SEVENTH FRAMEWORK PROGRAMME

NEWSLETTER
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MATRANS

Micro and Nanocrystalline Functionally Graded Materials for Transport Applications

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EDITORIAL

The second issue of the MATRANS Newsletter has been prepared when the Project just **completed the second year of its activities.**

The FP7 cooperative project "**Micro and Nanocrystalline Functionally Graded Materials for Transport Applications**" MATRANS is coordinated by the European Virtual Institute on Knowledge-based Multifunctional Materials (KMM-VIN). It started on 1 Feb. 2010 for a duration of 3 years.

The consortium comprises 16 partners including research institutes, academia, industry and technology transfer centres from 7 countries (see the column "CONSORTIUM").The project is devoted to a complex approach including design, processing, characterization and modeling of Functionally Graded Materials (FGMs). It is shortly described in the column "ABOUT THE PROJECT".

The main part of this Newsletter is composed of the columns **"**RESULTS OF YEAR 2" announcing recent results obtained in the specific domain of bulk FGMs: ceramics-copper/copper alloys and ceramics-intermetallics, presented by the coordinators of the four research Workpackages: WP1. Materials Requirements and Preparation of Starting Materials, WP2. Processing of FGMs, WP3. Characterisation of FGMs and WP4. Modelling.

In the column "PARTNERS' PROFILES " the teams involved in the project are shortly presented.

For information on current project events you are kindly invited to visit the site Projects/Matrans at the KMM-VIN webpage www.kmm-vin.eu.

We hope that this issue of the MATRANS Newsletter will be a source of information for all interested in research and/or applications concerning new advanced FGMs.

ABOUT THE PROJECT

The Project aims at development of novel metal-ceramic functionally graded materials (FGMs) for aerospace and automotive applications in: (i) exhaust and propulsion systems ("thruster"), (ii) power transmission systems ("valve"), (iii) braking systems ("brake disk"), with the main objective to enhance the mechanical properties of these materials through spatial variations of material composition and microstructure. Specifically, MATRANS deals with two groups of bulk FGMs: ceramics-copper/copper alloys,ceramics-intermetallics.

These FGM systems have not yet been used in the transport sectors targeted. The MATRANS methodology is problem-oriented and comprehensive combining interrelated activities of material processing (core activity of the project), characterisation, modelling and demonstration. The processing encompasses starting materials (e.g. nanopowders) and the resulting FGMs. Characterisation of the FGMs includes detailed description of microstructure, measurements of physical and mechanical properties and residual stresses. The modelling is carried out at a design phase and for the material response to combined thermomechanical loading and extreme service conditions. Extensive use of multiscale approaches and numerical methods will be made. The project addresses the joint design of the FGM and the structural component it is intended for.

Economical and ecological aspects of processing are included and risks aspects of material non-performance are tackled, too. MATRANS has mobilized a critical mass of interdisciplinary expertise and highly specialized equipment.

CONSORTIUM

1. European Virtual Institute on Knowledge-based Multifunctional Materials AISBL* (KMM-VIN) coordinator, Belgium
   - 1a. Institute of Electronic Materials Technology (ITME), Poland
   - 1b. Institute of Fundamental Technological Research, Polish Academy of Sciences (IPPT), Poland
   - 1c. Institute of Metallurgy and Materials Science, Polish Academy of Sciences (IMIM), Poland
   - 1d. Technische Universität Darmstadt (TUD), Germany
   - 1e. Politecnico di Torino (POLITO), Italy
   - 1f. Universita Politecnica delle Marche (UNIVPM), Italy
2. Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung (FRAUNHOFER), Germany
3. National Technical University of Athens (NTUA), Greece
4. Wroclaw University of Technology (WRUT), Poland
5 Institute of Materials and Machine Mechanics (IMSAS), Slovakia
6. Cardiff University (CU), UK
7. EADS Deutschland GmbH (EADS), Germany
8. Centro Richerche FIAT (CRF), Italy
9. Steinbeis Advanced Risk Technologies GmbH (R-TECH), Germany
10. Technische Universität Kaiserslautern (UNIKL), Germany

) **KMM-VIN is a **grouping** according to FP7 definition, including in the MATRANS project KMM-VIN itself and the 1a – 1f core members (via Special Clause 10 of the Grant Agreement).*

EVENTS

MATRANS will hold its **M24** project meeting on February 23-24, 2012 in Brussels.

At the conference FUMAT2011 ("Future Materials for Grand Challenges of our time"), held on 22-23 Sep. 2011, Warsaw, http://www.fumat2011.eu the results of MATRANS were presented by M. Basista in the context of synergy with the Polish key project on metal-ceramic composites for automotive and aerospace applications (KomCerMet). A joint dissemination event of these two project is foreseen as an **Industrial Workshop** to be held in Warsaw in July 2012.

The 3rd meeting of all MATRANS participants (**M18 Meeting**) took place at IPPT in Warsaw on 7-8 July 2011.

The Project concluded the first year of its R&D activities with a review **M12 Meeting** held in Brussels on 23-24 February 2011. Representatives of all 16 Participants and the Project Officer attended the meeting.

A technical meeting was held at Centro Ricerche Fiat (Orbassano) on 1-2 February 2011 **to discuss the progress of work in three Workpackages: WP1. Preparation of Starting Materials, WP2. Processing of FGMs and WP3. Characterizations of FGMs.**

At the E-MRS 2010 Fall Meeting of the European Materials Research Society (Warsaw, 13-17 September 2010) MATRANS was presented at the session devoted to FP7 projects.

The 2nd MATRANS Meeting (**M6 Meeting**) was held at IPPT in Warsaw on 6-7 July 2010. It was focused on the results obtained in the workpackages scheduled for the first six months of the project execution.

The **Kick-off Meeting** of MATRANS was held in Brussels on 24 February 2010.

SUMMARY OF THE SECOND YEAR RESULTS

WP1. Materials requirements and preparation of starting material

Synthesis

Mass production of composite alumina/copper powders with different alumina content (2 %, 3.5, 5 % and 10 % vol.) for FGM-I has been accomplished by high energy ball milling, displaying an average particle size around 15 μm, round shaped morphology and excellent alumina dispersion, according to final specifications. This production is followed by proper microstructural and morphological study of the composite alumina/copper powders by means of SEM micrographs, elemental mapping and laser particle size analysis.

Processing – FGM design

The production of gradient porous preform (from 20 to 80% of porosity) on the thickness of 8.3mm with seven different layers using "polymeric sponge method" was inapplicable. Two groups of materials were investigated, namely FGM I Cu-Al_2O_3 (with low content of Al_2O_3) and FGM II NiAl-Al_2O_3. The technology of FGM I materials by foil casting technique (tape) with low content of Al2O3 for thrusters application was applied, since this method was not suitable for FGM II application. The single foils of copper and copper-aluminium oxide were used to prepare the functionally graded materials. The technological process includes 3 stages, namely lamination process of single foils to create the stack, burning process of organics and sintering process. The aim of this activity was to obtain FGM structure consisting of 4 layers (pure copper and three composite layers with copper and 2.0, 3.5 and 5.0 vol.% of aluminum oxide).

As for slip casting technique, the processing was focused on samples for evaluation and optimisation of gas pressure infiltration of Cu with the addition of CuO for improvement of wetting. Samples were made from both ceramic powders, also including samples containing rice starch: Square samples for test specimens for characterisation of properties, and circular samples for screening wear tests after metal infiltration. Additionally, circular disks of diameter ~ 120 mm were successfully prepared for future demonstrator tests (ungraded brake disks), from both ceramic powders, also including samples containing rice starch.

First burn-out and sintering experiments had been performed on laminated samples containing layers with and without starch. The samples did not exhibit any interface between the former tape cast layers but showed slight warpage; this warpage could be eliminated by sintering of recent samples between flat alumina disks.

Using Wet Powder Spraying technique (WPS), production of FGMs was accomplished, performed with copper mixtures with 0, 5, 10 and 15vol% Al_2O_3 CT800 (thickness of sheets 1-3 mm). Spray tests with milled Ni-Al materials for the FGM-II system were also performed. Suitable spraying conditions were developed for both systems.

Costas A. Charitidis WP1 Coordinator

WP2. Processing of FGMs

Several techniques for fabrication of materials and components based on FGM I (Al_2O_3-Cu, Al_2O_3-CuAg3Zr0.5) and FGM II (Al_2O_3-NiAl) are under investigation. The key findings of the last year of the project are summarised for the selected target applications below:

Thruster

After many tests it was concluded that it is impossible to prepare the target FGM I in a good quality using alternative techniques like wet powder spraying or foil casting with subsequent sintering. These fabricated products exhibit defects, like cracks, bubbles, interlayer delamination, surface curving, and no full density.

However, the deposition experiments proved the feasibility that a FGM I system can be applied by thermal spraying using an HVOF technique. Each layer and also the interface between the layers can be made with very low defect rate. The single layer thickness is suitable for the envisaged thruster application with 3 to 4 layers and a total thickness of about 1 mm.

Properties of the composite layers are promising. A simple technique has been used for assessing the susceptibility of Cu alloys to blanching, a mode of degradation which limits their service life and performance in thrust cell liner service. The results suggest that a fine grained copper microstructure stabilised by an alumina particle reinforcement or small additions of oxide formers like Cr; Nb, Ti can improve the resistance of the materials against the blanching effect. Further application-related testing on the most promising thermally sprayed materials is planned.

Brake Disk

Copper infiltration with and without pressure assistance of defined porous alumina preforms were investigated in this period. The most important problem in processing alumina/copper composites is the lack of wettability of alumina ceramics by pure copper. The investigation of the influence of active elements (e.g. Ti, Cr, Mn) show promising results to meet the requirements of the appropriate wetting angle, which must be much smaller than 90°. The use of the precipitation-hardened CuAgZr alloy did not improve the infiltration at all, due to a strong reaction of Zr with alumina. The alternative investigation included experiments of the improvement of the wetting of Al_2O_3 by Cu/Cu_2O. The oxygen content in a Cu/Cu_2O alloy above a critical level seems to be sufficiently for a good wettability of the Al_2O_3 surface. Further application-related testing on the most promising infiltrated ceramic preforms is planned.

Valve

The activities in this task were further focused on the preparation of a valve demonstrator. The preliminary results showed that the preparation of valves as 3D objects is not realistic via plasma spraying particularly if large scale production needs to be achieved. Therefore, reactive infiltration of Al_2O_3 and Ni+Al_2O_3 powders with molten aluminium was proposed as an alternative for the FGM II system. New valve design was introduced and agreed and the objectives were modified. First data on the reaction kinetics and reaction products were obtained on samples similar to valve shape and dimensions. The valve tip separately fabricated by powder metallurgy will be integrated in the developed infiltration process. Promising graded tip parts were produced by powder stacking and subsequent consolidation by hot pressing or SPS. Further activities are focused on the optimisation of the infiltration process for the valve fabrication.

Thomas Weißgärber WP2 Coordinator and Thomas Schubert

WP3. Characterisation

Most of the characterisation work in year 2 was focused on a sound selection of materials for the demonstrators to be manufactured in project phase 2, (i) mechanical and physical properties related to target properties and for modelling and simulation purposes, and (ii) screening experiments for assessing resistance to service conditions.

In year 1 characterisation experiments had been done on first samples only as evaluation of manufacturing routes, preparation of materials and test specimens and their machining had required plenty of time.

Tests on characterisation of **microstructure and of residual stresses**, which are scheduled for project phase 2 were preformed exemplarily on a few samples of thruster materials (Cu-Al_2O_3, 2-10 vol.% Al_2O_3) and of brake disk materials (Al_2O_3-Cu, 50-80 vol.% Al_2O_3), mainly for getting familiar with these new materials.

Mechanical and physical properties tests were concentrated on hardness, thermal expansion coefficient and thermal conductivity of FGM I and FGM II materials for all three applications. Assessment of Young's modulus and of Poisson's ratio was concentrated on samples of brake disk materials which were easily amenable in sufficient dimensions and quantities by the bulk manufacturing method slip casting. Critical properties for thruster application as strain to failure and tensile strength at various temperatures were determined on a few materials.

High emphasis was laid on the definition and re-evaluation of screening test methods and suitable test specimens for assessing the **resistance to service conditions** and for testing materials. For the thruster application the main achievements concerned methods and common specimen dimensions for thermal shock, blenching and erosion tests, and results of oxidation tests on Cu-Al_2O_3 and CuAg3Zr0.5-Al_2O_3. Regarding the valve three critical areas and loadings were identified to be of interest, wear at the tip, stem and head and friction at the tip and the stem. The following tests have been performed: pin-on-disk on NiAlFe-Al_2O_3 (0-10 vol.% Al_2O_3) and NiAl-Al_2O_3 (0-30 vol.% Al_2O_3) for the tip and cylinder-on-disk on NiAlFe-Al_2O_3 (0-10 vol.% Al_2O_3) for the stem. Friction and wear pin-on-disk tests were done on small brake disk like samples of Al_2O_3-Cu of Cu contents of 30, 25 and 20 vol.% and of two Al_2O_3 grain sizes and of 3 Cu ligament diameters. Best performance was shown by high Cu content and small Al_2O_3 grain material.

Characterisation of phase 2 materials is under way.

Ludwig Weiler, WP3 Coordinator

WP4. Modelling

A considerable amount of modelling tasks in MATRANS, which is otherwise a materials development project, deserves emphasizing in this Newsletter.

Modelling of microstructure of individual ceramic-metal composite layers to obtain a composite of required

thermomechanical properties was completed in year 2 with regard to the effective thermo-elastic linear and non-linear properties for particulate composites. Estimates of optimal content of the ceramic phase for required thermo-mechanical properties of composites was another issue solved by as a multi-criterion optimization problem of continuum mechanics.
The **effective elastic properties** of the FGM constituent layers made of interpenetrating phase composites, IPC (brake disk application) were modelled using analytical and numerical models, with real microstructure 3-D images obtained with computer microtomography.

The **effective thermal properties** of particle-matrix composite layers for FGM I and FGM II were calculated by a homogenization scheme with the finite element (FE) method using a mesh of voxels (cubic finite elements). Also, a **nanoscale approach** was employed to modelling effective mechanical/thermal properties of the composite layers constituting FGM I.

The **modeling of graded profile of FGM II** (for valves) was investigated by considering deformation and damage evolution dependent on structural parameters variation. The analysis applied a robust optimisation technique and resulted in a multicriterion optimal design of multilayer and graded FGM II subjected to thermal and mechanical loading, including contact interaction and accounting for some uncertain properties of geometrical and material parameters.

Modelling of **thermal residual stresses** arising in sintered metal-ceramic composite layers during cooling process is one of the most needed models for the producers of the FGMs in MATRANS. An effective FE model of thermal stresses was developed in year 2 making use of microstructural data from micro-CT images. The model predicts the thermal stresses with a good accuracy as compared with the experimental measurements by the XRD method.

Models of microcracking in FGMs induced by processing and service conditions were also developed. The models are based on a grid of voxels representing either the metal or the ceramics phase of the composite with the microstructural data coming from micro-CT scans or assumed to be randomly distributed.

Multiscale **model of wear** in FGM I (brake disk) system have been developed for pertinent wear mechanisms based on the micromechanics. Progressive wear during reciprocating ball-on-flat test has been modelled using the developed wear model. The model is based on asymptotic wear states so that detailed analysis of contact is avoided. The model is highly efficient as compared to the usual approach employing repeated 3D contact analysis is combined with shape updating.

A series of complementary **FE models of brake disk demonstrator** were developed and tested. The focus was on the optimal design of the brake disk and on simulation of mechanical strength. Realistic geometry and a realistic material data of brake-like demonstrator were used and different thermal boundary conditions.

One of main causes of degradation of thruster under operational conditions is the process of oxidation. A **model of oxidation** for FGM I material (Cu-Al_2O_3) coupled with wear was formulated. The main conclusion of the simulations is a minor effect of surface roughness on stress distribution and resulting oxidation factors, and a strong effect of the wear level.

Models of **mechanical and thermal fatigue** for FGM I intended for the thruster application were developed, too.

Michal Basista, WP4 Coordinator

From Industry's perspective

Most important project developments of year 2 from the CRF point of view were the decisions concerning FGM I and FGM II automotive demonstrators processing routes. Reactive pressure infiltration of Al_2O_3 and Ni+Al_2O_3 powders with molten aluminum was selected for engine valve and porous ceramic preforms with Cu pressure assisted infiltration was chosen for brake disk demonstrator.

Flavia Gili, Centro Ricerche Fiat

PARTNERS' PROFILES

1. European Virtual Institute on Knowledge-based Multifunctional Materials AISBL (KMM-VIN), Brussels, Belgium

KMM-VIN is an international, non-profit association (AISBL) head-quartered in Brussels and incorporated under Belgian law. KMM-VIN has the Registered Office in Brussels and the Remote Office at IPPT in Warsaw, Poland. KMM-VIN is a single legal entity with a supranational character offering integrated basic and applied commercial research, educational, innovation and managerial activities in the field of knowledge-based multifunctional materials. It is currently composed of about 40 members from 14 European States (universities, research institutes, large industry, SMEs, technology platforms, individual persons). KMM-VIN has emerged from the FP6 (NMP) project: Network of Excellence 'Knowledge-based Multicomponent Materials for Durable and Safe Performance' (KMM-NoE) devoted to the study, understanding, design and development of new advanced materials (ceramic, metallic, metal-ceramic, intermetallic, or functionally graded) with a view to enhance their functional properties. KMM-VIN AISBL has specialized Management Office employing experienced R&D managers and staff capable of managing multipartner projects or industry contracts. Its offerings to project consortia include comprehensive package of administrative, financial, legal, IT services according to international quality standards.

1a. Instytut Technologii Materialow Elektronicznych (ITME), Warsaw, Poland

Instytut Technologii Materialow Elektronicznych (Institute of Electronic Materials Technology, Warsaw) founded in 1970, is a research, development and consultancy institution offering a unique combination of scientific and technological capabilities (ca. 100 patents). Staff: 300 employees (120 researchers). The R&D activities of ITME include processing of advanced materials (e.g. semiconductor materials, thick-film materials, glass and ceramic products, monocrystals, substrates for electronic systems, metal-ceramic composites: MMC and CMC, functionally graded materials, materials for opto- piezo- and superconductor-electronics) and devices based on these materials.

1b. Instytut Podstawowych Problemow Techniki Polskiej Akademii Nauk, (IPPT), Warsaw, Poland

I**nstytut Podstawowych Problemow Techniki** (Institute of Fundamental Technological Research in Warsaw) is one of the largest research centres of the Polish Academy of Sciences (staff of 280) with 55 years old tradition in technological research. The research staff of about 170 highly qualified researchers of whom 50 are full or associate professors, 90 senior researchers with PhD degree. The IPPT has rich experience both in scientific research and management of collaborative projects. The most important areas of scientific expertise include theoretical, experimental and computational mechanics of materials, structures and fluids, acoustoelectronics and medical ultrasound, physics of continuous media, polymer physics, electromagnetic phenomena, applied information science, mechatronics and robotics, ecologically oriented structural engineering. Since 1953 the IPPT has promoted ca. 600 doctors with the PhD degree, 180 persons have graduated with the D.Sc. degree (habilitation), and 104 were promoted to the position of full professor. IPPT publishes 6 regular journals: and several book series.

1c. Instytut Metalurgii i Inzynierii Materialowej Polskiej Akademii Nauk, (IMIM), Krakow, Poland

Instytut Metalurgii i Inzynierii Materialowej (Institute of Metallurgy and Materials Science, Krakow) established in 1953 is one of the leading research institutes of the Polish Academy of Sciences in the filed of materials science. Staff: 90 including 48 researchers (18 professors and associate professors, 25 assistant professors, 5 research assistants) and 20 PhD students. Main research fields include: user-friendly materials and technologies (e.g. lead-free soldering, multicrystalline silicon solar cells, biocompatibile coating in blood contacting materials), knowledge-based functional materials (e.g. gradient materials produced by different methods, light alloys of new generation with improved mechanical properties, production and optimization of intermetallics, bulk metallic glasses), nano- and micro-crystalline materials (e.g. mechanical alloying and hot-pressing intermetallics, severe plastic deformation and fabrication of ultra fine-grain materials), development of modern research tools and diagnostic methods (e.g. crystallographic orientation mapping for diagnosis and prediction of mechanical properties of metallic, ceramic and composite materials; data processing of local crystallographic orientations; orientation distribution function, orientation topography; quantitative description of microstructure; complex characteristics of advanced materials using new techniques of transmission electron microscopy).

1d. Technische Universität Darmstadt (TUD), Darmstadt, Germany

Technische Universität Darmstadt, founded in 1877, consists currently of 13 departments and 3 study centers with a wide range of subjects. The university has about 20.000 students, 300 professors, 1.000 assistants, and 3.000 technical and non-technical personnel. The fraction of foreign students is about 15 percent, clearly higher

than the average for German universities. Especially, interdisciplinary studies and an early integration of young motivated students into research and development characterize the education at TUD. Most of the research funds are acquired by individual scientists and scientists groups in competition from public institutions like the German Science Foundation (DFG) or directly from industrial partners. Traditionally the departments and institutes at the TUD cooperate closely with industrial partners and perform a lot of application oriented research.

1e. Politecnico di Torino (POLITO), Turin, Italy

Founded 150 years ago, **Politecnico di Torino** represents a leading public university, in Italy and in Europe, in technical-scientific teaching and research. There are currently 26000 students on more than 115 courses. Staff members are more than 900 (professors and researchers), plus about 1000 administrative and technical staff. Research activities are organized in 18 Departments. The group participating in this project- "Glasses and Inorganic Composites" is within the Materials Science and Chemical Department (DISMIC), and it is composed of 2 Full Professors (P. Appendino, M. Ferraris), 5 Senior Researchers, 2 technicians, 10 grant holders, 7 PhD students.

1f. Universita Politecnica delle Marche (UNIVPM), Ancona, Italy

The Section of Physical Sciences of the SAIFET Department of the **Universita' Politecnica delle Marche** (UNIVPM, Ancona) is an academic Institution devoted to research and educational activities. About 20 people are employed in the Section. The main research activities concern applied and fundamental research in the field of non-destructive materials investigations by using neutron and x-ray diffraction, neutron and X-ray radiography, small Angle neutron and x-ray scattering and reflectometry, also with the support of other techniques such as electron microscopy and atomic force microscopy. The section has also a large experience in the analysis of the microstructural properties of materials by means of X-ray microdiffraction and microtomography.

2. Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung (FRAUNHOFER), Dresden, Germany

The **Fraunhofer Institute for Manufacturing Technology and Advanced Materials** (IFAM) in Dresden is one of the 60 research institutes of the Fraunhofer Society in Germany. The Fraunhofer Society is the largest organisation for the development and realisation of new technologies and applied research in Germany.

The Dresden branch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials is involved in fundamental and applied research to develop new sintered and composite materials as well as cellular metallic materials manufactured with innovative technologies derived from powder metallurgy. The institute's scope of services includes the industrial implementation of the results obtained, up to the manufacture of prototype components. Substantial experience with technology and material structures enables the scientists to design cellular metallic and composite materials in which combinations of properties are enhanced and tailored to individual applications. The design of materials and components is facilitated by special technologies, such as melt-spinning, melt extraction, spark plasma sintering, microwave sintering, 3D direct printing of metal powders and molding techniques. The development is focussed on lightweight materials, materials for tribological applications and thermal management (e.g. composite materials for passive cooling, thermoelectric materials for active cooling), high temperature and special powder metallurgy (PM) materials, metal matrix composites (MMC), PM compound materials, hydrogen storage alloys and highly porous materials (e.g. metal foams, hollow spheres, 3D wire structures, fibre structures) to be used in transportation industry, electronics, energy technology, mechanical engineering, aerospace industry and biomedical applications. Furthermore, a great range of analysis methods can be offered by Fraunhofer IFAM Dresden, such as tribological tests and material testing (e.g. thermal analysis, mechanical tests at room temperature and at temperatures up to 1,500 °C).

For more detailed information, please visit the institute's website at http://www.ifam-dd.fraunhofer.de.

3. National Technical University of Athens (NTUA), Athens, Greece

The **National Technical University of Athens** (NTUA) is the oldest and most prestigious educational institution of Greece in the field of technology, and has contributed unceasingly to the country's scientific, technical and economic development since its foundation in 1836. It consists of 9 Academic Faculties and 33 Departments.
The NTUA team involved in MATRANS includes 2 main groups. ***NanoLab*** (nanomechanical/micromechanical and tribological characterization, extensive deformation mechanisms investigation (yielding, onset of plasticity, creep etc.), corrosion behaviour and mechanisms, anticorrosive mechanisms) is situated at the School of Chemical Engineering (Department of Materials Science and Engineering) of NTUA. It was established in 2006 and the research group mostly focuses on the study and analysis (mathematical modeling) of the nanomechanical properties of materials (soft matter, metals, ceramics, polymers, thin films and coatings).

The group is also working on the synthesis and characterization of nanostructures, nanostructures degradation and drug absorption delivered by nanoparticles and the mathematical modeling of cancer invasion. In the period 2006 till now, the group has published over *85* papers in Peer Reviewed International Journals & Proceedings of International Conferences.
NanoLab research activity aims to interact with Academia, Research Institutes and Organizations and Industry, produce new materials and knowledge, and transfer its technology to scientific and industrial users, through National and European funding projects. ***Ceramics Group*** (advanced ceramics processing, ceramic shaping and sintering techniques, powder consolidation methods, development of ceramics with tailored properties, synthesis of ceramic nanopowders through chemical methods, coating techniques) research team's expertise is on Introduction, production methods of powders in metallurgy, properties of powders (particle size distribution, specific surface, additives), thermal treatment of powders. Compression and shaping, thermal coagulation (mono- or multi-component). Powder metallurgy products: iron and steel, copper, nickel and super alloys, hard metals, high-melting-temperature metals, metal composites.
The NTUA team comprises chemical & mechanical engineers, physicists and chemists (10) and technicians (2). The NTUA team is specialized in the fields of materials research and development possessing a very experienced staff (including several professors, research scientists and PhD students) as well as extensive facilities for materials processing and characterization.

4. Politechnika Wroclawska (WRUT), Wroclaw, Poland

Politechnika Wroclawska (Wroclaw University of Technology), founded in 1945, consists of 12 faculties carrying out teaching and research activities in 25 specialisations. Currently WRUT has about 33 000 students and almost 2000 of teaching and research staff. The Department of Mechanical Engineering of WRUT is composed of three Institutes and the investigations connected with MATRANS will be performed at Chair of Foundry and Automation of the Institute of Mechanical Technology and Automation.

The research group involved in MATRANS has expertise in foundry and powder metallurgy processes of aluminium and copper alloys and other non-ferrous alloys, foundry processes of special cast iron, powder metallurgy processes of aluminium and copper and manufacturing of composite materials strengthened with ceramic particles by mechanical alloying technique, sintering and plastic working of sintered materials, automation of foundry processes.

5. Ustav Materialov a Mechaniky Strojov Slovenskej Akademie Vied (IMSAS), Bratislava, Slovakia

Ustav Materialov a Mechaniky Strojov (Institute of Materials and Machine Mechanics Slovak Academy of Sciences, Bratislava) is a state research organization with 75 members of employed staff. State's financial contribution represents less than 60 % of overall budget, wherein rest is being acquired via cooperation with domestic but mainly with foreign industrial organizations. IMSAS has been dealing for more than 5 decades with synthesis of special metallic materials, especially with synthesis of composites, heat treatment of composites and with a control of reaction on the interfaces of components or phases. Gas pressure infiltration, hot extrusion, plasma spraying, hot isostatic pressing, directional solidification, vacuum diffusion bonding and equal channel angular pressing are among well adopted techniques. All the related technological facilities as well as testing methods and techniques for microstructural observations are available, being systematically completed and upgraded.

6. Cardiff University (CU), Cardiff, United Kingdom

Cardiff University (CU) is a public University whose mission is 'to pursue research of international excellence and research-led learning of the highest quality'. CU has 23 schools covering a wide range of subject areas. Engineering is one of the largest Schools with approximately 1600 undergraduate, 300 PhD students and 150 academic/research staff. The research activities within the School are grouped into 7 multidisciplinary Research Institutes. The researchers participating in this project are all members of the Theoretical, Applied and Computational Mechanics Group of The Research Institute of Mechanics and Advanced Materials (IMAM). They belonged to the research unit which received the highest rating in the 2001 and 2008 U.K. Research Assessment exercises in recognition of the international excellence of its research.

7. EADS Deutschland GmbH, EADS Innovation Works, (EADS), Ottobrun, Germany

EADS (Ottobrun) is a global leader in aerospace, defence and related services. In 2007, EADS generated revenues of € 39.1 billion and employed a workforce of about 116 000. The Group includes the aircraft manufacturer Airbus, the world's largest helicopter supplier Eurocopter and EADS Astrium, the European leader in space programmes from Ariane to Galileo. Its Defence & Security Division is a provider of comprehensive systems solutions and makes EADS the major partner in the Eurofighter consortium as well as a stakeholder in the missile systems provider MBDA. EADS also develops the A400M through its Military Transport Aircraft Division. The EADS Innovation Works are the corporate research facilities of EADS, with sites in Germany, France, Spain, Singapore and Russia. They provide world-class capabilities in aeronautics, defence and space

research topics consistent with the EADS research & technology strategy. Covering the skills and technology fields that are of critical importance to EADS, the EADS Innovation Works are organized in five trans-national Technical Capability Centres: Composites Technologies - Metallic Technologies & Surface Engineering - Structures Engineering, Production & Mechatronics - Sensors, Electronics and Systems Integration - Simulation, Information Technologies & Systems Engineering. The EADS Innovation Works foster technological excellence and business orientation through the sharing of competences and means between the various partners of the EADS Group and they develop and maintain partnerships with world-famous schools, universities and research institutes. The German part of the EADS Innovation Works in Ottobrunn near Munich and Hamburg employs a permanent staff of 220 people, 70 % of which are senior scientists. It is legally an organisational unit within EADS Deutschland GmbH, tthe German subsidiary of EADS N.V.

8. Centro Ricerche FIAT (CRF), Orbassano, Italy

Centro Ricerche FIAT (Orbassano) is an industrial organisation with the mission of promoting, developing and transferring innovation in order to provide competitiveness to its clients and partners which include the different companies in the FIAT Group, automotive suppliers, companies from other sectors of industry, SMEs, and national and international research agencies. Priority areas of R&D at CRF include Energy and the Environment, Safety and Well-Being, and Sustainable Growth.

The core competence of CRF is centred on land transportation: advanced vehicles and propulsion systems, innovative components with associated manufacturing processes and methodologies for product development. In developing and applying these core competencies, considerable emphasis is placed on the transfer of advanced technologies from automotive applications to other sectors of industry and areas of business. In this context, CRF actively supports the technological growth of SMEs working outside the arena of the automotive industry in fields ranging from business process re-engineering, advanced product and process methodologies, to micromechanics and optics, IT, telematics and others.

CRF currently has approximately 870 employees and is organised in the following principal technical divisions: Vehicles Architectures, Vehicles Systems, Materials and Process Technologies, Infomobility, Powertrain Research and Technology The state-of-the-art facilities include: electromagnetic-compatibility chambers, anechoic and hemi-anechoic cells, NVH laboratories, optoelectronics and microtechnologies laboratories, engine, fluid dynamics, rapid prototyping, computed tomography, virtual reality.

9. Steinbeis Advanced Risk Technologies GmbH (R-TECH), Stuttgart, Germany

Steinbeis Advanced Risk Technologies (Stuttgart) is one of the transfer centres belonging to the Steinbeis Foundation, established in 1971. The Foundation and its 700+ Transfer Centres in 50+ countries offer global services in technology and knowledge transfer. The R-Tech was founded in July 2001 and the main competence of the centre is in the area of assessment, analysis and management of business and technical risks. The centre is currently active in the area risks related to industrial safety and technology related risks. Organizing European and national stakeholders, promoting and supporting technology transfer, introducing new approaches to the risks and their management, development of specific methods and tools are examples of these activities. Large web-based system iRiS (Integrated Risk Management System) is developed for the petroleum and power industries and has been applied in several dozen applications worldwide. Steinbeis supports ETPIS and coordinate activities in the area of emerging risk. Steinbeis has led the activity on standardizing the EU approach in the area of RBI (Risk Based Inspection), leading to the CEN WA document.

10. Technische Universität Kaiserslautern (UNIKL), Kaiserslautern, Germany

The **University of Kaiserslautern** is a relatively new research-oriented German university with a scientific-technological profile. It consists of 10 departments offering 85 study programmes to 11000 students. The University has 1126 employees, 167 professors, and 600 academic staff.
The Lehrstuhl für Technische Mechanik (LTM, Chair of Applied Mechanics) in the Department of Mechanical and Production Engineering is responsible for the research and teaching in the field of solid mechanics. The Chair has a long tradition in computational mechanics and mechanics of materials. The Chair participates in several local, national and international research activities, e.g. “Center of Mathematical and Computational Modelling”, “Advanced Materials Engineering”, “Engineering materials at different length scales”, “Electric fatigue in functional materials”.

NOTES

Project Coordinator:

European Virtual Institute on Knowledge-based Multifunctional Materials (KMM-VIN AISBL)

Registered Office
rue du Trône 98, 1050 Brussels, Belgium
Phone: +32 2 213 4160, Fax: +32 2 791 5536

Remote Office (c/o IPPT PAN)
Pawinskiego 5 B, 02-106 Warsaw, Poland
Phone: +48 22 826 2522, Fax: +32 2 791 5536