Project n°: NMP4-CT-2004-500355

NAIMO

NAnoscale Integrated processing of self-organising Multifunctional Organic materials

Integrated Project

Priority 3

24-MONTH PERIODIC ACTIVITY REPORT

PUBLISHABLE EXECUTIVE SUMMARY

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Project coordinator: Prof. Yves GEERTS		Duration:	4 years
Project coordinator organisation: ULB		Version:	1

NAIMO

Publishable executive summary

1. NAIMO objectives

The EU-funded NAIMO project will add ground-breaking multifunctionalities to nanoelectronics materials in cost-effective and environmentally friendly ways. Its distinctiveness lies in transforming a plastic film substrate into a multifunctional composite. The four-year funded project will contribute to the development of new products, such as organic electronic integrated circuits and displays, sensors, flexible solar cells, and magnetic structures that will directly benefit health, welfare, security and the environment, while improving the competitiveness of the European industry. One of the first Integrated Projects signed under Thematic Priority 3 of the EU Sixth Framework Programme (FP6), the NAIMO research project has the potential to create new impetus for the European industry and evolution in the field of science and technology. It combines smart materials with solution-based additive manufacturing techniques such as printing.

The main project objectives are:

- Obtaining major fundamental advances in material design, synthesis, process techniques and manufacturing tools;
- Providing the scientific and technological foundations needed to support the creation of a new industry of thin-film multifunctional materials for the construction of new products resulting in better performance and usability.

Typical examples include replacing barcodes with electronic labels that will simplify the tracing of food products and provide better information on and safer control of medicines. NAIMO will also contribute to the fabrication of electronic paper and to the production of solar cells. These applications will minimise use of energy and cut raw materials consumption, contributing to the citizens' well-being.

2. Contractors involved

NAIMO brings together 20 participants from the enlarged EU, combining academic and industrial expertise and stimulating the interactions between them:

ULB: Université Libre de Bruxelles

UMH: Université Mons-Hainaut

CNR: Consiglio Nazionale Delle Ricerche:
- Institute for Nanostructured Materials Studies
- Istituto per la Sintesi Organica e la Fotoreattività

UCAM: University of Cambridge

UNIBO: Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali, Università degli Studi di Bologna

TUE: Technische Universiteit Eindhoven

LIU: Linköpings Universitet

CSIC: Consejo Superior de Investigaciones Científicas:
- Institut de Ciència de Materials de Barcelona
- Instituto de Microelectrónica de Madrid

MPG: Max Planck Institute for Polymer Research

UWUERZ: Bayerische Julius-Maximilians-Universität Würzburg

POL: Politechnika Lodzka

IMEC:	Interuniversitair Micro-Electronika Centrum vzw
RISØ:	Risø National Laboratory
MERCK:	MERCK Chemicals
PHILIPS:	Philips Research Eindhoven
ST:	STMicroelectronics, FTM Group, Adv. R&D NV Memories & Derivatives – Post Silicon Technologies
PLL:	Plastic Logic Ltd
JM:	Johnson Matthey plc. (Technology Center)
INNOVA:	INNOVA SpA
MARTEC:	MARTEC Consulting Sprl

3. Coordinator contact details

The Coordinator of the NAIMO project is Professor Yves Henri Geerts.

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4. Work performed

The research activities aim to contribute to the creation of a sustainable industry of organic electronics in Europe. During this second year, the consortium has started to implement the work plan of the NAIMO project. The main research lines are:

- Nanomaterials: molecules, oligomers, polymers, clusters, etc…
- Nanofabrication methods: self-assembling, phase separation, dewetting, printing, etc… Processes at ambient pressure and temperature that consume little energy and produce no pollution are being developed.
- Theory, simulation, and modelling: input from theory for the design of nanomaterials, rationalization and conceptualisation of physical measurements by a theoretical approach, simulation of large ensemble of molecules, modelling of electronic devices …
- Integration of nanomaterials and nanofabrication techniques: molecules that self-assemble into functional materials that self-organize into parts of devices. The driving force is the simplification of fabrication at nanodimensions.
- Assessment and standardisation: industrial assessment of technologies developed at lab-scale, standardisation of production …
- Nanoscale metrology and tools: development of tools for characterization of electrical, optical, and magnetic properties, tools for nanofabrication, contribution to norms at nanodimensions …

The research activities are connected to each other in a global self-evolving matrix to ensure that all elements for the creation of a sustainable industry of organic electronics are put together. For example, recent environmental legislation is integrated in the design of new materials and fabrication processes. Young researchers are trained at technical, societal, environmental and legal level, in particular, the early protection of intellectual property rights. A summer school was been organized in September 2005 in Erice.

Another important aspect of the creation of a sustainable industry of organic electronics is the societal acceptation of nanotechnologies. NAIMO contributes with an active communication policy to promote its research activities to various targeted audiences, such as general public, journalists, young people, etc...

5. Results achieved so far

During the second year, NAIMO has largely respected the work plan, and most of the objectives foreseen have been successfully achieved. In order to discuss the main achievements, draw a coherent analysis of the status of the project, and assess the level of integration, we have classified the results according to three main research lines:
a) Organic Field Effect Transistors;
b) Photovoltaic and other optoelectronics devices;
c) New Emerging applications.

a) OFETs. The activity has been characterised by a high level of integration among materials design, fabrication and processing, device fabrication, modelling and characterisation. The charge transport properties of several materials, mainly molecules and oligomers, reported by different groups, are routinely close to the state-of-the-art mobilities (routinely 0.001-0.01 with a few examples of 0.1-1 cm2/Vs mostly in the case of single crystals and highly ordered oligomer thin films) and on-off ratios in excess of 10^4. These materials, although mostly p-type, can also be patterned or printed on polymers and across large areas with original fabrication approaches devised in NAIMO. Among the prominent groups of materials, TTF derivatives and oligothienyls, discotic and calamitic LCs have been especially functional to the integration of the different activities, and to promote a broad interdisciplinary collaboration among groups. TTF derivatives appear at this stage as the best compromise in terms of versatility in the fabrication and properties, and charge transport properties. LCs activities benefit from a good level of integration between materials design, synthesis, simulations, and different structural and spectroscopic techniques.

A wealth of unconventional fabrication methods, both serial and parallel, has been successfully applied to OFETs, with major breakthroughs especially in the case of molecules. The FET fabrication capability in NAIMO spans length scales ranging from a few tens nm up to three orders of magnitude. Several of these methods are based on joint research among NAIMO groups, as for instance, zone casting, stamp-assisted deposition, micro-contact printing and direct EBL writing of OSCs. OFET activities have prompted a substantial support from modelling at the multiscale, and from diverse SPM techniques, especially with electrical probes, XRD, photoelectron spectroscopy. The need to control environment conditions has lead to the construction of a dedicated chamber for electrical measurements of OFETs at variable T, vacuum or controlled atmosphere, and SPM. In summary, the activities in OFETs are a paradigmatic example of the fully operating potential of NAIMO.

b) Photovoltaic devices: these activities represent a considerable smaller effort in comparison with the one put on transistors. The level of integration is good between WP1, WP2, WP3 and WP6. Synthesis of materials sees a predominance of polymeric materials, (blends and copolymers), large molecules (graphene-like) and discotic LCs. The fabrication effort is mostly based on the control of the nanoscale self-organisation of polymers. Major breakthroughs have emerged for discotic LCs which may lead to a patterning of active layers in the proper orientation, or with a coupling between nanoimprinting and thin film deposition. Important contributions on the electronic structure of organic-organic interfaces have emerged from photoelectron spectroscopy; photophysics is thoroughly investigated experimentally and theoretically, and the knowledge acquired on order parameters from NMR is important.

c) New emerging applications: under this label, activities not specifically aimed to a single application or material (thus, intrinsically aimed to form a broader platform) have been classified. During the second year there has been a considerable progress in the development of new materials, dielectrics and metal clusters and nanoparticles.

Polymer brushes constitute an extremely interesting family of dielectrics, whose adaptive functionality to environment expands their scope further beyond transistors, towards sensors, biocompatible materials, smart surfaces, memory storage. The interface between brushes and active materials, organic and inorganic, has been the subject of an intense research work at UCAM.

6. Expected end results

The expected results that are anticipated to be reached at the end of the project are summarized by the specific objectives:

1. Synthesis of self-organising solution-processible multifunctional materials: metallic clusters, nano-particle metals and magnets, molecular semiconductors and dielectrics, in amounts suitable for development (1-10 g scale) and with standardised properties;
2. Control of microstructure on 10 nm scale by self-organisation & self-assembly;
3. Ability to design and predict properties by multi-scale modelling;
4. Additive solution-based manufacturing of functional systems and a variety of working devices, with control of fabricated features better than 100 nm;
5. Assessment of reliability and manufacturability based on sustainability criteria;
6. Development of tools for metrology at the nanoscale and providing specifications for manufacturing equipment;
7. Form an advanced, gender-balanced, skilled base of entrepreneurial workers;
8. Achieve the alignment of technological direction with environmental and societal needs.

7. Intentions for use and impact

Results will be exploited at three levels:

- To constitute a solid scientific and technological platform to generate new research projects in the field of nanomaterials and nanofabrication processes;
- To help governments and public authorities to establish norms and standards in the emerging field of nanotechnologies;
- To lead to novel industrial developments in the chemical and electronic sectors.

The anticipated impact on society resides in the contribution to create the conditions necessary to generate a new industry of organic electronics in Europe.

8. Project website and logo

NAIMO website	NAIMO logo
http://www.naimo-project.org	NAIMO