Project no.: 500328-2

Project acronym: FRONTIERS

Project title: Research, processes and facilities directed at instrumentation for manufacturing and analysis of single molecules, individual nanostructures and 2-3 D architectures of them, targeted at life sciences

Instrument: Network of Excellence (NoE)

Thematic Priority: NMP 3.4.1.4

Publishable Executive Summary

Period covered: from 01-08-2006 to 01-08-2007 Date of preparation: 10-09-2007

Start date of project: 01-08-2004 Duration: 4 years

Project coordinator name: Prof.Dr. Vinod Subramaniam

Project coordinator organization name: University of Twente

Executive summary

FRONTIERS
Where Life Science and Nanotechnology Meet and Commercialization begins

FRONTIERS (*www.frontiers-eu.org*) is a European Commission Network of Excellence focused on the crossover between Life Sciences and Nanotechnology supported by the Sixth Framework Program (FP6). FP6 supports research cooperation and integration of research efforts, promotes mobility and coordination and invests in mobilizing research in support of other EU policies. FRONTIERS aims at establishing leadership in research and innovation in life science related nanotechnology by creating structures that build on the existing strengths and facilities of the network partners. The FRONTIERS program is one vehicle created by the European Commission to strengthen the EU position in Nanotechnology.

Specifically the FRONTIERS initiative focuses on creating a critical mass in life science related nanotechnology. The FRONTIERS Program does this by leveraging and focusing existing strengths, expertise, and investments within Europe. One goal of the program is to focus the development of this Nanoscience cluster around industrial problems whose solutions will lead to marketable new technologies, processes, tools and devices that will in turn have great effects on science, industry, and society. The FRONTIERS program has an impressive list of partners (see Table below) located throughout North and Western Europe (see figure on the left) and are represented through approximately two hundred researchers with varying backgrounds that bring together a considerable knowledge of nanotechnology-related life science research.

Frontiers Partners	
MESA+ Institute for Nanotechnology, The Netherlands	www.mesaplus.utwente.nl
University of Åarhus, Denmark	www.phys.au.dk/main/home-uk.shtm
University of Cambridge, IRC in Nanotechnology, United Kingdom	www.nanoscience.cam.ac.uk/irc/
Interuniversitair Micro-elektronica Centrum, Belgium	www.imec.be
Forschungszentrum Karlsruhe GmbH, Germany	www.fzk.de/
CeNTech GmbH, Germany	www.centech.de
Chalmers University of Technology, Sweden	www.fy.chalmers.se/
National Center of Competence for Nanoscience, Switzerland	www.nccr-nano.org/nccr
Max Planck Institute for Solid-State Research, Germany	www.fkf.mpg.de/kern/index.html
Nanoscience Group CEMES/CNRS, France	www.cemes.fr/
University Münster, Germany	www.uni-muenster.de/Physik.PI/

What Does FRONTIERS Do?

Nanotechnology is a field that by its very nature is multidisciplinary. The FRONTIERS program has developed a meritocracy based process creating centers of excellence in science as well as facilities. Partners concentrate more on focused core areas, spending less effort on R&D and facilities outside these areas. The main elements of FRONTIERS are aimed at increasing research, infrastructure, and education efficiencies and at building more and better business cases. FRONTIERS joint program of activities is organized into four blocks:

- Coordination of research, leading to a joint research program amongst the partners;
- Implementation of a Virtual European Nanoscience Laboratory to ensure efficient use of infrastructure as well as the availability of equipment for researchers through sharing;
- Creation of an integrated European Joint Curriculum, a master-level educational program on life science related nanotechnology; and
- Spreading of excellence, with a focus on joint management and the development of new business cases (science-to-industry). The science-to-industry chain must capitalize on the knowledge generated in the network by transforming it into applications and products.

Coordination of research

The research program in Frontiers is created and continuously adjusted in a bottom-up fashion. Over the past years FRONTIERS researchers initiated more than 50 research collaborations and there were many exchanges, meetings and workshops. Through this process of interactions research focus areas gradually started to evolve. Currently most of the research projects can be assigned to one of the following categories:

- **Drug-delivery**

Typical examples: intracellular trafficking of drug-delivery nanoparticles, nanotechnology based targeted drug-delivery, 3D Nanopore Scaffolds for Drug-delivery, disassembly of drug delivery nanoparticles in cells, other.

- **Nanopores**

Typical examples: DNA sequencing with nanopores, DNA in nanopores, DNA in solid-state nanopores, the fabrication of solid-state nanopores, the mechanism of DNA traversal in a nanopore, nanopores for probing DNA-protein interactions, nanopores for RNA (un)folding, and nanopores for measuring the charge screening of DNA and RNA, creation and characterization of nanoporous structures, spanning lipid bilayers, other.

- **(Bio) Sensors**

Typical examples: Bio/nano hybrid structures, coupled plasmon affinity biosensors, cantilever sensor experiments, experiments using cantilever array sensors in biochemical environment, other.

- **Analytical Techniques**

Typical examples: Various manipulation techniques, such as nanoneedles, probes, and tweezers (optical and magnetic), local surface plasmon enhancement, near-field optical microscopy, atomic force microscopy imaging with functionalized probes, non-contact AFM, Virtual AFM, STM, single cell MS, leading edge top-down lithography.

- **Bio-interface and –compatibility**

Typical examples: Tissue engineering & implants (biomolecule adsorption as well as cell and tissue growth on biofunctional nanostructured surfaces, bio-interfacial processes including adhesion, interaction, signal transport, and molecular and nanoparticle transport), membrane-based strategies and technologies, addressing and manipulation of biomolecular structures, cell adhesion (neurons-on-chip), protein attachment techniques, other.

- **Nanostructured Surfaces**

Typical examples: Self-assembly, self-organization, and functionalization of surfaces (monolayers, multilayers) and probes, surface structuring and molecular printboards, nanoparticle 3D assemblies, patterning for guided neuronal growth, two-dimensional surface arrays, functionalized linear nanostructures, other.

- **Molecular Machines**

Typical examples: Single molecules, molecular motors, quantum mechanics, simulations, connect one molecule and use it as a calculator.

Virtual European Nanoscience Laboratory

The Virtual European Laboratory for Nanosciences enables network members to use instruments and facilities at any other FRONTIERS network partner. The Virtual Laboratory is accessible through the FRONTIERS website (members only) and contains two searchable databases; one on expertise and one on equipment. Both databases contain hundreds of entries including names and details of responsible contact persons. The use of the databases is user-friendly and fully automated.

European Joint Curriculum

Interdisciplinary education and training for research personnel are prerequisites to develop and maintain centers of excellence in Europe. FRONTIERS has developed an integrated *European Joint Curriculum (EJC)*; a master level educational program on life sciences related nanotechnology. Student and teacher exchange is a key aim. The FRONTIERS educational program is based on the strong current programs at the partners in the area of life science related nanotechnology. The strength of the EJC lies in the harmonization of these educational programs. The EJC works with the European Credit Transfer System (ECTS); a minimum of 10 ECTS is needed for a FRONTIERS student. Students can combine the FRONTIERS theoretical curriculum with research projects as their master thesis work. Guidance occurs through an implemented e-based learning structure and research supervisors from both their home institution and the visited institution. Hence, in addition to the developed educational programme, the EJC will contribute to the integration of research

collaborations within FRONTIERS by initiating cross-institute technology projects via student exchange.

During the last period a group of nanosciences students from NCCR and iNANO organised the first international conference for nanosciences students, INASCON. The conference was a great success with international speakers, including many from the FRONTIERS network. Students had the opportunity to meet their peers and present and discuss their own work on an international level. Several workshops and discussion sessions were organised with such themes as employment, nanotoxicology, nanosciences in the media and combining an academic career with family life. The conference was very successful and the invited speakers were impressed by the high level of engagement by the participants: "…indeed it was a great pleasure, lots of really interested and bright people. Very promising for the future."

Science-to-Industry

The transfer of generated scientific knowledge and of new technologies developed within the network into products is key issue within this part of the FRONTIERS network. An effective transfer of know-how and technology towards the industry requires one to:

- Assess the business and market potential of the research projects
- Identify and to monitor the proprietary know how within the network
- Define the needs of the market and of potential industrial cooperation partners

In order to meet these requirements FRONTIERS established a task force "Science to Industry", a working group on IPR Management and an Application Committee containing members from industry for advice on research directions.

The network has developed a roadmap on nanotechnology and life-sciences with focus on:

1) Drug-delivery

2) Molecular Imaging

3) Bio-chips/sensors

4) Tissue Engineering & Implants

5) Market trends in Life Science Nanotechnology

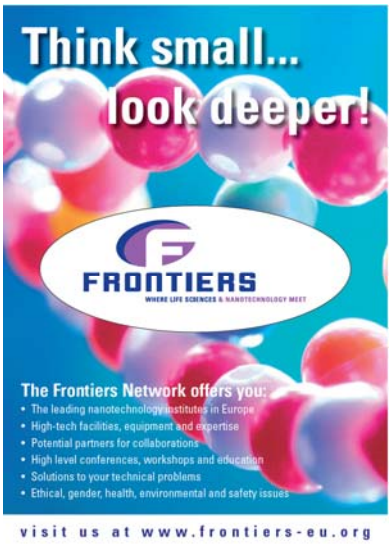
Each chapter describes: market drivers, potential of nanotechnology, research within FRONTIERS, industrial involvement, trends and challenges.

During the third year of FRONTIERS' existence technology transfer occurred (patent transfer), indicating the significance of nanotechnology for industry. Several projects have been considered for formation of spin-off companies and a case study of one such project was completed.

The development of nanotechnology based products in a safe and responsible manner requires participation in social and ethical discussions surrounding this new technology. Regular communication to the general public, policy makers, investors and members from industry is ensured through the FRONTIERS PR-Policy plan

including flyers, promotion banners, press releases, interviews, publications and posters. Additionally, FRONTIERS actively participates in societal discussions through its Ethical Advisory Board representing prominent members in the nanotechnology field. Moreover a Technology Assessment Program was launched offering workshops to members on concrete, close-to-market nanotechnology applications (www.technologyassessment.info/) and their possible social / ethical implications.

To increase the number of female scientists working in the field FRONTIERS nominated a Gender Awareness Group which developed a Gender Action Plan. Through the implementation of Gender Monitors the Gender Action Plan is updated continuously.



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