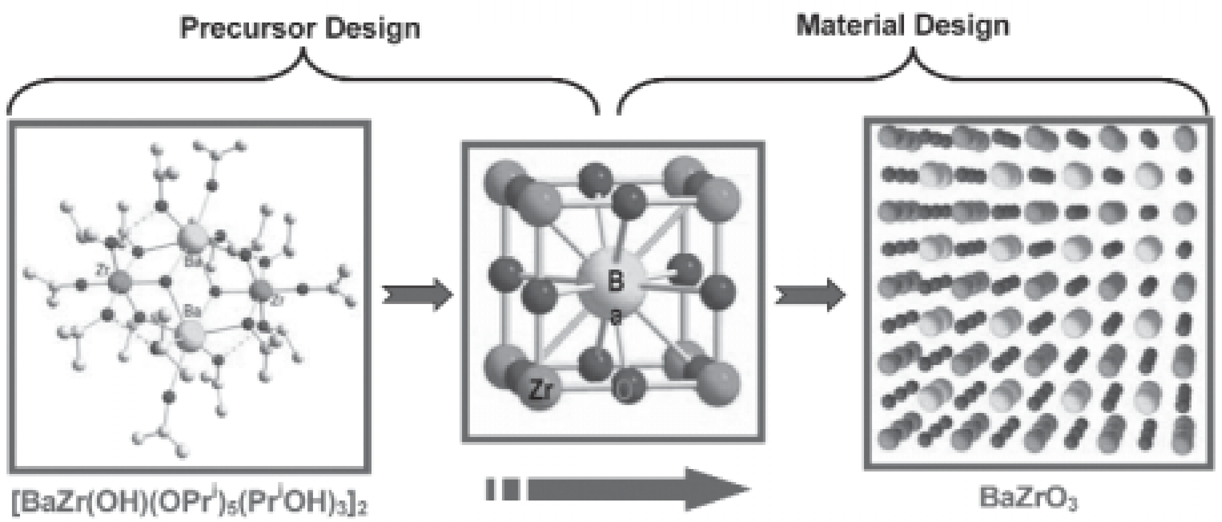

Figure 1. Schematic representation of molecule-derived materials concept

The use of metal-organic compounds as starting materials simplifies the precursor delivery and allows controlling the reaction kinetics, which can be used to influence the particle size and size-dispersion in the final material, for instance, ultra-fine particles can be obtained by encouraging particle nucleation over particle growth. Further, the nucleation process can be regulated by varying the amounts or ratios of the reactants or reaction time, for example by massively exceeding the supersaturation ratio in precipitation reactions or by increasing the amount of water added in an alkoxide-based sol-gel process to drive hydrolysis at the expense of condensation reactions. Further, the reaction kinetics can also be influenced by adjusting the thermal energy input or thermal energy distribution in the reaction vessel. Finally, direct formation of crystalline materials allows in situ passivation and functionalization of their surface (Fig. 2).

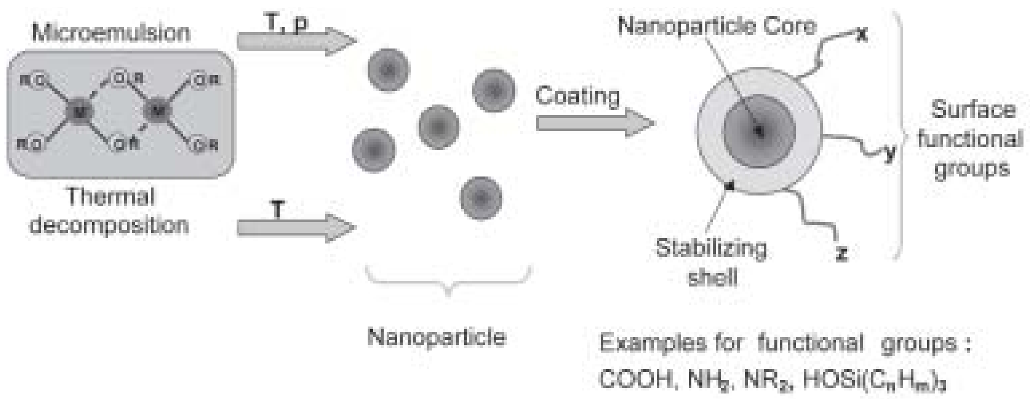

Figure 2. Representation of molecule-based synthesis of nanopowders and dispersions

Hematite nanoparticles, for example, were produced by controlled hydrolysis of the alkoxide precursor $[Fe(OBu^t)_3]_2$, containing pre-formed Fe–O bonds. The xerogel obtained was calcined at 300°C (1 h) to remove the organic residues and further heat-treated (1 h) at 400°C to obtain pure hematite (Fig. 3).

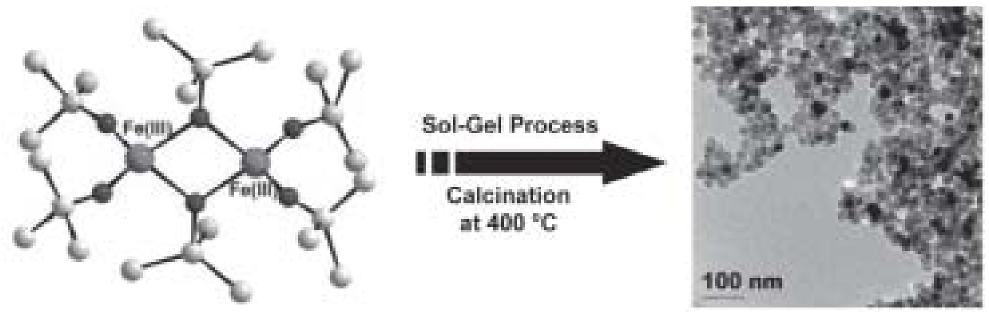

Figure 3. Hydrolytic transformation of $[Fe(OBu^t)_3]2$ into crystalline hematite (Fe_2O_3).

Similarly, size-selective synthesis of zinc aluminate nanoparticles was achieved by the controlled hydrolysis of a single molecular source $[ZnAl_2(OBu^t)_8]$ containing Zn:Al ratio required for the formation of the spinel phase (Fig. 4). Given the intrinsic chemical control on the phase composition and nucleation kinetics, $ZnAl_2O_4$ nanoparticles were synthesized in the range 15- 260 nm and their optical properties were investigated, which confirmed the confinement effects (band gap variation) expected upon size reduction in the samples [14].

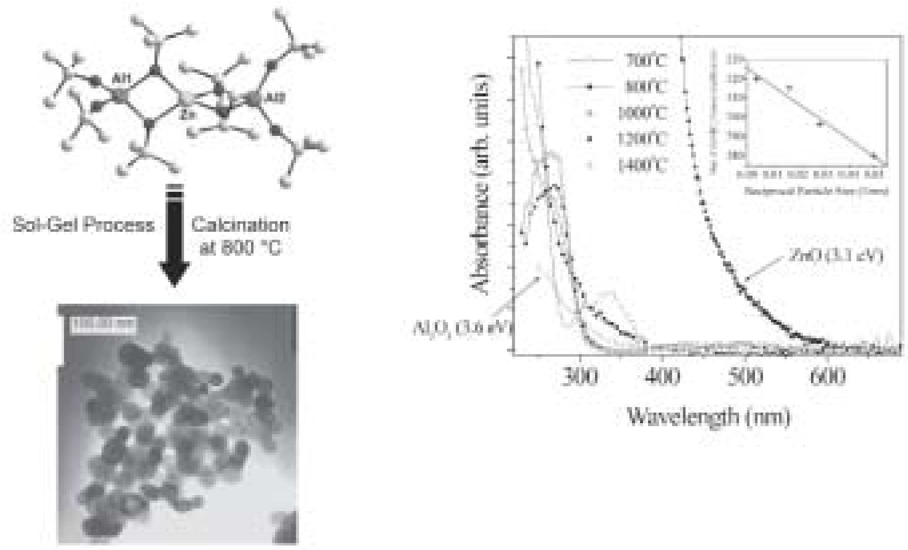

Figure 4. Size-selective synthesis of $ZnAl_2O_4$ nanocrystals and corresponding absorption spectra together with those of ZnO and Al_2O_3.

One of the major challenges of precursor-based synthesis is to demonstrate the phase-selective synthesis of compositions that are thermodynamically less favoured (metastable). For example, the perovskites $YAlO_3$ and $YFeO_3$ are difficult to obtain as monophasic materials mainly due to their labile nature and facile phase-transformation into thermodynamically favored garnet compositions ($Y_3Al_5O_{12}$ and $Y_3Fe_5O_{12}$). We have used a novel class of heterobimetallic precursors $[YM(OPr^i)_6(Pr^iOH)]_2$ (M = Al, Fe), which include all necessary elements for nanomaterial in a single molecule [15]. The superior potential of molecular precursor concept has also been demonstrated for doped-systems such as Ln:YAG, where the photoluminescence efficiency of Nd:YAG nanocrystals could be enhanced manifold due to better distribution of optically active Ln^{3+} centers in the host yttrium aluminium garnet (YAG) matrix [16].

4. Synthesis of nanostructured coatings

We are combining the precursor advantage with the application of cold plasmas in plasmaassisted chemical vapour deposition process (PE-CVD) that allows depositing nanostructured coatings at room temperature [17]. Inert and/or reactive gas plasmas efficiently excite and break up molecular species by collisions with electrons, ions and neutral possessing high kinetic energy without excessively altering the original chemical configuration of the precursor molecules. A complete or partial removal of the organic periphery produces unsaturated fragments, which are prone to condensation and coalescence reactions thereby facilitating the growth of solid films under 'cold' conditions. This enables deposition of functional coatings even on temperature-sensitive substrate like polymers, aluminium and alloys. Other features of molecule-based PECVD approach are: (i) excellent film uniformity, (ii) high deposition rates, (iii) control over material composition and phase, (iv) conformal coverage on complex geometries, and (v) good adhesion [18] (Fig. 5).

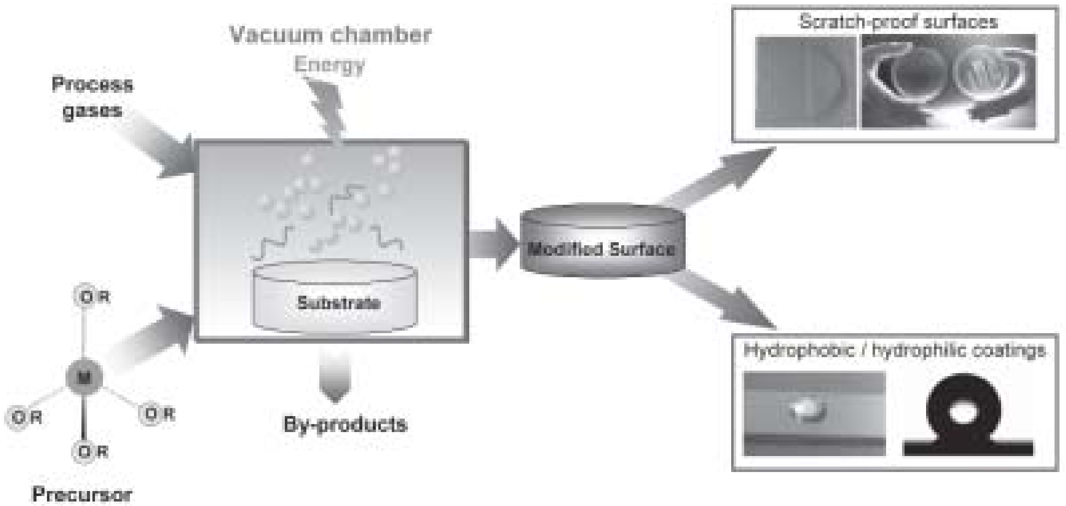

Figure 5. Schematic representation of processes active in PE-CVD

Tin oxide nanostructures with plate-like morphology and tetragonal rutile structure were obtained by chemical vapour deposition of molecular precursor, $Sn(O^tBu)_4$ [19]. Post-deposition modification of tin oxide nanostructures in r.f. plasma (25-125 W) containing oxygen and argon as reactive and carrier gases, respectively resulted in formation and incipient crystallisation of tin sub-oxides (Sn_2O_3, Sn_3O_4, SnO) [19]. Plasma treatment for more than 5 mins. led to formation of elemental tin due to progressive reduction of tin oxide. The preferential etching of oxygen from the tin oxide lattice was evident in the increased surface wetting properties of plasma-treated surfaces, which was also associated with significant enhancement in the ethanol sensing properties of tin oxide films (Fig 6).

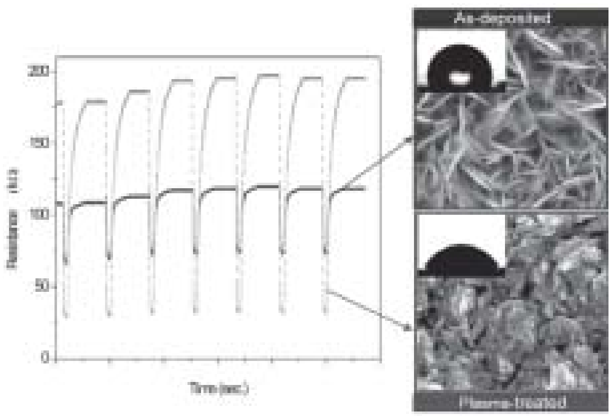

Figure 6.
SEM micrographs and ethanol sensing properties of CVD-deposited SnO_2 nanoplates and plasma treated samples

5. Conclusions

The synthesis of inorganic materials has been revolutionized by the impact of (soft) chemical approaches, which now allow synthesizing phases and materials previously inaccessible in the thermodynamic space. Chemical methods have not only contributed to the development of new materials but have also provided insight in the reaction mechanisms involved in the formation of solid phases from chemically-defined modular units. Our strategic concept 'molecules to materials' allows to design and produce (in large quantities) molecular precursors in which, we can a priori tune the compositional features of the desired material at the molecular scale.

Acknowledgement

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Water and organic soluble gold nanoparticles via placeexchange reactions

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Metal nanoparticles capped with organic ligands generate considerable interest due to their broad spectrum of applications. The unique size-related properties in conjunction with the chemical features controlled by the capping agent make them valuable materials for nanotechnology. From bio-labeling and drug carriers to catalysis and polymer composites, gold nanoparticles are finding the way into industrial use. Several synthetic procedures have been developed over the past decade. However, functionalized gold nanoparticles are still a synthetic challenge due mainly to limitations in controlling their size and monodispersity, key factors for practical applications. A synthetic procedure has been developed based on a place-exchange approach using stable, easily available DMAP-Au nanoparticles as a starting material. The procedure is simple, convenient, and easy to perform. Under mild reaction conditions, the initial DMAP is displaced by a large variety of thiols. An important advantage is the only very small excess of incoming ligand required for completely removal of the initial DMAP from the protective layer. The procedure offers full control over the protective layer composition leading to single component monolayers. The monodispersity of the initial DMAP-Au nanoparticles is preserved upon the place-exchange reactions with different thiol-functionalized molecules. This approach is particularly attractive for capping ligands that are incompatible with the conditions required by sodium borohydride or Superhydride reduction. Polymer-protected gold nanoparticles with a remarkably high grafting density were easily and efficiently prepared by using this procedure.

Nanoparticulate protective coatings for magnesium alloys

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Abstract

Magnesium is the lightest construction metal. Its alloys offer facile workability and excellent mechanical properties. This makes magnesium an attractive material especially for transport and electronic industries. However, this highly reactive metal demands outstanding corrosion protection. Because most established coatings are based on organic or organic/inorganic hybrid materials, they lack thermal and mechanical stability. Environmentally compatible and at the same time purely inorganic coatings can not be applied on the thermally precarious magnesium alloys by conventional techniques.

Due to their large surface area and short diffusion paths, compacts made of nanoparticles densify at temperatures far below their melting point [1]. Thus originating from SiO_2 nanoparticles dense, crack-free protective coatings with a thickness of up to several microns could be applied onto the wrought alloy AZ31 and the cast alloy AZ91 under mild conditions via dip coating, brushing or electrophoretic deposition techniques. Texture and composition of these coatings are studied e.g. by IR, AFM, REM. Their corrosion protection properties and resistance are investigated using standard tests as well as electrochemical methods.

Commercial aqueous dispersions

One strategy is based on commercial aqueous, base stabilised SiO_2 dispersions [2]. Additives can be added as salts, e.g. $Al(OH)_3$ or $Na_2B_4O_7$, and react readily with the particles (figure 1) to form larger aggregates and finally a gel. Depending on the composition the aggregation can be controlled. Dried gel bodies consisting of 20 nm SiO_2 particles already sinter at temperatures as low as 1100°C, which is far below the melting point of quartz (1713°C). Appropriate additives (e.g. B_2O_3, Al_2O_3) decreased the sintering temperature even further (figure 2).

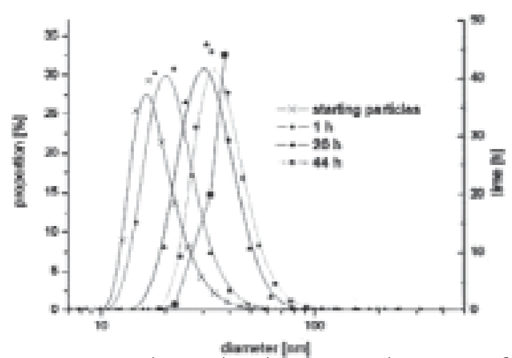

Figure 1. Particle size distribution in a dispersion of 20 nm SiO2 particles, $Na_2B_4O_7$ and Na_2HPO_4 in H_2O as a function of time; composition: 9.6 % SiO_2, 0.8% B_2O_3, 0.2% P_2O_5, 0.6% Na_2O (dynamic light scattering in highly diluted dispersions).

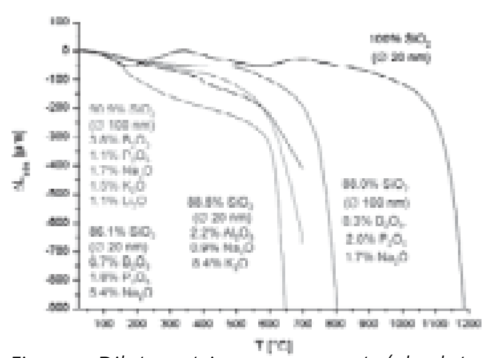

Figure 2. Dilatometric measurements (absolute shrinkage vs. temperature) of gel bodies consisting of 20 nm or 100 nm SiO_2 particles with different sintering additives.

Before gelation these dispersions can be applied onto magnesium by dip or brush coating prior to drying and thermal densification. Both methods enable to obtain thin, crack-free layers with a thickness below 1 µm (figure 3a). Multiple applications of the dispersion with alternate sintering help to increase the over-all coating thickness. So far up to 5 layers could be applied onto AZ91 by dip coating without the formation of cracks. Investigations by electron microscopy do not show any interfaces or gaps between the layers (figure 3b). While a single layer only shows a slight improvement of the corrosion resistance compared to uncoated substrates by electrochemical impedance spectroscopy (EIS), the protective properties improve with the number of applied layers (figure 4).

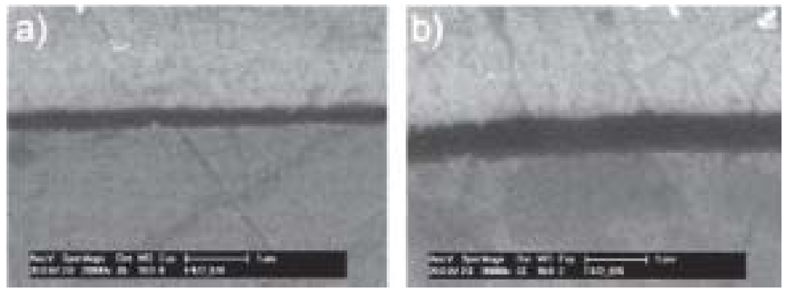

Figure 3. SEM pictures of cross sections of dip coated layers on AZ91: a) ca. 300 nm thick single layer b) ca. 700 nm thick double layer of 20 nm SiO_2 particles with sintering aids H_3BO_3, LiOH, KOH and NaH_2PO_4 (80.0% SiO_2, 11.7% B_2O_3, 2.1% P_2O_5, 2.7% Na_2O, 1.7% Li_2O, 1.8% K_2O); sintered at 400 °C / 2h.

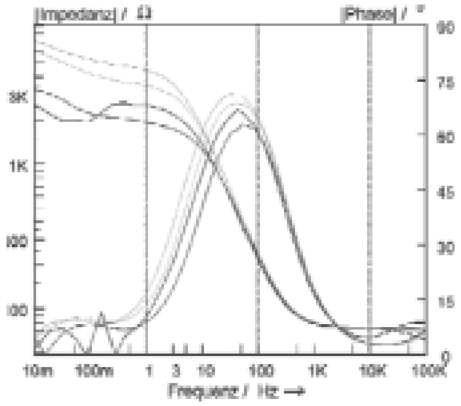

Figure 4. EIS spectra in 0.1 M Na_2SO_4 after 30 min immersion, 10^5-10^{-2} Hz, amplitude 10 mV: uncoated (blue) and dip coated AZ91: 1 layer (pink), 3 layers (green) and 5 layers (yellow); composition see figure 3.

Electrophoretic deposition

Another strategy to coat magnesium is the electrophoretic deposition [4,5]. Because only solid compounds can be deposited by this method, all sintering additives have to be contained in the particles. Non-aggregated mixed oxide particles with a diameter between 10 and 500 nm and low polydispersity can easily be obtained by a basic sol gel process [2,3]. These particulate sols were either directly used or isolated mixed oxide particles were redispersed. At a solid content of 2% or less and a constant voltage of 5V coating deposition was performed in ethanol up to 30 minutes. Up to 10% water content could be tolerated to increase dispersion stability and conductivity without appreciable water hydrolysis. Ammonia was used as electrolyte and stabiliser. At pH 9-10 SiO_2 particles are negatively charged. The magnesium sample to be coated was therefore switched as the anode with a platinum net as cathode.

Especially at the beginning of the deposition process a strong decrease of the current can be observed. This shows that the anode surface is covered by isolating nanoparticles. The amount of particles deposited per time decreases with the current flowing and longer deposition times do not lead to a significantly higher coating thickness.

The particle size is very decisive for the maximum coating thickness reached by EPD. Small particles (<20 nm) will completely cover the surface much faster so that at very low thicknesses (<100 nm) the current strongly decreases and no further deposition takes place. Larger particles (>200 nm) will lead to thicker coatings of up to 6 µm. However, despite the high green density obtained with this method, thicker coatings also tend to form cracks.

Polydiethoxysiloxane (PDES) can act as adhesion promoter and help to reduce the tendency to form cracks [2]. EPD coatings only consisting of 35 nm particles show some micro-cracks and an average roughness off 15.5 nm after sintering (figure 5a, roughness is determined by AFM). The addition of 1 Wt.% PDES to the same particles results in less cracked

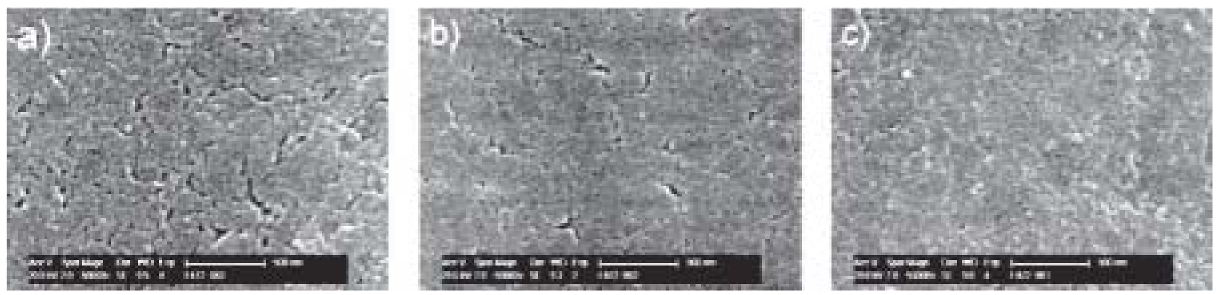

Figure 5. SEM pictures of EPD layers on AZ31 with: a) 35 nm particles (80.1% SiO_2, 13.8% B_2O_3, 6.1% P_2O_5; 2% in EtOH; 10V/30 min) b) same particles and 1.0 Wt.% PDES (10V/30 min); c) 40 nm particles with boronrich surface and 0.5 Wt.% PDES of same overall composition (10V/30 min); all sintered at 400°C / 2h.

layers with an average roughness off 12.7 nm (figure 5b). Higher concentrations of PDES inhibit particle deposition. Because mainly the particle surface is responsible for their behaviour, particles with boron rich surface but same over-all composition show a higher sintering activity. Such particles can be synthesised by a modified base catalysed sol gel process, where the addition of the boron source is temporarily delayed to the other reagents. With the addition of 0.5 Wt.% PDES the deposition of these particles results in crack-free coatings with an average roughness off 5.6 nm (figure 5c).

Thick layers can be obtained by the use of large particles (here with a diameter of 400 nm). But sphere packing of larger particles results in lower density than of smaller particles. High shrinkage during sintering leads to the formation of cracks and partly delamination (figure 6a). If a second deposition of smaller particles (here 10 nm) is conducted immediately after the first deposition, up to 6 µm thick, crack-free coatings can be obtained on AZ31 (figure 6b). Figure 6c shows an area of a cross-section of this layer where a large particle has been ripped off during metallographic preparation. Apparently this particle was embedded in some kind of matrix probably consisting of the second, smaller particles. So it is evident that the gaps between the larger particles can readily be filled by the smaller ones. Thus thick, dense layers with small shrinkage and therefore no crack formation during sintering can be obtained.

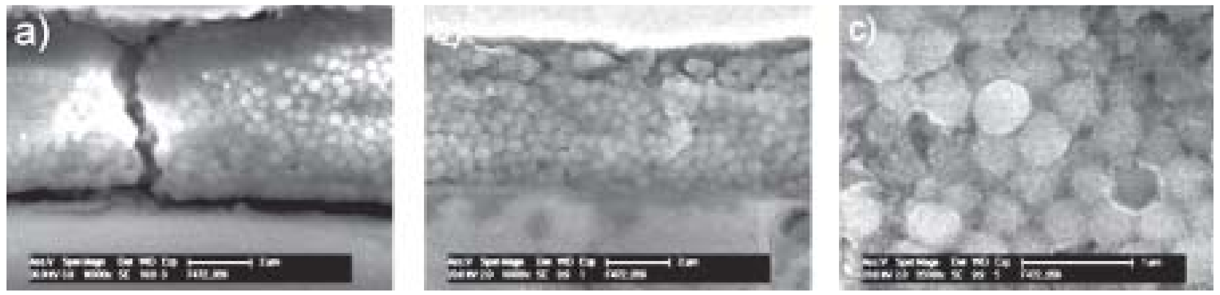

Figure 6. SEM pictures of cross-sections on EPD layers on AZ31: a) EPD with 400 nm particles (88.2% SiO_2 6.0% B_2O_3, 5.8% P_2O_5; 2% in EtOH, 3V/5 min); b), c) first EPD with 400 nm particles followed by second EPD with 10 nm particles (82.6% SiO_2, 11.4% B_2O_3, 6.0% P_2O_5 2% in EtOH; 6V/30 min); all sintered at 400 °C / 2h.

Conclusion

Crack-free coatings based on nanoparticles could be applied to the magnesium alloys AZ31 and AZ91 with these different techniques. Sufficient densification of the coatings was already possible at 400°C, but should be further decreased to eliminate any damaging of the magnesium substrate by the heat treatment. However, the coating thickness is still quite low and should be increased to guarantee a good corrosion performance. Coating properties (mechanical stability, corrosion protection) are still under research.

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Nanostructured solid-state gas sensors with superior performance (NANOS4 NMP 1528)

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Abstract
NANOS4 (NMP 1528) represents a breakthrough in advanced micro- and nanotechnologies for developing innovative metal-oxide gas sensing systems based on mesoscopic sensors. The sensors have been fabricated by nanoengineering techniques like vapour phase transport process crystal growth and other advanced techniques of preparation. Optical, ion and electron beam nanolithography were employed as a tool for selective removal of materials. The materials have been deposited as sensor arrays over micromachined semiconductor substrates with surfaces suitable for high-temperature growth of metal oxides and incorporated into miniaturised low-power-consumption gas sensing systems equipped with tiny micro-chambers operated in an active sampling mode as micro-reactors.
NANOS4 devices have been successfully field tested as innovative sub-system technology for increasing safety, comfort and economy of flying in large passenger aircrafts and in vehicles, early detection of smouldering fires, reliable and cost effective monitoring of environmental odour nuisances and workplace safety.

Introduction
Research on low cost and reduced size solid-state devices for gas monitoring has increased considerably during the past few years. It aims at real time low cost detection of gas species, an invaluable instrument for information processing in IST. Conductometric gas sensors are therefore most promising for developing low cost and highly reliable sensors for reasons of simplicity of the transduced physical quantity and the possibility of integration into Si technology. A lot of materials have been employed and investigated, each one prepared with various techniques and methods. The most relevant aspect in the preparation of these devices is related to the development of materials with high sensitivity, selectivity and long term stability – the so called three 'S' of gas sensing.
Nanoscale science and technology are experiencing a rapid development and they are likely to have a profound impact on every field of research in the first decades of the 21st century. Due to their peculiar characteristics and size effects, these materials often exhibit novel physical properties that are different from those of the bulk, and are of great interest both for fundamental study and for potential nanodevice applications. The hugely enhanced surface/volume ratio augments the role of surface states in the sensor response. Sensing mechanisms controlled at the nano scale level will therefore bring many benefits to the three 'S' of sensor technology.

NANOS4 outcomes
In this framework, the NANOS4 project sets out to extend this knowledge and to produce long-term innovation by considering top-down and self-assembled bottom-up approaches to develop mesoscopic gas sensors:

1. Single crystal and stable nanobelts of MOX deposited by Vapor Phase Process via catalyzed epitaxial crystal growth over pre-seeded substrates (self-assembled bottom-up figure 1). The deposition techniques are very simple and cheap. The surface to volume ratio is very high, the wire is single crystal and basically stable, the faces exposed to the gaseous environment are always the same and the size is likely to produce a complete depletion of carriers inside the belt.
2. MOX thin films prepared by sputtering and sol-gel and patterned by optical and ion beam –FIB- nanolithography to produce devices as nanowires and nanodots capable of providing high sensitivity, structural stability and low sensor drift (top-down).

Fig. 1 SEM image of a nanowire-based FET over a micromachined substrate

Fig. 2 Multipurpose Sensor System for in field characterisation

The devices, mechanically and environmentally stable, were introduced in a multipurpose sensor system and in a multi criteria fire detector made by a completely autonomous instrument equipped with a measurement chamber (sensor chamber), an electronic board, a pneumatic circuit (valves, pump, flowmeter) and a bundled software (see figure 2).
The sensor system was validated by field-tests in the following applications: fire detection in mobile applications (EADS-D), aircraft fire/smoke detection (EADS-D and AOA-D), combustion process control (FAE- ES) , upper air soundings (VAISALA-FI), industrial safety (VAISALA-FI) and odour nuisances monitoring (SACMI-I).
As spin off of NANOS4 a few projects will be submitted on FP7 in the field of nanotechnology-based portable sensing devices for security.

Overview about industrial applications of nanotechnology

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Nanotechnology has received vast quantities of funding in the last 7 years, and during that time there is no doubt that its presence is being felt. Analysis of conferences in terms of attendance and papers show a massive level of government funding, with nano centres being set up across the globe, and billions ofdollars being invested. The private sector is no less bullish about the technology, with significant activity across a broad range ofapplication areas.

However it is also true that as this money is and continues to be invested the actual number of new nanotech products entering the market appears very low in comparison.

Thls paper will review the issues that the nano industry must face is order to get its products into new markets, and attempt to highlight the issues facing new companies, both nano centric, and nano enabled conventional industry.
It will highlight some examples of early stage innovative nanotechnology, with reference to the approach that has to be taken to prepare it for market, and focus on the need for a multidisciplinary approach.

Reducing environmental load by nanotechnological proccesses and products – potentials and prospects

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As an enabling technology and basic innovation nanotechnology is expected to have a high impact on our current modes of production and consumption. Regarding the environment there are reasonable expectations that a technology enabling the design of materials, structures and devices on the atomic or molecular level will considerably increase resource efficiency. There is also reasonable concern about new environmental loads and unintended effects e. g. by nanoparticles and nanostructured materials.
Any assessment of opportunities as well as risks caused by nanotechnologies faces the fundamental problem that predictions struggle with an immense lack of knowledge. But a debate at such an early stage also opens up opportunities to influence technology development towards intended directions. The effects of nanotechnologies on the environment are not yet clear and can still be influenced. Thus analysis and (if possible) quantification of expectable effects induced by selected nanotechnology applications in different fields are of great importance. The focus should not only be on environmental engineering and technologies but also on products and processes, in which nanotechnologies have the potential to increase eco-efficiency considerably (product and production-integrated environmental protection). Striving to meet these challenges, we developed a three-tiered approach.

1. Technology characterization,
2. Ecoprofiles,
3. Explication of Leitbilder and visions.

1. Technology characterization.
Without having enough knowledge to fully apply established methods of assessment like cost-benefit-analysis, life cycle assessment, (eco)toxicological and risk assessment it is worthwhile to concentrate on those realities we are already able to study on. They regard the technology itself. To take nanoparticles as an example: In most cases the same new nanospecific functionalities are responsible for new opportunities as well as risks (e.g. biological and chemical activity, catalysis, solubility, mobility etcetera). In toxicological assessment of, e.g., new chemicals, this is done by shifting from risk assessment to hazard assessment, thus gathering information about the agent (the noxa). We first try to characterize the substance to gain some preliminary knowledge about possible hazards and exposure levels that are to be expected (e. g. the fate of the substance in the body or in the environment after being released). Important for this purpose are, amongst others, the physico-chemical properties of the substance, indicating the probability of human and environmental exposure (important aspects are, e.g., solubility in fat and water, mobility, boiling point, vapor pressure, persistence, tendency towards bioaccumulation, etc.). Thus by means of technology characterization information is gathered which might give first orientations for precautionary measures (see table 1 next page).

Table 1: Characterization of nanostructures regarding some anticipatable opportunities and hazards.

Nano-characteristic		+ Positive environmental impact and benefits / - Problems and hazards	Assessment approaches
Small particle size and particle mobility	+	Selective use for resource- and eco-efficient technology	Life cycle assessment (LCA), dispersal and exposure models, (eco-) toxicological testing, animal testing, epidemiology
	-	Intrusion into the lungs and alveoli Passes through cell membranes, e. g. via the olfactory nerve directly into the brain Mobility, persistence and solubility as indicators for bioaccumulation and environmental hazard?	
Precision, particle size / layer size, purity	+	Selective use for resource- and eco-efficient technology	LCA, entropy balance, question of "ecological amortization"
	-	Increased production costs, higher material and energy streams, increased use of resources	
Material characteristics	+	Possibilities to substitute hazardous substances	Toxicology, ecotoxicology, relationship between natural and anthropogenic material streams
	-	Health and environmental dangers due to hazardous (rare) elements or substance groups in environmentally open applications	
Adhesion, cohesion, agglomeration	+	Intrinsic safety due to adhesive, cohesive, and agglomerative tendencies of nanoparticles, thus loosing their nanocharacteristics	Dispersal and exposure models, (environmental) (eco-) toxicology testing, animal testing, epidemiology, atmospheric chemistry, risk analysis
	-	Behavior of nanoparticles or fibers set free in the environment. Mobilization and inclusion effects of nanoparticles on toxins and heavy metals (piggybacking)	
New chemical effects, modified behavior	+	Utilization of modified behavior for resource and environmentally efficient technology, e.g., use of catalytic effects for more efficient chemical processes or in the environment	LCA, dispersal and exposure models, (eco-) toxicology testing (e.g., allergy / sensitization testing), animal testing, epidemiology, atmospheric chemistry, risk analysis
	-	Changes in: solubility, reactivity, selectivity, catalytic and photo catalytic effects, and temperature dependence of phase transitions lead to increased expectability of surprising technological, chemical, toxicological, and environmentally toxic effects	
New physical effects, modified optical, electrical, magnetic behavior	+	Selective utilization of effects and modified properties for resource and environmentally efficient technology, e.g. GMR effect, Tyndall effect, quantum effects, tunnel effect	LCA, for technological systems: FMEA, fault-tree analysis
	-	New functions are generally dependent on purified, precisely regulated "technical environments"; in these environments (in the case of non-compliance) surprises can be expected (technical failure)	
Self-organization Self-replication	+	Selective use of biomimetic self-organization for resource / eco-efficient and consistent technology	Risk analysis, depth of intervention, LCA, environmental impact analysis, scenario techniques
	-	Danger of uncontrolled developments, self-reproducing nanobiostructures	

2. An ecoprofile

includes all life cycle stages from production to disposal, focusing on energy and material flows, and on emissions and recycling. Since the certified methodology is not applicable according to DIN ISO 14040 due to lack of data, estimation procedures are necessary. They are based on knowledge about scaling-up processes and technological learning curves (extrapolation) and on analogies with similar processes and products. Figure 1 shows the results of an ecoprofile comparing different coatings. The newly developed nanocoating from the firm Nano Tech Coatings (NTC) differs in many respects from conventional coatings. Like traditional liquid clear coats it consists of a binder, a liquid carrier, fillers, and additives. The binder, however, does not have the usual organic structure, but consists of a so-called inorganic-organic hybrid polymer instead. The investigation of combined energy and material streams over the entire life cycle was carried out by comparing them with other industrial coating systems, specifically waterborne, solventborne, and powder coatings, including their associated pre-treatments.

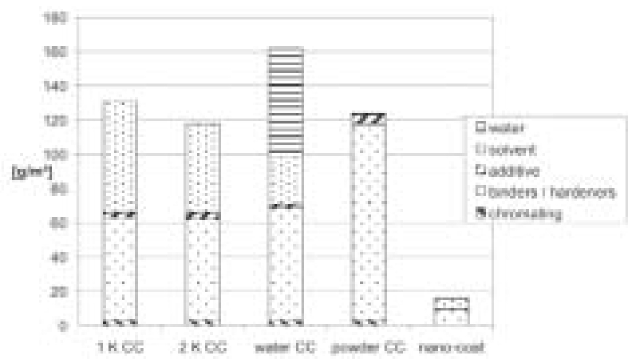

Fig. 1: Coating and chromating quantities (g/m² coated aluminum automobile surface area)

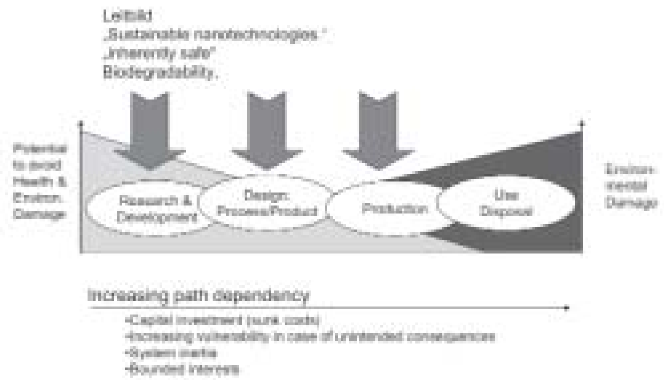

Fig. 2: Developmental time window in the life cycle

3. Explication of Leitbilder and visions

Technology development is often guided by expectations, *visions and Leitbilder* (guiding principles, models), nanotechnologies are no exception. If technology development is guided by *Leitbilder* like 'closed loop economy', 'green chemistry' or 'resource efficiency' from the very beginning, the probability to achieve these goals should be higher compared to the attempt of regulating already established technologies, products and processes. But of course, there is no guarantee for success, because Leitbilder are not to be mistaken for goals. They only give a rough orientation. In complex modern societies steering technological development by means of political intervention is either not possible at all or only to a very limited extent. However, the course of technological development is anything but chaotic. As a result of all interactions of the most varied agents a comparably stable course of development occurs, which can be formatively accompanied. The significance of independent paths of technological development (so-called technological trajectories) in the course of time and the opportunities they offer for timely assertion of influence are depicted in the following illustration (Fig. 2).

Scientific research on innovation and technological development has so far validated the importance of Leitbilder for the development of paradigms and technological trajectories (pathways) as well as for scientific and technological revolutions. But controversial debate about the possibilities to actively influence the development of Leitbilder and technology development by means of Leitbilder (not only with respect to nanotechnologies) persists.

In cases where certain technological sources of problems and hazards can be qualified by technology characterization – e.g., a certain combination of a substances qualities such as being xenobiotic, persistent, mobile, soluble, and bioaccumulative – in counterpoint we are able to express those qualities that are more desirable (biodegradability etc.). But this is a limited loop back and surely not sufficient. Leitbilder like 'green nanotechnology', 'sustainable nanotechnology' or 'nanobiomimetics' should reach far beyond simply avoiding problems. They should reflect the desirable and include a vision of how things ought to be. However, in contrast to visions Leitbilder should maintain a connection to reality and feasibility.

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High-precision multilayer coatings and reflectometry for EUVL optics

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Abstract
The ever-decreasing pattern size of structures in integrated circuits requires lithography processes using light of ever-shorter wavelengths. Currently, laser light with a wavelength of 193 nm is used for the illumination in production lines of semiconductor factories. However, since several years many research groups are already dealing with the most promising next generation lithography, the extreme ultraviolet lithography (EUVL) that will use light with a wavelength of 13.5 nm. This paper summarizes recent research and development results of IWS Dresden in the field of preparation of EUV reflection optics and EUV metrology.

Introduction
The application of EUV radiation requires completely new concepts for the illumination and projection optics in lithographic systems. Since EUV light is strongly absorbed by all materials, instead of transmissive lenses reflection optics have to be used. These mirrors consist of precisely shaped and superpolished substrates, which have to be coated with EUV reflection layers. In order to obtain high-reflecting coatings, the accurate deposition of more than 100 alternating single layers of molybdenum (Mo) and silicon (Si) with thicknesses between 2.5 and 4.5 nm is necessary. One of the main challenges of the multilayer synthesis is the optimization of the interface region between the Mo and Si layers, where roughness and interdiffusion must be avoided.
The development of high-reflection EUV mirrors can only be successful if adequate metrology tools are available. Until several years ago, the only possibility to characterize EUV multilayers was to use synchrotron light. Hence, many of the investigations were performed at Physikalisch-Technische Bundesanstalt (PTB) at BESSY2 in Berlin. However, the rapid development of EUV optics requires on-site reflectometry. Therefore, IWS together with other project partners (Carl Zeiss, PTB, Bestec, Max-Born-Institut, AIS, GBS Elektronik) has developed a laboratory EUV reflectometer that enables fast and precise in-house EUV metrology. Using the reflectometer, large convex and concave optics with diameters of up to 500 mm can be qualified.

High-reflection EUV coatings
The EUV reflectance of single metallic layers is extremely low. Mirrors with reasonable reflectances can only be realized by using the principle of constructive interference between hundreds of single reflections. Therefore, EUV mirrors consist of up to 240 single layers which are periodically deposited on superpolished substrate surfaces (BRAGG stack = multilayer).
The two main components of the multilayer are Mo and Si layers with thicknesses of approximately 3 and 4 nm, respectively. Additional layers (carbon, boron carbide, …) with thicknesses in the range of 0.2-0.8 nm are necessary to reduce the interdiffusion of Mo and Si and to increase long-term and thermal stability [1-3].
The main challenge for the production of the reflective coatings is the high precision that is needed. The thicknesses of each layer of the stack have to be identical within a level of only a few pico-meter. Furthermore, the interfaces between adjacent layers must be sharp and smooth, i. e. steep chemical gradients and atomic flat layers have to realized on every single interface.
In order to meet the requirements, sophisticated deposition technologies are applied. In IWS Dresden, different methods with complimentary physical properties are available: pulsed laser deposition (PLD), magnetron sputter deposition (MSD) and ion beam sputter deposition (IBSD). These UHV techniques ($p_{base} < 2\cdot10^{-8}$ mbar) enable the coating of multilayers with demanding thickness gradients [4-6].

Fig. 1: UHV cluster tool for the deposition of nanometer multilayers. The hybrid machine comprises the modules for magnetron sputtering, pulsed laser deposition, a sample magazine, the load lock and a central handling system.

Research and development of the recent years resulted in EUV mirrors with maximum reflectances of 70.1 % at $\lambda = 13.3$ nm and $\alpha = 1.5$ °. Excellent uniformity with thickness deviations of $\sigma_{d,\ relative} \leq 0.05$ % across a diameter of 150 mm and run-to-run reproducibility of 99.9 %, high thermal and long-term stability and low internal stress were also obtained [7].

High precision EUV metrology
The characterization of reflective multilayers for EUV radiation stringently requires metrology tools in this special wavelength range. Just the initial multilayer characterization can be performed by conventional grazing incidence Cu-Kα reflectometry. From this method substantial information about period thickness dP, thickness ratio $\Gamma = d_{Mo}/d_P$ and interface roughness can be derived, but already the application of concave curved substrates needs EUV reflectometry, since grazing angles below a certain critical angle can not be measured.
Additionally, the precise values of EUV reflectance and EUV peak position can only be obtained by EUV reflectometry.
EUV reflectance measurements are predominantly carried out at synchrotron beamlines. The continued improvement of the measurement quality has resulted in an outstanding accuracy of these measurements. At Physikalisch-Technische Bundesanstalt (PTB) at BESSY2, an absolute uncertainty of 0.10 % for the spectral peak reflectance is achieved. The long-term reproducibility of the peak wavelength is better than 1.1 pm with a short-term repeatability of 0.06 pm [8].
However, for the production process of EUV optics for the lithography, the immediate access to metrology tools is necessary and the availability of stand alone devices is mandatory. Within the last years a stand alone EUV laboratory reflectometer for large samples has been developed, which meets the following specifications [9]:

- Spectral range: 10 - 16 nm
- Spot size: ø < 2 mm
- Sample size: ø ≤500 mm (Sample weight ≤ 30 kg)
- Relative standard deviation of the EUV reflectance: < 0.2 %
- Absolute uncertainty of the EUV reflectance: < 0.5 %
- Relative standard deviation of the EUV peak position: < 0.02 %
- Spectral resolution $\Delta\lambda/\lambda$: < 0.3 %

Fig. 2: Photograph of the laboratory EUV reflectometer. From the left to the right the following modules are shown: 1: goniometer chamber for large samples, 2: beamline with beam splitter, filters and monochromator and 3: chamber with the EUV source.

Summary
In IWS, research and development of the recent years resulted in EUV mirrors with high reflectances (70.1 % at $\lambda = 13.3$ nm and $\alpha = 1.5$ °), excellent uniformities or precise gradients (thickness deviations of $\sigma_{d,\ relative} \leq 0.05$ %), run-to-run reproducibility of > 99.9 %, high thermal and long-term stability and low internal stress.
In parallel to the coatings development a laboratory EUV reflectometer for samples with diameters of up to 500 mm has been developed and installed. The main tool parameters relevant for EUV optics developments are the relative standard deviation of the reflectance of < 0.2 % and the relative standard deviation of the peak wavelength of < 0.02 %.

Acknowledgments
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Nanotechnology in cementitious field

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In terms of volume used, cementitious materials, mainly in the form of concrete, are the most successful materials in the world. More than 1 m^3 is produced per person worldwide every year.

Concrete is a low cost, low energy material made from the most widely available elements on earth; it is a composite mixture of a binding phase, cement paste, composed of hydrated Portland cement and water, fine and coarse aggregates. Through a complex chemical reaction, the *hydration*, the paste hardens and gains strength to form the rock-like mass known as concrete.

There is no doubt that the performance of cementitious materials is controlled by physical and chemical processes occurring at nano level. Hydrated cement has a complex nanostructure, which still remains to be fully understood. The pores within the hydrated phases have a diameter ranging from nanometers to millimetres. The hydrates (C-S-H) are formed by chemical processes that can be modified and controlled at nanoscale level. It seems feasible that with enough effort the nanostructure of C-S-H could be manipulated to change its properties by using nanotechnology-based principles. The question is at what cost and whether the resulting properties would be sufficiently attractive relative to those of other higher value-added materials.

In the construction industry, nanotechnology is already used in a variety of ways to produce innovative materials. Nanoparticulate additives are now widely used as fillers in protective paints, coatings, and clean-up systems for buildings.

Nanostructured TiO_2 particles are already industrially used in cementitious products having photocatalytic activity. The basic principle consists of introducing a nanoparticle of titanium dioxide, mainly in anatase form, into both cement-based materials and organic-based coatings. The photocatalytic properties of the anatase form of TiO_2 originates from its ability to initiate, when exposed to UV-light, oxidation-reduction (redox) cyclic reactions that lead to the decomposition of the organic molecules adsorbed on its surface. As indicated, the behaviour of TiO_2 is that of a photocatalyst and therefore it is not consumed during the process. This gives rise to its chemical durability. To date there is significant evidence relating to the fact that TiO_2 will exhibit its photocatalytic properties on the surface of these materials when it is incorporated in the cementitious matrix. Self-cleaning properties were evaluated by monitoring via colorimetric measurements of the disappearance of a dye tainted into the surface whereas de-polluting properties were monitored through the abatement of volatile organic compounds (VOCs) and nitrogen oxides (NO_x). The results show good performances and efficiency for the considered materials.[1]

Research is in progress[2,3] in the following broad areas that would lead to nanoproducts specifically developed for the use in cementitious materials:

- Carbon Nanotubes (CNT). CNT are excellent reinforcing materials because of their extremely high strength, toughness and aspect ratios (length/diameter). They could also have the capability of controlling crack propagation. Incorporation of nano-tubes into the cement matrix would result in a ductile and energy absorbing concrete. The performance of such concrete can be further enhanced by functionalizing the CNT in order to improve the compatibility with cement matrix. The high thermal conductivity of carbon nanotubes may also make possible to develop new application as conductive concrete. The current obstacles of high cost and poor binding are likely to decrease in the future.
- Nanoparticles: Addition of nanoparticles to cement and concrete can lead to improved mechanical properties and extended life of concrete structures. Cement based materials containing SiO_2, Fe_2O_3 or alumina as nanoparticles show increased compressive and flexural strength with respect to the use of traditional fillers materials like silica fume. The addition of nano-$CaCO_3$ particulates accelerates the hydration of silicate phases.
- New admixtures: controlled release superplasticizers for a better workability control.
- Bio-additions: incorporation of bacteria, which produce a filler material within the pores can lead to a 'self repairing' concrete.
- Eco-binders modified by nanoparticles could reduce carbon dioxide emissions , which is one of the main problems for cement industry for the future. According MIT researchers the C-S-H particles which are about 5 nm across in all the cement

samples can be considered as a 'nano- signature' for these materials. Consequently the strength of the concrete products should not depend on specific mineral but on the way in which the mineral is organized as packed particles. This should open the way in using alternative elements (like magnesium) capable to have the same packing density of cement but would not need the same high temperature to produce.

The interest on the great potential and importance of nanotechnology in the cementitious field is reflected by different initiatives and activities worldwide. In Europe the research network 'Nanocem' *(www.nanocem.org)* coordinated by Karen Scrivener is an example of bringing academic research groups together with the industry to carry out the basic research needed to enable innovation.

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Cancer treatment with magnetic nanoparticles

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MagForce Nanotechnologies AG is the world's leading company in the area of nanotechnology-based cancer therapy. Its patented therapy enables the targeted destruction of tumors using magnetic nanoparticles. MagForce's nanotechnology represents a revolutionary approach to the future successful treatment of solid tumors.

Medical need / market

- Cancer currently accounts for the second highest number of deaths worldwide after heart diseases. Over 6.7 million people die every year as a result of a cureless cancer disease (Globocan2002).
- About 90% of these are solid tumors, of which roughly 25% exhibit failure of tumor control after the conventional therapy, i.e. 1.5 million patients could be targeted by the MagForce® nano-cancer therapy every year.
- Different therapy approaches today include surgery, chemotherapy, radiation therapy and a number of experimental therapies. However, all of them have substantial side effects and dramatically reduce the quality of life even when they are successful.

Company

MagForce has invented a new nanotechnology based cancer therapy with contactless activation of specific nanoparticles, adaptable to most solid tumors. It consists of two components: a therapy system (the MFH®-300F) and specific nanoparticles. Both are available for clinical trials. All products are being tested in several clinical trials since March 2003.

- Research history: 20 years of R&D at international recognized institutions: Charité University Medicine Berlin, Institute of New Materials (INM)/Leibniz Association, Technical University Berlin and Zuse Institute (ZIB), Berlin, Germany.
- Based on two companies founded in 1998 and 2000, MagForce Nanotechnologies was founded in 2001 and is funded by venture capital and additional national and federal research funds.
- 10 International patent families (80% granted), 2 new patent applications filed in 2006.

Technoloy / products

- General approach: With minimal invasiveness, nanoparticles are injected into the previously located tumor using conventional methods, and are then heated up by an alternating current magnetic field, which destroys the tumor in almost all regions of the body.
- What happens at the cellular level: due to the patented nanoparticle shells, tumor cells take up the particles rapidly and to a huge amount in contrast to normal cells.
- Mode of action: Temperature increase of above 43°C (110°F) up to 70°C (158° F) inside the tumor inflicts irreparable damages to the tumor cells, while leaving normal cells unharmed. In multi-modal therapy schedules the tumor cells are merely weakened by radiation and many drugs.
- The therapy system MFH®-300F: Comparable to a MRI or a CAT-Scanner, the patient is positioned in a short tunnel, which is homogeneously filled with the specific high-energy magnetic field. Whereas the human body is 'transparent' to this field, particle loaded tumors are excessively and high-selectively heated on the cellular level.
- The nanoparticles: The nanoparticle coating is highly functional in terms of tumor cell uptake and deep tumor tissue infiltration. It allows a stable particle load as long as the tumor tissue exists. Expensive antibodies are not necessary for the particle performance as described before.

MAGFORCE Technology

- Is specific.
- Has an excellent patient tolerance (results from clinical trials).
- Is minimally invasive (in the future, the procedure will be non-invasive).
- Is often repeatable.
- Is accurately administered, safe and can be precisely planned in 3D.
- Easy to apply.

The technology leaves normal tissue unharmed and can be used alone (thermoablation) or in combination (hyperthermia) with all conventional methods, such as drugs or radiation to enhance overall efficacy.

Clinical trialis

- Phase I: trial for patients with highly malignant brain tumors (Glioblastoma multiforme): Successfully completed with 14 patients (March 2003 - June 2004).
- Phase II: regulatory trial for patients with Glioblastomas brain tumor recurrence: 65 patients (January 2005 - OPEN).
- Phase I: trial for patients with highly resistant recurrent tumors of different type: 24 of 45 patients successfully treated so far (March 2003 – OPEN).
- Phase I: trial for patients with prostate carcinoma recurrence after a curative therapy: 10 patients, recruitment finished (February 2004 – CLOSED).
- Phase I: trial for patients with esophagus carcinoma (January 2006 – OPEN)
- Phase II: regulatory trial for patients with prostate carcinoma, intermediate risk: 130 patients (January 2007 – OPEN)
- 3 further clinical trials in preparation

Vision

- In less than 10 years, MagForce® nano-cancer therapy will have the importance equivalent to radiation therapy today, but with far less side effects.
- Multi-resistant tumors do not lead to inescapable deaths of cancer patients.
- MagForce® nano-cancer therapy becomes 'Golden Standard' within multi-modal cancer treatment regimes due to the repeatable enhancement of the clinical outcome in standardized procedures.

Founder

Dr. Andreas Jordan, the globally renowned developer of the MagForce® nano-cancer therapy, is the founder and the CSO of MagForce Nanotechnologies AG. He studied biology at the Freie Universität Berlin (Free University Berlin) and, parallel to this, he studied biochemistry in a second degree course at the Technische Universität Berlin (Technical University Berlin). In 1993, he already started focusing his activities on the new nanotechnology-based cancer therapy in his dissertation that was awarded the grade 'excellent'. In 1997, he founded MFH Hyperthermiesysteme GmbH, and in 2000 the MagForce Applications GmbH. After a successful closing of a B-Round venture financing in 2004, the two companies were merged into MagForce Nanotechnologies.

The therapy device: Contactless activation of specific nanoparticles

With minimal invasiveness, nanoparticles are heated within the previously defined tumor region

The MagForce magnetofluid consists of iron oxide particles which are colloidally dispersed in water.The nanoparticle core mainly consists of magnetite and has a size of 10 - 15 nanometers in diameter

Plasma technology - a tool for creating new functionalities on a nanoscale for biomedical application

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Abstract

The contribution will focus on several applications of polymers in contact with a biological environment. Thus, the requirements for appropriate interaction on nano-scale (often summarized as biocompatibility) of the respective materials surfaces with living cells (mammalian as well as prokaryotic cells) and bio-molecules will be discussed in the frame of usually mentioned surface properties like wettability etc..

In a following step several plasma-chemical approaches for the generation of well defined surfaces with uniform functionalities are described. The needed densities and availability of the functionalities, will be given in functions per surface area or per film volume. The different plasma-chemical strategies for the deposition of a chemically uniform film on surfaces are evaluated with respect to their technical and economical appropriateness. Beside surface properties like surface energy, surface charges and roughness the aspects of structuring (2D) and penetration into trenches, fissures and pores (3D) will be discussed shortly. Examples of carboxylated two- and three-dimensional structures will be shown and discussed with respect to their application.

Some special applications as for example the production of regio-selective finished surfaces of separation membranes, a field where an unique potential of plasma-technology is obvious, will be presented in more detail.

Introduction

It is well known that almost any material surface will be changed by exposure to glow discharges. This is due to the impact of species generated in plasmas having enough energy to break chemical bonds and/or to create new ones. While the first step, creating of a glow discharge or a plasma, is relatively easy done. The second, the control of the interaction of the plasma phase with solid surfaces differs depending on branches of application. For example the possibilities to modify material surfaces used in microelectronics (silicon and silica-based) by plasma treatment are broadly examined (1). The same is valid for hard coatings to enhance wear resistance of inorganic surfaces. The intentional use of glow discharges for coating of polymers started with Goodman's first attempts to deposit thin dielectric films for capacitors (2). Since that time a lot of examinations have been performed to create appropriate surface properties on different kinds of polymers. Many of the preferentially applied polymers, e.g. polypropylene, polyethylene or fluorocarbon based polymers, are difficult to activate by wet chemical procedures (comparable with those silicon-based materials in micro-electronics), therefore the plasma treatment is a more and more used alternative method. The main feature of plasma processing independent of areas of application is that only the outer surface of materials in contact with the discharge is involved, in consequence the processing is restricted to a nano-level. That means controlling the ablation and deposition processes results in nano-manufacturing. This contribution is focused on polymers as substrates for biomedical devices because there is at least since the sixties of the last century a strongly growing use of polymers in the area of biomedical application. The reasons for this are manifold, beside economic aspects, physical properties like low-weight, variable elasticity, transparency for diagnostic purposes, ease of manufacturing of three-dimensional devices e.g. microtiter plates and the suitability as disposables are the main ones. Therefore about 1 to 2 % of the world wide production of polymers is used for biomedical applications. That means about 50 % of the materials used in biomedical application is plastic. Thereof approximately one half serves for packaging and the other half for fabrication of devices. For examples of devices the reader is referred to the excellent reviews of D. Castner and B. Ratner (3).

Biomedical Requirements

For the use of materials in the biomedical area some requirements are well defined, whereas other are not and often not really known.

- The materials must not release any substances, like additives or residual monomers in the case of polymers into the biological environment.

- The materials must not change their properties within the duration of their use. That means they have to be stable against the biological environment. Exception: biodegradable polymers.
- A procedure for sterilization of the polymer (often thermo-labile) materials must be available.

These requirements are valid for the bulk materials but must also be fulfilled by surface coatings. Further requirements are only vaguely defined but are summarized under the expression “biocompatibility” which in turn is described as “the ability of a biomaterial to induce the appropriate answer in a specific application” (4). Thus a set of biological testing procedures (mainly cell-based) are established to evaluate materials under consideration for the special application. Together with the surface elemental composition and structure some other aspects have to be considered. Because of the complex composition of biological media with several components bearing charges like ions, or at least partial charges like proteins and cells the interaction with materials is influenced by electrostatic forces if the material surface also carries charges. Thus adsorption reactions under such conditions will be dominated by charge attraction or repulsion as well as by other surface relevant forces like van-der-Waals forces or a development of hydrogen bonds, acid-base interaction an so forth.

Plasma processing on polymers substrates

In a first glance two types of surfaces are of interest for biomedical application. One type has to consist only of the appropriate surface structure with defined chemical groups, where the thickness of the layer has no influence of the wanted properties. Such surfaces are prepared often by plasma treatment based on non-polymerizing gases and followed by grafting where some functionalities are introduced. The density and distribution in such cases is not well controlled and often far below the needed one, in addition sometimes the surface chemistry will change due to reorganization of the surface by turning hydrophilic groups inside for energetic reasons. That is why nowadays to get uniform and stable layers thin film deposition is preferred instead of treatment with non-polymerizing glow discharges and eventually grafting of molecules. Starting with some monomers like acrylic acid to get carboxylic groups or glycidyl methacrylate to generate epoxy groups on surfaces a thin film is deposited in such a way that first the substrate is activated by generation of radical sites. Simultaneously the monomer on its way through the discharge and at the surfaces is only partly destroyed. A film results, bearing a certain amount of available functionalities depending on the plasma parameters applied (5). Thus a thin film with a thickness of less then 50 nanometers is the appropriate interface between material and biological environment. Depending on plasma parameters the amount of available functionalities can be controlled. Normally it is varied in the range from few functionalities per square micrometer up to five functional groups per square nanometer. For some medical application where the film thickness is of importance, e.g. release systems or barrier coatings the process has to be conducted for a longer time, up to tens of minutes to get thicker films whilst cross-linking is enhanced and the amount of functionalities will be reduced. In parallel to the growth of knowledge on the requirements for biological application plasma chemists succeed in designing chemically stochastic but well defined surfaces with respect to available functional groups via plasma processes.

Interaction of plasma deposited layers with biological counterparts

The Interaction with biological systems e. g. bio-molecules, microbes, mammalian cells is mainly due to intermolecular forces and therefore restricted to an interface with a thickness of less than 10 nm. Films with thicknesses below 10 nm may show incomplete coverage of the used substrates. In Fig. 1 it is shown that films become complete if the mean thickness exceeds 2.5 nm, that means surface tension becomes constant. It will be shown that surface properties in such cases are determined by the degree of coverage and islands or domains generated at the start of film deposition will influence biological systems.

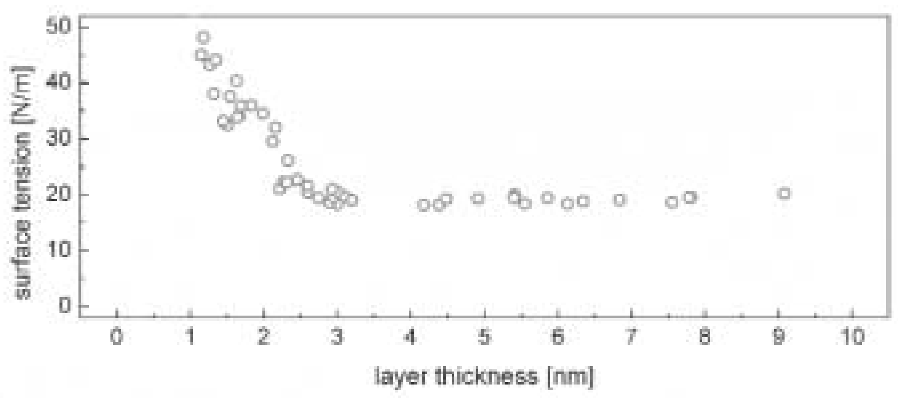

Fig. 1: Decreasing of the surface tension with increasing film thickness.

The interaction of mammalian cells with partly covered surfaces will be discussed in more detail. Thus layers from a fluorocarbon precursor (CHF_3) were plasma deposited on hydrophilic materials in a way that depending on plasma deposition parameters the degree of coverage is varied. This results in macroscopic in graded surface energies which can be widely manipulated from about 60 mN/m down to 20 mN/m depending on the degree of hydrophobic coverage. Cells (primary fibroblasts) grown on these surfaces will follow exactly the trend of the surface energy (6).

Outlook

To understand more of the interaction of materials with biological systems a lot of different analytical methods are needed. Biology happens on the nano-scale when bio- molecules are in the focus, thus instrumentation for examining chemical composition and structure in this dimension is necessary. Developments of plasma polymerized films are therefore accompanied by XPS-measurements as well as by atomic force probing in various modi. The later offers the appropriate lateral topographic resolution and can be use under biological conditions (wet and atmospheric pressure) while the first is constricted to high vacuum measurements but gives excellent data on chemical composition. Methods are need to examine surface in nano- as well as in micro dimensions without using vacuum systems. Therefore, a trend becomes apparent to use "hyphenated" analytic techniques for in-situ-characterization. A promising development is the combination of probe measurements with optical methods realized in the combination of AFM, confocal spectroscopy and micro-Raman spectroscopy to explore microbes and mammalian cells in-situ on artificial surfaces. All three techniques reveal a sub-micron resolution which is adequate for the research objects.

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Progress in using magnetic nanoobjects for biomedical diagnostics

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Abstract
A magnetic biochip using the combination of magnetic nanoobjects as markers and magnetoresistive sensors has proven to be competitive to standard fluorescent DNA-detection, at least at low concentrations. Additionally, magnetic nanoobjects provide the unique possibility to manipulate biomolecules on-chip which paves the way to an integrated 'magnetic lab-on-a-chip' with detection and manipulation. It is shown that the hybridization process on a biochip can be accelerated. Looking forward, a paradigm change from the 'magnetic lab-on-a-chip' to the 'magnetic lab-on-a-bead' is discussed as a future device solution. The nanoobjects themselves are thereby directly used as both the molecular recognition site and the detection unit.

Introduction
Recent research progress in fabrication and characterization of magnetic nanoobjects like rods and beads has triggered many ideas and possible applications; amongst others also in the biomedical field. The size of the nanoobjects ranges from a few nm up to few 100nm and can be reliably reproduced by physical or chemical processes. Trivial and nontrivial applications are e.g. contrast enhancement in imaging, in-vivo drug targeting, cancer treatment by hyperthermia, and labeling on biochips [1],[2].

Magnetic lab-on-a-chip
The idea of integrating standard laboratory diagnostics into easy-to-use portable devices has received growing attention both by researchers and biotechnology companies. A recent development is to combine magnetic markers and magnetoresistive sensors in a magnetic biochip. Magnetic nanoparticles and so-called beads as markers are commercially available in a wide range of sizes, functionalities and magnetic properties. Such systems promise a number of advantages. First of all, the MR sensors are compatible with the established semiconductor process technology and directly provide an electronic signal suitable for automated analysis. They are scaleable and can be tailored to meet any desired functionality. Furthermore, there is no disturbing background signal like in the case of fluorescent methods. Contrary to fluorescent markers, magnetic markers are stable so that measurements can be repeated many times.

Magnetic markers have proven to have a higher sensitivity at the detection of biomolecules at low concentrations, as compared to the established fluorescent labeling method [3],[4]. Superparamagnetic microspheres are thereby detected via giant or tunnel magnetoresistance sensors. A further advantage of magnetic nanoobjects is their use as manipulable carriers; manipulable either by an external magnetic field or on-chip via currents running through specially designed line patterns on a chip platform.

Reaction acceleration by moving nanoobjects
By applying magnetic gradient fields, magnetic nanoparticles can be manipulated on-chip, which for example can be utilized to pull the analyte molecules to specific binding sites or to test the binding strength and distinguish between specifically and non-specifically bound molecules [5]. Furthermore, a strong magnetic gradient field can also remove the hybridized analyte DNA and ensure reusability of the biosensor. Finally, if the sensor area decreases for low concentration measurements, it is indispensable that active manipulators accelerate the dwell time of the hybridization step. It can easily be calculated and imagined that it would take years for a single molecule/marker to find a nanoscale sensor only by diffusion. An acceleration of DNA hybridization can be also achieved by motioning magnetic nanoparticles via externally applied fields. Magnetic beads which are immersed in a hybridization solution, e.g. in a fluidic channel, may be moved around and cause a local whirling of the fluid. Figure 1 shows the positive effect on hybridization. Two standard hybridizations were carried out in parallel: in one experiment, superparamagnetic beads of 250 nm diameter were added and actively moved around.

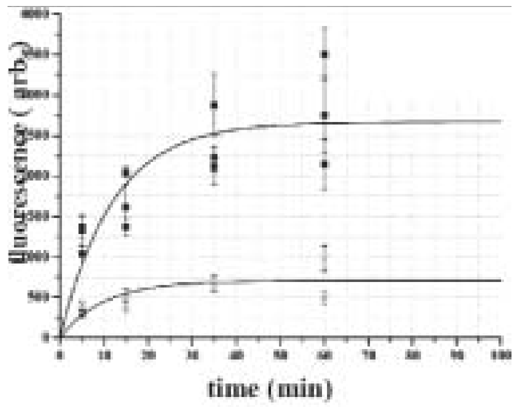

*Figure 1:
Fluorescent signal vs. time for 12 hybridization experiments with Enterococcus faecium: standard (red line, bottom); with magnetic nanoparticle motion (blue line, top).*

The hybridization degree was measured by fluorescence of the target DNA. The magnetic bead supported hybridization was more than three times as effective as the standard procedure if only diffusive motion is present [6].

Magnetic lab-on-a-bead
Although a lab-on-a-chip, including the magnetic version, already provides advantages of a portable and fully automated device, a challenge of future developments is an overall simplification at large. Most lab-chips are designed in such a way that surfaces play a major role, either as substrate where molecular reaction takes place or as sensor environment for detection. Proper dealing with substrate surface, microfluidic constrictions, washing and PCR steps for DNA replication make device fabrication and handling complicated and finally unreliable. Therefore, we propose a rugged and easy-to-use solution which would certainly mean a paradigm change from the 'lab-on-a-chip' to a 'lab-on-a-bead' idea. The nanoobjects themselves are thereby directly used both as molecular recognition site and as detector via certain changes in its properties; i.e. magnetic relaxation in fluids, precipitation by agglomeration, or plasmons resonance, for example. This approach promises (a) easier fabrication due to the lack of any chip surface preparation and sensor embedding, (b) easier fluidics as only one reaction and observation chamber is required, (c) and higher sensitivity because an intentional motion and biomolecule tracking is possible.

With the magnetic lab-on-a-bead, two different detection techniques are first choice: magnetorelaxometry and plasmon detection. The magnetorelaxometry measures the Brownian relaxation time of magnetic nanoobjects which depends on their viscous behavior in a fluidic environment [7]. If an externally applied magnetic field which rotates the nanoparticles and orients their magnetization is switched off abruptly, the Brownian rotational motion gives a distinct relaxation profile of the magnetization for biomolecular recognition. The relaxation time depends on whether analyte molecules are bound to the target molecules on the nanoparticles (figure 2). If the nanoparticles are too small or magnetically isotropic, the relaxation is governed by the thermal Neel relaxation. If they are too big, they become insensitive to small reaction changes on their shells.

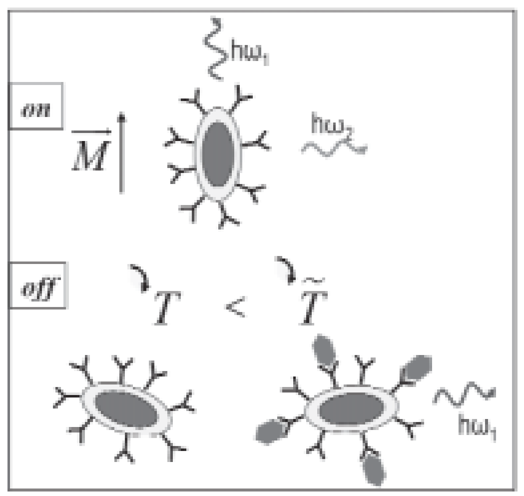

Figure 2: The principle of magnetorelaxometry in combination with plasmon detection. 'Loaded' nanoparticles relax slower what can be detected most sensitively be comparing the two orthogonal plasmon intensities at energies $h\omega_1$ and $h\omega_2$.

The second possibility is to detect plasmon polaritons in metallic nanoobjects. They are sensitive to changes of the refractive index of the surrounding medium respectively the biomolecular binding on their shell. Additional polarizable charges in the medium cause a red shift of the plasmon peak. Numerical modeling shows that core-shell nanoparticles

are well suited to such a task. While the magnetic core (e.g. Fe_3O_4) provides externally navigated mobility, Au shells show prominent plasma response. The resonance wavelength can independently be tailored to any point in the visible and infrared spectra.
Furthermore, our simulations based on Mie theory reveal that the resolution of any standard spectrometer is sufficient to detect a molecular analyte-target binding process. The calculations indicate the existence of best resolution conditions at certain core diameters and shell thicknesses, i.e. 12 nm for maghemite core with 4 nm thick Au shell, for example.
Because the plasmonic shifts are still small, we propose a combination of magnetorelaxometry and optical detection with asymmetric, anisotropic, magnetic core-shell nanoparticles for the lab-on-a-bead. Two distinct plasmon modes are available in e.g. elliptical nanoparticles, a low-energetic long axis and a high-energetic short axis mode (figure 2). The rotation of the nanoparticle due to Brownian motion, for example, switches between these two modes. This offers largest intensity changes instead of a peak shift [8].

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Nanomedicine - from the lab to the clinic, while gaining public acceptance

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Introduction: a definition
There are a number of definitions of nanomedicine but, for the purposes of this presentation, the definition adopted by the European technology Platform on Nanomedicine has been used:

> *Nanomedicine:* the application of nanotechnology in medicine. It exploits the improved and often novel physical, chemical, and biological properties of materials at the nanometric scale. Nanomedicine has potential impact on the prevention, early and reliable diagnosis and treatment of diseases

The key aspect of this definition is 'the improved and often novel... properties of materials at the nanometric scale'. 'Nanomedicine has potential impact on the prevention, early and reliable diagnosis and treatment of diseases' is a neutral, scientific way of saying that there is great excitement in the possible application of nanotechnology to a wide range of medical conditions.
This presentation examines some of the novel applications of nanotechnology to medicine and also looks at the challenges to be overcome to gain public acceptance of these new treatments or procedures. It is important to note also that nanotechnology is one of a number of convergent disciplines or enabling technologies that are typical in innovative new generation medical products and treatments.

Some examples of nanomedicine
Diagnostic imaging is a routine tool in many branches of medicine. Improvements are continually being made to increase the resolution of imaging equipment to enable the more accurate or earlier diagnosis of a variety of conditions.
While such devices are of immense benefit, their resolution is currently limited by current agents used for contrast which may not be able to penetrate the finest structures of the body preventing the earliest diagnosis. One major objective in the area of medical imaging, therefore, is to be able to visualise finer and finer anatomical features in order to facilitate earlier diagnosis.
There is, consequently, a great interest in exploring the possibility of using nanoparticulate-based contrast agents to improve the resolution of conventional medical imaging.
Further research focuses on the possibility of combining imaging and treatment, so-called theranostics, e.g. where nanoparticles may be precisely targeted, imaged and then activated to provide therapy.

Regenerative medicine is a major area of research and development where nanotechnology is actively being applied. A major area within regenerative medicine is human tissue engineering which relies on a convergence of several medical and scientific disciplines, including advances materials science for the scaffold element, cell and tissue biology, biochemistry and pharmacology. Nano-engineered substrates may often aid cell and tissue proliferation both by chemical and physical means as cells will respond to both chemical and physical changes in their environment. Nanotechnology will enable scaffolds to be constructed at the cellular level. This approach has huge possibilities in that it mimics of the natural environment within the human body in which cells grow and differentiate.

'Intelligent' biomaterial implants may be able to provide an environment in which cells are 'recruited' within the body and grow actively on the substrate, e.g. nerve conduits for peripheral nerve injury.

Early stage diagnosis is also a very promising area for nanotechnology-based innovation. Lab-on-a-chip devices have been under development for some time but the application of technologies such as nanofluidics and quantum dots now means that minute (e.g. picolitre range) quantities only of analyte may be required and miniaturisation allows for the possibility of carrying out dozens, or even hundreds, of analyses simultaneously on one device.

Novel medical nanomaterials are an important and rapidly growing area of medical technology research. Improved functionality and performance, better biocompatibility and improved patient safety are all important driving factors.

There are many areas where novel nanomaterials are beginning to have an impact. For example, new generations of stents are in development where, by means of nanoporous coating, the ancillary drug is released gradually, extending the effectiveness of the stent and helping to prevent re-stenosis.

New types of surface coating such as conducting nanocrystalline diamond can be linked with biomolecules to create new types electrochemical bioinorganic interfaces. This will open up the possibility of creating, for example, new types of biosensor. Nanocrystalline diamond coatings are also already used in ultra sharp scalpels for use in microsurgery, e.g. of the eye.

Targeted drug delivery using nanoparticles is a major area of research and many types of nanoparticles, e.g. micelles, dendrimers, liposome-enclosed nano-caged drugs are being explored as delivery vehicles for precise targeting of minute quantities of drugs.

To the clinic: the challenges

Challenges in bringing nanotechnology-based novel medical products to the patient include:

- regulatory issues
- funding and reimbursement issues
- healthcare technology assessment (HTA) issues
- perceptions of risk: political, professional and public levels
- creating a favourable environment for research and development
- improving the environment for investment in medical nanotechnology
- medical professional knowledge and attitudes

Some of these will be examined in more detail as follows.

Regulatory issues for nanomedicine

The application of nanotechnology to medical products may present some new challenges to regulators. It is important to face these issues as soon as possible both to encourage innovation and investment and to mitigate possible litigation

Some novel products may fit comfortably under the scope of existing Directives, e.g. the Medical Device Directive (MDD) (93/42/EEC) or the Medicinal Products Directive (2004/27/EC). However, in some cases the convergence of technologies facilitated by the application of nanotechnology may serve to somewhat blur 'traditional' demarcation boundaries between these two quite different regulatory regimes.

In either case, these Directives were never conceived with nanotechnology in mind. For the MDD, which is a 'new approach' Directive and supported by voluntary 'harmonized' European standards which give a 'presumption of conformity', some of those standards may be inadequate to address the new types of risks posed by nanotechnology). Prescriptive requirements in pharmaceutical legislation may be inappropriate for nanotech-based products

Regulatory challenges may therefore include:

- Resolving demarcation issues where application of nanotechnology results in novel 'hybrid products' that straddle the line between different regulations

- Designing effective and efficient regulation that addresses the specific risks inherent in nanotechnology-based products, that is innovation-friendly and that facilitates fast access of patients to improved therapies and fast access to market across the EU for manufacturers whilst ensuring safety. This implies a risk management-based approach.
- Ensuring regulatory expertise is available to adequately assess nanotech-based medical products

Funding and reimbursement

A lack of any guarantee of eventual reimbursement of nanotechnology-based products or treatments by public or private healthcare funding organizations could be a major disincentive in investing in R&D in nanotech-based products.

Because of the demographic shift to an ageing EU population European Governments face a common problem in that demand for healthcare is sometimes outstripping available financial resources. The result has sometimes been to force down reimbursement prices (e.g. Germany) or to refuse reimbursement of some new technologies (e.g. France). As for other innovative medical technologies, healthcare funding reimbursement for nanotech-based products is likely to be a major challenge. Reimbursement schemes currently vary widely from country to country, and patient access can vary even within a country. Alongside regulatory development, lobbying at EU level for equitable and adequate reimbursement schemes across Europe will be vital.

Healthcare technology assessment (HTA)

Like reimbursement schemes, HTA schemes vary widely across Europe. It seems highly likely that medical advances involving nanotechnology will fall under HTA scrutiny. A key need will be to provide appropriate education and resources to HTA assessors and those involved in decision-making based on HTA. This is particularly important as HTA has routinely been applied to pharmaceutical products and a transposition of the methodology used there to nanotechnology-based products and the subsequent interpretation of the results may require appropriate adaptation

Perceptions of risk of nanomedicine

The following statement was made by a current serving MEP and echoes the concerns that some politicians and members of the public have about nanotechnology. Cases like GM foods should serve as a reminder that risk perception issues should not be ignored or overlooked.

> 'We must therefore adopt a moratorium on the commercial production of nanotech until we can establish a regulatory framework, including regulations on liability for the negative impacts of nanotech and strict labelling requirements and compulsory assessments of their effects.'

As with all medical technologies, nanomedicine needs to be accompanied by a systematic approach to risk analysis and risk management. In addition a clear and unambiguous communication is required of both the benefits of the therapy and of any residual risks that remain. This approach is already the norm for medical devices and is articulated in legislation. If risks and benefits are clearly communicated (as opposed to just information on risks alone in some fields), then the public and decision-makers have a much better opportunity to reach an informed decision. Such communication needs to be in language that is understandable to the target audience

More on risk management

The usual definition of a risk used in the medical technology industry is:

Risk: combination of the probability of occurrence of harm and the severity of that harm; where harm is defined as follows

Harm: physical injury and/or damage to the health of people, or damage to property or the environment

However, this is not the only way risk is understood. The following is a list of some more common definitions that emphasise the need for clarity and common concepts in communication:

- any issue that has doubt associated with it
- the possibility of a good or bad occurrence
- the possibility of suffering a loss
- the possibility of loss, injury, disadvantage, or destruction
- the combination of constraint and uncertainty
- the challenge that accompanies opportunity
- what Murphy is known for recognising

The following is an extract from the conclusions and recommendations of the EU Scientific Committee on Emerging and Newly-Identified Health Risks (SCENIHR) Opinion on 'The appropriateness of the risk assessment methodology in accordance with the technical guidance documents for new and existing substances for assessing the risks of nanomaterials'.

> 'It is recommended that a tiered approach is developed in order to set out a rationale framework for assessing the potential risks from engineered nanoparticles. The intention is to produce a scientifically valid, cost-effective framework that enables a scientific judgement to be made on the risks to human health and to the environment from nanoparticles'.

This Opinion has recently been circulated (29/03/07) for public consultation.

What organisations are doing at EU level

It is likely that the SCENHIR Opinion will have an impact on EU regulatory activities. With regard to nanotechnology-based products falling under the Medical Device Directive (MDD), the Medical Device Experts Group (MDEG) established under the MDD set up a New and Emerging Technologies Working Group that has provided a position to the effect that:

> 'In general, the Working Group considers the medical device legislation suitable to deal with medical devices manufactured utilizing nanotechnology. The medical device legislation is based on risk management, and this risk management approach is in principle suitable to address all kinds of risks, including the risks associated with medical devices manufactured utilizing nanotechnology.'

For pharmaceuticals, EMEA circulated a 'Reflection Paper on nanotechnology-based medicinal products for human use' and created an Innovation Task Force to provide a forum for early dialogue with applicants on regulatory, scientific or other issues that could arise from the development of emerging therapies and technologies, including nanotechnologies.

IoN work on promoting nanomedicine

Professional focus	The IoN now has a full-time professional specialist dedicated to nanomedicine and the lifesciences with long-term expertise in risk and risk management. The IoN also participates in European standardization concerned with nanotechnology and risk
NanoMedNet	NanoMedNet www.nanomednet.org is a recent initiative by the IoN to establish a network of clinicians, researchers, industry and other interested stakeholders to collaborate on all aspects of nanomedicine including risk issues. Planned outputs are likely to include educational materials.
Investing in Medical Nanotechnologies I & II	The IoN ran a successful conference on nanomedicine in December 2006 and a follow-up conference, including also risk topics, will be held in November 2007

EuroNanoForum, R Moore – Abstract - 03/05/2007

CENARIOS® - The first certifiable nanospecific risk management and monitoring system for industry

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Abstract

Nanotechnology means fast-growing future markets and many new business opportunities. Numerous big companies and a lot of start-up companies provide many new and exciting products for industrial and consumer applications. Nanomaterials and nanoproducts offer new possibilities in product development. Adopting nanotechnology can therefore significantly improve product properties. However, these new properties could also pose potential risks, since mid- and long-term effects of nanosized materials on human health and the environment have not been fully understood. In addition, there are many legal uncertainties, as it remains unclear to which extent nanomaterials can be treated under regulations similar to 'traditional' chemicals. To meet these new challenges, The Innovation Society Ltd. (St. Gallen, Switzerland) and TÜV SÜD (Munich, Germany) have developed CENARIOS®, the first certifiable nanospecific risk management and monitoring system. CENARIOS® provides a 'state-of-the art' hazard and risk assessment, encompassing risk monitoring tools to minimise the potential risks. The system will be implemented by mid 2007 at the first industry company and can be applied sector independent in industry, retail and research organisations.

What is CENARIOS®?

CENARIOS® is the world`s first certifiable risk management and monitoring system for nanotechnology. The system was developed in 2006 to meet the particular requirements of nanotechnology risk assessment. The concept of CENARIOS® ensures that HSE-risks of products and processes are assessed according to 'state-of-the art'-standards and new findings from science and technology are continuously included in the risk management process. An up-to-date evaluation will be applied and combined with a foresight element, monitoring strategic and relevant risk areas (toxicity, regulation, consumer attitude, etc). It sets the basis for strategic decision making processes under conditions of high uncertainty. CENARIOS® is certified and audited regularly in an independent quality standard process in which a TÜV SÜD certificate is awarded. This certificate testifies a foremost safety level for the risk management system. It documents the company's great safety efforts towards customers, authorities and the public.

Risk management cycle

CENARIOS® considers all the well-known steps of a risk management system (see Figure 1):

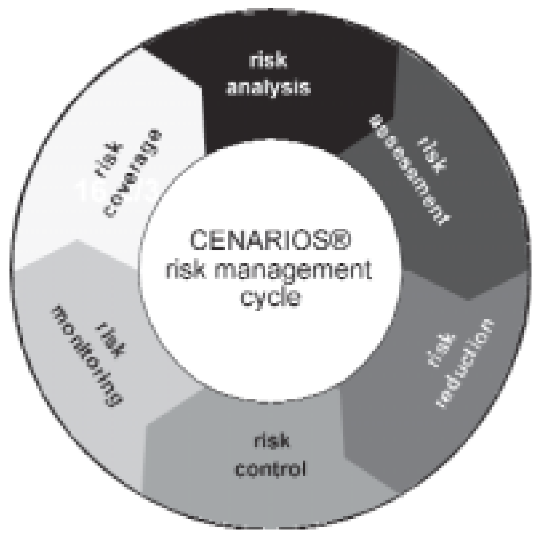
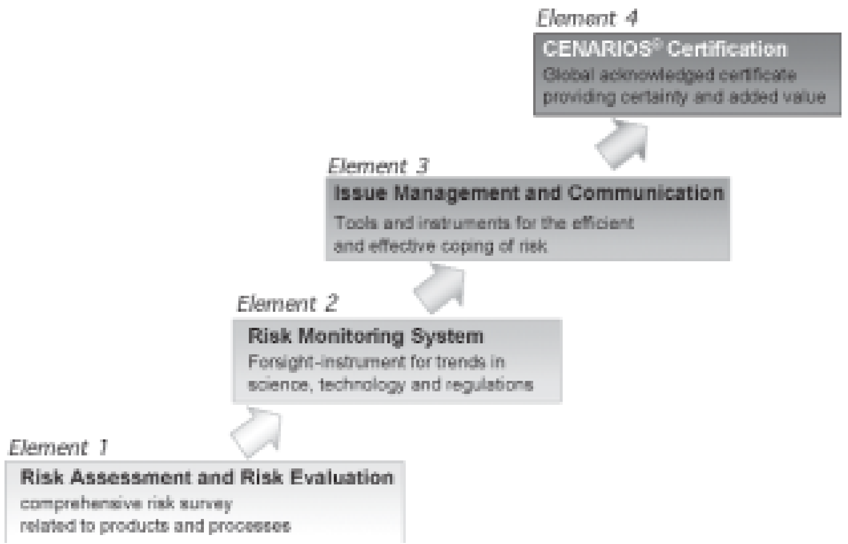


Figure 1: Steps of a risk management system

The special needs for a risk management for nanotechnology show up in the way these steps are performed. This becomes transparent in the approach of CENARIOS® with four distinct elements. These elements provide a coherent fundament for strategy and product decisions and serve as benchmarks. They are described in more detail below.

Figure 2:
The four elements of CENARIOS®



Risk and hazard assessment / risk evaluation

Risk assessment in nanotechnology is difficult because of the lack of knowledge concerning the possible consequences. 'Risk assessment' in itself is not a uniquely defined term: For toxicologists, it's more or less the assessment of hazard of a given substance and of exposure.

The approach of CENARIOS® is to monitor the state-of-the-art of science and technology and to use this knowledge for a risk assessment. Therefore an objective method has been developed consisting of two steps:

Step 1: Estimation of the quality of the database

Step 2: Risk evaluation based on the results of 1.

In the first step, an evaluation scheme for the credibility and transferability of the results of current research activities (the 'database') was developed. This scheme results in a matrix where the credibility of the database (b) is plotted against the consequences (a) described in this database (possible and proved respectively) .

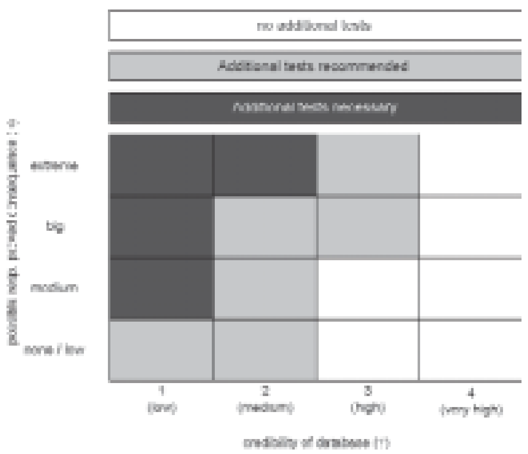


Figure 3:
Evaluation scheme for the credibility of the databases

Depending on the evaluation of these factors of influence additional tests to improve the database and the quality of the risk assessment are recommended, if necessary. The factors α and β are then transformed in an event-tree where the endpoints result in 6 categories A to F depending on the credibility and transferability of the database.

Risk monitoring system

To perform the step 1 of the risk assessment a monitoring tool was developed, which allows us to observe the state-of-the-art in science and technology in the following fields:

- Science
- Society
- Technology
- Market

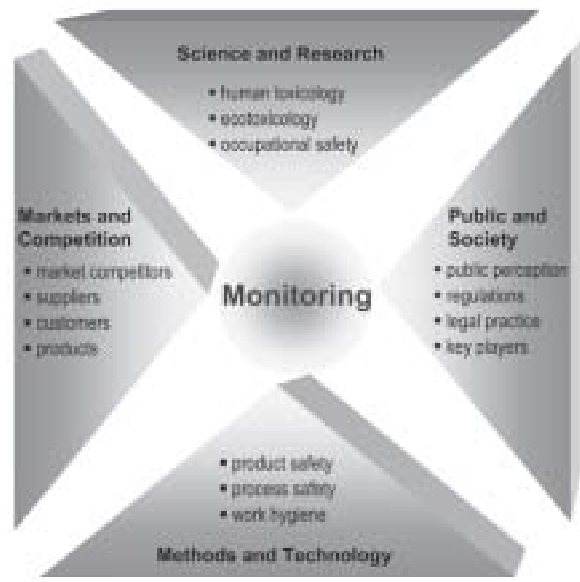


Figure 4:
The four fields of Monitoring

The risk monitoring system provides a comprehensive outlook on strategically relevant developments and therefore provides a competitive edge. Future risk areas are monitored in order to anticipate strategically relevant risks. It includes risk related trends in health, occupational safety and the environment. Scientific, societal and legal trends as legislation, liability claims, media coverage, public perception etc. are analysed and evaluated. Furthermore, specific developments in technology and market trends are monitored.

Issues-management and communication

Risk communication plays a crucial role in crisis management. Tools for crisis prevention have to be created and measures (documentation, trainings and workshops, etc) for professional crisis management should be provided.

The CENARIOS® Issues-Management provides a four step approach where the need for actions is dependent on the severity of risk (see Figure 5 next page).

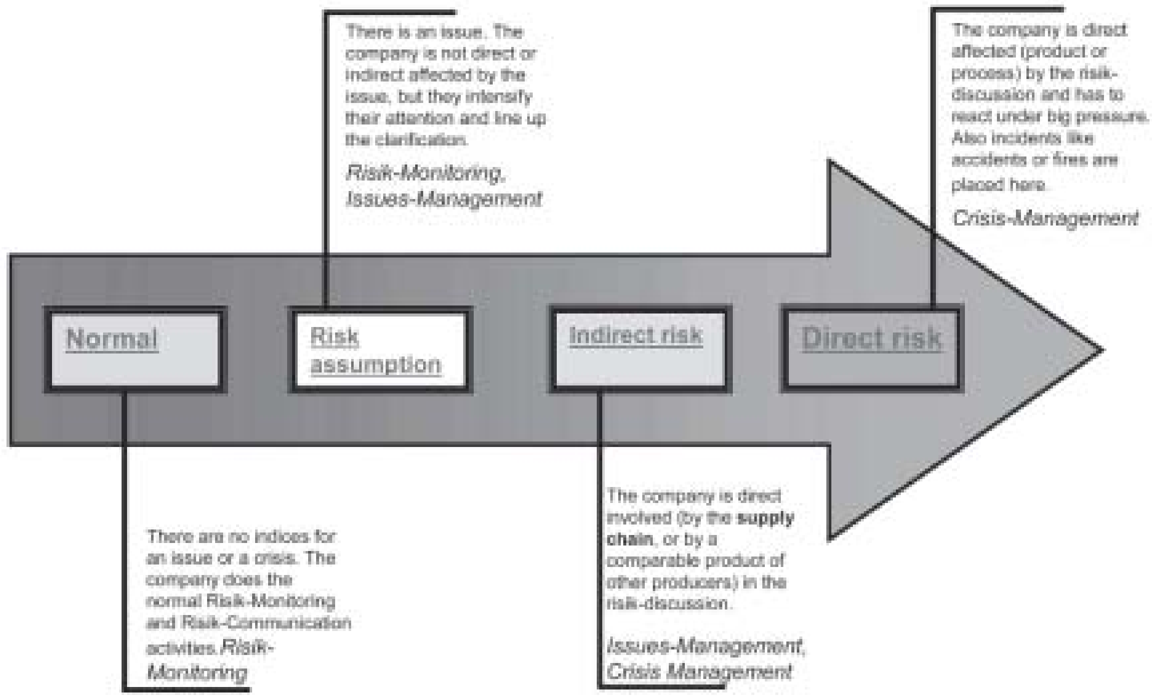


Figure 5: The four Step Issues-Management concept

Certification
CENARIOS® includes certification criteria with special requirements to

- Staff
- Organisation
- Risk assessment and monitoring
- Risk coverage

For these requirements a base of certification was developed. This base consists of 5 documents, one for each of the issues above and one general list of criteria which serves as customer's information, e. g. as help for the preparation for the certification.

Figure 6: CENARIOS® Base of Certification

As the state-of-the-art in science and technology is changing rapidly in nanotechnology, the certificate has a restricted duration of validity. A Re-Certification has to be performed after at least one year (see Figure 7).

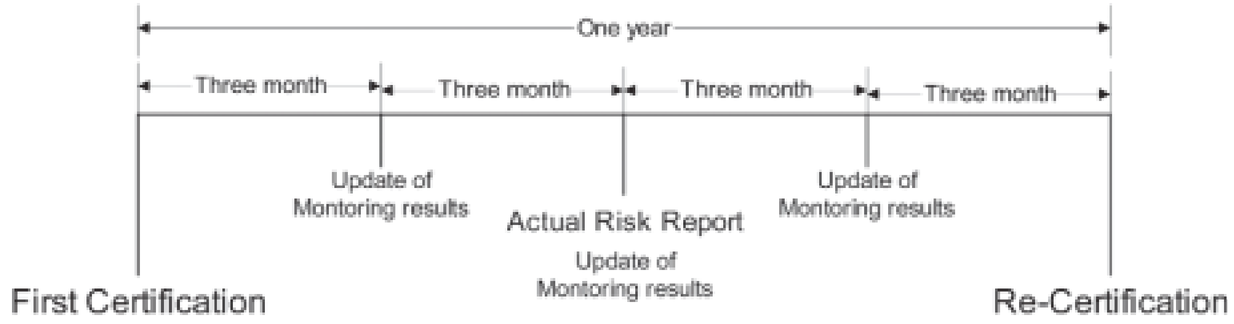


Figure 7: Periodicity of Certification, risk reporting and monitoring

The requirements shown in Figure 7 ensure the 'evergreen-status' of the Risk Management System. So it demands a continuous monitoring (at least an update every three month) and an actualisation of the risk inventory and a new risk report less than half a year before certification.

Toxicology and health risk assessment of carbon nanomaterials (TRACER)

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Abstract
Nanomaterials and especially manufactured/engineered carbon nanotubes and nanofibers are well known as material with unique and extraordinary properties. Many potential applications have been proposed for carbon nanotubes in the fields automotive, aeronautic, semiconductor devices, polymer composites, field emission displays and medical devices. Some of these applications are now realized in products. Others are demonstrated in early to advanced devices. A key issue not only for producers and manufacturers of carbon nanotubes but also for end users of CNT containing products is the possible impact of carbon nanotubes and CNT containing products on human health. The TRACER-project deals with the risk assessment and toxicological studies of carbon nanotubes along the value-added chain.

Introduction
In this contribution we report about the TRACER-project funded by the German Federal Ministry of Education and Research (BMBF) as part of the WING program. The aim of the project is the assessment of the cytotoxicity and biocompatibility of carbon nanotubes and carbon nanofibers over the whole value-added chain from CNT/CNF-production via CNT-polymer composites to the processing of products from half-finished parts. Besides the raw material also dusts collected during production and processing of CNTs and CNT-polymer-composites will be assessed.

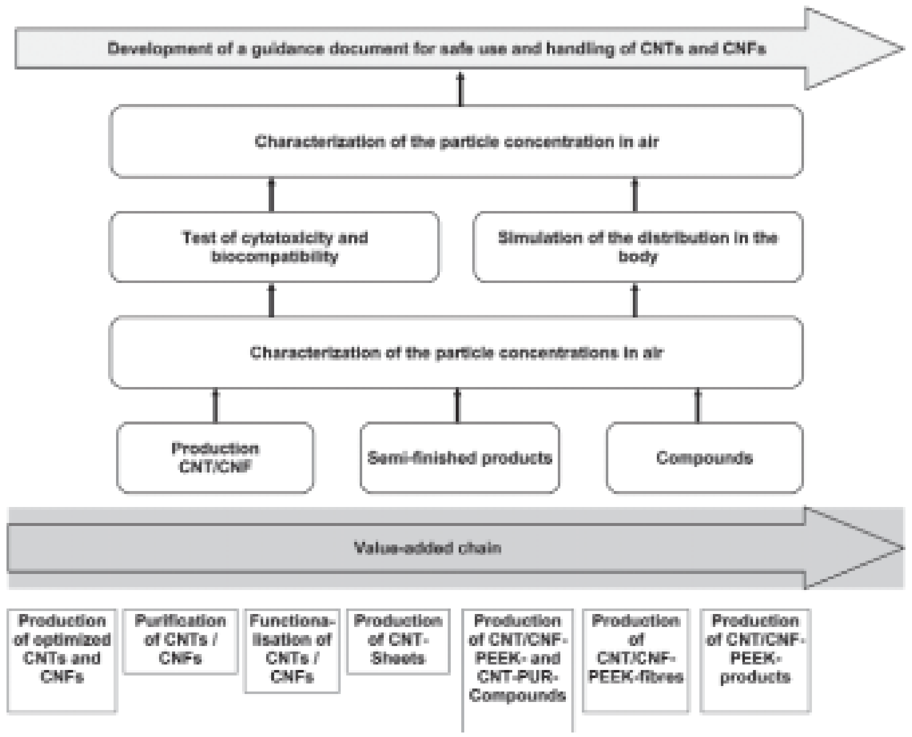
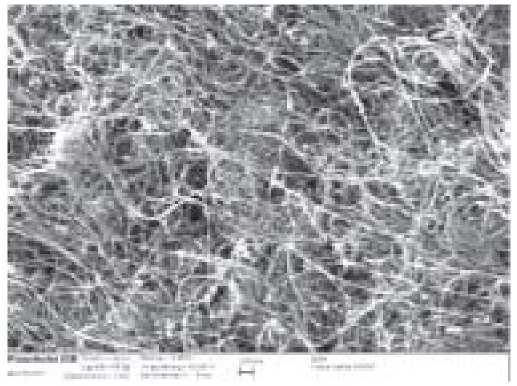


Figure 1: Cooperation scheme of the TRACER project



The various test materials (different in type, purity, kind and amount of remaining catalysts) are characterized by physico-chemical analyses like ESCA, RAMAN, SEM/EDX, TEM, BET and others. In Figure 2, a SEM-picture of MWNT-nanotubes is represented.

Figure 2: SEM figure of MWNT-nanotubes

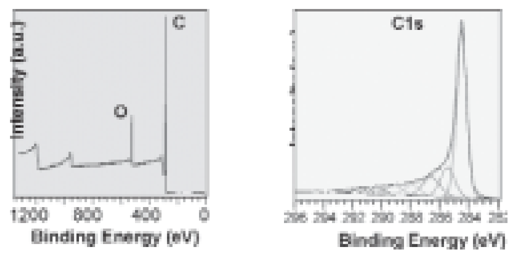
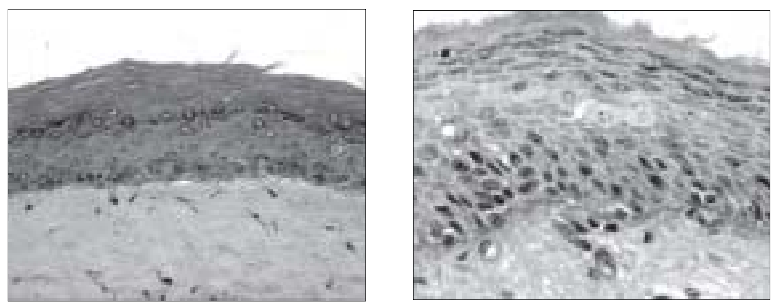


Figure 3 shows a survey spectra and a C1s -ESCA-spectra of carbon nanotubes with the typical tail at the higher binding energy site.
The amount of oxygen in the raw material depends on the production parameters and consecutive purification steps.

Figure 3: XPS-survey scan and C1s-detail scan spectra of a carbon nanotube sample

Cytotoxicity tests will be assessed with the aim to find correlations between physico-chemical parameters and, if traceable, a biological response.
To examine the biocompatibility and possible cytotoxicity characteristics according to DIN ISO 10993, we apply different kinds of dispersed and converted CNT materials in validated procedures. Relevant primary cells and cell lines with diverse CNT probes are incubated and, consequently, the proliferation attitudes as well as inflammation mediators are measured and compared with defined reference materials. Therefore, defined CNT-dispersions were facilitated in serum-rich culture media by ultrasound. Optical density and particle size distribution were measured after centrifugation. It has been shown that producing CNT-dispersions depending on particle size and catalyst material is possible. According to the reference material, the in vitro biocompatibility will be estimated with cell proliferation assays (WST-1), reactive oxygen species detection (ROS) and activation of immune cells (FACS).
In addition, established 3D tissue cultures (test-systems) composed of primary tissue specific cells where used to facilitate new information on how CNTs can penetrate the body barriers through the human skin or the respiratory tract. The 3D human skin model is shown in figure 4.



skin (in vitro) skin (in vivo)

Figure 4: Figures of in vitro and in-vivo skin used for the assessment of the cytotoxicity

The purpose of such a tissue engineered 3 D model is to evaluate organ specific influences of materials and nanomaterials on cellular level taking into account various interactions between different cell types. In order to optimize the selection of potential effectors, the test systems must mimic the human tissue with increasing accuracy. At the end of the project the dissemination attitudes in the human body of CNT materials which can cross the physiological barriers (skin or respiratory tract) will be examined in 3D vascularized test systems under perfusion conditions. The biological test-systems will be presented in detail.
Furthermore, the toxicological investigations will be accompanied by a current evaluation of the published data on the toxicity of CNTs and CNFs to bring recent information into the TRACER-project. In addition, findings on toxicity gained from in vitro studies will be compared with existing results from in vivo tests.

A further aspect of the project is the simulation of the particle distribution in the human body. A model to simulate the uptake, distribution and excretion of nanoparticles will be developed on the basis of an existing whole-body model up to now used for research and development of pharmaceutical agents. Modifications and supplements to the model are intended to describe the specific uptake and path of transport of nanoparticles in mammalian organisms. The analytical results as well as the results of the toxicity studies will be used to optimize the model.

Finally the results of the project are intended to give advices for the handling of CNT-materials and the appraisal of potential risks.

BMBF project INOS - evaluation of health risks of nanoparticles - a contribution to a sustainable development of nanotechnology

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Abstract
Nanoparticles, which are much smaller than human cells, are being used already in many products: cosmetics, paints or ires. These tiny particles are even a selling point for car-care products. So far, little research has been done to evaluate their impact on the environment and humans. However, experience with other emerging technologies has shown that they are only accepted by society if possible health effects are analysed and published early on.
INOS, the 'Identification and Assessment of the Effects of Engineered Nanoparticles on Human and Environmental Health' research project funded by the Federal Ministry of Education and Research (BMBF), now aims to shed light on these issues. The project involving five research partners aims to explore how ceramic and metallic nanoparticles and carbon nanotubes affect cells without performing tests on animals. The synthetic nanoparticles investigated are manufactured by project partners or already in use for engineering purposes. These nanoparticles are sheathed in oxide or organic films. The films are formed in practice during processing or are applied specifically to modify properties. These protective coatings can however influence how materials interact with water, cell culture media and cells. The nanoparticles are investigated – with and without protective sheaths, individually and as agglomerates – in cell cultures. This approach allows us to find out how the particles interact with cells of the skin, the lungs, intestine or nervous system. Do they cause DNA damage or have an effect on general cell functions and the immune system? The project aims to answer these questions. The findings will be made available to the public in a database. The project partners also intend to create an accredited laboratory, which will act as a point of contact for small and mid-sized enterprises in particular and carry out further analysis of nanoparticles.

Motivation
The research activities of Fraunhofer IKTS in the fields of nanoscaled powders, hardmetals and ceramics (Fig. 1), materials research at TU Dresden and Max Bergmann Center of Biomaterials and the manufacture of metallic nanopowders at NAMOS (Fig. 2) imply handling and processing of nanoparticles. The wish to develop products which are safe for producers and users led us to investigate health and environmental risks of nanoparticles.

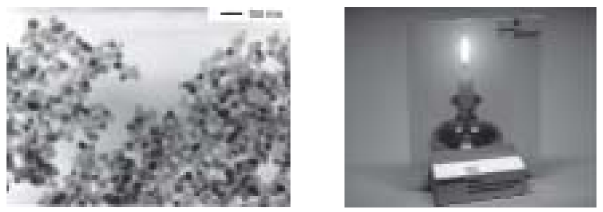

Figure 1:
Nanoscaled alumina powder and a alumina ceramic made from it. At reduced grain and defect size the ceramic becomes transparent (courtesy of A. Krell, IKTS).

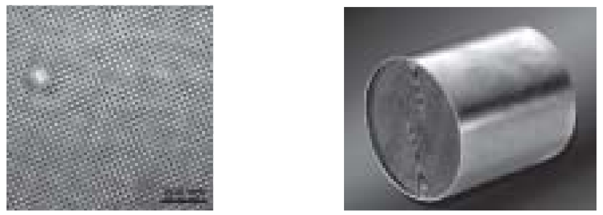

Figure 2:
S-Layer (Bacillus sphaericus) used as biotemplate for the manufacturing of nanoparticles by NAMOS and a catalyzer (courtesy of Interkat Katalysatoren GmbH)

Aims of INOS

The BMBF project initiated aims to investigate the interactions of nanoparticles and cells and understand underlying mechanisms. The behaviour of particles in aqueous systems is analysed and correlated to the reactions of the cells which are brought into contact with a nano-particle suspension (In-vitro investigation, in-vivo for validation, translocation). Generalized rules of cell-nanoparticle interaction, based on material-typical properties, are to be derived. The results will be published in a public data base.

Nanoparticles taken into consideration

The project focuses on particles in the transition between research and market. It includes nanoparticles used to make hard and wear-resistant materials like diamond, WC, Ti(CNO) with the ionic character of the bonding varying from 0% to 90% and the size of primary particles ranging between 20-200 nm. Furthermore, a metal-ceramic-mixture (WC-Co) and metallic nanoparticles like platinum or cobalt (4-10 nm) will be considered. Micro-crystalline powders will be tested for purpose of comparison. Due to their high importance in many scientific fields and their economic potential also the interaction of carbon nanotubes (CNT) and cells will be investigated.

Cell cultures used

Different cells like lung epithelial cells, intestinal epithelial cells, epidermal cells, different fish cell lines, a rat oligodendrocyte precursor cell line, rat primary culture of micro-glial cells, rat primary culture of astrocytes, rat primary culture of neurons and rat neuronal stem cells are used in the in-vitro experiments. A broad variety of end-points is investigated.

Results

A chemical reaction between nano-WC and salt solutions modifies the surface of the particles and the pH-value of the solution. The agglomeration behaviour is strongly influenced by proteins like albumin (BSA) or fetal bovine serum (FBS) added to the salt solution (Figures 3, 4).

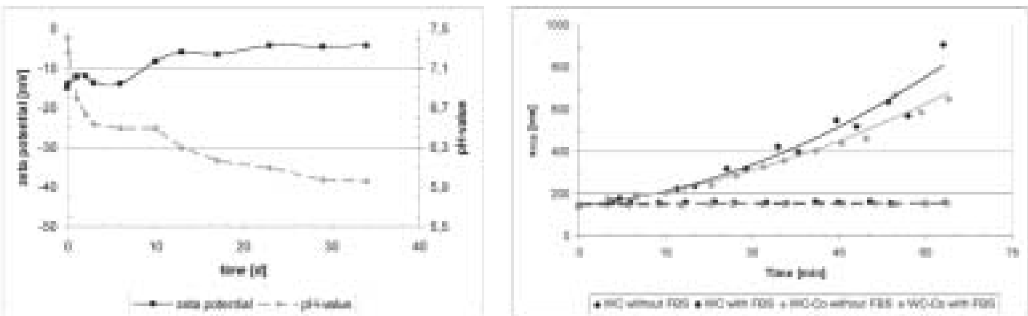

Figure 3: Zeta potential of WC particles and pH-value of a 154mM NaCl solution versus time (left); the agglomeration of WC and WC-Co particles in DMEM is suppressed by the addition of FBS (right)

The viability of cells is not or only slightly influenced by WC nanoparticles but clearly affected by WC-Co mixtures at higher dose (Figures 4 and 5).

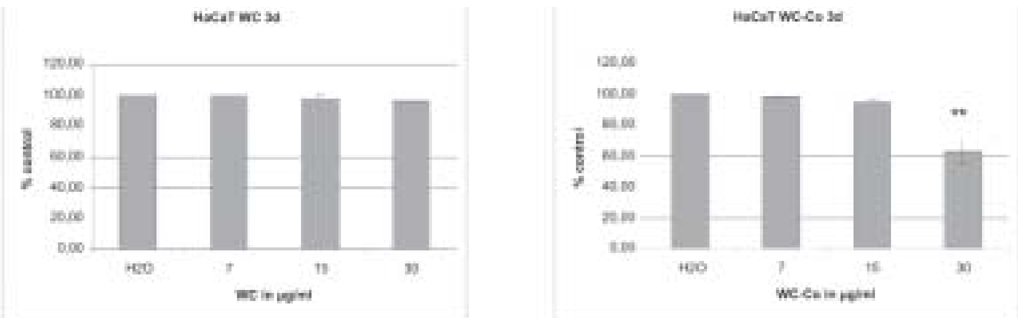

Figure 4: Viability after 3 days of exposure, measured with Neutral Red (HaCaT cell line)

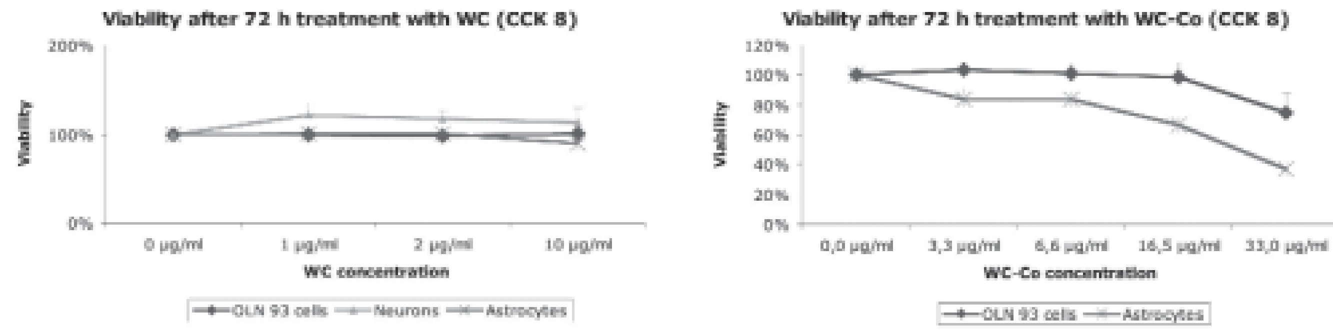

Figure 5: Viability after 3 days of exposure with WC and WC-Co, respectively (CKK 8)

The highest toxicity was found with nano-platinum of an extremely low primary particle size of only a few nanometers. This might be a hint that metals are more toxic than ceramic particles due to their higher dissolution rate in water (as shown for WC and Co) or underlines the importance of particle size and surface area. However, cobalt chloride dissolved in water reduced viability to a lesser degree than WC-Co particles at similar concentration. In the case of WC and WC-Co the particles seem to enrich in the neighbourhood of organelles (Figure 6).

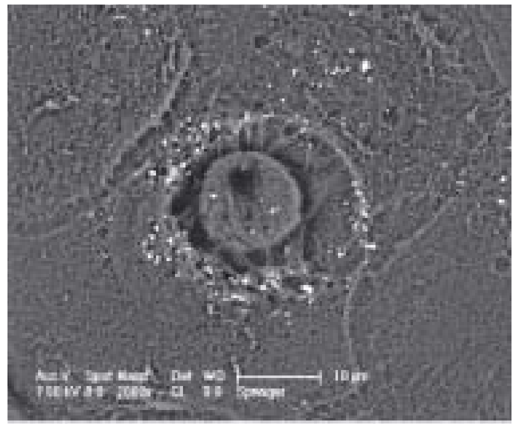

Figure 6: HaCaT cells exposed to WC nanoparticles with the WC-particle visualized by back scattered electron detector (BSE)

Localization as seen by scanning electron microscopy: particles show a pattern of localisation around the nucleus, which may indicate enrichment in membraneous structures. This assumption has to be verified by further studies.

Conclusions

WC particles are chemically modified by the physiological medium and change, vice versa, the physiological medium, for example, the pH-value of a salt solution. WC nanoparticles agglomerate in phosphate buffered saline (PBS) forming particles of micrometer size.

Proteins (bovine serum albumin, BSA) added to PBS stabilize the WC suspension, i. e. WC-nanoparticles exist as primary particles. Fetal bovine serum (FBS) acts in a similar manner as BSA. Pure tungsten carbide powder does not seem to have a significant effect on viability of different cells. Mixtures of tungsten carbide and cobalt seem to affect viability of cells at higher dose. The effect depends on cell type: glia cells are more sensitive than neurons. Metals seem to have a greater impact on cell viability than ceramic powders (due to dissolution?). Cobalt particles seem to have an even stronger affect than dissolved cobalt. Nano-WC seems to enrich in specific organelles of the cells. At the moment, several of the conclusions still have hypothetic character and have to be verified by on-going investigations.

Acknowledgement

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Risk management of nanotechnology from a life cycle perspective

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Abstract
Nanomaterials are predicted to have a strong influence on environmental health. These influences may be of beneficial or harmful nature. Nanomaterials have a wide application field and can be used for example for light weight materials, energy storage, and drug-delivery systems. However, nanomaterials have also been reported to cause toxic effects. A responsible development of nanomaterials will promote beneficial applications while safeguarding environmental health through effective risk management strategies. These strategies take place on many levels: the societal, the individual actor and the technological level.
In this presentation the results of a project investigating risk management strategies for nanomaterials with empirical data in regards to regulatory policy, industrial initiatives and results of life cycle screening tools will be presented.

Risk management approaches
The first study shows how different stakeholders approach nanomaterial risks in Europe and how they evaluate regulatory initiatives [1]. The objectives of this study were to understand where consensus points may be and which may be cooperative obstacles for risk management. The stakeholder study found that the type of regulation, industrial voluntary measures or topdown regulations and whether regulations should be proactive or evidence-oriented were cooperative obstacles.

Industrial voluntary measures are proposed as currently the most viable type of risk management, and therefore investigated another study how industry today approaches the issues of risks in regards to nanomaterial properties and risk assessment initiatives [2]. A written survey of 40 companies working with nanomaterials in Germany and Switzerland was conducted. It was found that the nanomaterials in this sample exhibited such a diversity of properties that a categorization according to risk and material issues could not be made. Twentysix companies (65%) indicated that they did not perform any risk assessment of their nanomaterials and 13 companies (32.5%) performed risk assessments sometimes or always. Fate of nanomaterials in the use and disposal stage received little attention by industry and the majority of companies did not foresee unintentional release of nanomaterials throughout the life cycle.

The stakeholder study also found that the state of scientific evidence and the implications for regulations were disputed. Therefore was the state of evidence of the nanomaterial carbon nanotubes (CNT) investigated. A technological risk assessment takes into account both the potential hazard as well as the potential exposure. CNT environmental health impacts were first reviewed [3] and thereafter potential release situations were investigated through life cycle case studies of potential CNT applications [4]. The findings of these studies suggest several key points: There are different types of CNT and therefore they cannot be considered a uniform group of substances. In environmental compartments CNT can be bioavailable to organisms and their properties suggest a possible accumulation along the food chain and high persistence. In organisms the absorption, distribution, metabolism, excretion and toxicity of CNT depend on the inherent physical and chemical characteristics, such as CNT functionalisation, coating, length and agglomeration state, which are influenced by the external environmental conditions during the CNT production, usage and disposal stages. The findings of the case studies suggest that a release of nanotubes can occur not only in the production phase, but also in the usage and disposal phases of nanotube applications. The likelihood and form of release is determined by the way CNT are incorporated into the material. Characterized exposure scenarios could therefore be useful when conducting toxicological studies. However, CNT will produce a toxic response once reaching the lungs in sufficient quantity, reactions produced in a time and dose dependent manner.

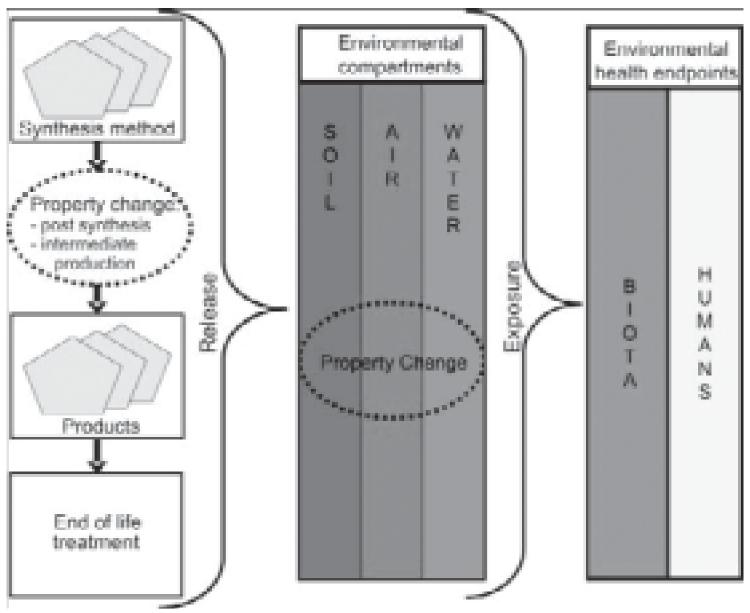

Figure 1: The life cycle and environmental fate of CNT [3]. CNT may change properties during the life cycle of the product and in the environmental compartments. Humans and biota may therefore be exposed to different types of CNT.

A major element of the effort to manage the risks of technology development will be the exploration and organization of mediating processes between different actors [5]. Many analysts agree that sustainability will remain a highly desirable, but unrealistic, option for technology development if people do not feel a degree of ownership and identity with the goal of the technology and a preference for its policy implications. Many targets of nanomaterial risk management on the societal level require voluntary collective actions by different players in society, most notably industry, government, unions, and environmental groups [6].

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Nanomaterials – the opportunities and challenges

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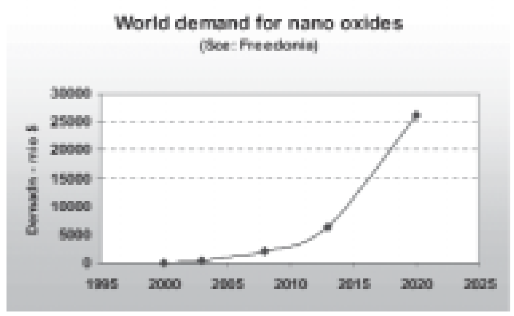
Umicore S.A, Olen (Belgium)

Abstract
The talk will present the authors views and experiences on the dilemmas facing new business ventures and the necessary trade offs between developing radical breakthrough and disruptive technologies with potential high gains and the risks of developing technically and commercially in unfamiliar territory.
The talk will endeavour to define the context, raise the appropriate questions but will not attempt to propose the solutions, but rather leave these for an open discussion either at the conference or afterwards.

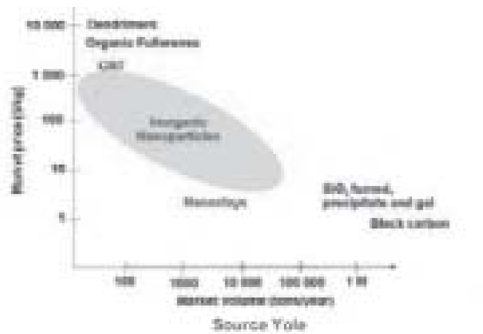
Outline
1. Umicore and nanomaterials
2. The prize for industry
3. The benefits to society
4. The hurdles and time to market for new nano scale materials
5. Summary and conclusions

1. Umicore and nano materials
- Umicore is a Belgium headquartered materials technology group with industrial and research facilities on all continents
- 17 180 employees / Sales € 8.8 billion / EBIT € 336 million
- Activities in both the manufacturing and recycling of various metals based materials – precious metals, germanium, cobalt, nickel, zinc...
- Focus on application areas where a combination of know-how in materials science, chemistry and metallurgy can make the difference
- Umicore has been involved for a long time in ultra fine materials and has been investing actively in nanomaterials since 1997
- Today Umicore is producing commercially specialty nano oxides with a combined production capacity of several hundred tons with an ongoing research programme to develop new applications and nanomaterials

2. The prize for industry

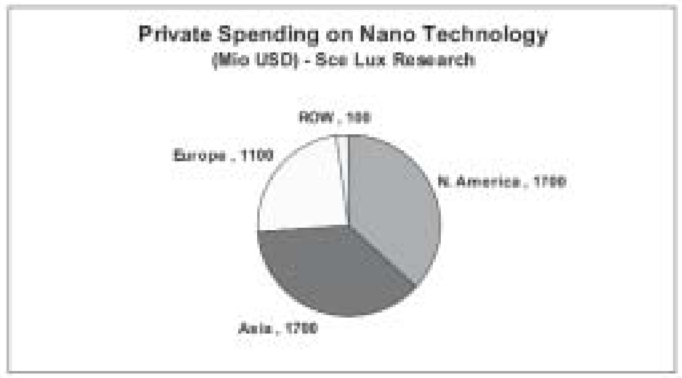


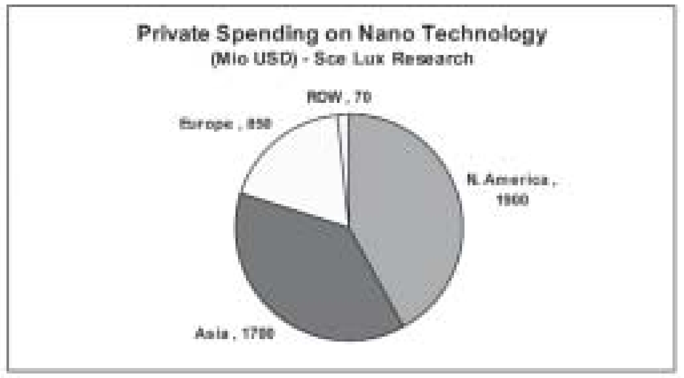
Strong growth is forecast in the adoption of nanomaterials – e.g. nano oxides due to their increased functionality.



One of the main challenges to industry is to bring this about at an acceptable cost.

Charts





In 2005

- More than US$ 9 billion was spent on nanotechnology
- Nano-enabled products were equivalent to US$ 30 billion (forecast to grow to US$ 2.6 trillion by 2014)
- Lux Research estimated that nano-enabled products earned a weighted average price premium of 11%

3. The benefits to society

Solve a number of society's problems, for example in the fields of:

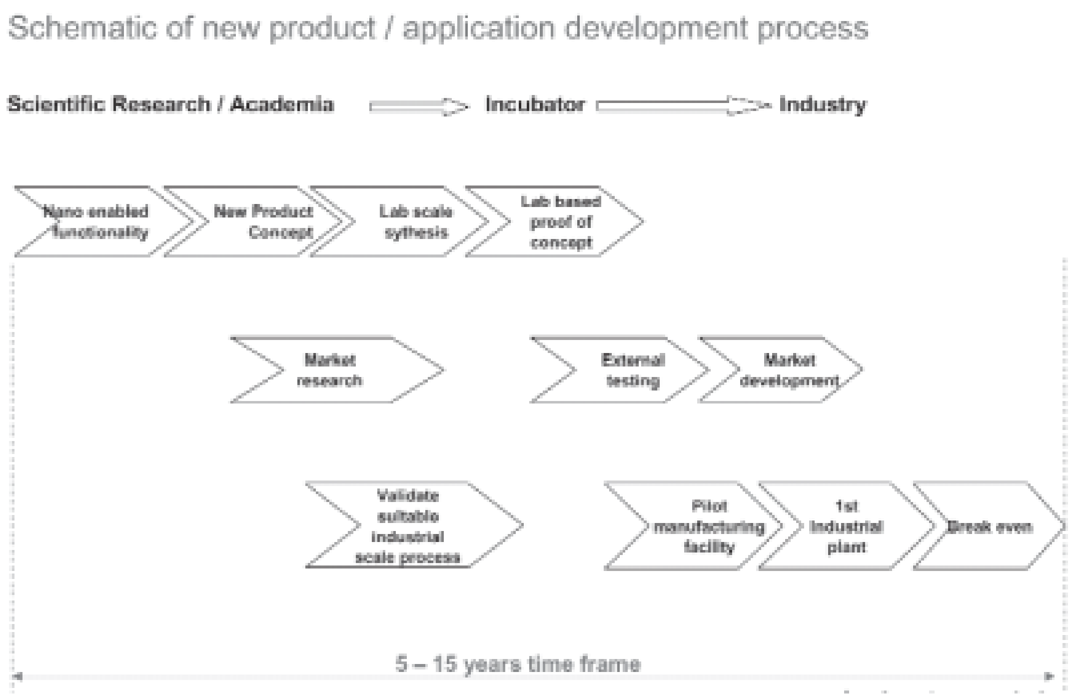
- Energy
  (solar, rechargeable batteries, emissions control........)
- Medicine
  (UV protection, targeted drug delivery, anti bacterial...)
- Electronics
  (miniaturisation, printed electronics-conductors/components...)
- ....
- ....

Introduce a new economic / industrial wave

- Revitalise existing businesses
- Create new industries
- Boost competitiveness overall for the winners

4. The hurdles and time to market for new nanoscale materials

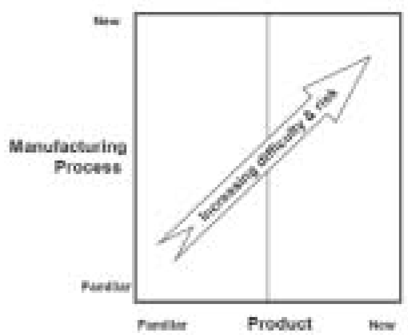
Schematic of new product / application development process



Product – manufacturing process

New products usually require new production processes.

Combining the development of a new production process with the optimisation of a new product is high risk and takes time



Product concept / functionality – market application

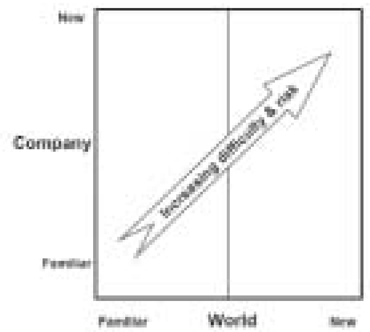
Convincing the market that a new product will resolve their problems or improve the performance of their own product is a long path.

Compounding this with a new application is increasing further the risk and time required to develop to a commercial stage.

New to world – new to Company

Nano is the case whereby the product developer is often not familiar with the market and its players. This can take an enormous amount of energy to become accepted by the market.

When the application is 'new to the world', this takes longer !



Other hurdles

- Patents – By 2005, there were almost 4000 US patents alone that had been issued since 1985 in the field of nanotechnology. Some of these patents appear at first sight spurious, but do exist and will require attention. There will be a lot of future negotiations on this subject.
- Environment, health & safety concerns are still very dominant in the public's perception and of the legislators pre-occupations. Most proactive companies are taking on the challenge and not waiting for legislation to define the rules. They assess the risks objectively and apply best working practise to protect their employees. However, a number of the questions currently on the table will take time to answer to everybody's satisfaction.

5. Summary and conclusions

- There are very clear potential benefits to industry and society by adopting nano technology.
- However, it has to be done in a responsible manner so as to ensure it is safe to the consumer and the producer and avoid a negative backlash from the public and the legislators.
- IP is likely to be an issue in the future
- By its nature, Nano is new to everyone in what it can do and how it is perceived. The barriers to developing new applications with new materials in new markets should not be underestimated. Stakeholders have to be made aware of the difficulties that this represents and the time lines typically required to bring such new ideas to a commercial success.
- Strong collaborative links need to be established between industry and academia to ensure that both sides expectations are in tune and met.

Nanoscaled titanium dioxide - use in coatings, plastics and cosmetics

Dr. Jochen Winkler

Titanium dioxide (TiO_2) is widely known as the economically most important pigment that is used in all composite materials and also in cosmetics to achieve a white appearance. The worldwide production capacity lays currently at about 4.6 million metric tons per year.

In order to be useful as a white pigment, a substance must fulfil a number of conditions. Firstly, it must not absorb light in the visible region between 380 and, say, 780 nm wavelength. Secondly, it must have a high polarizability, leading to a high refractive index, and, thirdly, it must have a particle diameter of approximately half the wave length of the incident light.

TiO_2 pigments are therefore manufactured to have a particle size of approximately 0.3 µm (or 300 nm), which is optimal for the scattering of visible light. When the size of the particles is reduced, the light scattering action, which is prerequisite for white appearance, diminishes. Nanoscaled TiO_2 products, if dispersed sufficiently and in a reasonable loading, may therefore be tailored to be next to transparent in use.

Whereas light scattering ability is greatly dependent upon particle size, light absorption is much less so. Therefore, nano-titanium dioxides are next to transparent, yet still have the UV-absorption characteristics similar to TiO_2-pigments, so they may be used as UV-absorbers to protect substrates and matrices from being damaged by harmful UV-light. For this, however, the intrinsic ability to act as a photocatalyst must be suppressed by doping the crystal lattices of the nano scaled TiO_2 particles with atoms that act as recombination sites for so called 'excitons'. Additonally, layers of inorganic matter are deposited on the particles to suppress their photoactivity.

Selective blue light scattering

Some of the uses of nano-titanium dioxides are based on their ability to selectively scatter blue light. Although the blue light scattering is not extremely pronounced, dramatic effects can be achieved both when combined with coloured pigments as well as when used in metallic base coats. In the first case, the selective blue light scattering leads to a change in the appearance of a coating to a bluish hue. So, when combined with a red pigment for example, the colour magenta is reached. With blue pigments, the colour becomes more saturated and 'cleaner', since a possible green hue is suppressed.

Whereas the colour impression is independent of the angle of observation in relation to the oncoming light when nano-titanium dioxides are used in normal, coloured coatings, this is no longer the case when they are put into metallic base coats. In this case, the light is first scattered by the nano-particles and then reflected by the metallic pigments in the base coat. Since red and green light is hardly scattered by the nano-titanium dioxide particles, it is reflected directly, whereas the blue light is first scattered and then reflected. Therefore, when viewing facially, it appears yellow (green plus red), whereas from a slanting view the coating looks blue. This so called 'Frost Effect' shown schematically in figure 1.

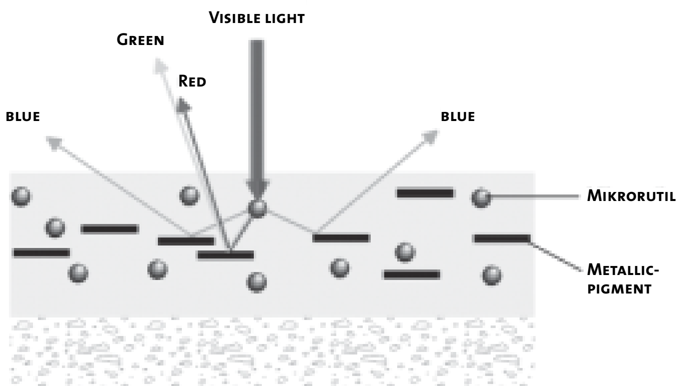


Figure 1: The Frost Effect

Stabilization of other pigments against flocculation

Like other nanoparticles, nano-titanium dioxides are able to stabilize pigments against flocculation in certain binder systems such as polyester / melamine or alkyd / melamine. In these resins, the nano-TiO_2 particles obtain a highly positive surface charge. By attaching to the flocculates of the coloured pigments, they force this charge onto all the pigment particles, which then repel each other, leading to an even distribution of all the pigment particles within the system. This not only improves the colour strength of the coating but also its gloss to a high degree. Figure 2 shows an electron microscopic image of a cross section of such a paint film. It can be seen that every coloured pigment particle (larger and light grey in colour) is surrounded by numerous nano-TiO_2 particles (smaller needle shaped particles) and that there is an even distribution without flocculation in the system.

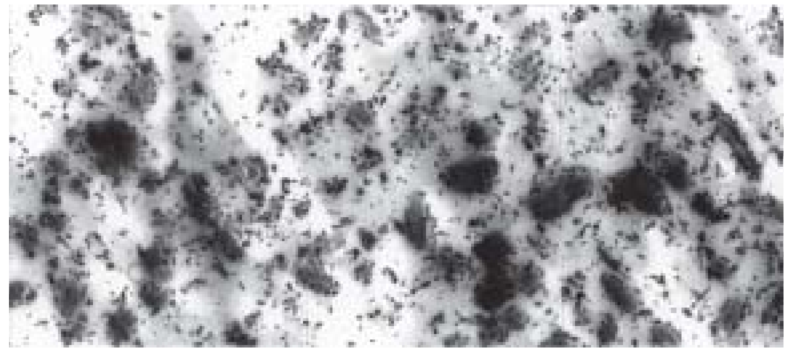


Figure 2:
Organic coloured pigments stabilized by nano-TiO_2 particles in a polyester / melamine topcoat.

Nano-TiO_2 as a photocatalyst

Titanium dioxide is photoactive material. When irradiated with UV-light, electrons from the valency band may be hoisted into the conduction band of the photo-semiconductor. The energy necessary for this to happen is different for the two crystal modifications, rutile and anatase. In the case of rutile, an energy of 3.05 eV (corresponding to light of 415 nm wave-length) is required, whereas anatase needs photons with an energy of 3.29 eV (415 nm).

From this ('excited') state with charge separation, which is called an 'exciton', the titanium dioxide is able to oxidize its surroundings in a first step and, in a second step, with the aid of moisture, to reduce oxygen to form very reactive hydroperoxide radicals.

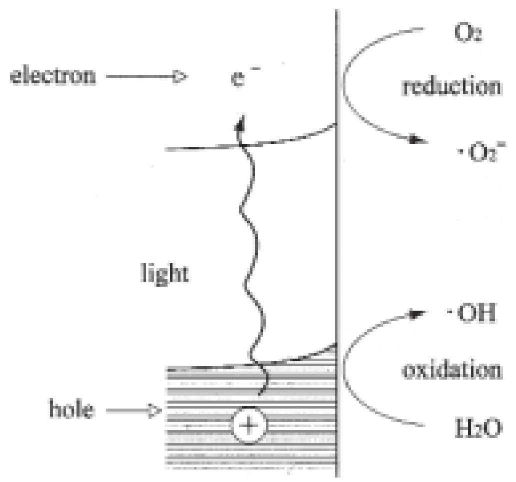


Figure 3
Photocatalytic activity of titanium dioxide

This makes un-stabilized titanium dioxide useful as a photocatalyst for example for water purification. A newer application is the use of titanium dioxide in so called 'self cleaning' coatings for indoor and outdoor use.

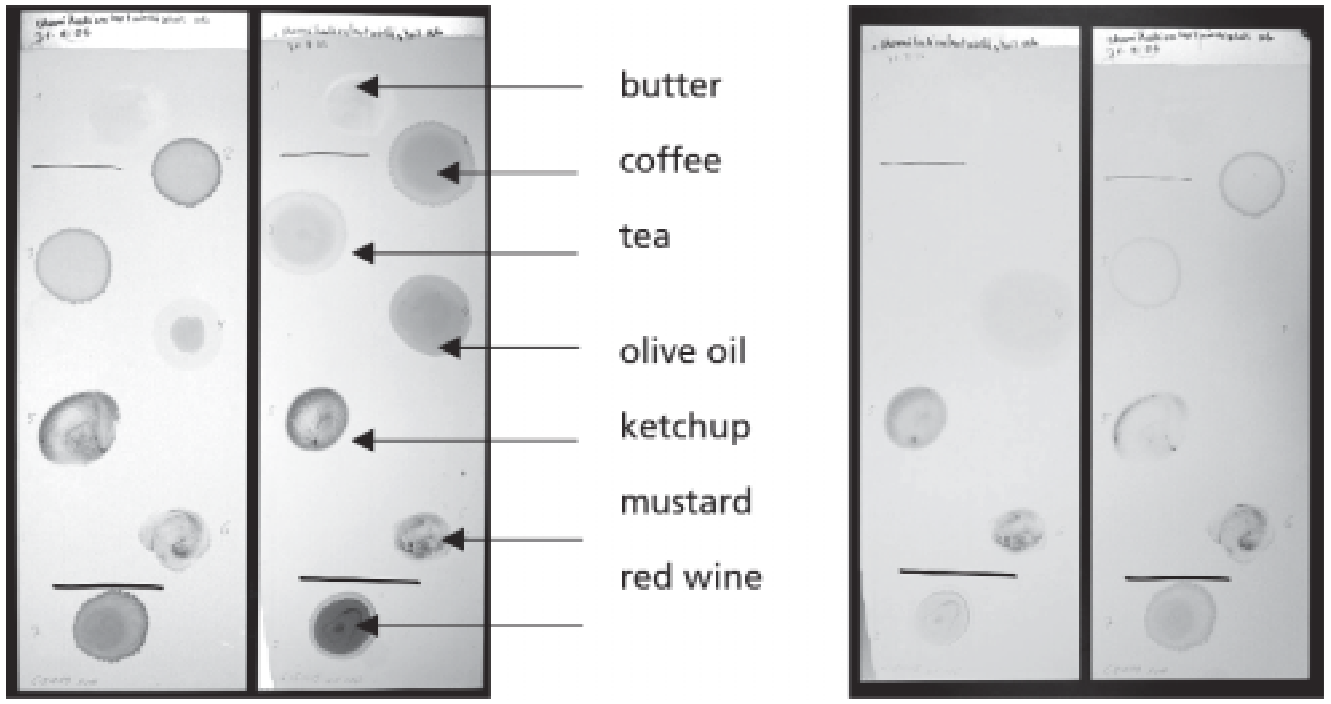


Figure 4
Stains of different foodstuffs on a coating with nano-TiO_2 after application (left) and after 18 days of indoor solar irradiation (right)

Nano-titanium dioxide as UV absorber
In order to suppress the photocatalytic activity of nano-TiO_2, the crystals are doped with other metal atoms and the surfaces are heavily coated with inorganic matter. This way, it is possible to avoid the photocatalytic activity almost completely, so that inorganic UV-absorbers are created that are used in sun screens to protect the human skin from harmful irradiation and in polymeric materials to protect either the matrix itself, or, otherwise, an underlying substrate. The latter is the case in, for example, transparent wood protection coatings.

Conclusions
Nanoscaled titanium dioxides are fairly new materials with a large scope of different application possibilities. Due to selective blue light scattering, they may be used in combination with coloured pigments to achieve very bright and 'clean' colours which are shifted to a bluish hue, or otherwise, when used in metallic base coats, to create the so called 'Frost Effect'. Like other nano-particles, they are able to stabilize pigments against flocculation in certain systems, leading to high gloss coatings. Depending upon their being surface treated or not, either their use as inorganic UV-absorbers or as photocatalytic materials prevail.

Fabrication of self-organised metallic nanostructures

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Self-organised metallic nanostructures are pursued for a potential use as arrays in nanotechnology. Nanowires and nanotubes are of special interest as they are 1-dimensional objects that can carry a function on one side and inherently provide a proper connection. Besides, they provide models to study the influence of dimensionality and size confinement on electrical transport, optical and other properties. Among the fabrication methods employed, some are based on vapour phase techniques, while others are solution techniques. Compared to physical methods such as nanolithography and other patterning techniques, chemical methods have been more versatile and effective in the synthesis of the nanowires.

Here, a novel combined method is presented for producing self-organised metallic nanostructures [1-2] which is especially applicable, but not restricted, to metals. It combines directional solidification of eutectic alloys with chemical and/or electrochemical processing. In the first step directional solidification of a eutectic alloy with fibrous morphology yields self-organised arrays of nanowires of a minor phase embedded in a matrix of the other phase. The process is based on simultaneous crystallization and aligned growth of two phases parallel to the direction of heat extraction. Directional solidification is commonly used to produce high strength materials for the application at high temperatures such as turbine blades. Thus, it may sound contradictory to apply a method that was developed to produce large single crystals to generate nanostructures. In the next step either metallic nanowires or nanopores may be produced. Metallic nanowires can be obtained from such eutectics by selective etching of the matrix.

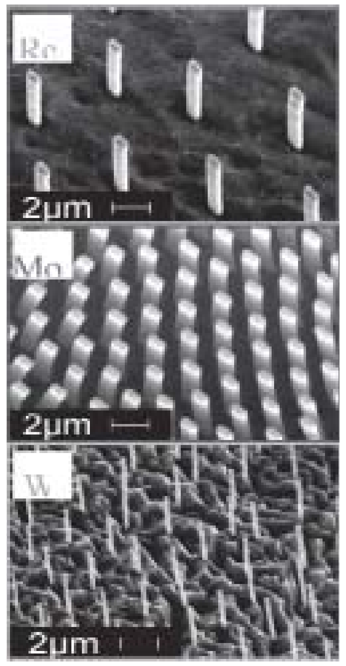

Figure 1. Nanowires of Re, W and Mo released from the NiAl matrix by selective etching

This method has several advantages. First of all, it is one of the few top-down methods that allow the production of large amounts of nanostructures. In addition, both wires and matrix are single crystalline which may favour them for certain applications. Further, the obtained nanostructures exhibit extremely high aspect ratios (>1000), unreachable by most of the techniques. Next, wire diameter and spacing can be controlled by the processing parameters such as growth rate and temperature gradient [3].

Moreover, the method is highly versatile and applicable to a broad range of materials for different applications. Finally, it combines well-established and industrially developed techniques, thus enabling immediate scaling-up and industrial application, as well as production at large scale and low costs. The feasibility of the method is demonstrated with the preparation of pseudo-binary NiAl-X (X = Re, W, Mo) eutectics (Figure 1).

The differences in the chemical properties namely nobility, passivity formation of insoluble precipitates, kinetic hindrance of dissolution are of great importance for the later processing of the material. The approach described here focuses on electrochemical methods for separating the phases of the *ds*-materials. As a starting point for the determination of optimal electrochemical conditions for the selective dissolution of either the wires or matrix phase the thermodynamic stability diagrams (Pourbaix diagrams) were employed [4]. These diagrams show the regions of stability for the various species (solid metal, ions of different valences, oxide and hydroxide species, etc.) as a function of the given pH and the electrochemical potential. By combining the diagrams for the individual elements it was possible to choose appropriate pH and potential for dissolving one phase while keeping the other phase in a passive or immune state. Figure 2 (see next page) shows such a combined Pourbaix diagram for the NiAl-W system. By choosing conditions where W is stable but Ni and Al corrode (pH 1.0, 200 mV SHE) the matrix can be dissolved while the W wires are mildly oxidized. Alternatively, choosing conditions where the passivates and W dissolves (pH 6.0, 500 mV) yields nanopores in the matrix NiAl matrix; it should be noted here that in the case of forming nanopores Al dominates the behaviour of the matrix phase allowing passivation of the NiAl phase [5].

Potential applications for these nanostructures can be seen e.g. in sensor and probing technologies. The feasibility of this approach was tested by preparing a W wire rigidly embedded in and electrically contacted to a thick stem (Figure 3).

The protruding wire was then applied to the acquisition of an STM image of HOPG test substrate. However, this technique enables not only the formation of nanowires, but also the production of nanopores, regarding the initial electrochemical polarisation is run under conditions which benefit from both the passivation of the NiAl matrix and the dissolution of the fibres (0.7 V for the studied systems). This procedure results in formation of a very stable passive NiAl substrate which presents an array of nanopores uniformly distributed in its structure.

The final product has a potential application as a substrate for the formation of nanosensors by electrodeposition of metals along the pores, as demonstrated by the deposition of gold in the pores left by the dissolution of Re and W fibres [6].

Figure 4 is a roadmap that summarizes the structures described here. After cutting a certain peace from a directionally solidified material an electrochemical step is employed in which one phase of the material is selectively dissolved in a well controlled way. This allows a tailoring of these self organised structures opening a number of possible applications such as sensors, STM tip, field emitter and basic material for physical characterisations.

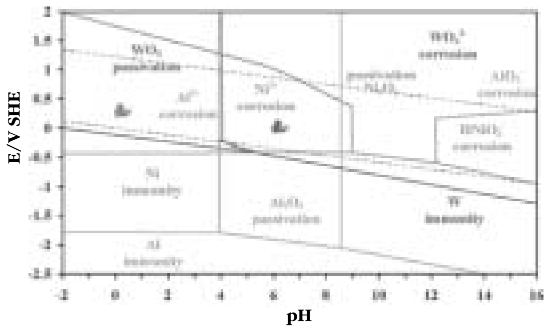

Figure 2. Combined Pourbaix diagram for the NiAl-W system.

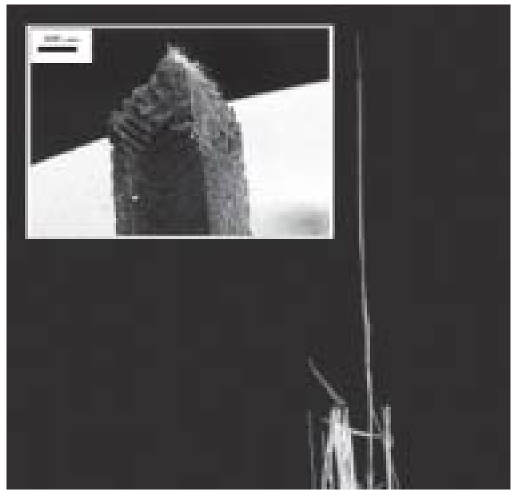

Figure 3. W nano wire tip prepared by electrochemical thinning of a directionally solidified material with subsequent cutting by a focussed ion beam.

Acknowledgements
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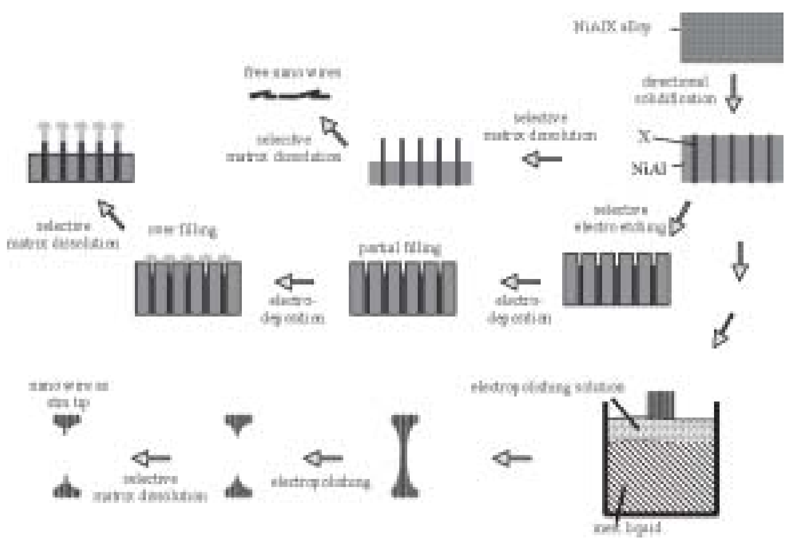

Figure 4. Roadmap of the different processes employed to prepare the various structures introduced here

NanoCentral : a pivotal gateway enabling the successful commercial use of nanomaterials

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Abstract
This paper highlights the challenges and opportunities associated with the commercialisation of nanomaterials. These challenges are being addressed through the creation of NanoCentral, a new hub-and-spoke industrial network with the aim of accelerating the commercialisation of nanomaterials. The network comprises a series of Technology Providers, who offer facilities and capabilities spanning the nanomaterial supply chain. Technology Providers capabilities and the growth of the network are described in this paper. In the short term, the success of the network is measured in the number of collaborative projects enabled by the NanoCentral Hub.

Commercialisation of nanomaterials
Nanomaterials are widely forecast to play an increasingly crucial role in market sectors as diverse as healthcare, plastics, coatings, electronics and energy. Their use offers enormous potential for product innovation, both in the creation of new products, exploiting new properties of nanomaterials, and in the revitalising of existing products extending product life cycles. However, exploitation of this potential is being hampered by a number of issues. Firstly, many businesses are unable to establish a reliable and connected supply chain to get nanomaterial containing products to market. Often there is a need to source suppliers covering several of the process steps typically making up the nanomaterial supply chain: Synthesis; Dispersion, Functionalisation and Formulation; and Applications Development. In addition there may well be novel requirements associated with material characterisation and Safety, Health and Environmental (SHE) considerations. Secondly, costs associated with producing nanomaterials are very often seen as prohibitive, even though there may well be enormous benefits. Thirdly, there are a vast number of providers of nanotechnology that cannot connect with the market place, either because they lack the appropriate commercial expertise or they are unable to identify relevant opportunities to link with the right people. All of these issues slow down the commercial introduction of nanomaterials and potentially impact economic growth.

NanoCentral
NanoCentral is a hub-and-spoke network supported by UK Government funding and backed by the Centre for Process Innovation. NanoCentral Hub has been set up at the Wilton Centre, Teesside, as the pivotal gateway enabling potential businesses looking to develop products using nanomaterials to connect with a network of key technology Providers. NanoCentral accelerates the commercialisation of value-adding nanomaterials by offering technical expertise and broad business experience that is strategically placed to create and increase awareness of the competitive advantages to be gained through nanomaterials. Additionally, NanoCentral believes that concerns relating to nanomaterial SHE must be adequately addressed by promoting access to targeted advice. Businesses are able to take advantage of a seamless and coherent service spanning Synthesis, Dispersion, Functionalisation and Formulation, Applications Development and Characterisation. NanoCentral also assists with the formation of supply chain collaborations to develop and exploit nanomaterials.

NanoCentral was initially formed with four Technology Providers: Johnson Matthey, ICI Measurement Science Group, QinetiQ Nanomaterials and the University of Liverpool. These organisations received funding to build new facilities that provide technical capability spanning the nanomaterial supply chain. The facilities can be accessed by organisations carrying out pre-competitive research and development, on an open-access basis, by paying an agreed tariff. Users of the network therefore benefit from being able to access leading edge facilities without significant capital investment and consequential risk, thereby delivering a significant boost to nanotechnology commercialisation. The initial group of four Providers has now expanded to over twenty.

Johnson Matthey: Liquid-feed flame-pyrolysis

This is a one-step process by which a metal precursor(s), dissolved in a solvent, is sprayed with an oxidising gas into a flame zone where the droplets are combusted and the precursor(s) converted into nano-sized metal or metal-oxides particles, depending on the metal and the operating conditions. This is a versatile technique, which allows for the use of a wide range of precursors, solvents and process conditions providing excellent control over particle size and composition. A wide range of materials can be synthesised including metals, metal oxides, mixed and doped metal oxides, and combination metal/metal oxide materials. Johnson Matthey has specialised in using the technique to make metallic nanoparticle catalysts and has developed considerable in-house expertise in this area. This knowledge is also transferable into other application areas. Johnson Matthey currently operates a reactor for producing small quantities (1-2 g/hr) of nanomaterials and is in the process of building a higher throughput reactor (typically 100 g/hr). This reactor will be available from July 2007 on an open-access basis.

QinetiQ Nanomaterials: Plasma processing

Since their formation in 2002 QinetiQ Nanomaterials (QNL) have developed and refined their plasma technology to manufacture a wide range of inorganic nanomaterials. These include complex, doped, alloyed and non-stoichiometric particles. Application areas of interest in development by QNL include their use as an antiviral agent in filters, coatings and healthcare products. Recent advances in the production technology will now enable a broader range of materials to be produced at small scale as part of the open-access COMINA facility, which will run at 100-500 g/hr scale and will be available from July 2007.

University of Liverpool: Ultra-high energy mixing

The mixing of fluids takes place by diffusion and by convection. The latter is usually a mechanically induced processes such as stirring. Both mechanisms are typically occurring on completely different length scales with diffusion being fast and efficient in the microlitre regime (micro fluidics), whereas mixing of macroscopic volumes depends chiefly on convective processes. While it is principally impossible to scale up diffusion, mechanical mixing can be made effective right down to the molecular scale provided high enough shear and/or dispersion forces can be applied. The facility to be fully operational at the University of Liverpool by autumn 2007 will house the world's first prototype research mixer that has been designed to do just that. The mixer, which was developed in collaboration with Unilever and Maelstrom APT, will consist of multiple feeds, and operate at up to 5000 bar and 10 – 250 ^{o}C. This will give access to completely new properties of fluids by mechanical mixing and re-organisation of matter on the nanometre length scale, i.e. down to the size of individual molecules. For example, traditionally heterogeneous systems such as emulsions, could be homogenised down to a domain size of a few nanometres, which will result in different optical, rheological and chemical properties.

ICI Measurement Science Group: Characterisation of nanomaterials

The development of new materials having structure on the nanometre scale raises many challenges in the area of measurement science. The aim of such work is of course to achieve enhanced properties (such as toughness, clarity or electrical conduction) in the final product, and a typical approach is the incorporation of nanoscale fillers within a matrix, which is often polymeric. Measurement is key to all stages in the process – from knowledge of filler properties, through an understanding of how uniformly dispersed the filler is in a matrix, to the characterisation of the effect of the filler on the final physical properties. ICI MSG has a broad range of characterisation capabilities and have recently invested in new photon cross correlation spectroscopy and a highly instrumented injection moulding capability. Further developments will include acoustic methods for characterisation of particle size distributions in dense media.

A growing network of technology providers

NanoCentral continuously scans the technological and market environments to identify capability gaps. Additional Providers already recruited include:

- CEMMNT – a characterisation and metrology network involving BAE Systems, Loughborough University, QinetiQ, NPL, Taylor Hobson and Coventor

- HARMAN technology – high shear aqueous precipitation and multilayer coatings
- IGM Resins – nano-resins and dispersions
- Ilika – high throughput screening
- Imerys Minerals Ltd. – mixing and grinding
- Institute of Occupational Medicine – SAFEnano programme (SHE)
- MacDermid Autotype – coatings onto plastic substrates
- Maelstrom APT – mixing and dispersing
- Netzsch – nano beadmilling
- Noveon – Supplier of dispersants for nanomaterials

These Providers operate on a commercial basis. Discussions are currently under way with a further series of potential Providers.

Collaborative research

In the short term, the success of NanoCentral can be measured in the number of collaborative projects underway. Active marketing began in September 2006, and at the present date, May 2007, forty projects are underway, at various stages from prospecting, scoping, work in progress through to complete. This success validates the need for NanoCentral and the value in collaborative research. NanoCentral is interested in hearing from any organisation that may be interested in using our network or becoming a network Provider.

The quest for ultimate patterning tools and techniques - focused ion beams: status, future applications and new ideas

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Abstract
The aim of this presentation is to present our results and new ideas aiming to explore the nano-structuring potential of ultimately focussed pencils of ions and charged clusters. We will show that Focused Ion Beam technology (FIB) is capable of overcoming some basic limitations of current nano-fabrication techniques and to allow innovative patterning schemes, in particular for nanoscience. We will first detail the very high resolution FIB instrumental approach we have developed specifically to meet nano-fabrication requirements. Then, we briefly introduce and illustrate some new patterning schemes we are currently exploring for next generation FIB processing. These patterning schemes are (i) Highly charged ions (HCI) as projectiles for intense and defect-free potential sputtering; (ii) Local guiding, focusing and deposition of metal cluster beams; (iii) High brightness noble gas ion beams for sub-nanometre scale patterning and inspection.

The development of effective nanofabrication tools and processes are keys to the advancement of miniaturization into the nanometric regimes, thus enabling novel breakthroughs in important technologies, such as for example in electronics, data storage and biology. In this context, reproducible patterning and direct imaging with lateral dimensions down to the scale of one nanometer or even below remains a challenging, but attractive concept for many application purposes. Here is a clear demand for direct, i.e. resistless patterning techniques that would combine high-resolution capabilities together with reasonable throughput, costs and complexity. In principle, an ion beam can be focused to the scale of single atoms or molecules, if the image spot can be made small enough. This 'pencil-beam' nanoprobe could be used to locally remove material, create nanostructures, new alloys or compounds, enhance surface reactivity or surface chemistry, all at the scale of nanometres. One can even foresee the atomic-level deposition of low-energy selected particles.

1. NanoFIB: Highest demonstrated patterning resolution

In this first part, we will present our work aiming to explore the nano-structuring potential of a highly focussed pencil of Gallium ions that was started under the EC-funded NanoFIB project (GRD-CT-2000-00344) [1]. Starting this project, we were anticipating that the gallium-based Focused Ion Beam technology (FIB) was capable of overcoming some basic limitations of current nanofabrication techniques and to allow innovative patterning schemes. Our effort concentrated on:

1.1. A high performance gallium Liquid Metal Ion Source
Liquid Metal Ion Sources (LMIS) were introduced in the late seventies, allowing the development of focused ion beams. The LMIS has been shown to be a remarkably high brightness source for a large number of ionic species. As a result, these ion sources have allowed the development of the highly successful FIB technology [2]. The very high brightness and small source size of the LMIS, and its easy handling, remain its chief and most decisive advantages. We have developed and optimised a Gallium ion source geometry which is described elsewhere [3]. We will describe our emitter that is extremely stable and allows long unattended nanofabrication processes. This stability is a first basic requirement for nanofabrication purposes, the second related to 'brightness' or on-axis angular intensity reaches the record value of 80 µA/sr.

1.2. A non compromise and innovative ion optics
The instrument we have developed is dedicated to one key application: nano-fabrication i.e. direct patterning at the sub-10 nm scale. This ion optics was designed to allow the routine generation of ion probes with FWHM diameters well below 10 nanometres. The performance of this high-resolution ion optics column were calculated for various configurations using state-of-the-art theory and modelling software, described elsewhere [4], giving an optimum value of the spot diameter about 5 nm (FWHM). Nevertheless, if the FWHM spot diameter is essential for direct FIB nano-fabrication processes, another crucial parameter is the shape of the ion probe current density profile at the target plane. We have patented our column design that allows a strong reduction of the so-called tails in the generated FIB probes. It is the result of our analysis and experience, that injecting wide spread gallium ions from a LMIS into a condenser lens will allow, on one hand to easily maximize the probe current. On the other hand, ions with perturbed trajectories will be redirected onto the target following unpredictable paths. As a result, these atypical paths will cause non-negligible spreading of particles away of the central distribution axis. This is the main cause of the deleterious tails often reported in FIB probes that are impossible to control afterwards at the user side. This is the base of our patented approach and, in addition, we have also developed specific methods for shaping the FIB probe with settings different from those for 'best focus' images.

1.3. A dedicated 'Nanowriter' instrument architecture
We will present the instrument that was finally integrated as a FIB nanowriter with additional functionalities such as pattern placement, beam handling, scanning and imaging with fully automated 'intelligent instrument' architecture. The specimen stage possesses 6" travel range and up to 8" wafer handling capability. This highly accurate stage is controlled by a 2-axis Michelson-laser interferometer with a physical resolution of 2 nm, allowing stitching capabilities. A three point height piezo levelling system ensures stable working distance over a wafer with precise height adjustment. Beam handling is achieved via a 10 MHz pattern generator governing the ion beam allows the very large (6 orders of magnitude) dose range required for FIB applications required for imaging and direct patterning (within a single writing field). Innovative writing schemes have been added such as fixed beam moving stage allowing stitching-free writing of elongated structures over mm at nm-sized resolution and pattern placement. A general control software for the complete instrument was finally developed giving the instrument automated operation with diagnostic and auto-correction platform allows to combine wafer navigation with multilayer direct GDSII-based exposure capabilities. The exposure routine dwell time can be increased up to the very large dose range required for FIB applications. This capability allows very high patterning speeds (low pixel dwell times down to 100 ns/point) as well as milling tasks (high pixel dwell times, several ms/point) to define reference marks.

1.4. Unrivalled performance level: Direct nano-engraving of sub-5nm artificial nanopores
Amongst several application examples that will be detailed in the presentation, we have selected to highlight in this abstract the application of direct nano-engraving of sub-5nm artificial nanopores. Translocation of molecules through a nanopore that is a key method of biological control. As already shown [5], the translocation of one single molecule through a nanopore can be detected if this nanopore has an adequate size and thickness. When a macromolecule (transported by electrophoresis) enters this nanopore, it will prevent the ions from conducting the current in the pore and will result in a current blockade. The main technological aspect there was to define a nanopore size below 5 nm and then to ensure the integration of the membrane in an accurate setup allowing the measurement to be made. In this experiment, we have used SiC films with a thickness of 20 nm. Figure 1 shows some of the smallest nanopores we were capable to define. The dose necessary to drill such nanopores stands around $1x10^6$ ions/point. The evidence of opening is made by TEM observation of a white Fresnel diffraction annulus around the white spot. The nanopores we have fabricated (on a 20 nm thick SiC membrane) exhibit an average diameter of 4.5 nm, with a minimum diameter of 2.5 nm [6]. These FIB-drilled nanopores are almost spherical, even if the border of some holes appears jagged, being limited by the grain structure of the SiC foil. The damaged zone surrounding each nanopore is approximately 15 nm wide, a value in perfect agreement with collisional straggling effects generated by the 5 nm probe.

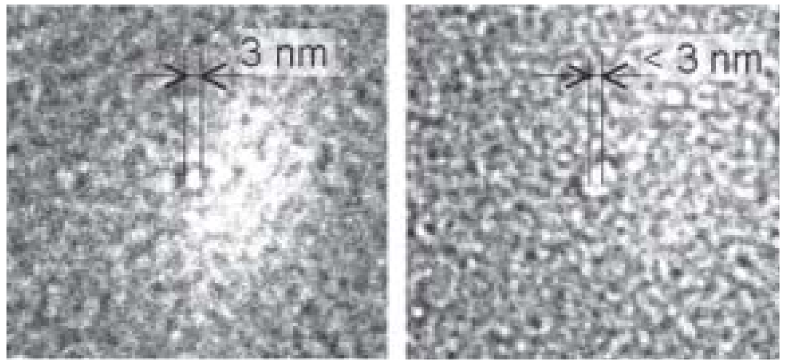

Fig 1: 50 nm x 50 nm transmission electron microscopy images showing a nanometre-sized pore (bright) drilled in a 20 nm thick membrane for the same point dose ~10^6 ions.

2. Future applications and new ideas for FIB technology

2.1. Highly charged ions as projectiles for defect-free potential sputtering

The sputtering of solid surfaces induced by accelerated ions has been extensively studied over the past years and the effect of the kinetic energy of incident ions on sputtering is widely used in techniques such as Focused Ion Beam (FIB). The availability of a new class of projectiles, slow highly charged ions (HCIs), would enable the creation of nanometre-scale structures in the surface without causing implantation-like damages in deeper layers of the solid. Compared to kinetic sputtering (i.e., sputtering of target atoms due to momentum transfer trough multiple collision cascades), which unavoidably generate damage in deeper layers, sputtering induced by the potential energy of slow highly charged ions, termed potential sputtering, holds great promise as a tool for more gentle nano-structuring [7]. We have started to explore this research field by coupling a HCI source with our NanoFIB machine. The ion source we have used was engineered to meet the requirements of both allowing appropriate ion beam emittance and reliability, and also ease of use in the implementation and operation of the FIB machine. The ion source (so-called Dresden EBIT) [8], coupled with our NanoFIB were routinely and reliably operated over several months allowing the production of noble gas ions. Evaluation tests on imaging and patterning potential were successfully achieved using helium, Neon, Argon and Krypton gases with promising results in the direction of 'clean patterning' using noble gases [9]

2.2. Local deposition of nanometre-sized charged metal clusters.

Even if an extremely wide variety of LMIS have been developed since the middle of the 70's, today this emitter is almost exclusively known as a Ga^+ ion emitter. Nevertheless others ion species can be also produced. The most important to date are pure elements including Al, As, Au, B, Be, Bi, Cs, Cu, Ga, Ge, Fe, In, Li, Pb, P, Pd, Si, Sn, U, and Zn. In addition, elements such as As, B, Be, and Si may be also produced using metal alloys [10]. Even if the LMIS remains the highest brightness metal ion source ever fabricated, in practice elements other than gallium are not very popular in FIB technology. This is mainly because of the important energy width of the emitted beams. Consequently, the chromatic aberration contribution term in the transported beam becomes too large to allow deep sub-micrometer focusing and deposition. In this last project, we are exploring the idea to focus, guide, count and depose a beam of such LMIS emitted particles (ions or charged clusters from a given metal or alloy) at selected places on a sample. The UHV set-up we are developing, which is described elsewhere [11] consists of injecting a LMIS emitted beam, operated in high emission current mode (20-50 µA) in an ion optics terminated with a movable objective lens, working in the immediate vicinity of the sample surface. This lens allowing adjustment of the charged particle landing energy avoids fragmentation effects of deposited metal clusters, while ensuring a good adhesion/embedding, when they impinge on the surface. We have already demonstrated that it was possible to condense such clusters (gold) on a sample surface retaining the dimensions of the free particles emitted by the source (2 to 5 nm). Interestingly, surface diffusion effects of the deposited islands appear limited [12]. These remarkable properties attributed to the sufficiently high landing energy used in our experiments should be very promising for organising and improving the seeding of structures like nanowires [13] and for direct and high quality metal interconnects fabrication at the nanometre scale.

2.3. High brightness noble gas ion beams for ultimate patterning.

This project aims to develop a nano-patterning and imaging instrument for bridging the 'Top Down – Bottom Up' gap and hence allowing decisive advances in nanosciences and nanotechnologies. The key innovation is the development and integration of a high brightness, monochromatic noble gas ion beam into our FIB nanowriter. We have started the development of a compact, stable and low temperature source stage capable of cooling a tip below 10 K. We are now investigating and developing tip models and engineering techniques allowing the 'supertip' emission mode of a noble gas ion beam [14]. Our technological goal here is to develop and validate the concept of such an ultimate patterning instrument, by developing an advanced FIB concept able to provide sub-1 nm imaging and to carry out patterning. The first technological node identified in our project was to develop a low temperature fridge mechanically stable allowing the production of a high brightness beam of noble gas ions (He, Ne) to be coupled with our NanoFIB platform. This first step has already been achieved with a 4.2 K temperature and a p-p vibration level below the one nanometre level. It is worth mentioning that a FIB patterning process free from residual Gallium ions 'left behind' and suffering from very little scattering at sample surface will open a new class of applications for nanoscience. It is also clear that such a source holds great promises in terms of resolution since its virtual source size is estimated around 0.5 nm and the energy width around 1 eV. Without to mention the record brightness of $5x10^9$ A/cm²sr, these values are respectively 10 times and 5 times lower than for a Ga LMIS. Narrowly focusing such noble gas ion beams and scanning them across the substrate, imaging and creation of feature sizes in the sub-nanometre range should be made possible. Thus extending and developing the new paths we have pioneering under the NanoFIB project.

In this presentation, our aim will be to present our results and some new ideas our motivated and expert group has started to work on. We are aiming to explore the complete nano-structuring potential of ultimately focussed pencils of charged particles following the route and benefiting of the expertise gained during the NanoFIB project development and exploitation phases that are not terminated.

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From nanosensors to the artificial nerves and neurons

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Abstract
A superconducting field-effect transistor (SuFET) based transducer (sensor) with carbon nanotubes (CNT) or pickup coil kind of input circuit for the nerve and neuron impulses has been designed. A nanoSuFET with a high-temperature superconducting channel is introduced into the nerve fibre or brain tissue for transducing their signals in both directions. The range of picked up signals varies from 0.6 nA to 10 μA with frequencies from 20 to 2000 Hz. The output signal lies in the range of -5 - 5V $7\cdot10^{17}/cm^3$ molecules and 2 - 10 pH.

Nanosensors: the input signals and flows
There are a number of methods and devices for transducing different biosignals (BSs) into recordable or measurable information. The transfer of nerve impulses (NIs) is the main data flow which carries sensory information to the brain and control signals from it and the spinal cord to the limbs. That is why detecting currents between neighbouring neurons and ionic currents in the nerve fibres is an important area of research. Electric-field control of physical properties is highly desirable from fundamental and technological viewpoints because it does not introduce any chemical or microscopic structural disorder in the pristine material. This is also the basis of FETs, in which accumulation, depletion, and inversion layers are formed at the interface. Moreover, the complex view on BSs requires further stages of precise processing in order to decode the received or control information.

As an electrical signal, the BS has two components: electrical potential or voltage and ionic currents. The first component is sufficiently developed and does not require penetration into the substances of BS propagation. The marketable progress in transducing of the second component began when the necessary instrumentation for measurement of micro and nano dimensions had been created.

The main informational flux from organs of the senses to motor nerves is transmitted through nerve fibres which consist of a myelin shield with axons as a core (Fig. 1). Recent research results suggest that such an arrangement is similar to a transmission line. The nerve impulse in motor nerve of a frog is equal to 2 nA. Synaptic currents between first order neighbouring neurons into in vivo or brain slice preparations have an order of 50 pA.

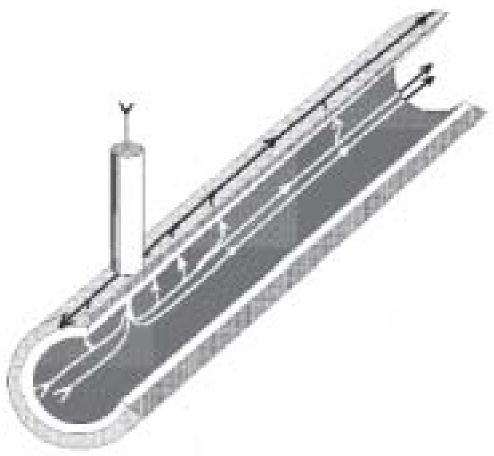

Fig.1 Longitidinal section of an axon showing a few lines of current flow

The components for superconducting nanosensors
Superconducting nanowires are unusual in that they newer show zero resistance, although resistance does exponentially upon cooling. A new class of metallic devices based on DNA molecules is promising due to the self-assembly properties of DNA. As the resistance of the devices is controlled by the spatial profile of superconducting phase within the leads, there is the potential for applications. These include local magnetometry (as is widely done with conventional SQUID) and the imaging of phase profiles created by supercurrents—in essence a superconducting phase gradiometer.
Traditional materials have been pushed to their limits, which means that entirely new materials (such as high-kappa gate dielectrics and metal gate electrodes), and new device structures are required. Entirely new device structures (such as nanowire or molecular devices) and computational paradigms will almost certainly be needed to improve performance. The development of new nanoscale electronic devices and materials places increasingly stringent requirements on metrology.

Organic FETs (OFETs) are of great interest for future electroritic applications due to their flexibility. Up to now, a lot of fabrication processes or device configurations of OFETs have been reported. Most of them were based on thin film technique

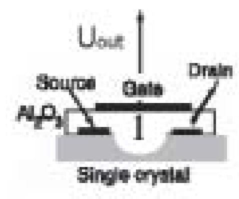

Fig.2 An organic SuFET device and its electrodes

such as vapor deposition. In general, the thin films for example, amorphous, poly crystalline, polymeric, and so on, consist of grains, and therefore, charge carriers behave as hopping conduction. This decreases the field-effect mobility of devices. Thus, annealing the organic thin films or surface preparations of substrate grows grains, and consequently these devices have few boundaries of grains between source and drain electrodes (Fig. 2).

Devices for matching of biosignal to electronic element (circuit)
Creative integration of microchip technologies and nanostructures is feasible. By tuning the dielectrophoretic frequency within a microdevice, nanoparticles can be manipulated with the same precision as cells because a one-to-one correspondence exists between a given alternating current frequency and a nanoparticle interaction or biological event. Multiple biological events could be probed simultaneously provided that their corresponding frequencies are distinct. Combined with electroporation, electrokinetics also enables inclusion of molecular complexes inside the cells. Alternatively, functionalized nanoposts can be used to impale cells and relay information from the cell interior to nanoelectronic circuits. By merging the fields of microfluidics, electrokinetics, and cell biology, microchips are capable of creating tiny, mobile laboratories. The challenge for the future of designing a nano-interface in a microfluidic chip to probe a living cell lies in seamlessly integrating techniques into a robust and versatile, yet reliable, platform.

A planar FET can be configured as a sensor by modifying the gate oxide (without gate electrode) with molecular receptors or a selective membrane for the analyte of interest. Binding of a charged species then results in depletion or accumulation of carriers within the transistor structure. An attractive feature of such chemically sensitive FETs is that binding can be monitored by a direct change in conductance or related electrical property, although the sensitivity and potential for integration are limited. The so-called floating gate architecture combines a complementary metal oxide semiconductor (CMOS)-type n-channel FET with an independent sensing area for recording extracellular signals from electrogenic cells was presented. This concept allows the transistor and sensing area to be optimised separately. The noise level of the devices was smaller than of comparable non-metallised gate FETs. The potential of NW nanosensors with direct, highly sensitive real-time detection of chemical and biological species in aqueous solution has been demonstrated.

The report shows how the scientists fabricate FETs from CNT with the precise electrical properties and any variable band-gap desired. In parallel studies of CNT, researchers have been working to improve the electrical characteristics of individual nanotube transistors (Fig. 3).

Fig.3 Schematic of nanosensor in the parallel connection

The main arrangements of nanosensors
Among the variety of the above presented FET devices there are majority of them, mainly modifications of nanoFETs, which allow simultaneous processing of a number of BSs directly or from the pickup coils. There are two factors that make simultaneous processing possible. First of all, the sizes of nanoFETs and nanopickup coils are in the same order as the transmitting substances of BSs, such as axons, neurons, and the DNA spiral. Secondly, the cNW-FET array is, in itself, multiinput.

The remaining part of FET devices are applicable for serial connection to the said mediums. In addition, some of these FETs can be arranged in the chain in order to transduce the BSs into different physical and chemical quantities and vice versa.

Results
Application variety of the novel superconducting, organic and CNT FETs allows us to design transducers of BSs (electronic, nerve, DNA, etc.) that transduce them into different quantities, including electric voltage, density of chemical and biomolecules. On the other hand, the said BSs can be controlled by the applied electrical signals, or bio and chemical mediums.
The described nanosensors (SuFETTrs) designed on the basis of organic and nano SuFETs are suitable for describing the wide

range of BS dynamical parameters. Following the columns of the table, it should be noticeable, that serial connection of the external pickup coils allows us to gain some integrated signal, i.e., the whole sensing or control electronic or NI, which spreads along the number of axons of the nerve fibre; the amount of ions passing through the pickup coils and the generalized BS passing through one or both spirals of DNA. When SuFET channel(s) of are implanted into the tissue or process we can acquire more precise data about the frequency distribution of NIs, volume distribution of ionized molecules and detecting activity of individual nucleoteds.

The preliminary calculations confirm the possibility of broadening the SuFETTr's action from magnetic field to the biochemical medium of BSs. The main parameters of such BSs can be gained by applying the arrangement of the SuFETTr(s) to the whole measurement system. Two directions of SuFETTr function enable decoding of the BS by comparing the result of its action on some process or organ with an action on them of the simulated electrical or biochemical signal after their reverse transducing through the SuFETTr(s). Furthermore, this decoded signal will provide a basis for creating feedback and feedforward loops in the measuring system for more precize and complete influence on the biochemical process.

IonScan 800 – ultra-precise film thickness trimming for semiconductor technology

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Abstract
Many applications in semiconductor technology are characterised by extreme requirements in terms of film thickness homogeneity. When manufacturing Bulk Acoustic Wave (BAW) components, it is necessary to adjust film thickness values of different materials with accuracy values in the nm-range. Standard processes, such as the film deposition technique, do not fulfil these homogeneity requirements. Thus it is necessary to perform local correction of the film thickness in a follow-up process. [1,2]

The authors here introduce a new method of local film thickness trimming and its technical implementation. During the process, the wafer is moved in front of a focussed ion beam. The local milling rate is controlled upon the residence time of the ion beam at certain positions. A modulated velocity profile is calculated specifically for each wafer, in order to mill the material at the associated positions to the target film thickness.
Depending on whether an inert or reactive ion beam process is used, it is possible to apply the IonScan technology for any material desired, such as Si_3N_4, SiO_2, Al_2O_3, AlN, W or NiFe.

1. The principle of the ion beam trimming technology
Over the past years, ion beam technologies have increasingly found their way into material processing in optics and semiconductor technology. The reason for this success is based on the characteristics of the ion beam processes outbalancing alternative technologies in terms of quality. In ion beam methods, the ion angle of incidence may be adjusted in a defined manner. Moreover, the process is characterised by a narrow ion energy distribution, controllability of the ion beam composition, as well as a high time and spatial constancy of the ion flow. Consequently, ion beam methods are mostly used for large area milling processes whose removal depth accuracies get close to the atomic scale. These procedures enable homogeneous removal or structuring with outstanding anisotropy characteristics across the whole substrate surface.[3-5]

Ion beam technologies not only allow a homogeneous substrate removal, but also locally resolved etching by controlling the local ion dose. Upon this dose, it is possible to correct heterogeneities of particular characteristics. When correcting film thickness or depth values of a structure, an error function gets etched down to the required function. The terms 'ion beam trimming' or 'ion beam correction' were introduced for this technique. Ion beam trimming can be performed with either an aperture or a residence time method. The residence time method uses a focused ion beam, which is moved in relation to the substrate to be corrected according to a defined motional strategy. It is possible to calculate the required residence time values at the corresponding positions and the appropriate motional mode being aware of the static etch profile of the ion beam. The basic process arrangement of the residence time method is shown in Fig. 1.

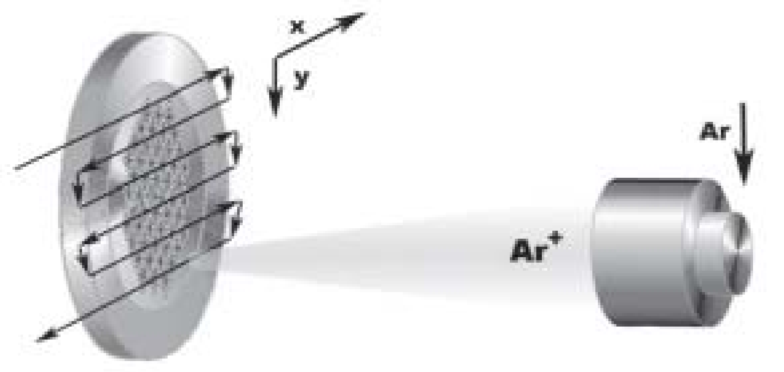

Fig. 1: Function diagram of film thickness trimming controlled upon residence time

2. IonScan 800 system layout
The IonScan 800 system is designed for wafer based film thickness trimming in semiconductor technology. With the handler and the process module, it is possible to create a cluster layout of the entire system, which is able to integrate both two load-locks and up to three process modules (Fig. 2).

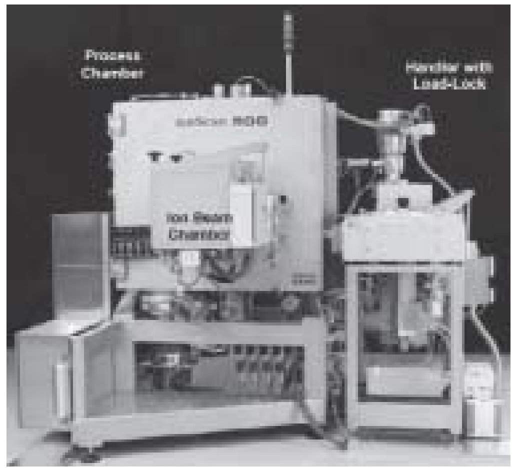

Fig. 2: General view of the IonScan 800

The process chamber is fed with a 4 port handling robot (Fig. 2 right) which comprises a separately pumped loadlock, fitted with cassette lift and indexer, as well as a prealigner with combined OCR and barcode reader.

The system components for ion beam trimming are housed in the process chamber (Fig. 2 left). An additional chamber at the front door houses the ion beam source to be accessed for maintenance activities upon a separate lid. A filament-free ion beam source cyberis 40-i made by Roth & Rau is used in the IonScan system [6]. The source is mounted completely in the vacuum with discharge chamber and impedance matching. According to the ICP principle, radio frequency power (13.65 MHz) is transferred inductively to the gas discharge. In addition to the ion beam source, a hot filament or a RF neutraliser are used to neutralise the ion charge during processing of isolating substrates. It is possible to achieve a maximal total ion flow to 100 mA, as well as up to 2 keV ion energy.

For typical film thickness errors, a beam profile standard deviation of 5...10 mm is sufficient for a satisfying machining result with the cyberis 40-i. The ion beam standard deviation is mostly influenced by the geometry of the grid system and the D.C. voltage applied. Ion current densities up to 20 mA/cm² are generated in the ion beam focus under typical operating conditions.

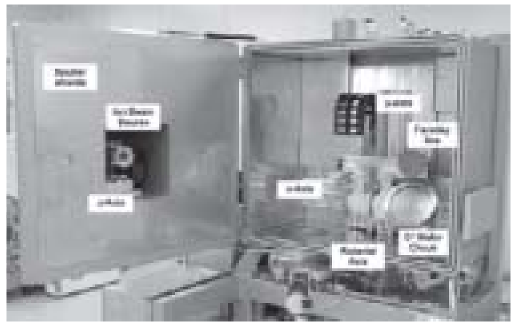

Fig.3: Interior view of the process chamber with ion beam source (left) and axis system with wafer chuck (right)

In most of the processes, the ion beam source is run with inert gases (Ar, Xe). The discharge chamber of the source is completely made of aluminium oxide, so that fluorinecontaining process gases are used without any constraint, too.

At the right of Fig. 3, the axis system with the wafer chuck are shown at opened chamber door. The axis system is dimensioned to machine wafers up to 200 mm. Wafer chucks are available in versions with 4", 5", 150 mm and 200 mm, both for wafers with flat and with notch. The wafer chuck is equipped with a clamping and transfer mechanism actuated by compressed air. A helium back side cooling is used for efficient heat transfer from the wafer to the water cooled chuck body. With this cooling principle, a power input of typically 100 W may be deduced efficiently out of the ion beam. As a rule, the resultant temperature at the wafer front side is below 120 °C.

In addition to ion beam source and wafer chuck, the following components are functionally relevant:

Rotational axis:
The wafer chuck is mounted on a rotational axis. The rotational axis is designed to tilt the wafer from the horizontal handling into the vertical processing position. It is possible to continuously vary the tilting angle of the wafer holder from 0 to 100 deg. Generally the wafer is processed at vertically incident ions, but one may also adjust any angle of incidence desired in order to increase the process rate or to control material selectivity.

X-Y axis system:
The x-y axis is designed to run the calculated residence time profile. The x-axis is equipped with a linear drive. Providing velocity values up to 500 mm/s and acceleration values of 20 m/s², one may exactly run the residence time data. Due to the high velocity, base etching may be kept very low, at 0.5 ... 1 nm only. Base etching defines the minimal removal carried out at each position of the wafer. The y-axis is designed for linefeed in the meander shaped motion.

Z axis:

The z-axis is applied for positioning of the ion beam source related to the wafer. This way, the exact focus distance may be adjusted automatically. The z-axis is additionally necessary to process the wafer if the ion angle of incidence is different from 90°. Focus distance to the current line is automatically readjusted with each linefeed.

Faraday array:
The IonScan 800 system is equipped with a Faraday array to run a complete current density profile of the ion beam within a few seconds. The array is used for routine check of the ion beam stability and to determine the exact focus position of the ion beam related to the wafer.
All IonScan 800 components and functions are controlled upon a PC system. The system environment is fitted with various modes for manual and automatic wafer processing, recipe administration, an MS SQL data base to log the system operation data, as well as an SECS/GEM interface for the process control system.

3. Process flow and calculation of residence time
To fulfil the high homogeneity requirements in the IonScan applications, each wafer has to be processed in a specific way. Before ion beam trimming, it is required to measure the film thickness error of each wafer separately. This measurement is regularly carried out by an appropriate metrology (RF probes, ellipsometry).

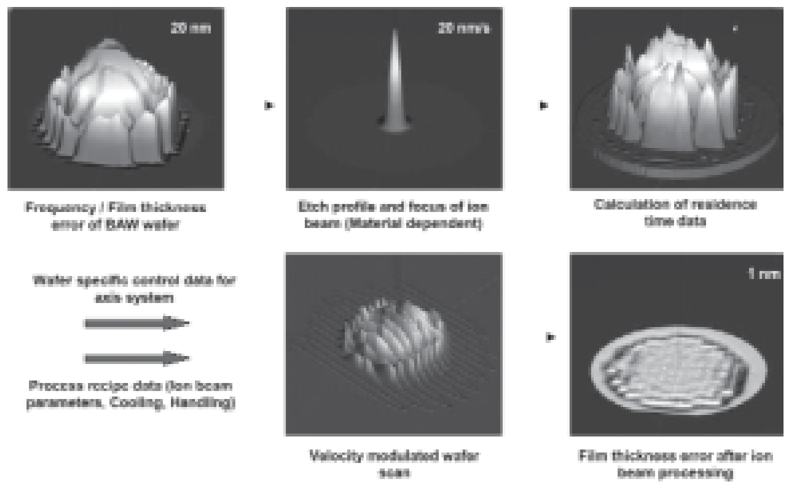

Fig. 4: Flowchart representation of wafer processing on the IonScan 800

As the first next step, it is necessary to calculate the residence time for a known etch profile of the ion beam. The mathematical representation of the problem leads to a convolution between the residence time t(x,y) to be found and the etch function R(x,y) of the ion beam, which has to be comply with the film thickness error $z_0(x,y)$ (Fig. 4). The two dimensional etch function of the ion beam has to be determined specifically for each material and for each parameter set of the ion beam source.

$$z_0(x,y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} t(x',y')\, R(x-x',y-y')\; dx'dy' \qquad /2.1/$$
$$= t(x,y) \circ R(x',y')$$

In the frequency domain, convolution operations can easily be executed as multiplications of the Fourier transformed functions.

$$FT[z_0] = FT[t] \cdot FT[R] \qquad /2.2/$$

As a result, the inverse problem turns out to be in the frequency domain as follows

$$t = FT^{-1}\left[FT[z_0]\, FT[R]^{-1}\right] \qquad /2.3/$$

Inverse problems are generally known as sophisticated subjects in mathematical and numerical techniques.[7] Real problems according to /2.3/ can not be solved exactly. Approximate solutions for t(x',y') may be found by iterative methods when predefining special target criteria.

When executing the iteration in the frequency domain, transformation back into the space domain is carried our after each iteration step i, and residual error f of the calculation is determined:

$$f^{(i)} = z_0 - FT\left[t^{(i)}\right]FT\left[R\right] \qquad /2.4/$$

Based on the error function, the new residence time matrix $t^{(i+1)}$ is calculated with an damping factor α. The iteration is aborted either after achieving a predefined cycle number or if dropping below a residual error of the iteration.

$$t^{(i+1)} = t^{(i)} + \alpha\, FT^{-1}\left[FT\left[f^{(i)}\right]FT\left[R\right]^{-1}\right] \qquad /2.5/$$

The residence time matrix provides the wafer specific data for the axis system control. Finally, they are transformed into local velocity and acceleration data.

Into process control, there are not only incorporated the wafer specific residence time data, but also recipe data specific to each material to be trimmed. (Fig. 4).

The wafer is machined with these input data, without additional feedback of the process.

In the IonScan 800 system, a special software IonTrim is available for residence time calculation according to the above described method. IonTrim was particularly engineered for this technique. IonTrim contains separate process modules for data interpolation, filtering, residence time calculation, error analysis and calculation of axis control data.

For modelling and optimisation of film thickness trimming, IonTrim cannot be only installed at the IonScan 800 system, but also any other PC.

4. Use in frequency trimming of Bulk Acoustic Wave (BAW) components

High-frequency components for the mobile radio technology increasingly use Bulk Acoustic Wave (BAW) rather than the Surface Acoustic Wave (SAW) components, which have been established up to now. The reasons for this change result from several advantages like enhanced product characteristics, smaller device size, less sensitivity against influences from the outside, such as temperature or electrostatic discharge, as well as the lower production costs based on as wide as possible standard CMOS technologies, thus avoiding special materials for substrates.

The main item of each BAW component (Fig. 5) is a piezoelectric film regularly made of aluminium nitride and contacted by two electrodes. To generate an acoustic resonator, the thickness of the piezoelectric film has to be $\lambda/2$ of the wavelength of the transversal acoustic wave.

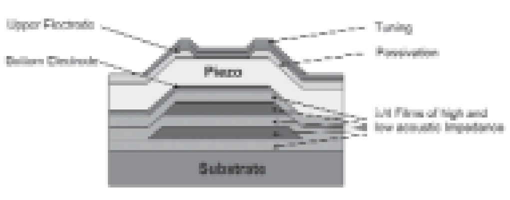

Fig. 45: Principle structure of a Bulk Acoustic Wave (BAW) resonator

The resonator has to be sufficiently acoustically isolated from the substrate material. In the past, so called Free Bulk Acoustic Resonator (FBAR) arrangements were used. In this construction, isolation is obtained by building an air cavity. The resonator is built up unsupported over this cavity. In the meantime, the Solid Mounted Resonator (SMR) principle has become accepted (s. Fig. 5). In this structure, acoustic isolation is achieved with an acoustic Bragg mirror made of alternating $\lambda/4$ films with high and low acoustic impedance.

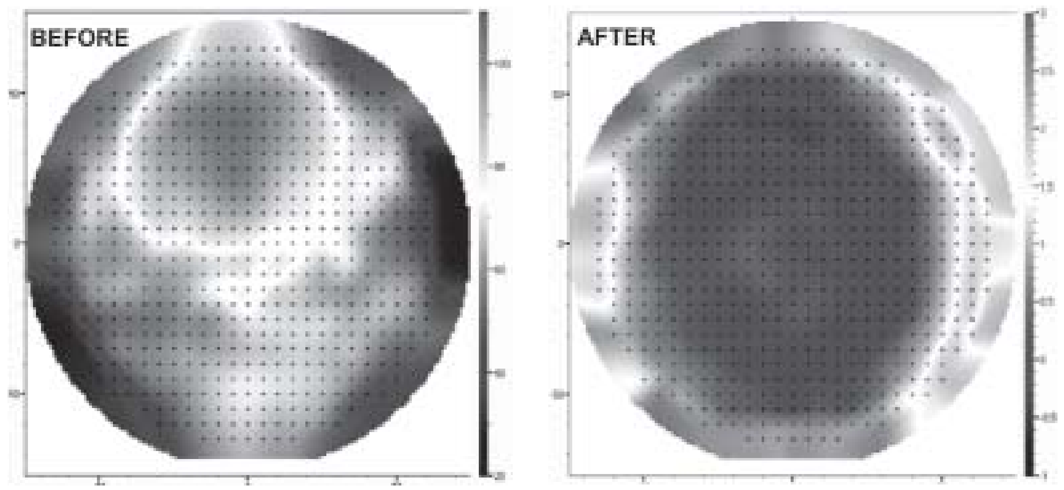

Fig. 6: Film thickness error of an Si3N4 film before (left) and after ion beam trimming (right) (position coordinates left/bottom [mm], film thickness error right [nm])

Error range: 20 … 110 nm
Mean error: 69.1 nm
Standard deviation: 16.6 nm

Error range: -1 … 3 nm
Mean error: 0.46 nm
Standard deviation: 0.59 nm

Depending on the impedance differences, such as between tungsten and silicon oxide, it may be possible to achieve an excellent acoustic isolation even with only a few films.

The frequency is finally tuned with a low additional mass, which is deposited onto the upper electrode as another film, mostly silicon nitride.

The operation that makes the production of BAW resonators mainly demanding, is exact adjustment of the required film thickness values, in order to keep the low frequency tolerance range of about 0.1 %. It is also necessary to guarantee an adequate accuracy of the film thickness values across the whole wafer, which can not be obtained in these narrow tolerances with standard semiconductor technology equipment.

The IonScan 800 is a system suitable to manufacture these components by adequately trimming of all films in a BAW stack. In addition to the film thickness trimming of the mass load, IonScan can also be applied for trimming of the piezo-resonator and the acoustic mirror. With this step like trimming strategy not only the final variation of the device frequency is better met but also other device parameters like the Q-Factor gets clearly improved.

Fig. 6 elucidates the thickness distribution of a Si_3N_4 film, measured by ellipsometry, before and after ion beam trimming. With the IonScan 800 system, it is possible to correct film thickness errors arbitrarily distributed across the wafer. The local resolution of the technique is significantly determined by the standard deviation of the ion beam profile. In the example demonstrated, the ion beam was run with argon. For Si_3N_4, in the focus of the ion beam a removal rate of 20.0 nm/s and a volume rate of 6.1×10^{-3} mm^3/s are achieved. Under these working conditions, base etching at all wafer positions is only 1.7 nm.

Typical rates for materials to be processed range from approximately 10 to 30 nm/s for argon processing. With reactive gases, one may rise the rates to the three- or fourfold, depending on each material. Due to the reserves in the axis parameters, the IonScan 800 system is capable of handling such high milling rates without any problem.

In the example demonstrated in Fig. 6, the average error is diminished by about a factor of 150, and the standard deviation of the film thickness error by about 30. After machining, there remains only a 0.46 nm deviation from the nominal film thickness at a standard deviation of 0.57 nm across the whole wafer. Fig. 7 represents the film thickness distribution before (red) and after trimming (blue). The process time to machine the wafer was less than 5 min.

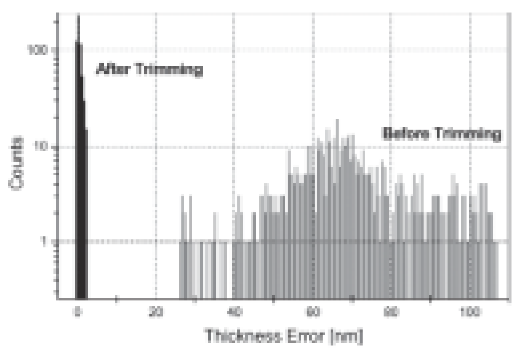

Fig. 7: Film thickness distribution before and after ion beam trimming

A slight processing error appeared towards the wafer edge. These marginal effects result from the calculation and the extrapolation procedures used, on the one hand, and from a slightly changed neutralisation at the wafer margin, on the other hand. These deviations may be compensated in the software when defining a locally variable milling rate.

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Nantero's NRAM™ universal memory developed with microelectronics grade carbon nanotube formulation

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After their discovery in 1991, the properties of carbon nanotubes were investigated by academia and corporate research and the results, measured or modeled, led scientist around the work to envision a myriad of applications.

In 2001 Nantero was incorporated with the goal of developing a universal memory, NRAM™, using carbon nanotubes as the switching elements in the memory cell. NRAM incorporates all the positive attributes of DRAM, SRAM and Flash all of which are the currently available memory chips. The intrinsic properties of carbon nanotubes enable the NRAM memory's following characteristics: scalability < 5nm, high-speed, highdensity, and nonvolatility. To enable development and production of the carbon nanotube-based memory at an industrial scale, Nantero had to envision and implement a process which used the existing tools in production fabs.

Nantero was successful in developing a carbon nanotube-based formulation (NTSL-4) which meets microelectronics industry requirements (high purity and stability) and is a consistent product for enabling product development. The formulation was qualified for use in two production fabs, and was integrated with other materials and tools to develop NRAM prototypes.

Using the existing tracks in its partners' fabs, the NTSL-4 formulation and Nantero proprietary spin coating protocols, Nantero generated carbon nanotube films of required densities on silicon oxide wafers. Subsequently the carbon nanotube films are patterned, using standard procedures and equipment available in any microelectronics fab, leading to the manufacturing of carbon nanotube memory cells arrays.

This presentation will introduce the properties of the microelectronics grade carbon nanotube formulation developed by Nantero. It will describe the characterization methods and the process used to integrate the carbon nanotubes in the manufacturing fab. Existing and potential products which can be developed using Nantero's carbon nanotube formulation will also be discussed.

Worldwide societal acceptance of nanotechnology

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1.Introduction

In 2005, worldwide total public and private investment was approximately 9.7 billion Euro, including almost half from private sources. About €2.4 billion was spent in Europe, including a third from private sources, about $3.5 billion in the USA, including 54% from private sources, about €2.7 billion in Japan, including two thirds from private sources. It appears that companies and private investors are currently overtaking governments in investing in nanotechnology, but that European companies are lagging behind their American and Japanese counterparts. (Hullmann, 2006) There are already at least several hundreds of products on the market with nanotechnology inside, at least according to the producer or experts. (Woodrow Wilson, Project on Emerging Nanotechnologies) Many more are in the pipeline and can be expected to enter the market in the near future. At the same time, worldwide public awareness of nanotechnology and what it may mean for society is still low.

However, potential risks and ethical, legal and social aspects of nanotechnology have been discussed by policy makers, researchers and industrialists since the beginning of this millennium, and more and more NGO's and mass media are entering the debate about responsible nanotechnology development. In this article, I discuss the state of the art of the debate on nanotechnology and society in Europe, North and South America and India. The main questions discussed are: which issues have been discussed in different parts of the world, which stakeholder groups are participating and are any cultural or religious differences noticeable?

2. Public acceptance of nanotechnology in Europe

Whereas 42% of 25,000 participants in the Eurobarometer study on Europeans and Biotechnology in 2005 (Eurobarometer, 2006) don't know if nanotechnology will improve the quality of their life over the next twenty years, 40% is positive, 18% expects no change and only 5% is negative about it. Only 44% said they had heard of nanotechnology. Nanotechnology is considered morally acceptable, useful and not risky, and most respondents believe it should be encouraged. 55% of respondents support nanotechnology.

Since about 2003, the European Union and national governments in the UK, Germany, the Netherlands, Switzerland, Belgium (Flanders) and France have taken initiatives for public dialogue on nanotechnology. Several of these projects have finished already, before large scale public debate has taken off.

The European Commission's Action Plan on Nanosciences and Nanotechnologies (2005-2009) has been discussed in the European Economic and Social Committee (EESC) and the European Parliament. The EESC recommended the development of national action plans in addition to the EU plan, which have been presented by several governments. The European Parliament adopted a resolution on nanotechnology in 2006, pleading for responsible nanotechnology development, more or less agreeing with the European Commission.

As of 2006, mass media, politicians and more and more NGO's are beginning to show awareness of nanotechnology and its potential implications for society. The public debate tends to focus on the promises nanotechnology offers and on the potential risks of engineered nanomaterials and their applications in consumer products such as cosmetics, washing machines and food. Taking a precautionary approach, the lack of investment in risk assessment projects on nanomaterials, consumer choice and informed consent are key issues. Ethical concerns from civil society representatives and religious groups tend to focus on nanomedicine, converging technologies and human enhancement.

3. Public acceptance of nanotechnology in the USA

The US federal government launched the 'National Nanotechnology Initiative' in 2000, with expert workshops and projects on ethical, legal and social aspects of nanotechnology incorporated from the beginning. (Roco & Bainbridge, 2001) NSF is funding two Centres for Nanotechnology in Society, at Arizona State University and at University of California, Santa Barbara. The US congress has adopted 'The 21st Century Nanotechnology Research and Development Act' (US Congress, 2003) to authorise appropriations for nanoscience, nanoengineering, and nanotechnology research, and for other purposes, in fiscal year 2005-2008.

Since 2006, public debate on nanotechnology has increased, stimulated by publications by independent research centres including the Woodrow Wilson Institute Project on Emerging Nanotechnologies. The Food and Drug Administration FDA (October 2006) and NSET (January 2007) have organised public hearings as part of their policy making on risk assessment of nanotechnology. A range of stakeholders, including industry and NGO's, participated. The opinions expressed vary from demands for moratoria on consumer products with nano-inside (or more particularly cosmetics or washing machines) and worries about the lack of resources of FDA to regulate nanoproducts, to requests for stimulating innovation in nanotechnology.

In the USA, 81% of 1800 participants in a recent survey on nanotechnology had heard very little (28%) or nothing at all (53%) about nanotechnology. Only 5% had heard a lot. Despite the lack of knowledge, 53% believe benefits outweigh the risks, and 36% believe that risks outweigh the benefits. Only 11% is not sure. White men are considerably more optimistic than women and African-Americans. People's emotions play an important role in people's perception on nanotechnology, and values determine people's reactions to information on nanotechnology. (Kahan et al, 2007)

In March 2007, the US Congress Joint economic Committee published a visionary report entitled 'Nanotechnology: The Future is Coming Sooner Than You Think', expecting a nanorevolution to take place after 2020, and recommending moving authority on budget allocations from the individual research funding agencies to the National Nanotechnology Initiative, to stimulate truly interdisciplinary research on the boundaries between traditional disciplines. They also propose to put more effort in public dialogue including with critics. (Kennedy, 2007)

4. Public acceptance of nanotechnology in India

In 2007, there is no awareness of nanotechnology among the Indian population. Even very few undergraduate students have followed any nanotechnology courses. The low level of awareness is not surprising, since the first Nanoscience and Technology Initiative only started in 2001, with a budget of US$15 million in five years. About 100 projects are being funded and nine centres of excellence have been earmarked.[1] Nanotechnology research projects are being funded by the Department of Science and Technology (DST), Department of Biotechnology (DBT), Ministry of Communication and Information Technology, and the Department of Scientific and Industrial Research (DSIR). (EuroIndiaNet, 2007) In 2006, the Indian government announced a proposal to invest another €170 million in a Nanotechnology Mission over the next five years.[2]

India's President Dr. A.P.J. Abdul Kalam has mentioned the opportunities nanotechnology is expected to offer for India's economy and society in speeches on many occasions. On 18 April 2006, he discussed the energy independence of India in an inaugural lecture to the South Asian Conference on Renewable Energy in New Delhi. India has no oil reserves, and hence is dependent on imports for much of its energy supply. India aims at Energy security by 2020 and energy independence by 2030. The Indian electricity generating capacity must increase from 130,000 MW to 400,000 MW in 2030. This should include 50,000 MW hydroelectricity; 55,000 MW solar; 50,000 MW nuclear; and conventional and other renewable energy sources. Therefore, there is great interest in the development of sustainable energy technologies including solar cells and hydrogen storage based on carbon nanotubes and energy efficient solid state lighting.

In 2007, president Kalam discussed trends in research in nanotechnology and converging technologies. He considered Richard Feynman, K. Eric Drexler and India's top-nanotechnologist C.N.R. Rao to be 'three scientists who have laid the foundation for nanoscience and nanotechnology'[3]. President Kalam foresees potential applications of nanotechnology in aerospace and in healthcare. He expects convergence of nanotechnology and biotechnology to lead to Intelligent Bioscience, and 'a disease free, happy and more intelligent human habitat with longevity and high human capabilities'. He believes convergence of nanotechnology, ICT and aerospace technologies may enable inter-planetary transportation.

The Department-Related Parliamentary Standing Committee on Science & Technology, Environment & Forests of the Parliament of India has debated about potential risks of nanotechnology in 2005. They expressed great concern about environment, health and safety risks of synthetic nanomaterials, but eventually agreed to the plans of DST which included relevant research and education.

1 *See http://www.dst.gov.in/scientific-programme/ser-nsti.htm*
2 *PIB Press release, 18 december 2006: http://pib.nic.in/release/release.asp?relid=23442%20*
3 *Interestingly, Drexler's concept of molecular nanotechnology appears to be taken seriously by the Indian nanotechnology community, contrary to his hostile reception among the nanotechnology research community in Europe and the USA.*

Since India's independence in 1950, technology development and scientific education have been set up separately. Now, the trend is towards integrating science and technology and interdisciplinary collaboration. Currently, natural sciences and social sciences are still mainly separated. At the University of Delhi, social scientists and economists plead for broad interdisciplinary collaboration for societal relevant development of nanotechnology. The social scientists can introduce their knowledge on the needs of society to which the natural scientists and engineers can target their research projects. SMEs should be included as well. In general, technology transfer and private R&D still hardly exist in India. Most companies lack the capacity to absorb well trained researchers and give them qualified jobs. (EuroIndianet, 2007)

Some social scientists in India have already published about nanotechnology and society. Bürgi and Pradeep (2006) consider nanotechnology to be a fusion technology where information technologies and biotechnologies converge. Developing countries as well as developed countries can participate in nanotechnology development and benefit from its applications right from the start. The unexplored biodiversity of the South offers opportunities for bionanotechnology development. Chatpalli and Patil (2006) explore ethical issues of nanotechnology and recommend incorporating ethics research in nano R&D; stimulating public dialogue; and education in technical as well as social aspects.

In 2003 and 2006, conferences have been organised with school children on nanotechnology. In the future, societal aspects might also be discussed in outreach events for school children and college students, in teacher training programmes and in TV programmes.

5. Public acceptance of nanotechnology in Latin America

In Latin America, significant research activities in nanotechnology are taking place in Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Venezuela. Most emphasis is on basic research and the need to stimulate innovation and technology transfer to industry.

In Argentina, the president launched the Argentinian Nanotechnology Foundation (FAN) by decree on 29 April 2005, which created a lot of political and public debate, including in congress, the Argentine Physics Association and the National Committee on Ethics in Science and Technology (Foladori, 2006). The main issues are political, including fear of foreign military funding, and economic. The FAN was launched without the need for approval by the congress. The government announced an investment of $10 million in it, and the US company Lucent Technologies was granted exclusive rights to develop products arising from the research. In June 2005, the congress discussed a ten year nanotechnology development plan proposed by the technology commission headed by Mrs. Lilia Puig de Stubrin. (Sametband, 2005) The outcome of the discussion is unclear, but the FAN is operational.

In Brazil, research in social sciences and humanities of nanotechnology takes place in RENANOSOMA, the Research Network in Nanotechnology, Society and Environment. They also stimulate public engagement and actively seek to establish international collaborations in annual Seminars on Nanotechnology, Society and the Environment since 2004 (Renanosoma website, 2007). A National Committee for Bioethics has the task to regulate impacts of scientific and technological development projects on the environment and on health. (Malta, 2004) In 2003, the parliament was discussing a Law on Technological Innovation relevant to nanoscience and nanotechnology. The media were publishing articles on nanoscience and potential applications. There was little public awareness of nanotechnology in Brazil (Ozorio de Almeida, 2003).

In Colombia, Advanced materials and nanotechnology is a key area of research since 2004, and a National Council for Nanoscience and Nanotechnology started in 2005. The research includes ethical and social implications of nanotechnosciences.

In Mexico, Guillermo Foladori of Universidad Autonoma de Zacatecas is interested in nanotechnology and society. (Foladori, 2006)

In November 2006, in Brazil, the Latin American Network on Nanotechnology and Society RELANS was launched, aiming to stimulate dialogue on nanotechnologies in Latin America. (RELANS website) It is too early to tell what role this network will play in this dialogue.

6. Discussion

As announced in the introduction, three questions are discussed in this article. Which issues have been discussed in different parts of the world? Which stakeholder groups are participating? And are any cultural or religious differences noticeable?

Even though it is clear that even in Europe and the USA (let alone Latin American countries and India), public awareness of nanotechnology is still very low, some similarities and differences can be observed already.

7.1 Which issues have been discussed in different parts of the world?

In Europe as in the USA, governments and the European Commission have stimulated political and stakeholder debate aiming to identify possible societal and ethical issues related to nanotechnology since 2001. A broad sweep approach has been taken, examining any issue which could possibly present problems of public acceptance. Since 2004, the policy debate has focused mainly on economic/education; risks of synthetic nanoparticles/nanomaterials; nanomedicine/converging technologies/human enhancement; and international collaboration/development. In 2006, nanofood has emerged on the policy makers' agenda.

In India, the government launched the first national nanotechnology programme in 2001. The political debate focuses on potential opportunities including for energy independence and nanomedicine. Parliament is concerned about risks of engineered nanomaterials, and social scientists highlight the need for involving SMEs, education and outreach. Evidence about discussion of other issues has not been found.

In Latin America, substantial research programmes and activities in nanotechnology have started in the period 2003-2005. Except from Argentina, no evidence has been found about substantial political or public debate on the priorities in nanotechnology or other issues. The issues discussed in Argentina were related to who controls nanotechnology development and which foreign influences are acceptable. No evidence has been found about political or public debate on risks of nanotechnology or ethical concerns. The networks and research groups in nanoscience and society (started by social and humanities' scientists) are trying to stimulate such debate. RENANOSOMA in Brazil is the first and best known, with annual international seminars since 2004.

7.2 Which stakeholder groups are participating?

In Europe, until 2003 only researchers, policy makers responsible for research funding and some industry representatives participated in the discussion on nanotechnology. From the call for a moratorium on nanomaterials by the Canadian ETC group and Prince Charles in the UK in 2003 onwards, government organisations have tried to attract the attention of NGO's and stimulate public awareness and dialogue. In the period 2004-2006, some NGO's have shown interest. Patients' associations appear to be more positive than negative. Some others, like Greenpeace UK were not immediately hostile to nanotechnology, because they expected potential benefits as well as risks. Others, like the ETC group were more suspicious and some refused to take part in any discussions, but just held demonstrations during nanotechnology conferences in the UK and at the MINATEC research centre in France. Religious groups in the UK (Church of Scotland), Germany (Evangelical Church) and EU (European Bishops Conference COMECE) are also concerned about responsible nanotechnology development and ethical aspects of nanomedicine/converging technologies/human enhancement.

As of 2006, the number of NGO's which have issued statements on nanotechnology or are participating in or organising conferences or other discussions is increasing rapidly.

In the USA, a similar trend can be observed. The Foresight Institute and Transhumanism Association have been interested in potential benefits and risks of nanotechnology already in the 20th century; other NGO's have entered the field after 2000. As of 2006, public hearings organised by FDA and NSET have been focal points where representatives from research, industry and several NGO's have issued oral or written statements. Many NGO's are collaborating in global networks and participating in policy debates at global, EU and national level in North America and Europe.

In Latin America, the policy debate seems to be dominated by researchers and policy makers. Interest from companies is not clear. Evidence has been found about participation in the debate by NGO's based in North America or Europe. It is not clear whether national or local NGO's are aware of nanotechnology or have issued statements about it.

In India, the president, parliament, researchers and policy makers are involved in discussions on nanotechnology. Industrial companies are beginning to show interest. No evidence has been found that Indian NGO's are interested in nanotechnology.

7.3 Are any cultural or religious differences or similarities noticeable?
The influence of cultural or religious differences on attitudes to nanotechnology in the USA and Europe has been discussed elsewhere (e.g. in Nordmann et al, 2006). It is generally believed that the European public is more risk averse, whereas the public in the USA would accept risks as long as they are balanced by benefits. It is too early to tell whether this will be the case for public acceptance of nanotechnology. The main differences between the USA and Europe are at the moment related to attitudes to human enhancement, and different legislative systems and traditions for market acceptance of nanomaterials and products with nano-inside. In the USA, military applications of nanotechnology are more openly endorsed than in Europe. Also, US politicians tend to endorse more long term visions about the nano-revolution (even after 2020), whereas European politicians tend to be more interested in the medium term socio-economic benefits (typically until 2015) and more mundane applications like in new materials, coatings, nanomedicine and nanoelectronics.

In Argentina, the main issues in the public debate on nanotechnology in 2005 were political, not specific to nanotechnology. Guillermo Foladori (2006) complains that decisions on public investment in nanotechnology in other Latin American countries were taken without serious debate. There is no evidence about government action plans or visions on nanotechnology potential for society. However, in several Latin American countries nanoscience and society research groups and networks have started, which may play a role in stimulating such debate. Also, several labs are specialising in risk research of nanomaterials.

In India, President Kalam has a grand vision on nanotechnology, building upon ideas of the Americans Richard Feynman, K. Eric Drexler and Indian top-nanoscientist C.N.R. Rao. This vision clearly connects nanotechnology research with strategic needs of the Indian society and humanity such as energy independence or space travel. Indian parliament is clearly aware of potential risks of synthetic nanomaterials and demands appropriate safety measures.
The main differences between nanotechnology policies in different parts of the world seem to be related to national political cultures and structures of the research system and economy. India seems to put more emphasis on the needs of its own socio-economic development, whereas Latin American countries appear to be more inclined to import nanotechnology policies from the Western countries, apparently without much consideration of the needs of their own society.

There is a clear trend towards a global standardised approach to the development of nanotechnology, including research on Environment, Health and Safety risk assessment and Ethical, Legal and Social Aspects. This trend is reinforced by opening the European Union Seventh Framework programme and national programmes for international collaboration including North-South as well as South-South collaborations. Examples of the latter are the Argentinian-Brazilian nanotechnology centre and recent discussions about collaboration between India, Brazil and South Africa. These collaborations are likely to contribute to standardised nanotechnology development and research in nanotechnology and society issues. Public acceptance is another matter. More research is needed on public acceptance of nanotechnology, especially in emerging economies and developing countries.

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Nanotechnology in social perception

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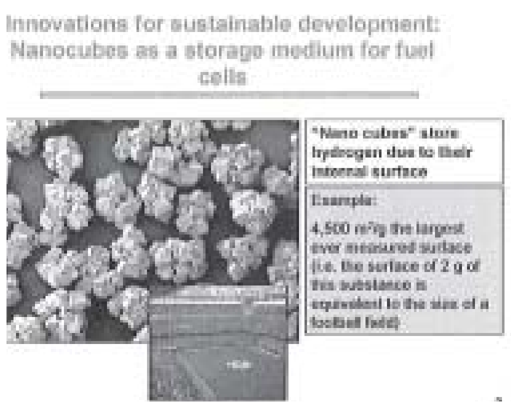
The presentation is built along the following lines :
1) Examples of the benefits of nanotechnologies
2) Perception of the use of nanotechnologies at the stakeholders
3) What is a way forward by Cefic and its members?

1) Examples of benefits of nanotechnologies.
The use of nanotechnologies can be divided in general in the following categories:
- Energy savings
- Conserving resources
- Health efficiency
- Quality of life

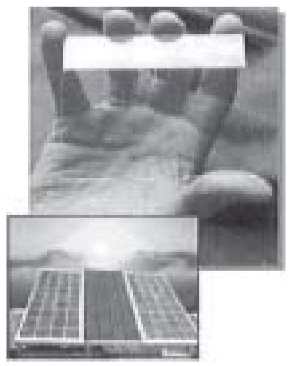
Examples for energy savings are:

Automotive catalysts and catalysts in chemical industry:

H_2 storage for fuel cells:



Anti reflecting coatings:



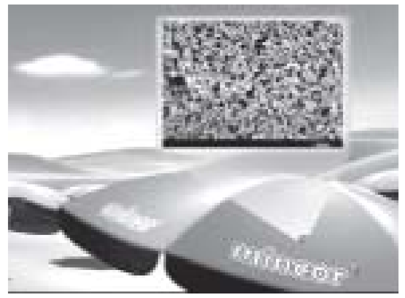
Advantage: higher energy yield

Membranes for large lithium batteries:

Advantage: reduced weight, reduced fuel consumption, higher acceleration

Examples for conserving resources are:

Nanostructured surface savings, like:



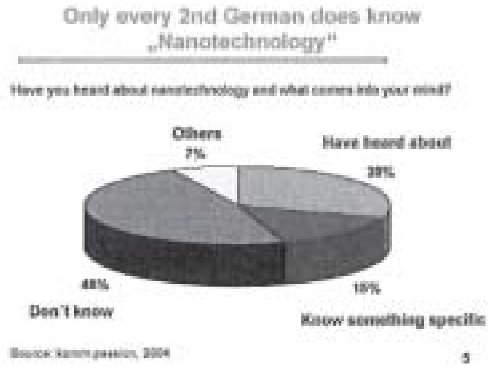
Examples for health efficiency are:

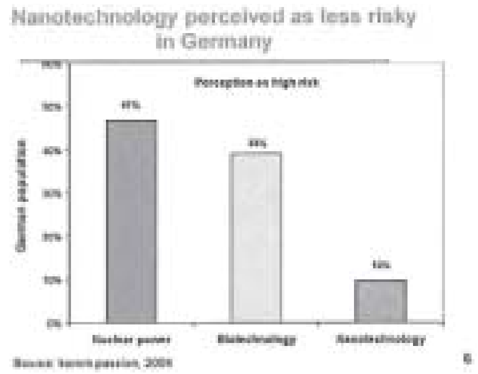
2) Perception of the use of nanotechnologies at the stakeholders
A number of studies have already performed and published to show the perception of nanotechnologies at the different stakeholders. The following studies will be summarized or statements as made by the authors will be mentioned:

- Komm Passion GmbH, 2004
- Perception of risks and nanotechnology, E. Schuler, 2004
- Woodrow Wilson Center, 2006
- Perception of nanotechnology in Japan, 2006

Also what the different industry members are communicating via their corporate social responsibility communication programme will be addressed.

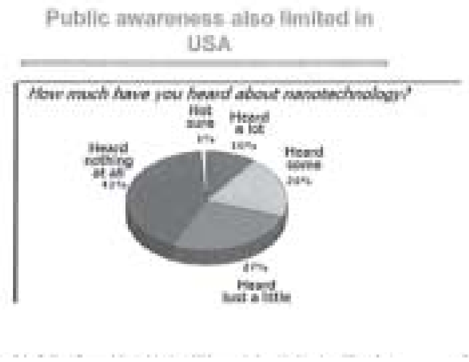
a) Komm Passion GmbH, 2004

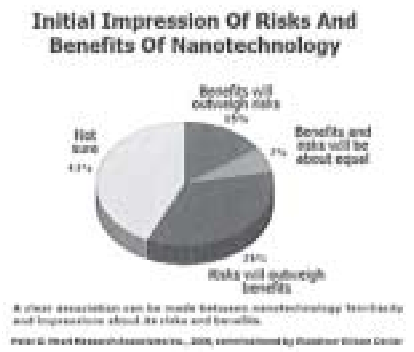




b) Perception of risks and nanotechnology, E. Schuler, 2004
Schuler is stating that the perceived risks of nanotechnology are likely to overestimate the risk of nanotechnology. Some of the concerns expressed in the media by environmentalist groups, and by a handful of scientists as well, happen to be the trigger points that lead to risk overestimation. She continues that they catalyse the lack of familiarity with nanotechnology among the public, the uncertainty over the equitable distribution of knowledge and equitable balance of the risks and benefits, the difficulty in predicting the potential hazards, and - last but not least - the association of nanotechnology with the public backlash against genetically modified foods.

c) Woodrow Wilson center, 2006





d) Perception of nanotechnology in Japan, 2006
The NRI Nanotechnology Research Institute conducted a general survey in the general public at the end of 2004. The key results of the study were reported to be:

- 54.5 % feel worried about the advancement of the nanotechnology. The concerns expressed vary from safety issues, unexpected outcomes and moral issues.
- The interviewees indicated their desires for reliable information in the areas of health, environment, and technical as well as benefits for the consumers.

The lessons from these studies are that industry needs to communicate their knowledge on all aspects of nanotechnologies in a balanced way with their marketing strategy.
An overview on the way some members of Cefic is communicating on the different aspects of nanotechnologies is summarized in the next table (from Wuppertal Institute).

	1	2	3	4	5	6	7	8	9	10	11
CSR report	√√	√	-	√	-	-	-	-	-	√√	-
NT Policy	√√	√√	-	-	-	-	-	-	-	√	-
Opportunities	√√	√√	-	√	√	-	-	-	√√	√√	√√
Risks	V	V	-	-	-	-	-	-	-	√	-
Dialogue	√√	√	-	-	-	-	-	-	-	√√	-

The way industry is communicating about the nanotechnologies shows that it more or less confirms the outcome of the perception studies and that there is ample room for improvement.

3) What is a way forward by Cefic and its members?
To increase the confidence of all the stakeholders in nanotechnology in all its aspects, Cefic and its members will initiate in 2007 a 'Stakeholders Dialogue' on European level with all the stakeholders identified. It is the planning that a first try-out will take place in the autumn of 2007 and that based on the results of this try-out a full stakeholder's dialogue will be organised at the end of 2007.

In supporting the dialogue the members of Cefic will prepare key messages on all the aspects of the nanotechnology and will define a strategy to identity in the area of H, S and E the good ones and the bad ones.

Assessing and communicating social and ethical issues of nanotechnologies - the role of information and public dialogue

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Nanotechnology and the public - What do we know?

Although nanotechnology is still an emerging technology there is already some public debate about opportunities and risks of its various applications. Empirical social research into public perception of and public attitudes towards nanotechnologies is still in its very early stage. Some quantitative research has been done so far to figure out what laypeople think about nanotechnology in general, but it often is rather isolated and results are hard to compare with each other. Thus, a 2005 Eurobarometer survey questioned people from the 25 EU member countries about their attitudes towards science and technology (EC 2005). Amongst others, participants were asked about their areas of interest in the field of science and technology. Whereas medical (60 per cent) and environmental research and innovations (45 per cent) were mentioned quite often, nanotechnology was referred to by only 8 per cent of the people, thus taking the last position. Some detailed studies in the U.S.A., the U.K. and Germany show a similar picture: Approximately 30 per cent of the participants of different studies had already heard of nanotechnology, only 10 to 20 per cent had more specific associations connected to the technology. Although the public possesses little or no knowledge about nanotechnology, a majority of the U.S. citizens is convinced that benefits outweigh the risks (Cobb & Macoubrie 2004). Europeans appear to be less optimistic (Gaskell et al 2005). Contrary to that, a recent Eurobarometer found that Europeans do not perceive nanotechnology as risky, they rather support its development (EC 2006). Siegrist et al. state that how the public reacts to nanotechnology in the short or midterm strongly depends on how industry, governmental agencies and NGOs handle the topic (Siegrist et al 2007).

Overall, the results of the above mentioned quantitative studies show that the interest of the general public in and the knowledge about nanotechnology are rather low and that there is a strong relation between the public perception of nanotechnology and other technologies. If at all known, 'nanotechnology' is a fuzzy concept to laypersons and can probably best be described as 'no specific attitudes' technology.

Participatory approaches - methods and outcomes of participatory exercises

To find out more about the reasons that lay behind peoples perceptions of opportunities and risks of nanotechnology as well as about possible 'hot topics' that will decide about success or failure of the emerging technology, qualitative and participatory approaches have been applied in various countries in the last few years.

Generally speaking, participatory approaches advocate actively involving 'the public' in decision-making processes, whereby the relevant 'public' depends on the topic being addressed. The public can be average citizens, stakeholders of a particular project or policy, experts or representatives from government or industry (Slocum 2003). Technology assessment (TA), a scientific, interactive and communicative process which aims to contribute to the formation of public and political opinion on societal aspects of science and technology, applies participatory methods as one possible way for a direct inclusion of affected social actors in the TA process (DBT 2000). An increasing number of TA organisations, but also governmental and academic institutions or NGOs, are experimenting with and implementing participatory methods, enabling a better interaction between the public, stakeholders, experts and policy-makers in the process of shaping a technology and its regulatory framework.

A number of participatory methods have been developed and tested over the years. They all have their advantages and weaknesses with regard to reasons for involvement and expected outcomes, nature and scope of the issue considered, participants and resources. They do not claim to be representative for the public in general, but often can give important hints to deeper-rooted attitudes and reasons for peoples acting.

The most prominent methods for the inclusion of the general public in discussions about future developments in science and technology are focus groups, citizens juries, consensus conferences, and variations thereof. With regard to

nanotechnology, we have identified about 20 participatory exercises in The Netherlands, Denmark, the U.S.A., the U.K., Australia, France, Switzerland and Germany. Despite some methodical difficulties like a varying quality of documentation, occasionally insufficient information about the actual process and participant selection, and language problems (some project reports are only available in the respective national languages), we found some similarities that allow for drafting a number of 'general' statements:

- Health effects of engineered nanoparticles, nanotechnology in food, some biomedical applications of nanotechnology and outcomes of the convergence of nanotechnology with IT, biotechnology and cognitive sciences are areas of particular public concern.
- Transparency and open information are considered to be crucial prerequisites for trust in and acceptance of nanotechnology. Consumers demand coherent declaration of nanoparticles (or nanotechnology) in products.
- Participants vote for unlimited research opportunities but simultaneously expect researchers to responsibly handle nanotechnology and its applications. They ask for benefit and risk analyses, their results should be communicated to and discussed with the public.

Cases: Focus groups in Germany and Switzerland

As a form of qualitative research, focus groups are basically group interviews that collect data and insights from group interaction on a given subject. A recent focus group exercise within the German NanoCare project concentrated on the attitudes of laypeople, experts and multipliers towards nanotechnology and tried to find out more about the information needs especially of the lay public (Fleischer/Quendt 2007). Similar to other studies, the participants of the lay focus groups mostly had only little knowledge about nanotechnology, but were nevertheless interested to learn more about the technology itself and its applications. Advances in nanotechnology were considered to be very important for solutions of medical, environmental and energy-related problems as well as making everyday life easier. Though most interviewees were positive about nanotechnology they would not accept products that were not tested before introduced to the market. Many of them expressed their fear of 'unreflected commercialisation' of nanotechnology. They demanded independent control of research and transparent declaration of products containing nanoparticles as fundamental prerequisites of public trust. Furthermore, the participants asked for more information and clarification especially on the topic of risk assessment of the various nanotechnology applications, and for more discussion of the new scientific outcomes with the public. Only then, they argued, can nanotechnology in general be successfully introduced in a huge number of fields in our lives.

A similar dialogue-oriented approach – the so called publifocus method – was chosen in Switzerland to examine more closely the attitudes of the public towards nanotechnology (TA-SWISS 2006). The outcomes of this research project are largely similar to what we found in our study, thus making it possible, at least for the German-speaking countries, to speak of attitudinal patterns. A deeper look at these patterns can provide hints on how to handle future (risk) communication about progress in nanotechnology.

Outlook

Against the background of experiences with governance of - and resistance against - other technologies like GMO, governments and administrations in Europe are searching for innovative forms of social debate and dialogue. These include new forms of providing information to the general public, participatory approaches like focus groups or citizens' juries, stakeholder dialogues or new forms of deliberation processes involving members of the general public.

Our experience shows that laypeople are interested in participating in discussions about future developments in science and technology. The participants in our recent focus group exercise - randomly selected from the population of Karlsruhe - almost unanimously indicated that these instruments should be used more often to gather opinions of the general public about new technological developments (Fleischer/Quendt 2007). Given the broad scope of values and attitudes, the early developmental stage of nanotechnology and the low level of information about this subject, open formats like focus group interviews appear to be more appropriate than formats that work towards consensus statements or votes.

To inform, to be responsive to other perspectives on nanotechnology, and to demonstrate transparency are the main goals of so-called public or stakeholder dialogues. Although their was no systematic evaluation so far (which would make for an interesting research topic), we got the impression that many of the recent German events were not even close to a real two-way dialogue between policymakers, scientists or industry and the public. To avoid a devaluation of this approach or a 'dialogue fatigue', more innovative forms of communication have to be developed, and the relevance of the outcome of these processes needs to be clarified.

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Nano-Conceptions : a sociological insight of nanotechnology conceptions

Gian Carlo Delgado

Nano-Conceptions was published on July, 2006 by *The Journal of Philosophy, Science & Law* which is sponsored by the University of Miami and the Georgia Institute of Technology.
The report is a product of a survey among diverse actors involved in nanotechnology issues. Most of them are what we in general tend subjectively to categorize as experts.

The range of 'expertise' has included politicians, scientists, businessmen, and journalists. The general public has been considered but as a 'barometer' of the social awareness of nanotechnology implications.
For methodological and practical purposes, and owing to funding limitations, the Nano-Conceptions survey was implemented via the Internet through email contact of around 1,500 experts mostly from Europe, the United States and Japan. A low percentage replied to the survey (89) and even fewer participated (51). Despite this, it can be said that the quality of the responses from the participants makes the surveys' sample a good one but, certainly, in any case a sufficient one.

Yet, considering the limited spectrum of the survey, this first approach seems to be a very useful instrument for an introductory and general appraisal of the sociological nature of the nano communities and the diverse groups that can be classified as being in a dialogue methodology for policymaking. These, in broad terms, are:

- Natural Sciences Community
- Social Sciences Community
- Government Community
- Private Sector Community
- And, Society

Every nano-community (as seen in this report) has an extensive number of 'clusters', fields or disciplines (e.g. Chemistry, Physics; Sociology, Philosophy, Economics; NGOs, Mass media, etc) that are successively shaped by several 'sub-clusters', schools of thought or particular groups that 'feel' a kinship with each other. Such sub-clusters as representatives of particular conceptions and interests might differ considerably with each other and may or may not be carriers, in some degree or another, of hype.

In order to 'map' the sociological context in which nanotechnology development is embedded, the report has been conceived as a 'constructed dialogue' and hence built-up on the diversity and similarities of the points of views and beliefs of the contributors to the Nano-Conceptions survey.[1]

How the conceptions and particular interests of each sub-cluster and cluster are transforming; how they 'model' the advancement and the characteristics of nanoscience and nanotechnology in one or another direction; and what the implications are of this (e.g. the institutionalization of conceptions and interests, etc), are aspects beyond the scope of this Report even though it is evident that these are key issues which need to be studied using a profound and detailed sociopolitical insight of nanotechnology development and its implications.

Instead, the explanatory purpose is quite limited. The idea is to offer, in one exercise, some of the main conceptions that are circulating among the 'experts' and that mainly dominate the 'nano debate'. It is evident that the conceptions presented 'are very general first comments' and, as pointed out by Dr. Maj M. Andersen of the RisØ National Laboratory (Denmark), '…in all, there is not much new coming out.'

The report should thus be seen as an exercise to grasp the range and variety of general nano-conceptions as such and as a way of recognizing the process in which these are usually being disseminated from the 'experts' arena and into the public sphere in general.

The main issues assessed are:

- Stages of nanoscience and nanotechnology development
- Constraints, gaps, quality and certainty of nanoscientific and nanotechnology Knowledge
- Concerns relating to potential and plausible environmental, ethical and societal impacts
- Aspects of military defense and security nanotechnology applications
- Nanotechnology, practical problems and 'underdeveloped' countries
- Communication proposals among actors and communities for policy making

Therefore, the report can be seen as a raw material source for a wider discussion and evaluation of the aspects and dimensions of the development of nanotechnology just mentioned –and the like; and not as an evaluation per se.

However, the discussion and evaluation have to be considered as a relevant 'must' not only because the lack of dialogue is costly, but also because in the very near future we will have to face, not only the (nano)technological 'context of justification', and the 'context of application', but the 'context of implications' as well.[2]

An evaluation effort based on the establishment of a real, serious and active dialogue seems to be an unavoidable necessity since the public acceptance of novel technology in general is no longer a trivial thing; rather it is a prerequisite for the successful implementation of technology.[3] In this regard, the main worries are related to the kind of nanotechnology that society needs; and to questions concerning by whom and by which instruments these areas are being developed and regulated. This means that future consequences of nanotechnology (and indeed of converging technologies) are increasingly becoming relevant. Key issues include the 'distribution of risk', as well as economical and political justice and power affairs within international, regional and national spheres.

A major reflection should then be made because, '...scientific and technological innovation has the fundamental characteristic of being unpredictable in the sense that the results are in principle unknown until they are found.'[4]

If nanotechnology is considered to be a powerfully transformative technology, then '...it is critical to understand where this technology is coming from and where it is going'. Analytical clarity is crucial in order to advise policy makers properly. Presently there is widespread confusion between the reality of nanotechnologies (in the short term), their potential (in the medium and long term) and the 'stuff' of science fiction, and not only on the part of the general public.[6] Similarly, there seems to be some naïve suppositions 'out there' regarding certain social and ethical aspects of nanotechnology, specially a naïve assumption of a context of power-relations emptiness and therefore of class conflicts.
Hence, this report on a Sociological Insight of Nanotechnology Conceptions expects to contribute with the current debate while clarifying some delusions and at the same time by taking the dialogue forward by proposing 'A Dialogue Methodology for Policy of Nanotechnology Implications.[7]

References
[1] *Quotations have been directly taken from written answers to the survey, except when specified; all contributions are person-specific and do not necessarily represent the position of centers, agencies, etc, where the contributors work.*
[2] *See: Nowonthy, M., et al (1994). The New Production of Knowledge. Sage Publications. London; and, Funtowicz, S (1990). Uncertainty and Quality in Science for Policy. Kluwer Academic. London.*
[3] *Strand, Roger (2001). 'ELSA Studies of Nanoscience and Nanotechnology', MEMO to the COST Nanoscience and Technology Advisory Group (NanoSTAG). November 16.*
[4] *Ibid.*
[5] *Mehta, Michael (2003). 'Nano-hype', AgBiotech Bulletin, 11(6), 5-6.*
[6] *Delgado, Gian Carlo quoted in: 'Down to the nearest billionth', RTD Info Magazine. European Commission. No. 47. January 2006.*
[7] *I presented, as a poster, a preliminary proposal of such a methodology at the Euro Nano Forum 2005 (5th-9th September. Edinburgh, Scotland).*

The NanoCare project – introduction and overview

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Nanotechnology is an emerging technology with multiple visions. It will enable science and industry to provide new and better product solutions to society. The goal of the NanoCare project is to broaden knowledge about nanomaterials with regard to the potential impacts of nanomaterials on human health.

Thirteen companies, universities and research institutes are contributing their expertise to this partnership. They work together to develop generally acceptable measuring and test methods that can be utilized to address safety issues connected with nanomaterials.

The work plan of the NanoCare project is composed of three different parts: (1) the generation, (2) the management, and (3) the transfer of knowledge.

The project partners intend to create new nanoparticles and to use model materials to analyze their possible effects on human health. The expertise of the partners from industry will play a crucial role in characterizing the physical and chemical properties of the chosen materials. *In vitro* studies contributed by universities and institutes of toxicology will systematically investigate biological mechanisms of action of nanoparticles and the dependency on their size, shape, zeta potential and other important properties. Industry will evaluate the *in vitro* data acquired by *in vivo* studies. Furthermore, working place exposure situations will be acquired with improved and established devices and methods.

All data created within the NanoCare project consortium will be interpreted in depth including available information from the literature. The results will be presented in a data base on the world wide web. Furthermore, the results will be discussed with the public, politicians and NGOs at dialogue events. Through this the NanoCare consortium hopes to achieve acceptance for nanotechnology via a better understanding of its benefits and the assessment and management of possible risks.

This open dialogue on the possible risks of nanotechnology, or better nanoparticles, is a fundamental element of the project, which is funded by the German Federal Ministry of Education and Research (BMBF). Together with two other projects (INOS and Tracer) this initiative will help to standardize analytical procedures and will substantially increase knowledge about the biological activities of nanomaterials.

Instrumentation for nanoparticle exposure analysis and control at industrial workplaces

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Abstract
The presentation focuses on measurement techniques for concentration measures of nanoparticles in air at industrial workplaces for nanoparticle production. Number and surface area concentration measures are discussed with respect to their detectability and their relevance with respect to health effects. Limitations of the available instruments concerning the covered size range and their capability to also deliver information about agglomerates have been investigated. Finally the state of the art of available aerosol instrumentation applicable to nanoparticles in workplaces is defined.

Introduction
In order to assess possible environmental implications of nanoparticles it is necessary to be able to detect and quantify nanoparticles in the corresponding matrix; soil, water, and air in the ambient and/or workplace environment.
Up to now inhalation appears to be a more important route for potential nanoparticle toxicity than all others. In workplaces of nanoparticle production the likelihood that engineered nanoparticles accidentally occur is the highest. Therefore for the time being we consider only engineered nanoparticles in workplaces in the airborne state.
Different measurement and sampling techniques are necessary as well as specific strategies to identify and quantitatively determine nanoparticles. The latter topic is addressed in a separate presentation by Kuhlbusch et al. (2007). Especially challenges regarding background concentrations and other sources will therefore not be addressed here.
This paper focuses only on on-line capable methods and instruments, although sampling and off-line analysis methods are needed for a detailed study of the nanoparticle properties and to identify their sources.

Health relevant nanoparticle measures
Engineered nanoparticles are discussed to be potentially health relevant. In the future their concentrations may increase in the environment because of increasing use of nanoparticles produced to create nanostructured materials and devices. For risk assessment, hazard and exposure have to be known. Hazard is determined with in vitro/in vivo bio-testing.
It is still largely unknown which physical and/or chemical measures the hazards relate to. The dose is derived from mainly concentration measures taken outside of the biological system. Information about physical and chemical properties of nanoparticles is of particular interest.
Thus far, workplace exposure as well as environmental analysis is mainly based on mass related measurement quantities, therefore emphasizing supermicron particles. The particle size change of interest from supermicron to nanometer dimensions makes it necessary to reconsider the existing particle measurement techniques, whether they can be adjusted to the drastically changing measurement object 'nanoparticles' compared to supermicron particles. Also the measures of interest change with particles size. The measurement of number concentration rather than mass concentration has been proposed mainly for reason of better sensitivity. The measurement of surface area concentrations has been promoted for their possibly higher health relevance.
The demands for instrumentation for the determination, characterization, and identification of nano- and ultrafine particles are different for exposure analysis and for control purposes. The latter focuses mainly on particle detection, robustness, and easiness of handling, whereas the prior focuses mainly on the characterization and identification for exposure assessment towards specific particles or particle sources besides aerosol properties described by concentration measurements.

Number and surface area distribution of agglomerates
In exposure analysis more detailed information, e.g. size distributions, is needed. Static measuring devices may be sufficient but they should be at least quasi-on-line. For control purposes the interest is more towards personal measurements delivering total concentration measures integrated over time.

The SMPS is the main tool for measuring the number concentration-size distribution which in case of spherical particles can be easily calculated from the measured data. In case of agglomerates the surface area of a single agglomerate is depending on the size of the primary particle, the number of primary particles, and their degree of necking. In case of no necking the largest possible surface area occurs. For these kind of agglomerates Lall and Friedlander (2006) developed a model based on literature data, which allows the calculation of the surface area distributions of agglomerates from SMPS-measurements for given size of primary spherical particles. The model also takes into account a changed charging efficiency of agglomerates compared with spherical particles in the upstream neutralizer. Fig. 1 shows an example of a Diesel soot measurement. The surface area distributions are shifted slightly towards larger particle sizes and increase with decreasing particle size. However, the model allows only consideration of the extreme case of agglomerates without necks. Therefore, a method is needed for (partly) sintered agglomerates.

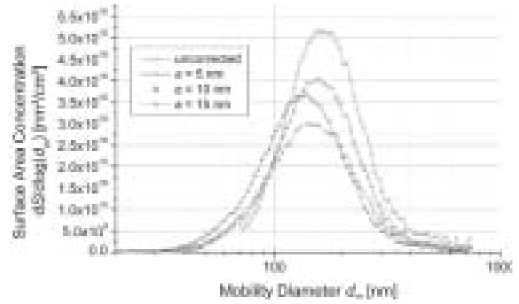

Fig. 1: Surface area distribution of Diesel soot, measured with SMPS, uncorrected and corrected under the assumption of primary particle radii a of 5, 10, and 15 nm

Requirements for number and surface areas monitors
Monitors, which integrate over the size distribution, have to have a certain response function, the sensitivity (e.g. surface area per particle as function of particle size). Tolerable errors can be described as allowed deviations from these response functions. In Fig. 2 the response function for surface area concentrations as function of mobility diameter is shown for spheres. Shown are also the allowed deviations for a tolerable error of 10% surface area of a particle with 100nm diameter. The deviation in surface area changes rapidly with decreasing particle size. However for large particles it decreases. But fortunately the number-concentration, which determines the relevant total error usually drops rapidly for particle sizes above 100 nm in case of workplace air. In some cases a pre-separator may be needed to separate larger particles.

There is also great interest in measuring more health relevant quantities for control purposes. Toxicologists claim that particle surface area correlates very well with certain health effects after particle intake into the lung. Therefore they are interested in the particle surface area deposited in different compartments of the lung or even in biological responses after particle deposition. A better correlation between this quantity and the observed health effect is expected (Fissan et al., 2007).

The error considerations also hold for these instruments (e.g. **N**anoparticle **S**urface **A**rea **M**onitor, NSAM, TSI). Errors are caused by differences between the actual response function of the instrument and the wanted one. Another error occurs if agglomerates are measured due to calibration for spheres This influence can be estimated by using Lall's model. The ratio of surface area per particle of agglomerates and spheres is shown in Fig. 3. The arrows indicate the allowed ratio for 10% error (at d_m=100 nm). The errors are within the tolerable range.

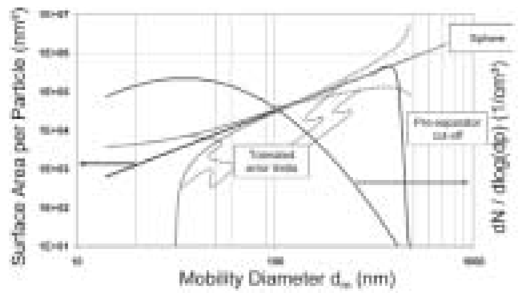

Fig. 2: Response function as surface area per particle as a function of mobility diameter along with defined tolerable errors

State of the art of available instrumentation

An analysis of existing instrumentation was performed for number concentration and surface area measuring devices. Instruments for mass concentration are not of interest here because of their low sensitivity. All instruments are not available in the form of a personal sampler. The highest biological relevance maybe attributed to measures of deposited particle surface area in different compartments of the lung. Detailed information about the response function, which is needed for error analysis is thus far publicly only available for the NSAM (Shin et al., 2007).

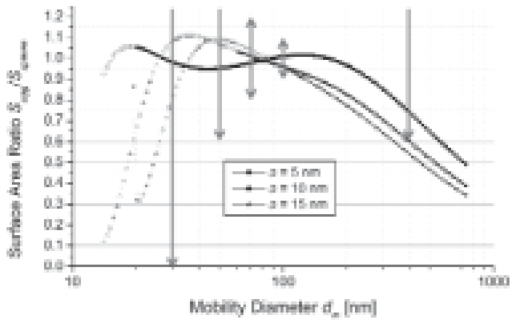

Fig. 3: Surface area ratios of agglomerates according to Lall theory compared with spheres as a function of mobility diameter for agglomerate primary particle radii of 5, 10, and 15 nm. Open symbols indicate areas out of scope of the theory.

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(Eco)toxicological tests and bioavailability recombinant microbial models in evaluation of hazard and mechanism of action of manufactured nanoparticles: contribution to 3Rs and REACH

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Abstract

Very small size of nanoparticles could noticeably change their bioavailability and toxicity compared to their not nano-analogues. Thus, for sustainable development of nanotechnologies their potential harmful effect to biota (incl. humans) needs to be studied. Study of biological effects of NPs with organisms representing different trophic levels helps to understand mechanisms of uptake and following biological effects of NPs. In our laboratory different tests (photobacteria, protozoa, daphnids, algae) have been used for the toxicity investigation of chemicals (solvents, pesticides, phenols, heavy metals, xylidines etc). In the current study we have applied these tests for evaluation of hazard of anorganic (ZnO, CuO, TiO_2), and organic nanoparticles (PAMAM dendrimers and polyethyleneimine) In addition, recombinant sensor bacteria were used for quantification of solubilised Zn^{2+} and Cu^{2+} ions from ZnO and CuO, respectively. Our results showed that rapid (eco)toxicological tests are valuable screening tools for nanoparticle safety evaluation, contributing to 3Rs strategy and thus helping to reduce the number of experimental (vertebrate) animals in toxicity testing.

Introduction

The growing awareness of hazard of chemicals is clearly shown by the approval of EC new chemical legislation REACH in December 2006. The current knowledge on unforeseen biological effects of various chemicals should promote the intensive research on safety of new chemicals/materials entering the market, e.g., manufactured nanoparticles.

Nanoparticle is a particle with one or more dimensions less than 100 nm. Nanoparticles either occur naturally (e.g. humic substances, viruses, by-products of combustion, milling etc.) or can be engineered (e.g fullerens, dendrimers, metal oxides/salts) with specific desired properties. Man-made nanoparticles range from the well-established multi-ton production of carbon black and fumed silica for applications in plastic fillers and car tyres to microgram quantities of fluorescent quantum dots used as markers in biological imaging (Hoet et al., 2004). At nanosize range, the properties of materials may differ substantially from those bulk materials of the same composition, allowing them to perform exceptional feats of conductivity, reactivity, and optical sensitivity (Nel et al., 2006). As by today there is increasing scientific evidence that these physical and chemical properties of manufactured nanoparticles (compared to their bulk forms, if existing) lead to an increase of toxicity and bioavailability.

Amanda S. Barnard in her commentary articles 'Nanohazards: Knowledge is our first defence' in 'Nature Materials' (2006) summarises the problem of potential hazard of nanoparticles/materials very illustratively: .'...Nanohazards are different because nanomaterials do not behave in a predictable way. They are the Jekyll and Hyde of materials science, giving us unique chemical, electrical, optical and physical properties; as well as a new range of possible carcinogens, poisons and allergens....'. Nevertheless, nanosized materials were till recently treated as variations of the technical material or existing formulation and thus do not requiring a separate registration (Oberdörster et al., 2005).

Safety testing of chemicals implies the usage of a very large number of laboratory animals. Thus, the use of the whole non-vertebrate organisms (e.g. bacteria, crustaceans, protozoa, plants, yeasts) in human health risk assessment, especially for regulatory purposes, should be increased as indicated in the 3Rs (Reduction, Replacement, Refinement) policy. 3Rs concept was introduced by Russel & Burch in 1959 and that means that alternative, non-animal tests systems (mainly eukaryotic cell cultures) should be introduced to supplement, and, in some cases, to replace toxicity tests using animals.

The aim of our research was i) to work out cost-effective, predictive and ethical testing strategies for evaluation of biological effects of nanoparticles applicable also for risk assessment and ii) to obtain comparative information on toxicity and mechanism of action of nanoparticles of various type and size for cells/organisms of different biological complexity (e.g., bacteria, yeasts, human and animal cell lines, protozoa, algae and invertebrate animals).

Materials and Methods

Nanoparticles studied.
Metal oxides (ZnO, TiO_2, and CuO, 20–70 nm) and nanoscale organic polymers PAMAM G5 dendrimers and polyethyleneimine (PEI) were studied. All chemicals were purchased from Sigma-Aldrich and the sizes indicated are these advertised by producers. These nanoaprticles were chosen, because TiO_2 and ZnO are already used in different consumer products (as UV filters and/or antiseptics; Oberstörster et al., 2005; Nel et al., 2006) and the dendrimers and PEI are promising gene and/or drug delivery vectors (Haensler & Szoka, 1993; Kircheis et al., 2001). In case of metal oxides bulk forms of oxides and respective soluble metal salts ($CuSO_4$ and $ZnSO_4$*$7H_2O$) were used as controls.

Biotests
1) 30 minute *Vibrio fischeri* luminescence inhibition test
2) 48h immobilisation test with crustaceans *Daphnia magna*
3) 24h growth inhibition test with protozoa *Tetrahymena thermophila*
4) 24 h growth inhibition test of human erythroleukemia cell line K562 (24 h IC50)

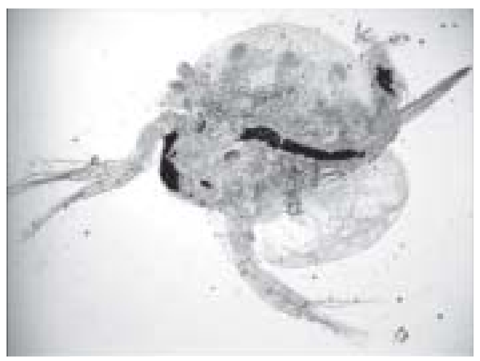
Biosensors
1) recombinant E. coli MC1061(pSLcueR/pDNPcopAlux) sensing Cu^{2+}
2) recombinant E. coli MC1061(pSLzntR/pDNPzntAlux) sensing Zn^{2+}.

Results
The toxicity ranking of studied particles (all were studied as aqueous suspensions) was as follows:
1) L(E)C50 = 1-10 mg/L: PEI (protozoa), ZnO & nano ZnO (Vibrio fischeri, Daphnia magna), nano CuO (D. magna, T. thermophila);
2) L(E)C50 = 10 -100 mg/L: PEI (V. fischeri, human cells in vitro), CuO, nano ZnO and ZnO (T. thermophila);
3) L(E)C50 >100 mg/L: PAMAM G5 dendrimer (V. fischeri, human cells in vitro); CuO and TiO_2 (V. fischeri, D. magna) nano CuO (V. fischeri).

TiO_2 was of lowest toxicity as its aqueous suspensions did not show adverse effects even at 20 000 mg/l level (i.e. 2%).

The results obtained showed that:
1) Protozoa and crustaceans were more sensitive than bacteria towards all tested nanoparticles;
1) Dendrimers were less toxic than PEI;
1) ZnO and nanoZnO were of comparable toxicity;
1) Nano CuO was remarkably more toxic than bulk form of CuO.

Fig. 1: Crustaean *Daphnia magna* (intestine full of CuO nanoparticles)



Discussion
Currently, the main **mechanism of toxicity** of NPs is thought to be via oxidative stress (Kohen & Nyska, 2002). The reactive oxygen species (ROS), such as hydroxyl radical, hydrogen peroxide, and superoxide anion, generated by nanoparticles, damage lipids, carbohydrates, proteins, and the DNA (Kelly et al., 1998). In vitro studies (Long et al., 2006) report that TiO_2 NPs cause oxidative stress -mediated toxicity in diverse tissues, including brain cells. Near-UV-light irradiation potentiates the toxic effect (Maness et al., 1999) and causes ROS-mediated genotoxicity of TiO_2 (Ashikaga et al., 2000). However, for bacteria the oxidative stress - mediated toxicity remains still not clear Lyon et al., 2006; Adams et al., 2006). In case of metal-containing nanoparticles, also **liberation of toxic amounts of metal** ions may cause the toxicity.

It has been shown for CdSe quantum dots liberating Cd^{2+} (Derfus et al., 2004). Aqueous solubility of ZnO is ~ 1.6-5 mg/l *(http://www.epa.gov/fedrgstr/EPA-TRI/1995/September/Day-12/pr-25.html)* and Zn ions at that concentration are already toxic to many aquatic organisms (Kahru et al., 2005). In addition, the release of toxic metal ions from metal containing nanoparticles can be increased due to direct contact of biological entities (e.g., bacteria, cells) with nanoaprticles. The close contact of organisms with nanoparticles may cause changes in microenvironment (pH etc) and initially not soluble forms of metals will solubilise, analogously to particle-bound metal solubilisation in soils due to soil-microorganism direct contact; Ivask et al., 2004).

The higher sensitivity of crustaceans Daphnia magna and protozoa Tetrahymena thermophila to all tested (nano)particles was probably due to the fact that they are particle-ingesting organisms (Fig. 1). There was one exception, ZnO, that will be discussed below. Differently from particle-ingesting organisms, bacteria are largely protected against the NP entry as they do not have mechanisms for the transport of supramolecular and colloidal particles across the cell membrane. For example, only <5 nm quantum dots entered the bacterial cells, probably by means of light-aided oxidative damage of the cell membrane (Kloepfer et al., 2005). In addition, in aqueous media the NPs are aggregating and thus the uptake of even small nanoparticles by intact bacterial cell is of small probability. However, ZnO (both, nano and bulk form) was equally toxic to bacteria and crustaceans. The use of specific Zn^{2+} sensing recombinant bacteria showed that the toxicity of ZnO and nano ZnO was largely caused by dissolved metal ions that can enter also bacterial cells.

Conclusions
1. The nanoparticles have to be studied case by case as it was also stressed in SCENIR 2007 Report 'The appropriateness of the risk assessment methodology in accordance with the technical guidance documents for new and existing substances for assessing the risks of nanomaterials'.

2. The application of ecotoxicological tests and (recombinant) microbial models at the screening stage of all areas of in vitro toxicological research should be seriously considered, as this could save a lot of money, manpower and lives of experimental animals.

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Regulatory considerations for nanotechnology in the EU

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Abstract
Nanotechnology is an 'enabling' technology; and similarly to for instance information technology, it is expected to have an impact on all areas of our lives. There is unanimous consensus among representatives of the European industry, public and private research organizations and academia that nanotechnology will dictate the future technological developments .

Proper harvesting of this enormous potential requires however careful planning on a global scale both in terms of scientific/technological developments and the relevant regulatory environment. We have to understand the potential inherent toxicology of manufactured nanoparticles from relevant studies. We have to study their environmental and biological fate, transport, persistence, and transformation; in order to assess their overall exposure. And only then can we design relevant regulatory measures.

The old Chemicals Legislation, EU Directive 67/548/EEC, as amended, on the classification, packaging and labeling of dangerous substances (DSD) covered all chemicals placed on the EU market, with exemptions under the scope of other equivalent approval schemes. Chemical substances were treated differently if they were considered to be (i) existing substances; i.e. substances already on the EU market before 18 Sept 1981 or (ii) new substances. Existing substances listed on the Community inventory list, EINECS could be freely used by everybody. New chemicals had to be notified in order to get listed on the Community list of permitted new substances, ELINCS, a company specific, proprietary list. Now, since 1 June 2007, after years of preparation and debates, REACH, the new European chemicals legislation, Regulation (EC) No 1907/2006 is in force.

The objective of REACH was clearly stated: to increase the protection of human health and the environment from chemicals, while ensuring the competitiveness of the EU chemical industry. This objective was claimed to be achieved by requiring industry to obtain data on all chemical substances produced in and/or imported into the EU ensuring that the risks from them are adequately controlled via the proposed registration.

How would this aim be achieved?
Manufacturers or importers will be required to register all chemical substances manufactured in or imported into the EU, as such or in preparation, above 1 tonne per year. Registration involves the submission of a technical dossier by producer/importer including necessary data and identified downstream uses. The information requirement depends on the manufactured/imported volumes; the higher the tonnage bands, the more the data requirements. Exemptions from registration exist for some substances as specified in the legislation, such as polymers. Importantly, use of substances in articles ; i.e. objects, which during production are given a special shape, surface or design which determines their function to a greater degree that does their chemical composition ; if not already registered, may also require registration if they are intended to be released during normal or foreseeable conditions of use and are present in quantities of 1 tonne or more per article producer or importer per year. Further, substances in articles may require notification if they are identified by the Agency as being of very high concern, they are present in articles in concentrations above 0,1% w/w and are present in quantities of 1 tonne or more per year per article producer or importer.

The use of 'substances of very high concern' will be subject to authorization within a given timeframe. Ultimately, this process aims at the delisting of substances of very high concern: substances that are category 1 and 2 carcinogens, mutagens; toxic to the reproductive system (CMR 1 or 2); substances that are persistent, bioaccumulative and toxic (PBTs) or very persistent and very bioaccumulative (vPvBs); and substances such as endocrine disrupters which are demonstrated, on a case-by-case basis, to be of equivalent concern. Authorization is granted if the operator can demonstrate that the risks related to the use of the substance are adequately controlled, unless it is impossible to determine a threshold for risk. If not, authorization can still be granted if the risk is outweighed by socio-economic benefits and no alternative substances are available. However, authorization will be subject to a time-limited review so the authorization system will encourage companies to switch to safer alternatives. In fact, all applications for authorization need to include analysis of safer alternatives and a substitution plan where a suitable alternative exists.

How will all these regulatory developments influence the manufacturing and use of nanoparticles in the EU?
Interestingly, the European Parliament in its second reading proposed amendments to consider all nanoparticles as substances to be authorized due to their unknown potential effects on the human body and the environment. However, these amendments were not taken up in the final consolidated text; the EU is further considering a proper and suitable regulatory framework with fast paced developments in certain areas which can already offer some guidance to industry on the appropriate regulatory approach.

First, the EC Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) adopted an opinion on the appropriateness of existing methodologies to assess the potential risks associated with engineered and adventitious products of nanotechnologies. In essence, the SCENIHR scientific opinion states that, given the uncertainties concerning hazard and exposure, the current risk assessment procedures require modification for nanoparticles.

Further, the European Commission is performing a regulatory inventory, covering EU regulatory frameworks that are applicable to nanomaterials (chemicals, worker protection, environmental legislation, product specific legislation etc.). The purpose of this inventory is to 'examine and, where appropriate, propose adaptations of EU regulations in relevant sectors' as expressed in Action 6d) of the Commission Action Plan. Preliminary findings indicate that the regulatory frameworks in principle give a good coverage; different aspects of production and products are at the same time subject to various Community provisions. However, many of the knowledge gaps (toxicity thresholds, test schemes etc) will need to be addressed to ensure implementation. Those knowledge gaps are in line with the ones earlier identified by EC and others and reported to the OECD (Organization for Economic Cooperation and Development) which is tackling fundamental questions about nanomaterials.

What should companies do who are manufacturing/importing or using nanomaterials in the EU already today?
For the time being, companies need to get ready to fulfill their duties according to the very strict time limits required by the new European chemicals legislation.. The manufacturers/importers and users of nanoparticles have to watch carefully to see exactly what the fast paced regulatory activities around the globe will bring them to regulate their products.
The fact that no nanotechnology-specific regulation exist today should not prevent industry developing new products - as new developments are not made in a regulatory vacuum. Current legislation applies and must be correctly interpreted to cover new developments.

NanoSci-ERA: Nanoscience in the Euopean Research Area

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Centre National de la Recherche Scientifique, Département MPPU, Paris, France

The ERA-NET scheme was introduced in the 6th Framework Programme (FP6) as the principal means to support the cooperation and coordination of research programmes carried out at a national (or regional) level. Over FP6, close to 100 ERA-NET contracts have been signed covering a wide spectrum of science and technology fields.
Launched in March 2005, NanoSci-ERA is an ERA-NET whose focus is basic nanoscience research. Coordinated by the CNRS, the NanoSci-ERA consortium consists of 18 research agencies and ministries from 12 ERA-countries whose programmes altogether benefit to a vast majority of the European nanoscience research community.

The principal objective of NanoSci-ERA is the increased collaboration and integration of the national Nanoscience research communities in Europe through transnational research projects and evaluation. This objective is served by three operational objectives, namely the effective and durable coordination of the Partner agencies, the development of a coherent scientific policy on the multidisciplinary development of Nanoscience throughout the ERA, and the concerted outreach to the societal players. These 1+3 objectives are addressed through 5 WorkPackages structuring the project.

The work of the consortium will be illustrated by a few actions selected among past and on-going tasks showing the variety of issues addressed with an emphasis on the first transnational call for proposals run by NanoSci-ERA in 2006 as a successful action relevant to the advanced level of coordination which the consortium aims at achieving. Through this call, 12 collaborative projects involving close to 50 research teams could be funded on a budget of 8.7 M€, part of which was mutualized in order to avoid any trade-off on the scientific quality of the selected projects.

MNT ERA-Net: Opportunities for transnational cooperation in micro- and nanotechnologies

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Abstract
MNT ERA-Net is a network of national and regional funding programmes for micro- and nanotechnologies (MNT) with the aim to reduce fragmentation of European funding. MNT ERA-Net opens calls for proposals for transnational, applied R&D projects in all areas of micro- and nanotechnologies and makes national and regional funding programmes accessible to transnational consortia.
MNT ERA-Net started in January 2004 with a core group of 8 European funding programmes. After two expansion phases the consortium now comprises 20 countries and regions, represented by 23 ministries and programme agencies with combined annual public funding of more than € 365 million.

Mission
Europe has a strong research base in many MNT areas but its funding programmes are fragmented and dispersed among many national funding bodies.
It is the mission of MNT ERA-Net to enhance the competitiveness of the European industry by coordinating European support measures for micro and nano technologies, by implementing sustainable joint and coordinated activities, by securing mid-term cooperation between the participating funding programmes from all over Europe and through the continuous improvement and streamlining of MNT support services.

Calls
MNT ERA-Net has already launched coordinated calls with the intention to offer new channels for applied R&D projects which complement the portfolio of other European initiatives. These calls have been based on national and regional rules providing funding for project partners of transnational project consortia through a coordinated action of their respective national or regional MNT support programmes. As a comprehensive clustering analysis of competences and industrial requirements in member countries/regions has not delivered a clear common thematic focus the overall scope of the calls has been defined wide on European level in order to have as many programmes as possible participate in the calls thus achieving critical mass; however national and regional priorities and restrictions apply.

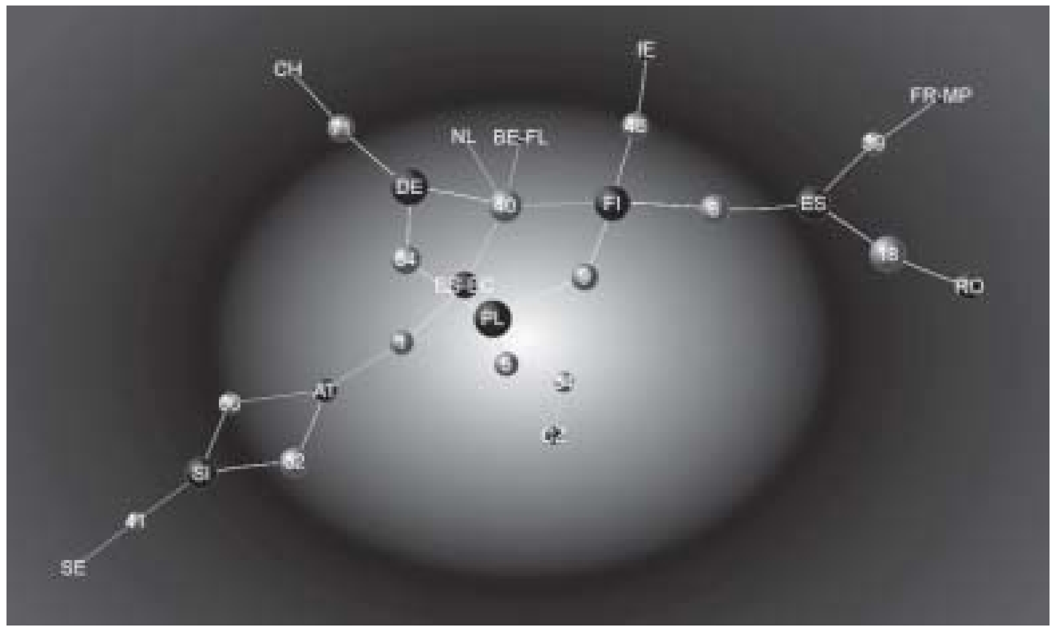

Figure 1: 14 funded projects are the results of the first Coordinated Call 2006. This image shows how partners from participating countries and regions (dark) are connected to each other by projects (light) forming a network of predominantly bilateral cooperations.

The first coordinated call was organised in 2006 and was considered successful by the 18 participating countries and regions. 42 full proposals underwent the coordinated procedure which resulted in a common listing of recommended proposals. 14 collaborative projects have been funded covering topics such as powders, CNT, polymers, composites or microsystems. At close to 40% the participation of industrial partners was comparatively high.
With the coordinated funding of such projects in this pilot action MNT ERA-Net has proved that the ERA-NET scheme is a suitable instrument for establishing transnational collaboration in micro- and nanotechnologies. Moreover, the common call procedures have required little bureaucratic effort making the scheme highly attractive for project consortia and funding bodies at the same time. After the successful call in 2006 the consortium has already launched a second call in 2007. Particular efforts have been undertaken to achieve maximum transparency of eligibility criteria in joint calls as well as full understanding of the ERA-NET instrument as such.
The main benefits of the coordinated calls are the proximity to clients and the low administrative barriers which especially encourage small consortia and newcomers. Participants benefit from an accelerated funding decisions process as well as synchronised and coherent funding decisions.

Relation to European R&D activities
With the execution of coordinated calls MNT ERA-Net has the potential to support the implementation of European MNT strategies thereby complementing initiatives such as the Framework Programme. MNT ERA-Net can help establish links between strategic aims of European Technology Platforms (ETP) and respective target groups. It provides practical aspects of innovation through complementary project types and close relations to national and regional clients. Proposals submitted to MNT ERA-Net calls will typically be more market-oriented and smaller than proposals submitted to the Framework Programme.

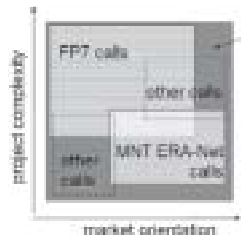

Figure 2: The large field of MNT (dark) is covered by various calls and instruments.

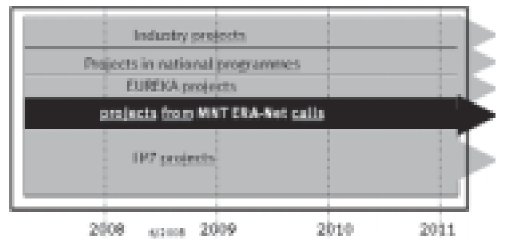

Figure 3: MNT ERA-Net supports the implementation of European MNT strategies.

Figure 4: The MNT ERA-Net network connects partners from 20 countries and regions.

Outlook
Under FP7, the consortium intends to consolidate and assure a high commitment on national and regional level. Sustained transnational cooperation should yield added value for all participating programmes. Activities will be expanded to Eastern European countries. The consortium intends to establish a system of yearly Transnational Calls and to explore possibilities for streamlining and mutual opening of national programmes as well as for joint programmes. All efforts will as also be undertaken to fully exploit the ERA-NET PLUS scheme and to cooperate closely with other networks and initiatives.

Participants
FFG *Austria,* IWT *Flanders,* DGTRE *Wallonia,* CSNMT *Czech Republic,* TEKES *Finland,* CEA *France,* CEMES / CRMP *Midi-Pyrénées,* VDI/VDE-IT *Germany,* PTKA *Germany,* Enterprise Ireland *Ireland, Invest Northern Ireland Northern Ireland,* RCN *Norway,* IET *Poland,* MES *Poland, PUB Romania,* SAS *Slovakia,* MHEST *Slovenia,* MEC *Spain,* Basque Government *Basque Country,* SenterNovem *The Netherlands,* VINNOVA *Sweden,* KTI/CTI – TEMAS *Switzerland,*

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MATERA, ERA-NET Materials

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Abstract
MATERA is one of the European Commission's ERA-NET projects aiming at the coordination and opening up of national and regional research programmes. The main goal of the MATERA project is to create a durable cooperation platform for policy makers and managers having strategic activities in the field of materials science and engineering. In a long run it will have a major impact on the R&D activities in strengthening the European cooperation, combining the research resources and personnel, equipment and finance which alone wouldn't form a critical mass needed for successful material research and development. MATERA consists of 17 organisations in 14 European countries.

MATERA connecting the key players
The MATERA partners come from different European national and regional science and technology authorities. Within the project they collaborate to improve the diffusion and transfer of knowledge and skills in Europe. MATERA is also a good platform for benchmarking and further development of the national and regional strategic measures.

MATERA project will gradually increase ambitious programme-type collaboration between European countries and regions in order to deepen the European Research Area. The project helps the national and regional decision makers to intensify their policy making operations and to strengthen their own development. At this moment the MATERA project consists of 17 national funding organisations representing 14 countries (Table 1). Duration of the project is four years: 1 February 2005-31 January 2009.

Table 1. MATERA partners

Organisation	*Country/Region*
Tekes	Finland (Coordinator)
AKA	Finland
IWT	Belgium / Flanders
DGTRE	Belgium / Wallonia
MIWFT	Germany / North Rhine - Westphalia
RANNIS	Iceland
EI	Ireland
MOST	Israel
MUR	Italy
LCS	Latvia
FNR	Luxemburg
RCN	Norway
MSHE	Poland
WUT	Poland
MHEST	Slovenia
KTI/CTI	Switzerland
Invest NI	United Kingdom / Northern Ireland

Materials make the world go round
Materials science and technology is one of the cornerstones of European industry. The development of this technology is of high importance, not just for the material manufacturers but also for many other important sectors such as ICT, transport, health, and sports and leisure. High-level knowledge and utilisation of materials is essential for both existing and new enterprises in Europe. MATERA aims at activating innovative, multiscale (from nano to macro), multidisciplinary R&D projects on materials.
MATERA project strives to shorten the innovation value chain from basic materials science and engineering into innovation related projects for the benefit of European society and business. By improving and accelerating transfer of knowledge related to materials the competitiveness of European enterprises can be sharpened.

Collaboration based on activity and trust
MATERA progresses well towards its goals. Mutual trust between the partners has been formed as well as enthusiasm for common activities. The MATERA meetings and workshops enable the continuous change of information and the deepening of the cooperation. The partners have clearly understood the value of combining the national and regional resources and activities: together we can achieve more.

Common calls deepen cooperation in practise
The common calls for transnational projects are one way to strengthen the cooperation between the national and regional programmes and other strategic activities. MATERA has so far launched two Calls for enterprises, research centres and universities. Different call procedures were piloted in these calls to find out the most suitable ones for MATERA. Almost 200 organisations were involved in these two pilot calls showing the need for cooperation between the national/regional activities.

The first Call arranged in 2006 had three topics: Advanced engineering materials, Novel materials for health and welfare, Materials for sustainable energy. Eight proposals ranked the best were rewarded a total of 5 million euros. As shown in Fig.1 the selected projects cover a wide European research area.

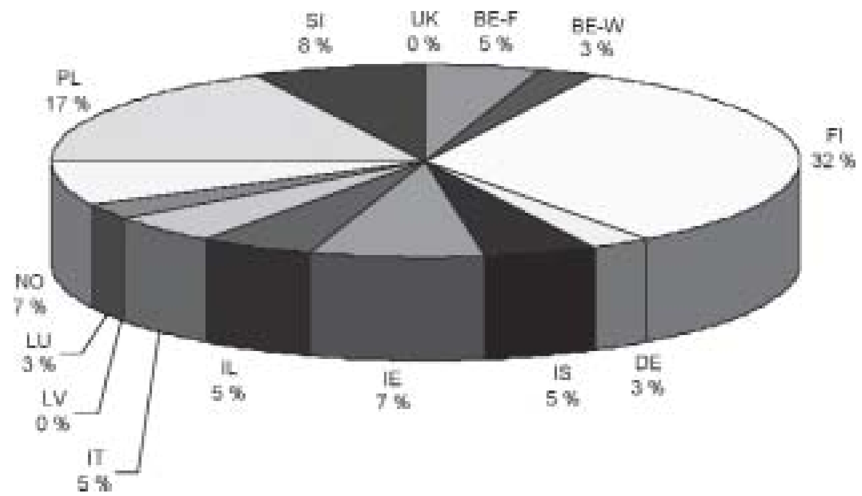

Figure 1.
Proportion of countries involved in the first funded MATERA projects.

MATERA's second Call in 2007 was more focused: Materials for Sustainable Use in Renewable Energy. The call aims at innovative development and use of materials for new energy technologies like bio energy, fuel cells, solar, wind, wave, tidal, and geothermal energy. The funding decisions for the second Call will be available year-end 2007.

Coming up next
The MATERA project is now in its midpoint. MATERA Outlook Conference will be arranged 27th of June in Oslo. The Conference will give a good overview of MATERA and also other material related activities in Europe.
MATERA's main Call will be launched in 2008. The Call will be open also for other European funding organisations who are interested in strategic developing of their nation/region by using the possibilities material science and engineering can offer.

The public funding organisations in MATERA see the ERA-NET cooperation on materials as beneficial for their national/regional activities and will continue the collaboration also after the MATERA project. MATERA welcomes new partners who see the role of materials science and engineering vital. Further information related to MATERA is available in MATERA website (www.matera.fi).

An ERA-NET financed by FP6

The outcomes and future of Nanoforum, European nanotechnology network

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Nanoforum is a pan-European nanotechnology information network funded by the EC under FP5, to provide information and support to the European nanotechnology community. Starting in 2002, Nanoforum's remit was to:

- establish a website to inform the community of developments in nanoscience and nanotechnology (N&N);
- raise awareness of nanotechnology, through reporting new developments in different technology and industrial sectors and issues associated with these developments;
- support education for nanotechnology, through online tools, summer schools and information days for students; support the networking of EU nanotechnology, through workshops and conferences;
- establish links with other EU and global organizations and networks to facilitate information exchange.

The partnership
Nanoforum has brought together thirteen organizations over the course of the project. It is lead by the Institute of Nanotechnology (UK) and currently includes the following partners: VDI Technologiezentrum GmbH (DE), CEA Leti (FR), Middle East Technical University (TR), UNIPRESS (PL), University of Sofia (BG), Spinverse (FI), Malsch TechnoValuation (NL) and the European Nanotechnology Trade Alliance (UK). It has two associate partner organizations: FFG (AT) and NanoNed (NL). Previous partners of the project were CMPC (ES) and Nordic Nanotech (DK). These partners have brought complementarity in disciplinary experience and geographic location, achieving an effective networking of EU expertise in N&N.

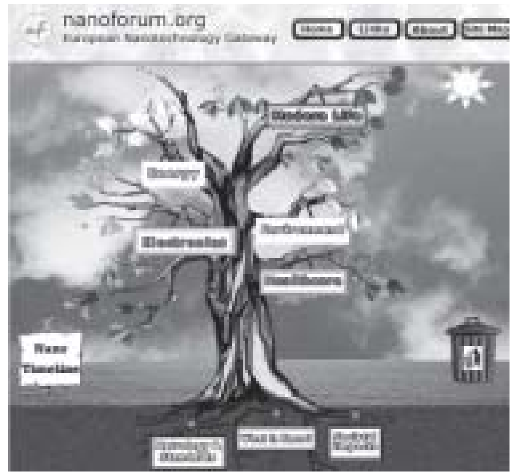
nanoforum.org
The Nanoforum website provides access to all of the output from the project.
From the home-page users can access: the latest N&N news from around the globe (with an EU focus); all the Nanoforum reports and publications from other sources; a database of over 2200 European N&N organizations; an events calendar; information on funding calls and programmes; educational material; support for SMEs; links to international organizations; a discussion board; and information for journalists, including media friendly journalists. The website now attracts more than 80 000 visits and 800 000 hits each month, and has over 13 000 registered users.
To have full access to this wealth of information all users must do is register online. This is entirely free and requires only an email address and country of residence.

Nanoforum reports
Nanoforum has published a total of 23 reports many of which have been downloaded several thousands of times. These cover many different topics such as: technologies and industrial sectors (for example energy; health and medicine; agriculture and food; construction; aerospace; security); societal and ethical issues; environment; education; economic impacts; and reference documents describing nanotechnology infrastructure

and networks in the EU. Nanoforum also coordinated one of the most successful online questionnaires on nanotechnology issues in the EU. In partnership with the European Commission, Nanoforum held an 'Open Consultation on the European Strategy for Nanotechnology' during 2004, which attracted 750 responses, and gave researchers, industrialists, and representatives from both government agencies and NGOs the opportunity to voice their opinions.

Nanoforum events
These have included conferences on industrial applications (for example smart medical devices), workshops exploring different aspects of nanotechnology RTD (for example environment; security; commercialisation and technology transfer), summer schools to help train the next generation of nanotechnologists; information days for students and those seeking access to EU funding; and investment days. Partners in these events have included the European Commission, leading EU institutes, universities and companies, and other EU-funded projects. Through these events Nanoforum has reached out to different sections of the community to support their activities in nanotechnology. In addition, PDFs of presentations and proceedings from many of these events are available to download from the Nanoforum website.

Education
Nanoforum provides lists of higher education courses, short training courses and links to other resources such as the nanotechnology Masters recognition scheme. In addition, it has produced two online resources for educationalists, and for those who are 'beginners' to nanotechnology. The first is a series of educational modules that can be downloaded as PDFs for use by teachers.
These cover: nanotools and nanofabrication; nanostructured materials; nanoelectronics and devices; and nanobiotechnology. The second is an interactive 'Education Tree' where users with little or no experience of nanotechnology can discover some of its history, myths, potential risks, and societal impacts, and learn more about five areas: electronics, energy, environment, healthcare, and modern life.



Networking
Nanoforum has been actively networking the community, establishing collaborations with other EU projects such as Nano2Life, Nanologue, NanoDialogue, WomeninNano, NanoforumEULA, and EuroIndiaNet. It has also established collaborations with networks in other global regions such as Asia Nano Forum; Minapim; and the South African Nanotechnology Initiative. Through its own events and participation of partners in other projects and events, Nanoforum has reached out to the wider community and invited feedback on its activities. Finally, the website provides a forum for feedback and networking through its discussion board, comments facility under news and reports, response to the registered user annual questionnaire, and contact details for the partners. The project has encouraged users to send in news and information regarding events and publications, which it then disseminates to the wider community. Since December 2005, Nanoforum has published a monthly newsletter informing users of the latest activities from the project, and important news from the European Commission and from other members of the European nanotechnology community.

The future
Funding for the Nanoforum project ends in July 2007. The partners have agreed to continue its work and seek further support (through FP7 and through some commercial activities). To this end Nanoforum will be established as a European Economic Interest Grouping. All users are encouraged to continue visiting Nanoforum and support its activities through this transition period.

European projects and networks Session D2

NanoCap, capacity building for environmental NGOs and trade unions

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NanoCap[1] is a European project set up to deepen the understanding of environmental NGOs and trade Unions of environmental, occupational health and safety risks and ethical aspects of nanotechnology (NT). Structured discussions with academic researchers and other stakeholders (such as industry and consumer organisations) are organised. These will enable the environmental NGOs and trade unions to participate in a debate on nanotechnology at European level, to formulate their position within their actual policy context supported by scientific input, and to inform their members and the general public.

Another goal of NanoCap is to provide industry with tools to introduce a 'responsible nanotechnology' (i.e. stimulating industrial R&D performers to focus on source reduction regarding nano-particles and to make risk assessment an important dimension in their work). Especially concerning the development of a safe workplace, but also with respect to environmental care. Thereby, an open dialogue between industry, NGOs and trade Unions about occupational and environmental health, safety and ethics is of major importance. Such a dialogue allows NGOs and trade unions better insight in the current activities of industries with respect to risk management in relation to NT-developments and the precautionary measures taken to minimise occupational and environmental exposure. For Industry, this dialogue will be one step forward to build a basis of trust and enhance the societal acceptation of nanotechnology.

The NanoCap consortium consists of 5 environmental NGOs, 5 trade unions and 5 universities. Within this consortium, the universities provide the scientific input, whereas NGOs and trade unions will bring in their preliminary positions after discussions with their members. At present, the process of weighing the potential risks against the possible benefits and prospects of innovation has just begun. Starting from the precautionary principle, the fact that new nanoproducts and the nanosizing of existing products could also have many benefits is well recognised and therefore it is discussed to which extend and how this precautionary principle should be applied.

One of the factors influencing this process is the present uncertainty with respect to health and safety characteristics of nanotechnology. There is a clear need for reliable measurement techniques to assess occupational and environmental exposure and to determine the health and safety risks involved. In addition, NanoCap will therefore also develop recommendations to enable public authorities to address the health, safety and environmental risk issues related to the rapid introduction of nanotechnology into society.

During the three year period of the project, NanoCap will subsequently consider the themes NT-R&D at universities and in industry, environmental implications and risks, occupational risk assessment, test systems and REACH, ethics, and the different roles of NGOs, R&D and industries.

Main goals
The goals of NanoCap can be summarised as follows

- Main goals:
  1. To give support to environmental NGOs and trade unions to develop their own position in the debate on nanotechnology based on scientific information.
  2. To give academic and industrial R&D performers tools to introduce a 'responsible nanotechnology'.
  3. To develop preliminary recommendations for public authorities to address ethics and health, safety and environmental risk issues.
- Subsidiary goals:
  1. To have environmental NGOs and trade unions better understand nanotechnology and ethics and health, safety and environmental risk issues, with which they can better inform their members and the general public and with which they can better recommend public authorities on these issues.
  2. To stimulate academic and industrial R&D performers to choose an approach focused on source reduction of nano-particles in their work.
  3. To stimulate academic and industrial R&D performers to accept a risk approach as an item of comparable importance in their design of nanotechnological products as the technology itself.

Starting position NanoCap
The limited amount of new toxicological and hygienic nano-findings, and at the same time the growing amount of opinion forming articles, governmental position statements, health councils reports etc. do emphasize the need for an extreme cautiousness with the introduction of dispersive toxic and badly-biodegradable nanoparticles. At the same time the exalted excitement about the almost unlimited benefits the further development nanotechnological materials may bring to our society, without the need to even reflect on our actual over-consumption of energy and raw materials, is a trigger for NanoCap to follow the developments in a critical way. The experience with the dominance of common economical arguments over environmental and even occupational health arguments is a reason for a high alert on possible negative consequences of nanotechnology. In this respect the debate on ethical issues is of the utmost importance. An important aspect is the discussion on the interpretation of the precautionary principle in the context of nanotechnology, and to find a way to put it in practice in an acceptable way. Handling chemical substances without (enough) knowledge on the environmental and health hazards and risks do require a high responsible operational approach of industry and society. The development of good practices as well as an initiative to introduce a life cycle approach into the nano-debate are possible ways. NanoCap's close cooperation with European trade unions and environmental groups will reflect the critical, but especially independent vision.

Risk approach for nanoparticles
It is quite clear that the actual level of scientific knowledge on hazards and exposure to nanoparticles is too low to carry out proper environmental and health risk assessments. Only little is known about the toxicological and chemical/physical characteristics of nanoparticles in general, and even less of specific nano-substances. However, there are indications, and there is growing evidence that shows that is reasonable not to consider the properties of nanoparticles to be equal to their larger counterparts, but in contrary, that we have to take into account that nano-particles may have specific (new) toxicological properties. Therefore the approach of nano-risks will have to be transparent in choices we make in dealing with the existing uncertainties. A closer look at the way we like to deal with the risks is necessary.

In the commonly used risk assessment methodologies, the risk is measured by counting for the yearly additional chance for adverse effects. For carcinogenic substances for example, an increase in 'death risk' or cancer incidence of 10^{-6} due to occupational exposure is agreed to be acceptable. In feasibility negotiations a lower safety level is generally accepted, up to the lowest accepted level of 10^{-4}. For carcinogenic substances REACH does foresee an authorisation procedure, finally leading to a substitution obligation after a few years if alternatives are obtainable. For actual nanosubstances under research and development it seems to be too early to put them under the stress of this substitution approach. This, because during the development of a new substance, the search for new properties and applications, it seems to be acceptable that not all the requested toxicological and environmental data are directly available. Nevertheless, at the moment of a broader market introduction, the relevant data on health and environmental hazards must be available to give insight in a possible increase of risk, and to give the community the possibility to weight these (change of) risk towards possible benefits that may be expected from the market introduction. The manufacturers and the importers of nano-substances are unambiguously responsible for the generation of these data. The same manufacturers and importers as well as the researchers and governmental policy makers contribute to the nano-hype, ventilating the benefits and the future wealth the nanotechnology will bring to our society. An attitude that carries the risk of too much indulgence towards lacking knowledge on adverse effects.

After all, based on the preliminary scientific findings it seems naïf to think that the introduction of new nano-substances in the market will proceed without the introduction of new risks. Therefore it is wise to think as well about the boundaries in which we, as a community, are ready to accept (an increase in) nano-risks.

Besides the chance and the magnitude of harmful effects, the quantifiable effects, there are more aspects (qualitative aspects) that play a role in risk assessment and the acceptability of the actual estimated risks. There is for example the degree to which the activity (use or exposure to the nano-substance) is voluntary. There is the question about equity, the fair distribution of joy and burden of the new nanoproducts. The level to which the new risks are manageable is important and of course there is familiarity and the social benefits.
In short, the legitimacy of the development and introduction of new nanoproducts can be seen as a sum of quantitative and qualitative risk characteristics.

For the time being, as long as the quantitative risk cannot be estimated due to a 'simple' lack of data, the precautionary principle can (or must) be used as an approach to limit hypothetical[2] risks. To what extend, and for what specific situations the precautionary principle should be applied is subject to political debate, in which the approach of the Dutch Health Council may be helpful.

The Dutch Health Council, in its report on the health significance of nanotechnologies of 2006, sets itself at the position that a further development of nanotechnology should not be restricted by extreme cautious measures. They propose to distinguish risks in the categories 'simple', 'complex', 'uncertain' and 'ambiguous'. This arrangement of risks may give direction to the search for the best risk management strategy. The sequence, from 'simple' to 'ambiguous', corresponds to an increasing involvement by stakeholders including members of the public in the decision-making process. According to the committee, issues relating to privacy, self-testing, and the toxicity of readily degradable nanoparticles can best be classified as 'simple'. Questions concerning the gap between rich and poor, and perhaps those concerning sustainability as well, belong in the 'complex' category. The issue surrounding the toxicity of synthetic nanoparticles that do not readily degrade is placed in the 'uncertain' category because the existing knowledge on this subject is incomplete. The committee classifies issues involving the gap between diagnosis and therapy, advanced home care, enhancement, and military applications into the 'ambiguous' category because they involve value judgements which will differ from one individual to another or from one interest group to another.

Toxic, not readily biodegradable synthetic nanoparticles can be classified in the risk category 'uncertain', with as a consequence the implication that the most suitable risk management strategy is one that is based on the precautionary principle. The Dutch Health Council suggest the following three measures:

- performing life-cycle analyses on products that contain nanoparticles to determine the extent to which such particles are released during the production, use and disposal phases; curtailing emissions from, and exposure within, research centres and factories; focusing on the risks associated with nanoparticles during (mandatory) safety assessments of applications (e.g. soil remediation) and products (e.g. medications) and only granting admission if the benefits counterbalance the risks.
- as a result of their unique properties, the nano-forms of existing substances should be dealt with as if they were novel substances; there should be a lower production threshold or import threshold (or none at all) for nanomaterials in the new European regulations governing chemical substances (REACH);
- more internationally coordinated (OECD's role) research into the toxicity of nanomaterials; modification of the current toxicity tests for substances to improve their suitability for use in nanomaterials; expressing the dosage administered in terms of the mass, surface area, and number of particles; an improved physico-chemical characterisation of nanomaterials; energetically pursuing the recently proposed screening strategy for nanomaterials.

Nanoproducts in the market

Important in the assessment of the hazardous nature of nanoparticles is the fact that manufactured chemicals (i.e. particles) are never 100% pure chemicals. They may contain contaminants, unreacted products, by-products and in the case of particles in general a scattering of different particle size. A recent article examines estuarine copepods on the toxicity of single walled nano-tubes (SWNT) [3]. They suggest a size-dependent toxicity of SWNT-based nanomaterials, with the smallest synthetic by-product fractions causing increased mortality and delayed copepod development over the concentration ranges tested.

The purified SWNT fraction showed no significant effects on mortality, development, and reproduction across exposures. Exposure to the more complex as-prepared-SWNT mixture, the actual SWNT product, which is a mix of the purified fraction with by-products, shows significantly increased life-cycle mortality, reduced fertilization rates, and reduced molting success in the highest exposure.

Furthermore important in hazard assessment is the fact that tear and wear of surfaces in the outside (or indoor) environment, may result in the formation of new (or dispersion of already existing, but initially not free available) fine particles. Therefore the long-term behaviour of (nano-) products in their environment should be subject for risk assessment as well.

And of course, the way we approach these items, the actual operationalisation of the precautionary principle is crucial.

The scope of the NanoCap

The area of nanotechnology, as an enabling science (and technology) with the potency to influence most of the existing sciences and technology, is almost unlimited. Most of the (industrial and public) attention is focussed on the further development of science and technology, to gain economical benefits with the production of new technologies and new products, to generate new products and technologies to reduce environmental pollution (or polluting processes), to design cleaner and safer production, to discover and develop new medical applications, military applications etc. etc. About 10% of the publications about nanotechnology concerns published patents.
Only a limited amount of the scientific and technological research potential is focussed on environment, health and safety issues. Inventories made of the distribution of research resources do show that, for example for the US, ca. 7.5% of the available agencies budget for 2006 is allocated to research with 'societal dimensions'. Under this heading, however, much research is concentrated, as for example research to the development of nano-environmental remediation techniques. Research focussed on the toxicological properties of nanomaterials, hazardous behaviour of these particles, safe working methods etc. is still quite rare.
For NanoCap, which is primarily focussed on facilitating the formation the opinion of the environmental NGO's and trade unions in the NT-debate, it might be helpful to structure the mind setting somewhat and introduce some structuring in the thinking about the heterogeneous nanotechnology field. Of help might be the technology assessment matrix designed by the Dutch Rathenau institute (table 1):

Field of application	*Societal issue*	*Dream scenario*	*Horror scenario*
Nanomaterials / industrial production	health and environment	sustainability	nanoasbestos
Nanoelectronics	privacy	'smart' products	big brother
Nanotechnology in medical sphere	predictive medicine	early diagnostics	genetic coercion
Military technology	arms race	safe world	new weapons, terrorists
General / innovation	economy	economic growth	structural unemployment

Table 1: Societal issues and scenarios for different fields of applications in nanotechnology[4]

Traditionally the field of occupational health risks is covered by trade unions, while the environmental movement does focus on environmental health and sustainability issues. In this respect at least the first field of application (nanomaterials and industrial production) will be of importance for Nanocap, especially for what concerns questions like how to deal with insufficient (or incomplete) information and when and how to apply a precautionary principle. Other fields are interesting as well, but do not seem to deal directly with occupational health and environmental risks and might therefore be farther away from a high priority of Nanocap. Nevertheless some NGOs are involved in discussions on the other items as well, while trade unions as well may be involved in more fundamental, workrelated social/ethical questions.

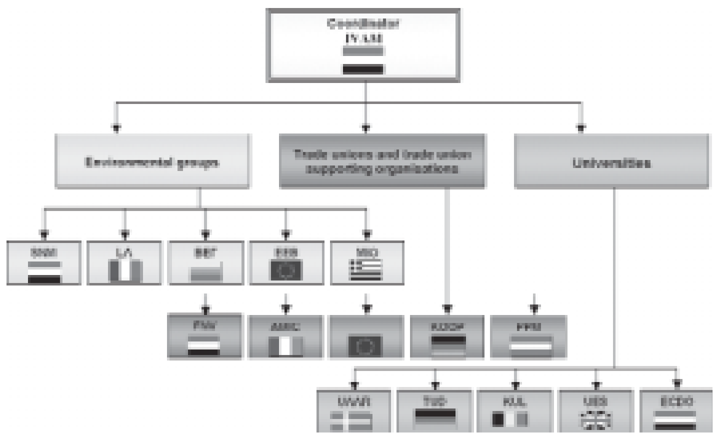
NanoCap borderlines and ethical questions

For NanoCap an important item is to restrict the scope: trying to set some borderlines in the activities. A strong focus on environment, health and safety issues of dispersable and non (or badly) biodegradable nanoparticles seems to be evident. In this respect and additional to the national activities of the NanoCap partners, a focus on international operating organisations (and industry) seems relevant. Secondly, the focus on the development of a responsible nanotechnology is relevant. In this respect ethical issues are of utmost importance.

With respect to nano-risks and the 'choice' for risk taking the following questions can be formulated:

If risk-taking is a social process that commits our societies as a whole and also future generations,
- can public engagement bring about an intelligent investment for specific societal benefits at all? How might this be performed?
- will risks be evenly distributed and how can we compensate those who carry a greater share?

Concerning limits and borders the following questions can be formulated:
- What does it mean to claim ethical responsibility and question claims of unlimited potentials?
- How can we proceed with non-knowledge (ignorance)? And to what extent is a concept of non-knowledge involved in the design of a consent model? What kind of entanglements are involved and anticipated?
- Nanoscience and -technology are said to work interdisciplinary and therefore cross the borders of various disciplines. What kind of knowledge and practices are produced in these border zones and what does this mean for its evaluation and classification in order to assess the consequences for societal implementation? Are there already concepts in the interdisciplinary discourse to describe these issues appropriately?



Code	Organisation name	Country
IVAM	IVAM, Research and Consultancy on Sustainability	NL
SNM	Stichting Natuur en Milieu	NL
LA	Legambiente	IT
BEF	Baltic Environmental Forum	LT
EEB	European Environmental Bureau	EU
MIO	Mediterranean Information Office for Environment, Culture and Sustainable Development	GR
FNV	Federatie Nederlandse Vakbeweging	NL
AMIC	AMICUS the Union	[illegible]
ETUI	European Trade Union Institute for Research, Education and Health and Safety	EU
KOOP	Kooperationsstelle Hamburg	DE
PPM	ppm forschung und beratung	AT
UAAR	University of Aarhus Interdisciplinary Nanoscience Center (iNANO)	DK
TUD	Technische Universität Darmstadt, Institut für Philosophie	DE
KUL	Katholieke Universiteit Leuven, Department of Public Health	BE
UES	University of Essex, Biological Sciences	UK
ECDO	University of Amsterdam, Expertisecentrum Duurzame Ontwikkeling	NL

[1] NanoCap is the acronym for 'Nanotechnology Capacity Building NGOs'. This Coordination Action is financed by the EU within the KP6 Science and Society programme.

[2] There is a difference between potential risks and hypothetical risks. Based on existing knowledge with existing substances one may extrapolate or forecast certain toxic properties that may describe the adverse effects of nanoparticles. In those case some quantification of measures may be proposed. But in case one deals with new substances with 'new' dimensions it may give a false estimation of the effects to use existing substances as a model. In those cases quantification gets quite complex and more extreme measures should be accepted to prevent 'hypothetical' risks. In those cases the use of the precautionary principle is opportune.

[3] Templeton RC, Ferguson PL, Washburn KM, Scrivens WA, Chandler GT, Life-Cycle Effects of Single-Walled Carbon Nanotubes (SWNTs) on an Estuarine Meiobenthic Copepod, Environ. Sci. Technol., 40 (23), 7387 -7393, 2006

[4] Adapted from: van Est, Rinie and van Keulen, Ira (2004) 'Small technology – Big Consequences': Building up the Dutch debate on nanotechnology from the bottom, in Technikfolgenabschätzung – Theorie und Praxis, 13, 3: 72-79

Nano2Life, European network of excellence in nanobiotechnology

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Nano2Life (N2L) is the first European network of excellence in nanobiotechnology supported by the European Commission under the 6th Framework Programme. Its objective is to support Europe position as a competitive player and to make it a leader in nanobiotechnology transfer by merging existing European expertise and knowledge in the field of Nanobiotechnology. Founded in 2004 for 4 years, N2L comprises 23 major European organizations and more than 40 industrial companies within the field of Nanobiotechnology.
The network acts as a European nanobio think tank supporting a strong exchange of knowledge, ideas and vision among its members through the incubation of joint research projects; the networking of intellectual and technical resources; new education and training courses and the transferring of technology.
Nano2Life's main target is willing to contribute significantly to the European integration of people, disciplines and R&D organisations in nanobiotechnology. In fact, the current fragmentation and dispersion of these resources each one contributing to one facet of nanobiotechnology represent a major limit to the development of the European scientific excellence and industrial competitiveness.
The benefits for citizens from nanobiotechnological research are expected to be several, for example the development of a more personalised and less invasive medicine, and more thorough control measures of the environment and food.
The medical benefits are based on the miniaturisation, sensitivity and integration of several functions in a single device. This will bring a more sensitive and faster medical diagnosis; a more efficient therapy with less side effects, and new artificial replacements of deficient functions in regenerative medicine.
In order to accomplish its goals, N2L has more than 400 participating scientists presently involved in a Joint Programme of Activity (JPA) aiming at:
- creating the first ever technological roadmap for nanobiotechnology,
- identifying the key bottlenecks that need to be overcome in nanobiotechnology,
- founding the first European Ethical, Legal and Social Aspects Board (ELSA) in the field of nanobiotechnology,
- implementing a scientific programme focused on eleven strategic research areas, considered as key areas for the future development of innovative nanobio-devices,
- constituting a durable and long lasting integration of the network partners resources.

After more than 3 years of successful operation, the core partners of Nano2Life are definitively looking to the future to keep a favourable environment for a sustainable integration of experts from various disciplines while providing them with an infrastructure supporting their R&D in nanobiotechnology and nanomedicine.

European Network of Excellence supported by FP6 of the European Commission *www.nano2life.org*

Micro- and NanoManufacturing (MINAM) Community

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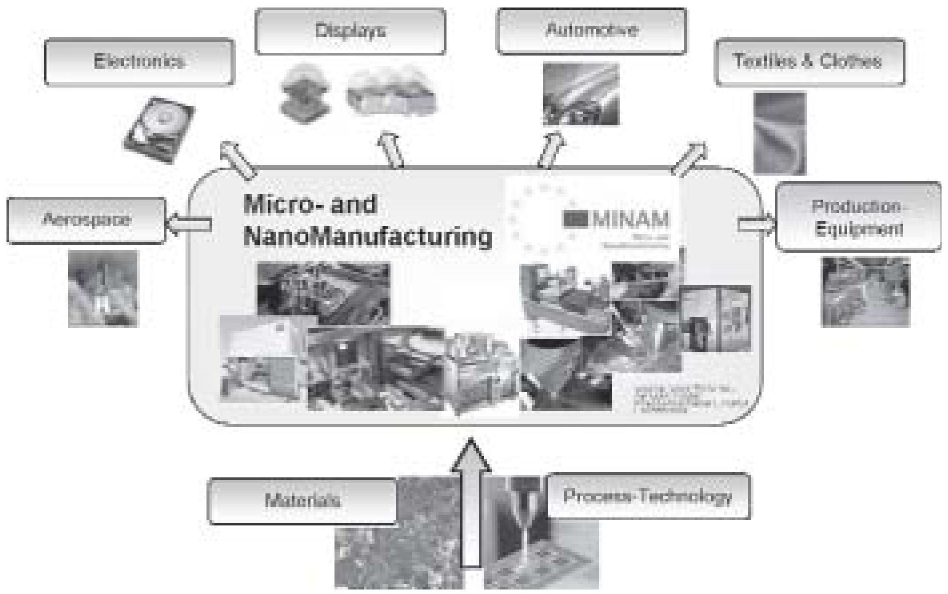
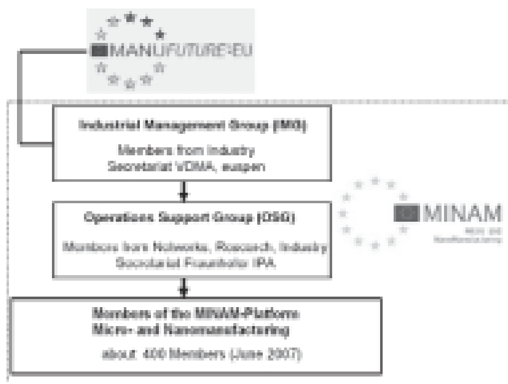
Abstract
Since many years there are research activities in the field of micro and nanotechnology. Nowadays new product innovations are not imaginable without micro and nanotechnology. A very important requirement for dissemination of these new technologies is the control of manufacturing. Micro and nano manufacturing is getting more and more important for innovative applications and has a strategic importance for Europe. A new Micro- and NanoManufacturing community (www.micronanomanufacturing.eu) is emerging at European level involving collaboration of manufacturers of micro- and/or nano-inside-products, equipment suppliers, research organisations and networks. Theses groups cooperate through the establishment of the Micro- and Nanomanufacturing (MINAM) platform for structuring a global position. Today the MINAM community comprises more than 400 members and coordinates technological and organisational questionings.

Structure of MINAM



Industrial stakeholders showed clearly the necessity of a European platform at the meeting on 14th September 2006 in Brussels. The decision was taken to establish and structure a platform with two organisational groups: an Industrial Management Group (IMG) and an Operational Support Group (OSG). MINAM will be closely associated with the existing platform Manufuture (www.manufuture.org).



The new industrially driven community for Micro- and NanoManufacturing (MINAM) develops the Vision and Strategic Research Agenda (SRA) for the coming years. First results of the platform have already been provided as input to the 7th Framework Programme and more specific the NMP programme. The platform intends to further strengthen the effect of European, national and regional funding programmes in terms of a higher level of coordination and implementation by industry.

Activities of MINAM
The MINAM platform is currently under construction. The establishment is supported by the EU-projects IPMMAN, µSapient and 4M. Expert groups will develop the development needs in future in the areas of ‘Production of Nanomaterials’, ‘Production of Micro- and Nanosurfaces’, ‘Production of Micro components’ and “Equipment Integration“. The expert knowledge will flow into the roadmapping activities. A group of roadmapping experts launched joint activities to integrate results from existing roadmaps into a Micro NanoManufacturing Meta-Roadmap.

MINAM organises for example Brokerage events and informal member meetings. The first MINAM Brokerage event attracted 130 participants in Brussels on 24 January. Latest FP7 information, networking opportunities and project match-making were the scores of the agenda of this successful day. In future there will be further events to forward the activities and to strengthen the relations between industry and research on European and world-wide level.

MINAM Experts groups: production of nanomaterials and production of nanosurfaces

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Nanomanufacturing is the way from materials and process technologies to production lines for various applications. Therefore it's necessary to develop new manufacturing technologies, equipment and equipment components including test and metrology systems. Most important applications are Electronics, Displays, Automotive, Textiles & Clothes, Aerospace, and Production-Equipment.

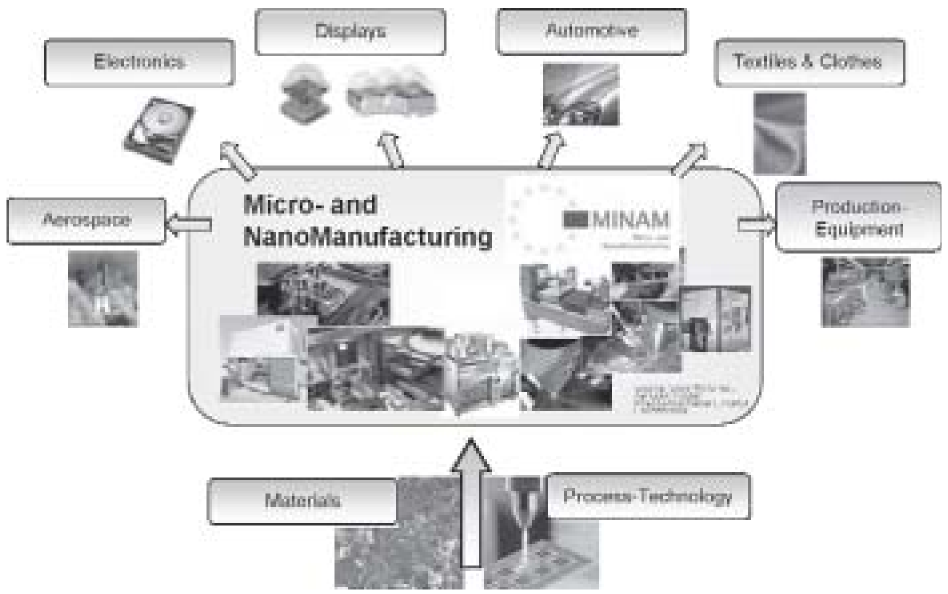

Fig.1: Micro-/nanomanufacturing - from technology/materials to application

Nanomanufacturing processes are needed for a wide variety of products. The demands are as heterogeneous as the applications: according to macro- large area processes to micro- small scale processes. Therefore also the manufacturing questions to be addressed have to consider mass production of materials, large area (e.g. coating) but also the fabrication processes of small devices, and processing of defined local areas for generating local characteristics.

Targets of a micro- and nanomanufacturing industry are:
1. To establish a new industry for the manufacturing of products based on emerging micro- and nanotechnologies.
2. To develop Europe as the leading location for the production of nanoparticles, micro- and nanostructures and components with 'Micro/Nano inside'.
3. To establish the complete micro- and nanotechnology value chain leading to the manufacturing of European MNT products.
4. To ensure that the new MNT products are produced at European facilities using equipment and systems of European origin.

To develop and assist the development of this nanomanufacturing there is the European technology platform MINAM (www.micronanomanufacturing.eu) and inside there the two expert groups (nanomaterials and nanosurfaces). These groups are an expert board for the industrial members, for the European commission and for other private and public bodies dealing with micro- and nanomanufacturing.

The **nanomaterial mass production** processes may focus on a closed production chain from Production of nanophased, particles & functionalisation and nanocomposites incorporation up to special methods to direct surface creating. This includes:

Nanophased particle production and functionalisation
1. Economical production & automation: yield, ease of implementation, low cost material; up-scaling, reproducibility, reliability
2. Production environment: healthcare, safety handling, easy handling, environmental effects
3. Quality: low cost tool, simulation model, online control, easy to use
4. Automation: up-scaling, reproducibility, reliability

Sectors: Electronics, Automotive, Aeronautics & Space, Energy

Bulk Integration
1. Economical production & automation: yield, easy implementation, low cost material; reproducibility, upscaling
2. Production environment: easy handling, safety handling, healthcare, environmental effects, automation: reproducibility, up-scaling
3. Quality: online control, easy to use

Sectors: Electronics, Automotive, Aeronautics & Space, Energy, Consumer, Life, Science, Environment

Processes for production of nanophased particles e.g.:
1. Colloid chemistry, sol gel, hydrothermal chemical methods, green chemistry
2. Plasma synthesis, PVD, flame pyrolysis
3. Milling and mechanical alloying

Processes for functionalisation of nanophased particles e.g.:
1. In-situ synthesis, grafting, sol-gel and MW-RF plasma

Requirements to an Economical production are:
1. High yield, easy implementation and low-cost material
2. Automation: up-scaling, reproducibility and reliability

The manufacturing of new nanomaterials with new properties calls for development of processes and equipment for industrial production of (functionalised) nanophased particles as basis for incorporating nanocomposites and other bulk nanomaterials. In addition, special designed nanophased functionalised particles can be the basic material and could be straight used for an instant coating for realising new surfaces. The target is to industrially manufacture and functionalise nanophased particles of highest industrial relevance for the end-user groups in the nano-micro-manufacturing value chain. As example the energy sector covers a wide range of applications driven by strong industrial needs. By energy application it is understood (i) the production of nanoparticles needed to build devices for energy production like fuel cells (PEMFC, SOFC), for energy storage (batteries, super-capacities or even hydrogen storage) and (ii) for the reduction of energy consumption. The second point can be achieved through the development of nanopowders Roadmap Micro- and Nanomanufacturing 47 needed in the transportation field. As an example new generation of nanopowders are needed to build thermal barrier in different part of an aircraft engine in order to increase its operation temperature leading to a higher combustion efficiency and therefore to an optimum fuel consumption. Focus is on developing industrial production processes for a cost efficient, high yield manufacturing of nanophased particles:
1. Continuous process from material to production without transport leak
2. Expert Data base for production parameters
3. Equipment for safe transports of particle
4. Standardised control system and parameters

A key issue related to the production of nanomaterials is the collection of the nanopowders. The collection should be as efficient as possible (high yield of recuperation) and safe. The actual more promising methods for producing nanopowders are based on batch processes. A huge effort has to be done to switch to continuous production mode which is more relevant for industry. The high specific surface area is an inherent property of nanopowders. It implies that the raw nanopowders exhibit a low tap density. At an industrial production scale with a production rate of kg /hour the corresponding high volumetric production (m^3/hour) has to be carefully managed. This issue remains the same if the nanopowders collection is implemented in a solvent. At the production line end the as-produced nanopowders have to be stored in a safe way in order to limit the potential contamination and to avoid agglomeration which is harmful to the unique properties of nanomaterials. A general target is the zero emission of nanopowders during the whole production processes. The deliverable from research proposed under this topic should clearly demonstrate how nanophased particles can be produced on industrial scale that will make these new materials available in required quantities and at affordable prices. Up-scaling the processes and simultaneously increasing reproducibility and reliability can be reached by a higher degree of automation. Automation, easy production and safe handling are necessary. The production should be assisted by simulation. These are indicators for integration of known technologies and equipment from existing processes. The importance of automation, safety handling and online control systems shows the overall production approach (from material to bulk, in situ).

Processes and equipment for an economical and automated industrial production of bulk nanomaterials:
The manufacturing of new nanomaterials with new properties calls for development of processes and equipment for industrial production of nanocomposites and other bulk nanomaterials, incorporating (functionalised) nanophased particles. Focus is on industrial manufacturing of bulk nanomaterials of highest industrial relevance for the end-user groups in the nano-micro-macro-manufacturing value chain. Up-scaled processes and equipment with high yield, easy implementation, and high reproducibility are required.
Processes may include sol gel, melt compounding, sintering, laser sintering, HIPing, spark, plasma sintering, finished products net shaping, finished products rapid manufacturing,
Results from research proposed under this topic should clearly demonstrate how bulk nanomaterials can be economically produced at industrial scale, with high yield, easy implementation, low cost materials, reproducibility and up-scaling, making these new materials available in required quantities and at affordable prices.

Production environment for nanophased particles production and functionalisation:
The manufacturing of new nanomaterials with new properties calls for development of processes and equipment for industrial production of (functionalised) nanophased particles as basis for incorporating nanocomposites and other bulk nanomaterials.
The focus is on production environment: healthcare, safety handling, easy handling, environmental effects and safe handling and transport of 'nanoparticles' and integrated quality control methods.
Results should provide 'easy to use' processes with a full standardization of' nanomaterials and flexible production technologies with a control and quality system for safe processes. Processes include nanophased particles production, sol gel, colloid chemistry, hydrothermal chemical methods, PVD, PE_CVD, plasma synthesis, flame pyrolysis, self assembly, electrodeposition, Milling, mechanical alloying, mechanochemical production, nanophased particles functionalisation.

The **nano-surface production processes** may focus on specific processes or a combination, for a cost efficient, high yield industrial processing of functional surfaces. This includes:
1. Technologies to produce surface functions and nanostructures optimized for industrial applications
2. Procedures for robust functional surface nanostructures (e.g. grafting to / grafting from approach; incorporation of nanosized building blocks such as nanoparticles, nanorods, nanotubes,…
3. Systems for the fabrication of smart responsive coatings
4. Combination to obtain hybrid process like top-down / bottom-up approach; combination robotics/self-assembly, or wet/dry

Three key parameters for the production of nanosurfaces are generally identified:
1. Chemical composition (and crystalline structure at nanosized domains),
2. Thickness
3. Topography (including nano-scale patterning of nanosurfaces).

For this last one many approaches are developed, three main will be presented:

Nanolayer with sub-micron thickness can be used to tailor surface properties such as eg. wettability and non-fouling (eg. Surface functionalization with polymer or sol-gel thin films based by grafting/crosslinking methods). Such layers can be also designed in a way to be responsive (smart coatings) with controlled surface chemistry and properties which can be adjusted at the nanometer scale in response to variation of environment or to application of some physical/chemical incentives (eg. temperature, light exposure, Ph, …).

Nanocomposites made of a matrix including nanoaggregates are very attractive to develop concepts of multifunctional materials by using a knowledge based approach. The properties of both matrix and aggregates can be adjusted to promote synergetic effect between the nanoaggregates activity and the surface interaction with the environment. Coupling of deposition process have to be considered as prevalent synthesis routes.

Nanotextured surfaces means surface of a material containing at least one dimensional feature smaller than 100nm. The structure can be topographical, as thin-film, modified surface presenting designed nanostructures (pores, pillars, gratings,…) tailored for a specific application resulting in outstanding properties. Nanotextured surfaces might also involve coatings (up to the mm size) having phase modulations, crystal sizes, embedded particles in the mentioned range. Nanotextured are created on the surfaces of varied solid materials, e.g. metals, ceramics, glasses, semiconductors, polymers. Concerning the nanotexturing processes both top-down (e.g. nano imprint lithography, electron and ion beam writing) and bottom-up (e.g. self-assembly) approaches are considered.

For both production of nanomaterials and nanosurfaces, different bottlenecks will be highlighted. In fact, while the processes which have been developed in nanoelectronics production are quite well understood and well controlled, many of the techniques need further research. Several questions are described by the NanoRoadmap of the 7th Framework Programme. For example the generic bottlenecks which will have to be considered are:

- Lack of understanding how to integrate the new technologies into existing production processes
- Lack of links of the nanotechnology with current other industrial technologies.
- Lack of high volume production equipment
- Lack of innovation of new product designs which considers applications of nanomaterials
- Lack of understanding adhesion mechanisms
- Lack of software for modelling and simulation
- Lack of equipment for characterisation, especially for quality control in high volume production, and for manipulation/handling
- Lack of standardisation of testing procedures for surface metrology
- Lack of understanding interfaces, stoichiometry and decomposition processes.

Vision
The European Community of Micro- and NanoManufacturing aims at the worldwide leadership of European manufacturers and equipment suppliers in the field of manufacturing micro- and nanotechnological products – it will be the European network in this field.

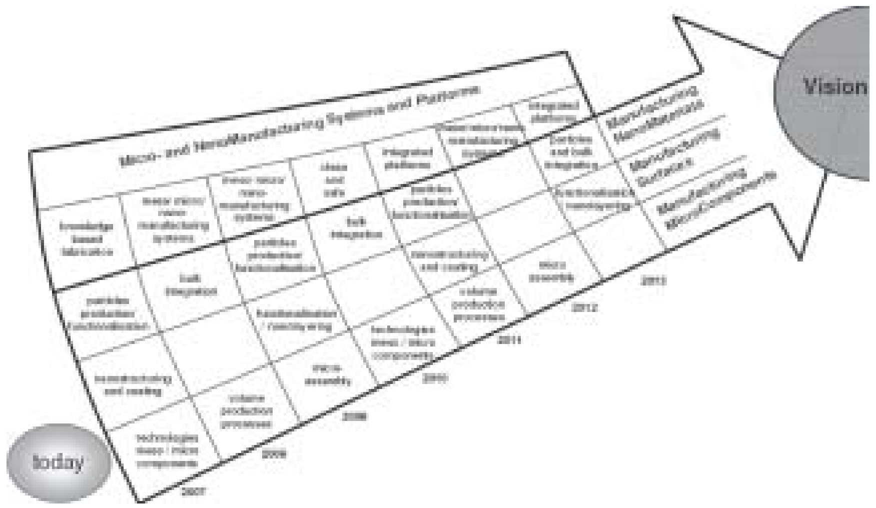

Fig.2: from Today to the Future - Vision of Micronanomanufacturing

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4. 4M - http://www.4m-net.org/filestore2/download/1539/4M%20A%20roadmapping%20study%20in%20Multi-Material%20 Micro%20Manufacture%20v1.pdf

5. Roadmap µ-Sapient - http://microsapient.tekniker.es/Best%20practices/Microsapient_Roadmapping_Results.pdf

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European Nanoelectronics Initiative Advisory Council (ENIAC)

Norbert Lehner
Infineon Technologies, Munich (Germany) and Chairman of the ENIAC Support Group

Nanotechnology, being the key for present and future economic, ecologic and social developments, can be described by mainly three elements: 'Materials' + 'Intelligence' + 'Nano-Dimensions'

'Intelligence' and the 'Nano-Dimensions' are the main assets of 'Nanoelectronics', which is at the starting point of the value-chain of nearly all high-tech products (Fig. 1):

Source: NXP

In view of the enormous importance and impact of Nanoelectronics, it was selected as one of the candidates for a European Technology Platform (ETP) and even for a Joint Technology Initiative (JTI). The objective of ETPs (and JTIs) is utilisation of all available resources for the selected topic. This includes strong and very well co-ordinated research and development (R&D) in co-operation of the most competent companies, institutes and universities as well as co-ordinated funding from the European Commission and the national Authorities. In addition to this, extra financing can be activated via the European Investment Bank (EIB) and specific needs with respect to standardisation or legislation can be addressed by the involvement of the corresponding bodies.

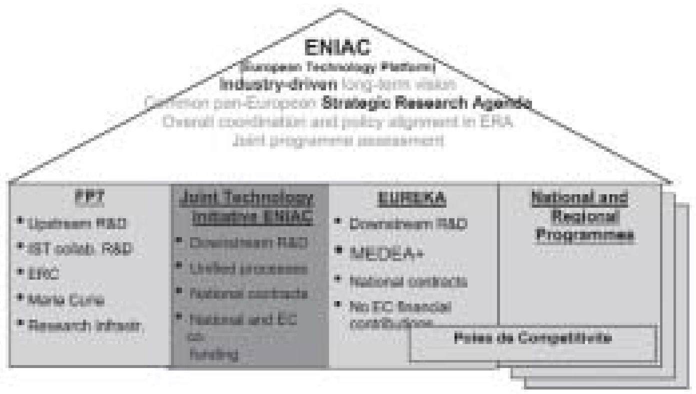
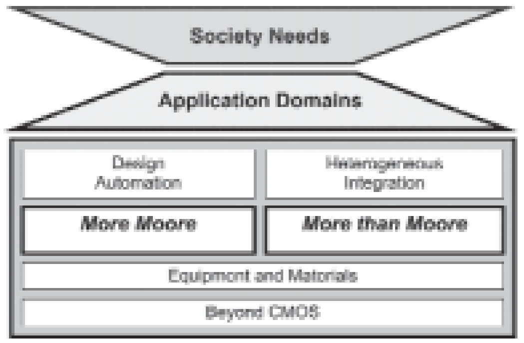


Figure 2 (left) shows how the Nanoelectronics Platform and it´s JTI, both called 'ENIAC' fit into the already funding schemes.

Source: ENIAC

The main output of the ENIAC Platform is the Strategic Research Agenda (SRA), which will be used as guideline for future European funding schemes for Nanoelectronics. The SRA was developed by six domain teams composed of experts from all over Europe. The structure of the SRA is shown in *Figure 3:*

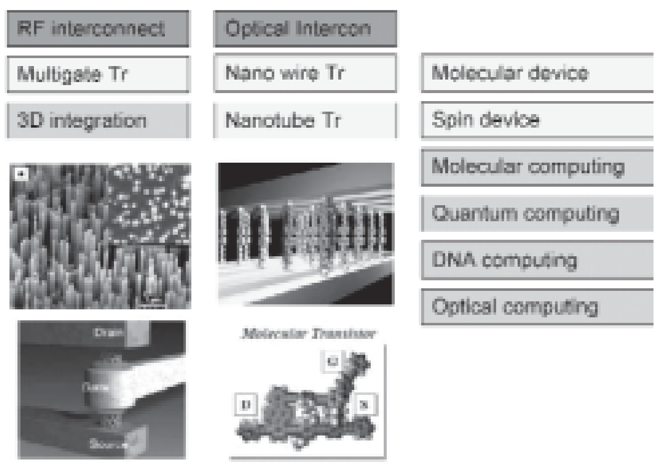


Source: ENIAC

What this figure describes is essentially, that the motivation and the final objective of all the R&D work on Nanoelectronics is to satisfy the needs of the society by providing the most cost-effective, specifically tailored technology solutions. The link between 'Society Needs' and the 'Technologies' are the 'Application Domains' as detailed in *Figure 4:*

Source: ENIAC

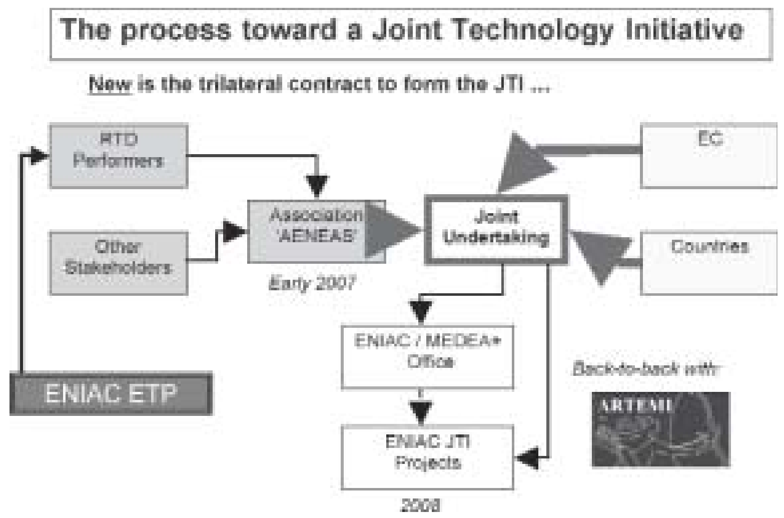
To visualise the long way along the value chain in Nanoelectronics and its applications, Figure 5 shows some examples of future technology options in the time frame, when conventional CMOS technology will come to its end (Domain 'Beyond CMOS' in Figure 3).



Source: ENIAC

Of course, the final version of the SRA will contain not only identify R&D needs in nanoelectronics, but will also show priorities and will develop scenarios how to close the technology gaps.

The implementation of all measures as proposed in the SRA document requires an enormous effort and will only be possible by activating projects of a large critical mass. The new instrument to do this, will be the ENIAC-JTI. The way to realise the visions is in a systematic way shown in Fig. 5:



Source: ENIAC

Today, we are at the point, where the Association AENEAS is launched and starts its operation. At the same time, the proposal text for the Council Regulation, which will be the legal frame for the ENIAC JTI, is ready for submission to the Council. It is expected, that the official launch of the ENIAC JTI will be announced at the end of 2007 and that the JTI operation can start in 2008.

This will be an important step to improve Europe's competitiveness in nanoelectronics and as a consequence to ensure further progress in the industrial application of nanotechnology.

Hub Nanosafe in the frame of the European initiative ETPIS – European Technology Platform on Industrial Safety

Dr François Tardif
CEA, Grenoble (France)

It is expected that improving the level of industrial safety will sustain and foster the competitiveness of the European industry. In particular, improved control of industrial risks will contribute to the sustainable growth of the European industry. There is also a benefit to be expected from the development of a co-ordinated effort in safety-related research across industry sectors. As it stand today, the effort in Research & Development often remains fragmented, at both national and European levels, and no coherent attempt is made to transfer success from one industry to another or the benefits of research in one sector to another.

The European Technology Platform Industrial Safety –ETPIS- recognises that only an integrated approach to industrial production, risk assessment and management will help introduce improved and integrated safety standards across the European industry, along with occupational practice that matches the objectives of industrial safety. Such integration includes: man-machine interactions, organisational and cultural factors, influence of safety culture, etc. The ETPIS also recognises that it is through education and training that can be established a context wherein managers, technology developers and designers can create production adapted safety systems, while operators at facility level also know how to operate and maintain them in a safe and efficient way.

The ETPIS is closely co-operating with the industry-specific platforms, such as MANUFUTURE, ECTP, Sustainable Chemistry, transport related TPs… so as to turn the methods and technologies developed within the Platform Industrial Safety into practical, accessible and easy-to-apply principles and tools.

The Nanosafe Hub is an important part of the new industrial risks taken into account by ETPIS.
Industrial needs in terms of nanomaterials are increasing. Many sectors are concerned, ranging from mature high volume markets like automotive applications, high added value parts like space & aeronautic components or even emerging activities like new technologies for energy. Also are concerned domains with a planetary impact like environment and new products and functions for health and safety of people. Nanotechnologies (e.g. nanoparticles) will play a key role in promoting innovation in design and realisation of multifunctional materials for the future, either by improving usual products or creating new functions and new products.
Nevertheless, this huge evolution of the industry of materials could only happen if the main technological and economic challenges are solved with reference to the societal acceptance.

Those concern the mastering, over the whole life cycle of the products, of the potential risks, by an integration of the elaboration channels, while taking into account recycling. Some initiatives have already proposed a global concept for risk evaluation and management (NANOSAFE 2 Integrated Project), a next step, industrial production-oriented, is will start in 2006 with SAPHIR Integrated Project, with the objective to add the missing industrial bricks to the desired responsible approach, by means of the development of the concept of the future 'factory for nano's' and to set it up for a selected number of representative examples.

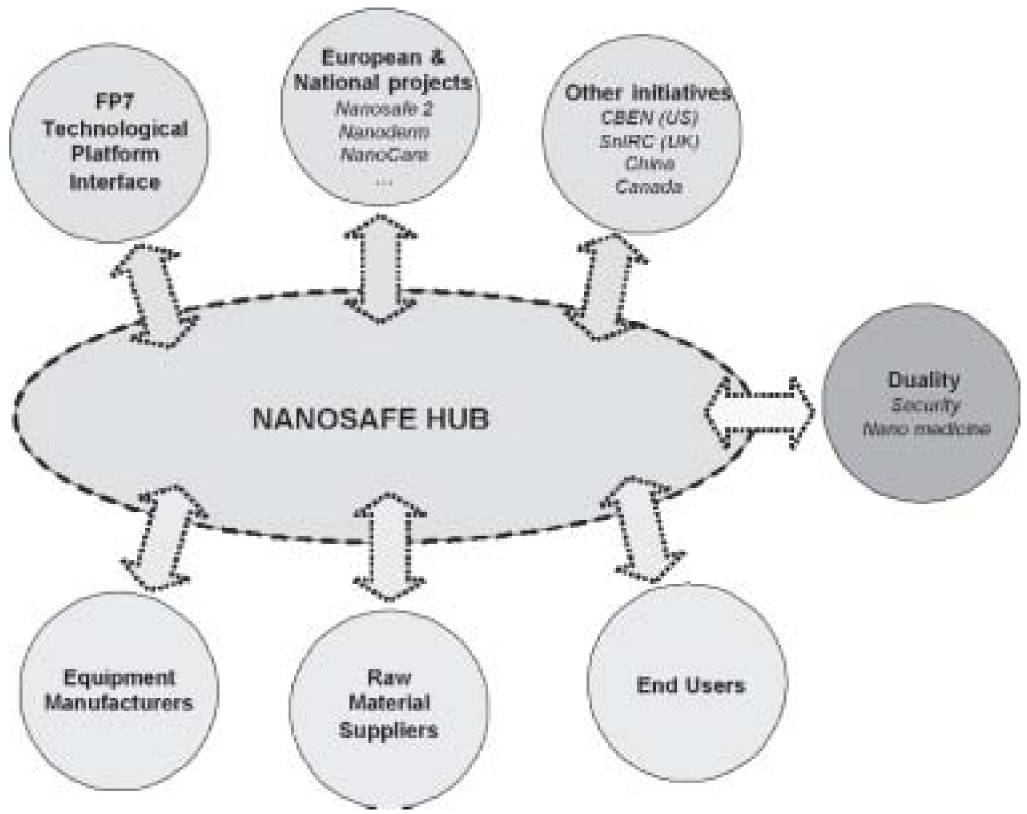
The overall objective of the HUB NANOSAFE is to develop synergies between projects dealing with the safe nanomanufacturing. This includes the development of:

- advanced detection and monitoring technologies at workplace
- secure integrated industrial processes
- a global approach all along the life cycle
- knowledge on health and environmental effects of nanoparticles

In operational terms, the HUB NANOSAFE will bring together companies, research institutes, the financial world and regulatory authorities at the European level to define a common research agenda mobilizing a critical mass of National and European public and private resources.

According to the main objective, the initial structuration of the NANOSAFE HUB partnership is achieved through the synergy development of four integrated projects.

- NANOSAFE 2 (Risk Assessment & Risk Management)
- SAPHIR (Industrial deployment of nanomanufacturing through demonstration platforms)
- MEDITRANS (development of nanoparticles for medical applications)
- NANOSECURE (development of nanomaterials for security and environment)



The talk will describe the work already performed in the different project of the Nanosafe Hub and will precise the link with the different National initiatives in Nanosafety area.

SusChem – The European Technology Platform for Sustainable Chemistry

Dr. Marian Mours
Cefic (European Chemical Industry Council), Dept Research & Innovation

Sustainable chemistry is the driving force for global sustainable development. Closer to home sustaining chemistry and molecular science and engineering in Europe is at the heart of im-proving industrial competitiveness, maintaining and improving further our quality of life. It forms a significant basis for the future knowledge-based European economy. The European Technology Platform for Sustainable Chemistry (SusChem) is leading a pan-continental initiative to boost chemistry, chemical engineering and industrial biotechnology research activi-ties and enhance collaborative R&D.

SusChem was jointly initiated by Cefic (the European Chemical Industry Council) and EuropaBio (the European Association for Bioindustries) in 2004. It is an open multi-stakeholder forum with additional organisational support from GDCh, Dechema, The Royal Society of Chemistry and ESAB (European Federation of Biotechnology Section of Applied Biocatalysis) and financial support from the European Commission. SusChem foresees a sustainable European chemical industry with enhanced global competitiveness and minimal environmental impact powered by a world-leading, technological innovative drive. It sees the chemical community as an essential and leading partner in the European knowledge-based economy providing growth and social equity for all its citizens.

Working Groups
Three strategic technology areas (Industrial Biotechnology, Reaction & Process Design, and Materials Technology) were identified and working groups established to map out research requirements and roadmaps in each area. In addition a fourth group, the Horizontal Issues Group, was tasked with looking at cross-cutting issues common to all three technology areas.

The emerging field of Industrial Biotechnology has increasing impact on the chemical sector. It enables both the use of renewable resources and the conversion of conventional raw materials using biotechnological processes. Industrial Biotechnology allows the production of a wide variety of chemical substances, some of which cannot be made by other synthetic routes. It will play an increasingly significant role in the chemical and other manufacturing industries in the future.

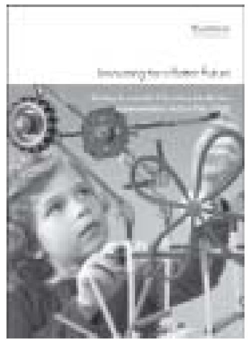
Tomorrow's society will require materials with increasing demands on properties and flexibility. Innovative Materials Technology will enable new business creation and sustainable development of downstream industries. In addition to their unique properties innovative ma-terials will minimise the use of resources and limit environmental impact. Among other priorities, the SusChem SRA emphasises the importance of nanoscience and nanotechnology as a fundamental underlying area of knowledge in this area.

Reaction & Process Design is of vital importance for the chemical and biochemical industries. Innovation in this area aims to incorporate highly efficient, inherently safe and environmentally benign technologies; tailor-made products with designed properties making efficient use of resources; and increasingly flexible, affordable equipment. It contributes all the way from synthesis to viability of process plants.

Clearly there are many synergies between the technology groups and they work closely with each other. In addition, SusChem's Horizontal Issues Group effectively addresses the integration of all the factors underpinning sustainable innovation, from regulatory to economic, environmental and societal. The group's role is to tackle generic issues that impinge on all three technology areas. Effectively there are two main themes: stimulating innovation and addressing societal concerns.

Vision
SusChem started its work by formulating a vision for 2025. It foresees a sustainable European chemical industry with

enhanced global competitiveness and minimal environmental impact powered by a world-leading, technological innovative drive. It sees the chemical community as an essential and leading partner in the European knowledge-based economy providing growth and social equity for all its citizens.



Roadmap and Action Plan
SusChem's Strategic Research Agenda (SRA, published in December 2005), and its detailed Implementation Action Plan (IAP, completed in December 2006) represented and will con-tinue to represent a significant contribution to the formulation of the European Commission's FP7, future European R&D Framework Programmes and other major collaborative European research initiatives. Within the chemical research community SusChem can help to co-ordinate European, national and regional initiatives, working together with Member States, related Technology Platforms, ERA-Nets and other organisations. SusChem will help to build bridges between the different disciplines of chemistry and biotechnology with other molecular sciences, technologies and engineering as well as between stakeholders.
SusChem's IAP is structured around eight themes of major importance for sustainable chemistry and society: bio-based economy; energy; health care; information and communication technologies; nanotechnology; sustainable quality of life; sustainable product and process design; and transport.

The IAP is now moving from words to action. FP7 calls already contain clear references to ideas from the IAP. SusChem is working proactively to facilitate the building of collaborative research teams through initiatives such as 'Brokerage Events' and a 'Partnering Database' hosted on its website. SusChem-relevant projects may also be independently commissioned by industry, via national government research programmes, or through other European sources. SusChem will monitor implementation and work to ensure that all topics are covered within the IAP timeframe.

SusChem and nanoscience/nanotechnology
Nanotechnology is enabling new developments in material science, providing innovations for industries ranging from construction, information & communications, healthcare, energy, transportation through to security. Sustainable development of nanomaterials, including an appropriate assessment of possible risks and their potential for environmental protection will contribute to sustainable economic growth.
Materials science deals with the design and manufacture of materials, an area in which chemistry plays the central role; there is also considerable overlap with the fields of chemical engineering, biotechnology and physics. To understand the phenomena that arise at the nanometre scale and to gain the ability to structure, control and integrate new properties that are related to a reduction of the material size, a fundamental understanding of structure property relationships is necessary. SusChem interest lies in the synthesis and function of nanoparticles, nanostructured surfaces, and nanostructured materials (porous materials).
The corner stones needed are an understanding of the phenomena at the nanometre scale and the tools to make use of these properties by controlling the size and the structure of the materials, and developing the industrial production of nanomaterials, by bridging the gap between the laboratory and the market.

Conclusion
The SusChem programme clearly shows the chemical sciences and the chemical industry as the drivers of beneficial change for society and finding the solutions to the tremendous challenges facing humanity today. To quote Dr. Alfred Oberholz, Deputy Chairman of the Board of Management of Degussa and Chairman of the SusChem Board: 'SusChem is a unique opportunity for the chemical community in Europe to demonstrate and grow its strengths and contributions to society.'

European Technology Platform on Nanomedicine – a world unique platform on nanomedicine

Patrick Boisseau
CEA-Léti-MiNaTec, Grenoble (France)

The challenge
Mankind is still fighting against a high number of serious and complex illnesses like cancer, cardiovascular diseases, multiple sclerosis, Alzheimer's and Parkinson's disease, and diabetes as well as different kinds of serious inflammatory or infectious diseases (e.g. HIV). Most of theses diseases have a tremendous negative impact not only on the patient himself but also on the whole society and linked social and insurance systems. It is of utmost importance to face these plagues with appropriate means.

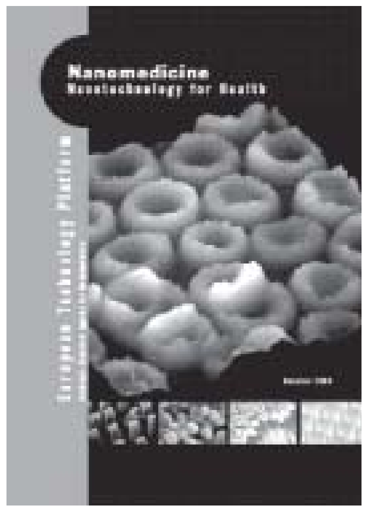
Nanomedicine, the application of nanotechnology to health, raises high expectations for millions of patients for better, more efficient and affordable healthcare and has the potential of delivering promising solutions to many illnesses. Research in nanomedicine will allow for a better understanding of the functioning of the human body at molecular and nanometric level and it will thus give us the possibility to intervene better at pre-symptomatic, acute or chronic stage of illnesses.

Several areas of medical care are already benefiting from the advantages that nanotechnology can offer. Several nanotechnology-based targeted drug delivery systems are already on the market, others are in clinical trials or, by far the largest part, are under development. Another highly attractive area of nanomedicine is diagnostics at nanoscale. The aim is to identify a disease either in vivo or in vitro at the earliest possible stage. Ideally already a single cell with ill behaviour would be detected and cured or eliminated. New concepts for regenerative medicine give hope to many patients with organ failure or severe injuries. Already today artificial skin, bone and cartilage are in an advanced stage of development and partly already on the market.

The promising possibilities that nanomedicine might offer in the future have to be counterweighted against possible risks of this new technology. It is of utmost importance to examine upfront with care and responsibility its possible side effects to human beings and the environment. Several European projects are already dealing with this highly important issue. Also ethical concerns have to be taken into account. It may also be necessary to examine existing legislation for its applicability to nanomedicine.

Industry has increasing interest in stepping into the area of nanomedicine and the expected market share of final products is expected European Technology Platform on Nanomedicine to be significant. In addition to the improved quality of health care, the creation of new jobs can be expected.

An important initiative, led by industry, has been set up together with the European Commission. A group of 53 European stakeholders, composed of industrial and academic experts, has established a European Technology Platform on nanomedicine. The first task of this high level group was to write a vision document for this highly futureoriented area of nanotechnology-based healthcare in which experts describe an extrapolation of needs and possibilities until 2020. Beginning of 2006 this Platform has been opened to a wider participation (April 2007: more than 160 member organisations) and has delivered a so-called Strategic Research Agenda showing a well elaborated common European way of working together for the healthcare of the future trying to match the high expectations that nanomedicine has raised so far.



Policy objectives:

- Establish a clear strategic vision in the area resulting in a Strategic Research Agenda
- Decrease fragmentation in nano-medical research
- Mobilise additional public and private investment
- Identify priority areas
- Boost innovation in nanobiotechnologies for medical use

Topics:

Three key priorities have been confirmed by the stakeholders:

- Nanotechnology-based diagnostics including imaging
- Targeted drug delivery and release
- Regenerative medicine

Dissemination of knowledge, regulatory and IPR issues, standardisation, ethical, safety, environmental and toxicity concerns as well as public perception in general and the inputs from other stakeholders like insurance companies or patient organisations play an important role.

The CEOs of Philips Medical Systems and of Siemens Medical Solutions have taken over the chairmanship of this platform together. They are seconded in the Executive Board by the leaders of the working groups:

- Nano-diagnostics incl. imaging (chair: Patrick Boisseau, CEA, France)
- Targeted drug delivery and release (chair: Mike Eaton, UCB, UK)
- Regenerative Medicine (chair: Alessandra Pavesio, FAB, Italy)
- Ethical, Legal and Societal Aspects (chair: Klaus Michael Weltring, Bioanalytik-Muenster, Germany)
- Intellectual Property Rights (chair: Maaike van Velzen, Philips, The Netherlands)

A Mirror Group composed by official representatives from the EU Member States as well as from some Associated States are also part of the organisation of the European Technology Platform on Nanomedicine. Since this time, the European Technology Platform on Nanomedicine convenes its general assembly twice a year.
The next general meeting of the platform will take place on 12th September 2007 in Chalkidiki, Greece.

How to express your interest in a possible participation in this Technology Platform
You are invited to submit an Expression of Interest that should include a short overview of your organisation's activities in the nanomedicine sector as well as the motivation for participating in this European Technology Platform on Nanomedicine. A short CV of the person from the organisation that would be the contact point (including a web link) should also be included. Applications may be submitted via e-mail to: uta.faure@ec.europa.eu

http://cordis.europa.eu/nanotechnology/nanomedicine.htm

Self-formation theory application and its relevance for nanotechnology related KIBS sector in Lithuania

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Abstract
The paper will discuss the relevance of self-formation theory for nanotechnology-related Knowledge Intensive Business Service sector in Lithuania by tracing back its development to self-formation theory applications in microelectronics. The paper will show the potential of self-formation manufacturing concept in developing nanotechnologies for lead markets. Finally, organizational developments as related to the Centre of Excellence in Self-formation Theory (CESFA) and the current attempts to set up networked organizational structures to boost knowledge transfer in this particular sector will be discussed.

Self-formation theory and its early applications
Self-formation theory was formulated by Lithuanian scientist Prof. Stepas Janušonis in 1984 on the basis of the findings from his experimental development work in microelectronics in the period 1974-1984, when around 30 international patents were registered for technologies based on self-formation principles, including bipolar transistors and high-frequency integration circuits with self-adapting submicron emitter, injection logic integrated circuits. Later self-formation principles were successful applied in developing Shotkey barrier field-effect transistors (1984-89) and self-adapting metalization in solar cell technology (1994-95); the latter opened up self-formation theory for its further adoption in developing PV technologies and showed its increased relevance for other material science related applications.

Due to political restrictions and the tacit nature of R&D involved (microelectronics industry in the Soviet Union was a closed area for outsiders) the knowledge of self-formation theory and its early applications did not reach the scientific circles in Western Europe at that time. It was the time when a similar, bottom-up approach in material sciences, nonlinear physics and theoretical chemistry was being formulated by such prominent scientists as Ilya Prigogine (the Nobel prize winner), who postulated the laws of nature in a framework of the scientific paradigm of self-organization, Manfred Eigen, who developed the theory of self-organization of biological macromolecules, and Hermann Haken, who formulated the concept of synergetics and principles of Nonequilibrium Phase- Transitions and Self-Organization in Physics, Chemistry and Biology. Compared to these theories, self-formation theory differed significantly as it derived directly from RTD work in microelectronics and was primarily concerned with solid state phenomena; hence its application potential for nanotechnologies. The fundamental principle of self-formation is generation of structural growth processes as found in nature by applying smart cellular automata software, based on 8-dimensional topological approximation of the self-increasing complexity of artificial systems. Self-formation is in line with other levels of self-processes in the materials design. At the atoms and molecules level self-assembling governed by a known set of quantum mechanical postulates and some finite wave functions can be observed. Thus self-assembling mechanisms are responsible for the development of elementary building blocks for the next grade of materials. At nanostructures level one can talk about an introduction of interactions between chaotic media and elementary building blocks, which are shaping properties of developed nanostructures; hence self-organization of chaotic media mechanisms dominate in this scale. As a result of an interaction of self-assembling and self-organization mechanisms, an initial object with smart properties can be generated.
Self-formation method has already proven itself in microscale structuring for the first generation solar cells manufacturing which was developed and implemented under the FP projects HELSOLAR ('High-Efficiency Low-Cost Solar Cells', 2003-2005) and REFLECTS (Novel bifacial single-substrate solar cell utilizing reflected solar radiation, 2004-2006). The most recent application of self-formation is under way in the project SELFLEX ('Demonstration of SELF-formation based FLEXible solar cells manufacturing technology', 2007-2010).

Self-formation use for nanotechnologies
Further plans are under way to expand the application of self-formation theory into the field of nanostructured materials. The preliminary findings show that self-formation is applicable in nanoscale in the development of non-lithographic technology for the fabrication of relatively large, periodic arrays of semiconductor nanostructures which would be inexpensive, reliable and suitable for different application areas.

The foreseen expansion of a generic underlying knowledge base of self-formation theory for multi scale applications combines two aspects: first, the development of nanostructures with required periodicity and defined pattern, and, second, the fabrication of relatively large arrays of nanostructures enabling development of macro-objects. The technology, which is being developed, is based on the industrial processes used in Si based photovoltaic cell manufacturing, with proposed different technological steps and routes. Self-formation enables the time and cost reduction of 'research-development-prototyping-manufacturing' cycle needed for introduction to the production. Alfa, Beta and Production Tools in manufacturing technology development, meaning process selection and technology optimisation are merged and replaced by self-formation based computational modelling.

Centre of Excellence in self-formation theory
This application of self-formation theory into nanostructural materials was made possible thanks to the FP5 project FIRSTSTEP (Self-formation Research Towards Stairway to Excellence in Photovoltaic) and the FP6 SSA project NENNET (High Quality Research Network on Nanosciences, Material and Energy research in Lithuania), both implemented by the Institute of Lithuanian Scientific Society (MSI).

FIRSTSTEP which ran from 2003 to 2005 was indeed the first step towards gathering the human and management resources around the promising field of self-formation. The main objective of this project was achieved with the establishment of the Centre of Excellence on Self-formation (CESFA), the first of its kind in the EU.

The NENNET project (2004-2007) built upon the initial success of FIRSTSTEP and further explored and promoted the theory of self-formation in the fields of possible technological applications such as nanomaterials and renewable energy technologies (solar cells, hydrogen storage and fuel cells). While FIRSTSTEP was integrating and coordinating exchange of research between individual researchers in Lithuania and elsewhere in Europe, NENNET was setting up an institutional framework for building a network of organizations in public and private sector with an interest in applied research and development of self-formation theory based technologies. As a result of this project three national technology platforms in PV, hydrogen and fuel cells and embedded systems were established in the second half of 2006. The NENNET report 'Future perspectives of Lithuanian research in sustainable energy and nanotechnologies' (April 2006) showed the potential of Lithuania in the application areas of nanomedicine technologies, photovoltaic technologies and hydrogen technologies.

Developing industry-relevant knowledge base
MSI established in 1996 by the Society of Lithuanian Scientists, the largest non-governmental, professional organization of scientists in Lithuania with a membership of few thousand, has been the major driving force behind the CESFA activities. During the period of running up to Lithuania's accession to the EU MSI played a role of catalyst for bringing together individual researchers into project-based and outcome-orientated research teams. In the period of 1999-2006 over 100 researchers worked on different projects managed and coordinated by the institute.

The established Centre of Excellence served its purpose as the integrator of critical mass of R&D knowledge in self-formation theory relevant fields of research across disciplines. The next step which is being taken is to turn CESFA into a dual networked research and knowledge transfer organization. The idea is to turn the existing CESFA from a virtual research community, which integrates R&D performers from major research institutes in the country, into a networked Centre of Excellence. The upgraded CESFA would be twinned/linked to other similar centres of excellence in Europe, thus forming a frontier research network on self-formation/self-organization theory and application while at the same time being firmly anchored to a local cluster of industry. By creating a self-sustaining model of industry-linked centre the project expects to answer the socio-economic needs of the country – to stimulate the growth of KIBS sector in RTD (NACE K73) in the high growing lead markets – and to make an impact on the development of science-industry ties in the EU's convergence regions through a wide dissemination of the NEXTSTEP model and the Good Practice Guidelines. The model integrates elements from traditional Centres of Excellence, virtual research environments and open grid architectures.

The structure for the networked CESFA will be made of three organizational structures which will comprise a Community of Practice, namely:

1) Open Knowledge Market which is the CESFA knowledge base (CESFA R&D output and research and networking infrastructure) linked up externally with other centres of knowledge elsewhere in Europe;

2) Knowledge exchange layer is created by the CESFA R&D staff and knowledge transfer office which upon receiving a request from Market Information Infrastructure will place a demand to Open Knowledge Market open to access from Knowledge users (individual or institutional R&D performers) who provide supply of knowledge and expertise.

3) Market Information Infrastructure is a CESFA knowledge transfer office which should expand the capacity of the existing RTD consultancy unit as a result of the proposed project. The Institute is a member of the PV national technology platform and has a cooperation agreement with the Applied Research Institute for Prospective Technologies (Protech) on developing CESFA in the fields of self-formation applications in PV, hydrogen and fuel cells. Protech is a founding partner of the Association of Hydrogen Energy, the managing partner of the Hydrogen and Fuel Cells NTP. Market Information Infrastructure receives market information from individual Technology End Users national sectoral technology platforms via direct links (as mentioned above) and from the respective European technology platforms via their 'mirror groups'.

Early birds - trapped in a cage? Interpretation and organisation of nanotechnology in Sweden 1984-2006

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Whereas much of the underlying rationale for the increasing focus on nanotechnology has to do with innovation and expectations of long term economic growth – or fear of a lack thereof – there is still much to be done in the study of nanotechnology as field of innovation processes. Resent emphasis under the label of Ethical, Legal, Social Aspects/Implications of nanotechnology have so far not showed particularly strong interest in trying to understand nanotechnology as an ongoing field of innovation. To somewhat mitigate this situation we present a history of an emerging system around nanotechnology in Sweden.

A common expectation is that since nanotechnology knowledge is science-based, and since scientific knowledge is distributed and communicated in broad open collectives, then so is nanotechnology innovation nessesarily also a general phenomena. The present case of the Swedish development of nanotechnology tells another story.

By invoking the specific historical context of Sweden to analyse the emergence of discourse and organising of nanotechnology, we explain how a lack of discourse and concerted national initiative can coexist with a strong nanotechnology development. In particular we point to the paradox that the Swedish nanotechnology expertise - by being early to pursue research in this area, and by being so well funded in closely related science areas - in effect seems to have blocked their own discursive and political capability to join the international nanotechnology 'bandwagon' and e.g. failed to mobilize a Swedish Nanotechnology Initiative.

For foreign observers not familiar with the Swedish history and culture, there are a few points that need to be made in relation to the present focus on nanotechnology, but for sake of space here presented with little argument. (1) The Swedish expert discourses are usually confined and closed, and not broad and public. This is a common pattern in the Swedish context, and the discourse on nanotechnology is no different in this respect. (2) The public to a larger extent than in many other countries put faith and trust in scientific and governmental expertise, meaning for example that there is virtually no debate on risk issues relatated to nanotechnology in Sweden (the debate that do occur is spill-over from international discussions). (3) Sweden has a history of non-military alliance, which has forced government to invest heavily in advanced science and technology capability. This is especially important for microtechnology and microelectronics, and obviously for its extensions to nanotechnology. (4) Swedish science policy analysts have shown that the Swedish university is to a much larger extent than elsewhere responsible for research and development usually conducted in intermediary organisations, as institutes, meaning in practise that science policy and innovation policy are closely related. (5) Globalisation of industry and the reduction in military induced expenses due to the end of Cold War has reduced the number of potential research intensive collaborators for these research groups. What was earlier an evolutionary grown 'natural', embedded and interwoven relationship between science and technology is today reconstructed and institutionalised under the banner of the innovation theory concepts such as the entrepreneurial university, Triple Helix and Mode 2. With this as a common ground we now move to the details of the Swedish case of nanotechnology.

There is an early identification of a general scientific field called Micronics, which both in its detail and as a general proposition accord with what later and especially outside Sweden is called 'nanotechnology'. Visions of future technological impact from Micronics was envisaged in early 1980s, and became institutionalised in dedicated programme structure in the late 1980s.

The discussion of a micronics technology has a longer history. From at least 1959, and the proposition by physisist Richard Feynman, it was in a sense known that 'if' one could manipulate matter in a controlled way this would open up for novel material properties and a new horizon for technology. That theoretical possibility and the possibility horizon for technology application was brough forward by developments in physics through development of new instrumentation. With possibilities materialised this made it at least conceivable to craft a dedicated policy for the field. Scientists and science policy actors in several nations engaged in trying to frame a policy for this new technology, the UK being one example, and Micronics in Sweden another.

The research on Micronics was however not expanded, and the issues pertinent to this novel field remained an internal scientific discussion, within a narrow scientific discourse. But the research field in a broader sense was not terminated. On the contrary, there is an astonishing build-up of Swedish nanotechnology capability beginning with the early 1990s. But this growth is based on other rationales than micronics or nanotechnology.

The growth occur as a translation and reframing process that construct the scientific and technological idea to be more adapted to the contemporary historical context and interest of industrial actors. Micronics was translated into interdisciplinary Materials Science Consortias, however still representing quite novel organisation and drastically increased emphasis on interdisciplinarity and long term funding. This activity had the concerns of the large national industrial trajectories and national security rationales in focus, which interlocked with earlier expectations and R&D during the 1980s on the rise of a new industry in computer technology. Industrialised nations generally pursued microelectronics research, but the size of this research was in the Swedish case amplified by underlying national security rationales. In effect, and later, this emphasis turned out to have created a strong position within important areas of nanoscience, providing research groups of critical mass and advanced instrumentation and world-class laboratory capability - in other words, providing the basic material resources and material culture for a subsequent nanotechnology research and development.

By the late 1990s and early 2000 we witness continued strong build-up, however distributed and with little or no co-ordination. All funding actors have developed their own science-focussed programmes on nanotechnology, and increasingly also use this term nanotechnology to denote this activity.

This result today is that the potential strength for nanotechnology as an organisational reality is not currently balanced by an equally developed discource on nanotechnology. Part of this is ‘normal‘ state of affairs for Sweden, but it becomes problematic not to discuss what we can and want to do with national expertise. When nanotechnology emerged internationally as the ’next big thing‘, such discourse was ignored or even downplayed in the Swedish case, and we argue, this had a lasting effect on the ability of Swedish actors both to create political mobilisation and to contextualize nanotechnology in terms of potential applications and potential risk. This include also other than nanoscientists. The choices made on search paths among companies as well as among social, health and environmental scientists did not in general include nanotechnology. A late awakening has occurred, however, due to the pressure of a flourishing international science and innovation policy discourse on nanotechnology, including a bandwagon of EU policy activities aimed at promoting nanotechnology. This has opened up for a broader set of issues and actors also in the Swedish system, and it will hopefully pave the way for a versatile, dynamic and robust development.

Acknowledgement
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RENAC: Network for the nanotechnology application in materials and products for construction and habitat

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Abstract
RENAC is the Spanish network for application of nanotechnology in construction and habitat products. It has been established as a scientific and technological platform that primarily intends to overcome fragmentation of costly research effort by integration and generation of a knowledge base for the construction sector to meet EU objectives (sustainable development, social cohesion). The final objective is to facilitate industrial exploitation and improve the competitive position and employment prospects of the construction and habitat sectors. RENAC integrates at this moment 18 groups from the Technological and Scientific Valencian Community in Spain. The multidisciplinary expertise comes from the integration of Technological Institutes groups dealing with research in different traditional materials (wood, plastic, concrete, ceramic, stone, metal) with University research groups with a recognised excellence in nanoscience fields such as interface science, nanoparticles, photovoltaic nanomaterials, nanocomposites, mesoporous materials, chemical sensors, and polymer science.

Introduction
Nanotechnology, whose objective is the control of the behaviour and the fundamental structure of material at both atomic and molecular level, will revolutionize during the next decades the way to understand the design and the production of materials and products in all the industrial, services and consumption environments.

RENAC, with the support of the Regional Ministry of Enterprise, University and Science, was born as an initiative of different Nanomaterials research groups from the Technological Institutes and the Universities of the Valencia Region, with the purpose of facilitating to the Construction industrial weave the advantage of the opportunities generated by this scientific and technological revolution.
The Research Centres and the Industries have the greater opportunities to consolidate their capital in Industrial Property in the emergent stage of the development of a new technology. This will allow them to bring to the market innovating products and to avoid the dependency of external technology.

Objectives
RENAC aims to become a sustainable scientific and technological platform able to put together the Nanotechnology research efforts in the fields of Construction and Habitat, focusing on two major targets:

- Generation of a critical mass required to be competitive at national and international scope, thus allowing an optimization of the economic resources
  - Optimizing scientific infrastructures and to elaborate agreements of equipment exchange
  - Coordinating the scientific and technologist personnel and facilitating the integration of the research groups of the Valencia Region
  - Harnessing the participation in National and European Research Programs
- To facilitate the industrial exploitation and the potential enterprise development. This is implicit to the application of nanotechnologies in the products and systems dealing with the construction and habitat sectors.
  - Opportunities detection
  - Technology transfer to the traditional sectors
  - Promotion of the creation of technology base companies

RENAC main target is to help the companies related with the construction and habitat sectors to be on a level with other higher technological level sectors, and as a result, to take profit of the opportunities that this new technology offers to them.

The Universities and the Technological Centres are aware about:

- The greatest industrial opportunities of implementing the scientific developments of the nanotechnology area in the new materials and in the traditional products for construction and habitat.
- The great scientific and technologic complexity of this knowledge area, that requires the integration of multiple disciplines knowledge, as well as great investing on scientific equipment
- The importance of the international competition that has been generated in the field of the nanotechnologies.

Scientific capacity

At present time, RENAC is integrated by more than 100 scientists and technologists. This important scientific capital gathers knowledge and experience in the fundamental research areas:

- Nanoparticle synthesis
- Organic and inorganic nanopigments synthesis
- Nanocomposite-based coatings
- Organic-inorganic hybrid materials
- Photovoltaic nanomaterials
- Surface functionalization of nanomaterials with active groups
- Sensors based on functionalised mesoporous solids
- Electric, electromagnetic and optical properties definition
- Polymer ceramic, metal and cement matrix nanocomposites
- Nanostructured materials: organoclays, mesoporous, nanocapsules
- Application of nanoparticles in ceramic glazes
- Nanocomposites process by extrusion, injection and compounding

RENAC has been structured in two committees, one addressed at the scientific world and another one at the industrialist. The first one is in charge of making a pursuit of the state of the technique in the field of nanotechnology, the definition of the research lines and the execution of the R&D projects. The second will make a search and study of opportunities; it will be the interphase of the network with the companies, being in charge to manage the activities of needs analysis, promotion and results transfer.

Some technological resources

Process and nanofabrication	Characterization
- Nanofibers extrusion system	- Atomic Force Microscopy (AFM)
- Freeze-dried nanoparticle synthesis	- Nanoindenters
- Sol-gel synthesis	- Scanning and transmission electronic microscopies
- Chemical vapour deposition	- Zeta potential analysis
- Spin coating	- X-ray photoelectron spectroscopy
- Spray pyrolysis	- X Ray diffracction
- Ion beam sputter deposition system	- Energy dispersive X-ray spectroscopy
- Low pressure gas RF Plasmod	- Gas porosimetry analyzer
- Template synthesis of nanoparticles	- Mercury porosimetry analyzer
	- Interferometer microscope
	- IR-Scope II infrared microscope

Proved experience

Despite of the newness of the technological area, the research groups integrated in RENAC have significant research curricula in nanotechnologies. They concentrate more than 40 related research projects, mainly of national and European scope, and that approach lines like:

- Nanoparticles and nanofibers
- Nanocomposites and hybrid materials
- Smart materials and sensors
- Nanotechnology and characterization

RENAC secretariat, Construction Technology Institute – AIDICO, nano-renac@aidico.es; www.nano-renac.com

Spanish technology platform on nanomedicine: a joint initiative to promote translational research

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Abstract

Spain presents a lag with the European Union in terms of R & D in both total investments relative to GDP and company involvement in the financing of such investment. Spanish companies' research shortfall suggests that they fail to develop know-how of their own and, moreover, they are failing to take advantage of the technology generated by public research centres. This makes it essential to increase the critical mass and research excellence of our Science and Technology System. To meet these challenges, the Spanish government started in 2005, the INGENIO 2010 program, to maintain and improve existing R & D and Innovation programs and to focus significant resources on new strategic initiatives.

The INGENIO 2010 programme aims to achieve a gradual focus of these resources on strategic actions to meet the challenges faced by the Spanish Science and Technology System. This gradual focus will be achieved by allocating a significant portion of the minimum annual increase of 25% in the national R & D and Innovation budget to strategic initiatives grouped in three major lines of action:

The CENIT Program (National Strategic Technological Research Consortiums)

to stimulate R & D and Innovation collaboration among companies, universities, public research bodies and centres, scientific and technological parks and technological centres. The CENIT program co-finance major public-private research activities. These projects will last a minimum of 4 years with a minimum annual budgets of 5 million euros, where i) a minimum of 50% will be funded by the private sector, and ii) at least 50% of the public financing will go to public research centres or technological centres.

The CONSOLIDER Program

to reach critical mass and research excellence. CONSOLIDER Projects offers long-term (5-6 years), large scale (1-2 million Euros) financing for excellent research groups and networks. Research groups may present themselves in all areas of know-how of the National R & D and Innovation Program.

CIBER Projects

promote high quality research in Biomedicine and Health Sciences in the National Health Care System and the National R &D System, with the development and enhancement of Network Research Structures.

In addition to these three main programs, support actions to increase human resources creating new stable research positions and a strategic scientific and technological infrastructures program to ensure the availability and renewal of scientific and technological equipment and the promotion of scientific and technological parks linked to universities and public research bodies, are also included in the Ingenio 2010 initiative.

In this framework, the Spanish Technology Platform on NanoMedicine (STPNM) is a joint initiative between Spanish industries and research centres working on nanotechnologies for medical applications. This initiative is supported by the Spanish government through the Centre for Industrial Technology Development (CDTI) and the Spanish Ministries of Education and Science (MEC), Industry, Tourism and Trade (MICyT), and Health (MSC).

The main objectives of the Platform are:

- Improve the collaboration within the Nanomedicine community in Spain avoiding fragmentation and lack of coordination,
- Promote the participation of Spanish stakeholders in international initiatives, from transnational co-operations to European projects, especially regarding the European Technology Platform,
- Establish recommendations concerning strategic research lines in the nanomedicine field,
- Dissemination of nanomedicine results to the scientific community and society-at-large.

The focus of the Spanish Platform, with more than 72 members, is divided in five strategic priorities: Nanodiagnostics; Regenerative Medicine; Drug Delivery; Toxicity and Regulation; and Training and Communication. This activity has facilitated a wide participation of Platform members in Spanish strategic research programmes run by the Spanish government through the Ingenio 2010 initiative.

In September 2006 the Spanish Platform published a report focused on current status of nanomedicine in Spain 'strategic vison of nanomedicine in Spain' in order to establish research and development priorities and action plans on certain strategic issues to be solved in the medium to long term.

This report emphasizes that nanotechnology will have direct applications in medicine by contributing to improvements in health and life quality, while decreasing the economic impact. The report concludes that Spain can play a relevant role in the development of this field because it has cutting-edge research centres, industrial and pharmaceutical sectors interested in using these new technologies as well as a health care system based on a network of hospitals with a very good basic and clinical research, interested in the development of translational research programs.

As an example of the Spanish nanomedicine capabilities the results obtained last year in the first competitive calls of the Ingenio 2010 were: among the first 17 'Consolider' projects financed, one was in the field of Nanotechnologies in nanomedicine; from 17 industrial CENIT projects financed in 2006, two correspond to nanomedicine. One of them is in drug delivery (nanopharma) and the other one in nanodiagnostic for cancer (oncnosis). Finally the Ministry of Health created 7 national biomedical research centres in network. The one dealing with bioengineering, biomaterials and nanomedicine involve 32 research groups from hospitals, research centres and universities.

Taking into account that the participation in the different instruments is in many cases incompatible, and the calls were open to all the Spanish science and technology system, these results confirm that the nanomedicine is a research priority in Spain and that exists a potentially strong sector to be developed in the next years.

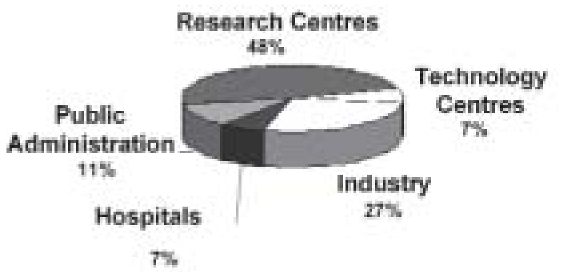

Figure 1: Distribution of the organizations involved in the Spanish nanomedicine platform.

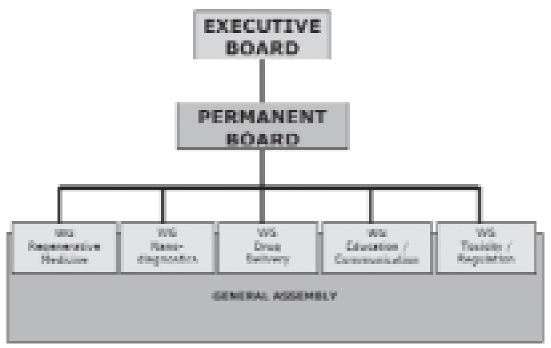

Figure 2: Structure of the Spanish nanomedicine platform

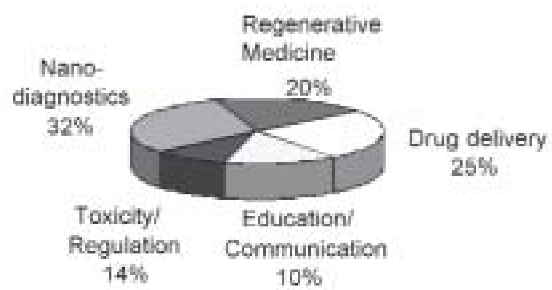

Figure 3 : Member participation in the five working groups existing in the Spanish nanomedicine platform.

Fraunhofer Nanotechnology Alliance: Focus on materials - examples for industrial implementation of nanotechnologies

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Introduction

Nanotechnologies (NT) - which can be characterized as the combination of size (1-100 nm) and function useful in industrial products/systems - cover a wide area of applications and industries (see fig. 1).

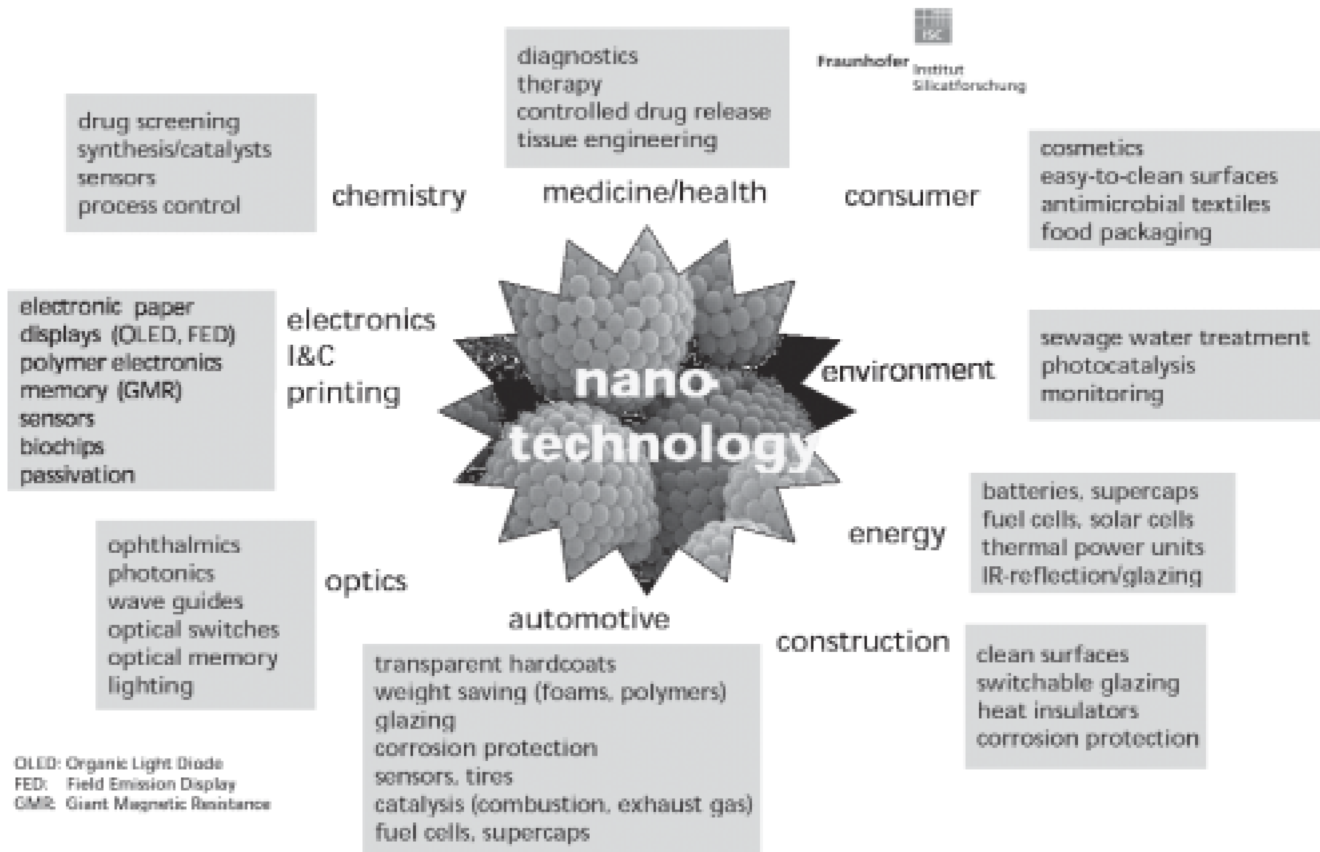

Figure 1: Application areas of nanotechnologies

More than one third of the 58 Institutes of the Fraunhofer-Gesellschaft (FhG) in Germany is working in the field of NT *www.nano.fraunhofer.de*. The research areas encompass materials, electronics/optics, life science, production technologies and analytics (see fig. 2). The focus of this contribution is on the material development for different applications and gives examples for industrial applications of NT .

The Fraunhofer Nanotechnology Network (FNT)

The main task of FhG is to contribute to industrial implementation of new technologies and processes. FhG Institutes are part of various regional, national and european networks dealing with NT f.e. 'Ultrathin functional films' *www.nanotechnology.de*, 'nanomaterials' www.nanomat.de, FAME 'NOE for Advanced Materials' *www.famenoe.org* and many more. FNT is representing the NT activities of FhG bringing together all the expertise necessary in R&D projects especially for industrial clients. Due to the highly interdisciplinary character of NT (material science, chemistry, biology, physics, engineering etc.) Institutes have to work close together, since in contrast to 'classical' projects, not all the competencies necessary for a NT-project can be covered by a single Institute. Within FhG NT-related projects cover around 10 % of all research efforts: Nearly 100 Million Euro including basic funding, public funded projects and industry financed projects. More than one third of all NT-related projects of Fraunhofer are application focused projects with industrial partners. SME play an important and critical role in this process, since they often do not have the expertise and processing/analytical equipment necessary for sucessful NT-projects. FNT is a cluster type network relying on self-organization processes (bottom-up-approach) in order to foster cooperation and R&D projects within FhG and also with external partners. FNT is a network linked through common targets and not through additional funding or by administrative means. Impulses and ideas for new research areas/projects are generated by regular meetings and projects. FNT also serves as a communication point for all types of questions which might arise in terms of NT ('Ask one and get the competence of many').

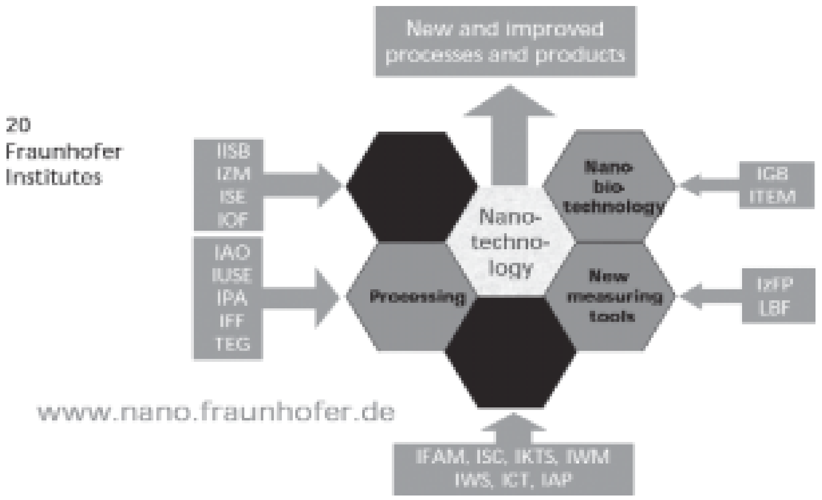

Figure 2: NT-areas and institutes within the Fraunhofer-Network Nanotechnology

Examples of material driven nanotechnology applications

Nanomaterials are an essential part of NT. The use of nanomaterials has already led to numerous applications in various industrial segments e.g. as polymer nanocomposites, hybrid nanoscaled polymers, nanoparticles, ultrathin films etc. The synthetic approach is mostly based on chemical nanotechnologies or PVD/CVD techniques. Chemical nanotechnology, which is the generation of nanoscaled materials by chemical means f.e. polymerization reactions, self-organization or sol-gel-processing, is frequently used. Figure 3 shows examples for research fields which are covered by the sol-gel-process (forming inorganic or organic-inorganic networks by solution/gelation processing). In quite a few cases this has led to industrial implementations (marked by * in fig. 3).

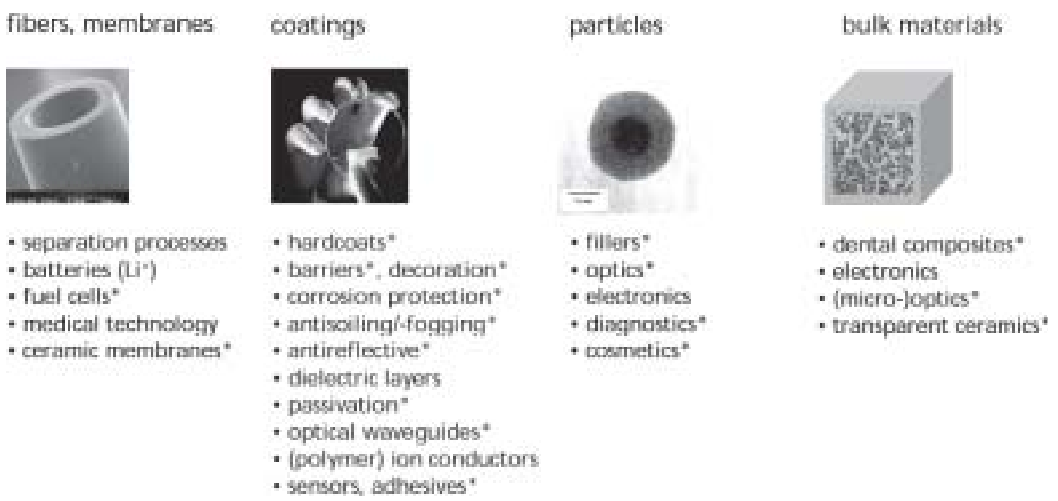

Figure 3: Application areas of materials based on chemical nanotechnologies (sol-gel-process) for inorganic and hybrid organic-inorganic materials

An application example for ultrathin films generated by laser assisted physical vapor deposition (PVD) is shown in fig. 4. Ultrathin film technology (< 10 nm) has continously evolved from thin to ultrathin in the last than 20 years. In the example shown in fig. 4 this ultraprecision leads to extremly high reflectivity for the X-ray optics needed in new lithographic systems for micro-/nanoelectronics.

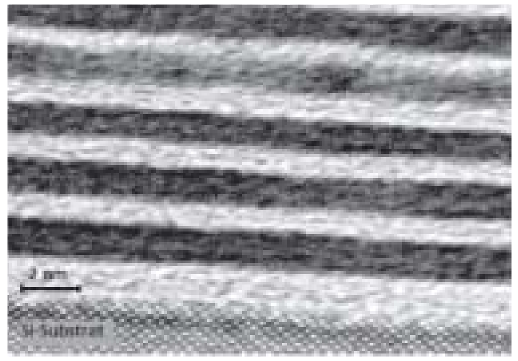

Figure 4: Ultrathin multilayers (Ni/C) generated by pulsed laser deposition for X-ray reflective optics (IWS Dresden)

Carbon nanotubes (CNT) can be used in composites to improve mechanical and/or electrical properties. An example is shown in fig. 5. Here CNT were added for an improved damping properties.

Figure 5: Tennis rackets with improved mechanical damping properties by the addition of CNT (TEG Stuttgart)

Conclusion

NT can already be found in quite a number of products. Enhancing the properties of products/systems *continously* by adding 'Nano' to conventional products can minimize the development risks (e.g. tennis racket with CNT). It is also important to show that new functions are possible through NT.

So not only size, but function matters !

Micro- and nanotechnologies applications for automotive

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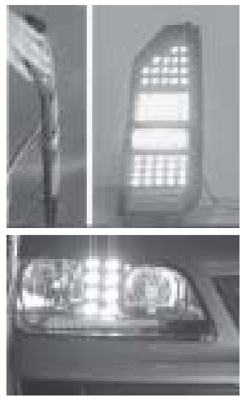
Microtechnologies
The miniaturisation of components, particularly in computer electronics, telecommunications and transportation industries, has been at the forefront of economic growth for the last 20 years.
MEMS (Microelectromechanical systems) and MST (Microsystems Technologies) devices are now produced in large volumes at low costs.
The cost of automobile systems and subsystems developed in electronic foundries is approaching 15% of the total cost of a car and is expected to increase considerably in the future with the full penetration of MEMS/MST, both in new applications and in the replacement of traditional technologies.

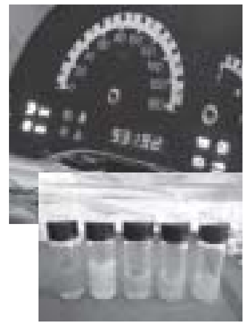
Nanotechnologies
Nanotechnology lies at the intersection of chemistry, physics, biology, electrical engineering, computer science, and material science.
It concerns the deeper understanding and control of structures at atomic, molecular and supramolecular levels where materials and systems can exhibit novel and significantly improved physical, chemical, and biological properties.
Important functions of nanotechnologies are:
- modelling the properties of materials from their nanoscale form to the final macroscopic form;
- achieving economical production of nanodevices, systems and materials;
- extending the introduction of sophisticated metrological systems, making it possible to visualize complex nano functional blocks, to track their evolution, and understand their interface with the surrounding world.

The direct and indirect involvement of nanotechnology in the automotive industry is considerable. Starting from energy storage, it covers almost all areas: high efficiency energy converters, new fuels, super-tough and low friction coatings, iridescent paints, novel materials with electrical, mechanical, thermal and optical engineered properties, selective filters, electro-chromic coating, electro-optical films, etc.
CRF developments in Micro and Nanotechnologies involve in particular the following areas:
- lighting
- information
- sensing
- multifunctional materials
- energy.

Lighting
The guidelines for innovation in the lighting area are improved functionality, efficiency and compactness of lighting systems. Activities are therefore aimed at developing novel solutions with the following features:
- smart/adaptive capabilities with respect to the operating contest;
- advanced design solutions involving micro-optics;
- integration technologies for light sources.
Chip LED technologies have been applied to pre-production taillights and a specific laboratory has been set up at Centro Ricerche Plas-Optica in Amaro (UD) to facilitate the transfer of technology to the Automotive Lighting plant. Prototype headlamps based on white chip-LED technology have been developed and demonstrated.



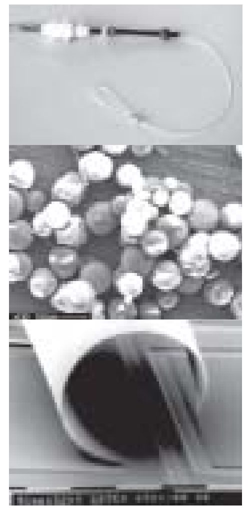
Information displays
The aim of this area is to develop advanced technologies for both wearable and in-the-dashboard information systems. Development has focused on multifunctional eye glasses and fixed eye-up floating display buses. The integration of miniaturized optoelectronics, novel active materials and microtechnologies have received particular attention with great potential impact in terms of:
- increased safety and comfort during driving
- vision enhancement and information easily accessible
- little interference with primary driving task



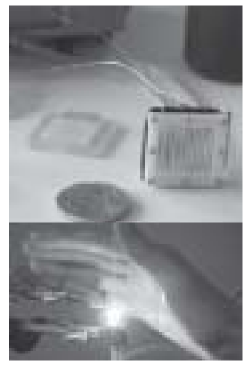
Sensors
The technical objective of sensing research is to provide a full, accurate and robust 3-D description of the manoeuvring area around the vehicle. This is done by capturing spatial data and extracting specific information on the overall geometry, depth, position and motion of different objects. Development is addressed towards the multifunctional integration of optical sensing functions into a single sensing unit, using a systemon-chip approach to detecting obstacles and weather conditions. Nanotechnologies apporaches will help in increasing the sensing performances allowing:
- safety and comfort by emission gases detection
- optimisation of engine control reducing pollutants and fuel consumption

Multifunctional materials
Smart materials are materials able to modify their functional characteristics if stimulated with electrical or magnetic fields, temperature, light, etc... They can function as sensors or as actuators simultaneously and they are able to produce controlled mechanical functions without the need of external mechanisms. They are adaptive with respect to environmental conditions; they reach an high level of miniaturization and permit the development of new functions.

To obtain the maximum advantage from the application of smart materials as automotive components. The activity is highly concentrated on synthesis and functionalization of materials, on development of new processes for multimaterial integration and on design of new active structures. Smart materials for microactuation, in particular SMA (Shape Memory Alloys) and Magneto-Rheological Fluids, are now viable for early application in the automotive field, where they bring advantages, mainly in terms of weight, cost and size reduction.



Energy
The development of micro power sources will enable the miniaturisation and improve the functionality of new systems. The use of MEMS technology has already demonstrated size reduction and power enhancements through new concepts and new materials functionality. Micro power generation techniques include micro fuel cells, micro reactors, microcombustors, thermo-electric converters and photovoltaic cells. Research is currently focused on nanostructured materials, electrolytes, catalysts, modeling and packaging. Novel solutions have been demonstrated for micro fuel cells on film, micro-combustors and thermoelectric technology.



Integration of nanofeatures at micro-macro (product) scale: developments needs

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Abstract
Key needs on the route to a full nanomanufacturing chain are: 1) availability of source nanoscale systems; 2) integration strategies and technologies to include nanofeatures into 3D products. Source nanosystems and integration technologies are strictly correlated and needs interacting, strongly dedicated, developments quite often using available-known technologies, but with relevant adaptations and innovations. The MINAM platform allowed to introduce such a discussion in a very deep way, underlying and focusing on the actual needs for a nanomanufacturing EU based industry.

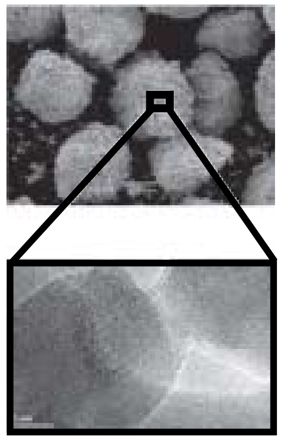
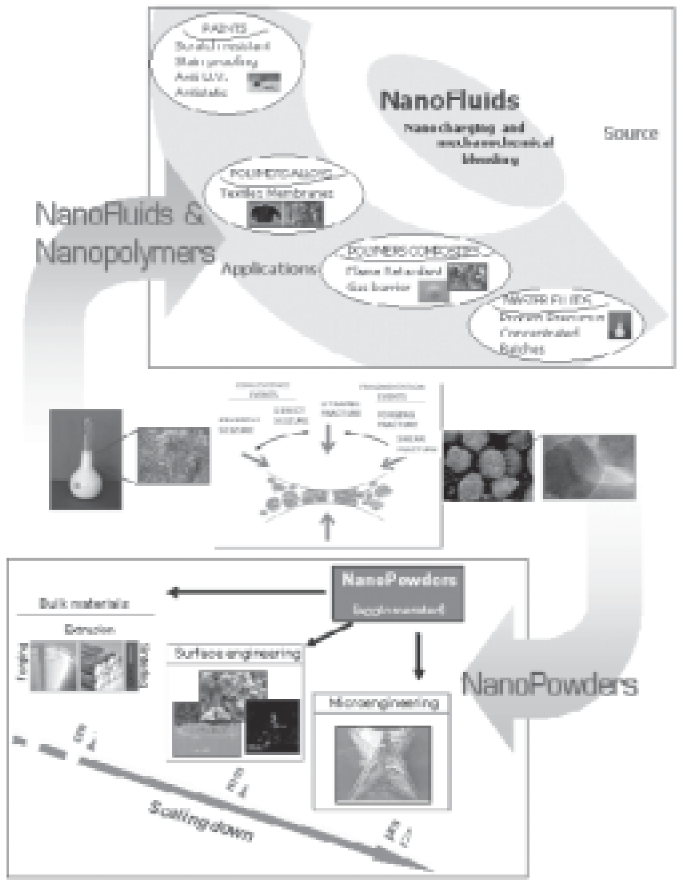


Figure 1: Agglomerated Nanopowders

Summary
Generating nanostructures at different length scales, from micron (ore less) up to the macro scale could be the actual challenge (or one) of nanomanufacturing. Incorporating nanostructures into objects or products could be considered another paradigm of the term.
Embedding nanostructures in 3D solid objects open the way to create entirely new generation of products with tailored and innovative properties. MBN Nanomaterialia SpA (founded in 1994) brought into full industrial [1] scale the process of high energy milling (mechanical alloying) reaching now a production capacity (quite expandable) of about 200 ton per years. Typically aggregated powders can be produced (or as well liquids) in which nanoscale features crystals are embedded at micron scale in particles as in Fig. 1. These systems are ideal for being used in further integration processes and strategies. Fig. 2 gives an idea of actual key aspects, opportunities and difficulties encountered in embedding nanofeatures into products.

Figure 2: Nanomanufacturing routes at MBN



The source nanosystems (even in the advantageous form of aggregated systems, which for example show far less environmental problems then nanoparticles) needs the development or adaptation of a number of technologies to obtain various classes of products.
In the area of bulk integration (Fig. 2) from powders basically three routes appear critical:
1) bulk integration via consolidation (HIPing, SPS, net shaping etc, direct manufacturing), plastic processing (like rolling);
2) nanostructured surfaces by exploring/adapting new routes to depositing nanophased particles (like high velocity spraying);
3) micromanufacturing capable of embedding in a controlled (micron scale) way nanofeatures into 3D small parts. In this area, by the way also of some EU (FP5, FP6) [2- 4] projects, is has been established the viability and potentials as well as the difficulties and developments needs. In Fig. 3 are summarized results which can obtained in every single area. Extrusion of aggregated nanopowders (Fig. 3a [2]) leads to properties of nanostructured alloys (for example Mg alloys up to 400 MPa of yield strength). Using appropriate developments in the techniques of thermal spraying [3] open the way to coatings with superior performances respect to conventional, non nanophased coatings. Tribological improvements in the order of ten time are achieved, bringing to compete alloy based systems to ceramic based systems (Fig. 3b).
Embedding nanofeatures into 3D objects is ideally performed using high resolution micromanufacturing approaches [4]. Direct manufacturing embedding full control of materials and geometries are achievable, with spatial resolution down to 1 micron. Challenging is the area of nanofluids and nanopolymers, as shown in Fig. 4. Properties modifications, customisation (fire retardancy, thermal conductivity, mechanical properties), open the way to upgrading the areas of usage of polymers toward those typical of metals, but using mass production techniques like injection moulding. Nanofluids themselves have potential to deliver wide impacts in several sectors (thermal management and heat transfer, lubrication, inks, paints).

These industrial experiences allow to give some views on needed developments in the area of nanomanufacturing, starting from a first consideration: in this area it is not enough to develop manufacturing segments (although advanced) without taking care of all the manufacturing chain involved in going from the raw materials synthesis to products. This is particularly critical for nanomaterials, because they open NEW problems (unknown, unforeseen) even using conventional processing. For example, a nanostructured alloy may open totally new issues regarding corrosion/electrochemical behaviour or need the development of NEW heat treatment procedures to get the best performances from the systems.
Based on our view, developments needs in the area of nanomanufacturing can be summarized as follows:
1) integration technologies at bulk, surface and microscale levels, covering all the manufacturing chain to a particular class of products. I.e. high strength light alloys: synthesis, consolidation, shaping (quick ways), heat treatment, nanostructures behaviours
2) materials and components design, establishing new tools available to embed knowledge into materials and products, by virtual materials design concept. Materials can be thought in the property space, and nanomanufacturing can realize a particular, ideal, material/gradient with best suitable combination of properties. Eco-design aspects to be included as for

Nominal chemistry, w/w	Description	Density, g/cm³	YTS, MPa
[illegible]	High strength aluminium alloy	[illegible]	[illegible]
[illegible]	α-Titanium alloy	4,54	[illegible]
[illegible]	Titanium alloy Grade 5	4,45	[illegible]
[illegible]	α + β Titanium alloy	4,50	[illegible]
[illegible]	Biomedical titanium alloy	4,98	[illegible]
[illegible]	High strength, high conductivity copper based MMC	[illegible]	800
[illegible]	Aluminium MMC	[illegible]	[illegible]
[illegible]	Mg-Li ultra light alloy	1,40	[illegible]
[illegible]	Mg light alloy	[illegible]	400
[illegible]	Mg light alloy	1,81	[illegible]

Fig. 3a: Table of mechanical properties achieved in MBN nanophased alloys (YTS= yield tensile strength).

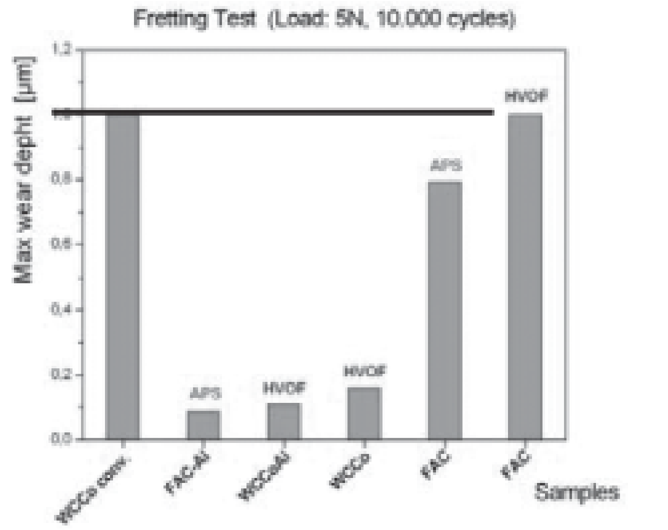


Fig. 3b: Tribological behaviour of nanostructured coatings.

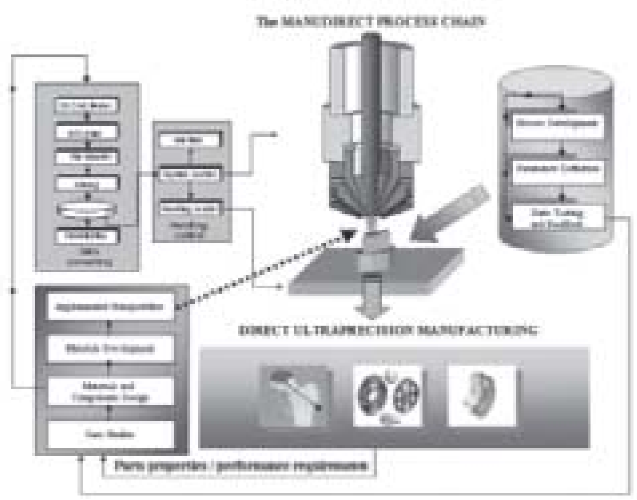


Fig. 3c: Micromanufacturing using aggregated nanopowders

example 'Reach' loop and others.

3) direct manufacturing technologies, as net shaping (quick-full density forming) and high resolution manufacturing, capable of delivering full 'nano' properties
4) surface nanostructuring using high velocity ('cold') processes, allowing the transfer on the surface of the original powder nanostructure. Tribological modelling embedded in materials/components design cycles.
5) Nanofluids and nanopolymers needs entirely new modelling (and design) approaches joined by viable manufacturing routes, understanding of properties structure correlation and customization possibilities. Covering as well the manufacturing chain would be a key for example for: gas barrier properties in polymers, new textile fibers (polymer alloys or composites), heat transfer management, lubrication, paints, nanomedicine (nanofluids including nanoparticles with targeted viral or bacterial activities).

References

[1] P.Matteazzi, 'Mechanomaking of Nanophased Materials', Interface Controlled Materials, Wiley- VCH, Vol 9, 1999, 119-125

[2] Project Eureka Factory 1733 Achen

[3] EU FP5 Thermal spraying of nanophased powders 'NANOSPRAYING' (www.nanospraying.com). Contract G5RD-CT-2002-00862

[4] EU FP5 Microscale fabrication of graded materials components 'MICROMAKING'; Contrract N. G1RD-CT-2000-00195 and FP6 Direct ultraprecision manufacturing 'MANUDIRECT' (www.manudirect.eu) Contract N. NMP2-CT-2006-026467

Metrology and quality control in nanomanufacturing

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Abstract

The nanomaterials are already used in some applications like re-inforcement of materials with nano-components as SiO_2 nano-particles in tires or nano-tubes of carbon in polymeric structures, etc... In the case of top to bottom application, the micro-electronic is of course the application most cited.

In near future, many new applications will emerge where the new nano-structured materials will replace old components with the advantages of their new features.

The main characteristics of nanomaterials are the surface to volume ratio and the non linear effects as new quantum effects. The volume and mass may be small but the effect may be new and large.

There are several features which need to be assessed, at first the chemical composition and the phase, amorphous or crystalline.

The dimensions of the nano-materials as their size in case of particles, fibers, or layers must be measured with a precision better than 1 nm.

In the case of assembly or incorporation in systems as nanostructured layers, nanocomposites, aggregates, complex mountings, the position of the nano-components must be measured and controlled with high precision in a non destructive way.

Motivation of metrology:

The manufacturing always needs development and quality control.

The soonest we can find the best conditions and the best process window, the fastest a product can be produced in volume.

The metrology must be adapted for the development phase at first and then actualized for the quality control in line or at the final stage before delivery.

The type of metrology must be chosen to be as less costly as possible, and the non destructive way is better because it is possible to control real products without destroying them, so it becomes less costly and more representative. Usually the optical technique is used.

This is the case in micro-electronics where the new equipments for the 300 mm lines are sold by their ability to control real products without contaminating them with particles or metals. Another argument is the cost of ownership, how much it finally costs to the user for controlling the production. The cost depends of the choice of the sampling and the time for measuring several points per sample more than the capital cost.

There are several techniques used for control of nanomaterials, at first the material, a destructive technique where materials are dissolved in liquid; like atomic composition and phase can be assessed by classical chemical techniques as AA, ICP emission, chromatography , then IR and Raman for molecular composition for instance in dry phase.

The X-Rays, fluorescence and diffraction are also largely used, these techniques are non destructive and can give thickness and roughness of thin layers as well as nanolayers and crystalline orientation and distance between dots and atoms and the stress.

In case of very thin layers, XPS is used to give the chemical composition of the surface.

When new development must be conducted on a process which uses nano-dimensions, materials as well as dimensions, there is a need to control with high precision.

The microscopy is the best way to observe the structures, but below the size of 0.5µm, the optical microscopy cannot measure accurately anymore except when the structure is designed for it as the case of lines and box in the box for overlay in photolithography.

The stylus, with contact, has a resolution limited by the tip, in the 100 nm typically. Then the near field microscopes are used as SNOM, STM and AFM with resolution at atomic scale.

Unfortunately the speed of measurement is slow, µm square within minutes, but fortunately this is a non destructive way. There are several limitations to the STM, AFM and SNOM as the accuracy which depends upon the piezo displacement and only the topography of the surface is accessible. Recently other complementary parameters have been added to near field equipments. Resistivity, capacitance and magnetism and wear of the surfaces can be measured also.

White light interferometry does not reduce the lateral limitations but enables to determine the height or thickness with a resolution in the nm range but the material composition must already be known.
Another technique based upon spectroscopic ellipsometry gives the complex refractive index and thickness of multilayers. The refractive index and absorption coefficient are the fingerprints of the layers. The infra-red range can give, in addition, the molecular bounds LO and TO as the incidence angle with the surface is oblique. The Drude tail enables to measure the conductivity of the layer and then, associated with the thickness, the sheet resistance can be measured without contact. When the surface is structured with lines as gratings or with periodic structure, the diffraction or scatterometry enables to measure the pitch and the critical dimension with 0.1 nm precision. The beam needs to capture enough lines for high resolution and then the spot size is typically in the 10's µm. This technique is indirect and needs a modelling which is the weak part of the optical analysis. The result is an average of lines and spaces and CD at the difference of the CD SEM which is capable of one single line only.
The e-beams are the most precise and easy ways to scan a surface and to display a surface. The energy in the kV range does not affect most surfaces. It is even possible to see the surface without coating conductive layers which affect the behaviour of the picture.

Figure 1:
SOPRA GES5E Spectroscopic Platform

Figure 2:
Diffraction at 400 nm of Poly Silicon LTPS

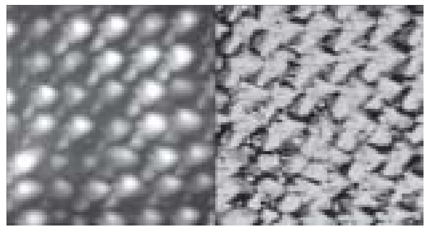
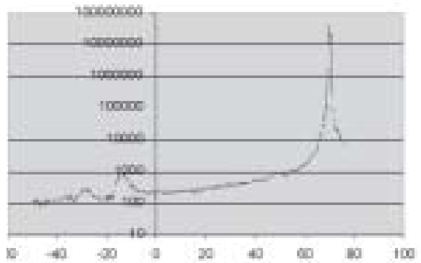


Figure 3:
AFM image of LTPS diffraction



Conclusion
In conclusion, there are several metrology techniques which can be used for quality control in manufacturing of nanomaterials, this presentation will not be exhaustive but presents a few analysing techniques useful for material analysis and size analysis. The optical techniques spectroscopic ellipsometry and X-Rays are non destructive but require modelling to describe the features of the surface and structures. In addition to the need of improving the modelling and the spot size, there is a need of standardization. We definitely need terminology, methodology and standard reference materials which can be used by several techniques to cross correlate the results in the nanomaterial analysis.

References
www.sopra-sa.com

Projection Mask-Less Patterning (PMLP) for high value-added nanomanufacturing

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Abstract
Nanomanufacturing has to fulfill industrial needs of being 1) flexible, 2) rapid and 3) cost-effective even for small production lots. Projection Mask-Less Patterning (PMLP), based on hundreds of thousands of finely focused particle (ion) beams with <10nm resolution, is able to fulfil these requirements. A PMLP proof-of-concept tool has been realized as part of the FP6-NMP integrated project CHARPAN (Charged Particle Nanotech, www.charpan.com) already demonstrating < 20nm resolution and 3-dimensional nanopatterning of surfaces.

Introduction
The reliable and cost-effective fabrication of 3D structured nanosurfaces is prerequisite for numerous industrial applications: (i) leading-edge complex masks for the semiconductor industry, (ii) high-precision nanoimprint templates, and (iii) nanofunctionalised surfaces, materials and 3D structures for applications in nanoelectronics, nanophotonics, nanomagnetics and nanobiotechnology. Projection Mask-Less Patterning (PMLP) is a technique based on hundreds of thousands of charged particle beams with <10nm resolution working in parallel. In particular, with PMLP technology 3D design data can be transferred directly, without a need for resist processing, into almost any material surface of a substrate. PMLP will allow rapid manufacturing of 3D nanostructures on large (mask/template/wafer-size) surface areas in various materials (semiconductors, quartz glass, metals, polymers) either as a direct nanopatterning process or in combination with nanoimprint technologies, where the patterning can be cost-effectively multiplied. Thus, PMLP will provide significant contributions to a European high value-added nanomanufacturing industry.

1. Principles of Projection Mask-Less Patterning (PMLP)
Flexible, cost-effective, and rapid manufacturing can best be achieved by implementing maskless techniques, requiring massively parallel working beams with resolution capability in the nanometer range. Projection Mask-Less Patterning (PMLP), implementing hundreds of thousands of programmable, finely-focused particle beams, provides suitable throughput and flexibility for rapid nanomanufacturing tasks under industrial production conditions. For PMLP nanopatterning a broad charged particle beam is directed to a programmable aperture plate system with thousands of apertures of micrometric dimension (Figure 1). Near the apertures are tiny deflection plates, each of which can be individually powered (to several

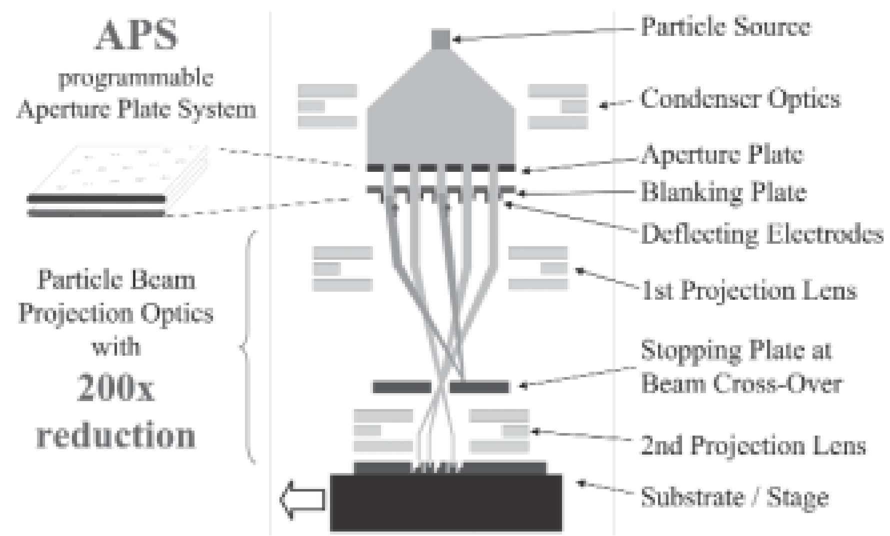

Figure 1: Principles of Projection Mask-Less Patterning (PMLP)

Volts) using integrated CMOS electronics. The slightly deflected beams are stopped near the cross-over of a charged particle beam projection optics with 200x reduction. The undeflected beams are projected to the substrate with nanometer resolution. When using 2µm apertures finely focused beams of 10nm spot size are generated.

2. PMLP proof-of-concept tool realized as part of the CHARPAN integrated FP6-NMP project and first exposure and resist-less 3D nanopatterning results

A PMLP proof-of-concept (POC) Tool (Figure 2) has been realized as part of the CHARPAN (Charged Particle Nanotech) integrated FP6-NMP project (*www.charpan.com*). Operating the system with argon ions 'beam-on' has been achieved in February 2007: for the first time an electrostatic charged-particle projection optics with 200x reduction has been realized and is operable. The exposure field is 25 µm x 25 µm and the targeted resolution ‹20nm. Figure 3 shows fulfilment of the resolution target with 16nm lines & spaces realized in HSQ resist material.

Figure 2: Elmar Platzgummer, CHARPAN project manager, in front of the PMLP POC Tool, realized as part of the CHARPAN integrated FP6-NMP project

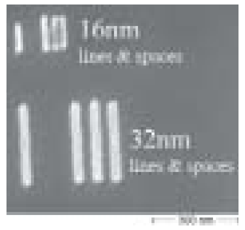

Figure 3: CHARPAN PMLP POC Tool exposure result in HSQ resist using 10keV argon ions

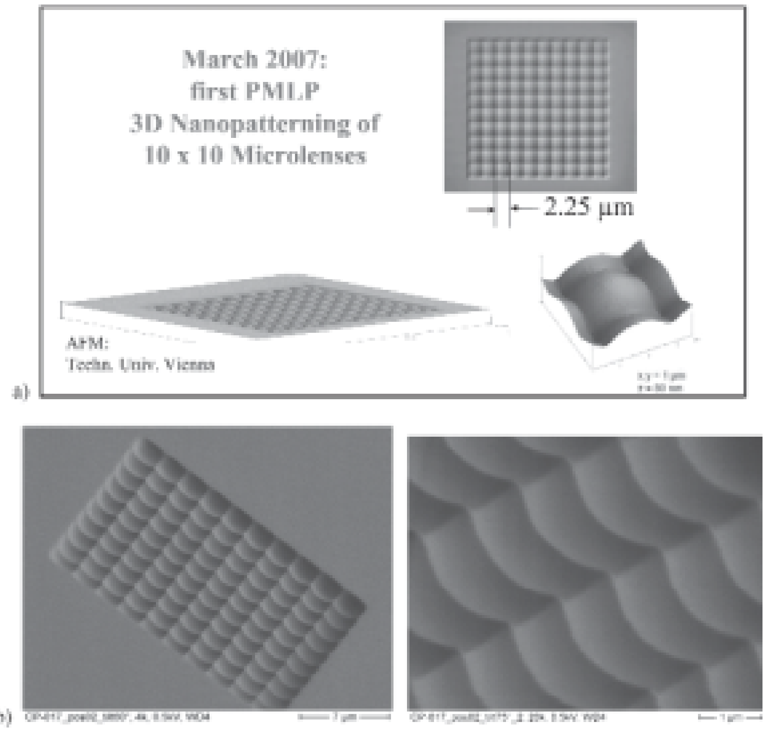

Figure 4 (a,b): CHARPAN PMLP POC Tool 10keV argon ion multi-beam nanopatterning of a 10 x 10 array of a) convex and b) concave microlenses on a silicon wafer surface

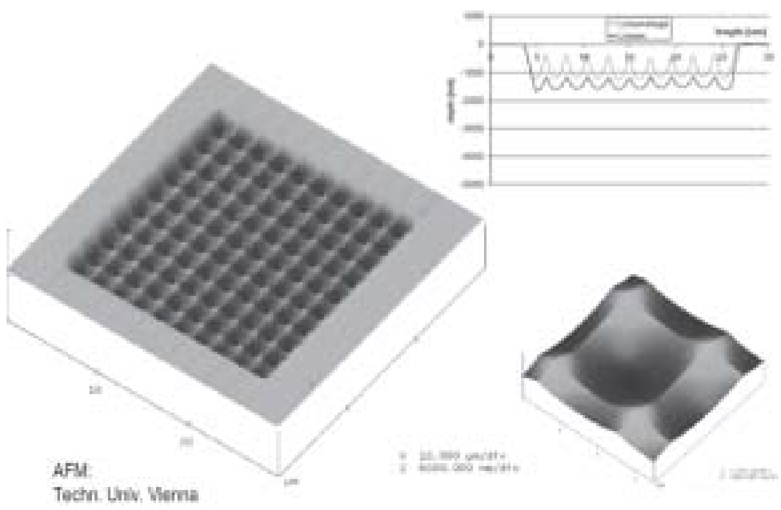

Figure 5: CHARPAN PMLP POC Tool 10keV argon ion multi-beam nanopatterning of a 10 x 10 array of concave microlenses on a GaAs wafer surface

In March 2007 the first resist-less 3D nanopatterning of surfaces could be accomplished by realizing a 10 x 10 matrix of microlenses in different materials with nanometer surface definition (Figures 4 and 5).The next objective of the CHARPAN project is to insert a programmable Aperture Plate System to the PMLP POC Tool with the target to realize ca. 40,000 programmable finely focused ion beams. In parallel, ion multi-beam nanopatterning science and various industry oriented PMLP applications are studied within the CHARPAN integrated FP6-NMP project.

MINAM – Micro- and Nanomanufacturing – new platform on European level with support of IPMMAN and µSAPIENT

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Micro- and nanomanufacturing is getting more and more important for innovative applications and has a strategic importance for Europe. A new Micro- and NanoManufacturing community is emerging at European level involving collaboration of manufacturers of micro- and/or nano-inside-products, equipment suppliers, research organisations and networks.

The industrial stakeholders showed clearly the necessity of a European platform at the meeting on 14th September 2006. The decision was taken to establish and structure a platform with two organisational groups: an Industrial Management Group (IMG) and Operational Support Group (OSG). The proposed name is MINAM (Micro- and NanoManufacturing)[1]. MINAM will be closely associated with the existing platform Manufuture[2]. MINAM is supported by the EC funded coordination Action IPMMAN and µSAPIENT.

The new industrially driven community for Micro- and NanoManufacturing develops the Vision and Strategic Research Agenda (SRA) for the coming years. First results of the platform have already been provided as input to the 7th Framework Programme and more specific the NMP programme. The platform intends to strengthen the effect of European, national and regional funding programmes in further terms of a higher level of coordination and implementation by industry.

Companies and Institutes from more than 20 countries in Europe met in January in Brussels for the first Brokerage and Information Event of the MINAM Platform.
Projects for cooperative research and industrial solutions were presented on 20 topics in nanomaterials, production technologies, advanced integrated nanobased products, metrology and process control.

MINAM continues to offer direct service online match making for project proposals and partners at www.micronanomanufacturing.eu. Almost 400 stakeholders today are contributing to a fast build up of R&D excellence in Europe combined with direct transfer into industrial products.

[1] *www.micronanomanufacturing.eu*
[2] *www.manufuture.org*

Prototype cell for photoelectrochemical water splitting

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Abstract
Hydrogen generated from the splitting of water using solar energy, termed solar-hydrogen, represents a sustainable fuel that is environmentally safe [1]. The most critical issue in the development of solar-hydrogen is the development of a special class of new photosensitive materials for efficient and clean conversion of solar energy. There is a growing awareness that titania (TiO_2) and TiO_2-based oxide systems are the most promising candidates for the development of photoelectrodes for photoelectrochemical cell (PEC) for solar-hydrogen production [1]. The PEC prototype realized in our laboratory is equipped with a single photoelectrode (photoanode) and cathode, both of which are immersed in an aqueous electrolyte. Exposure of the photoanode to sunlight results in charge transport within the PEC and evolution of gases at the photoanode and cathode. Nanocrystalline semiconductor films are constituted by a network of mesoscopic TiO_2 particles witch are interconnected to allow for electronic conduction to take place. Because of their ultra low density and high surface area, TiO_2 aerogels are attractive for their applications in solar energy conversion [2].

In the present work our attention was focused on the obtaining photoelectrodes for photoelectrochemical cell (PEC) that incorporate two substrates at least one of which has been coated with a transparent conducting oxide (TCO), referred to as the primary electrode and the other, the counter electrode, coated with TCO or a non-corrosive metal such as titanium upon which is coated a very thin layer of platinum. A porous layer of a semiconductor such as TiO_2 is deposited on the conductive surface of the TCO. The nanoporous TiO_2 film was deposited onto a sheet of ITO conducting glass and treated with porphyrin dyes and/or derivatives.

Several complementary investigation techniques like BET, SEM, SAXS, Raman and XRD were used to follow the influence of the reactants molar ratio and thermal treatment on the TiO_2 aerogels structures.

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Mechanical preparation of phyllosilicate nanoparticles and nanocomposites

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The nanoparticles and nanomaterials are extensively studied for many years. Increasing interest has focused on a variety of nanostructured materials with clearly defined particle size. Size, shape and surface chemistry are determining factors that are among key properties to the utilization of nanomaterials.

Modern technologies open the possibilities to fabricate the nanomaterials with various dimensionalities of nanostructures. An attractive category of nanomaterials are nanoparticles. Nanoparticles become more and more important in many areas, especially in development of new high-tech materials. Nanoparticles can be produced using various processes such as wet milling, high-pressure homogenization, emulsification, precipitation, rapid expansion or/and spray freezing. The milling methods represent one of the most popular approaches to produce nanoparticles by the mechanical way. Generally are referred as a 'ground'. The resulting particulate powders can exhibit nanostructural characteristics on at least two types. At first, the natural particles are 'nanoparticles' if their average characteristic dimension (diameter for spherical particles) is less than 100 nm. Secondly, many of the milled materials are highly crystalline, such that the particle size after milling is often between 1 and 10 nm in diameter.

As mechanical preparation technique of defined particles we used jet mill (Sturtevant Micronizer®). This technique is relatively simple preparation method for particles with defined size, although is energy consuming. The jet mill is widely used in industries for grinding the solid materials (agricultural chemicals, minerals, metals, metal oxides - titanium and iron oxides, pigments, ceramics etc.). Principle of grinding in jet mill is in regulation of feeding and grinding pressure (kPa). The pressure of compressed air provides the grinding energy. The milling in jet mill consists of two stages:
1) the mixing of solid materials with compressed air;
2) the acceleration of compressed air and solid materials flow in the grinding chamber. High speed rotation of materials in chamber causes the particle-on-particle collisions creating increasingly smaller particles.

In this paper we present an optimization of the jet milling conditions applied for clays minerals (phyllosilicates – vermiculite and kaolinite) and clay nanocomposites (types clay/teflon, clay/aramid fiber, clay/dye etc.). The final product size of grinding materials is with narrow particle size distribution and relatively uniform particle shape. Jet milling offers no-contamination products, which is highly required attribute for following utilization of nanoparticles.

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Plasma modification of nanoparticles

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Low temperature plasmas have become a useful tool for surface treatment in many applications. For particle processing it offers a unique possibility of confinement, control and tailoring of their properties. The aim is to tailor particle properties for specific purposes like deposition, etching, cleaning or surface activation. The treatment of nanoparticles and nanofibres is a high challenge because of their agglomeration. For a homogeneous treatment of powder special fluidization methods are necessary. The selection of methods depends on the pressure range, the particle size and the specific material. In addition, the fluidization behavior is influenced by interactions between the walls in the plasma zone of the apparatus and the particles.

Carbon nanofibres (vapour grown carbon fibres, VGCF) can be used as filler in polymers to adjust certain thermal, electrical and mechanical properties. Fibres can be incorporated in polymeric or metallic materials. To ensure these properties a good bonding between fibres and polymer is necessary. Therefore, the surface of the graphitic carbon fibres has to be activated or coated.

For the reinforcement of polymeric materials the carbon nano fibres has to be activated by plasma treatment. At this treatment functional groups like hydroxyl, carbonyl and carboxy groups are covalent bonded on the surface and the surface energy is enhanced. To achieve a homogeneous treatment of VGCF in large enough quantities to prepare polymer-fibre test samples appropriate techniques have to be developed. The plasma treatment was carried out in three reactors in which the fibres were agitated by different means: mechanical vibration (vibrating bed reactor), a gas stream (fluidised bed reactor) and a rotating drum, respectively. The surface energy and surface composition of the fibres were characterised before and after the treatment by contact angle measurement, XPS (X-ray photoelectron spectroscopy) and water contact angle measurement.

Carbon fibres have been used as reinforcement in various metallic matrices. Many applications have been identified for example: heat sink materials, electric contact materials or lightweight materials. To improve the interface between carbon surface and metal matrix fibres have to be coated. The coating process was carried out by magnetron sputter deposition. The fibres were investigated by TEM (transmission electron microscopy) and SEM (scanning electron microscopy).

New technology for applying micro- and nanostructured composite materials

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Tools for the 3D sheet metal forming process in the automotive industry demand highest contour profile accuracy and surface quality in line with high geometrical complexity. The application of new high-strength steels leads to problematic forming conditions due to high mechanical load and an increasing wear. This research work aims to develop a new technology for manufacturing 3D tool surfaces for the novel sheet metal forming processes based on micro- or nanostructured composite coatings with enhanced functional and structural (tailor-made) properties by employing ultra fine and nanosized powders. Low specific weight and high reactivity of ultra fine and nanosized powder materials due to high surface energy require special equipment for the thermal spraying process. Thermico GmbH, Dortmund (Germany) offers two different HVOF (High Velocity Oxygen Fuel) flame spraying techniques that are specially optimized to spray such kind of powders. With the 'Temperature Controlled CJS HVOF-Gun' the operating flame temperature as well as the particle velocity can be precisely controlled so that ultra fine particles with grain size < 10 µm can be employed. Another HVOF technique called 'ID Cool Flow' is designed for the coating of interior parts with internal diameters up to 79 mm. This technique provides low flame temperatures so that an overheating of the substrate can be avoided. Another key problem for applying nanosized powders is the feeding process. Ultra fine powders have great affinity to moisture that leads to fast agglomeration. In order to dry the powder material and to stabilise the feeding process the powder feeder designed by Thermico is equipped with a vacuum pump, a gas-heater and a heating sleeve for the powder hopper. Nanostructured coatings processed by these technologies offer a smooth and a near-net-shape surface. In addition they provide outstanding coating characteristics, such as higher hardness combined with enhanced ductility. Therefore they are not only well-suited to protect forming and machining tools against wear and corrosion, but also offer a great potential for various other industrial applications. Apart from metallurgical properties as described above feeding of ultra fine and nanosized metal-matrix-composite powder materials and corresponding adapted thermal spraying process have to be investigated.

Synthesis and properties of the conductive polymer brushes

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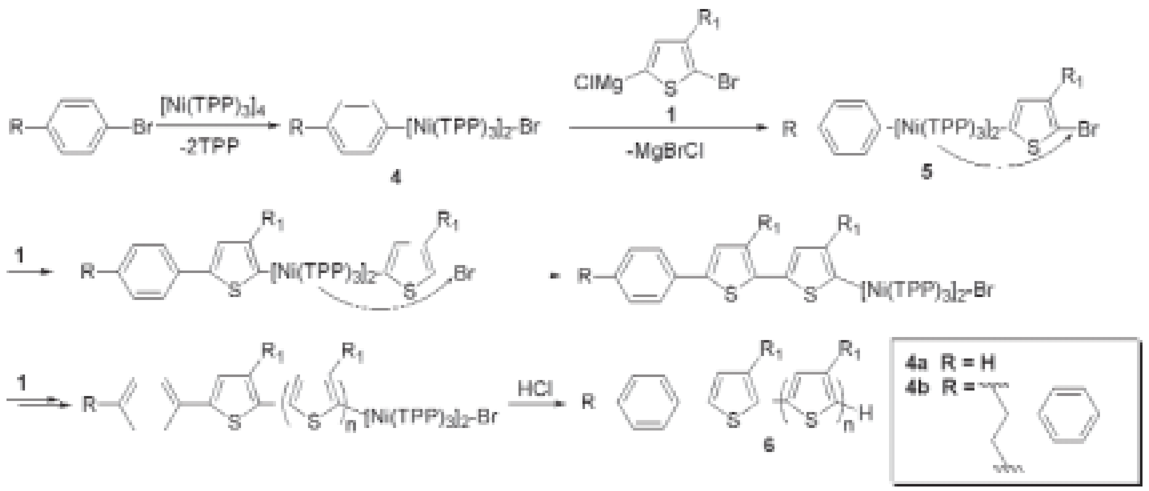
We propose a new approach for growing thin conductive polymer films from various objects via surface-initiated polycondensation. In the first proof-of-concept example we describe grafting of regioregular head-to-tail poly-3-hexylthiophene (HT P3HT) from photo-cross-linked poly-4-bromsterene (PS-Br) films. The process involves catalyst-transfer polycondensation of 2-bromo-5-chloromagnesio-3-hexylthiophene (1) selectively from the sites on the surface where tetrakis(triphenylphosphin)-nickel(0) catalysis (Ni(TPP)4) was covalently immobilized.

Recent development of advanced polymerization techniques, such as surface-initiated and controlled polymerizations, allowing to selectively grow polymers from the desired sites on large-area surfaces or nanoscale particles, or from initiators immobilized on other macromolecules, is one of the most important achievement of modern polymer chemistry. It provides an access to various block copolymers, polymer brushes, "hairy" nanoparticles and other related nanostructured materials, which already applied for fabrication of stimuli-responsive surfaces, drug delivery systems, for control of adhesion, lubrication, etc.

Synthesis of vinyl polymers generally proceeds through an addition polymerization reaction and involves chain growth polymerization mechanism, which itself is easily adaptable for initiating from surfaces and realization of controlled (living) polymerization processes. However, vinyl polymers represent only relatively small and yet not the most functional part of a broad population of polymers. Unfortunately, synthesis of a large number of industrially important (such as polyamides), and really functional polymers (such as polypeptides or electrically and optically active conjugated polymers) involves polycondensation reactions that proceed through a step-growth polymerization mechanism. In this case polymer chains propagate randomly by the coupling of monomers and/or earlier formed oligomeric fragments via abstraction of small molecules. Thus, step-growth polycondensations are hardly applicable for synthesis of both block copolymers and polymer brushes. In a few cases this obstacles was overcame, such as in an elegant process of a ring-opening polycondensation of N-carboxy anhydrides, which gives an access to various polypeptides, block copolymers and corresponding brushes.



Scheme 1. Polycondensation of 1 initiated by low molecular weight or macromolecular initiators.

However, a synthetic toolbox of conjugated polymers is still much more restricted. It is therefore not surprising that despite of obvious promises little is done in the field of conductive polymers brushes (CPBs). Recent discovery of the Ni-catalized chain-growth polycondensation of 1 to regiregular HT P3HT (McCullough, R. D. et al. Macromolecules 2005, 38, 8649; Yokozawa, T. et al. J. Am. Chem. Soc. 2005, 127, 17542.), attracted our attention as a viable opportunity to develop the surface-initiated polycondensation leading to CPBs and other related polymer architectures Thus, the key peculiarity of the mechanism is that it involves selective intramolecular transfer of the Ni-catalyst to the polymer end group, resulting into one-by-one successive addition of monomers to the growing point of the polymer chain instead of usual for polycondensations random coupling of all reactive species.

We aim to develop a complimentary process - a procedure allowing one to grow P3HT selectively from the initiator immobilized onto surfaces, or spherical particles, or macromolecules, giving rise of either flat CPBs, or spherical CPBs, or CP stars or molecular brushes with CP-side chains. Easily available poly(4-bromsterene) was used in this work as the macromolecular initiator and brombenzene (Ph-Br) - as its small-molecule model. The direct coupling of Ni(0) complexes with arylhalogenides, as shown on the Scheme 1, would be one of the most economical route to the crucial organonickel compound 4. Ni(TPP)4 smoothly reacts with various arylhalogenides, including Ph-Br, giving 4 within few hours at room temperature. Unsymmetrical isomer 1, prepared from (7) and t-BuMgCl was used as the monomer. We found that initiator 4 efficiently induces polycondensation of 1 giving P3HT. Resulting P3HT was extensively investigated with NMR, MALDI-TOF, SEC and UV-vis methods (Figure 1).

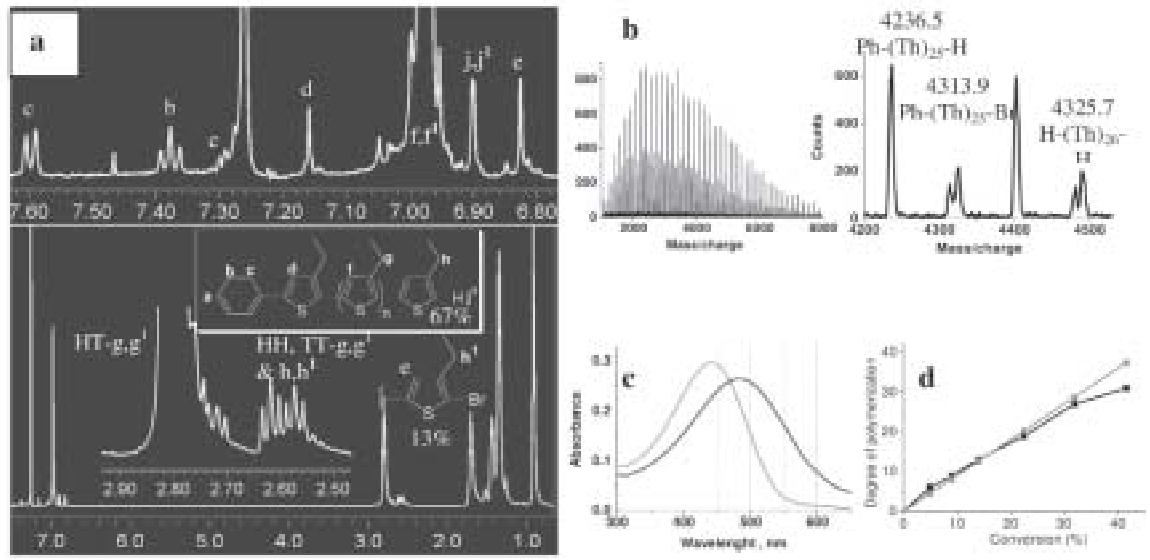


Figure 1. NMR1H (a), MALDI-TOF (b), and UV-vis (c) spectra of the resulting P3HT obtainer through Ni(0)(TPP)$_{4}$2Ph-Br-initiated polycondensation. Polymerization degree versus monomer 1 conversion plot shows near "living" nature of the polycondensation.

Here we will firstly show that the Ni(0)-initiated polycondensation of 1 indeed involves the chain growth mechanism. Undesired termination reactions will be also discussed. Then we will describe preparation of P3HT brushes via surface-initiated polycondensation of 1 from the surface-immobilized macroinitiator. Finally, morphology, optical and electrical properties of the resulting brushes will be presented.

Thermoset nanocomposites for protective coating applications

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The nanocomposites for engineering applications are mainly based on thermoset or thermoplastic polymers, the spectrum of the applied nanofillers becoming constantly wider. However, there are still technological problems hampering the large scale application of these novel materials, mainly related to particle dispersion at nanolevel in the polymer matrix and to the control on interfacial interactions, which are the basic factors for nanocomposite formation.

We have developed nano-reinforced thermosets by the incorporation of diamond (BAS, Bulgaria) and alumina (SASOL, Germany) nanopowders in epoxy and unsaturated polyester resins. As varying the surface treatment by organic modifiers, the state of dispersion and the agglomeration processes of nanofillers in the matrix polymers are controlled, by rheology analysis. This study shows the utility of rheological, physical and mechanical studies in understanding the effects of different nanoparticle reinforcement in thermoset polymer matrices, intended for protective coating applications.

Significant improvement of wear resistance has been found for nanocomposites, strongly dependent on the hardness of the nanoparticles, degree of dispersion and interfacial interactions. At a relatively low volume fraction (0.5–5 vol%), the diamond nanofiller improves the wear resistance of the matrix polyester resin with 11–35%, respectively. Moreover, the effect of diamond and alumina are compared at a given volume fraction of 1.3 vol%, and it was observed that the wear resistance improvement of the epoxy/alumina systems (~ 31%) is higher about 2 times of magnitude than that of the polyester/diamond systems.

Epoxy and polyester nanocomposites with alumina show significant improvement in flexural modulus (about 22% at 1.3 vol% filler) compared to the pure epoxy resin. Moreover, the thermoset nanocomposites with alumina nanofiller treated by targeted organic modifiers demonstrate relatively low values of water absorption. These are strongly related with the attractions of the resin molecules at the large and active nanofiller surface, as well as the high degree of dispersivity.

Importantly, the maximal properties improvements seem to appear around the rheological percolation threshold (~ 3 vol%), which is obviously due to the structural transition from the single floccules towards the three-dimensional network of floccules, formed by nanoparticles in polymer matrix. Wear resistance improvement was related with the physical properties of nanopowders – extreme hardness and good thermal conductivity.
The advantages of the thermoset nanocomposites developed make them an excellent alternative of conventional composites for protective coating applications, providing broad possibilities of improving the existing characteristics as well as of attaining new specific properties. The acquired novel properties are determined not only by the presence of the nanodispersed phase in the polymer matrix but also by the new interfacial phenomena emerging on the boundaries between phases.

Preparation and characterization of vermiculite / TiO_2 composite with photodegradation properties

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Nanosized titanium dioxide (TiO_2, titania) acts as very efficient photocalyst for degradation of environmental pollutants in water and air. Improving the efficiency of photocatalytic reaction is achieved especially with the increasing of the photocatalyst surface area and reducing of its dimension to nanometer-size. The most employed technique for preparation of nanosized TiO_2 is hydrolysis of organotitanates followed by subsequent thermal treatment to obtain photocatalytic active anatase form. Other precursors for nanosized TiO_2 preparation are $TiCl_4$ and $TiOSO_4$.

The utilization of TiO_2 for photodegradation of organic pollutants in waste water requires dispersion of particulate TiO_2 in treated water or utilizes TiO_2 thin film deposited on suitable substrate rinsed in treated water. In the first case the complication with photocatalyst separation after the treatment occur. In the case of thin films, the reduction of contact area cause reduction of TiO_2 photocatalytic efficiency. The immobilization of nanosized TiO_2 on substrate with diameter in the order of tenths to hundred micrometers enable the application of such prepared photocatalyst in form of suspension. The process of water treatment is then easily accomplished by setting or filtering of photocatalyst. Among the possible candidates on this substrates the natural clay minerals fit the requirements pose on catalyst as nontoxicity, easy availability as well as availability of simple procedures of clay/TiO_2 composite preparation.

Layered clay minerals (phyllosilicates) represent an important class of native materials used for wide variety of technical application. Phyllosilicates can be classified on the basis of layer type, layer charge and type of interlayer. In the case of 2:1 phyllosilicate (e.g. vermiculite) one octahedral sheet is inserted between two tetrahedral sheets. Each layer is separated from others by interlayer space. Common phenomena which occurs is octahedral substitution of Al^{3+} cationts by lower valent cations mainly Mg^{2+}. Due to this substitution the layers have negative charge which is compensated by exchangeable cations.

In the present work we focus on the preparation of vermiculite/TiO_2 composite using hydrolysis of titanyl sulphate. Crystalline phases of vermiculite/TiO_2 composite were studied with X-ray diffraction method. The photodegradation ability of prepared samples was tested on Orange II.

Supported nanosystems as fillers for polymers

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The use of nanoparticles in polymers is established for a long time, as soot is used since nearly 100 years. But new particles have entered the market and often are agglomerated and difficult to disperse, so that their full activity can not be evolved in all cases of application. Additional, some ceramic nanoparticles can be hazardous to the environment or the health after they are emitted from the polymer into the air by thermal or mechanical forces.

These problems can be overcome when using supported nanosystems. Here, the nanoparticles homogeneously distributed and fixated on the surface of larger particles, which are not hazardous (Fig.1).

commercial nanoparticles *supported nanoparticles*

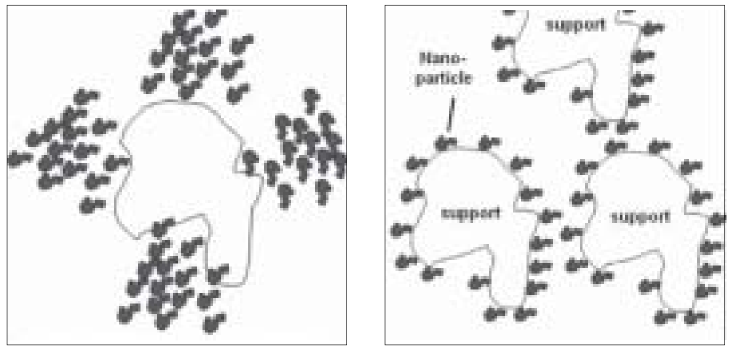

Fig 1: Morphological comparison of commercial and supported nanoparticles

When replacing common zinc oxide in rubber mixtures by such supported systems, here zinc oxide supported on soot, the necessary zinc oxide content can be reduced by 60 weight-percent. Such systems can be easily and cost-effective produced by chemical or mechanical procedures.

Nanostructured matal surfaces by plasma immersion ion implantation

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For bare metal stents the in-stent restenosis was a serious problem for about 25 - 35% of the patients and this spurred the medical device companies to come up with a solution. Drug-eluting stents are designed to deliver a drug locally from a polymeric coating to reduce tissue in growth and reduce restenosis to less then 8% of the treated patients. Development of novel materials and structures for drug delivery systems is still very actual topic.

In the present work plasma immersion ion implantation (PIII) using helium or argon plasmas has been employed for the nanostructures formation on metal surfaces with a view to their applications for metal-based drug-eluting stents. A multi-layer pore system on stent surfaces in the range from nanoscale to microscale sizes is desired for drug loading and controlling the rate of elution of therapeutic agents.

Recently we have investigate the formation of nanostructures on stainless steel surfaces by PIII at different gases (He, Ar), ion energies (between 5 – 35 keV) and ion fluences ($> 10^{18}$ at/cm^2). The surface topography and structure of the implanted materials were analysed by scanning electron microscopy and atomic force microscopy. The phase and element compositions were examined by grazing incidence X-ray diffraction analysis, auger electron spectroscopy, and elastic recoil detection analysis.

Variety of nanostructures as well as their characteristics (e.g. size, distribution, degree of interconnection) can be controlled by varying the implantation parameters. The results of these studies have demonstrated that PIII is a promising technique for the surface topography modification of stainless steel for cardiovascular application.

Nanoscale silicon oxide barrier layers deposited from low pressure plasmas on polypropylene foils for packaging applications

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Presently, high-barrier polymer materials used for food packaging applications mainly consist of a multi-layer structure of different polymers. This kind of multi-layer polymer packaging material provides excellent barrier properties towards the permeation of oxygen or water vapour, for example, but the comparatively high production costs pose an increasing disadvantage to packaging industry. Homopolymeric materials would offer a cost and material saving option, but generally no homo-polymeric material can provide all requirements in regard to barrier properties.

Adding the missing barrier functionalities by low-pressure microwave plasma deposition of nano-scale SiO_x barrier layers on the surface of homo-polymeric materials not only provides an excellent and low-cost alternative to commercially available multi-layer polymer packaging, but also does not affect the recyclability of the polymer material. Moreover, even heat-sensitive polymer materials like polypropylene can be easily functionalised by low-pressure microwave plasmas.

Two different low-pressure microwave plasma sources, a Duo-Plasmaline® type plasma source forming an axially homogeneous plasma and an Electron-Cyclotron-Resonance plasma source, have been applied for the deposition of nanoscale SiO_x barrier layers on polypropylene foil material, using oxygen as working gas and hexamethyldisiloxane (HMDSO) and hexamethyldisilane (HMDSN) as precursors. Subject to the process parameters gas mixture, working pressure and plasma treatment time, different nano-scale SiO_x barrier layers were deposited on the polypropylene foil material. The quality of the SiOx barrier layers with regard to the remaining permeability of oxygen was determined with the carrier-gas method by means of a ceramic (zirconium dioxide) detector, while the morphology and the chemical composition of the barrier surface were characterised by optical light microscopy, scanning electron microscopy, energy dispersive X-ray analysis and Fourier transform infrared spectroscopy measurements, respectively.

The experiments on polypropylene foil material are targeted on the development of SiO_x based nanoscale barrier layers deposited by low-pressure microwave plasmas on 3-dimensional polypropylene packaging for food applications which is much more critical with regard to the homogeneity of the layer thickness.

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Plasma-synthesized self-organized quantum dot arrays for nanodevice applications

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Unique optical and electronic properties of low-dimensional semiconductors such as quantum dots have contributed to a flourish of research interest. Quantum dots are small structures whose sizes (typically 3-60 nm), on the scale of the carrier de Broglie wavelength, produces high levels of spatial confinement for such carriers (electrons), namely quantum-confinement. Quantum confinement of electron motion extends from three to zero dimensions corresponding to bulk semiconductors, quantum wells, wires and dots respectively. The Ge-Si QD system is a nanostructure that has been synthesized using many of the fabrication methods providing a broad field of comparison between the various methods. In this work we investigate the fabrication of zero-dimensional Ge-Si(100) quantum dots (QD) on Si(100) wafer substrate.

A series of numerical experiments made on plasma deposition of Ge-Si Quantum Dots have demonstrated that the self-ordering processes can indeed take place in the plasma-surface systems. We have shown that the arrays deposited from ionized fluxes demonstrate a clear tendency to the organization, due to the effect of electric field on growing QD and subsequent quantum dot movement about substrate surface.

Hybrid Monte Carlo simulation method was used to determine the growth and displacement of germanium quantum dots on Si (100) wafer substrate via plasma enhanced chemical vapor deposition. The plasma method of quantum dot fabrication is shown to exhibit self-organized behavior. Peak quantum dot density was achieved with a total coverage of 0.42 with a population of 400 dots. The final mean radius of the quantum dot ensemble was observed to be 18 nm with the mean radius of ~14 nm representing the value quantum dots were most uniform. Growth rates were found to be higher for small and more isolated quantum dots while retarded for larger closely pack quantum dots, indicating self-organized behavior to achieve uniform size distribution. The non-uniform adatom flux model of quantum dot displacement indicated tendency for quantum dots to migrate into regions of lower population density, with magnitude displacements showing an inverse dependence relation to quantum dot size. Observations qualitatively suggest spatially self-organized behavior.

Molecular modeling in design of dye-clay hybrid nanostructures

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The use of molecular modeling (molecular mechanics and molecular dynamics) will be illustrated on the design of dye-clay hybrid nanostructures prepared for optical applications [1,2]. In the design of nanostructures with photofunctions the structural ordering is the key factor affecting the optical properties. Present work is focused on nanomaterials based on layer silicates intercalated with organic dyes. The main problem in the molecular nanotechnology based on the host-guest interaction is the complementarity of the guest molecules with the host structure. This complementarity is described by a series of factors like: charge distribution on the host matrix and guest molecules, the presence and arrangement of active sites on the host structure, the size and shape of guests [3]. Molecular modeling using empirical force field represents just the right tool allowing a preliminary estimation of the host-guest complementarity and prediction of structure and properties for nanomaterial desing in molecular nanotechnology.

We used molecular modeling in Materials Studio modeling environment combined with X-ray powder diffraction and IR spectroscopy to analyze the structure and to elucidate the structure-properties relationship in nanomaterials based on layer silicates intercalated with organic dyes. Our investigation was focused on fluorescence and on the possible fluorescence tuning by combining various organic dyes with different phyllosilicate matrices. Strategy of modeling including the search for global energy minimum and the test of the force field was worked out, based on all available experimental data (first of all X-ray powder diffraction and IR spectroscopy) [4,5].

Molecular modeling revealed the structure ordering of guest molecules in the interlayer space of clays for a series of dye molecules, helped to find the suitable guest matrix (type of layer silicate), to choose the suitable host-guest combination, the optimum guest concentration, the intercalation conditions, to understand the structure-properties relationship and consequently to correct the technology for the following systems: Rhodamine B, Methylene blue, methyl red-clays intercalated into the structure of various types of phyllosilicates.

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Tuning fluorescence in dye-clay nanocomposites

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Intercalation and surface modification of layer silicates (phyllosilicates) offers the way to nanomaterials with new functionalities and with a wide scale of practical applications. Anchoring of dye molecules on the silicate layer affects strongly their optical properties. This is the challenge for tuning the optical properties via various host-guest combinations [1,2]. Intercalation of dyes into phyllosilicates results in a hybrid organo-inorganic layered structure, where the ordering of guest molecules is affected by a series of general factors describing the host-guest complementarity (for details see [3]). Understanding the relationship between all these factors, structure and fluorescence properties was the aim of the present work focused to the tuning the fluorescence wavelength range using various combinations of the host dye molecule and a type of phyllosilicate matrix. Our strategy is based on the close cooperation between molecular modeling (molecular mechanics and molecular dynamics), experimental analytical methods (X-ray diffraction, IR spectroscopy, fluorescence measurements) and the technology.

Present work summarizes the results of fluorescence study obtained for series of intercalates, where the dye guests were: rhodamine B [4], methylene blue and methyl red. As a host matrix we used: three types of montmorillonite with different total layer charge and vermiculite. Vermiculite and montmorillonite used in our study differ strongly in charge distribution on the silicate host matrix (i.e. with different charge in octahedral and tetrahedral sheets). Results showed that the ordering of guest molecules and fluorescence wavelength range is affected by a series of factors like: layer charge, charge distribution on the silicate layer (i.e. charge on octahedral and tetrahedral sheet), the way of sample preparation (concentration of intercalation solution, repeated saturation etc), the size and shape of the dye guest molecule and their intercalation ability. The shape and position of fluorescence emission band is a result of cooperation of all these factors, where the key role plays the layer charge on the tetrahedral sheet in silicate layers.

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Quantification of nanoparticle releases from surfaces

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In many fields of application nanoparticles are employed to improve the properties of surfaces. Easy-to-clean coatings, corrosion protection and fiber reinforcing are some examples. Unfortunately, particles in this size range are harmful to health if inhaled and deposited in the respiratory tract.

For the resuspension of particles in gas flows, the ratio of the drag force to adhesion force is the determining criterion. Larger particles easily detach from surfaces, but with decreasing particle size the decrease in drag force is larger than the decrease in adhesion force. Furthermore even when using a turbulent airflow, there is a laminar sublayer at the surface, reducing the effective drag force on the particles. Consequently, particles smaller than 10 µm are usually not removed from a surface by air currents. For new nanoparticle-doted products this has to be proven by the manufacturer.

In the presented project, a test device that quantifies nanoparticle releases from surfaces has been developed. It focuses on the particle reentrainment by drag force into an air flow. Furthermore it can be adapted to assess textile samples like gas filters or clean room clothes with regard to particles released from the filter material.

The device consists of a nozzle and a sample carrier which can be moved in two directions. Through the nozzle, a controlled side channel blower draws a flow rate of up to 20 l/min. The nozzle has a diameter of 5 mm. This narrow bore hole is necessary to attain large shear stresses at low flow rates. Therefore, it becomes possible to avoid unacceptably high dilution ratios. The examined sample can have a maximum area of 100 x 100 mm. It can be moved at a feed rate of 0 – 5 mm/s by a stepping motor. A controller enables the coverage of a selectable number of tracks. Consequently, a well-defined scanning of a surface sample can be achieved.

The detection of the released particles is done by Condensation Particle Counter and a light scattering technique. Due to the different detection limits of the particle detectors, a distinction between particles in the nanometer and the submicron range at low concentrations is possible.

Analytical assessment and functionalization of carbon nanotubes and bucky papers

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Since S. Iijima initiated the ever-growing interest in their remarkable properties by his findings in 1991 and 1993, carbon nanotubes (CNT) are meanwhile available as single wall carbon nanotubes (SWNT), double wall carbon nanotubes (DWNT), multi wall carbon nanotubes (MWNT) along with different types of carbon nano fibres. The purification grades depend on the production technique as well as on consecutively performed purification steps such as acid treatment, thermal treatment, etc.

From the powder-like raw material, carbon nanotube sheets –often referred to as bucky papers– can be produced. A prerequisite is the production of a good dispersion of the CNTs in a solvent. Typically an aqueous solution of some surfactant is used in combination with ultrasonic. The filtration of this dispersion through a 0.45 µm pore size membrane enables the manufacturing of CNT-sheets up to a size of 150 mm in diameter.

Carbon nanotubes as well as bucky papers naturally show a hydrophobic behavior. Contact angles of CNT-sheets typically range from 80° to up to 140°, depending on their morphological structure. Radio frequency glow discharge plasma treatment enables the alteration of the chemical composition and therefore the engineering of the wettability from hydrophilic $<10°$ up to superhydrophobic $> 150°$. The first can be obtained by applying oxygen containing monomer gas mixtures whereas superhydrophobic surfaces are achieved by carbofluorine coatings. An optimization of these functionalization can be achieved by variation of the process parameters such as power, gas flux, pressure, duration, and gas composition.

The characterization of the different CNT-types and the produced bucky papers before and after the plasma treatments was accomplished by SEM/EDX, ESCA, RAMAN, BET and contact angle analysis.

An outlook gives possible applications for the produced bucky papers e.g. as actuator in artificial muscles or as substrate for cell adhesion experiments.

Coating of filaments and fabrics with superparamagnetic iron oxide nanoparticles by a sol-gel process

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Superparamagnetic particles increase the strength of an external magnetic field immensly, comparable to ferromagnetic substances but after shutdown of the magnetic field the particles do not show residual-magnetization characterizing paramagnetic particles. The superparamagnetic phenomenon is only observed if the size of the magnetic crystals is below a critical size of, e.g. 25 nm for Fe_3O_4. The superparamagnetic behavior is exhibited by various metal salts based on iron, cobalt and nickel as well as by doped compounds.

Superparamagnetic particles offer a high potential for several applications in areas such as ferrofluids, color imaging, controlled transport of anti-cancer drugs or for the separation of certain bio-molecules from solution.

Another interesting area of application could be the production of flexible materials like filaments or fibres with “switchable” magnetic properties. To achieve this in a sol-gel-process, magnetic iron oxide particles, in this case Fe_3O_4 (magnetite) are produced by aqueous synthesis whereas in a second step the formation of aggregates or agglomerates of these particles must be prevented by stabilizing the particles either electrostaticly or stericly. In a third step, filaments and fabrics must be coated.

Transmission electron microscopy (TEM), X-Ray diffraction (XRD) pattern and magnetic studies with a superconducting quantum interference device (SQUID) magnetometer were used to evaluate the superparamagnetic properties of the coated filaments and fabrics.

Aerogels for industrial applications

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Aerogels are nanostructured highly porous materials. They provide the opportunity of a wide range of possible industrial applications due to their unique optical, thermal and acoustic properties.

The sol-gel-polymerization of a various number of metal alkoxides leads to the formation of highly cross-linked gels. To obtain inorganic aerogels the solvent of the pores has to be removed preserving the gel skeleton under supercritical conditions.
Beside the inorganic aerogels also organic aerogels can be prepared by the polymerization of certain multifunctional organic monomers. The removal of the pore solvent of aerogels formed of formaldehyde and resorcinol can be carried out under ambient conditions depending on the ratios of the reactants and the catalyst.
In addition the synthesis of aerogels based on biopolymers as cellulose has been realized (s. poster presentation), too. The resulting materials have an ultra fine porous structure composed on interconnected colloidal particles (oligomers of $M\text{-}(OH)_n$, $M\text{-}O_n$ particles or polymeric chains) with a typical size of 10nm and a high surface area of up to 2000 m^2/g.

Not only pure aerogels provide an unexpected brilliant quantity of properties also the combination of aerogel with common materials promotes a great number of innovative ultra light composite materials. In each case the convincing properties of the aerogels improve the new high tech materials for industrial applications.

The presentation will give an overview about the already realized innovative industrial applications and in addition will give an outlook to future industrial applications using the innovative aerogel material with its never expected properties.

Transferring nanotechnology applications from the lab to industry

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It has been said many times before: EU scientists are among the world leaders in cutting-edge research and are effective at publishing their results, but when it comes to patenting and commercialising this knowledge, the EU lags far behind its North American and Asian peers. Is this a result of a lack of support or risk-taking, poor vision, or an over-burdensome regulatory and legislative system?

The Institute of Nanotechnology continues to play an active role in the removing barriers to innovation through, for example, its participation in advisory groups to the European Commission, drafting of the vision document for the European Technology Platform on Nanomedicine and establishment of the NanoMicro Club and European Nanotechnology Trade Alliance to support innovation and the growth of small businesses.

This presentation will discuss barriers to innovation, routes to the exploitation of nanotechnology applications, and how initiatives such as the framework programmes, trade associations, networks, and the new European Technology Platforms are starting to redress the balance between the EU and other regions.

Mecanochemical synthesis and characterization of ZnO nanoparticles

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Nanocrystalline zinc oxide (ZnO) powders were synthesized by mechanochemical method. Mechanochemical processing involves the mechanical activation of solid–state displacement reactions at low temperatures in a satellite mile. First, zinc carbonate ($ZnCO_3$) precursor was synthesized via MCP method and ZnO nanoparticles were then made by calcinations of the precursor at different temperatures. Statistical design was used to investigate the effect of main parameters (i.e. milling rate, milling time and different temperature of calcinations) on ZnO particles size and morphology.

The structural properties of the as prepared ZnO nanoparticles were studied in detail using thermogravimetry (TGA), differential thermal analysis (DTA), X-ray diffractometer (XRD), scanning electron microscopy (SEM) and transmission electron microscopy (TEM), respectively. The particle size of ZnO samples calculated from Williamson-Hall method consistent with the TEM images, estimated to be <30 nm and showed hexagonal wurtzite structure.

Carbon nanotube growth from LG

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By combination of two CVD (Chemical Vapor Deposition)-based processes (HFCVD - High Frequency CVD and TCVD-Thermal CVD including a simple annealing process) we have developed a method for carbon nanotubes (CNTs) growth. The resulted CNTs are multiwall CNTs (MWCNT) and have diameter about 30-50nm and several micron length. However, we observed that CNTs grow without annealing process but the process noticeably increases CNTs efficiency production and decreases their diameter. The resulted CNTs have 'bambooshaped' morphology and grown under 'tip-growth' mode. The catalyst deposition system used in this study is a very simple and inexpensive system. Except methane and argon gas other materials used in the process are industrial and not pure. Even though we did not use pure materials the resulted CNTs have good crystallinity and the amount of impurities (such as amorphous carbon, diamond like carbon) are relatively low and we have a good efficiency of the CNTs production. We believe our method of CNTs growth is a very quick, simple and low costly procedure which can be easily commercialized.

Nanospider technology

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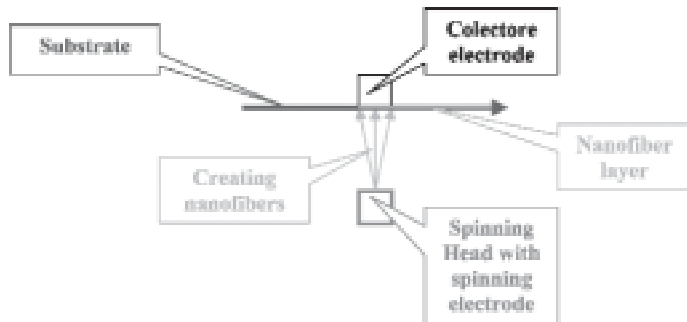
In the 2004 Technical University of Liberec invented prestigious modification of method for preparation of nanofiber layers by electrospinning. In this year our company – Elmarco started cooperation with TUL.

Original idea is based on using cylinder as spinning electrode. By that time the known method used nozzles as spinning electrodes. Nozzles have one disadvantages, which cylinder method has not. These are: low output, low homogenity of layer and complication with maintenance.

Basic scheme of electrospinning for preparation non-woven's nanofiber layers is:



Specialist team in Elmarco brought important knowledge leading to improvement this technology and their transfer to the industrial scale. This team has developed next type of spinning and colector electrodes. It was to find, that solution of polymers it is possible divide by roughly on two basic category:

• Solution based on water
• Solution based on non-water solvents

The solvents have many of important parameters. For example:

• Viscosity
• Conductivity
• Surface pension
• permitivity

etc.

Above all permitivity determinate type of spinning electrodes. The other parameters determinate output, homogenity of nanofiber layers, time stability of polymer solution etc. Today we are able to prepare in industrial scales nanofiber layers of these polymers:

• PA (PA 6, PA 612, PA 66)
• Many types of polyurethanes
• PVAL

In semi-industrial scale we are able to process:

• One natural polymers (gelatine, chitosane, etc.)
• PEO
• Silicones
• PET

Etc.

Industrial scale is for us:

• Output of process polymers: 0,01 – 1 g/min*m
• Output of nanofiber layers: min 3 000 000 m2
• Time work: 16 hours
• Diameters of nanofibers: 50 – 500nm

Preparation and characterization of (WO_3)-$(V_2O_5)_x$ nanostructured films for super-windows applications by pulsed laser deposition

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Modified tungsten oxide films by vanadium oxide provide neutrally coloring electrochromic coatings for super-windows technology. Also Pulsed Laser Deposition (PLD) has excellent pure end products because of direct interaction of laser light with materials. In this study nano-structured W-O-V mixed oxide films were fabricated by Nd:YAG (λ=1064 nm) PLD of mixed pressed powders of (WO_3)-$(V_2O_5)_x$, x=0.1-0.5, at 100 mTorr oxygen partial pressure and 200 °C substrate temperature upon glass sheets. Optical band gaps of deposited films were determined by transmission and reflection spectra of as deposited samples. As the molar ratio of vanadium oxide increases, the optical band gap reduces from 3.55 eV for WO_3 films to 2.5 eV for films prepared from targets with x=0.5. X-ray Photoelectron Spectroscopy (XPS) reviled that vanadium oxide counterparts in the films are V_2O_5 and a lower oxide state in the form of V_6O_{13} or VO_2 while tungsten atoms have WO_3 chemical composition. Scanning Electron Microscope (SEM) images showed that for x=0.1 and 0.2 films have porous nanostructured morphology, while at higher amounts of x, grain size and roughness enhance considerably. The V:W ratio at films determined by WDX and XPS then compared with the targets amounts. For their application as gasochromic windows, palladium nanoclusters as hydrogen catalyst were deposited upon the films surface by electroless deposition of $PdCl_2$ in H_2O-HCl solution. The gasochromic investigation by dilute hydrogen in argon indicated that sample prepared from target with x=0.1 provides the highest of maximum optical density and also faster gasochromic switching in comparison with pure tungsten oxide and also those films which prepared of higher vanadium oxide portions. Our data shows that nanostructured morphology and surface composition play the important roles in the gasochromic switching mechanism.

Keywords: tungsten oxide, vanadium oxide, pulsed laser deposition, gasochromic

Barrier and release properties of thin model HDFD/Ag-plasma polymer nanocomposite films

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Antibacterial properties of silver composite coatings are of increasing interest in medical and household applications. While numerous reports demonstrate the positive antimicrobial properties of silver-based coatings, only little is known about the precise relationship between silver content, silver ion release and toxic effects of silver composite films. For commercial applications it is of high importance to achieve a sustained release of silver and to maximize the longterm stability of composite films during release process.

Thin Heptadecafluoro-1-decene (HDFD) films can be tailored in their chemical composition and barrier properties by means of plasma polymerization. Such films act as a rate-limiting barrier for the silver ions and by this means a sustained release of silver can be achieved.

HDFD/Ag-plasma polymer nanocomposite films were synthesized by combining plasma polymerization of HDFD and electron beam evaporation of silver. The thickness of the silver nanocomposite films was controlled in-situ by means of quartz crystal microbalance during deposition process and determined ex-situ by spectroscopic ellipsometry. The characterization of the nanocomposite films and the study of their stability during the release process were done by means of TEM, XPS and UV-Vis Spectroscopy. In order to determine the barrier properties of the tailored nanocomposite films, electrochemical impedance spectroscopy was carried out. Further, the release of the silver ions from the nanocomposite films was investigated by means of atomic absorption spectroscopy. The performed measurements illustrate the release mechanism of silver nanoparticles embedded in a highly crosslinked perfluorinated matrix and how this leads to an effective release of silver.

Generation of periodic structures in polymer-metal nanocomposites by irradiation with femtosecond laser pulses

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The spontaneous formation of periodic surface gratings or so called 'LIPS' (laser induced periodic structures) due to laser irradiation has been investigated on surfaces of different materials, including semiconductors, metals, and dielectrics. It is generally accepted that the effect originates from interference of the incident laser light with the scattered light near the surface resulting in an intensity modulation on the irradiated material. To the best of our knowledge, up to now, this effect was not used to modify and to arrange metal nanoparticles to ordered structures within a polymer matrix.

The nanocomposite thin films which were taken for the irradiation were produced by plasma polymerization or polymer sputtering and thermal evaporation of noble metals (gold, silver, copper). Due to the serial conduction of the deposition steps, the films possess a multilayer structure, i.e., the metal particle layer is embedded in the polymer matrix. The films were irradiated with linearly polarized fs-laser pulses in a multishot as well as a single shot regime. A mode-locked Ti-sapphire laser with regenerative amplification was used for irradiation. Pulse energies of about 1 to 150 µJ per pulse were applied.

Within certain ranges of laser parameters, line-like periodic structure changes are created. The orientation of the lines is parallel to the laser polarization. The period length is determined by the irradiation wavelength. The laser-treated areas are characterized by longish regions with changes of particle size and shape distribution which alternate periodically with regions without apparent particle changes. The structure formation process contains two major steps: the periodical input of energy (interference) and the mechanism that converts the absorbed energy into a structural modification. We assume that after the ultrafast energy input, thermally driven diffusion processes, like reshapening and coalescence, are induced leading to the modification of the particle sizes and shapes.

Beside a detailed description of the structural changes and the anisotropic optical and electronic film properties, we focus in our contribution on the discussion of the physical mechanism of the periodic structure formation. A series of irradiation experiments were performed to proof the applicableness of the classical LIPS-model to the effect reported here. A verification of different parameter dependences - laser polarization, wavelength, and angle of incidence as well as laser intensity - on the structure formation was made. Further we investigated the temporal development of the periodic structures by irradiating the material with different numbers of laser pulses. Technological applications, e.g. in the field of optics, are conceivable. This method to generate anisotropic metallic nanostructures inside a protecting polymer matrix, with period lengths simply selectable by the irradiation wavelength can be adapted for large-scale fabrication.

Melt electrospinning of poly(propylene) nanofibers

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Electrospinning is an innovative method for nanofibers production. Nanofibers produced by this method can be introduced into several applications. For example they can be used for textiles, for filtration and for bioengineering applications. Two methods of electrospinning are well known: solution and melt electrospinning. With melt electrospinning, the usage of toxic solvents can be avoided, which gives this method a strong advantage for some applications in comparison to solution electrospinning. Furthermore, melt electrospinning is the best method of choice for polymers that do not have proper solvents at room temperature like poly(propylene), poly(ethylene) and polyesters.

Several attempts were done to obtain fine poly(propylene) fibers by melt electrospinning; however, to achieve the nanometer scale with high yield of nanofibers remained a big challenge. In this research, different poly(propylene)s with varying molecular weights were melt electrospun in an attempt to produce poly(propylene) fibers with very small diameters (nanofibers). The effect of additives as well as the effect of mixing small and large molecular weight poly(propylene)s on the fineness and properties of the produced fibers was studied.

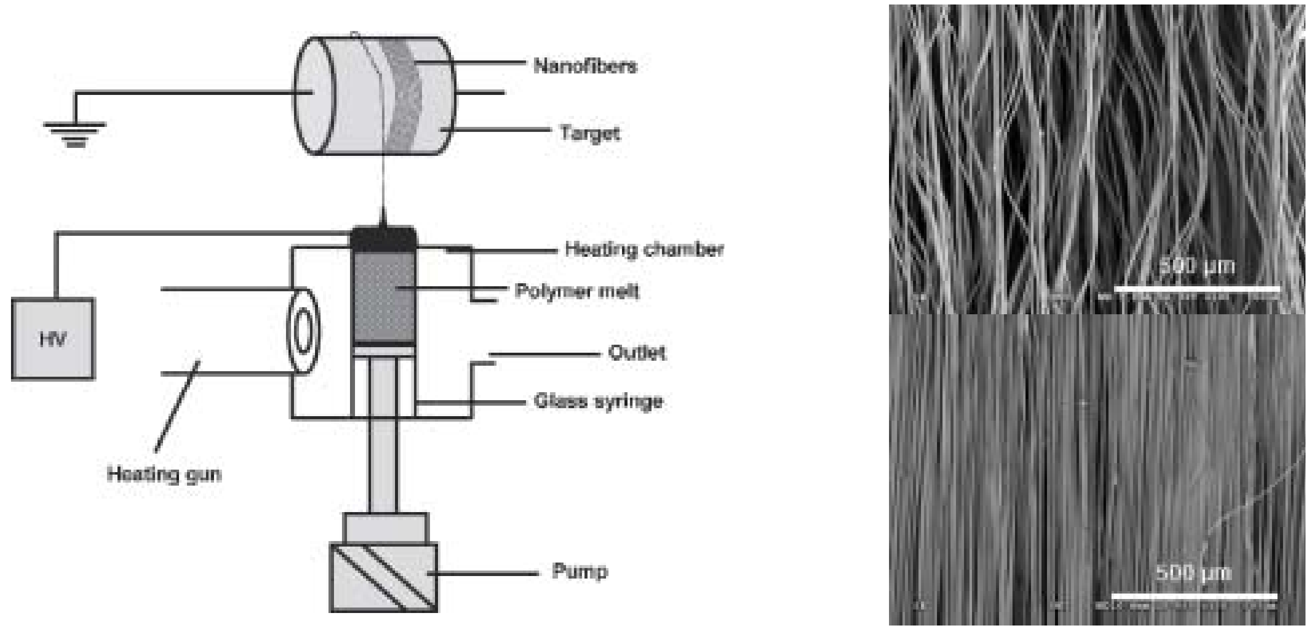

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Figure 1: A) Schematic illustration of the setup of the melt electrospinning device.
B) Scanning electron microscopical images of poly(propylene) fibers produced by melt electrospinning.

Capacoat® Antiscratch lacquers

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Highly scratch resistant coatings can be produced by incorporation of inorganic nanomaterials in organic matrices. The adsorptive particle organophilation (APO) allows the preparation of stable nanodispersions in organic media without formation of volatile or harmful by-products.

UV/EB curable Capacoat® Antiscratch lacquers with an inorganic filler content of 25-30% are produced using the adsorptive process.

The lacquers show a considerable reinforcement of the organic matrix can be applied by common techniques (rolling, spraying, etc.).

Capacoat® Antiscratch lacquers are solvent-free and combine superior coating performance. Simple applicability and rapid UV/EB curing.

Efficient solar energy conversion using TiO_2 nanotubes

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In 1991 O'Regan and Grätzel reported on highly efficient TiO_2 based solar cells based on the principle of the dye-sensitization [1]. Since then many attempts have been made to improve the solar energy conversion efficiency using different substrates of TiO_2 such as e.g. synthetic or natural single crystals, nanoparticulate or nanoporous films. A nanoscale morphology is typically preferred as it provides a high surface area for dye attachment which is crucial for high photocurrent conversion efficiencies.

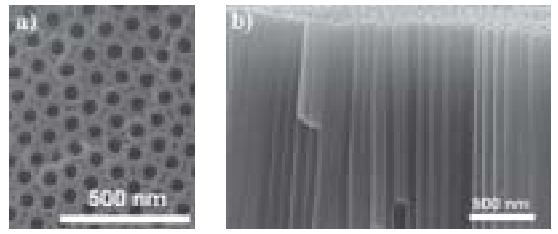

Fig.1: SEM top view on TiO_2 nanotube array a) cross-section b) and HRes-TEM of single crystalline tube wall.

In the present project, we replace the nanoparticulate TiO_2 structure by vertically aligned TiO_2 nanotubes (Fig. 1). This eliminates grain boundaries and is thus expected to lead to a significantly enhanced solar energy conversion efficiency. An example for a dye sensitized solar cell based on nanotubular TiO_2 structures is shown in Fig. 2. One approach for nanotube production is based on the self-organized growth of highly ordered TiO_2 nanotube layers by optimized electrochemical anodisation of titanium surfaces. Electrochemical anodisation of titanium under well defined, optimized conditions is a straight-forward way to produce self-organized TiO_2 nanotube layers in a parallel processing approach which has been recently reported [2-6].

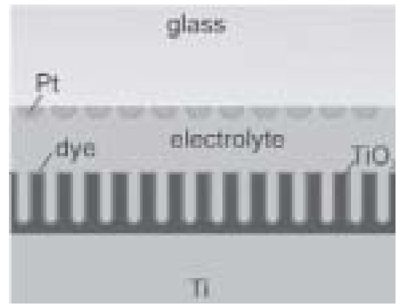

Fig.2: Schematic drawing of TiO_2 nanotube based dye-sensitized solar cell.

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The effect of temperature and strain rate of hot compression test on nano-precipitation in interstital free steels

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In the present work hot compression tests of interstitial free steels were carried out with different strain rates and temperatures. The work hardening in the sample compressed is high and as a result there are more appropriate sites for precipitate nucleation, which can be related to the increase in the density of defects and high energy sites. Thus, there are more appropriate sites for precipitate nucleation and as a result of distribution of precipitates; dwindling in size of the precipitates to the extent of nano sizes can be expected. Furthermore, decreasing in the size of precipitates to nano and adjustment with the field causes the hardness of the sample compressed to be higher than the casted steel. Besides, the amount of Ti used to stabilize the IF steel was more than the stoichiometry amount. With increasing the amount of Ti, stacking fault energy decreases and consequently it results in decreasing dynamic recrystallization. Dynamic recrystallization is retarded by dynamic precipitation and vice versa. To make dynamic precipitation overcome dynamic recrystallization, thermomechanical factors should be controlled so that the formed precipitates affect the dynamic recrystallization and prevents it from happening; therefore the strength and ductility increase. Investigating the structures by the means of SEM and AFM showed that tests achieved with an optimum temperature and strain rate contain precipitates in nano sizes. In other cases the size of the precipitates were increased and dynamic recrystallization could be observed. The micro hardness tests of the sample with nanosize showed an obvious increase in hardness compared with the casted steel.

Influence of filler particle size on the conductivity and permittivity of metal-polymer composites

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The behaviour of the conductivity σ and static permittivity ε of metal-polymer composites comprising Ni particles dispersed in the phenilon was studied. It is found that the percolation-like behaviour of σ and ε, which is observed when the Ni particles are the sizes of 1-3 μm (high-dispersed particles), gave way to another behaviour characterized by an additional contribution to σ and ε below the percolation threshold when the Ni particles are the sizes of ≤ 30 nm (nanoparticles). It is shown that this peculiarity of the behaviour of σ and ε of the composites is in agreement with the network hierarchy model of composites, which was proposed recently by Balberg et al.

Keywords: Conductivity; permittivity; metal-polymer composites; nanoparticles

Nanometallization of the surface of microgranules

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The interest in nanoparticles of different compositions has been growing rapidly during last years due to their unique physical characteristics that are very different from the properties of the corresponding solid materials. Extremely high chemical reactivity of nanoparticles along with their ability to spontaneously compact with loss of the properties mentioned above make the task of nanoparticles stabilization very important.

In this report, microgranules of polytetrafluoroethylene, SiO_2, and nanodiamonds were used for stabilization of nanoparticles.

A versatile method for introducing metal-containing nanoparticles onto the surface of microgranules has been developed, which allows fabrication of large amounts (kilogram-scale) of polymer nanoparticle composites. The encapsulation was done via thermal decomposition of metalcontaining compounds (MRn; M = Mo, Co, Ni, etc.; R = CH_3COO, HCOO, C_2O_4, etc.) in a dispersion system of microgranules on the surface of mineral oil. The optimum conditions were developed for decomposition of MCC in order to introduce highly reactive nanoparticles into the polymeric matrix with the concentrations of 2-60 wt. %.

Our experiments demonstrated that we were able to stabilize and characterize nanoparticles of various compositions using microgranules of polytetrafluoroethylene, diamonds, and SiO_2. The matrix, on which nanoparticles are synthesized, plays an active role in determining their composition and physical properties in addition to providing means for particle dispersion. This research demonstrates the significant potential of MCC thermodestruction processing for synthesis of appreciable quantity of nanoparticles in the volume or on the surface of matrixes.

Magnetic properties of the nanoparticles obtained by means of these methods have been studied.

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Effect of irradiation on intercalation strengthening of MWNTs and CNTs composites

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Many experiments show that application of carbon nanotube in composite does not improve strength very much. That is because that the load transfer between layers in Multiwall Carbon Nanotubes (MWNTs) and between MWNTs and matrix is very weak in tensile load. We increase the load transfer performance of MWNTs in tension by ion irradiation; hence increase the overall stiffness of MWNTs. Also the most reactive vacancies created by irradiation in MWNTs can help form the chemical bonds between CNTs and matrix in composites. Using ion irradiation on CNTs composites directly, more chemical attachments form between carbon nanotube and matrix in composite, hence the overall stiffness of composite is increased greatly.

Core/shell nanoparticles for scratch resistant polyurethane coatings

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Today, coatings manufacturers have to face customer expectations, which are not in every case realizable with conventional polymer chemistry. In the past it could be shown, that inorganic nanoparticles, e.g. in UV-curing coatings, can lead to significant improvements of scratch resistance. The transfer of these encouraging results to polyurethane coatings however was not always possible due to a lack of available reactive nanoparticle dispersions in suitable solvents and due to compatibility problems.

A new approach to solve these existing problems are core/shell particles, consisting of an inorganic core and a shell of organic polymer.

These particles can be synthesized as almost transparent dispersions in common solvents like MPA, butylacetate or benzene up to solid contents of 80 weight% and can be formulated with a variety of polyols and isocyanates to yield haze-free glossy coatings, even on deep black surfaces.

The widespread 'hammer wire-wool' test and the Daimler/Chrysler crockmetertest show that the scratch resistance of OEM series clearcoats can be significantly increased and that spot repair coatings can achieve the scratch resistance of coatings which were cured under OEM conditions.

Production of ZnSe nanowires for chemical sensors applications

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This work reports a simple route for vapor phase synthesis of ZnSe nanowires on GaAs substrate mounted in PC-controlled horizontal cylindrical quartz reactor with three axial channels for the vaporization of source materials. The key approach in this synthesis is a shock supply of strong supersaturated ZnSe vapor into the relatively cool reactor's zone just before the substrate. In this case the synthesis occurs in extremely nonequilibrium conditions, which yield samples with nanowires shown in Figure.

The samples quality was assessed by SEM, X-ray diffraction and photoluminescence techniques.

Due to a large surface-to-volume ratio, the surface conductivity of the grown samples exhibit superior sensitivity (at room temperature) to surface chemical processes particularly to chemisorption of hazardous industrial gases (such as CO, H_2, H_2S, CH_4, etc.) At the same time the samples under investigation can be easily refreshed either thermally or via UV illumination. So, with the appropriate design they have a great potential to be manufactured into commercial sensors.

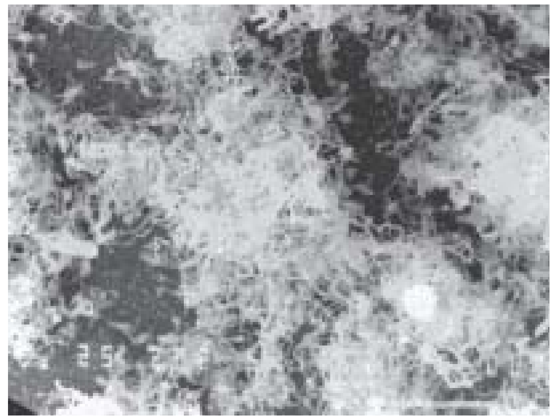

Figure. Electron microscopy image of ZnSe nanowires on the surface of GaAs.

Structure formation of carbon nanoparticles in polymer material

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Recent ways of regulation of electric and heat conductivity of polymer materials are based on introduction of nanodispersed fillers into composition. In particular, carbon containing components found an application for attainment of electric and heat conductivity of the polymer materials. Structure formation and generation of continuous clusters penetrating into the bulk takes place due to introduction of the carbon nanoparticles into the polymer binding agent. Electric and heat conductivity increases along with substantial increase of viscous properties of the composition. In spite of the lower electric conductivity of the carbon materials compared to metals, they have a pronounced ability to form chain clusters. This allows to obtain polymer materials with an electric conductivity comparable to that of metal-filled materials at relatively low filling degrees.

Main processing factors, influencing the formation of continuous arrangement of carbon nanoparticles in the polymer matrix, have been studied in the context of this work. Temperature, volume filling, shear rate, time of structure formation as well as the influence of medium viscosity on the processes of structure formation of nanocarbon filler are among these factors. Experimental studies of structure formation of the superfine components in the polymer medium were carried out using rotary viscometer Rheotest RN4.1 and retrofited rheoconductometric installation based on viscosimeter Reotest 2.1 for determination of electric conductivity of the composition.

Electric conductivity of the composition was shown to be the main parameter used for determination of initiation of nanocarbon continuous structures. Initiation of electric current, passing through the composition, indicates the structure of carbon in the composition to be continuous and the structure elements to be commensurable to the distance between electrodes and cylinders of the viscosimeter. It was determined, that the current increases proportionally with the increase of the number of carbon nanoparticle chains per volume unit. Formation of the cluster structures in the polymer nanomaterials was confirmed by visual image obtained using optical microscope Olimpus. The results obtained make possible creation of polymer materials with electric conductivity of $(1 \div 20)\cdot 10^{-6}$ cm/m and increased value of heat conductivity.

The work was carried out at financial support of Russian fund of fundamental research (grant no. 05-03-08005-ofi_p, grant no. 06-03-32551a and grant no. 07-03-00050a).

Tailored functional properties of Ag-nanoparticles in thin TiO_2-films

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Silver nanoparticles embedded in TiO_2-films have received increasing attention in recent years due to their high potential for applications in the fields of solar energy conversion, photocatalysis, chemical and biological sensing, antibacterial coatings and unique optical components. The special optical properties are mainly based on surface-enhanced Raman scattering, localized surface plasmon resonance, and metal-enhanced fluorescence. Especially the structure, size, shape and arrangement of the embedded nanoparticles play an essential role in tailoring the functional properties of such nanocomposite coatings.

In the present study Ag-TiO_2 nanocomposite films were prepared by means of RF-magnetron sputtering and subsequent annealing. The structural, chemical and optical properties of the deposited films have been characterized by means of SEM, UV-Vis Spectroscopy, XRD, Raman Spectroscopy, XPS and X-Ray Absorption Spectroscopy for different film structures like Ag nanoparticles on top of TiO_2 layers or Ag nanoparticles embedded in TiO_2 as intermediate layers. The influence of the deposition parameters on the structure of the nanocomposite film and on its optical properties was investigated.
A controlled modulation of Ag content and particle size, shape and distribution in a TiO_2 dielectric film matrix could be obtained as a function of the applied RF-power, total pressure, annealing temperature and deposition time.

In order to achieve a detailed microscopic understanding of kinetic mechanisms in such heterogeneous photoelectrocatalytic nanocomposite films, in-situ electrochemical Surface-enhanced Raman Spectroscopy was used to study the adsorption behavior of carboxylate species (COO^-) on adsorption sites of the nanocomposite film and the interaction between semiconductor and metal under external electric field. The results will be linked to the further applications like dye photosensitization in solar cells.

Recent developments in the use of nanoparticles for fire protective coatings

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Intumescent coatings are very effective in terms of protecting substrates in case of a fire. Intumescence is defined as the swelling of substances when they are heated. By the impact of heat these coatings swells up and build an insolative foam. Because of some drawbacks at the coating properties the commercial use is limited.

This poster describes the effects of the use of nanoparticles on the properties of intumescent coatings. The main emphasis is put on the processing of nanoparticle, the coating properties and the effects at the fire protective properties of the nanoparticles containing materials.

In a cooperative research project researcher from Fraunhofer Institute for Chemical Technology (ICT), Fraunhofer Institute for Wood Research (WKI), Technical University of Braunschweig, Institute for Fire Safety (iBMB), Byk-Chemie GmbH Sachtleben Chemie GmbH und DuPont Performance Coating develop and optimise a new high-performance fireproof coating based on nanoparticle additives.

This new technology will probably lead to better intumescent coatings so that these systems become as commercially successful as they should be.

Prediction of material properties in CNT-polymer composites

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In recent years, development of carbon nanotubes (CNT) for industrial applications has grown rapidly due to their unique material properties. Addition of low levels of carbon nanotubes into other materials like polymers can enhance material properties considerably, especially electrical and thermal conductivity, mechanical strength as well as structural properties. Today, first CNT-polymer composites are commercially available on the market.

A major restraint in a broad market acceptance of the new technology are the wide variations in electrical conductivity and other material properties of the finished plastic products as function of the matrix polymer used and the processing conditions. In addition, broader property variations are also visible within the plastics part itself.

Starting from existing models for filler kinetics in polymers, from the percolation theory, and from knowledge on molecular interactions between polymer chains and CNT a complete model for the formation of the percolation network from carbon nanotubes in polymer melts and reactive blends during processing and solidification shall be derived. By combining this model with commercially available tools for the design of plastic parts (including FEM) and semi-finished products shall allow production of plastic parts with reproducible electrical conductivity and mechanical properties.

This project has been approved for financial support by BMBF within the program 'virtual material development'. The work program has started January 1st, 2007 and shall be finished by December 31st, 2009. Project partners involved are Technical University Darmstadt, Leibniz Institute for Polymer Research in Dresden, and German Plastics Institute in Darmstadt from science, and from industry Siemens AG, Coperion Werner & Pfleiderer GmbH, Bayer Technology Services GmbH, and Bayer MaterialScience AG.

Polymer-carbon nanotube composites with tunable conductivity for electrostatic powder painting applications

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During the last decade composites of carbon nanotubes (CNT) with polymers have gained big attention for industrial applications. One possible field is in automotive constructions. Next to enhancement in mechanical properties due to the inclusion of high modulus and strength fibrous fillers, also electrical properties can be adjusted by the addition of CNT. Thereby, next to structure and properties of the embedded carbon nanotubes the melt processing conditions strongly determine the formation of a percolated network of nanotubes within the insulating polymer matrix and thus, influence the materials electrical conductivity. When using such composites i.e. for automotive outdoor parts, as it is a present development direction, the electrical surface properties are important for their electrostatic painting behaviour.

It is the task of this study to evaluate the influence of injection moulding conditions on the electrical surface resistivity of test plates (80x80x2mm^3). For these investigations, polymer composites based on polycarbonate with 2 and 5 wt% multiwalled carbon nanotubes (MWNT) were chosen. A homogeneous dispersion of the nanotubes within the matrix polymer was obtained using a masterbatch dilution technique starting from a masterbatch with 15 wt% MWNT (Hyperion Cat. Inc., USA). Injection moulding was done using a two-levels four-factors factorial design after evaluating the four most important influencing factors. Electrical resistivity was measured on the sample surface using integral and location resolved methods.

The results indicate that the surface resistivity vary in a broad range depending on the injection moulding parameters selected. For 2 wt% composites, only for four combinations significantly reduced resistivity values in the range of 10^7 Ohm/square were found, whereas most parameter combinations did not lead to the formation of a percolated nanotube network within the sample geometry. For 5 wt% MWNT composites, the values varied between 10^5 and 10^{11} Ohm/square depending on the parameter combination. The injection moulding parameters having the highest impact could be extracted and were shown to be the same for both compositions. Thus, choice of injection moulding conditions enables a fine tuning of surface resistivity.

For selected samples, electrostatic painting experiments using a weather-resisting low temperature curing powder coating based on a polyester resin and uretdione crosslinkers, were performed. It could be shown that the composites having resistivities in the range of 10^7 Ohm/square showed excellent paintability and adhesion properties of the paint layer. For the 2 wt% samples, the resistivity values were found to vary at different location within the sample plates resulting in local inhomogenities of electrostatical paintability and film thickness as well.

In summary, the use of MWNT containing composites realises a permanent surface conductivity so that additional treatments of plastic compounds before the electrostatic coating procedure can be saved. Thus, this is a promising way.

Carbon nanotubes / polyamide composites

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Composites of carbon nanotubes (CNT) and polymers are potential candidates for applications in automotive constructions. Next to enhancement in mechanical properties due to the inclusion of high modulus and strength fibrous fillers also electrical properties can be adjusted by the addition of carbon nanotubes with defined electrical conductivity. Thereby structure and properties of the embedded carbon nanotubes strongly determine the electrical conductivity of the composite material. One possible application is the use for electrostatic painting of automotive outdoor parts.

Different mixtures of single-, double-, and multi-walled carbon nanotubes were synthesised by chemical vapour deposition (CVD) and embedded in polyamide 6.6. Based on a structural characterisation of the 3 different types of carbon nanotubes their dispersion and percolation behaviour in the polyamide 6.6 composites was investigated.

It was found that the usage of catalyst material with different concentration of iron (Fe) by the synthesis of carbon nanotubes influences the carbon nanotube-diameter and carbon nanotube-shell structure. A high content of iron leads to a high part of multi-walled carbon nanotubes. If the catalyst material include a medium concentration of iron than a mixture of multi-walled and single-/double-walled carbon nanotubes is synthesised. The synthesis with a low content of iron generates mainly single-/ double-walled carbon nanotubes.

The influence of carbon nanotubes characteristics on percolation behaviour was investigated using a polyamide 6.6 matrix. Composites containing between 1 and 5 wt% CNT were produced by melt mixing in a micro compounder (DACA Instruments, USA) at 280°C. The extruded strands were pressed into plates of 0.35 mm thickness and electrical resistivity was measured using a 4-point test fixture and Keithley electrometers.

It could be shown that the CNT material characteristics significantly influences the electrical percolation behaviour and achievable conductivity values. The mixture of multi-walled carbon nanotubes and single-/double-walled carbon nanotubes leads to the lowest concentration of electrical percolation, which was found between 1 and 1.5 wt%. At higher concentrations, the composite with single-/double-walled carbon nanotubes showed the lowest volume resistivity, as low as 10^3 Ohm cm.

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Photo-catalytic coating of textiles with nanoparticulated anatase

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One of the outstanding features of titanium dioxide in form of anatas, are its photosemiconducting properties. Due to its oxidizing and reducing potential and the environmentally and toxically harmlessness titanium dioxide can be selectively used in photo-catalytic purification processes as an ingredient of surface coatings for the degradation of organic compounds, reduction or elimination of polluted, volatile or annoying compounds on the surfaces or of the indoor air. Our work focuses on finishing of textile surfaces with nano-sized titanium dioxide particles.

In order to protect the textile against oxidation during the photo-catalytic reaction the surface can be pre-coated with an ultrathin layer, e.g. of an inorganic-organic hybridpolymer, by means of sol-gel process. The sols can be applied on the textile by spraying, dipping or other conventional textile coating procedures. The presence of the appropriate functional groups of the finishing layer on the fabric surface supports immobilisation of nano-particles. The photo-catalytic activity of titanium dioxide particles deposited in-situ or directly on the previously prepared textile is compared and examined. The best possible cleaning and deodorization effect should be combined with the adhesion strength of the deposited particles, their crystal structure, size distribution and porosity.

Controlling Mesoscopic Phase Separation ('CoMePhS')

FP6 STREP project No. 517039

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Abstract
In chemically homogeneous manganites one can achieve phase coexistence (exotic magnetic, electronic and crystal structures that coexist at different locations in the same crystal) by tuning a wide range of parameters: sample chemical composition or microstructure, electric or magnetic field, strain, electromagnetic radiation etc. The coexisting phases may form robust magnetic, electronic and crystallographic textures of 'mesoscopic' length scales – i.e. over tens or hundreds of nanometers. By controlling an array of textured phases analogous to those in liquid crystals, CoMePhS aims to control locally the electronic structure and properties without atomic-scale fabrication. The long-term goal of the research is to provide basis for a new set of electronic technology based on the manipulation of soft electronic matter.

Summary
Highlights of scientific results of the first 18-month progress report:
1. CoMePhS has demonstrated the feasibility of using epitaxial strain as a tool to manipulate the electronic systems of manganites. Other manipulation routes: high hydrostatic pressure, magnetic field, and X-ray illumination.
2. Scanning Tunnelling Microscopy and Spectroscopy provide an atomic-resolution basis for the control of mesoscopic effects. Also used: electron holography, magnetic force microscopy, and conducting atomic force microscopy. State-of the-art scan-probe instruments image and manipulate the mesoscopic phase separation in a variety of materials. A spectacular library of images of inhomogeneous electronic states is under construction.
3. Besides manganites CoMePhS investigates a series of related compounds for which there is also strong evidence for electronic phase separation, such as the cuprates, vanadates, dibori-des, or organic compounds. All these compounds have been prepared and characterized by various techniques in order to identify regions of electronic phase separation and defect structures that can be exploitable.
4. The experimental effort is supported by a significant theoretical activity.

More info and contact details: www.comephs.com

Using friction cladding for improvement of surface with nanocomposite coatings

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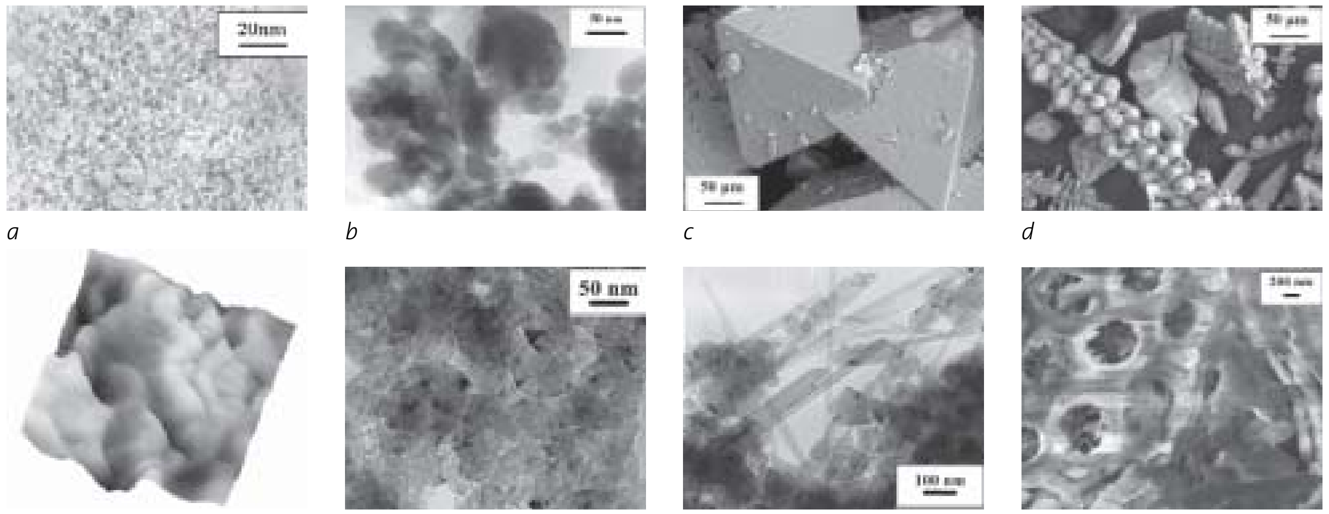
Abstract
Nanocomposites (composites with metal matrix and nano-reinforcements) are perspective materials for coatings because, from the one hand, nano-level of particle size allows obtaining uniform distribution of reinforcements inside thin layer of coating and, from another hand, addition of different reinforcements allows achieving various properties of coatings (for example, big or small friction coefficient, various corrosion resistance etc.). The paper is about development of new method of deposition of nanocomposite coatings by friction cladding.

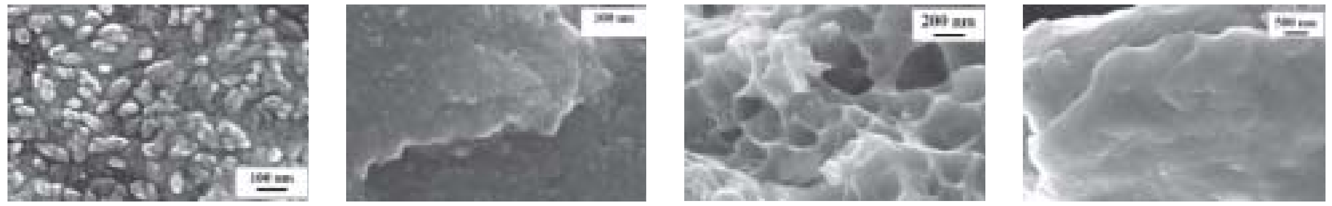
Method of nanocomposite fabrication
Method of nanocomposite fabrication is based on mechanical alloying of components mixture and compaction of obtained nanocomposite granules. Composite materials were produced by mechanical alloying in a planetary mill, in which drums with quasicylindrical milling bodies were mounted. Copper was selected as matrix material. Nanodiamonds, nanosilica, diatomite or boron hydrides were used as reinforcing particles (Fig.1). Size of single particle of nanodiamond equals 5 nm, nanosilica – 30 nm, but agglomerates of these nanoparticles have size up to tens microns. It seems that boron hydride particle has size more than 100 µm, but investigation of structure with Nanoscan scanning probe microscope-nanoindenter and transmission electron microscope shows that this big particle consists from nanosized units, sometimes – from nanotubes. Diatomite particle is plate with thickness of 100-300 nm.

Surface morphology of obtained granules is depended from kind of reinforcements and technological conditions of mechanical alloying (fig.2), for example, after 30 min treatment in planetary mill nanodiamonds agglomerates are practically separated, but nanodiamonds are located on granule surface (fig 2 a). And only after 2 h milling (fig.2 b) it is possible to obtain uniform distribution of nanoparticles inside copper matrix. Surface morphology influences on technological conditions of granules compaction, for example, consolidation of granules with diatomite (fig.2 c) is easer than granules with boron hydrides (fig.2 d). Main method of compaction for this study was cold and warm pressurizing with subsequent thermal treatment in protective atmosphere.



a b c d
e (scanning area 4,9•4,9•0,3 µm) f g h

Figure 1: Reinforcements: a) nanodiamonds, b) nanosilica, c, d, e, f, g) boron hydrides, h) diatomite

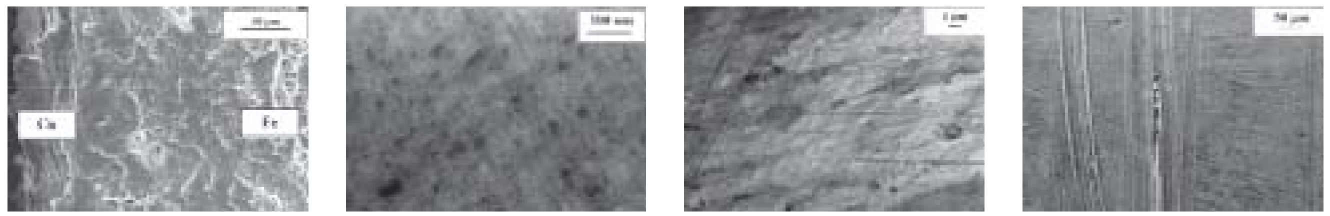


a b c d

Figure 2: Surfaces of granules of composites with various reinforcements: a, b) nanodiamonds (a-after treatment in planetary mill during t=0,5 h, b- t=2 h); c) diatomite; d) boron hydride

Method of coating deposition
Friction cladding was selected as method of coating deposition [1]. It is performed as follow. The coating material is a rod or similar item. The main tool is a rotating cylindrical metal brush. The brush rotates with a high speed and is pressed to the processed surface. A rod with the coating material is pressed to the brush at a nearby point. By the ends of its wires, the brush scrapes metal particles fractions of a micron in size off the rod and transfers them onto the treated surface. The high speed of rotation of the brush leads to a considerable strength of impact of a particle on the surface; the particle welds to the treated surface. A large number of wires in the brush and a high speed of rotation provide for a high performance and uniform transfer of the material of the rod onto the treated surface.

Developed nanocomposites were deposited on steel cylindrical parts by friction cladding. The coatings were studied by scanning electron microscopy. The micrographs obtained confirm the high quality of the coatings (Fig. 3). The coating tightly adheres to the base (fig.3a). Reinforcing nanoparticles are distributed uniformly inside copper matrix; no agglomerates (fig.3b). Variation of friction cladding technological conditions (speed of brush rotation and moving, shape of brush, length of wires, level of pressing etc.) allows obtaining different relief of surface: smooth (fig. 3c) or with various scratches (fig.3d). Sometimes it is necessary to produce such scratches for keeping lubricants on surface of parts.



a b c d

Figure 3: Developed copper nanocomposite coatings: a) fracture in cross direction; b) cross section of nanocomposite produced by ion beam; c, d) planar view of coatings produced under various technological conditions

Conclusion
The investigation has shown that friction cladding allows fabricating high-quality coatings from copper nanocomposites reinforces by various nanoparticles.

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Synthesis and characterisation of nanofibrillar cellulose aerogels

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On the basis of nanofibrillar cellulose fibres linked to a network ultra light, organic aero- and cryogels are produced. Colloidal cellulose dissolved in calciumthiocyanate was gelled, aged and dried supercritically and by freeze drying. The influence of the drying procedure on the porous matrix is examined. The density of cellulose aerogels is in the range between 10-60 kg/m^3 with a surface area of 200-220 m^2/g contrary to cellulose cryogels which show strong tearing in their shape, induced by the lamellar-structure of the ice-crystals, with a maximum surface area of 160 m^2/g. By pyrolysis it is possible to produce carbon aerogels. Sputtered cellulose aero- and cryogels as well as conductive carbon aerogels are examined with a scanning electron microscope.

In addition to these, the gels produced from cellulose can be spinned and threads of aerogels produced, which offer new innovative possibilities.

Composite powders with bactericidal properties

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The antimicrobial properties of silver have been known for several thousand years. The silver colloids and silver nanopowders are of a great interest due to their large specific surface that leads to a high bactericidal activity.

The practical applications of these particles are limited by the lack of a reproducible method that would allow the control of the grain size and dispersion. This disadvantage may be avoided by deposition of nanosilver particles on some solid supports in form of films or by deposition on powder particles in order to obtain some core-shell composite powders.

The present paper is related to the obtaining and characterization of some composite powders consisting of nanosilver – doped ZnO and TiO_2 powders with bactericidal properties. The chemical and photochemical formation of the nanosilver particles on the ZnO and TiO_2 was investigated. The initial concentration of the solutions, temperature, stirring, purity of water and reactants are critical parameters. The deposition of nanosilver particles from $AgNO_3$ solutions on the oxide powders surface was proved by RDX, SEM and UV-VIS spectrophotometer analysis. The obtained composite powders present a high antibacterial effectiveness against S. aureus, P. aeruginosa, E. Coli and Acinetobacterand and a high antifungal effectiveness against Aspergillus niger, Aspergillus fumigatus, Aspergillus flavus, Aspergilus versicolor, Paecilomyces varioti, Aspergillus terreus, Aureobasidium pullulans, Penicilium glaucum, Penicillium citricum, Stachybotris atra, Tricoderma viride and Scopulariopsis brevicaulis. The bactericidal effectiveness was proved by the determination of the minimum inhibitory concentration (MIC).

Reduction of crystalline biofilm formation on medical implants by amorphous carbon coatings

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Any catheter material placed in the urinary or biliary tract provides a surface for bacterial colonization and is therefore susceptible to encrustation with a crystalline bacterial biofilm. Encrustation and blockage by biofilms remain a major complication in patient care. Most patients with indwelling stents experience irritative symptoms related to these implants and many patients suffer from it.

We investigate the ability of different plasma deposited amorphous carbon coatings (a-C:H) to inhibit biofilm formation and to reduce implant-related side-effects. The typically 25 – 100 nm thick a-C:H films are deposited from a radio-frequency (rf-) activated (13.56 MHz) hydrocarbon gas plasma, using C_2H_2 as the main precursor gas with optional additional precursor gases (e.g. ammonia, oxygen) for variation of surface properties. a-C:H coated ureteral DJ-stents were tested *in-vitro* with artificial urine in the 'encrustator model' and *in-vivo* on patients suffering from recurrent obstructions of the ureter. a-C:H coated biliary stents were placed in the biliary ducts of patients suffering from indwelling times of only four weeks with common stents.

In-vitro investigations in artificial urine revealed that a-C:H reduces crystal adhesion by 50%. In ten patients with different underlying diseases and stent removal frequencies of less than six weeks due to encrustation, 26 a-C:H coated ureteral stents were successfully tested for their ability to reduce the extent of crystalline biofilm formation. In total, a 2750-day period of experience with a-C:H coated ureteral stents *in-vivo* exists. No stent-related complications occurred and no crystalline biofilm formation was observed.

Furthermore, facile handling and less painful replacement procedures are reported by physicians and patients. Due to low friction, a-C:H coated stents can be placed and removed much easier than standard ones. Frequency and severity of symptomatic urinary tract infections are reduced. Ongoing investigations show comparably promising results for the a-C:H coated biliary stents, suggesting a reduction of biofilm formation through a-C:H coatings on implants independently from the organ treated.

The *in-vitro* experiments as well as the *in-vivo* treatment attempts clearly reveal an effective reduction of the biofilm formation. The possibility of performing particular adjustments to the surface's physico-chemical properties with respect to, for example, the free surface energy and hardness, offers the promising opportunity to produce indication-specific coatings, resulting in optimized performance.

A novel horizontal black lipid bilayer system incorporated in a microfluidics chip

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A planar lipid bilayer, widely used for electrophysiological studies, is reconstituted on a micron-size glass aperture inside a microfluidic chip, forming a GΩ seal using giant unilameller vesicle (GUV) adsorption and rupture. This novel system offers very low noise recordings (under 1 pA RMS at 30 kHz filter, essentially equal to the open headstage noise of our system), complete control of the measurement environment, access to the bilayer on both sides, the use of μl analyte volumes, and a great potential for automation and parallelization. Access to both sides also enables rapid solution exchange. Minimizing the microfluidics thickness on the lower side of the BLM enables us to approach the bilayer with a 40X NA objective making concurrent electrophysiological and fluorescence microscopy studies possible.

The system is uniquely suited for the study of nanofluidics through biological protein channels incorporated into the lipid bilayer. Due to the low noise pS conducductance fluctuations can be observed, potentially combined with single-molecule fluorescence probes. Analyzing the ion current fluctuations through the nanopore allows us to calculate individual molecular binding constants in e.g. antibiotic translocation through bacterial pores.

Liposome-lactoferrin involvement in the cellular response during inflammatory process

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Liposomes are known as drug delivery system which can enhance the therapeutic effect of the encapsulated compounds. They are able to protect the pharmacological active principles from degradation, to release it at the site of action and to increase the cellular uptake.

Lactoferrin (Lf) is one of the functional proteins that play an important role in the immune response against infection and inflammation through its anti-inflammatory and immunomodulatory properties.

The aim of our study was to investigate whether the entrappment of Lf in liposomes could improve the anti-inflammatory capacity of the protein. ELISA detection of the pro-inflammatory cytokines released by THP-1 cells stimulated with bacterial endotoxines (LPS), revealed a higher decrease of TNF-α and IL-6 in the presence of liposomal Lf compared to free protein. At intracellular level liposomalization of Lf enhanced its ability to suppress the expression of ERK1/2, a protein of MAPKinase family involved in LPS-mediated cytokine production.

These results suggest that liposomal Lf might act more efficiently than the free protein and could be a novel agent useful in the prevention and/or the treatment of various inflammatory diseases.

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Delivery systems for beta-sheet breaker peptides

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Peptides are increasingly emerging as therapeutic drugs for a broad spectrum of diseases that includes Alzheimer's disease. However their wider use has been hindered by poor bioavailability *in vivo*. This work focus on the design of controlled delivery systems for betasheet breaker peptides. The peptide to be delivered is a short sequence homologous to the central region of amyloid beta-peptide (residues 17-21), with proline incorporated. This sequence inhibits the aggregation of amyloid beta-peptide, which is alleged to be a cause of Alzheimer's disease.[1] Polyelectrolyte multilayer capsules and polymer conjugates are used to increase the peptide plasma residence time and therapeutic index.

The peptide was conjugated to the polymers poly-L-glutamic acid (pGlu) and polyethyleneglycol (PEG). The conjugates were separated from the reaction substrates by gel chromatography using a sephadex column PD-10. The reaction was followed by UV-vis spectroscopy and SDS electrophoresis.

The nanocapsules were prepared using the layer by layer self-assembly (LBL) technique.[2] The oppositely charged polyelectrolytes poly(allylamine hydrochloride) (PAH) and sodium poly(styrene sulfonate) (PSS) or pGlu and poly-L-lysine (PLL) were assembled on polystyrene cores. After the assembly of the desired number of layers the template was decomposed with tetrahydrofurane producing a hollow capsule. The encapsulation of the peptide alone or coupled to pGlu or PEG is performed by several methods including shifting the pH and in the presence of acetone. Confocal laser scanning microscope images show that the peptide can be assembled on the hollow capsules as a last layer or between polyelectrolyte layers.

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Role of the nanosensors in interaction between the health and environment

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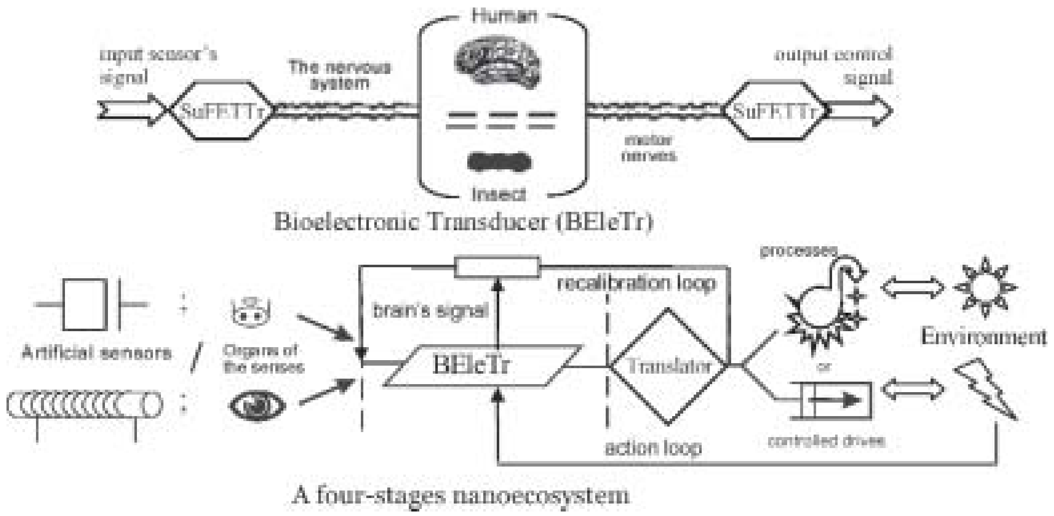
The economic potential of mobile health services is high. We could expect mobile health services to play a fundamental role in transforming today's health model, allowing access to high quality treatment and follow-up, anytime from anywhere. On the other hand, the state of our health can be separated from the surrounding environment.

Critical to all mechatronic system architectures is the role of sensors, (actuators and other interfaces to the world within which the system exists and operates and that provide the measurement and control functions fundamental to any mechatronic system). Sensors are integral to mechatronic system as providers of both the process and procedural data on which operation is based.

Multisensor data fusion is in effect intrinsically performed by animals and human beings to achieve a more accurate assessment of the surrounding environment. The aim of signal processing by multisensor systems is to acquire determined information, such as a decision or the measurement of quantity, using a selected set of measured data stemming from a multisensor system. Thereby, a big amount of available information is managed using sophisticated signal processing for the achievement of a high level of precision and reliability.

Fig. 1 A BEleTr based intelligent ecosystem



Application variety of the novel superconducting, organic and carbon nanotubes (CNT) field-effect transistors (FETs) allows us to design transducers of the biosignals (BSs) (ionic, nerve, DNA, etc.) that transduce them into different quantities, including electric voltage, density of chemical and biomolecules. On the other hand, the said BSs can be controlled by the applied electrical signals, or bio and chemical mediums.

The described SuFETTrs designed on the basis of organic and nano SuFETs are suitable for describing the wide range of BS dynamical parameters. Following the columns of the table, it should be noticable, that serial connection of the external PCs allows us to gain some integrated signal, i.e., the whole sensing or control electronic or nerve impulses, which spreads along the number of axons of the nerve fibre; the amount of ions passing through the PCs and the generalized BS passing through one or both spirals of DNA. When SuFET channel(s) of are implanted into the tissue or process we can acquire more precise data about the frequency distribution of the nerve impulses, volume distribution of ionized molecules and detecting activity of individual nucleoteds.

Multisensor data fusion is in effect intrinsically performed by animals and human beings to achieve a more accurate assessment of the surrounding environment. The described intelligent system is introducing a new multisensor-brain interface. On the one hand (internally), it is based on a nanoSuFET based transducer (SuFETTr) and the natural brain that includes; and on the other (externally), the artificial or natural sensors and the automatic equipment (processes) that follows. The intelligent nanoSuFET based sensor/transducer (BEleTr) (Fig. 1, upper) consists of a natural brain with SuFETTrs of input and output nerve signals. Further step will be inclusion of BEleTr into an environment (Fig. 1, lower). The environmental information picked up by the sensors and it is a source of the data for a living-being activities. As a result of the 'action' signal to a brain, its input signal will be adjusted by recalibration of BEleTr according to the technological exposure on the environment and control brain signal in BEleTr. On the other hand this signal could show a degree of the deviation both the state of an individual health and the surrounding environment from a normal value.

Cytotoxic and proinflammatory investigations of two siRNA-stabilizing polyethylenimines (PEI) in murin lung cells

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Non-viral gene therapy is based on the development of efficient and safe gene carrier systems able to transfer nucleic acids into cells. Polyethylenimine (PEI), one of the most promising non-viral vectors, with its high cationic-charge-density potential is able (1) to compact nucleic acids in complexes (polyplexes) smaller than those formed by liposomes (lipoplexes) and (2) to destabilize the endosomal membrane by a 'proton sponge' effect. Due to its property to efficiently stabilize nucleic acids by complexation, PEI allows the delivery of intact siRNAs into different target cells upon topical or systemic administration. In particular, the delivery by inhalation holds promise for the treatment of a wide range of pulmonary and non-pulmonary disorders and offers numerous advantages over more invasive modes of administration. For systemic siRNA delivery in order to induce RNAi in vivo, commercially available jetPEI has already been established, however, other PEIs with lower cytotoxicity and higher transfection efficacy may be desirable.

In this study we compare the cytotoxic and proinflammatory effects of two different PEIs and PEI/siRNA polyplexes in murine target cells of the lung: the macrophagelike cell line RAW264.7 and the alveolar epithelial-like cell line LA4. Particle-related cytotoxcity was determined using assays for cell viability (WST-1) and for the release of the cytosolic enzyme lactate dehydrogenase (LDH). Furthermore, to indicate an inflammatory response, the release of four different proinflammatory cytokines (TNF-α, IL-1β, IL-6, and CXCL1) by the cells was quantified by ELISA.
In both cell lines, cytotoxicity was dose-dependent. The influence on interference with the metabolic and mitochondrial activity and the LDH release caused by the polyplexes (PEI/siRNA) was found to be lower than that of the polycations themselves. When evaluating the proinflammatory effects of both polycations and their polyplexes, we observed for all of the analyzed cytokines no significantly secretion, except for IL-6 and CXCL 1 in LA-4cells.

We conclude that both PEIs and PEI complexes are non-toxic at concentrations relevant for RNAi induction. Further approval of these results in *in vivo* models would allow to evaluate their use as non-viral nanocarriers for gene therapy applications.

In vitro three-dimensional trachea model

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Background
Three dimensional cell systems have been already established for the cornea and the skin. These models are – due to their organ-specific properties – suitable for the analysis of different substances with regard to their biocompatibility and toxicology which up to now could be examined only by animal experiments. The airway represents also an important entry gate for many different pathogenic agents and environmental impacts as for example nanoparticles.

A three dimensional model of the trachea becomes also more and more important as an alternative for animal experiments because it shows similarities in structure and function of the human trachea. This model could be used as a test system for the analysis of different substances, to test the toxicology of nanoparticles and it could be also used as a biological graft.

Methods
For the construction of a three-dimensional trachea model, we isolate porcine cells with an enzymatic treatment and seed them in preliminary tests on 24-well inserts with a pore size of 1µm. For further tests, the colonisation also occurs in an air liquid interface in a special biomembrane reactor with a pulsatile flow of the optimized cell culture medium and regulate breathing rate.
The colonisation occurs with Airway Epithelial Cell Growth Medium and by way of comparison in DMEM Medium with different supplements. The cell characterization occurs via histological and immuno-histological methods and measurement of the ciliary beat frequency.

Results
In preliminary tests porcine respiratory cells were cultivated on inserts and they show a longterm but no metachrone ciliary activity. The cells were also cultivated on an acellularized scaffold in the bioreactor. Most of these cells are vital and show a high rate of proliferation and also longterm ciliary activity. There are ongoing experiments with a co-culture of fibroblast cells and ciliated epithelium cells and tests to initiate the metachrone ciliary beat in the bioreactor system.

Perspective
Our aim is to develop a functional tubular trachea test system in a bioreactor in which the different cells of the trachea are cultivated as a co-culture under physiological conditions and simulation of the respiration.

Keywords: Trachea, three-dimensional test system, primary cells, nanoparticles

Polyethylenimine / siRNA (PEI/siRNA) nanoplexes for therapeutic in vivo gene silencing

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RNA interference (RNAi) is a recently discovered method which allows the highly specific and very efficient silencing of any target gene. Thus, it offers great potential for in vitro target validation as well as in vivo as a novel therapeutic strategy. Since it relies on small interfering RNAs (siRNAs) acting as mediators of RNAi-induced mRNA degradation, the main issue for in vivo use of RNAi is the delivery of catalytically active siRNAs.

In vivo, the direct application of siRNAs without chemical modifications is severely limited by their instability and poor delivery into target tissues. Most desirable is the direct, non-viral administration of siRNAs through systemic or local application.

Polyethylenimines (PEIs) are synthetic polymers with a protonable amino group in every third position and a high cationic charge density. This allows the formation of non-covalent interpolyelectrolyte complexes ('nanoplexes') with nucleic acids.

We have developed nanoplexes based on PEIs as an efficient delivery platform for RNAi in vivo. The complexation of chemically unmodified siRNAs with various PEIs leads to the complete protection of siRNAs from nucleolytic degradation. Furthermore, certain PEIs mediate the highly efficient cellular uptake of siRNAs which, upon their intracellular release, display bioactivity already at low concentrations.

For nanoplex formation, we have introduced PEI F25-LMW, in addition to certain commercially available PEIs, as a low molecular weight PEI particularly capable of delivering siRNAs. In vitro, the transfection efficacy of nanoplexes based on PEI F25-LMW remains constant with increasing FCS concentrations and thus also allows siRNA delivery in the presence of serum.

In various mouse tumor models, we have explored PEI/siRNA nanoplexes for in vivo gene-silencing with regard to different target genes, PEIs, tumor entities, and modes of administration. In ovarian carcinoma, glioblastoma and prostate carcinoma xenografts, we show the efficacies and biological effects of PEIs for in vivo siRNA delivery by targeting different tumor-relevant proteins. The systemic (i.p., s.c. or i.v.) administration of PEI/siRNA nanoplexes, but not of naked siRNAs, allows the delivery of the intact siRNAs into different organs including tumors. This results in the specific downregulation of the target gene expression on mRNA and protein levels and in significant anti-tumoral effects.

Conclusions
1.) The delivery of siRNAs through PEI-based nanoplexes is a highly efficient and ease-to-use, non-viral system for gene silencing in vivo.
2.) The targeting strategies based on PEI/siRNA nanoplexes represent a universal platform for therapeutic applications of siRNAs without the need of chemical modifications.

Safety assessment of nanomedicines/nanodevices: current guidelines are sufficient to ensure safety

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The development in nanotechnologies is resulting in many new approaches which will have an important effect in the treatment of diseases. Current approaches in drug research and development include many restrictions to interesting molecules dependant on their properties: in general, one can say that a good new drug should mainly be available by the oral route of administration, possess a sufficiently good stability to allow once daily administration and, at the same time, avoiding accumulation, etc. In summary, current drugs are far from specifically reaching the target of the disease and/or obtaining the appropriate level to ensure the perfect balance between desired activity and side effects.

The nanotechnologies are resulting in new types of medicines, improving delivery, diagnostics, etc. However, one important question is to know if existing approaches for safety assessment are sufficient enough to test the safety of this new medicines/devices to allow clinical development.

In a first evaluation, the existing guidelines are enough for testing this new type of medicines. In fact, no discrimination can be observed against nanomedicines/nanodevices. However, the classical preclinical development usually considers a new drug as a single chemical entity, which is administered in an adequate and inactive vehicle. And this is precisely what nanomedicines/nanodevices are not, since they are complex mixtures, all of them necessary to the final objective. With the two exceptions of ecotoxicity assessment and the studies on drug-drug interactions, the field of toxicity assessment of complex mixtures is quite poor.

A second important aspect is related to the modified orientation in half-like of nanomedicines. In general, current practices require drug's half life short enough to allow daily treatment without accumulation. On the contrary, it is expected that some of the nanomedicines/nanodevices will possess very long half-lives. Bioanalytical methods to detect degradation products and metabolites are required. Related to this last aspect, one must think on the organisation of clinical studies. In fact, first-time-in-man studies are usually based on single administrations.

In conclusion, existing guidelines fully cover nanomedicines/nanodevices. More research is required on the safety evaluation of complex mixtures and the detection of very low amounts of degradation products. Rethinking of early clinical trials seem to be required.

Nanocoatings for textiles, for medical and hygienic application

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Abstract
The different finishing methods and methods for producing medical textiles represent an increasing market. Specially on the field of transdermal systems and on the field of the so called smart clothing's as well as nanotechnologies but also in the technical areas like laminates for operation covers there are several variation of coated products indispensably. The other aspect on the coating market is characterized by development of special coating materials like dispersion systems and nanomaterials or on the other side new hotmelt systems with content on medicals. The main target is to achieve additional properties which can be realized be coating. The presentation will show new trends in research and development of coating technologies and on the other side coating products under the aspect of medical textiles and advanced technologies for new innovative products.

Coating products for medical application
The use of textile products for medical application is rapidly increasing. Standard products for coating on the field of medical application are TDS's (TransDermale systems), standard self adhesive plaster, wound dressing and compresses, plaster- / bandage materials, collagen- / siliconised tissues, operation textiles (clothing and covers) and gelatine mint-strips and gelatine stripes with active ingredient too.

Available and demanded properties are: hydrophobicity, hydrophilicity, alcohol repellancy, water density, medical application, nano porosity, conductivity

The field of application and use are manifold. In parts can be named with hospitals (bandages, clothing, covers for tables and beds i.e), medical products (gelantine strips, transdermal systems, plastics i.e.), biotechnology (analysis, culture apparatures i.e.), and cosmetic industry (pads i.e.). The TD system is adhering to skin and delivers the drug through the intact skin into the body for systematic action. The drug dosage release is controllable over a long period of time (up to one week and more) and the active agent is resorpt directly by the blood without passing liver or the alimentary canal, therefor allowing a much lower dosage of the drug than in other applications such as tablets.

Products for smart textiles can be named with 'Interactive textiles' – materials, which can react to human and environmental conditions: phase-change materials (thermo-regulating systems), shape memory materials, change of colour in case of emergency, reaction by change of temperature, pH-value and electro active influences, micro encapsulation of specific agents (p.E. absorption of dangerous materials), transdermal systems – coating of textiles with active substances and medicals, production of layers from gel with encapsulation of additional substances (freshmint-strips u.a.) → dissolution by floating of active substances.

Resulting from the high demands on the coating of textiles for medical and hygienic application supplier of coating and laminating lines have to react with: creation of functional coating layers; application of thin medical layers; application of inorganic layers by use of sol-gel-application; application of coating materials to reach special properties; application of thin layers with a very high accuracy; production quality control; cleanliness; accurate record keeping functions; process documentation change control; batch traceability; quality assurance programs

Conclusion
The constant growing market of medical products and its versatility determinates the requirements. The market determinate the tendency of the future. Therefore the machine manufacturer has to meet the criterion of versatile and flexible machine equipment, modular construction, selection of different coating systems, various lamination processes and pre-treatments of substrates, like corona, plasma, UV-treatment.

Coatema is the right partner for R&D of new products or process technologies with its technology centre in Dormagen. You are welcome to visit!

Nanoparticle impact on life science research instrumentation

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Nanotechnology promises to exceed the impact of the Industrial Revolution as we continue to make scientific breakthroughs at a scale of a millionth of a millimetre. Nanoparticles are effectively a bridge between bulk materials and atomic or molecular structures. Theoretically, a bulk material should have consistent physical properties regardless of size, but at the nanoscale this is often not the case. Substances/materials that are fully characterised are not what they appear to be as their size approaches the nanoscale, for example Copper nanoparticles (< 50 nm) are considered super hard materials which do not exhibit the same malleability and ductility as bulk copper.

Nanoparticles already exist in the air - produced by the burning of fossil fuels and by volcanic eruptions, for example; but now we are engineering nanoparticles, controlling their size and shape, to increase their functionality for use in a range of industries, including pharmaceutical/ medical applications. Currently, over 200 consumer goods are available containing nanotechnology; these include cosmetics, toothpaste, sun blockers, paints, sticking plasters and numerous electronic products. The new possibilities offered by nanotechnology may however include certain risks,presenting possible dangers, both medically and environmentally. Nanoparticles can enter the human body via inhalation, through the skin and by ingestion. The most vulnerable entry point is inhalation, their small size enables their passage to the deepest branches of the lung and their high surface to volume ratio, can make the particles very reactive or catalytic. They may also be able to pass through cell walls, the subsequent effects being comparatively unknown. Additional concerns include the influence or hazards to our environment from nanoparticles that might escape to the atmosphere which in turn may also have an effect on human health.

Currently, there is no evidence of a toxicity profile common to the various nanoscale materials. Oberdörster et al. (2005) recommended 16 material classifications including shape, surface area and agglomeration state, which need to be studied in greater detail. Animal research has played a vital role in virtually every major medical advance of the last century, here, it is also necessary, that nano-scale ingredients be studied/ evaluated, just as any other substance.

Life Science Research Instrumentation used in the inhalation sector is already being adapted to enable nanoparticle research under laboratory conditions. There are four main stages to develop such an inhalation system: (1) Filtration, the laboratory air must be filtrated so that the free nanoparticles are removed, reducing the nanoparticle concentration to a minimum; (2) Test substance, this maybe introduced in situ from an environmental/ occupational source using a mobile inhalation system, or through the liberation of the nanoparticle test substance from its bulk material; (3) Exposure unit, the effects of static charge need to be minimised and the internal volume significantly reduced to accommodate the very small amounts of test substance as well as reducing the flow time and therefore the likelihood of nanoparticle agglomeration; and (4) Analysis, this can only be achieved by using specialised equipment, able to quantify changes in the concentration of the nanoparticles.

We design such inhalation systems allowing nanoparticles to be studied efficiently so that their benefits to us in the realm of scientific technology do not remain overshadowed by their risks.

Cytotoxic effects of chitosan-based formulations: ‘in vitro’ and ‘in vivo’ experiments

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Porphyrins and porphyrin precursors or derivatives and new chitosan/cellulose hydrogels based composites with porphyrins and porphyrin precursors or derivatives are used as active agent of killing tumoral cells using the **Photodynamic therapy (PDT)** of cutaneous malign tumors. **Chitosan** is a biodegradable, biocompatible, naturally occurring polymer [1]. **Photodynamic therapy (PDT)** is increasingly used for the treatment of skin cancers and other indications and it uses exogenously administered or endogenously formed photosensitizers activated by light to induce cell death via formation of singlet oxygen and other free radicals. Photodynamic therapy with topically applied ALA has been shown to be highly efficient in the treatment of cutaneous neoplasms by using intralesionally formed porphyrins as photosensitizers. For solar keratoses, best response rates have been described. δ-Aminolevulinic-PDT is also efficient in the treatment of superficial basal cell and squamous cell carcinomas. In addition, the fluorescence of ALA-induced porphyrins under a Wood light is highly selective in neoplastic cutaneous tissue and offers a useful technique in detecting and delineating skin tumors with ill-defined borders [2]. In our study we are presenting new formulations and tests of water soluble porphyrins and precursors, both *in vivo* and *in vitro*; in order to determine and to compare the biological effects whith those already known, produced by a natural PS: protoporphyrin IX (PpIX) induced by delta aminolevulinic acid (ALA). The studies were performed using the same preparative methods with chitosan gel or film applied to the *in vivo* tests. A comparison of the two directions of experiments is done, in order to determine the role of chitosan as biocompatible reconstructive and healing agent. The present work is based on regional know-how, giving innovative properties to biocomposite materials, thereby offering new value added to biocompatible nanocomposite materials and technologies for regenerative purpose and human health.

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Quantum dot-based nanobioprobes for multimodal imaging and biomedical diagnostics

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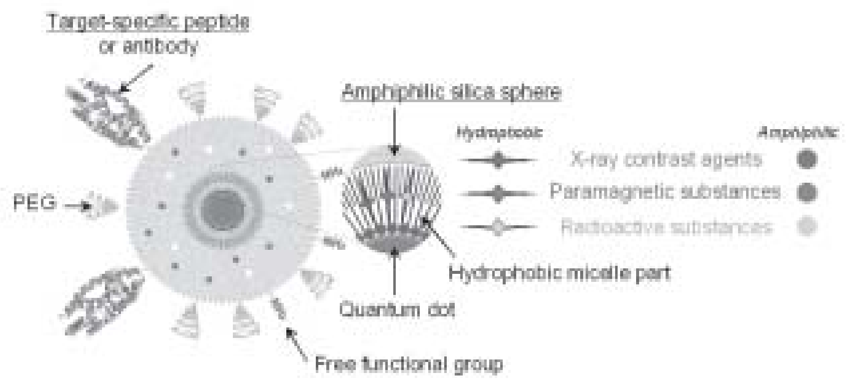
The present study describes an original approach in the synthesis of quantum dots allowing a development of novel hybrid nanobiomaterials with small size (up to 20-30 nm in diameter) and dual or multimodal properties (e.g., fluorescent, paramagnetic, radioactive, photosensitizing, etc.), as well as their intracellular delivery, cytotoxicity, and potential for application in biomedical imaging and diagnostics. The described hybrid nanoparticles are synthesized on the basis of silica-shelled single quantum dot micelles. The obtained products consist in approximately 92% of single nanocrystal (quantum dot) into one silica sphere. The presence of hydrophobic layer between the QD and silica-shell ensures an incorporation of other hydrophobic molecules in the close proximity of nanocrystal. Thus, it is possible to combine the characteristics of hybrid materials with the priority of small size. The silica-shelled single quantum dot micelles are considered as a basis for fabrication of new generation contrast agents with dual and multimodal imaging properties – appropriate for simultaneous deep-tissue imaging, using different imaging techniques [e.g., optical imaging, magnetic resonance imaging (MRI), positron emission tomography (PET), X-ray, etc.]. Novel multimodal imaging probes (for simultaneous optical and MRI imaging, as well as for sensitizing of cancer cells to light irradiation, Figure 1) will be introduced. These novel quantum dot-based hybrid nanomaterials show an ability for intracellular delivery, which makes them appropriate for cell tracing and drug delivery.



Synthesis and characterization of silver nanoparticles and their complex with lysine and antibody of PSA and their application in producing diagnostic prostate cancer kit

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For synthesis of silver nanoparticles we used silver nitrate ($AgNO_3$), hydrazine (N_2H_4), PVP (Poly Vinyl Pyrrolidione) ethylene glycol and ***polyol process*** method.

Silver nanoparticles have been prepared by a soft solution technique from the aqueous solution of silver nitrate and poly (vinyl pyrrolidone) (PVP) in the presence of ethanol used as a reducing agent. The resultant silver nanoparticles were characterized by using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD). It was found that the well-defined silver nanoparticles which had the 15-50nm.

After preparation and characterization of nanoparticles and confirmation of their size, they were reacted with lysine and were conjugated with antibody of prostate specific antigen (PSA) (due to the present of free amine groups).

This complex (silver nanoparticle-lysine-antibody of PSA) would be used in production of diagnostic cancer kit.

Key Word: Antibody of PSA (Prostate Specific Antigen), silver nanoparticles, lysine

Synthesis and characterization of copper nanoparticles and their complex with lysine and the antibody of PSA and their application in producing diagnostic prostate cancer kit

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A novel method for the preparation of copper nanoparticles by reducing $CuSO_4$ with hydrazine in ethylene glycol under microwave irradiation. The influences of reaction parameters such as molar ratios of $N_2H_4 \cdot H2O/CuSO_4$ and $NaOH/CuSO_4$, heating method and reaction temperature on the particle size and composition of powder were investigated by X-ray diffractometry (XRD), and particle size analysis. Well-dispersed copper nanopowder with a diameter of about 15 nm was obtained in the absence of a protective polymer.

After preparation and characterization of nanoparticles and confirmation of their size, they were reacted with lysine and were conjugated with antibody of prostate specific antigen (PSA) (due to the present of free amine groups).

This complex (copper nanoparticle-lysine-antibody of PSA) would be used in production of diagnostic cancer kit.

Key Word: Antibody of PSA (Prostate Specific Antigen), copper nanoparticles, lysine

B1500A nanoscale device analyzer: attractive solution for nanotechnology researcher

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Carbon nanotubes hold great promise as future transistors. With dimensions of 1 nanometer diameter and a few nanometers in length - these devices are much smaller than existing 65 nm semiconductors. Because of their size they are difficult to work with: traditional optical microscopes cannot see them, and very small electrical signal measurements that require accurate electrical equipment such as triaxial cable, guard line and shielding box, together with AC impedance measurements are fundamental in their characterization.

The B1500A semiconductor device analyzer together with nano probing systems represents the ideal solution to help nanotechnology researchers to overcome the above mentioned difficulties.

Shipped with Agilent's *EasyEXPERT* software, the B1500A is a *Windows XP Pro*-based analyzer that combines *CV* (capacitance versus voltage), and *IV* (current versus voltage) measurements in a single instrument. Highly accurate and stable low-current measurements can be performed by using the atto-sense and switch unit (ASU) which provides measurement resolution at 0.1 femtoamp and 0.5 microvolt, and the integrated CV measurement unit measures capacitance at up to 5 MHz.

The Windows-based graphical user interface with touch screen options is familiar, even to students or new engineers who are inexperienced with parametric measurement instruments. Thanks to a wide range of application libraries included with the software even a beginner can start making productive research within a few minutes of starting up, and automated test sequencing and data export is simple to apply. In those applications like CNT SET characterization where a high amount of measurement points has to be collected the B1500A software can control multiple tests by keeping trace of data continuously and holding the end status of the previous test application.

In summary, we present a solution to measure the unique electrical performance of CNT FET and CNT SET devices, including detecting single electron transfer at room temperature [1].

[1] Measuring CNT FETs and CNT SETs using the Agilent B1500A, Application Note 5989-2842EN

Field-effect transistor build on n-InAs single nanowire

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Semiconductor nanowires (NWs) represent a potential as key building blocks for future electronic and optoelectronic nanodevices, because of their remarkable electronic and optical properties. The vapour-liquid-solid (VLS) growth mode employed in our studies allows for the fabrication of NW devices with large lattice mismatch. Especially III-V semiconductors on a silicon substrate open innovative options for combinations with Si-CMOS. InAs Nanowires (NW) were grown in a low-pressure metal-organic vapor phase epitaxy (LP-MOVPE) using the vapour-liquid-solid growth mode (VLS) [1,2,3]. Omega-shaped-gate (OGS) n-doped InAs nanowires metal-isolator semiconductor field-effect transistors (MISFET) have been fabricated by e-beam lithography (fig.1). A set of nanowire transistors with variable SiN_X gate dielectric thickness has been fabricated. Realised NW-FETs exhibited pronounced *n-type* characteristics with very good saturation and a very high output current I_d = 3 A/mm (fig.2). Furthermore it showed a significant transconductance increase by reducing the SiN_X gate dielectric layer thickness from 90nm to 20nm. We achieved a maximum normalized transconductance (g_m/d) of 3.5 S/mm at room temperature for 20 nm gate dielectric layer, which is the highest value ever reported for InAs Nanowire FET. The scalability of the transconductance could be clearly demonstrated by variation of gate dielectric thicknesses. Using a MISFET model a good correlation to experimental transconductance data has been obtained. This study shows that the excellent transport properties of InAs are fully available in NW. They enable an outstanding FET device performance. In comparison to standard InAs channel FET an at least doubled transconductance, a very high drain breakdown voltage, and a very low output conductance are obtained.

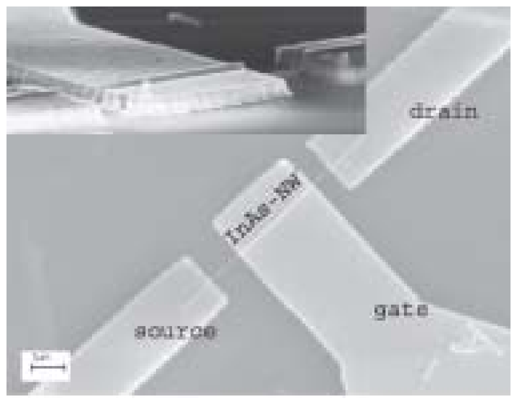

Fig. 1. SEM image of an omega-shaped gate n-InAs nanowire-FET.

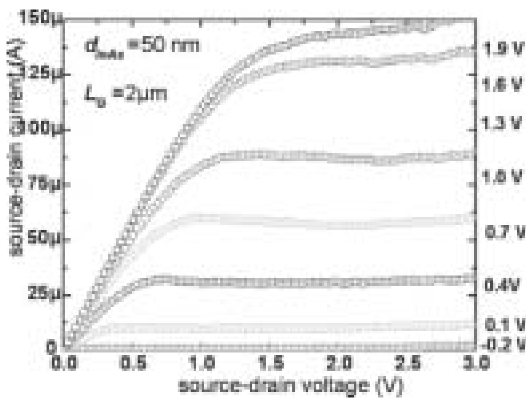

Fig. 2 ***I-V*** *characteristics of a single n-InAs nanowire field-effect transistor with a wire diameter of 50 nm and 20 nm SiN_X as dielectric.*

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A new type of powders mixtures for advanced electrical contact materials

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The electrical contact parts represent some important components of switching electrical devices having the role to carry, open and close nominal currents of different values ranging between some mA to thousands of A. They are subjected to temperature, electric and vibration stresses or erosion and welding in the short-circuit currents.

So, the electrical contact materials must have simultaneously high performances concerning microstructure, electrical and thermal conductivity, hardness, arc quenching ability and melting point.

There is a growing need to produce some sintered electrical contact materials with high functional characteristics, which in turn, depend on the properties of the starting powders.

It is known that the systems containing nanoparticles have electronic, magnetic, optical and chemical properties, which differ considerably from those of corresponding bulk material and depend strongly on the grain size and morphology.

The paper presents the results of the research concerning the obtaining of some new composite powders with high technological performances for electrical contact materials of Ag-MeO type (where MeO = SnO_2 of 6…10 wt. % and CuO or WO_3 of 0.3…0.8 wt. %). The improved characteristics result by designing of the microstructure where the nanosilver-doped metal oxides are fine and homogenous dispersed in a microcrystalline silver matrix. The metal oxides were first dispersed in water by ultrasonication, followed by a deposition covering with silver nanoparticles (1…25 wt. %). The obtained nanosilver composite particles were dispersed in an 'in situ' synthesized microcrystalline silver matrix.

The new composite powders were analyzed from shape and grain size, chemical composition and sinterabilty point of view. These composite powders proved a very fine dispersion and a high sinterability. Also, the electrical contact materials obtained from these composite powders present high functional properties. In the research of the powders mixtures for electrical contact materials, the silver nanoparticles deposited on the oxide supports are of interest from both the technological and functional point of view.

Application of electric fields for optimisation of laser-produced ion streams used for modification of semiconductor materials

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The laser ion source (LIS) seems to have several advantages over the conventional ion implanters. Since all materials can be ionized with lasers, solid, liquid or gaseous, the choice of kind of ions is nearly unlimited. An important advantage of the laser ion source is also the great ease of biasing the ion source to positive high voltage, which is important for moving substrates. The properties of ion streams (ion energies and current densities, the ion charge state, angular and energy distributions) depend on the target material and the laser pulse energy, pulse duration and intensity on the target surface.

Application of laser-produced ions for may be attractive for direct ultra-low-energy ion beam implantation in thin layer of semiconductor for modification of electrical and optical properties of semiconductor devices. Application of electrostatic fields for formation of lasergenerated ions enables to control the ion stream parameters in broad energy and current density ranges. It also permits to remove the useless ions from the ion stream designed for implantation.

For acceleration of ions produced with the use of a low flounce repetitive laser system in IPPLM the special electrostatic system has been prepared. The laser-produced ions passing through the diaphragm have been accelerated in the system of electrodes. The accelerating voltage, the distance of the diaphragm from the target, the diaphragm diameter and the gap width were changed for choosing the desired parameters of the ion stream. The characteristics of laser-produced Cu, Si and Ge ion streams were determined with the use of precise ion diagnostic methods. The laser-produced and post-accelerated Si and Ge ions have been used for implantation into semiconductor materials for nanocrystal fabrication. The work has been performed within SEMINANO project supported by EC (within 6FP).

Metal deposition nanotrenches from neutral and ionized gas environments

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We have considered the metal deposition and neutral gas / ion treatment of nanotrenches made in conductive and non-conductive substrates. In the work we demonstrate some of the most important peculiarities of metallization of linear nanofeatures (nanotrenches) from the low-density, low-temperature plasma environments. It was shown that the plasma process ensures a greater controllability in growing various conductive and non-conductive nano-trenches. For example, the use of plasma provides an effective control of the ion fluxes in the non-conductive patterns, and formation of deep well-shaped cavities in the surface.

The study made has elucidated the main advantages of the ion treatment. As seen from the results obtained, the ion flux at the cavity's throat is well-directed due to the focusing structure of the electric field. As a result, the current to the cavity walls is rather low, the flux mostly impinges on the cavity's bottom, which is being sputtered, and the cavity eventually deepens and reshapes into a narrow prolonged void. It is apparent that, if a low energy ion flux is used, the bottom and lower parts of the cavity walls can be uniformly coated.

In case of the neutral flux, the sputtering is impossible due to the low atom energies, and the deposition (coating) is a dominant process. In this case the atoms are directed randomly as they enter the cavity and are then deposited mainly at the upper parts of the cavity walls. As a result, the cavity throat is filled with the deposited material, becomes narrower and may eventually close thus turning the void into a separated pore.

It should be noted that the direct comparison for the atom and ion fluxes is impossible in this case, since the methods and aims of the atom/ion treatments of the surface cavities are quite different. Indeed, the ion flux is able to engrave, deepen and coat the cavities, whereas the flux of non-reactive (neutral) radicals can be used only for applying deposits on the cavities walls; thus, the possibilities of the ion treatment are much wider. Nevertheless, we have considered the possibilities of using both ways of treatment.

Plasma-assisted synthesis of multipurpose carbon nanotubes and nanorod arrays for microemitters

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Carbon nanotubes and nanorod arrays have recently been of a great interest for the nanoelectronics applications owing to their unique structural and electronic properties, as well as outstanding flexibility to coating, ordering, functionalization and eventual nano-device integration. The major issues that still await their solution are related to deterministic, i.e. highly-controllable and predictable synthesis of large and dense nanorods arrays, and nanodevice integration. In this work involving both experimental and theoretical studies we have investigated a biased nano-structured substrate immersed in a low-temperature, weakly-ionized plasma created by a RF discharge, as well as arc plasma.

An experimental study was made by depositing nanorod arrays from the RF plasma and synthesizing nanotubes in arc plasma. It was shown that the plasma parameters and substrate temperature/bias can indeed determine the nanorods shape and structure. To provide a deterministic approach in synthesizing nanorods arrays, one should implement a complex consistent model taking into account both plasma and surface processes.

In simulations, we have considered the substrate surface covered with an initial pattern of cylindrical nanorods with base radii up to 50 nm and height up to 300 nm. Close enough to the surface, the ions are driven by the local (microscopic) electric fields created by the nanotip array. The simulations have shown that manipulation of the main plasma parameters appears to be an efficient turning knob in the deterministic synthesis of the multi-purpose nanotip/nanorod arrays. By using multistage processes and adopting specific sequences of the plasma parameters, one can create a virtually unlimited continuum of exotic shapes.

The results of our investigations can be used for creating ordered arrays of carbon nanorods of various shapes, with various functional coatings and ultra-thin film deposits for various applications. In particular, nanorods can be used for making nonvolatile data storage elements, for interconnects in nano-electronic integrated circuits, for lasing optoelectronic devices, nano-plasmonic and photonic devices, protein and cell immobilization arrays and many others.

Optical properties of InGaNAs/GaAs single quantum well

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InGaAsN/GaAs single quantum wells emitting in the range of 850 – 1300 micron, are interested for telecommunications and long wavelength optoelectronic devices. We have investigated the optical properties of a set of $In_xGa_{1-x}N_yAs_{1-y}$/GaAs SQWs structures which are grown on undoped (001) oriented GaAs substrates with nitrogen concentration less than few percent by means of photoluminescence (PL) at different temperatures and different excitation powers. Influence of nitrogen give rise to localized fluctuation that increases PL efficiency and make localization. The presence of localized carriers can be inferred from the temperature dependence of the PL spectra in form of s-shape energy peak behavior in $In_{0.36}GaN_{0.006}As$ SQW (Fig. 1) and in near bandgap PL emission in the $In_xGa_{1-x}N_yAs_{1-y}$/GaAs that has a very asymmetric PL line shape at low temperatures and low excitation power (not shown). The localization energy is about 5 meV and delocalized temperature is nearly 75 K (Fig. 1). In this paper the role of the nitrogen on carrier localization have been discussed.

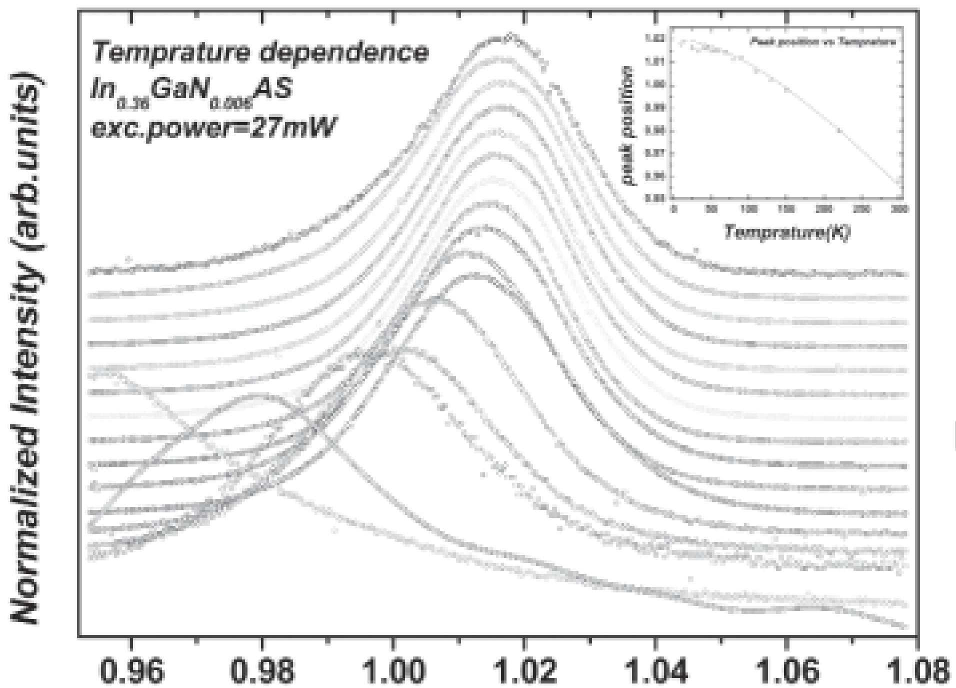

Fig. 1

Extreme ultraviolet radiation: a new access to 'nanoscopy' and 'nanolytics'

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Both, microscopic and analytic techniques using light (IR, VIS, UV) or X-rays reach their limits when dealing with mesoscopic or nanoscale samples. Conventional instrumentation for nanotechnology does the jobs as long as surface properties or thin layers are investigated, but lack of sufficient penetration and / or resolution when bulk properties of the samples become relevant.

Using photons, only the Extreme Ultraviolet (XUV) spectral range comprising EUV, soft-X-rays, VUV offers an outstanding combination of features needed for structuring and analyzing of matter on the 10 to 1000 nm lateral and vertical scale: XUV-radiation is traditionally exploited at beamlines at large storage-ring facilities like BESSY II. The fact that the roadmap of the semiconductor industry drives the development of the basic components required, allows to disseminate EUV-technology to laboratories for nanosciences and nanotechnology.

In the framework of existing cooperations, various techniques for characterizing nanosamples have been demonstrated with radiation in the spectral range of 10 to 20 nm. The range of application comprises measuring the spectral properties (spectral photometry) (reflectance, transmittance, chemical composition), scatterography and imaging or detection of nanoparticles.

Some of the work gratefully acknowledges the financial support of the Ministry for Innovation, Science, Research and Technology of NRW, Germany within the framework of a 'Lise Meitner Fellowship' and the of the by the German Ministry of Commerce and Technology (BMWi) within the joint projects SpeXUV under contract no. 16IN0210. and 'XUV-Nano' under contract no. xyz

Photocurrent spectroscopy of optical transitions in Ge/Si multilayer quantum dots

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Lateral photoconductivity spectra of multilayer Ge/Si heterostructures with Ge quantum dots were studied. The photocurrent with minimal energy 0.48 eV that is smaller than Ge band gap was observed from 8-layer structures at the geometry of waveguide excitation at room temperature. Analysis of the shape of the received spectra revealed that the optical absorption coefficient in the range from 0.48 to 0.83 eV followed a squared relationship that is supposed typical for indirect interband transitions. Generation of the photocurrent with the limit energy 0.48 eV was explained by indirect electron transitions from valence band of nanoisland into conduction band of Si surrounding. It was found out that the limit energy of such transitions decreased, as the number of Ge quantum dot layers increased. The studied structures are found to be photosensitive at 77 K in the spectral region from 0.29 eV to 0.4 eV. Two peaks with maximum at 0.32 eV and 0.34 eV were observed. The photocurrent in this region is likely to be due to hole transitions from ground states localized in the nanoislands to the delocalized states of the valence band.

Evaluating the nano *green-hype* and the dematerialization of economy

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A recent *hype* on nanotechnology's expectations has been identified within a complex and wide variety of conceptions among experts and the general public.[1] As a technology that has its foundations on the manipulation of matter at dimensions between a millionth (10^{-6}) and a billionth (10^{-9}) of a meter, it is seen by some as a brand-new disruptive field and, by others, as a body of knowledge and techniques about the same scale formerly part of already existing disciplines such as physics, chemistry, genetic, materials engineering and other such areas. Both perspectives, nonetheless, assume nanotechnology as a technological frontier that, along with biotechnology, information technologies/robotics/ artificial intelligence and cognitive sciences – the so called 'converging technologies' – could be capable, in the long run, of revolutionizing the world and 'human nature' as we know it; either positively or negatively.[2]

It is a context in which complexity and uncertainty are relevant features and in which societal, ethical and/or environmental aspects get more controversial as the stakes in dispute get higher.[3] A reason that seems to explain the stimulus of some stakeholders –mainly governments- to conform a variety of study groups on such implications.

In this context and in particular related to the environmental aspects of nanotechnology, the analysis of the nano-industrial metabolism characteristics, turns out to be a central measurement tool to reasonably dissipate hypes on 'dematerialization of the economy' while, at the same time, it can help to understand the type and the extension of the environmental impacts of nanotechnology (positive or negative). The poster presents a schematization of an environmental evaluation approach of nanomaterials based on an ecological economics and an industrial ecology perspective. It takes into account the (nano)materials and energy flows, as well as the waste and recycle processes. Finally, some recommendations are pointed out.

[1] *See: Delgado. Gian Carlo. 'NanoConceptions: A Sociological Insight on Nanotechnology Conceptions.' The Journal of Philosophy, Science and Law.July 1, 2006. Miami, United States.*

[2] *For some blueprints on 'converging technologies', read: Roco, Mihail C., y Bainbridge, William. Converging Technologies for Improving Human Performance. National Science Foundation. June 2002, US; Nordmann, Alfread (rapporteur). Converging Technologies – Shaping the Future of European Societies. European Commission. Brussels, Belgium., 20004; Bouchard, Raymond. Bio-Systemic Synthesis. Science and Technology Foresight Pilot Project. Report 4. Canadian National Research Council. Canada, June 2003.*

[3] *This is the main argument that some authors embrace for considering converging technologies' aspects as 'post-normal science' issues and therefore as those in which a new principle is necessary for their evaluation. This is mainly a process where open and extensive debate is a fundamental tool and where precaution is also adopted to confront ignorance, uncertainty and the incapacity to predict technological pitfalls. See: Ravetz, Jerome. Scientific Knowledge and its Social Problems. Oxford University Press. New York, US., 1971; Funtowicz, Silvio y Ravetz, Jerome. Uncertainty and Quality in Science for Policy. Kluwer Academic. London, UK, 1990; Funtowicz, Silvio y Strand, Roger. 'Models of Science and Policy' in Taavik, T., Kjolberg, K., Fenne, M. Genetic Engineering and Genetically Modified Organisms: PrecautionaryApproaches to Risk and Uncertainty. Tapir Akademisk Forlag. Noruega, 2006.*

Pervasive nanotechnologies yield privacy fear

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As it has been shown in the recent set up of nanotechnology super centres such as the French MINATEC nanotechnology centre [1], privacy has not been taken into account and user protestation has soon shown to be virulent. In June 2006, in parallel to the inauguration of MINATEC, the association called *'Pièces et Main d'Oeuvre'* [2] organised a street protestation against the centre and, since, has been publishing documents against most of MINATEC's related projects. For example, *'Pièces et Main d'Oeuvre'* renamed a nanoelectronics project aiming at manufacturing tiny intelligent sensors, also known as *'smart dust'*, as *'surveillance dust'*. That kind of privacy concerns is also raised in North America where *'the major privacy related issue-surrounding nanotechnology is the potential for intruding surveillance'* [3, 4]. Nanotechnologies extend existing sciences into the nanoscale, thus nanotechnologies have the potential to be pervasive in everyday life, not only in electronics but also in fabrics, drugs... There is a real risk that Langheinrich's *'daunting Orwellian visions'* [5] due to pervasive computing may even get worse with the advances in nanotechnologies.

The US-based Electronic Privacy Information Center recommends *'to enact legislation in advance of the adoption of nanotechnology innovations'* [4] and warns that *'if Congress waits to pass privacy-protective legislation until after the technology is prevalent in society, then it may be too difficult to deviate or restrict nano surveillance technology's use'* [4]. In Europe, privacy is mentioned as a human right in its potential constitution and more generally privacy is a fundamental human need according to Maslow's pyramid of human needs [6]. The EU may also envisage advanced enacted legislations with regard to privacy and nanotechnologies. Another line of defence may be the creation of technological protections in addition to legal protections.

The poster surveys the different privacy concerns that have been raised all around the world due to these potential pervasive nanotechnologies and the main solutions that have been proposed to mitigate these privacy concerns. Sound protections may relieve the citizens of privacy fear due to nanotechnologies and increase their adoption of nanotechnologies-enhanced products. It is expected that the poster will foster discussions on this topic at the conference as well as follow-up solution initiatives.

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Evaluation of the toxic potential of different nanoparticles in neuronal and glial cell cultures

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The aim of this study is to investigate neurotoxicity and gliotoxicity of nanoparticles to which humans may be exposed in the context of medical applications, during manufacturing processes or by using nanoparticle containing products.
In vivo studies have shown that nanoparticles can be found within the brain of exposed animals. However, there is little known about the interaction of nanoparticles with neurons and glial cells.

So far we assessed the effects of nanoscaled tungsten carbide [WC], nanoscaled tungsten carbide cobalt [WC-Co], which are released during the manufacturing process of tools, and purified single-walled carbon nanotubes [SWCNT] which are of growing interest in technical and medical investigations.

Culture systems used include the oligodendrocyte cell line OLN 93, primary neuronal cultures, astrocytes and microglial cells obtained from fetal or newborn rat brain. These cultures are exposed to nanoparticles and resulting effects are studied in a time and concentration dependent manner.

To identify whether cell toxicity occurs, we applied in a first step different *in vitro* viability and cytotoxicity assays (CCK 8, MTT, LDH). The results show that WC nanoparticles are less toxic than WC-Co nanoparticles and SWCNT in our cell culture systems. In OLN 93 cells all analysed particles reduced cell viability significantly. Using the TUNEL assay we found a small increase in apoptotic cells following treatment with WC. Cellular uptake and distribution of the examined nanoparticles is currently analysed by electron microscopy. The obtained data of our studies suggest that nanoparticle exposure may impose a risk for the central nervous system.

Do technical nanosized particles exert a toxic potential in vertibrate cell lines?

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The production of nanoparticles carries enormous potential for diverse industrial and consumer applications. They are much smaller than human cells. Yet, little is known as to whether nanosized particles impact human and environmental health. To develop nanoparticles in a sustainable way, a risk assessment has to be performed. Technical ceramic and metallic (e.g. tungsten carbide) nanoparticles are physicochemically characterized and analysed in human and fish cell lines under avoidance of animal tests. Due to the novelty of nanomaterials, appropriate exposure and testing methods have to be developed and implemented.

The chemical-physical characterization confirmed that tungsten carbide nanoparticles form a stable solution in cell culture media with an average diameter of 100 nm. Differences in growth behaviour of the human cell lines A549, CaCo-2, HaCaT and fish cell lines PAC2 and RTGill-W1 were assessed after treatment with nanosized tungsten carbide applying *in vitro* cytotoxicity assays. The results show that tungsten carbide nanoparticles are not acutely toxic to either of the studied cell lines. Subacute effects on cellular compartments are currently analysed more detailed.

Further studies are carried out to specify mechanisms of cellular response to different nano-sized particles e.g. tungsten carbide cobalt and platinum. Parameters to be assessed include differential gene and protein expression and inflammatory parameters. Cellular uptake and distribution of the examined nanoparticles is currently analysed by electron microscopy.

Suspension characterization of synthetic nanoparticles under physiological conditions as a tool for toxicological studies

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Due to their outstanding properties nanoscale particles can be found in many applications in medicine, cosmetics, electronics, environmental protection, civil engineering and material science. However, a critical view on possible risks of nanoparticles for the environment and human health is necessary. Our work is focused on the chemical-physical characterization of engineered nanoparticles like ceramics, hard materials such as tungsten carbide (WC) with and without cobalt, metals like platinum as well as carbon nanotubes, and their behaviour in physiological media. The results are used later on to describe and interpret the interaction of the particles with cells. The investigations are a part of the BMBF funded project INOS.

Our focal point with reference of health aspects is to study the behaviour of nanoparticles in physiological solutions. The interest of our research is to describe the interactions of the particles itself and reactions of nanoparticles with blood constituents such as proteins.

The particle size distribution is measured using dynamic light scattering, which allows the detection of nanosized particles. Besides the size, the surface charge of these nanoparticles has a significant function. The particle's surface charge is describable with zeta potential which can be obtained by measuring the electrophoretic particle movement. A specific attribute of physiological solutions is their high electrolyte concentration that causes a reduction of the electrochemical double layer down to 1nm according to the Debye-Hückel theory. Therefore, the particles converge and agglomerate because the double layer repulsive force is smaller than the van-der-Waals attractive force which can be explained by the DLVO theory.

The figure shows the agglomeration activity of tungsten carbide particles in phosphate buffer (PBS). In pure buffer solution agglomerates are formed within a short time as expected from DLVO theory. The agglomeration action is clarified by the low absolute value of the measured zeta potential (-20mV). If the phosphate buffer additionally contains albumin (BSA) in various concentrations, no agglomeration was obtained, although the measured zeta potential was lower than in BSA-free suspension. Interestingly, the zeta potential of BSA in PBS (~ -8mV) is nearly the same compared to the WC-BSA suspension (~ -11mV). Proteins do not agglomerate under physiological salt concentrations because they are not only stabilized electrostatically but also sterically. Obviously, BSA adsorbs on the particle's surface, assigns their steric ability to the new formed WC-BSA-particle, and stabilizes the suspension in that way. The same results have been achieved in culture medium DMEM containing 10 % FBS, which partly consists of proteins.

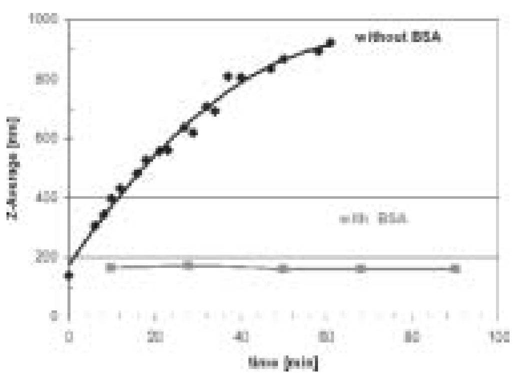

Figure: Particle size of tungsten carbide (c_{WC} = 0.05 mg/ml) in phosphate buffer depending on the presence of BSA

As one can see, the behaviour of nanoparticles has to be characterized under appropriate physiological conditions in order to be able to interpret results of toxicological studies.

Vascularized liver cell module: a possible 3D test system for the evaluation of the toxicity of nanocytes in tissues?

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Background
So far possible risks of nanoparticles for humans and environment have been hardly investigated. Since nanoparticles have almost the same size as cell proteins, they can be probably taken up easily by cells. Questions like: What will then happen to the cell, how will the human organism respond to the particles and which influence will they have over cells and organs, can be answered so far only inadequately.

The main issue, among other things, is the absence of suitable cell tests, which allow a fast and simple estimation of particle toxicity. At the Fraunhofer-IGB we have been developing a liver module, which enables a physiological co-culture of hepatocytes (HC) and endothelial cells (EC). Basis is a vascularized matrix which admits ECM contacts to the HCs and provides a blood vessel network for EC co-culture and the transport of nutrients, metabolites and gases or the removal of toxic metabolites by physiological perfusion.

Methods
The matrix used in our liver module consists of a chemically acellularized porcine jejunal segment with an obtained vascular system, an arterial inflow and a venous reflux. ECs were seeded onto the vascular structure of this matrix. During the cultivation the matrix was perfused with medium over the artery in a bioreactor system. The flow rate was controlled via a sensor and a PC. After 7 days the HCs were seeded into the lumen of the matrix and co-cultured with ECs for 3 weeks. The cells were characterized for the expression of liver specific markers, metabolic activity and for vitality.

Results
Porcine liver-ECs were seeded successfully via the arterial inflow in the vascular bed of the matrix. Vital HCs could be effectively populated on the surface of the lumen and partially migrate through the deep lying structures of the matrix. Thereby they form out plate-like structures of cell layers with typical hepatic morphology and formation of cell-matrix contacts. The culture of HCs on the matrix shows good results for vitality, conservation of liver specific functions (e.g. urea synthsies and phase I and II metabolism) over three weeks of culture. Perspective: Our aim is the development of a vascularized liver module with physiological liver cell functions. Liver derived ECs shall be co-cultivated with the HCs in such a way, that they can form a filtration barrier. For the first time a testing system should enable the arterial application of substances and the identification of metabolites in a venous system.

This system can then be used to test the toxicity of nanoparticles e.g. as drug carriers and their influence on cells and tissues.

Examination of lung toxicity of nanoparticles at workplaces

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Epidemiological studies show an association between the concentration of fine and ultrafine particles (PM_{10}, $PM_{2.5}$) in the atmosphere and the rate of mortality or morbidity due to respiratory and cardiovascular disease. The assessment of the risk of airborne nanoparticles in workplaces is therefore an urgent task. The causes of the toxicological effects of ultra fine and nanoparticles to the human organism are yet unknown. Besides the chemical composition, the physical properties of the particles seem to be of particular importance for the effects. For the quantitative assessment of the toxicity of airborne nanoparticles the dose – response relationship is essential. A technique was developed to expose human lung cells in vitro to analyse in particles with respect to their effects on human health which were determined by a special bioassay.

Industrial nanoparticles are suspended in cleaned air and carried to the exposure system containing the human lung cell cultures. The first steps of the exposure system are the separation of particles bigger than 1 µm and the humidification of the aerosol. Afterwards the human lung cell cultures are subjected to a constant flow of the conditioned aerosol. By this procedure an exposure of cell cultures at the air liquid interface is achieved, which resembles the conditions in the human lung. After exposure of the cells towards the nanoparticles they are incubated for another 24 hours in fre sh culture medium. The responses of the cells were analyzed by measuring the viability (LDH, AlamarBlue) as well as the release of Interleukin-8 (IL-8) as a marker for pro-inflammatory changes.

The exposure method and the lung specific bioassay seem to be an appropriate model to simulate the inhalation of particulate air pollution and to screen the biological effects of different particle sources.

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Uptake mechanisms and toxicological aspects of synthetic nanoparticles in human cells

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Synthetic nanoparticles show a broad range of usage in science, technology and medicine. Nanoparticles are produced on industrial scale and used as additives of drugs, cosmetics, printer toners, textiles, and many other applications. However, hitherto for most of the new nanomaterials little is known about uptake mechanisms and biological effects, such as genotoxicity. Therefore, information about safety and potential hazard of nanoparticles is needed.

The entry of particles into living organisms presupposes their uptake mainly by epithelial cells or phagocytes. This process is strongly dependent on the size and the surface characteristics of the nanoparticles. In any case, nanoparticles have various possibilities to find their way across cell membranes. Once internalized, they may affect the integrity of the cell in different ways. The induction of oxidative stress plays a major role and is suggested to be able to lead e.g. to DNA damage via oxidation of bases.

In our *in vitro* studies, we investigate the uptake and toxicological aspects of synthetic nanoparticles (such as silica or vanadium oxide) with human cell lines. Acute toxic effects and the formation of reactive oxygen species (ROS) were determined by cell viability assays (MTT-, WST- and LDH-viability assay) or the oxidation of fluorescence dyes, respectively. The comet assay was used to assess possible genotoxicity caused by strand breaks. For silica nanoparticles, neither an acute toxic effect, nor the production of ROS could be measured. Silica particles were taken up into the cells in a dose and time-dependent manner. These particles were localized in the cytoplasm, partly in agglomerates. Inhibitors of phagocytosis (cytochalasin D) and clathrin coated pits (chlorpromazine) had no effect on particle uptake. In contrast to silica, vanadium oxide particles exhibited strong toxicity. Nanosized particles displayed a higher toxicity than the corresponding bulk material. Comet assay experiments revealed an increased DNA damage after 36 h in cells treated with nanoscale V_2O_3, but not with nanoscale V_2O_5.

These results provide experimental evidence that synthetic nanoparticles are taken up in a dose- and time-dependent manner and that they may possess a genotoxic potential. These studies suggest the importance to investigate the uptake mechanisms in different cell lines and for different types of nanoparticles, regarding different sizes and material properties as well as the biological responses of cells to these particles.

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Gold nanoparticle induced death response in human lung carcinoma cells

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Despite the huge potential benefits of nanomaterials in biomedical and industrial applications, a very little information available about potential short and long term deleterious effects of such nanomaterials on cancer cells. We report GNP induced death response in human carcinoma lung cell line A549. In contrast, the two other cell lines BHK21 (Baby hamster kidney cells) and HepG2 (human hepatocellular liver carcinoma cell line) remained indifferent to GNP treatment. Flow cytometric studies indicated that the response was dose dependent and had a threshold effect (in A549). At higher GNP concentration there was an asymmetric accumulation of GNP in the periphery outside the cell nucleus of the A549 cells. This was confirmed by confocal microscopy, a green scattering (possibly, surface enhanced Raman Effect) appearing on selective z-slices of the image.

The cellular uptake of gold nanoparticle was already confirmed. But in our case the point may be important that GNP induced cytotoxic behavior is not responded by normal cells like BHK-21. Secondly it is not any universal inducer of cell death to cancerous cells. Thus HepG2 cells show negative response to GNP. The induction of cell death in the human lung carcinoma cells, A549 cell line has an all-none character as the cells exhibited this behavior only after a certain period of GNP incubation (~24hrs.). A concentration threshold (30 nM) exists for GNP; below which cytotoxic effect is absent and after exceeding there was a six-fold increase in the PI uptake. At high concentration GNP accumulates at a region adjacent to the cell nucleus, the clustering being polarized in a small niche around the nucleus. The origin of this optical feature is unclear, but it could be a surface enhanced Raman effect due to clustering of the gold colloid. Region specific cluster formation of GNP's indicates that the gold nanosurface may have a tendency to accumulate in certain cancer cell types, in specific cellular niche and induce a cytotoxic effect.

In vitro toxicity assessments of carbon nanomaterials

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Background
Carbon Nanotubes (CNT) exhibit outstanding chemical and physical properties compared to solid materials. Their application potential for many enterprises in surface coating, semiconductor manufacture and medical technology appears profitable. Nevertheless CNT may represent a potential health risk, because there are possible adsorbtion pathways through skin and trachea. In the blood they can agglomerate with lipophilic serum proteins and get in touch with many cell types and tissues. By their high surface as well as their residual concentration at catalyst materials these bioactive particles have the potential to harm cells by releasing inflammation reactions, oxidative stress and even necrosis and apoptosis.

Aim
For testing the biocompatibility according to DIN ISO 10993-5 in BMBF-supported 'TRACER' (Toxicology and health risk assessment of carbon nanomaterials) and Fraunhofer internal program 'CarNAk' (Carbon Nanotube Aktuatorik), we examine different kinds of dispersive and converted CNT materials for possible cytotoxic characteristics. Compared with special reference materials, proliferation attitude as well as inflammation mediators are measured with relevant primary cells and cell lines after incubation with CNT. In addition established 3D-test-systems (skin, trachea and vascularized matrix) with human primary cells facilitate new informations, if CNT can penetrate body barriers. Methods: Define CNT-dispersions were facilitated in serum-rich culture media through ultrasound. Optical density and particle size distribution were measured after centrifugation. Producing CNT-dispersions depending on particle size and catalyst material were possible. According to reference material in vitro biocompatibility was measured with cell proliferation assays (WST-1) and reactive oxygene species (ROS) detection.

Results
Investigations exhibit a changed proliferation attitude to CNT incubation concerning CNT kind, size distribution and residual concentrations of catalyst material. For this reason further biocompatibility tests for other nanomaterials have to be established for clinical relevance.

Outlook
Cytotoxical Assessment of carbon nanomaterials is facilitated with a combination of exact material characterisation and in vitro toxicological tests. After this, health risks could be estimate and guidelines for employment protection recommend.

Nanosized particles in metal-bearing sludges from steelmaking plants

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Pyrometallurgical works produce solid waste materials consisting of fine even ultrafine particles due to high temperatures in a furnace. These particles are being collected during purification of waste-gases and contain various compounds, e. g. heavy metals and PAHs. According to the purification device employed, we distinguish two major types of pyrometallurgical waste materials – dusts and sludges. Dusts are being trapped on electrofilters and sludges in wet scrubbers. The scrubbers are more efficient than the electrofilters in reducing particulate matter released into atmosphere and due to water spraying enable capture of finer particles. Therefore, we have investigated sludges from the oxygen coverter and the open-heart furnace using atomic force microscopy (AFM) in order to determine presence and morphology of nanosized particles. According to the particle size distribution measured by granulometry analysis, investigated materials contain airborne particles within the size range 0.5–100 µm. The AFM revealed nanosized particles in both wastes in the size range 50–100 nm in diameter. Thus, these materials may pose a risk in term of pulmonary toxicity when released directly into atmosphere or re-suspended from landfills and due to small particle size and high mobility may cause contamination of large area from the source.

This study was supported by the project: Ministry of Education, Youth and Sport of Czech Republic MSM 619 891 0016.

Keywords: nanosized particles, pyrometallurgical sludges, atomic force microscopy

Analysis of everyday consumer exposure to nanomaterials

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For the general population, consumer products are expected to be one of the major sources of exposure to nano-particulate materials. Today, there are already several hundred nanotechnology-based products on the market worldwide. In near future, this number is expected to rise significantly, which implies an increase of human exposure to nanomaterials. The range of possible applications is manifold and, therefore, consumers can and will be exposed to nano-particulate materials in various situations. In order to be able to assess the risk of nanotechnology-based consumer products, it is of immense importance to know the potential pathways leading to exposure.

We have analyzed the uses of nanotechnology in consumer products currently on the market and present an overview of the main types of products. We propose a way to categorize nanotechnology-based products and discuss a number of product-related pathways which describe how consumers can be exposed to nanomaterials, depending on the consumers' behaviour pattern. Additionally, we present scenarios to simulate the use of nanotechnology-based products, covering the whole spectrum of consumer behaviour, and exemplify this approach with certain products. These scenarios can be used to estimate the magnitude of exposure to nano-particulate materials occurring in typical everyday situations. Additionally, it is possible to assign the number of consumers to each scenario, which illustrates the dimension of exposure.

Development of a three-dimensional test system for intestinal absorption studies

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Background
The small intestine is the organ where the vast majority of digestion takes place. Orally administered nutrients and drugs are absorbed as far as possible over the small intestine epithelium into the blood vessel system. Additionally swallowed nanoscale particles could be transported over this way into the body. For this reason there is an increasing imperative for test systems, which reflect the physiological absorption of the intestine wall and which provides the investigation and classification of different substances. Three dimensional test systems offer in relation to conventional cell culture models by their almost physiological structure the advantage of an improved transmission of experimental data on humans and represent besides a suitable alternative to animal experiments. Methods: For the development of a three dimensional intestinal test system, we reseed the lumen of an acellularized biologically vascularised tissue matrix with primary porcine enterocytes or cells with similar characteristics (e.g. Caco-2 cells). To restore a functional blood vessel system, we form the inner lining of blood vessels in the collagen matrix with primary microvascular endothelial cells.

The intestine model is supplied in a bioreactor system via the arterial branch under physiological conditions with growth medium. The absorption of different substances into the blood vessel system can be experimentally determined through the descending venous branch.

The cell characterisation and the proof of epithelial and endothelial cell monolayers take place by histological and immune-histological analysis. The quantitative proof of absorbed substances in the perfused growth media takes place by the high performance chromatography.

Results
In preliminary tests Caco-2 cells and endothelial cells could be successfully cocultivated during a 14-day period on a biological vascularised matrix under physiological conditions in the bioreactor system. Besides first absorption studies on a native small intestine segment were accomplished with peptides in the bioreactor. The peristalsis of the native segment remained due to the physiological bioreactor system by the enteric nervous system during the experimental period from 4 hours. At present further experiments for the functional characterisation of primary intestine epithelium cells are in progress. Perspective: Our aim is the establishment of a three dimensional in vitro test system, which reflect the characteristics of the small intestine for the enforcement of different intestinal absorption studies. Due to the given blood vessel structures in our test system, in the future the oral bioavailability of drugs and active ingredients could be simplified tested by the use of such a model.

This project is founded by a cooperation of the Science to Business Center/Degussa: Creavis Technology and Innovation in cooperation with administrative district NRW and the European Union.

Key Words: small intestine, three-dimensional test system, intestinal resorption, nanoparticles

Social awareness: nano-era arising

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Working on nanotechnology education and research for more than two decades, the authors repeatedly faced students, researchers, industry representatives or common people reactions regarding 'nano' issues. Aware of the *nano-era* impact on all humans' activities: social, economical, political, military, cultural and industrial, or just assuming that sooner or later something wrong could happen in the wild *nano-race* under the Globalization pressure, the targeted groups equally expressed their concern on the nanotechnologies safety. As nanotechnology becomes wider and wider each year, the public awareness increases regardless lack of legislation, standardization or clear ethical limitations. Powered by numerous global actors the nowadays *nano-race* is equally a competency gaining against-the-clock battle and a market conquest war.

So, *nano-era* is already changing definitions not only in materials' science and technology, but also in politics, economy and technology. In this analysis the authors particularly focused their attention on these changes and on their possible harmonized addressing means.

NENNET – High Quality Research Network on Nanosciences, Material and Energy Research in Lithuania

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Profile
R&D integration processes on the EU level motivates Associate Candidate Countries to speed up R&D networking activities. Through the bundling of competences, the integration of industry and society, and the exchange with European partners, the network contributes to the development of a critical mass able to mobilise the resources needed for outstanding research and development and innovation-based growth in Lithuania. This ensures that Lithuania will become an attractive and highly-performing partner in the European Research Area.

Reaching the 3 % GDP goal is an ambitious task that, as one main precondition, requires high public awareness concerning the role of R&D for competitiveness, growth and development. This event is aimed at increasing this awareness through the initiation and moderation of a societal dialogue.

Objectives
NENNET is aimed at increasing public awareness concerning the role of R&D for competitiveness, growth and development through the initiation and moderation of a societal dialogue - for example within the framework of foresight studies or a web-based communication platform. Policy makers and public actors will be directly addressed by, and involved in, the activities of NENNET. In order to reach its ambitious goals, NENNET is based upon four pillars:

- Bundling and integration of scattered R&D activities in Lithuania;
- Development of a cross-disciplinary and application-oriented R&D environment;
- Increasing the application-orientation and links to industry of Lithuanian research;
- Stimulating framework conditions conducive to reaching the above-mentioned goals and creating synergies.

Partners
- Mokslininku sajungos institutas. Competence in self-formation applications in PV and fuel cells, networks management.
- Lithuanian Energy Institute. Competence in hydrogen applications and fuel cells technologies.
- Vytautas Magnus University. Competence in hydrogen applications and fuel cells technologies.
- Semiconductor Physics Institute. Competence in materials science and nanotechnologies.
- UAB Europarama. Competence in networks management.

International partners
- VDI-Technologiezentrum GmbH (Germany)
- CIRCA Europe Group Ltd. (Ireland)
- LORD (Belgium)

Education for industry – understanding nanotechnology masters

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Nanotechnology is widely predicted to affect over a trillion dollars of products within the next 5 to 10 years. However new training and skills are required, and many universities are now offering masters courses in nanotechnology – all of which have a different emphasis. Until now it has been difficult for prospective students and industrial employers to compare what different courses offer in terms of competences.

The Institute of Nanotechnology, in collaboration with a consortium of course-providing academics and industry representatives, has successfully bridged this gap by creating an online Nanotechnology Course Recognition Scheme. This presentation will describe the scheme and highlight the different courses available to students and industry across the EU, and how these courses fulfil different education and training needs.

Standards for SFM and nanoanalytical techniques

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Many techniques advance further into the sub-micrometer and the nanometer range. With the continuing miniaturization in many industries and the evolvement of novel key industries such as nanotechnology, many high resolution measurement methods are increasingly used not only in research & development, but rapidly introduced for quality inspection and failure analysis, e. g. in semiconductor fabrication. Consequently, suitable standards are urgently needed for the characterization & traceable calibration not only for purely dimensional measurement techniques such as AFM, but also for high-resolution spatial-chemical/analytical methods.

In several joint projects, different divisions from PTB as National Metrology Institute (NMI) of Germany and BAM (Federal Institute for Materials Research & Testing) are developing novel standards and reference samples with others NMIs worldwide and the relevant industries. Many of these standards are being discussed for inclusion in guidelines (e. g. VDI/VDE) and international standards, e. g. within ISO.

For dimensional calibration e. g. of Scanning Probe Microscopes (SPM) [1], a novel 3D standard has been developed by BAM and PTB, which uses sub-microscopic features as nanometer-sized landmarks. Unlike step height and lateral standards already established, this new method allows a complete 3D calibration with just one type of standard, i. e. the coupling of all three axes can be determined easily and automatically corrected [2] This novel 3D standard has proven to be well suited also for other high-resolution microscopy techniques such as stereo-photogrammetric SEM and Confocal Laser Scanning Microscopy (CLSM).

Standards for the calibration, beam alignment & resolution determination of spatial-analytical instruments such as Energy Dispersive X-Ray Spectroscopy (EDX), Secondary Ion Mass Spectrometers (SIMS) and Auger Electron Spectroscopy (AES) should show clear material contrasts while being topography-free.

Two different concepts have been realized at PTB and BAM with success: Firstly, a system of alternating layers of well-defined thicknesses in the range from a few nm to several hundred nm has been deposited by MOVPE, which is then cleaved so that a 1D stripe pattern becomes accessible [3]. Special polishing techniques ensure that the cleavage face is topographically flat.

Secondly, 2D analytical standards have been fabricated by placing patterns of well-defined geometry and size consisting of metal A (e. g. Au) in an environment of metal B (e. g. Ag) in a process involving several sophisticated lithography steps in order to avoid topographic steps at the A/B transition. While AFM is used to check to what extend these samples are really topography-free and to calibrate their lateral scales, these standards are now used by AES and EDX manufactures as high-resolution reference samples.

The talk/poster aims to show novel developments, discuss the challenges faced in high-quality fabrication of such nanostandards and illustrate the physical background of their application in high-resolution instruments.

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ISO standardisation in nanotechnology – terminology and definitions

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International standardization will play a critical role in ensuring that the full potential of nanotechnology is realized and safely integrated into society. Three categories of standards are proposed initially by ISO/TC 229:
- terminology and nomenclature standards provide a common language for scientific, technical, commercial and regulatory processes;
- measurement and characterization standards provide an internationally accepted basis for quantitative scientific, commercial and regulatory activities;
- health, safety and environmental standards improve safety, security, consumer and environmental protection, promoting good practice in the production, use and disposal of nanomaterials, nanotechnology products and nanotechnology-enabled systems and products.

Many of the standards produced by ISO/TC229 will be anticipatory as nanotechnology is still in the early stages of development and evolution [1]. The development of standards for measurement and characterisation and health and safety cannot be completed until consensus on terminology and a controlled vocabulary and nomenclature is reached. A key part of the strategy for WG1 'Terminology and nomenclature' of ISO/TC 229 is to develop a framework and roadmap for a controlled, first vocabulary, based partly on the results of the Strategy Task Group survey. Initial analysis of the survey shows that there is a high priority and high urgency for generic nomenclature standards for nanoparticulates and nanotubes.

An Active Work item on Nanoparticles – Terminology and Definitions is already underway – AWI TS 27687. Its scope is to define and develop unambiguous and uniform terminology and nomenclature in the field of nanotechnologies to facilitate communication and to promote common understanding.

To create an unitary standard, this terminology and definitions document will encompass terms used in both nanosciences and nanotechnologies concerning nanoparticles. It will provide an up to date listing of terms and definitions relevant to the area. It will form one part of a projected multi-part terminology and definitions document covering outstanding aspects of nanotechnology.

The plan for the 2007 includes 3 new work items,
- one on general terminology for nanotechnologies,
- one to develop a terminology framework for nanotechnologies, and
- another on terminology for nanomaterials.

[1] Business plan of ISO/TC 229 'Nanotechnologies' Doc. N162, 2006

Traceable measurements for nanoparticle characterization

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In the growing field of industrial produced nanoparticles the characteriszation of such nanoparticles gets an increasing importance, e. g. in pharmaceutical industry. To fulfil legal and also quality requirements physical and chemical measurements are carried out. Typical parameters are particle size and size distribution, shape, chemical composition or even the number of particles in a given volume resp. volume flow. For this reason industry (and also society) needs traceable measurement techniques to provide comparable characterisations of nanoparticles.

In the field of metrology for nanoparticles PTB is planning to realise traceability chains for physical and chemical measuring techniques. A broad variety of high accuracy and precise measurement facilities including AFM, SEM, optical and chemical measurement techniques are available at PTB and can be applied for this purpose. In a first step, size measurements of nanospheres are projected. PTB is further interested in research to realize traceability for combined physicalchemical measurements, e. g. to determine the chemical species on the surface of carbon-particulate matter. This work will be carried out amongst others in cooperation with other European metrology institutes in the framework of EURAMET, which is the federation of all European metrology institutes. In addition it is intended to co-operate with industry to provide internationally accepted standards, where they are needed.

Aspects on the standardization of the experimental characterization and specific parameters of nanoelectromechanical actuators and manipulators

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At the Moment there is no standardization method for MEMS and NEMS. This is a significant problem for the industry and economy and should be addressed soon. The authors propose a check list and a paper concerning the development of this topic.
The authors propose an experimental method for the standardization of nanoelectromechanical actuators and manipulators.
In general nanoactuators and nanomanipulators are characterized by parameters as dimension, mass, linear and angular speed, torque, force, displacement and friction. These should be measured by the appropriate method.

The proposed standardization system consists of three parts:
- O: standards for nanoelectromechanical terms, notions and specific definitions.
- A: standards for static measurements
- B: standards for dynamic measurements

The authors comment on the subdivision of these main standardization directions.
In direction O a clear distinction between the functional principles of nanoactuators (electromagnetic, piezoelectric, magnetostrictiv...) should be made.
Furthermore the authors discuss why the parameters mentioned in A and B are reasonable and suggest measurement methods.

Finally the paper gives an overview of the complete structure of the field of electromechanical nanoactuators and nanomanipulators.

Intercomparability of continuous particle number - based measurement techniques for nanotechnology workplaces

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Human exposure to nanoparticles has raised increasing interest, since recent studies have indicated that adverse health effects can be associated with inhaled nanoparticles. Different instruments exist to measure airborne particle concentrations and size distributions. For nanoparticles, these devices comprise e.g. condensation particle counters (CPC's) for the determination of the total number concentration and electrical mobility analyzers, such as scanning (SMPS's) or fast mobility particle sizers (FMPS's) that measure the number size distribution of airborne particles. These instruments can provide useful means to assess the human exposure to nanoparticles, e.g. in nanotechnology workplaces, where nanoparticles are produced, handled, or processed. Intercomparability studies under various conditions concerning instrument settings and operators among these instruments from different manufacturers are therefore crucial in view of standardization and the discussion of legislative issues. In this study, we challenged altogether seven instruments (4 different SMPS's, 2 handheld CPC's, 1 FMPS) with both intentionally produced and ubiquitous ambient particles. Intentionally produced particles included sodium chloride (NaCl) and Diesel soot that were mixed with dilution air in a wind tunnel and sampled from a 25 m^3 sedimentation chamber. The sample conditioning assured a homogenous distribution of the particles such that all instruments could be assumed to sample identical aerosols. Diesel soot and NaCl were chosen as test materials as these exhibit very different particle morphologies which might affect the measurement. While NaCl usually forms cubic particles, Diesel soot particles are complex agglomerates. Ambient particles were sampled over night directly from room air with no activities within the room. Size distributions of the different test aerosols are illustrated in Fig. 1.

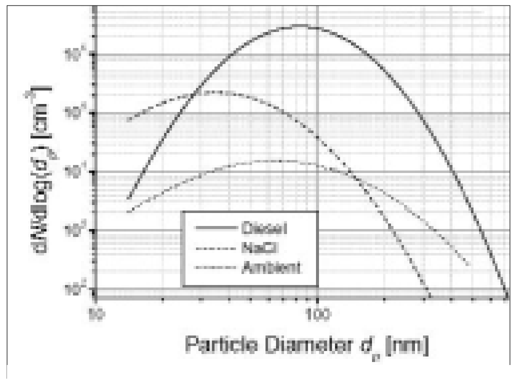

Fig. 1: Size distributions of test aerosols

Mode and median diameter, geometric standard deviation, and peak concentration of the size distributions, as well as the size resolved ratios of the concentration values were subject to a detailed intercomparison stud. The total number concentrations obtained from the different size distributions were compared with the concentrations measured with the CPC's within the size detection limits of the CPC's. The results of this comparison study will be presented and the implication of the resulting uncertainties discussed towards implementation into standardization.

This work has been funded by the German Federal Ministry of Education and Research (BMBF) as part of the *NanoCare* project.

Literature search – methodology of testing fate and effects of nanoparticles

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Nanotechnology has been identified as the technology of the future. Information concerning the environmental impact of nanoparticles, however, is still low and suitable methodologies for the environmental testing of nanoparticles are lacking. One reason for this is that standardized test systems commonly applied to characterize the fate and effects of conventional chemicals primarily have been developed to test soluble substances. These methodologies have to be adapted to the needs of nanoparticle testing. As the results of the investigations probably will strongly depend on the methodology applied, method development for testing nanoparticles poses a special challenge.

Nanoparticles are characterized by various parameters, such as chemical composition, size and crystalline structure. Testing all of the resulting numerous combinations will be impossible. Moreover, it is already known that at least some nanoparticles tend to agglomerate in suspension, which might influence the results as well. Therefore, general principles concerning fate and effects have to be elaborated, and results obtained for specific combinations have to be transferred to further combinations. To increase the comparability of results elaborated by different working groups, a harmonized procedure is necessary.

The investigation of fate and effects of nanoparticles requires an intensive cooperation of different disciplines. Whereas for conventional chemicals the cooperation of chemists and biologists may be sufficient, fate and effect studies of nanomaterials also require the expertise of physicists. Furthermore, the industry has to be involved by supplying relevant nanoparticles.

Several investigations have already been published and according to experience, the number of papers will increase exponentially. To base further experiments on already existing knowledge, available experience should be summarized and evaluated at an early stage. It is expected to obtain at least the following information:
- Suitable procedures to obtain stable suspensions
- Methods to characterize the suspensions/agglomerates of the nanoparticles
- Parameters known to influence the test results (e.g. addition of salts results in a modification of the agglomerates)
- Parameters regarded necessary to be determined and reported
- Suitable reference substances

By the envisaged compilation of information, gaps in knowledge and methodology will become obvious and respective investigations can be initiated. Concerning the fate of nanoparticles in soil and effects in aquatic organisms (especially in daphnids and algae) the existing methodology is being compiled. The obtained results will be presented.

Characterization methods in the nanoworld-problems, mistakes and solutions

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Nanomaterials have triggered a revolution in the world of functional materials expanding the options to tailor materials properties far beyond chemical composition, porosity and composites.

To quantify the effect of different synthesis parameters on the material's properties the novel materials have to be characterized. Hereby, well established methods are mostly applied. However, in case of nanostructured materials the unquestioned confidence in these 'standard' techniques can lead to crucial experimental artefacts and misinterpretations of data. This is mostly due to the underestimation of the increase of interactions with the decreasing size of the structural entities within the nano-system under investigation. Thus 'new' effects seem to appear once the characteristic dimension fall short of the magic length scale of 1 micron. Only a careful revision of the boundary conditions and the impact of the underlying physics of the experimental method will reveal potential flaws. If well understood, the 'artefacts' can be used in some cases to even extract additional valuable information on the nanostructured materials.

We give several examples for misinterpreted 'side-effects' such as

- the large deformation of highly nanoporous material upon gas adsorption measurements (micro- and mesopore effects),
- the compression of compliant nanoporous materials upon characterization with mercury porosimetry (macro- and mesopore effects),
- the interpretation of Infra-red spectroscopic measurements in terms of extinction,
- evaluation of the gas barrier properties of novel coatings,

and discuss modified or alternative data evaluation techniques and experimental methods such as

- thermal conductivity measurements of open porous materials at high gas pressure,
- simulantaneous ad-/desorption and length change measurements,
- high resolution and gas pressure dependent gas permeation measurements and
- NMR-imaging.

Raman study of ceria based nanomaterials for solid oxide fuel cells

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Among the electrolyte materials that have been widely employed in the fuel cells ultrafine ceria (CeO_2) powders represent an important material due to the cerium's ability to change valence states and intrinsic oxygen vacancies can be produced in CeO_2 lattice. Ceria doped with rare earth oxides is a promising candidate for solid oxide fuel cells (SOFC) because it exhibits higher ionic conductivity at lower temperatures. The vibrational properties and phase transformation of doped ceria nanopowders as a function of temperature were examined by Raman spectroscopy over the temperature range 293-1400 K (Fig. 1). Raman spectroscopy can be a rapid and effective tool in monitoring nanocrystalline particle size and size distribution. Raman scattering technique demonstrated its capacity to be used for phase diagram investigations of these nanomaterials, as well as for the detection of presence of intrinsic and introduced oxygen vacancies whose concentration increases with doping. From the temperature-induced changes in these materials we detected that only in Nd doped samples there is an increasing intensity of Raman modes ascribed to extrinsic and intrinsic oxygen vacancies. Such a behavior can have a significant implication of Nd-doped ceria in fuel cells.

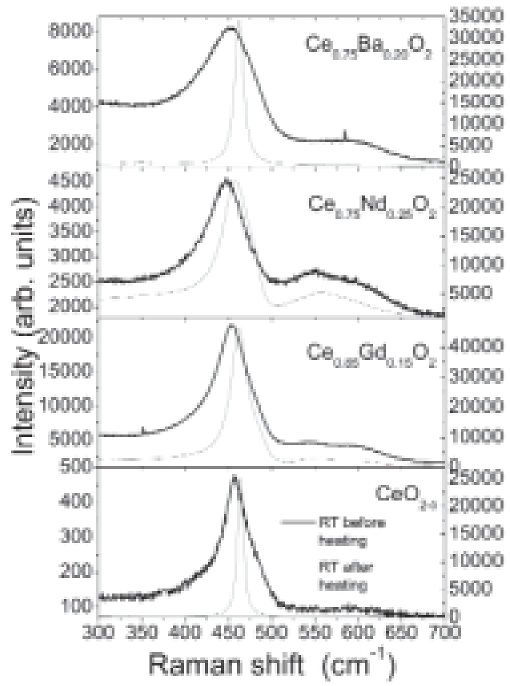

Figure 1. Raman spectra of cerium ox-ide-doped samples at room temperature before and after annealing at 1000°C.

Application of transmission electron microscopy for characterization of nanostructured materials

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A technique of transmission electron microscopy combines the highest resolution power and the ability to provide a large information data on morphology, composition, ideal and defect crystal structure of nanomaterials. Despite being labor-consuming its use is considered as necessary to obtain the most trustworthy knowledge of structure related data of nanomaterials.

Mixed-valence perovskite oxides are materials displaying a number of interesting and important in practice phenomena such as metal-insulator transitions, superconductivity with high critical temperature, a colossal magnetoresistance effect. This paper reports about results of electron microscopic studies of bulk perovskite and related to them oxides on the basis of bismuth or copper. It is found that bulk oxides formed under two-phase synthesis conditions can be nanostructured materials consisting of intergrown off-orientated nanocrystallites of different phases. Such materials are described under structural studies as single-phased but, in fact, they are two-phased at least. This shows a limited nature of transmission electron microscopy for structural characterization of such nanomaterials and possibly other ones which must be taken into account for nanotechnology development.

The financial support from ISTC (project 3357) is acknowledged.

Applications of the magnetosomes of magnetic bacterium in nanobiological manipulators

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The specific structural characteristic of magnetotactic bacteria (MTB) is the presence inside the cell of particles named magnetosomes which are magnetic nanocrystals. Magnetosomes, with nanometric dimensions, are defined as intracellular, magnetic single domain crystals of a magnetic iron mineral which are enveloped by a membrane.

The use of isolated magnetosome can be a solution for a nanobiological manipulator structure.

The authors propose a biotechnology of formation that alternative of typically technological process of nano size magnetic particles:
- the milling powder method;
- the chemical synthesis method.

The new magnetosome nanomanipulators can be drive in magnetic field (because the nanomagnetic moment) and represent a interesting solution for drug transport application in biological structure .

The authors present also, some nanostructure of this nanomanipulators and theoretical and experimental considerations on:
- Determination of the magnetic moments.
- The static and dynamic of this nanomanipulators.
- Magnetic characteristics and control with this characteristics of the biological technology of the magnetosomes.
- Critical magnetic level for manipulation.
- An algorithm of production of magnetosomes.

Nanocrystalline TiO_2 using ionic liquid assisted photocatalytic degradation of azo dyes in aqueous solution

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The waste water generated by the textile industry contains considerable amount of azo dyes. Various methods have been applied for the removal of colored compounds but these methods are associated with the fact that they are not destructive and their action is limited to transfer of the pollutant from one phase to another. Thus, there is a need to develop new technologies that would be more effective in elimination of dyes: from the waste stream. TiO_2 photocatalysis is currently accepted as one of the most promising technologies for the destruction of commercial dyes. In this project, we focus on using an effective template, ionic liquid, in sol-gel method to prepare photocatalyst with small grain size,controlled porosity,and tailor-designed pore size distribution. In addition, ionic liquids are receiving much attention as environmentally benign solvents.

Therefore, nanocrystalline TiO_2 was synthesized by a modified sol-gel method with 2-hydroxy ethyl ammonium formate ionic liquid and the structural properties of TiO_2 particle were determined from the nitrogen isotherm at 77 K. The XRD patterns were collected with a D4 X-ray diffractometer using CuKa to determine the crystal structure and crystallinity of TiO_2 particles. Samples prepared with ionic liquid show significantly higher photocatalytic activity compared to commercial photocatalyst degussa p-25 consisting of an anatase/rutile proportion of 70/30 under similar conditions.

Impact of nanotechnology on the German energy sector

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Abstract
In regard to finite resources and in view of the global climate change, sustainable development in energy supply gains importance. In addition to the optimization of conventional technologies and the use of renewable energies in this context new technologies and innovations get more important. The described work analyses innovative products and processes based on nanotechnology, with respect to the German energy industry. In addition the following analyses includes nanotechnological applications from other economic sectors that lead to a reduction in energy consumption.

Nanotechnology
Nanotechnology deals with structures and methods on nanometer scale (10^{-9} m). The essential finding here is that the nanometer scale of materials leads to so far unknown characteristics we should benefit from for new product and process innovations. As a so called cross section technology the nanotechnology is used in various industry branches and the interest of the energy sector in this technology is huge. The use of nanotechnology in existing energy technologies by improved and functionalized materials can lead to an increase in energy efficiency.

The described work analyses innovative products and processes based on nanotechnology, with respect to the German energy industry. The description consists of a qualitative analysis of implications of nanotechnologial applications and a potential analysis based on scenarios that calculate the changes in energy consumption, under the influence of nanotechnology, until the year 2025. The quantitative analysis exhibits the potential of nanotechnological applications to reduce the energy consumption in Germany. Nanotechnological applications with impact on the energy industry are identified and illustrated. Based on this qualitative description the impacts of nanotechnology on the energy industry are calculated using different scenarios. Therefore eight representative nanotechnological applications are selected and modelled. The potential analysis consists of four different categories.

In the transport category the use of fuel cells, the fuel additive Ceroxid, nanoparticels in tires, supercaps in hybrid buses and LEDs for automobile lightning are analysed. The illumination category deals with the influence of LEDs for multiple coach lighting. In the heat generation category the application of stationary fuel cells for heating and energy production in private housings is matter of the analysis and the use of vacuum isolation panels (VIP) for isolation is analysed in the category heat consumption. For a sensitivity analysis three different scenarios (Base, Plus, Minus) are used to describe the incertitude of the assumptions in regard to the possible development of nanotechnological applications until 2025. The 'Base' scenario describes the most likely development. By variation of parameters for example market penetration or improvement of efficiency the scenarios 'Plus' and 'Minus' are calculated.

As a first result of this potential analysis it can be said that the use of the analysed applications in the scenario 'Base' lead to a reduction in the energy consumption of 283 PJ until the year 2025 based on a total energy consumption of 9237 PJ in 2004 what is equal to a reduction of 3.1 %. This reduction is only due to the use of the described applications. The analysis was done without a variation of other parameters of a portfolio. This first potential analysis shows that it takes a long time also for close to market applications to result in significant energy savings. In regard to the challenges concerning the use of energy it is necessary to work intensely and prompt on the development of innovative energy technologies to solve these given challenges. Nanotechnology is not going to change the energy sector radically but with

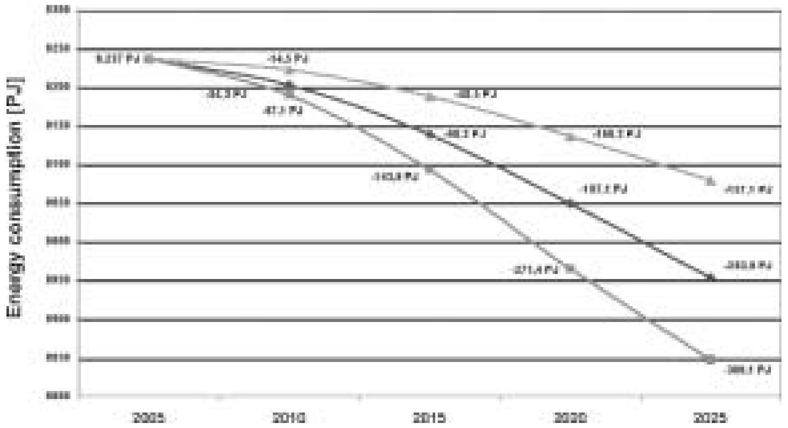

Figure 1: Development of total energy consumption of the three scenarios from 2005 to 2025

the development of innovative products, processes and applications it is going to make a contribution to the rational use of energy.

Colored silica nanoparticles as potential pigments

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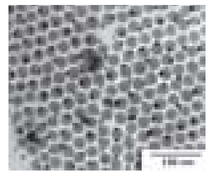
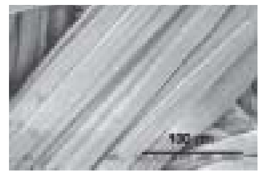
There is an interest in extra small transparent pigments for achieving special effects and coloration for textiles, paper, cosmetics and plastic materials. Fluorescent silica nanoparticles has attracted great interests because of their distinctive properties and potential applications in biological and analytical fields (e.g., in microscopy), in sensor, in optical computing or information technology, or as markers in safety areas (makers for bank notes or passports). Compared with other materials, silica nanoparticles possess several advantages – simple method of preparation, easy route of surface modification and functionalization, nontoxicity and stability etc. – which makes dye-doped silica nanoparticles show great promise in various applications. Here, we attempted to valuate the potential of such nanoparticulate dyed pigments for coloration.

Monodispersed silica nanoparticles are prepared by Stöber and microemulsion procedure. Organic and inorganic dyestuffs can be encapsulated into silica matrix by physical adsorption or chemical binding. In order to chemically bind organic dyestuffs into inorganic silica matrix, the dye molecules have to be modified first by suitable silanes depends on which kind of functional groups they have. The covalent attachment enables to enlarge the incorporated amount of organic ingredients, reduces dye leaching problems, and in some cases, leads to stabilizing effects. The silica particles doped by photochromic dyestuffs show color change effects. In addition, nanoparticulate noble metals are also embedded as chromophore into silica matrix taking advantage of the strong surface plasma band. The size and composition of the particles can be controlled precisely. Further modification and functionalization of these particles can also be performed for special applications. Primary research of applying these particles on textiles has been done.

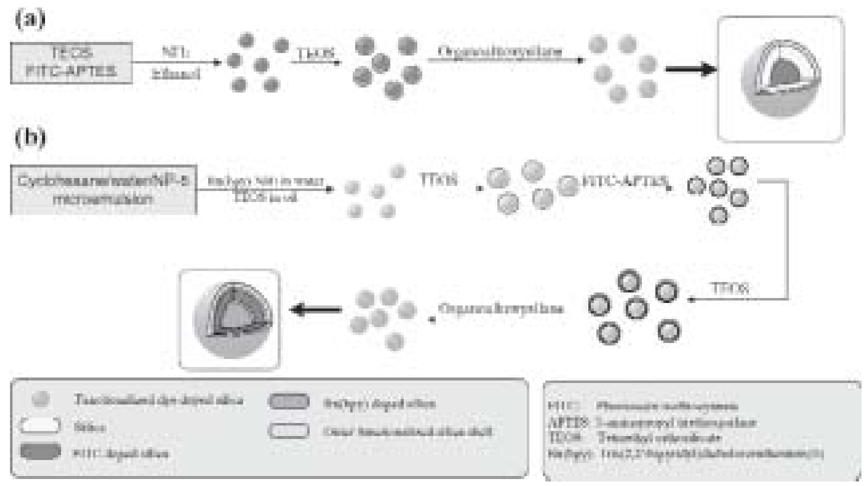


Ru(bpy) doped SiO_2

Wool



Polyamide



Incorporation of aquaporins in membranes for industrial applications

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In all living cells, channels transporting water – aquaporins – exist. Aquaporins are proteins, which only transport water, i.e. , pure H_2O molecules. Since the late 1990s, research in aquaporins in various organisms and tissues have intensified. Aquaporins have a unique selectivity and are extremely efficient being nature's own water transporting systems. Membrane for industrial filtration and separation processes using membrane technology is another rapidly growing technology. The purpose of the MEMBAQ research project under FP6 in the area of nanotechnologies and nanosciences (NMP programme of FP6) is to combine these two research spearheads with focus on industrially exploiting the unique features of biomimetic membranes. This is done by incorporating recombinant aquaporin molecules in different types of industrial membranes for water filtration. Combination of aquaporin research and membrane research with focus on industrial processes has never been done before and is indeed radical cross-cutting innovation at the frontier of today's knowledge.

Global needs for pure water and renewable energy are drivers for the initial test applications of the new biomimetic membranes. Membranes for water purification, wastewater reclamation and re-use, and salinity power production will be designed and tested. Future applications could be industrial use within filtration and separation of fluids and gasses other than water using other types of 'selective' recombinant proteins. Thus, the project will also stimulate further research and technology development in nano-biotechnological membranes.

Nano-FIB from research to applications – a European scalpel for nanosciences

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The interactions between energetic ions and solids lead to well-known processes that are widely used to modify the topography, crystallography or electronic properties of the irradiated target. These effects are widely exploited in microelectronics like ion etching and doping applications. Focused Ion Beam (FIB) is a technology that is extending these capabilities. Nowadays FIB instruments combining etching and deposition have become indispensable in such fields as failure analysis, transmission electron microscope (TEM) sample preparation.

We will describe our specific iterative effort started under the Nano-FIB EC project combining developments in liquid metal ion source geometries and research in ion optics specifically for high-resolution applications, together with ion induced damage fine characterisation. Our objective was to demonstrate that the Focused Ion Beam technique could be a challenging technique for nanotechnology. We were anticipating that lateral patterning of structures having one nanometre-sized dimension (thickness) with FIB would no longer rely on sputtering effects with high local incident dose ($> 10^{16}$ ions/cm^2), but rather on local defect injection and surface modifications of high crystallinity substrates [1].

We will present our work aiming to explore the nanostructuring potential of a highly focussed pencil of ions. We will show that Focused Ion Beam technology (FIB) is capable of overcoming some basic limitations of current nanofabrication techniques and to allow innovative patterning schemes for nanoscience. In this work, we will first detail the very high resolution FIB instrument we have developed specifically to meet nano-fabrication requirements. Then we will introduce and illustrate some new patterning schemes we have proposed for next generation FIB processing. These patterning schemes are ranging from nano-engraving to local defect injection via the functionalisation of substrates to selective epitaxy of semiconductors. Thus demonstrating that FIB patterning is fully compatible with 'bottom-up' or 'organisation' processes [1].

Finally we will present the potential of our instrument now capable to fabricate **directly** nano-pores with diameters below **5 nm**. To our knowledge this performance is defining a new state of the art in direct removal of particles using a focused charged particle beam.

[1] Exploration of the ultimate patterning potential achievable with high resolution focused ion beams, J. Gierak , D. Mailly, P. Hawkes, R. Jede, L. Bruchhaus, L. Bardotti, B. Prével, P. Mélinon, A. Perez, R. Hyndman, J.-P. Jamet, J. Ferré, A. Mougin, C. Chappert, V. Mathet, P. Warin, J. Chapman: Appl. Phys. A, 10.1007/s00339-004-2551-z (2004)

Organic PV cells, electricity collected from plant photosynthesis – feasibility and demonstration

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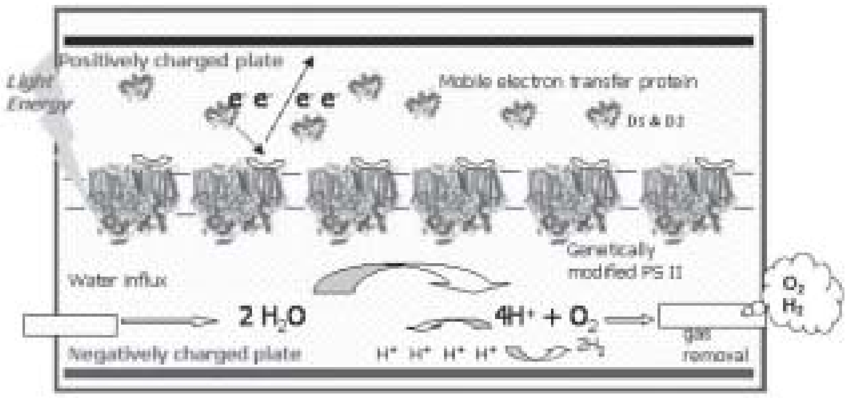
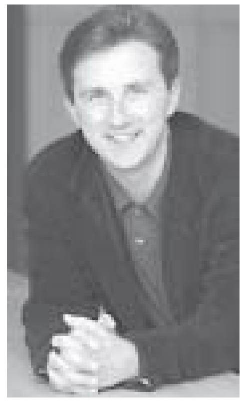
The main objective of this project is to demonstrate and develop new potential source of natural energy (electricity) by photosynthesis, and directly from living (inedible) plant. The electricity capacity will be evaluated based on various plants nature, and time for sunlight exposure. In this project, a new method for electricity current collection, based on micro-electrophysiology patches 'on plant', will be devolved and tested to optimize for the selected plant crop. A new genetic engineered plant, for high quality electricity current release, will be selectively tested and developed for best choice of growing line at in the field. The project combines information science, chemical and electric engineering, microbiology, plant cell and molecular biology, plant breeding, and integrates research with industrial R&D, to develop a novel, sustainable, renewable energy technology. The principle of the breakthrough is a photosynthetic plant extract, incubated in the sunlight, in which a genetically improved electron transport chain (E-chain) linked into a semiconductor element via an electron carrier protein (E-protein) will transport sunlight-excited electrons to generate electricity. The input of the planned system is sunlight, soil and water, while its output is electric power. The by-products, oxygen and hydrogen, will be collected for industrial use, and discharged plant extracts will be transformed to a fertiliser for crop farming. Thus, the project is characterised not only by its innovative technology, but also by its **sustainability** – completely free from any pollutants – and its circular economy. The **scientific outcome** of the project is a new concept and knowledge of solar energy conversion via the E-chain.



1. Voltage range of photosynthetic compounds

Oxidized	Reduced	Number of electrons transferred	Redox potential (Volts)
$X(Fe_4S_4)$	X^-	1	-0.73
$1/2O_2 + H_2$	H_2O	2	+0.82

Thus, a potential difference between -0.73 and +0.82 = 1.55 volt in any single step is significantly higher than in any photovoltaic cell available.

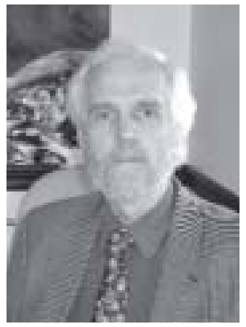


Nanotechnology: markets, potential and future applications (Opening session)

Donald Fitzmaurice

Donald Fitzmaurice is a Director of the General Partner of ePlanet Fund II based in the fund's London office. Donald is also an Adjunct Professor at University College Dublin. With over one hundred and fifty publications and patents to his name, he is established as a leading researcher in the field of nanotechnology. Recently, he was elected a member of the Royal Irish Academy and was awarded the Boyle-Higgins medal. He founded a number of start-ups to exploit his research including NTera, an innovative display company, and TopChem, a company developing specialized process technology to the pharmaceutical sector. Currently, Prof. Fitzmaurice is serving his third term as a member of the Science, Technology and Innovation Advisory Council, the body responsible for advising the national government on scientific developments. In his capacity as a Venture Partner in the ePlanet Fund I, he led the investments in HPL, SpinX and BiancaMed. Donald's interests extend beyond nanotechnology, to the two other key enabling technologies – biotechnology and information and communication technology. He is particularly interested in the convergence of these key enabling technologies and the emergence, as a result, of innovative and disruptive technologies that address the unmet needs of major markets.

Needs for and status of standardization for nanotechnologies (Plenary session 2)



Peter Hatto
Dr. Peter Hatto is the Chairman of ISO/TC 229 – Nanotechnologies, which was established in June 2005. He is also Chairman of the UK National Committee and was Convenor of the CEN Technical Board Working Group (CEN/BTWG 166) on Nanotechnologies, which delivered a strategy for European standardization to CEN in 2005. Peter is Director of Research for IonBond Ltd, a leading producer of advanced, thin film ceramic coatings. His research activities have covered subjects ranging from erosion protection for aircraft engines to osseo-integration of dental and orthopaedic implants, including two major collaborative projects focused on nanotechnologies, the most recent of which has been awarded over €11 million of funding from the European Commission. In addition to his standardization work on nanotechnologies, Dr. Hatto is also convenor of working groups developing standardized test methods for ceramic coatings within both CEN and ISO.

NanoDialogue: recommendations to achieve sustainable governance and social acceptance (Plenary session 2)

Wolfgang M. Heckl
Wolfgang M. Heckl is the Director General of the Deutsches Museum and professor of experimental physics and nanotechnology at the University of München (LMU) with a special interest in the field of organic self-assembly and the origin of life. His academic teachers are Nobel Prize winners Gerd Binnig and Theodor Hänsch.

As a dynamic and charismatic science communicator he received the *Communicator Prize* in 2002 from the German Science Foundation and was awarded the first European *Descartes Prize for Science Communication* in 2004.

Nanotechnology as a platform for innovation areas (Plenary session 1)

Péter Krüger
Bayer Working Group Nanotechnology, Bayer MaterialScience AG
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Since June 2006 Dr. Péter Krüger is heading the Bayer 'Working Group Nanotechnolgy' with the responsibility for the global coordination of all nanotechnology activities in all Bayer Subgroups and Service Companies with a reporting line to the 'Coordination Board Technology, Innovation and Environment' of the Bayer Holding.

During his 14 years with Bayer he held several positions in R&D, starting as a research scientist for polymer physics of thermoplastics within the Physics Unit of the former Central Research. Later he took over the responsibility for the entire Polymer Physics Department within the Central Research and in Bayer Polymers as well.

Péter Krüger was born in Budapest, has studied physics at the Technical University of Braunschweig and finalized it with Master Thesis in theoretical quantum mechanics. He obtained his PhD in Braunschweig for his research in the area of experimental physics and material sciences on the field of the relaxation and crystallization of amorphous metallic glasses.

He is married and has a daughter and two sons.

Possibilities for a global governance of nanotechnology
(Plenary session 2)

Mihail C. Roco

Dr. Mihail C. Roco is the Senior Advisor for Nanotechnology at the National Science Foundation (NSF) and key architect of the National Nanotechnology Initiative. He chairs the Nanotechnology Group of the International Risk Governance Council. Dr. Roco is credited with 13 patents and has contributed over two hundred articles and fifteen books, including 'Nanotechnology: Societal Implications – Maximizing Benefits to Humanity' (Springer Science, November 2006), significantly advancing the body of literature in the field. Dr. Roco coordinated the preparation of the U.S. National Science and Technology Council (NSTC) reports on 'Nanotechnology Research Directions' (NSTC, 1999) and the 'National Nanotechnology Initiative' (NSTC, 2000). Under his stewardship the nanotechnology federal investment has increased from about $3 million in 1991 to $1.3 billion in 2005/2006. Prior to joining the National Science Foundation, he was a Professor of Mechanical Engineering. His research included experimental and simulation methods to investigate nanoparticles and nanosystems. He is the Editor-in-chief of the Journal of Nanoparticle Research. Dr. Roco is a Correspondent Member of the Swiss Academy of Engineering Sciences, Fellow of ASME, Fellow of AIChE, and Fellow of Institute of Physics. Forbes magazine recognized him in 2003 as first among 'Nanotechnology's Power Brokers' and Scientific American named him one of 2004's top 50 Technology Leaders. In 2005, he received the AIChE Forum award 'for leadership and service to the national science and engineering community through initiating and bringing to fruition the National Nanotechnology Initiative.' He is a member of several honorary boards and was elected Engineer of the Year by the U.S. Society of Professional Engineers and NSF in 1999 and again in 2004.

Future of nanoelectronics in industrial applications
(Plenary session 1)

Alfred J. van Roosmalen

Dr. Alfred J. van Roosmalen is vice-president and general manager government and industry relations of NXP Semiconductors. In this position, he leads the company's worldwide network with industry and public bodies for leveraging R&D, standardization, business development, and academia programs. He chairs the ENIAC working group for the strategic research agenda in Nanoelectronics and the program board of the Dutch competence cluster Point-One, and represents NXP in the European industry's MEDEA+ board support group. Previously, he has chaired the SEMATECH executive steering council and the European ITRS committee, and participated in the IMEC scientific advisory board and the EC advisory group on human resources and mobility.

Alfred has a M.Sc. in Chemical Technology from the Technical University Eindhoven (NL) and received a Ph.D. in Mathematics and Physics from the University of Amsterdam (NL). He joined Philips in 1980, where he has worked with the Research, Flat Panel Display, and Semiconductors divisions. Presently, he is based at NXP Semiconductors corporate headquarters on the Eindhoven High Tech Campus.

Targeted nanomedicines (Plenary session 1)

Gert Storm

Professor Gert Storm studied biology at the University of Utrecht, The Netherlands. He graduated in 1983. He obtained his Ph.D. degree in 1987 at the Dept. of Pharmaceutics of the same university on a thesis entitled: 'Liposomes as delivery system for doxorubicin in cancer therapy'. In the same year he was appointed as a faculty member. His research interests are in the fields of biopharmaceutics and drug targeting. From September 1988 until June 1989 he was a visiting scientist at Liposome Technology Inc. in Menlo Park, USA, and visiting assistant professor at the School of Pharmacy, Dept. of Pharmaceutics, Univ. of California, San Francisco, USA. From February 1990 until September 1991 he was senior research scientist at Pharma Bio-Research Consultancy B.V. in Zuidlaren, The Netherlands. During this period he contributed to the design, co-ordination and evaluation of clinical pharmacological studies. In September 1991 he took up his present position. In 1999, he was appointed adjunct professor at the Department of Pharmaceutics, Royal School of Pharmacy, Copenhagen. In 2000, he was appointed as professor (Drug Targeting chair) at Utrecht University. He is author/co-author of over 240 original articles, reviews and book chapters, in the field of advanced drug delivery/drug targeting (in particular with liposomal systems). He is co-ordinator of an Integrated Project on targeted nanomedicines (MediTrans) based on the collaboration of 30 European partners and funded by the EC and industry. He was theme co-editor of Advanced Drug Delivery Reviews and co-editor of the book 'Long Circulating Liposomes. Old Drug, New Therapeutics'. He is involved in organizing conferences in the field of advanced drug delivery. He is member of the editorial (advisory) board of the journals Nanomedicine, J. of Drug Targeting, J. of Liposome Research, Eur. J. Pharmaceutical Sciences, S.T.P. Pharma Sciences, and Special Features Editor commissioning minireviews for Pharmaceutical Research. He acts as a consultant to a number of pharmaceutical companies and is on the Faculty of the course 'Liposome Technology', organized by the Center for Professional Advancement.

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Nanosciences and nanotechnologies in the 7th Framework Programme (Plenary session 3)

Renzo Tomellini

Born in 1960. Graduated in chemistry 'cum laude' in Rome in 1986. He worked in Italy as a researcher at the Centro Sviluppo Materiali[1]. He was also visiting researcher in Germany and France. His further education included management and business administration, European law and regulations, and leadership.

After university and industry research, he joined the European Commission in 1991, where was scientific/technical responsible for ECSC[2] steel research projects. Between 1995 and 1999 he was managing the ECSC-Steel research and technological development programme. In 1999 he became the assistant to the director of 'Industrial Technologies' in the Research Directorate-general of the European Commission. Amongst others, he prepared for the provisions to bring to its end the ECSC Treaty and to launch the new research fund for coal and steel (see the Nice Treaty). Meanwhile, since 1999 he promoted initiatives in nanotechnology. Since 2003 he is Head of the Unit 'Nanosciences and Nanotechnologies' and chairs the European Commission's interservice group 'Nanosciences and Nanotechnologies' (that he initiated in February 2000).

He deposited 4 patent applications (a new source for atomic spectroscopy and some innovative sensors), published some 50 articles, drafted 4 standards on analysis and measurements, edited 12 books and 2 as co-author, created one newsletter and 2 webpages, and realised 3 films on science and research issues (and a fourth one is in preparation).

See also: http://cordis.europa.eu/nanotechnology/

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[1] *Centre for development of materials*
[2] *European Coal and Steel Community (historically, the first of the European Communities)*

European Technology Platform on Nanomedicine – a world unique platform on nanomedicine (Session E1)

Patrick Boisseau
M. Patrick BOISSEAU is graduate from the *Institut National Agronomique* in 1983 and from the *Ecole Nationale du Génie Rural, des Eaux et des Forêts* en 1985. He has a Master's Degree in Human Nutrition. He joined the CEA in 1987 to work for 7 years as a researcher in plant biology. He then transferred to the Foresight & Strategy Division at the CEA headquarters where he remained for 4 years as an expert in strategy in life sciences and environment.

Between 2001 and 2004, he managed the **NanoBio innovation centre** in Grenoble, clustering SMEs and researchers from biology and engineering, in the field of nanobiotech. He was in charge of the design, the organization and the funding of this project, in close relationship with the **CEA-Minatec** innovation centre and national/regional authorities.

Since 2004, he is coordinator of the **European network of excellence in nanobiotechnology, Nano2Life** (www.nano2life.org). This network of excellence integrates 23 full academic partners and 41 associate companies in a comprehensive joint programme of activity. More than 400 scientists are participating to this network.

Mandates
- Founded in 2004 of the nanobiotech section at the **European Federation of Biotech**.
- Member In 2004-2005 of the steering committee of the **European Science Foundation Forward Look on Nanomedicine**, responsible for the working group on nanodiagnostics.
- Leader since late 2005 of the working group on 'nanotechnology based diagnostics and imaging' at the **European Technology Platform on Nanomedicine**, and thus member of its Executive Board.
- Experts for several international organizations like **European Science Foundation**, and the **European Commission**.

NanoSci-ERA: Nanoscience in the European Research Area (Session D1)

Guillaume Bourdon
Graduated from the Institut d'Optique Graduate School in 1993 and received a PhD in optics in 1999.

In 1999, joined Corning's Fontainebleau Research Center as a research scientist; involved in the development of SiO_2-based integrated optics devices and processes. In 2003, moved to OpsiTech, a start-up company specializing in the development of planar devices for optical transmission systems.

Since 2005, project manager of NanoSci-ERA, a Consortium of European research agencies and ministries whose objective is the increased collaboration and cooperation between the national nanoscience research communities in Europe.

MNT ERA-Net: Opportunities for Transnational Cooperation in Micro- and Nanotechnologies (MNT) (Session D1)

Roland Brandenburg
Email address: Roland.Brandenburg@ffg.at
Current position held: Coordinator of MNT ERA-Net

Roland Brandenburg is a physicist with several years of research experience in academia and industry. He joined the Austrian Research Promotion Agency (FFG), which is the largest funding organisation in Austria, in 2003. After involvement in EUREKA he took over the coordination of MNT ERA-Net (Micro- and Nano Technologies) which -as one of the largest ERA-NET projects- comprises 20 European countries and regions. MNT ERA-Net has already run its first and second Transnational Calls in 2006 and 2007.

EUMAT- European technology platform for advanced materials and technology (Session E1)

Ulrich Eisele

Studies in Materials Science in Erlangen and Lausanne. PhD in Materials Science from the University of Leeds.

Responsible for ceramic materials and processes as well as nanoceramics at the Corporate Sector Research and Advance Engineering, Applied Research 1 – materials (CR/ARM) of Robert Bosch GmbH.

The quest for ultimate patterning tools and techniques – focused ion beams: Status, future applications and new ideas (Keynote lecture, Session C2)

Jacques Gierak

Born on 12 Aug 1959 in Sedan (Ardennes) France – Married 2 children

Jacques Gierak is the Responsible of the activity 'Ultimately Focused Ion Beams' at the Laboratoire de Photonique et de Nanostructures (LPN-CNRS), he was the co-ordinator of the Nano-FIB project *(Nano-Fabrication with Focused Ion Beams G5RD-CT2000-00344)*. He is involved in FIB research since 1984, as he joined the LPN laboratory now located in Marcoussis (France). He is graduated from the 'Conservatoire National des Arts et Métiers' Paris in the Physics-Electronics dept., owner of a DEA in instrumentation, and of a PhD thesis. The FIB systems developed at LPN-CNRS have all defined in each of the addressed applicative fields, the international state-of-the-art. Recently his team demonstrated sub-5 nm direct patterning capability. This is from far the best patterning performance ever achieved for a FIB system.

Keywords

- Innovation: He is the main author of several international CNRS patents and secrecy collaboration agreements signed with industrial actors that are related to FIB technology, ion sources and nanoscience-oriented instrumentation.
- Collaborative approach: He has a strong interest for true collaborative approach of emerging applications (national and international) with complementary expertises. His team is involved in several collaborations with leading research institutes and high-tech companies.

Career highlights:

1984 Joins CNRS. In charge of developing liquid metal ion sources (LMIS).
1990 Responsible for the development of a dual lens FIB system.
1996 Responsible for FIB activity at UPR020. World record for FIB etching (10 nm).
2001 Coordinator of EU project 'Nanofabrication with Focused Ion Beam' G5RD-CT2000-00344 (2001-2004).
2003 FIB world record brought to 8 nm.
2004 Recipient of CNRS 'Crystal' Award.
2005 Sub-5 nm FIB direct patterning of nanodevices demonstrated
2007 Leader 'sub-nm FIB Project'

Publications and Patents

Author of more than 60 publications, 6 patents and more than 10 invited lectures. These lectures were given over the last 5 years in the most representative international conferences in the field of micro and nanofabrication.

Cancer treatment with magnetic nanoparticles
(Keynote lecture, Session B3)

Andreas Jordan
Dr. Andreas Jordan, who was born in 1959, is the CSO and founder of MagForce Nanotechnologies AG. He began his career with studies in biology at the Freie Universität (FU) Berlin (= Free University of Berlin) and additional studies in biochemistry at the Fakultät für Chemie der Technischen Universität Berlin (= Faculty for Chemistry at the Technical University of Berlin). His doctorate, which was evaluated as 'very good' and completed in 1993, addressed the production of nanoparticles and their use in cancer therapy. The work was based on research projects which were started in 1987 – long before the subject of nanotechnology had achieved international significance. This was followed by work in scientific project management for the Virchow-Klinikum der FU (= Virchow Clinic at the FU) (now the Charité) as well as for the Schering subsidiary 'Institut für Diagnostikforschung GmbH'.

Parallel to the biological work, Jordan also worked - on the basis of the many experimental structures for the animal tests - on developing an alternating magnetic field therapy system, which would later be used to treat patients. In order to finance the entire enterprise, in 1997 Jordan founded "MFH Hyperthermiesysteme GmbH" with venture capital. While the research on basic principles was largely funded by the Deutsche Forschungsgemeinschaft (German Research Association) as part of a special project, MFH Hyperthermiesysteme was involved specifically in product development. To bring the second component of the new cancer therapy procedure into a state of product readiness, Jordan founded MagForce Applications GmbH in 2000 for the production of specific nanoparticles for the new cancer therapy. In 2004 both companies were merged and renamed in MagForce Nanotechnologies.

Andreas Jordan has already given more than 500 scientific lectures about nano-cancer therapy. He authored more than 40 articles for peer-reviewed scientific journals, and cleared the way for a total of twelve international patent families (some licensed). The contacts to NASA, the National Cancer Institute (NCI), the Institute of Nanotechnology (IoN), the American drug licensing authority FDA, and some famous US hospitals, such as the University of California, San Francisco (UCSF), the Cleveland Clinic Foundation (CCF), Duke University, as well as to Asia provided a further foundation for his worldwide engagement.

The NanoCare project - introduction and overview
(Keynote lecture, Session C4)

Harald F. Krug
1978: first state examination in Biology/Chemistry at the University of Kassel (passed with distinction)
1982: doctoral degree at the University of Göttingen, Institute of Zoology (highest degree)
1983: Postdoctoral Stipendium at the GSF Forschungszentrum Munich
1986: Group leader position at the KfK, Institute for Genetics and Toxicology of Nuclides
1996: Head of Dep. of Molecular and Environmental Toxicology
1996: Habilitation 'Umwelttoxikologie' at the University of Karlsruhe
since 1999: Project Manager within the research funding program of Baden-Württemberg BWPLUS (http://bwplus.fzk.de/)
2001-2006: Speaker of the Study Group 'Biochemical Pharmacology and Toxicology' of the GBM (German Society for Biochemistry and Molecular Biology; http://www.gbm-online.de)
since 2002: Academic member of the DECHEMA Working Group 'Responsible Production and Use of Nanomaterials' (http://www.dechema.de/NANOSAFETY.html) and since 2005 member of the steering committee of this working group
since 2004: Member of the Council of the European Academy for the Research on the Consequences of Scientific and Technological Advance (http://www.europaeische-akademie-aw.de) Project Group: Nanomaterials, Nanodevices, Nanocomputing
since 2004: appointed as Referee for the German Federal Institute for Risk Assessment (http://www.bgvv.de)
since 2005: Member of the ISO/TC 229 mirror committee of the DIN, working group 3 'Health, Safety and Environmental Issues' (Secr. USA) - (http://www2.din.de/)
since 2005: appointed as a member of the 'Nanobotschafter', an initiative of the 'Deutsches Museum' in Munich (http://www.nanobotschafter.de/)
since March 2006: appointed as the manager of the consortium 'NanoCare', a research project of the German Ministry for Education and Research (http://www.nanopartikel.info)
September 2006: appointment to the EMPA in St. Gallen (Switzerland) (http://www.empa.ch)
since January 2007: Head of Materials-Biology Interactions at the Empa, St. Gallen
March 2007: appointed as member of the Action Group 'NanoDialog' of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) (http://www.bmu.de/pressemitteilungen/pressemitteilungen_ab_22112005/pm/39021.php)

European Nanoelectronics Initiative Advisory Council (ENIAC)
(Session E1)

Norbert Lehner

Norbert Lehner was born in Würzburg, Germany, in the year 1950. He studied Physics in Würzburg and got there 1978 his PhD. During that time, he worked for more than three years at the Nuclear Research Center in Karlsruhe (Germany) and – after his PhD – for nearly five years at the Institute Laue-Langevin in Grenoble (France). The focus of his scientific work was on Phase Transitions, Phonons and Magnons in Perovskite type crystals.

1983, Norbert Lehner joined the Semiconductor Group of the Central Research Department of Siemens in Munich. Since its carve out from Siemens, he is working for Infineon Technologies. Norbert Lehner was and is deeply involved in most of the large European co-operation programs like the MEGA-project (1984), the Framework Programs of the European Commission as well as in the EUREKA programs JESSI, MEDEA and MEDEA+. Some of the major projects, he was involved or leading, were on lithography and on the development of 300mm wafer technology. Actually, he is chairman of the Support Group of ENIAC, the Nanoelectronics European Technology Platform.

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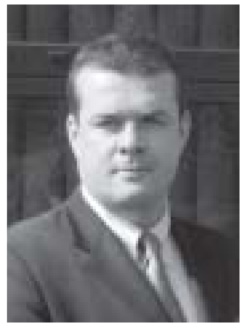

Carbon nanotubes: maturing products based on maturing processes
(Keynote lecture, Session A1)

Frédéric Luizi
R&D Director
NANOCYL
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Dr. Frédéric Luizi, **R&D Director and founding member of Nanocyl,** holds a PhD in Biology from the University of Stirling (Scotland). He has acted in various positions ranging from researcher in Universities (Portugal, UK, Denmark), civil servant in Canada to European Project Leader, project manager at BP (Norway) and technology transfer manager at the University of Namur (Belgium). His research topics cover all areas of nanotubes research ranging from catalyst development to material science, textile and biomedical devices.

Dr. Luizi is also founding member and board member of several other companies.

Worldwide societal acceptance of nanotechnology (Keynote lecture, Session C3)

N. H. Malsch
Drs. N. H. Malsch (Ineke) (1966), Director of Malsch TechnoValuation, a consultant in the field of (Nano)technology and Society, since 1 January 1999. My main interest is in the field of nanotechnology (since 1995). I am currently collaborating in two EU projects, Nanoforum (gateway to nanotechnology in Europe) and NanoforumEULA for nanotechnology collaborations between Europe and Latin America. In September 2007, a new project Ethicschool will start, organising summerschools and e-learning on ethics of nanotechnology and converging technologies. Two other EU funded projects have already finished: EuroIndiaNet stimulating nanotechnology collaborations between EU and India and NanoroadSME (a roadmap project on nanomaterials applications for SMEs). I have also been advising Dutch government organisations in science policy, evaluated international project proposals as well as edited and contributed writings to magazines, books, reports and websites for several years. Currently I am working on a part time PhD project on Nanoethics, with promoter Prof. Dr. J-P. Wils of Radboud University, Nijmegen, The Netherlands.

My prior working experience includes a research fellowship at the European Commission's Joint Research Centre IPTS in Seville, Spain, and a scholarship in the European Parliament's STOA unit in Luxembourg. My university education is in Physics (doctorandus), followed by post-graduate courses in Environmental Impact Assessment and Science and Technology Studies, and 1 year of theology (part time, 2004-2005). I have extensive experience in (inter)national NGOs and political organisations, including one year of the Third Chamber (2003), a national project which aimed to make Dutch politicians more aware of the interests of people in developing countries, where I successfully defended a motion to stimulate more ICT for education in developing countries. I have edited an international book on biomedical nanotechnology, including contributions from the USA, Europe and Japan. (CRC press, 2005) I am fluent in Dutch and English, good in Spanish and German and have a working knowledge of French.

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Chemical nanotechnology: From molecules to applications (Keynote lecture, Session B1)

Sanjay Mathur,

Research areas
- Synthetic Inorganic and Metal-organic Chemistry
- Materials Chemistry and Chemical Nanotechnologies
- Molecular Routes to Nanosized Particles, Wires and Films
- Biocompatible and Inorganic-Organic Hybrid Materials/Surfaces
- Chemical Vapor Deposition, Sol-Gel and Hydrothermal Techniques
- Nanocomposites for Gas Sensing, Optical and Magnetic Applications

Education
- Habilitation, Chemical Synthesis of Nanostructured Materials, 2004 Saarland University, Saarbrücken, Germany
- Doctor of Philosophy (Ph. D.), Inorganic Chemistry, 1993 Chemical Laboratories, University of Rajasthan, Jaipur, India
- Master of Science (M. Sc.), Physical Chemistry, 1988 School of Chemical Sciences, Vikram University, Ujjain, India

Employment (academia and industrial)
- Professor Inorganic Chemistry, Würzburg University (Since August 2006)
- Head, CVD Division, Leibniz-Institute of New Materials, Saarbrücken (Since May 2002)
- Senior Staff Scientist, Saarland University, Saarbrücken, (1999 – April 2002)
- Staff Scientist, Institute of Inorganic Chemistry, Saarland University, Saarbrücken (1996-99)
- Alexander von Humboldt Fellow (1994-96), Saarland University, Saarbrücken.
- R & D Panacea Pharmaceuticals Limited, New Delhi, India (1993 – March 1994)

Professional affiliations and community service
- American Chemical Society – Materials Research Society – Electrochemical Society
- American Ceramic Society – German Chemical Society – German University Association
- Referee for a number of leading chemistry and materials science journals
- Member of the International Editorial Board of Ceramics International
- Member of the Editorial Board, International Journal of Nanotechnology
- Associate Editor, Nanomaterials
- Scientific Consultant to ItN Nanovation Ltd. Saarbrücken, Germany and Terahertz Photonics, Edinburgh, United Kingdom

- Member of the Inorganic Chemistry Division of IUPAC for the period 2004-07
- Member of the Advisory Board of several International Conferences
- Member of the ECD Awards Committee of the American Ceramic Society

Awards, scholarships and prizes
- First Prize for the Best Technical Presentation in the American Ceramic Society Meeting, Advanced Ceramics for the New Millennium, Florida, 2002
- Young Observer Prize of IUPAC, 2003

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SusChem – The European Technology Platform for Sustainable Chemistry (Session E1)

Marian Mours
Dr. Marian Mours is Innovation Manager at Cefic, the European Chemical Industry Council in Brussels. Cefic is both, the forum and the voice of the European chemical industry. It represents, directly or indirectly, about 27,000 large, medium and small chemical companies which employ about 1.3 million people and account for nearly a third of world chemical production.

Among his responsibilities as Innovation Manager, the day to day management of the European Technology Platform for Sustainable Chemistry (SusChem) is currently the most important. SusChem seeks to boost chemistry, industrial biotechnology and chemical engineering research, development and innovation in Europe.

After completing his diploma in Chemical Engineering at the University of Karlsruhe, Germany, he went on to the University of Massachusetts, Amherst. He graduated from UMass in 1997 with a Ph.D. in Chemical Engineering.

Dr. Mours then joint the Technical Development unit at BASF in Ludwigshafen, Germany. Within BASF he held several positions in R&D before becoming Manager for governmental relations. He has been seconded to Cefic since May 2005.

Nanotechnology: Health and environmental risks of nanoparticles – research strategy (Keynote lecture, Session A4)

Bruno Orthen

Date and place of birth	March 10, 1961, Rheydt, Germany
Present position	Risk assessor and toxicologist at the Division Hazardous Substances of the Federal Institute for Occupational Safety and Health, Dortmund, Germany (since 1992)
	Coordination of the activities concerning Nanotechnology (since 2003)

Education, degrees, professional experience

1992–2007	Risk assessor and toxicologist at the Federal Institute for Occupational Safety and Health
1992–1996	Various courses in toxicology
1987–1991	Ph.D. in Biology, University of Berlin, Division of biochemical medicine
1987	B.Sc. in Biology, University of Cologne, Division of biochemistry
Specialization	Risk assessment and regulatory toxicology Occupational exposure limits EHS-aspects of Nanotechnology

Overview about industrial applications of nanotechnology (Keynote lecture, Session B2)

Paul Reip

Dr. Paul Reip has a PhD in Materials from Brunel University, and joined the UK MOD in 1982. He spent the early part of his career as research scientist in the EM Gun and RF research programmes, where he was heavily involved in International Collaboration with the USA, Europe and NATO. He was promoted to Department Manager Electro Optic Warfare in 1995, and in 1998 moved to lead the Guns and Warheads Department. During this time he founded and laid the groundwork for the Corporate Venture that has become QinetiQ Nanomaterials Ltd, a wholly owned subsidiary of QinetiQ, is currently Director and Chief Technology Officer, and sits on the Council of the UK Nanotechnologies Industries Association.

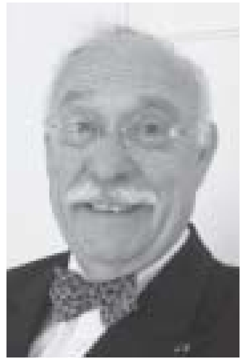
The opportunities and the challenges of developing nanomaterials (Keynote lecture, Session C1)

Peter Rigby
Innovation and New Business Development Manager @ Umicore, Belgium

Peter is a UK trained engineer complemented with an MBA from INSEAD. He has worked in a large variety of industries including aerospace, steel, powder metallurgy, oil and gas and electro optics with a predominant emphasis on roles in B2B marketing and business development. Since 6 years, Peter has been responsible for innovation programmes and New Business Development in the form of internal corporate venturing. His recent work has included bringing through venture projects in the fields of solar PV, recycling and nanomaterials.

Abstract –
'The opportunities and the challenges of developing nanomaterials'
The talk will present the authors views and experiences on the dilemmas facing new business ventures and the necessary trade offs between developing radical breakthrough and disruptive technologies with potential high gains and the risks of developing technically and commercially in unfamiliar territory.

The talk will endeavour to define the context, raise the appropriate questions but will not attempt to propose the solutions, but rather leave these for an open discussion either at the conference or afterwards



Techniques, instruments and special aspects of CEN and CEN-STAR with some views in nanotechnology for measurements and quality insurance (Keynote lecture, Session A2)

Gérard Rivière
Born 21 June 1942 in Poitiers, France, married – 4 children (1965-1968-1972-1988)

University studies and Diploma
- Civil Engineer 'Arts et Métiers' (Paris 1964)
- Diploma of the International Graduate School of Sweden (Stockholm 1965)
- Master of Social Sciences in Economics - University of Stockholm (1968)
- Doctor 'honoris causa' in Chemistry - Lomonosov Academy in Chemistry Technology of Moscow (1996)

International scientific co-operation
- French Embassy in Sweden - Scientific Services (1965-1978)
- French Embassy in Norway - Scientific Counsellor (1983-1987)
- French Permanent Representation to the European Union - Brussels - Scientific Counsellor (1988-1994)
- INTAS - Brussels - Scientific Officer for Chemistry (1994-1997)
- European Commission, DG Research, COST Scientific secretariat – Scientific Officer for Chemistry (1997-2000)
- Council of the European Union, General Secretariat, Scientific Expert on Secondment in Science and Technology (October 2000 - Mars 2004)
- AllChemE, Alliance for Chemical Science and Technology in Europe, Scientific Adviser (1997-2003)
- European Committee for Standardization – Chairman of the European Committee for Research and Standardization (since 2005)

French services in research and technical development
- CNRS (Centre National de la Recherche Scientifique)
- Scientific Secretary of the French Swedish Thematic Programmed Action 'Chemical Storage of Energy' (1975-1979)
- Acting Head of Paris A CNRS Regional Delegation (1978)
- Deputy to the Director of External Relations of CNRS (1979-1980)
- Leader of programme 'Energy savings at CNRS' (1979-1983)
- Director of the Energy savings Summer School in Cargèse (1981)
- Director of the Permanent Representation of CNRS to the European Union (1988-1994)
- ANVAR (Agence Nationale pour la Valorisation de la Recherche)
- Chargé d'Affaires III responsible of networks with industrialised countries at the International Delegation of ANVAR (1980-1983)

International scientific and technological missions
- Founding Member, General Secretary: French-Swedish Research Association (1967-1978)
- Founding Member: French-Finnish Association for Scientific and Technical Research (1972)
- French Head of Delegation for the French-Quebec programme on technical innovation (1980-83)
- Mission Co-ordinator of OCDE programme for innovation policy in Portugal (Paris/Lisbon 1982)
- General Secretary: AFAST French-German Association for Science and Technology (1982-1983)
- Founder, Director: French-Norwegian Foundation for Scientific Research and Industrial

Development (Oslo 1983 - 1987)
- Founder of CLORA (French Research Organisations Representation in Brussels 1990)
- Founder of Informal Group of Liaison Officers IGLO in Brussels (1991)
- Secretary in AllChemE - (Brussels 1997-2000)

University positions and scholarships
- Lecturer in French at the Royal Institute of Technology in Stockholm 1964-1968
- Research scholarship from the NFR (basic science research organisation of Sweden) at the Stockholm University Institute of Economics 1968-1969
- University lecturer in applied mathematics for economics at the Stockholm University Institute of Economics 1969-1970
- Lecturer at the Compiègne Technology University and at the ENSAM Paris (since 2004)

Administrative position
- Ingénieur de Recherche Hors Classe du CNRS (A 3ème chevron)
- Expert on Secondment from CNRS to the CEN

Miscellaneous positions
- Secretary General, Chairman: Comité d'Actions sociales de l'ANVAR (1980-1983)
- Association pour la valorisation de la recherche scientifique et technique AVRIST, (Trésorier 1980-1983, membre du Conseil d'Administration 1980-1999, Vice-Chairman 1990-1996)
- Président of Benelux group for the 'Société des Ingénieurs des Arts et Métiers' (since 2002)

Awards
- Commander of Royal Merit Order of Norway
- Chevalier des Palmes Académiques Françaises
- 'Chugaev' Medal from the Science Academy of Russia in Co-ordination Chemistry

Languages
French, English, Swedish, Norwegian, and Russian.

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Role of interface engineering in NanoBiotechnologies
(Keynote lecture, Session A3)

François Rossi
François Rossi received his engineering degree in Inorganic Chemistry from Institut National Polytechnique of Grenoble in 1977, and his PhD in Materials Science from Université Claude Bernard of Lyon in 1989. From 1981 to 1990, he worked at the Commissariat à l'Energie Atomique as a group leader in Materials Science and Surface Engineering. In 1991-1996, he was group leader at the Institute for Advanced Materials, Joint Research Centre of the EU in Petten with major activities in Plasma Surface engineering. In 1996, he moved to the JRC Ispra site where he is now head of the NanoBiotechnology laboratory and Action leader of the JRC programme 'NanoBiotechnology for Health'. During this time, he has coordinated or managed 14 R&D projects from FP4, 5 and 6.

MATERA, ERA-NET Materials (Session D1)

Sisko Sipilä

Present Function
Tekes, Finnish Funding Agency for Technology and Innovation
Helsinki, Finland, Chief Technology Adviser

Education
Helsinki University of Technology, Department of Mechanical Engineering, Material Technology, Master of Science, 1985

Employment History
- Tekes, Finnish Funding Agency for Technology and Innovation, Chief Technology Adviser (1994)
- VTT, Technical Research Centre of Finland, Senior Research Scientist (1986–1994)
- MIKES, Centre for Metrology and Accreditation, Inspector (1985–1986)

Major Experiences
- MATERA ERA-NET Materials, EU funded project with 17 partners, Coordinator (2005–2009)
- Tekes' National Technology Programme, Programme Manager
  - Industrial Applications of Engineering Materials (1994–1997)
  - Manufacturing Processes for Cast Components (1994–1995)
  - Partnership in Injection Mould-ing Business (1996–1998)
  - Materials for Energy Technology (1997–1999)
  - Control of Vibration and Sound (1999–2000)
  - Frontiers in Metallurgy (2001–2002)
  - Clean Surfaces (2002–2006)
- Tekes' Boston Office, Manager (2000–2001)
- Project Evaluation at Tekes, Chief Technology Adviser (1994–2007)
  - Industrial R&D projects
  - Applied Research Projects
- Fatigue Design, BRITE/EURAM 3051-89, Partner (1990 -1994)

Hub Nanosafe in the frame of the European initiative ETPIS – European Technology Platform on Industrial Safety (Session E1)

François Tardif
François Tardif, PhD, heads the Tracer Technologies Laboratories at CEA-Grenoble. A member of the Electrochemical Society, he has coorganized many congresses in the fields of silicon processes and ultra trace contamination and has authored more than 50 papers. He initially graduated from the engineering school of l'Institut National des Sciences Appliquées in Toulouse and received a PhD in Materials Sciences from the University of Marseille and a HDR degree from Grenoble Polytechnique School.

Tardif is specialist of nanoparticle adhesion and removal from surfaces, passivation of semiconductor surfaces… His team now focuses his work on optical nanotracers obtained by wet processes: nanocolloïdes fabrication, functionalization, incorporation in materials. He leads the European Nanosafe2 subproject dedicated to detection and characterisation of nanoparticles.

Tardif can be reached at +33 4 38 78 33 32 or ftardif@cea.fr

CENARIOS – the first certifiable nanospecific risk management and monitoring system for industry (Keynote lecture, Session B4)

Thorsten Weidl
Thorsten Weidl studied physics at TU Munich. In summer 2000 he joined TÜV SÜD Industrie Service GmbH in Munich where he is working as an expert for Risk Assessment and Risk Management Systems.

In his first years at TÜV he was in charge of performing Risk Analyses in different industries like nuclear industry, public traffic systems or car manufacturers. Since 2002 his work focussed on Risk Management System and their implementation.

Since 2006, Thorsten Weidl is the responsible Project Manager on the part of TÜV part for the Risk Management System CENARIOS®. This RMS was developed together with The Innovation Society, St. Gallen, to meet the specific needs of producers of nanoparticles and is ready for certification now.

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The event is established as the foremost European congress for the transfer of nanotechnology from research to industrial processes, products and applications.

The information gathered in these Proceedings provides an overview of the state-of-the-art in nanotechnology for industrial applications, presented by selected international top speakers to open up new perspectives in Europe for coming years. The conference is accompanied by a special industrial exhibition presenting European key players in nanotechnology and involves also a comprehensive press programme for journalists of the major European media agencies.

For further information:
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Düsseldorf view

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