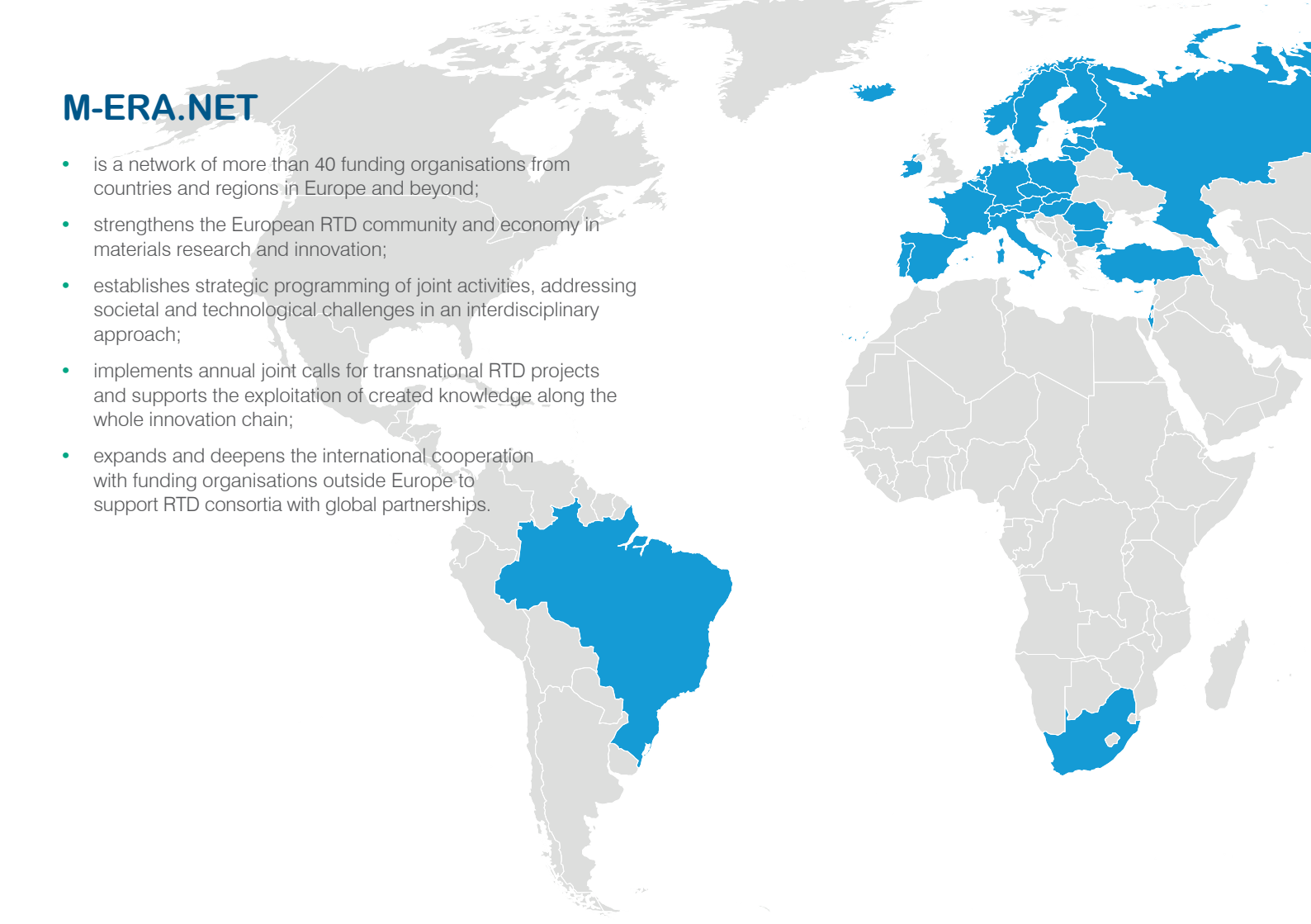
M-era.Net

SUCCESS STORIES

M-ERA.NET

- is a network of more than 40 funding organisations from countries and regions in Europe and beyond;
- strengthens the European RTD community and economy in materials research and innovation;
- establishes strategic programming of joint activities, addressing societal and technological challenges in an interdisciplinary approach;
- implements annual joint calls for transnational RTD projects and supports the exploitation of created knowledge along the whole innovation chain;
- expands and deepens the international cooperation with funding organisations outside Europe to support RTD consortia with global partnerships.



WHAT IS THE M-ERA.NET?

M-ERA.NET is an EU funded network which has been established in 2012 to support and increase the coordination of European research and innovation programmes and related funding in materials science and engineering. Between 2016 and 2021, the M-ERA.NET consortium will continue to contribute to the restructuring of the European Research Area (ERA) by operating a single innovative and flexible network of national and regional funding organisations. M-ERA.NET contributes to EU policies and is complementary to funding schemes at regional, national and European levels, supporting the exploitation of knowledge along the whole innovation chain from basic research to applied research and innovation. By stimulating scientific excellence and the creation of a new innovation oriented economy, M-ERA.NET will deliver lasting impact and significant breakthroughs. M-ERA.NET aims to develop a long-term cooperation between funding organisations from countries and regions across Europe and beyond.

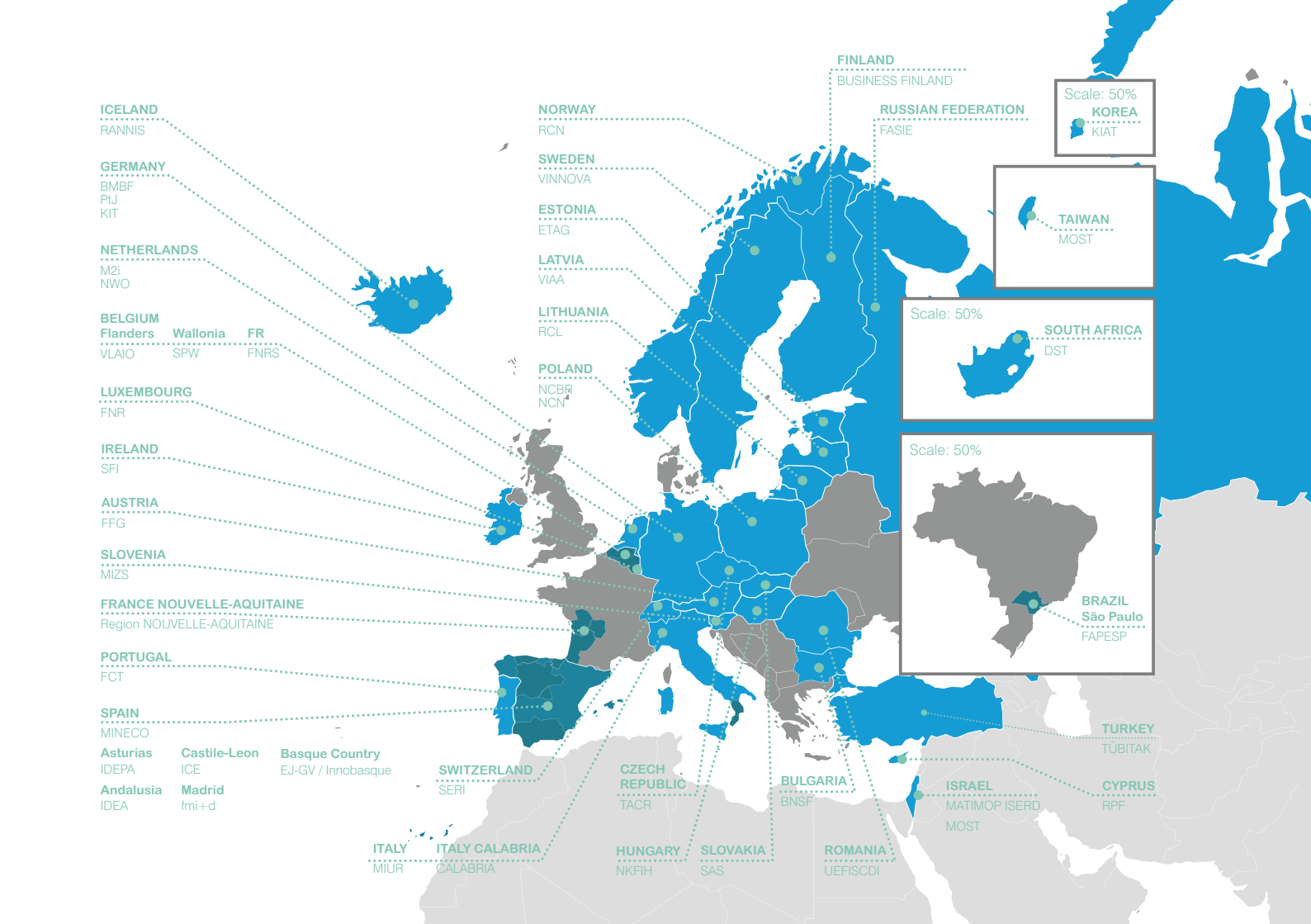
WHY FUNDING ADVANCED MATERIALS TECHNOLOGIES

Advanced materials technologies have been classified as Key Enabling Technologies (KET) with a wide range of product applications such as developing low carbon energy technologies and improving energy and resource efficiency. They have huge potential to fuel economic growth and provide jobs. In recent years, significant efforts have been made to ensure industry can meet the challenges it currently faces, in terms of the new materials being introduced and the stronger integration of products and processes required. Europe has a wealth of academic and industrial expertise and to ensure it stays at the forefront of developments it is crucial to have a strategic programme that helps to develop projects with impact on a global scale.

JOINT CALLS

The objective of the M-ERA.NET Calls is to enable transnational R&D projects between partners receiving funding from regional/national programmes. Benefits are combined in one approach: On the one hand the regional/national funding organisations apply their own well-established funding rules and procedures known to their applicants, and on the other hand the M-ERA.NET provides transnational coordination expertise. The funding organisations decide on a yearly base about their participation in the annual calls.

More details are available via our website:
https://m-era.net/joint-calls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CONTENTS

MAGNETICALLY ACTIVE ANISOTROPIC COMPOSITE SYSTEMS - MACOSYS

The project has targeted basic research on composite materials (ferronematics) consisting of liquid crystals and various magnetic nanoparticles (MNPs), with the key objectives: (i.) to determine optical and dielectric responses to low magnetic fields, (ii.) to explore the conditions influence these responses, (iii.) to contribute to the better understanding of the aggregation process, (iv.) to enhance the magnetic field induced phase transition temperature shift, and (v.) to produce a magnetically sensitive, optically anisotropic self-standing films. The project realisation has led to the following achievements:

- the optical and dielectric response of ferronematics to low magnetic fields have been measured with spherical and rod-like MNPs, as well as with carbon nanotubes;
- the role of the small bias magnetic field, and that of the anchoring conditions at the interfaces has been clarified;
- the influence of the aggregation of MNPs on the response to low magnetic fields, and on the magnetic susceptibility has been determined in various ferronematics – see figure;
- both positive and negative shifts of the phase transitions temperature have been achieved by the anisometry of MNPs, as well as by application of a magnetic field;
- novel photo-sensitive liquid crystal monomers and polymers have been synthetized and characterized.

The figure shows two ferronematics prepared in the identical procedure, with the same spherical Fe_3O_4 nanoparticles (having a mean diameter of 20nm), in the same volume concentration (10^{-4}), however, in different LC matrices: 6CHBT (on the left), and 6CB (on the right).

The project resulted in 18 peer-reviewed journal articles, with a cumulative I.F. above 40.

PROJECT DETAILS

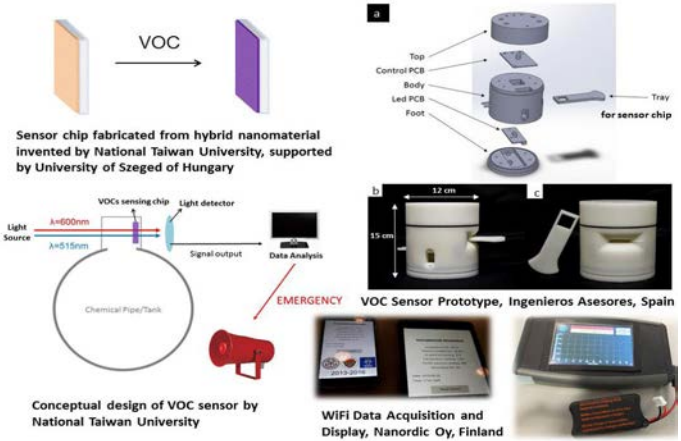
Call	Call 2012
Call Topic	High Performance Composites / Biobased Performance Material
Duration	36 months
Partners	Institute of Experimental Physics, SAS, Slovakia (Coordinator) Wigner Research Centre for Physics, HAS, Hungary (Partner) Institute of Physics, Academia Sinica, Taiwan (Partner)
Total project cost	€ 356,000
Contact	Institute of Experimental Physics, SAS Peter Kopčanský Watsonova 47, Košice, Slovakia Wigner Research Centre for Physics, HAS Tibor Toth-Katona Z.O.Box 49, H-1525 Budapest, Hungary tothkatona.tibor@wigner.mta.hu Peter Kopčanský Email: kopcan@saske.sk

Link to ERA-LEARN

HYBRID MATERIALS FOR LOW COST VOLATILE ORGANIC COMPOUND SENSOR SYSTEM - VOCSENSOR

Volatile organic compounds (VOCs) are one of the most vital areas for governments to monitor for pollutants and personnel safety. There are great needs in monitoring households, laboratories, planets, oil pipes, chemicals transports, etc., to prevent leakage and exposures of VOCs. In this project, novel nanocomposites thin films fabricated from conducting polymers and nanoparticles were invented by Prof. Wei-Fang Su of National Taiwan University. The thin films were used as highly sensitive sensor chips, aiming for low costs, high sensitivity and portable VOCs sensing system. The dramatic morphology and crystallinity changes of thin films upon the intake of VOCs vapor lead to higher absorption. Warning sets off to notify personnel once the absorbance of sensors is changed. In situ sensing system has been built according to special design for the project.

The consortium consisted of scientists from Taiwan (National Taiwan University), Finland (Nanordic Oy), Hungary (University of Szeged) and Spain (Ingenieros Asesores) to further original technology and develop a prototype product under a three-year M-ERA program. Taiwan and Hungary focus on the materials issues, increasing the sensitivity and reliability of the sensors; people from Finland and Spain make prototype product from our technology. The project was very successful. We achieved the following items for this program:



1. We made a prototype volatile organic compounds sensor that can detect toluene down to 100 ppm level which is complied with OSHA regulations. The development is still on going in National Taiwan University. The new version sensor can detect VOC down to ppm range (present in 2017 MRS Fall meeting).
2. We incorporated wireless communication into the prototype that can monitor the VOCs detection online through WiFi and internet.
3. The results of this program were published into 32 scientific papers in flag scientific journals such as Analytical Chemistry, Journal of Material Chemistry, etc.
4. Two Taiwan patents (I452288 and I537562), one US patent (9146222) were awarded to National Taiwan University.
5. The program provides an opportunity for Taiwan to work together with European scientific community not only on the technical side but also culture side. The relationship among participating countries is enhanced. We continue to collaborate on nano material research and development especially with Hungary and Finland. An internship program is built with Finland. We have a new MERA project (2017–2020) with Hungary and Netherlands on transparent perovskite solar cell (CLEARPV).
6. Please see our website: **www.vocsensor.com** for details.

PROJECT DETAILS

Call	Call 2012
Call Topic	High Performance Composites / Biobased Performance Material
Duration	36 months
Partners	National Taiwan University, Taiwan (Coordinator) Nanordic Oy, Finland (Partner) University of Szeged, Hungary (Partner) Envira Sostenible, Spain (Partner)
Total project cost	€ 780,299
Contact	National Taiwan University 1, Roosevelt Road, Sec. 4, Taipei, Taiwan Prof. Wei-Fang Su Email: suwf@ntu.edu.tw

Link to ERA-LEARN

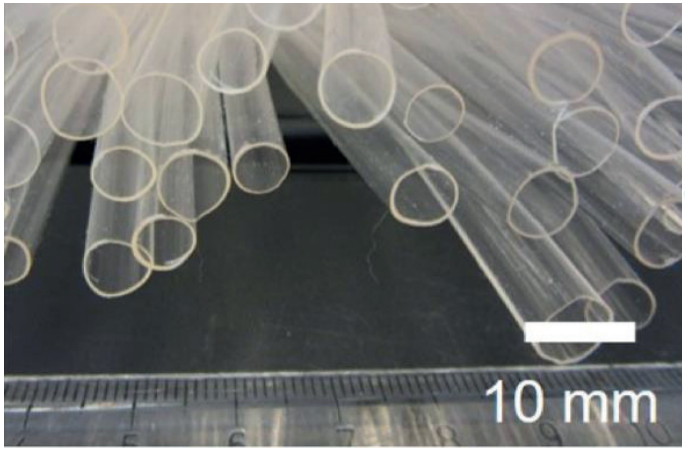
ENCAPSULATION OF POLYMERIC HEALING AGENTS IN SELF-HEALING CONCRETE: CAPSULE DESIGN - CAPDESIGN

We consider that € 40–120 million of the maintenance costs for concrete bridges, tunnels and retaining walls in the European Union could be saved by application of self-healing concrete. The encapsulation technique is however a bottleneck for valorisation since the capsules must possess multifunctional properties for self-healing concrete containing polymeric healing agents. The challenging objective of this project was to develop capsules which can easily survive the concrete mixing/ casting process at the one hand but break immediately when cracks appear in a hardened concrete matrix.

In the CAPDESIGN project, several encapsulation techniques and materials have been investigated. The most appropriate durable capsules were applied to evaluate their self-healing efficiency compared with their mechanical behaviour and liquid tightness. The feasibility of upscaling from laboratory to industrial proof of concept of the most promising capsule was also studied. The main achievements of the project include:

- The most promising materials which can survive the concrete mixing and break upon crack have been identified
- Promising capsules that are compatible with healing agents have been selected
- A low water uptake was measured in cracked samples containing capsules with healing agent, suggesting that a self-healing effect was obtained in concrete
- Upscaling of one selected type of capsule was realised

In addition, during the project period, the partners have published 7 papers in scientific journals and 20 presentations (oral and poster) in international conferences.



PROJECT DETAILS

Call	Call 2012
Call Topic	High Performance Composites / Biobased Performance Material
Duration	36 months
Partners	Ghent University, Belgium (Coordinator) Instituto Superior Técnico, Portugal (Partner) University of Mons, Belgium (Partner) BBRI, Belgium (Partner) CAO PRO sprl, Belgium (Partner) Microbelcaps, Belgium (Partner) SINTEF, Norway (Partner)
Total project cost	€ 1,731,000
Contact	Ghent University Faculteit Ingenieurswetenschappen en Architectuur Vakgroep Bouwkundige Constructies Laboratorium Magnel voor Betononderzoek, Belgium Prof. Dr. Ir. Nele De Belie Email: Nele.DeBelie@UGent.be

Link to ERA-LEARN

GRAPHENE-CERAMIC NANOCOMPOSITES FOR TRIBOLOGICAL APPLICATION IN AQUEOUS ENVIRONMENTS - GRACE

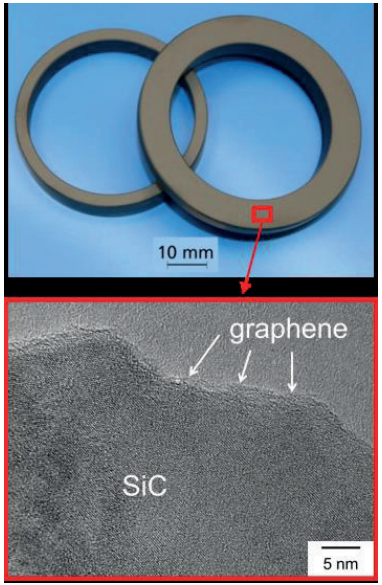
Ceramic materials like silicon carbides (SiC) are widely used in slide bearings and face seals as they provide a high wear resistance in aqueous media. Nevertheless, efforts are being made to keep energy losses caused by friction processes as low as possible and to increase the lifetime and durability of the tribologically loaded components. The addition of graphene into the SiC lattice is a promising approach to meet these requirements as this carbon modification strengthens the microstructure, chemically passivates the surface and decreases friction and wear.

Within the project GRACE, SiC-graphene-nanocomposites were produced and tested under water-lubricated conditions to assess their usability for technical applications. In addition, also silicon nitride-graphene nanocomposites were developed and assessed concerning their mechanical and tribological properties.

During the project, several goals could be achieved:

- Successful Development of innovative process routes to manufacture graphene dispersions and coat SiC particles with graphene
- Sintering, mechanical, microstructural and tribological characterization of SiC-and Si3N4-graphene-nanocomposites
  - Correlation of the graphene manufacturing process and graphene content with the mechanical, friction and wear behaviour
  - Evidence of the conditions and microstructures under which the best tribological results are achieved
  - Modelling of the wear mechanisms and tribo-chemical processes which determine the friction behaviour
- Atomistic simulation of the tribological contact on graphene layers on the SiC surfaces revealed tribological mechanisms to explain the friction behaviour on the macro-scale.
- Manufacture of seals with SiC-graphene-nanocomposites and demonstration of the results under operation conditions.

The results were presented and discussed at various conferences and published in peer-reviewed journals. In addition, a patent application concerning the coating of SiC with graphene was filed by EagleBurgmann Germany.



PROJECT DETAILS

Call	Call 2013
Call Topic	High Performance Composites / Biobased Performance Material
Duration	42 months
Partners	Fraunhofer Institute for Mechanics of Materials IWM, Germany (Coordinator) University of Freiburg, Germany (Partner) FCT Ingenieurkeramik GmbH, Germany (Partner) Centre for Energy Research, Hungary (Partner) Institute of Materials Research, Slovakia (Partner) EagleBurgmann Germany GmbH & Co KG, Germany (Partner)
Total project cost	€ 2,034,000
Contact	Fraunhofer Institute for Mechanics of Materials IWM Woehlerstr. 11, 79108 Freiburg, Germany Dr. Andreas Kailer Email: andreas.kailer@iwm.fraunhofer.de Phone: +49 761 5142-247

Link to ERA-LEARN

HIGH RESOLUTION ROLL-TO-ROLL PRINTING OF BIO-COMPATIBLE GRAPHENE/PROTEIN MULTILAYERS FOR BIOMEDICAL APPLICATIONS - BIOGRAPHY

The high-performance material graphene has great potential for use in biosensors. However, new production techniques are required for a rapid transfer of research results from materials science to industrial applications.

In the project, BIOGRAPHY, methods for automated roll-to-roll printing of graphene based electrode structures and their protein coating were developed for industrial-scale production of biosensors. A new graphene ink was developed and tested for biocompatibility, conductivity and printability. Printing cylinders were directly patterned using a newly developed micro-engraving machine with an ultra-short pulse laser. For sensor production, a roll-to-roll printing system was established. Biosensors with graphene electrodes were roll-to-roll printed with the new printing machine and tested for their suitability for automated validation of antiviral substances and for conducting toxicity tests.

Thanks to the success of the project, the following results were achieved:

- Compact two colour roll-to-roll printing machine with integrated corona unit for surface activation and near-infrared drying units.
- Process for patterning of micro-engraved printing cylinders: Structures with lateral dimensions $< 10\,\mu m$ were achieved.
- Biocompatible graphene ink suited for gravure printing. The printed structures have a square resistance of 10 Ω/sq at 25 μm.
- Process for printing biosensors comprising interdigitated electrodes down to 50 μm in width.

Single sensors and biosensors in multi-well plate format, integrated in incubators with customised sensor readout-systems, are ready for use in the labs of the project partners AiCuris Anti-infective Cures GmbH and cellasys GmbH.

Link to the final report in the database „Fraunhofer-Publica“: (rn:nbn:de:0011-n-5032931):
http://publica.fraunhofer.de/dokumente/N-503293.html

PROJECT DETAILS

Call	Call 2013
Call Topic	Innovative Surfaces, Coatings and Interfaces
Duration	42 months
Partners	Fraunhofer Institute for Biomedical Engineering IBMT, Germany (Coordinator) SAUERESSIG GmbH + Co. KG, Germany (Partner) AiCuris Anti-infective Cures GmbH, Germany (Partner) cellasys GmbH, Germany (Partner) Haydale Limited, United Kingdom (Partner)
Total project cost	€ 2,247,000
Contact	Fraunhofer Institute for Biomedical Engineering IBMT Joseph-von-Fraunhofer-Weg 1, 66280 Sulzbach, Germany Dr. Thomas Velten Email: thomas.velten@ibmt.fraunhofer.de

Link to ERA-LEARN

INVESTIGATION AND TUNING OF GRAPHENE ELECTRODES FOR SOLUTION-PROCESSABLE METAL OXIDE THIN-FILM TRANSISTORS IN THE AREA OF LOW-COST ELECTRONICS - CMOT

The CMOT project aims to tailor and develop solution based metal oxide thin-film transistors (MOTFTs) with graphene electrodes for the field of flexible, low-cost electronics. For this purpose, work-function engineering of both graphene and reduced graphene oxide electrodes was carried out. Additionally, the reduction of processing temperatures is of vital interest for flexible substrates. Thus, a laser-based technology for reduction of graphene oxide, conversion of the solution based metal oxide precursor and patterning of graphene electrodes and metal oxide semiconductor was developed.

Within the CMOT project the following results were achieved:

- Work function engineering of graphene electrodes in the range of 3.9 eV $\leq \Phi \leq$ 5.6 eV
- Waterless transfer process of monolayer graphene on the metal oxide film
- Laser induced graphene oxide reduction and patterning for application as electrode (Rsh $\approx$ 1 kΩ/sq)
- Development of UV-laser source with ps pulse length tailored for metal oxide conversion
- MOTFTs with laser converted metal oxide (μeff= 0.9 $cm^2V^{-1}s^{-1}$)
- Selective laser structuring of graphene and graphene oxide
- Flexible beam shaping with spatial light modulator (SLM) for sequential edge deletion of MOTFTs with ultrashort pulse lasers
- Enhanced reliability of the MOTFTs by implementation of an yttrium oxide passivation layer
- MOTFTs with graphene electrodes (μeff= 2 $cm^2V^{-1}s^{-1}$) exceed the performance of MOTFTs with conventional Ti/Au electrodes (μeff = 1 $cm^2V^{-1}s^{-1}$)

The interim results of the project are both of scientific and industrial interest. Several conference contributions as oral (**1**, **2**) and poster presentation (**3**, **4**) have been given. Also one paper for peer review has been submitted (**5**). The results concerning the technology of flexible beam shaping for thin film structuring, which was set up and evaluated by LPKF, show it can be deployed for several areas of laser material processing. The possibility to adapt the beam shape almost arbitrarily to the application is beneficial for

the productivity and flexibility of the laser process. LPKF sees potential for application in PCB processing (e.g. drilling of plated through contacts), glass processing and plastic welding and wants to evaluate and exploit this technology further. 3D-nano expects to benefit from the results of experimental research on the novel type of nanomaterials that is lacking today in the marketplace. It will therefore form the basis of a potentially substantial business opportunity for the company like 3D-nano.

1. Kasischke, M., et al. “Selective Femtosecond Laser Ablation of Graphene for Its Micro-Patterning.” ICALEO Congress Proceedings 2016 - 35th International Congress on Applications of Lasers & Electro-Optics, San Diego, CA, USA; 10/2016
2. Kasischke, M., et al. “Graphene oxide reduction induced by femtosecond laser irradiation.” Nanostructured Thin Films X. Vol. 10356. International Society for Optics and Photonics, 2017.
3. Subasi, E., et al. “Solution-processed bottom-contact metal-oxide thin-film transistors with transparent graphene electrodes.” Graphene Week 2017, Athens, Greece
4. Kasischke, M., et al. “Femtosecond lasers as micro-machining tool for graphene structuring and graphene oxide reduction.” Graphene Week 2017, Athens, Greece
5. Kasischke, M., et.al. “Simultaneous nanopatterning and reduction of graphene oxide by femtosecond laser pulses” (2017) submitted to: Physical Review Applied

PROJECT DETAILS

Call	Call 2013
Call Topic	Innovative Surfaces, Coatings and Interfaces
Duration	36 months
Partners	Applied Laser Technologies, Ruhr-University Bochum, Germany (Coordinator)
	3D-nano, Poland (Partner)
	Wroclaw Research Centre EIT+,, Poland (Partner)
	LPKF Laser & Electronics AG, Germany (Partner)
	EdgeWave GmbH, Germany (Partner)
	Chair of Electronic Materials and Nanoelectronics, Germany (Partner)
	Evonik Industries AG, Germany (Other)
Total project cost	€ 1,432,500
Contact	Applied Laser Technologies, Ruhr-University Bochum Universitätsstr. 150 44801, Bochum, Germany
	Prof. Dr.-Ing. Andreas Ostendorf Email: Andreas.Ostendorf@ruhr-uni-bochum.de

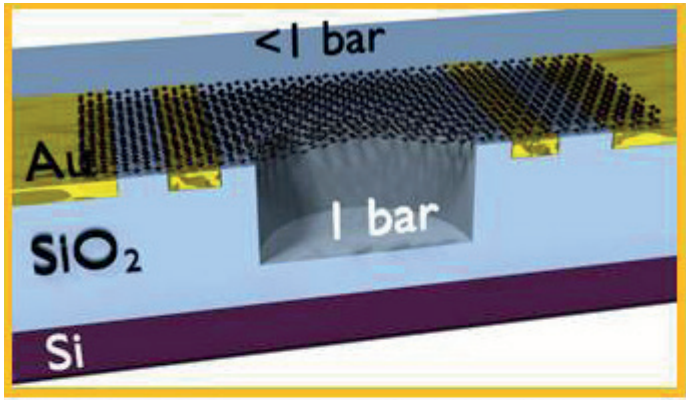
Link to ERA-LEARN

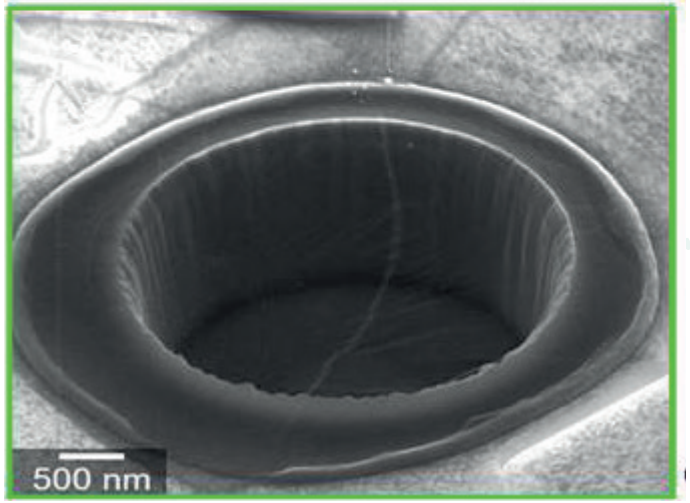
GRAPHENE FABRICATION, INTEGRATION AND METROLOGY FOR NANOELECTROMECHANICAL SYSTEMS - NANOGRAM

NanoGraM has explored new Nano-/Microelectro-mechanical (NEMS/MEMS) devices based on graphene interfaces and surfaces. 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 main results obtained in the framework of this project are:

- Development of semi-dry transfer process for graphene on cavities and holes
- Reduction of metal contamination by factor 10
- Characterization of the influence of gas adsorption on the electrical characteristics of graphene.
- Determination of the contact resistance between graphene and various metals. Palladium was determined as the most efficient system.
- Evaluation of non-invasive regime of Raman spectroscopy of free standing and suspended graphene
- Application of new measurement stabilization methods enabling large-area and high resolution characterization of quality and stress in extended graphene membranes
- First time implementation of 3D Raman topography to this kind of application (large-area graphene membranes)
- Demonstration and evaluation of the feasibility of freestanding graphene membranes in the addressed applications (microphone and magnetic field sensor)
- Demonstration of the principal feasibility of devices with integrated graphene membranes
- High-level training of future science and technology leaders through several PhD theses.

Three patent applications were filed within the project plus several which are still in the pipeline. At least seven papers were published in peer-reviewed journals out of which we explicitly highlight a publication by a consortium of authors from three NanoGraM partners: S. Wagner, T. Dieing, A. Centeno, A. Zurutuza, A.D. Smith, M. Östling, S. Kataria, M.C. Lemme, “Noninvasive Scanning Raman Spectroscopy and Tomography for Graphene Membrane Characterization”, Nano Letters, 17(3): 1504–1511, 2017.





PROJECT DETAILS

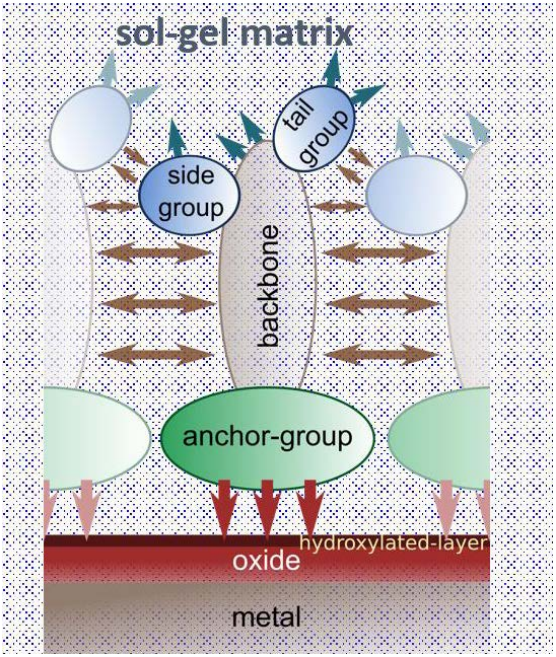
Call	Call 2013
Call Topic	Innovative Surfaces, Coatings and Interfaces
Duration	36 months
Partners	Infineon Technologies AG, Germany (Coordinator) WITec GmbH, Germany (Partner) Universität Siegen, Germany (Partner) Graphenea, Spain (Partner) Simune Atomistics S.L., Spain (Partner) RWTH Aachen, Germany (Partner)
Total project cost	€ 1,960,244
Contact	Infineon Technologies AG BEX RDE RDF; c/o Werner Weber, 81726 Munich Werner Weber Email: werner.weber@infineon.com

Link to ERA-LEARN

DESIGN OF CORROSION RESISTANT COATINGS TARGETED FOR VERSATILE APPLICATIONS - COR_ID

Corrosion is unfavourable process with huge economic and environmental adverse effects. Improvement of corrosion resistance of aluminium and its alloys, especially under operating conditions in aeronautical, nautical and automobile industries, is a necessity due to restriction of chromate conversion coatings. In the proposed project we investigate organic corrosion inhibitors and hydrophobic agents in combination with hybrid coatings for various aluminium metal substrates.

The objective of the project is to design multifunctional coatings which would simultaneously act as high-quality corrosion inhibitors and offer additional properties like hydrophobicity. These coatings will be used also for less corrosion resistant Al alloys or secondary Al alloys by industrial partner Talum to improve the functional performance of some of their products.



Through the project the following results have been achieved:

- Potential candidates for (i) hydrophobic compounds and (ii) corrosion inhibitor compounds based on alkyl and perfluoroalkyl chains were synthesized and tested on aluminum alloys. The most efficient compounds have been verified.The most corrosion resistant hybrid matrix has been selected and tested in field marine environment.
- A “virtual laboratory” is being established to enable the construction of parameters used in larger-scale simulations, such as, semi-empirical based molecular-dynamics.
- Pilot device for large-scale testing is under construction.

The project goals are being realized through the ICME (Integrated Computational Materials Engineering) paradigm consisting of integration of three fundamental disciplines: multi-scale modeling, multi-scale chemical synthesis, and high-throughput electrochemical and corrosion experimental testing and verification.

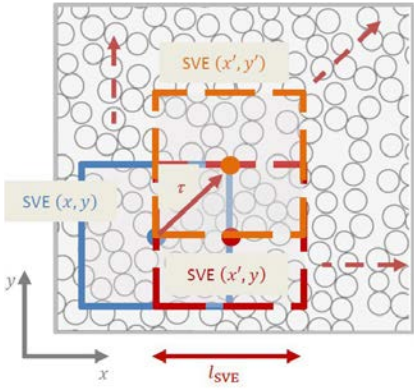
PROJECT DETAILS

Call	Call 2014
Call Topic	Innovative Surfaces, Coatings and Interfaces
Duration	36 months
Partners	Jožef Stefan Institute, Ljubljana, Slovenia (Coordinator)
	Talum d.d. Kidričevo, Slovenia (Partner)
	L’Ecole Nationale Supérieure de Chimie de Paris (ENSCP) and Le Centre National de la Recherche Scientifique (CNRS), France (Partner)
	Eötvös Loránd University, Hungary (Partner)
Total project cost	€ 597,300
Contact	Jožef Stefan Institute Jamova c. 39, 1000, Slovenia
	Prof. Ingrid Milošev, Ph.D. Email: ingrid.milosev@ijs.si

Link to ERA-LEARN

STOCHASTIC MULTI-SCALE MODELING METHODOLOGIES FOR THE ASSESSMENT OF FAILURE PERFORMANCE OF COMPOSITE MATERIALS - STOMMMAC

Objectives



Although composite materials offer many advantages, such as high strength-to-weight ratio, enhanced potentials for material and structure design, and many others, their potential is not realized in practice because their properties after manufacturing suffer from scatter, leading to over-designed structures. The aim of STOMMMAC is to develop an integrated stochastic multi-scale approach able to predict the failure probability of composite materials using uncertainty quantification (UQ) of the micro-scale constituents and microstructure, and by propagating them up to the macro-scale.

Publications

- An incremental-secant mean-field-homogenization method with second statistical moments for elasto-visco-plastic composite materials, Ling Wu (ULiege), Laurent Adam (e-Xstream), I. Doghri (e-Xstream), Ludovic Noels (ULiege), Mechanics of Materials 114 (2017) 180–200
- From SEM images to elastic responses: a stochastic multiscale analysis of UD fiber reinforced composites, Ling Wu (ULiege), Chi Nghia Chung (JKU), Zoltan Major (JKU), Laurent Adam (e-Xstream), Ludovic Noels (ULiege), Composite Structures, Revised version Submitted.
- Micro-mechanics based order reduction for uncertainty analysis of UD-fiber reinforced composites. Ling Wu (ULiege), Laurent Adam (e-Xstream), Ludovic Noels (ULiege), In Preparation.

Project Details:

In order to propagate micro-structural uncertainties to the macro-scale STOMMMAC develops an original stochastic mean-field homogenization (MFH) able to predict the probabilistic distribution of the material response at an intermediate scale, called the mesoscale. The method will be able to predict the probability distribution of:

- The properties of the homogenized composite material;
- The stress/strain state reached in each constituent;
- Failure states from the stress/strain level distribution in the micro-constituents.

The distribution of the meso-scale material properties can then be exploited at the macro-scale, i.e. the structural level, to study composite structures in a non-deterministic way. The project focuses on two types of composite materials, namely short fiber reinforced polymers (SFRP) and continuous fiber reinforced polymers (CFRP), as well as two performance indicators: isothermal static and fatigue failure (high number of cycles and low frequency loads).

PROJECT DETAILS

Call	Call 2014
Call Topic	Integrated Computational Materials Engineering (ICME)
Duration	36 months
Partners	e-Xstream engineering, MSC Software Belgium S.A., Belgium (Coordinator) University of Liège (ULiege), Belgium (Partner) University of Luxembourg (UL), Luxembourg (Partner) Johannes Kepler Universität (JKU), Austria (Partner) ACTION COMPOSITES GmbH (AC), Austria (Partner) BATZ, S.Coop, Basque Country,, Spain (Partner)
Total project cost	€ 1,579,214
Contact	e-Xstream engineering, MSC Software Belgium S.A. Axis Park – Building H 9, Rue Emile Francqui B-1435 Mont-Saint-Guibert, Belgium R&D Director Laurent ADAM Email: Laurent.ADAM@e-xstream.com

Link to ERA-LEARN

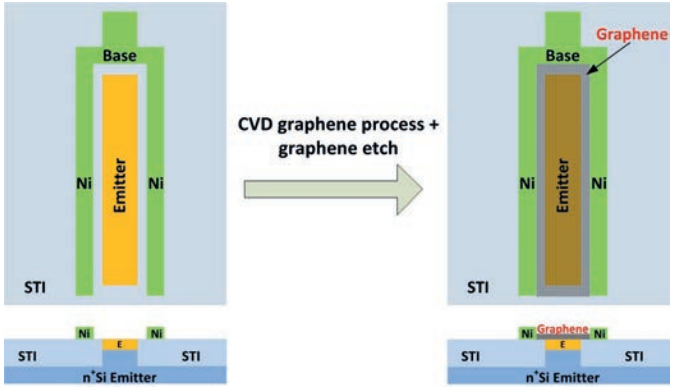
GRAPHENE FOR INTEGRATED CIRCUIT APPLICATIONS - GRAPHICA

Direct growth of high quality, large area and uniform graphene layers on arbitrary insulating substrates still remains one of a key challenges for the successful integration of graphene into the novel microelectronic devices. Therefore, developments of new approaches for the fabrication of graphene-based nanostructures with high quality graphene and tailored interfaces is of the highest importance.

In the GRAPHICA project, we aimed to develop Si-technology compatible graphene synthesis method and bring the growth method to a new level of technological maturity and demonstrate its suitability for fabrication of graphene-based electronic devices in a 200 mm CMOS pilot line.

During the project the following has been achieved:

- The influence of substrate layouts and catalyst thickness on the proof-of-concept graphene growth has been determined.
- he influence of the wide range of the CVD processing parameters on the properties of grown layers has been investigated.
- The pilot study and the integration of developed layouts into the CMOS platform for the fabrication of the graphene based devices has been demonstrated.
- A technical analysis for the development of next generation CVD equipment at Aixtron for CMOS based graphene application was obtained.



PROJECT DETAILS

Call	Call 2013
Call Topic	Integrated Computational Materials Engineering (ICME)
Duration	36 months
Partners	IHP, Germany (Coordinator) AIXTRON SE, Germany (Partner) ITME, Poland (Partner) Nano-Carbon, Poland (Partner)
Total project cost	€ 1,515,500
Contact	IHP Im Technologiepark 25, Frankfurt (Oder), Germany Dr. Mindaugas Lukošius Email: lukosius@ihp-microelectronics.com

Link to ERA-LEARN

DESIGN OF NEW METALLIC OXIDE-CARBON HYBRID COMPOSITES FOR SUPERCAPACITORS ELECTRODES - MOC@SUPCAP

The M.Era-Net project entitled “Design of new metallic oxide-carbon hybrid composites for supercapacitors electrodes” has been successfully developed by the proposed institutions, namely IST/Portugal, Sintef/Norway, and NTNU/Norway. The above-mentioned project gave rise to nine publications, which are all dedicated to the supercapacitors field. Besides these interesting publications, one of the materials utilized on the project, carbon foam as negative electrode, motivated a Portuguese company (C2C-NewCap - **https://www.c2cnewcap.com/**) to successfully test our approach of fabricating hydroxides-oxides and carbon-based materials as hybrid super-capacitors in its production line. In fact, this fabrication route has been published in one of the best journals devoted to power sources, the “Journal of Power Sources”, in which it is demonstrated the production of $Co(OH)_2$/carbon nanofoam composite as supercapacitor electrode operating at 2 V in friendly aqueous medium. In addition, we have dealt with graphene-based active materials which are undoubtedly the most studied materials in the current state-of-art and have extraordinary chemical and physical properties leading them to a myriad of applications.

In summary, we believe that our project has significantly contributed to both academia and industry fields and is part of an essential area for the sustainable and economic development of all countries around the world which is renewable energy.

In this project, different materials, e.g. MnO_2, $Co(OH)_2$, NiO, reduced graphene oxide (rGO), have been produced devoted to supercapacitor applications. Most of them have been obtained by electrodeposition technique which is no doubt a simple, versatile, and efficient approach to fabricate supercapacitor materials. More details about the obtained results originated from this work can be found in our list of publications from this work:

1. R. Della Noce, S. Eugénio, T.M. Silva, M.J. Carmezim, M.F. Montemor, ∂-$Co(OH)_2$/carbon nanofoam composite as electrochemical capacitor electrode operating at 2 V in aqueous medium, Journal of Power Sources 288 (2015) 234-242.
2. A. García-Gómez, R.G. Duarte, S. Eugénio, T.M. Silva, M.J. Carmezim, M.F. Montemor, Fabrication of electrochemically reduced graphene oxide/cobalt oxide composite for charge storage electrodes, Journal of Electroanalytical Chemistry 755 (2015) 151-157.

3. R. Della Noce, S. Eugénio, M. Boudard, L. Rapenne, T. M. Silva, M. J. Carmezim, S. W. Donne, M. F. Montemor, One-step process to form a nickel-based/carbon nanofoam composite supercapacitor electrode using Na2SO4 as an eco-friendly electrolyte, RSC Advances 6 (2016) 15920-15928.

4. K. K. Upadhyay, S. Eugénio, R. Della Noce, T. M. Silva, M. J. Carmezim, M. F. Montemor, Hydrothermally grown $Ni_{0.7}Zn_{0.3}O$ directly on carbon fiber paper substrate as an electrode material for energy storage applications, International Journal of Hydrogen Energy 41 (2016) 9876-9884.

5. T. Nguyen, M. Boudard, M. J. Carmezim, M. F. Montemor, $Ni_xCo_{1-x}(OH)_2$ nanosheets on carbon nanofoam paper as high areal capacity electrodes for hybrid supercapacitors, Energy 126 (2017) 208-216.

6. A. Adán-Más, Raquel G. Duarte, T. M. Silva, L. Guerlou-Demourgues, M. F. G. Montemor, Enhancement of the Ni-Co hydroxide response as energy storage material by electrochemically reduced graphene oxide, Electrochimica Acta 240 (2017) 323-340.

7. R. Della Noce, S. Eugénio, T. M. Silva, M. J. Carmezim, M. F. Montemor, Electrodeposition: A Versatile, Efficient, Binder-free and Room Temperature One-Step Process to Produce MnO_2 Electrochemical Capacitor Electrodes, RSC Advances 7 (2017) 32038-32043.

8. K. K. Upadhyay, M. Altomare, S. Eugénio, P. Schmuki, T. M. Silva, M. F. Montemor, On the Supercapacitive Behaviour of Anodic Porous WO3-Based Negative Electrodes, Electrochimica Acta 232 (2017) 192-201.

9. K. K Upadhyay, T. Nguyen, T. M. Silva, M. J. Carmezim, M. F. Montemor, Electrodeposited MoOx films as negative electrode materials for redox supercapacitors, Electrochimica Acta 225 (2017) 19-28.

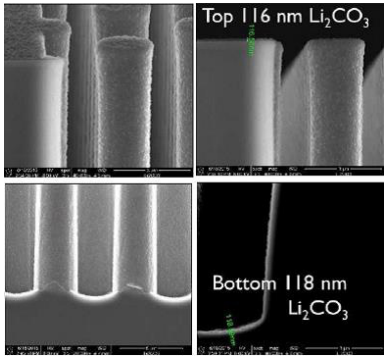
PROJECT DETAILS

Call	Call 2012
Call Topic	Materials for Sustainable and Affordable Low Carbon Energy Technologies
Duration	36 months
Partners	Instituto Superior Técnico, Portugal, Portugal (Coordinator) Norwegian University of Science and Technology, Norway (Partner) Sintef Materials and Chemistry, Norway (Partner)
Total project cost	€ 993,426
Contact	Instituto Superior Técnico - IST Avenida Rovisco Pais, 01 – 1049-001 – Lisboa, Portugal Maria de Fátima Montemor Email: mfmontemor@tecnico.ulisboa.pt

Link to ERA-LEARN

CONFORMAL LAYER-BY-LAYER GROWTH OF HYBRID POLYMER/ INORGANIC NANOLAMINATES FOR LI-ION BATTERIES - LAMINALION

Our modern society depends on lithium-ion batteries, which currently are used to power an increasingly diverse range of applications from large ships down to microchips. Safer batteries with high capacities and improved power capabilities are needed for future applications, and 3D structured all-solid-state batteries is one approach that could fulfil these demands.



The main goal of the current project has been to manufacture functional all-solid state 3D thin-film micro-batteries by atomic layer deposition. The current project has focused on conformal coating processes and solid electrolytes as well as cathode and anode materials for batteries. 3D structured batteries have been attempted, however, a fully functional device was not realised. New solid-state electrolytes combining organic- and inorganic materials were made, showing promising potential. The major outcome of the current project has been the gained insight into the interfaces occurring when materials are combined, thus opening for a functional demonstrator in the near future combining polymer thin films with ceramic properties.

A patent was filed:

"Methods for forming lithium manganese oxide layers" Nouha Labyedh, Marina Yurievna Timmermans, Philippe Vereecken, US 15339577 A1, Pub. Date: May 04, 2017. Related to the conversion of EMD (electrolytic MnO_2) to LMO ($LiMn_2O_4$) by coating with Li_2CO_3 using both sold-gel process and ALD coating.

We would like to emphasise the papers:

“100 nm Thin-Film Solid-Composite Electrolyte for Lithium ion batteries” Xubin Chen and Philippe M. Vereecken, Adv. Mater. Interfaces 4 (4), 1600877 (2017). DOI:10.1002/admi.201600877.

“Molecular Layer Deposition of “titanicone”, a titanium-based hybrid material, as an electrode for lithium-ion batteries” Kevin Van de Kerckhove, Felix Mattelaer, Davy Deduytsche, Philippe M. Vereecken, Jolien Dendooven, and Christophe Detavernier, Dalton Trans. 45, 1176-1184 (2016). DOI: 10.1039/C5DT03840E

“Electrodeposition of Insulating Poly(phenylene oxide) Films with Variable Thickness” Marina Timmermans, Felix Mattelaer, Sébastien Moitzheim, Nick Clerckx, Alfonso Sepulveda, Stella Deheryan, Christophe Detavernier, and Philippe Vereecken, J. of Appl. Polym. Sci, 44533-44539 (2016). DOI: 10.1002/app.44533

PROJECT DETAILS

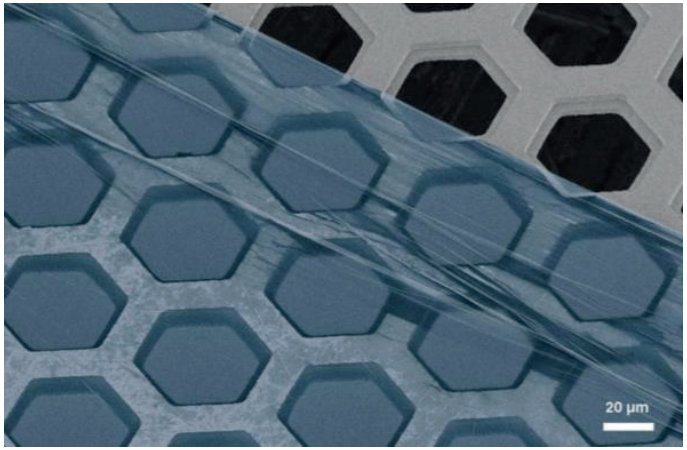
Call	Call 2012
Call Topic	Materials for Sustainable and Affordable Low Carbon Energy Technologies
Duration	36 months
Partners	imec, Belgium (Coordinator) UiO, Norway (Partner) Picosun, Finland (Partner) UGent, Belgium (Partner)
Total project cost	€ 945,587
Contact	imec Belgium Philippe Vereecken Email: vereeck@imec.be

Link to ERA-LEARN

GAS SEPARATION BY TAILORED MOLECULAR FILTERS MADE FROM CARBON NANOMEMBRANES (CNMS) AND GRAPHENE - MOLFIL-CNM

Carbon Nanomembranes (CNMs) are molecular thin, Carbon-based membranes, with wide application potential in many fields like electronics, energy, medicine and membrane technology. Due to their thinness of only about 1 nanometer and our ability to control the porosity, CNMs promise to enable energy-efficient separation based on molecular sieving and ballistic transport. The objective of the MOLFIL-CNM project was to develop CNM-based membranes and test them in practical applications.

During the project, we demonstrated that at least one type of CNMs show a record high permeance of 10^{-4} mol/m^2*s*Pa for water, which is several orders of magnitude higher than conventional polymer membranes and some recently developed graphene, carbon nanotube and biomimetic membranes. Additionally, this high permeance is coupled with an excellent selectivity: Besides water, only Helium as the smallest gas pass through this type of CNM, and that already with a permeance of two orders of magnitude less than water vapour. The permeance of all other tested materials were beyond our detection limit. The project partners also evaluated concepts, how to implement the molecular thin CNM as active layer in thin film composite membranes, which can be handled in real-world applications. CNM Technologies has developed a concept for a batch-based pilot-production of CNMs with a capacity of several 10,000 m^2 per year at a price comparable to conventional asymmetrical membranes. As CNMs can be easily processed and scaled up, they open a path for highly selective and highly permeable water filtration. The use of CNMs for water filtration as well as newly developed ways of membrane production were protected by two patent applications.



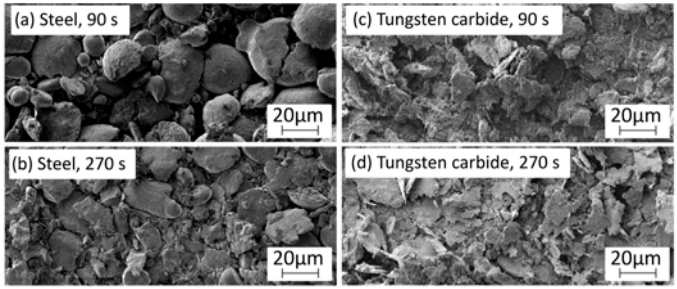
PROJECT DETAILS

Call	Call 2013
Call Topic	Materials for Sustainable and Affordable Low Carbon Energy Technologies
Duration	36 months
Partners	Universität Bielefeld, Germany (Coordinator) MPI für Polymerforschung, Germany (Partner) Helmholtz-Zentrum Geesthacht, Germany (Partner) CNM Technologies GmbH, Germany (Partner) Luxembourg Institute of Science and Technology, Luxembourg (Partner)
Total project cost	€ 1,588,954
Contact	Universität Bielefeld Universitätsstr. 25, 33615 Bielefeld, Germany Prof. Armin Gölzhäuser Email: ag@uni-bielefeld.de

Link to ERA-LEARN

NEW EXCHANGE-COUPLED MANGANESE-BASED MAGNETIC MATERIALS - NEXMAG

NEXMAG project has managed to cover successfully scientific research and technological development in the field of rare earth-free permanent magnets. In addition to scientific highlights achieved on the MnAl system, a patent focused on a functional prototype has been filled, and the world-leading manufacturer of metal powders –Höganäs AB (Sweden)– has established an on-going industrial collaboration for implementation and up-scaling of some of NEXMAG's results.



Permanent magnets (PMs) are a crucial element in several high-tech markets such as energy and transport sectors, medical technologies and a broad range of electronic products. In addition, PMs play a very important role in efforts focused on an increased use of low carbon technologies to ensure a high living standard. However, most of nowadays-technological PMs contain critical raw materials (rare-earths) as fundamental constituents and EU does not own the natural resources, which might result in a future bottleneck to the supply-chain.

NEXMAG **(http://www.nexmag.net)** has focused on the development of PM properties in Mn-based alloys: MnAl and MnBi. MnAl is an interesting PM candidate based on excellent theoretically predicted PM properties, low-density, low-cost and abundance of Mn and Al, together with good mechanical properties. MnBi offers excellent PM properties at high temperatures mainly intended for specific low-volume applications demanding high-magnetic performance under those conditions

Highlights of the project can be summarized as follows:

- Development of PM properties in gas-atomized MnAl particles by nanostructuration with unprecedented short milling times by application of an “ultrafast-milling” method: 30–270 s (vs 20–30 h typically reported).
- Tuning microstructure and phase transformation by ultrafast-milling and cryomilling followed by a single-annealing step makes possible to go from a multiphase phase to a ferromagnetic single-phase MnAl system, with customized PM properties. This has been proven on bulk alloy, gas-atomized particles and melt-spun ribbons.
- Establishment of the correlation between morphological, microstructural and magnetic properties, which allows the development of high-coercive (above 5 kOe) isotropic nanocrystalline MnAl powder.
- Development of particulate and continuous MnBi thin films with a coercivity of 29 kOe at 500 K, counting among the largest reported ones for the MnBi system.
- Production of MnAl/metal nanocomposites with enhanced magnetization by matching complimentary properties of dissimilar materials.
- First reported results on the fabrication of MnAl/polymer composites for 3D-printing of novel permanent magnets.

These achievements have led to results of relevance from both scientific and technological points of view:

Dissemination:

Invitation by the EU Commission to share its stand at the EuroScience Open Forum (ESOF)-2016 held in Manchester. A prototype using MnAl material was presented to the assistants.

Presence in the media reporting the first time fabrication by IMDEA of an extruded continuous magnetic filament (12 m long) of MnAl for 3D-printing technologies:

https://www.azom.com/news.aspx?newsID=49377

https://www.nanowerk.com/news2/gadget/newsid=50681.php

Patent (Ref. EP16382224):

“System to obtain three-dimensional information from the magnetic field generated by an external permanent magnet source with applications in: detection of structural instabilities in civil engineering, advanced security ID cards and biomedical applications”.

Impact on EU industrial leadership:

- The results obtained in NEXMAG have led to an industrial project with the company Höganäs AB (Sweden). This projects focuses on the up-scaled production of a new generation of rare earth-free permanent magnet material.
- The advances done in the field of 3D-printing of metal/polymer composites have extended the research to an industrial collaboration with the company RAMEM S.A. (Spain).

Relevant publications:

1. J. Rial, P. Švec, E.M. Palmero, J. Camarero, P. Švec Sr. and A. Bollero, "Severe tuning of permanent magnet properties in gas-atomized MnAl powder by controlled nanostructuring and phase transformation", Acta Mater. 157, 42 (2018).
2. E.M. Palmero, J. Rial, J. de Vicente, J. Camarero, B. Skårman, H. Vidarsson, P.-O. Larsson and A. Bollero, "Development of permanent magnet MnAlC/polymer composites and flexible filament for bonding and 3D-printing technologies", Sci. Technol. Adv. Mater., 19 (1), 465 (2018).
3. I. Janotová, P. Švec Sr., P. Švec, I. Mat'ko, D. Janičkovič, B. Kunca, J. Marcin and I. Škorvánek, "Formation of magnetic phases in rapidly quenched Mn-Based systems", J. Alloys Compd. 749, 128 (2018).
4. E. Céspedes, M. Villanueva, C. Navío, F. J. Mompeán, M. García-Hernández, A. Inchausti, P. Pedraz, M. R. Osorio, J. Camarero and A. Bollero, "High coercive LTP-MnBi for high temperature applications: from isolated particles to film-like structures", J. Alloys Compd. 729, 1156 (2017).

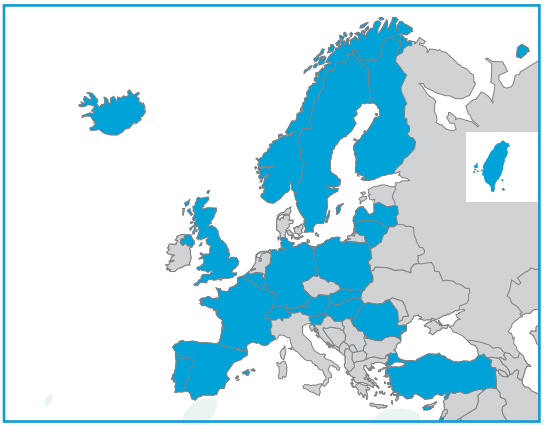
PROJECT DETAILS

Call	Call 2014
Call Topic	Materials for Sustainable and Affordable Low Carbon Energy Technologies
Duration	36 months
Partners	IMDEA Nanociencia, Spain (Coordinator) Institute for Energy Technology, IFE, Norway (Partner) Institute of Physics, Slovak Academy of Sciences, IPSAS, Slovakia (Partner)
Total project cost	€ 865,333
Contact	IMDEA Nanociencia C/ Faraday 9, 28049 Madrid, Spain Prof. Alberto Bollero Email: alberto.bollero@imdea.org Phone: +34 91 299 8758

Link to ERA-LEARN

INFORMATION ABOUT THE CALLS:

These success stories contain selected examples of projects funded under the M-ERA.NET Call 2012, Call 2013 and Call 2014.

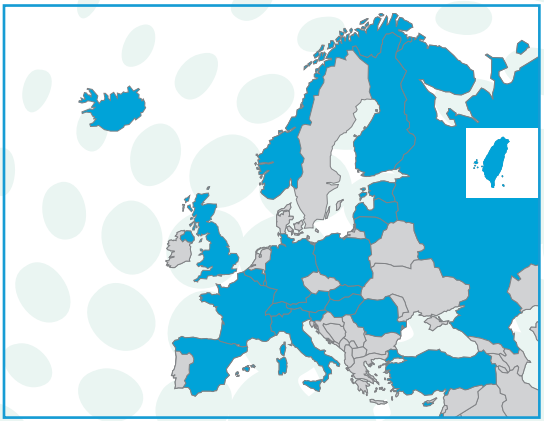


Call 2012:

30 funding organisations participated

124 pre-proposals were submitted
72 full proposals were submitted
23 projects were funded

Results are available here:
https://m-era.net/joint-calls/joint-call-2012/results



Call 2013:

32 funding organisations participated

166 pre-proposals were submitted
90 full proposals were submitted
26 projects were funded

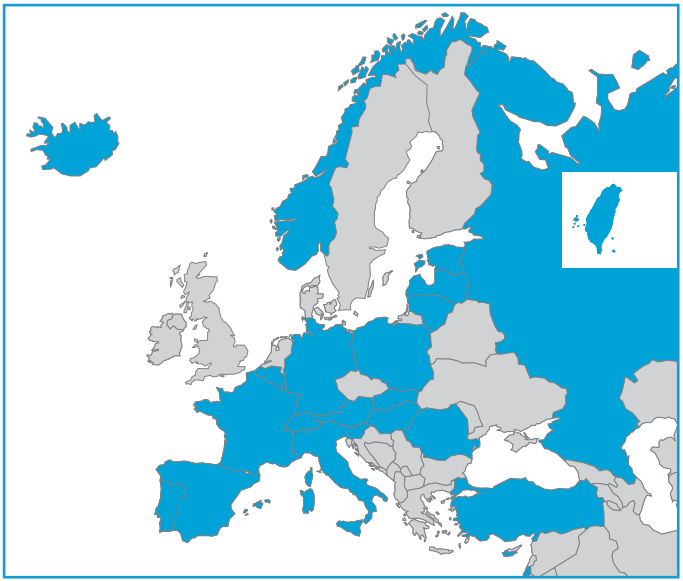
Results are available here:
https://m-era.net/joint-calls/joint-call-2013/results

Call 2014:

36 funding organisations participated

172 pre-proposals were submitted
105 full proposals were submitted
72 projects were funded

Results are available here:
https://m-era.net/joint-calls/joint-call-2014/results



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The M-ERA.NET Consortium is coordinated by

Austrian Research Promotion Agency –
Österreichische Forschungsförderungsgesellschaft mbH
Sensengasse 1
1090 Vienna
Austria

phone: +43 5 7755-0
fax: +43 5 7755-97900
Email: office@ffg.at
https://www.ffg.at

Editorial Staff:

Eva Brockhaus (PTJ)
Roland Brandenburg (FFG)
Fabienne Eder (FFG)

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M-ERA.NET 2 has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 685451.