M-ERA.NET Call 2013: Funded projects

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HeuMem: Heusler compounds for future magnetic memory and logic

The HeuMem team exploits the exceptionally versatile magnetic Heusler compounds and matching tunnel barriers to lay the ground for extremely small, fast and power saving devices that could enable visionary IT-concepts such as normally-off/instant-on computing, magnetic logic and more generally ultra-low power green electronics.
Theory and experiment target at a unique set of properties to enhance the functionality of magnetic tunnel junctions. These building blocks of spintronics need material systems combining low magnetic saturation and damping with high perpendicular anisotropy and spin polarization to enable easy Spin-Transfer-Torque switching, high data stability, large readout signal and fast read/write cycles.
HeuMem addresses key bottlenecks of future memories and logic such as non-volatility, scalability, and fJ energy consumption. It will impact both basic science by advancing the engineering of such complex material systems, as well as concepts for future electronics.

ANPHASES: Anisotropy of interphase boundaries in multiscale composite growth structures

ANPHASES project aims at a first-ever integrated study of pattern and texture formation in multiphase hierarchical structures driven by anisotropy of interphase boundaries (IB). Eutectics from the model system Al-Al2Cu-Ag2Al were selected; they display particular crystal-crystal orientation relationships with remarkably different IB properties, being excellent candidates for a systematic fundamental analysis of anisotropy effects on selforganization during growth and coarsening. Molecular-dynamics computations (MD) and phase-field simulations (PF) will be performed in interaction with innovative in-situ experiments to reveal the effects of IB anisotropy. Conclusive results on the emergence of collective order and on competitive growth of eutectic grains will be obtained. The project will lead to long awaited theoretical amendments to the theory of eutectic growth, to formalized ICME links between MD and PF and will open the way to knowledge-based novel micro-composites structures.

ICENAP: Integrated Computational Engineering, Characterization and Validation of Semiconductor Colloidal Nanocrystals with Advanced Properties

ICENAP will design new nanocrystals and tailor microstructural changes in known ones during processing to obtain the following improved properties:

- photoluminescent (PL) quantum yield exceeding 90% irrespective of QD concentration;
- minimum blinking;
- inorganic shells designed to ensure stable QD PL for at least 12 months;
- organic shells ensuring QD stability in biological media for at least 6 months.

New technologies will be developed based on modeling and simulation using material physics-based design principles. The results will be used for the synthesis of QD cores and their layer-by-layer coating with inorganic shells, utilizing structural models that fit their structure seen in HRTEM. The predicted properties of this next generation QDs will be experimentally validated.

ICENAP combines modeling, simulation and validation of a new class of nanomaterials, which will have a strategic impact and create new dynamism by accumulation of new knowledge along the innovation chain.

ICETS: Integrated Combinatorial control of Electrical and Thermal transport properties in Silicides

Silicides are an integral part of several important technologies, but current knowledge of their properties is fragmented and incomplete. Many phases still need to be explored and there is an urgent need for systematic determination and understanding of their transport properties.

We will introduce a novel method to measure the thermal conductivity of sputtered material libraries and, in the most thorough investigation of phase stability, thermal and electric transport properties to date, a comprehensive, systematic and combined experimental and theoretical dataset will be produced. Data-mining techniques will be employed to find the underlying correlations between stability and thermal transport properties of complex phases. Furthermore, multi-phase silicides with tailored transport properties will be designed, thereby demonstrating an integrated combinatorial control of electrical and thermal transport properties in silicides.

NanoGraM: Graphene Fabrication, Integration and Metrology for Nanoelectromechanical Systems

NanoGraM will explore new Nano-/Microelectromechanical (NEMS/MEMS) devices based on graphene interfaces and surfaces. NanoGraM will focus on three device concepts for potential future products:
• Graphene-membrane pressure sensors (industrial, automotive, smart homes, etc.)
• Graphene microphones (smart phones, laptops, automotive, industrial, smart homes, etc.)
• Graphene-membrane Hall sensors (industrial, automotive, smart phones, etc.)
The expected benefits are increased sensor sensitivity (up to factor 100), robustness (up to factor 5), reduction of size, enhanced signal-to-noise ratios and the avoidance of hazardous materials in processing. The integration of graphene NEMS/MEMS sensors with silicon technology will enable smart systems that enhance the well being of people, food quality, traffic safety, pollution monitoring or homeland security. The research activities will provide a decisive technology lead for the industrial NEMS manufacturer and the participating SMEs.

NOPYDET: Novel generation of pyroelectric detectors based on polar semiconductors

The project is proposing to develop a new generation of pyroelectric detectors based on wide gap polar semiconductor materials (e.g. AlN, ZnO) able to withstand high operating temperatures. The innovative aspects will go further beyond the state of the art by proposing multilayer structures based on nitrides (AlN, GaN, etc.) and ZnO-ferroelectric structures with the aim to enhance the sensitivity as much as possible at elevated temperatures. Specific innovative aspects can result also from packaging solutions, electronic for signal processing, etc. The detectors are primarily designated for internal combustion and jet engines used in automobile and airplane industries. The aim is to increase the lifetime of the engines, their safety and to optimize the fuel consumption with reduction of green house gases emissions. The expected impact is very high considering the share of the two industries at EU level and worldwide.

Ecofurn: Decorative functional coating and/or printing of natural fibre/wood-based lightweight composites used for eco-friendly furniture applications

Today the powder coating medium density fibre boards (MDF) technology can be seen as niche technology in the decorative coating market for wood-based furniture applications due to its limitation to the special designed MDF substrates. Other wood-based light-weight panels cannot be powder coated yet. The general aim of the project is to increase the know-how of the sustainable eco-friendly decorative powder coating by the identification, development and modification of light-weight natural fibre/wood- based composite materials suitable for powder coating, the necessary modification of the powder coating process for these substrates and the development of a functional decorative digital electrophotographic printing process on these materials for design individualization. Achieving this goal will be a breakthrough for this eco-friendly technology in the decorative coating market for wood-based furniture applications satisfying future demand for individualized sustainable products.

INTCERSEN: Integrated sensors with microfluidic features using LTCC technology

The main focus of the INTCERSEN is the development and fabrication design of innovative ceramic microfluidic devices with integrated sensing features with applications on bio-medical, environment and security. The LTCC technology versatility will allow the 3D integration of electrochemical sensing areas with microfluidic features, and further with advanced signal processing and wireless communication. The result will be one system to provide all of the possible required analyses for a given type problem, with all processing steps performed on the same chip, with no user interaction required except for initialization. The progress beyond the state-of-the-art represents, one side, the integration of sensing features within LTCC technology by use of innovative materials, for the purpose of integrating electrochemical sensing features, and, on the other side, the use of this reproducible technology for generating reliable microfluidic lab-on-chip systems with intersectorial applications.

METABIO: METhod to elaborate bio-inspired stable Antibacterial surface on metallic BIOmaterials for dental implants

Dental implants are key surgical components widely used, holding an 18% of the whole market's share. Nevertheless and, despite their extensive use, health risks inherent to the current technology can't be ignored. Indeed, the bacterial infection, during surgery and in the post operative period, is regarded as the most severe complication associated to the use of biomaterial-based dental implants, with important social, clinical and economic impacts. METABIO proposes to develop an original multifunctional coating by conferring simultaneously to dental implant surfaces bactericidal and anti-biofilm properties in order to kill bacteria and prevent their adhesion, without reducing or influencing the osseointegration property. To address the ambitious objective, a transnational and interdisciplinary consortium is proposed, including SMEs, research centres, academic entities and an advisory board, which will deeply involve the health industry and dental clinics.

COATELY: High performance coatings for PEM eletrolyser metallic bipolar plates

In order to be able to take full advantage of intermittent renewable energy sources, the energy needs to be stored. This energy can be stored as hydrogen, and later be converted to energy in fuel cells. The desired way to produce hydrogen is by water electrolysis, and the most energy efficient system is the polymer electrolyte membrane electrolyzer. A major obstacle for commercialization of PEM electrolysers is the expensive bipolar plates, which nowadays are made of titanium. The bipolare plate for a PEM electrolyzer is very challenging compared to a PEM fuel cell because of the fact that the anodic potential is twofold. The proposed project has acknowledged the problem, and two highly innovative ways to both reduce cost and increase the total system performance of the electrolyzer is suggested. The COATELY project aims at developing high performance new generation coatings for cost-effective stainless steel BPP for PEM technology deposited by advanced coating techniques.

B-IMPACT: Bronze-IMproved non-hazardous PAtina CoaTings

The B-IMPACT (Bronze-IMproved non-hazardous PAtina CoaTings) project aims at developing innovative eco-friendly and non-hazardous protective coatings to protect bronze surfaces exposed to the outdoor environment. Bronze artefacts and cultural heritage monuments exposed outdoors are prone to degradation processes, especially in polluted environments. Corrosion processes with the degradation of surface stability and appearance occur not only on ancient bronzes but also on newly exposed bronze surfaces. Their protection and maintenance remains a great challenge, requiring on-going investment. The B-IMPACT project will develop tailored "right off the shelf" formulations based on advanced protection strategies, offering reduced maintenance costs as well as efficient conservation solutions for end-users, including local authorities and other stakeholders (architects, artists, museums, etc.).

BIOGRAPHY: High resolution roll-to-roll printing of biocompatible graphene/protein multilayers for biomedical applications

The functionality of many biosensors is based on electrode structures on which proteins are immobilised. High electrical conductivity and outstanding electrocatalytic properties make graphene the ideal electrode material for impedimetric and electrochemical biosensors. BIOGRAPHY aims at printing graphene electrodes with biofunctional coatings on large-area polymer foils in a roll-to-roll process, similar to the printing of newspapers, thus establishing a highly cost effective mass fabrication process for graphene-based biosensors. Developments include
- a biocompatible, electrically conductive graphene ink for rotogravure printing,
- a fabrication method for micro (< 10 µm) patterning of gravure printing cylinders,
- a roll-to-roll process and production line for surface functionalization of large-area polymer foils by gravure printing of a micro-patterned graphene/protein multilayer,
- proof of suitability of the printed multilayer for two different biosensor applications.

CMOT: Investigation and tuning of graphene electrodes for solution-processable metal oxide thin-film transistors in the area of low-cost electronics

Within CMOT project solution based metal oxide thin-film transistors (MOTFTs) with modified graphene electrodes will be tailored and developed for the field of flexible, low-cost electronics. The work-function engineering of the graphene electrode gives the opportunity to develop a completely new complementary technology based on one electrode material and a single semiconductor. Additionally, the reduction of processing temperatures is of vital interest for flexible substrates. Thus, a completely new laser-based technology as well as a laser demonstrator with different beam shapings will be developed. The new technology includes laser reduction of doped graphene oxide, a laser conversion of the metal oxide (MO) precursor and a laser patterning of the modified graphene and metal oxide. The MOTFTs prepared by the new technology will be compared to MOTFTs prepared by conventional semiconductor technology in order to evaluate the electrical limits and the market potential.

GRAFAT: Graphene for Functionalization of Advanced Textiles

New functional surface modifications for technical textiles based on graphene will be examined. The following objectives are set:

- Development of water stable graphene dispersions
- Development of application method and process for use on textiles
- Characterisation of the obtained samples
- Further processing into prototype textile products.

Different graphene modifications and their water stable dispersions will be developed to be applied on technical yarns and fabrics for novel high added value functionalities:

1. Antistatic and conductive technical yarns

development of an industrial, multi-yarn impregnation equipment

better flexibility of the yarn is envisioned

further processability into intermingled yarns and by sewing, embroidery, weaving, knitting

2. Flame retardant, high strength technical fabrics

Multi-functionalization via a one-step application

Use in personal protective equipment (PPE)

Decrease of clothing thickness and thus weight reduction and an increased wear comfort

ExploGuard: Novel explosive welded corrosion resistant clad materials for geothermal plants

ExploGuard will develop cladded materials for geothermal industry. Original and innovative concept of using for the benefit of high corrosion resistance the immanent to explosive welding (EW) melted zones as barrier for hydrogen will be implemented. This will be achieved by careful selection of substrates, tailoring EW parameters and post-EW metal forming and heat treatment. The EW clads are combinations of nanomaterials, non-equilibrium material compounds and/or multilayers with exceptional properties. Fatigue tests of steels commonly used in Icelandic geothermal plants (GPs) have shown that the reduced life of components is due to stress corrosion cracking and hydrogen embrittlement. ExploGuard clads would extend the service life of GPs and reduce the need for expensive corrosion resistant bulk materials. The project will build a competitive advantage for European-owned explosive welding company and strengthen outstanding Europe’s position in surface and coating technology.

ENPIEZO: Enabling technology for high-quality piezoMEMS

ENPIEZO aims to develop piezoelectric-based energy-harvesting (EH) devices to provide a remote source of electricity from waste vibrations with countless applications. For instance, EH devices can be powered by a heartbeat to operate pace-makers or it can provide electricity for sensors at remote locations like wind-turbine air blades. Fabrication-friendly pulsed-laser deposition of high-quality Pb(Mg1/3Nb2/3)O3-PbTiO3 thin films on silicon will be developed, based on the delicate engineering of silicon-oxide interfaces. The study will be performed on laboratory- and industrial-scale systems, the first of its kind in the world, which is believed to result in a breakthrough for the production of EH devices with state-of-the-art performance. In the project, aerosol deposition and environmentally friendly Na0.5Bi0.5TiO3-based piezoelectric alternatives

will also be investigated. The project brings together four partners with expertise in a very diverse field of research and development.

SurLas: SurLas: Surface functionalization using innovative and cost-effective picosecond fibre Laser sources

The “SurLas” project will research cost-efficient, industrially viable cutting-edge fibre laser technologies for structuring thin-film photovoltaic systems and functionalizing metallic surfaces for large-scale automotive end-use. The project involves applied research by a group of five European partners (from Germany, UK, and Denmark) each a leader in their respective field, working in strong collaboration within the technical fields defined for the Interfaces, Surfaces and Coatings Programme of the M-era.Net Transnational Call 2013. The project is driven by end-user requirements (LPKF SolarQuipment and MAN Diesel & Turbo) which will demand innovation in new cost-effective and robust ps laser sources for improved surface processing tools. SPI Lasers will undertake industrial research to deliver laser source functional models in conjunction with the Leibniz Institute of Photonic Technology, taking advantage of new glass technologies being researched together with Heraeus Quarzglas.

GRAPHICA: Graphene for Integrated Circuit Applications

Development of new approaches for the fabrication of graphene-based nanostructures with high quality graphene and tailored interfaces is of the highest importance. In this proposal, the main objective is to develop Si-technology compatible and transfer-free graphene synthesis method. This project aims to bring the Ni-assisted growth method to a new level of technological maturity and demonstrate its suitability for fabrication of graphene-based electronic devices in a state-of-the-art 200 mm CMOS pilot line. Towards this goal, we will investigate the interdependencies between gas phase chemistry, graphene formation and reactions with the insulator surface, as well as the full spectrum of technology integration-related aspects. In addition, the optimization of the CVD graphene growth method on semi-insulating SiC will be carried out. Finally, the transfer methods for CVD graphene will be scaled up to 200 mm wafers to show their potential with standard microelectronic manufacturing.

NANOPTICSS: Nanocoatings for Optical Sensor Systems Improvement

The main objective of the NANOPTICSS project is the development of anti-sticking and anti-coking nanocoatings based on sol-gel technology to protect the optical components of on-line sensor systems developed for condition monitoring of hydraulic oils in industrial machinery. By means of the development of these nanocoatings, it will be possible to increase the robustness of the on-line sensor systems.
The project addresses new solutions considering new concepts for coating and surface treatment: new anti-sticking and anti-coking nanocoatings based on sol-gel technology; new optical components with specific nanocoatings compatible with the hydraulic oil and resistant to the attack of the compounds generated during the degradation of the oil and external contaminants and the development of new robust and long-life on-line sensor systems for hydraulic oil condition monitoring in industrial machinery.

GRACE: Graphene-ceramic composites for tribological application in aqueous environments

There is a strongly growing demand for highly wear resistant and reliable ceramic materials for power generation and chemical industries. The objective of the proposed project is to develop graphene-ceramic nanocomposites and to qualify them for technical applications, e.g. slide bearings and face seals. Main benefits will be robust and reliable systems that enhance the efficiency and safety of industrial plants (lower energy consumption, less down-times, no pollution).
Work areas range from graphene synthesis to qualification of the graphene-ceramic nanocomposites for technical applications to demonstrate their potentials and benefits. Superior properties and new functionalities of these novel materials will improve the competitiveness of the European industry.

HieroComp: Functional hierarchical composites for structural applications

It is proposed to develop a new class of composite materials: functional, hierarchical composites for structural applications. Mechanical properties of these materials will be enhanced by control-ling the state and properties of interfaces between reinforcements and matrix at both nano and microscales. The engineered microstructure will also allow monitoring the state of damage while in service. Epoxy-based composites, which have a broad range of structural application in vari-ous industries will be considered. The need for epoxies with superior toughness is significant in applications in which vibrations are important (e.g. wind turbine and helicopter blades), in glues and other applications in the automotive industry. The consortium is a close collaboration be-tween two academic partners and three industrial partners from Austria and Romania, with com-plementary expertise and with the capability to bring the proposed advances from the concept state to specific products.

COSiFlex: Composite organic and silicon technologies on flexible substrates

Organic light-emitting diodes (OLED) and photodetectors (OPD) are well suitable for fabricating thin, large area devices. OLED technology with electronic circuitry is widely used in commercial display applications, but limited to this application domain. This project will extend the state-of-the-art by integrating OLED/OPDs in interdigitated form on a flexible carrier. Such integrated processing technology creates the basis for sophisticated thin-film flexible sensor and actuator devices. Technologies combining OLED/OPD structures with polymer film and silicon substrates will be established to build novel high-tech composites that can serve as basis for new, smart products. The project gathers technology experts in all relevant fields of organic semiconductors, thin-film processes, micromechanical systems, and integrated electronics. Research and industrial partners jointly work on combining and improving existing process technologies and ultimately transfer the generated knowledge.

M2Neural: Multifunctional Materials for advanced Neural interfaces

M2Neural aims at significantly improving the performance of neural electrodes, used for interfacing the peripheral nervous system. This will be achieved by providing the electrode with an advanced multifunctional coating. A non-degradable hydrogel with precisely tuned properties will allow i) to minimize the mechanical mismatch between the

implanted device and the tissue, ii) to promote electrode biocompatibility and axonal health thanks to the gradual release of neurotrophic and anti-inflammatory factors, and iii) to provide neurons with indirect electrical stimuli, by means of piezoelectric nanoparticles embedded in the hydrogel and periodical external ultrasound stimulation of the implant.
M2Neural will allow the development of a new generation of human-machine interfaces for bidirectional neurocontrolled hand prostheses and other types of neuroprostheses dedicated to restoring sensory-motor functions. The SME involved will maximize the M2Neural exploitation possibilities.

CERACELL: Feasability study: Development of 3-D patient-tailored bone pieces combining scaffold and bone cells for the repair of bone defects

One of the major challenges of modern medicine is to improve treatment of serious conditions such as massive bone defects, since if treatments exist, they are not fully satisfactory. The aim of CERACELL is to assess the feasibility of developing customized bone tissue engineered products combining osteoblasts and 3D tailored bioresorbable scaffolds for the reconstruction of bone defects. This tissue engineering approach is expected to accelerate and improve bone regeneration. This innovative project will be possible because of the complementarity of its partners who, in turn, will each benefit from it: Bone Therapeutics will broaden its portfolio of bone products, Image Analysis will develop novel techniques for modelling voids in predicted shapes and SIRRIS will continue to extend its knowledge in ceramic manufacturing process for new purposes in bone engineering.

MOLFIL-CNM: Gas Separation by tailored molecular filters made from Carbon Nanomembranes (CNMs) and Graphene

Graphene and carbon nanomembranes (CNMs) are utilized for gas separation processes. The “ballistic” transport of molecules through these extremely thin (< 1 nm) filter membranes is expected to be much more energy efficient than the “solution-diffusion” transport in conventional polymeric membranes. To control the permeation of gas molecules, we will tailor the pore sizes of CNMs and functionalized graphene with the help of specially synthesized precursor molecules. The permeation properties will be characterized for various separation tasks such as O2/N2, H2 and N2/CH4 separation, and CO2 capture. We will demonstrate the scalability of the process through the production and evaluation of high surface area membranes and test them with Associated Partners under industrial conditions. MOLFIL-CNM has an impact on low carbon energy technologies by providing significant energy reduction in materials separation and a new material for the capturing of greenhouse gases.

PiezoMEMS: Piezoelectric MEMS for efficient energy harvesting

The project proposes to develop a new piezoelectric harvester based on micro-electro-mechanical system (MEMS) devices and piezoelectric materials together with storage module and power circuitry. It focuses on small-scale power energy harvesting techniques (1-100µW) for autonomous operation of portable or embedded micro devices and systems. The harvester will include a MEMS device based on 10÷20 micrometric structures, covered with a piezoelectric thin film (ZnO/doped ZnO or KNN), connected

together for increasing the power density.
Expected results: New technology and Prototype of a piezoMEMS harvester for powering portable biomedical devices or sensor networks, tested in real environment applications.
Potential benefits: Green and cheap energy, reduction of CO2 emissions, improving quality of life. The project will impact the field of MEMS and piezomaterials manufacture, portable medical devices, sensors networks and green energy production.