EUROPEAN VIRTUAL INSTITUTE ON
KNOWLEDGE-BASED MULTIFUNCTIONAL MATERIALS AISBL

KMM-VIN Newsletter

Issue 21, December 2019

In this Issue:

EDITORIAL

This is the 21st issue of the Newsletter of European Virtual Institute on Knowledge-based Multifunctional Materials (KMM-VIN). The Newsletter is published on a semi-annual basis, in July and December.

The purpose of Newsletter is twofold: to inform the external world about KMM-VIN activities, but also to serve as a source of useful information for the KMM-VIN members between the annual meetings in Brussels. For this reason, it has a more elaborated form than a typical newsletter providing relatively detailed information about the research conducted within KMM-VIN.

KMM-VIN was established in 2007 under the auspices of the European Commission as an international non-profit association (AISBL) based on Belgian law. It is based in Brussels and has a branch in Warsaw, Poland.

KMM-VIN is a self-sustaining network of universities, R&D institutes, industrial companies and private persons from across Europe, which was created to promote and facilitate cooperative research of its members, devoted to advanced structural and multifunctional materials.

The KMM-VIN joint research activities on materials processing, characterisation and modelling are being carried out within Working Groups (WGs). The research activities are funded by the members, while KMM-VIN supports integration through the Research Fellowships programme for PhD students and young researchers. The main industry sectors targeted by KMM-VIN WGs are Transport, Energy and Healthcare. The R&D activities are focused on:

- metals and alloys (including high temperature steels)
- advanced ceramics
- intermetallics and shape memory alloys
- composites of metal, ceramic or polymer matrices
- coatings, layered materials, surface modification
- biomaterials and bioinspired materials
- graphene and 2D materials
- joining of advanced materials
- modelling and simulation of materials.

Besides the internal networking activities for the members, KMM-VIN offers services for external customers such as integrated R&D solutions, access on market conditions to unique research infrastructure, database of KMM-VIN materials and members' expertise, customised Specialised Courses, participation in KMM-VIN Industrial Workshops.

This Newsletter issue summarises the main activities of the KMM-VIN association in the second half of 2019 as well as the actions and events planned for the near future. It begins traditionally with the "Latest News" containing up-to-date information on the membership and the forthcoming events.

The "News from the Working Groups" columns report on the ongoing collaborative research carried out within the Working Groups. Besides joint research activities, this column contains news from individual members within the thematic scope of a WG. At present KMM-VIN consists of five Working Groups of different size and cooperation schemes: WG1. Materials for Transport, WG2. Materials for Energy, WG3. Biomaterials, WG4. Materials Modelling and Simulation, WG5. Graphene and 2D Materials.

In the column "KMM Projects" a brief information is provided on selected European projects or project proposals in which minimum two KMM-VIN members are involved.

The column "Cooperation" presents KMM-VIN cooperative links with European organisations and initiatives on materials.

Within the "Research Fellowships, Courses and Trainings" column a preliminary information about the next call for KMM-VIN Research Fellowships (2020) is given. The current list of Specialised Courses offered by KMM-VIN members for external clients is included in this column.

The up-to-date register of the KMM-VIN core and associate members and the contact details of the KMM-VIN office are given at the end of the Newsletter. More information about KMM-VIN can be found on http://www.kmm-vin.eu/.

Marek Janas and Michał Basista, Editors

LATEST NEWS

PARTNERSHIP

The KMM-VIN association is currently composed of 60 core and associate members from 13 European States of whom 55 are institutions (research centres, universities, large companies and SMEs) and 5 are individual members.

New members interested in collaborative research within the scope of WGs are welcome. Applications for KMM-VIN membership are collected on a continuous basis but the final decision on accession is taken by the General Assembly at its annual meeting held each year in February in Brussels. At the upcoming GA meeting in February 2020 two new applications will be reviewed and decided upon.

For details of the accession procedure please see: http://kmmvin.eu/network/become_a_member/. Specific questions about KMM-VIN please send to: Michal.Basista@kmm-vin.eu

One of the advantages of partnerships such as KMM-VIN is the relative ease to form project consortia or bilateral collaborations and apply for projects to various research funding organisations. It is worth reporting that besides Horizon 2020, members of the KMM-VIN are applying to other funding programmes like MERA-Net (https://www.manunet.net), MANUNET (https://m-era.net), where the success rates seem to be higher than in regular H2020 calls. The MERA-Net and MANUNET programmes are based on national or regional funds and require special participation rules. According to the experience made by some KMM-VIN members (see column KMM Projects), within the small R&D projects category these two programmes offer an interesting alternative to H2020 calls, which are usually oversubscribed. Another opportunity to conduct jointly research is to invite KMM-VIN members as international partners to projects of individual researchers funded by their national funding agencies. For example, this is possible in basic research projects obtaining support from the National Science Centre (NCN) in Poland. Also, bilateral programmes like the Polish (NCN)-German (DFG) programme “Beethoven” including a call on materials science, are offering funding options to consider (see News from WG3. Biomaterials for a tangible example).

FORTHCOMING EVENTS

The General Assembly 2020 meeting of KMM-VIN AISBL and the annual technical meetings of the Working Groups will be held on 24-26th February 2020. The venue of all meetings will be: Brussels, rue du Trone 98 (KOWI conference room, 8th floor). The schedule of the meetings is as follows:

- Annual meeting of WG5. Graphene/2D Materials, Feb. 24, 2020 (Monday, 10:00-12:00)
- Annual meeting of WG2. Materials for Energy (EMEP), Feb. 24, 2020 (Monday, 13:00-17:30)
- Annual meeting of WG2. Materials for Energy (non-EMEP), Feb. 25, 2020 (Tuesday, 9:30-11:00)
- **General Assembly**, Feb. 25, 2020 (Tuesday, 13:00-17:30)
- Annual meeting of WG1. Materials for Transport, Feb. 26, 2020 (Wednesday, 9:00-10:30)
- Annual meeting of WG3. Biomaterials on Feb. 26, 2020 (Wednesday, 10:30-11:30)
- Annual meeting of WG4. Materials Modelling and Simulation, Feb. 26, 2020 (Wednesday, 12:00-13:00)

The EMEP Management Committee meeting will be held on Feb. 24, 2020 (Monday, 10:30-12:00). The KMM-VIN Governing Committee and Board of Directors meeting is scheduled on Feb. 25, 2020 (Tuesday, 10:00-12:00). These two meetings will be held in the KMM-VIN office (1st floor, rue du Trone 98).

The **Annual Dinner** of KMM-VIN partnership will take place after the General Assembly on Tuesday evening (25 Feb. 2020 at 20:00).

9th KMM-VIN Industrial Workshop (IW9) on Materials for Energy will be held on May 11-12, 2020 at Politecnico di Torino (POLITO) in Turin.

10th KMM-VIN Industrial Workshop (IW10) "Design and modeling of innovative biomaterials and bioinspired materials for industrial applications" will be held on January 18-19, 2021 at TUW in Vienna.

THERMEC’2020 11th International Conference on Processing & Manufacturing of Advanced Materials - Processing, Fabrication, Properties, Applications, will be held on May 31 - June 5, 2020 in Vienna (http://www.thermec2020.tugraz.at). It is organised by TU Graz, with Christof Sommitsch as the General co-Chair and Cecilia Poletti as the Program co-Chair.

LUBMAT 2020 – 7th Congress on Lubrication, Tribology and Condition Monitoring organized by IK4-TEKNIKER will be held on 9-10th June 2020 in Bilbao. Interested participants are requested to register on the conference website www.lubmat.org

SOLMECH 2020 - 42nd Solid Mechanics Conference will be held on September 7-10, 2020 in Wrocław (Poland) This is a series of biennial international conferences devoted to all areas of solid mechanis, which have been organized by IPPT since 1953. For more information and registration, please visit the conference website: http://solmech2020.ippt.pan.pl

ICTAM 2020 - 25th International Congress of Theoretical and Applied Mechanics will be organized in Milano from 23rd to 28th August 2020. For detailed information about the 25thICTAM, registration and abstract submission, please see the congress webstie: https://www.ictam2020.org

EUROMAT 2021 - will be held on 12-16th Sep. 2021 in Graz. Christof Sommitsch (TUG) will be the scientific chairman; https://www.euromat2021.org

WHAT'S NEW IN WORKING GROUPS?

Collaborative research between KMM-VIN members, applications for new projects to the EU, regional and national R&D programmes, as well as organisation of Industrial Workshops are for the time being the main activities of the KMM-VIN network carried out within the Working Groups (WGs). Currently, KMM-VIN is composed of five Working Groups:

WG1. Materials for Transport

Coordinators:

Pedro Egizabal, Fundación Tecnalia, Donostia/SanSebastian, Spain (TECNALIA)

Thomas Weissgärber, Fraunhofer Institute for Manufacturing and Advanced Materials, Dresden, Germany (FRAUNHOFER-IFAM DD)

WG2. Materials for Energy / EMEP

Coordinators:

Monica Ferraris, Politecnico di Torino, Italy (POLITO)

Christof Sommitsch, Graz University of Technology, Austria (TUG)

WG3. Biomaterials

Coordinators:

Aldo R. Boccaccini, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany (FAU)

Christian Hellmich, Technische Universität Wien, Austria (TUW)

WG4. Materials Modelling and Simulation

Coordinators:

Andrés Diaz-Lantada, Universidad Politécnica de Madrid, Spain (UPM)

Katarzyna Kowlaczyk-Gajewska, Institute of Fundamental Technological Research of Polish Academy of Sciences, Warsaw, Poland (IPPT)

WG5. Graphene/2D Materials

Coordinators:

Peter Hansen, Ammanford, UK

Antonios Kanellopoulos, University of Hertfordshire (UH), UK (*to be approved at General Assembly 2020)*

Any member of KMM-VIN (core or associate) can join any WG upon prior consent from WG coordinators, with the exception of EMEP (subgroup of WG2. Materials for Energy) where special rules apply (cf. members area of http://kmm-vin.eu after login).

NEWS FROM WG1: MATERIALS FOR TRANSPORT

During the second half of 2019 the activity in WG1 has focused mainly on the collaboration among participants through the internal collaborative projects and KMM-VIN fellowships. The project coordinated by Fraunhofer IKTS entitled "Manufacture of joined ceramics using high temperature stable titanium aluminides" that grouped three other KMM-VIN members has finished. The work in 2019 has been focused on alumina and the results have paved the way for possible new future projects. A more extended summary of the work is provided in the section corresponding to the internal collaborative projects.

The internal collaborative project related to the development of new aluminium and magnesium based particulate reinforced composites that is being coordinated by TECNALIA has continued its planned activities by producing pure aluminium and Al-Si7Mg0.6 samples reinforced with TiC submicron-sized particulates. The effect of ultrasound waves and the semisolid stir casting technologies to improve the dispersion of the particulates has been analysed. New tensile data and results of SEM and TEM analyses are now available. The work will continue in 2020 with the production of samples reinforced with nanosized particulates and possibly magnesium nanoreinforced alloys. The third internal collaborative project running in 2019 is related to study the "Effect of various severe plastic deformation parameters on grain refinement and mechanical properties of aluminium-based composites". In this new project, the Institute of Metallurgy and Materials Science in Krakow (IMIM) has started a collaboration with VSB TU Ostrava. A new ECAP-TC angular channel with helical exit geometry is being constructed to analyse its effect on the microstructure and mechanical properties of Al-Si alloys reinforced with ceramic particulates.

On the other hand, the KMM-VIN fellowships corresponding to the 2019 call have been implemented in this second half of the year. The 1-1.5 month stays of young researchers have finished in October and November and joint publications and further works among the participant research groups are foreseen.

Internal collaborative projects

1. Manufacture of joined ceramics using high temperature stable titanium aluminides

Partners:

- POLITO (Monica Ferraris)
- CNR-ICMATE (Fabrizio Valenza)
- UH (Andreas Chrysanthou)
- FRAUNHOFER-IKTS (Hans-Peter Martin)

This internal KMM-VIN project started in May 2017. Aim of the project is the adaption of the Ti-Al system as a high temperature braze for ceramic joining. TiAl is established as high temperature stable intermetallic material. Ceramic products are applied at high temperatures but available brazes suffer from limited thermal stability. The investigations in 2019 were focused on alumina ceramics. It was already reported in the previous Newsletter that the wetting behavior can be improved by additions (2…20 %) of Ni and Fe.

The minimum contact angle was reached at 1500°C with 29 deg. The investigated Ti-Al alloys were mixtures of 50:50 and 60:40 mol ratios of Ti:Al respectively. Some microscopic investigations were started during the last month. They show that the microstructure of the Ti-Al braze alloy crystallizes as a eutectic structure consisting of the expected Ti-Al intermetallic compounds and a residual TiAl alloy (Figs 1, 2).

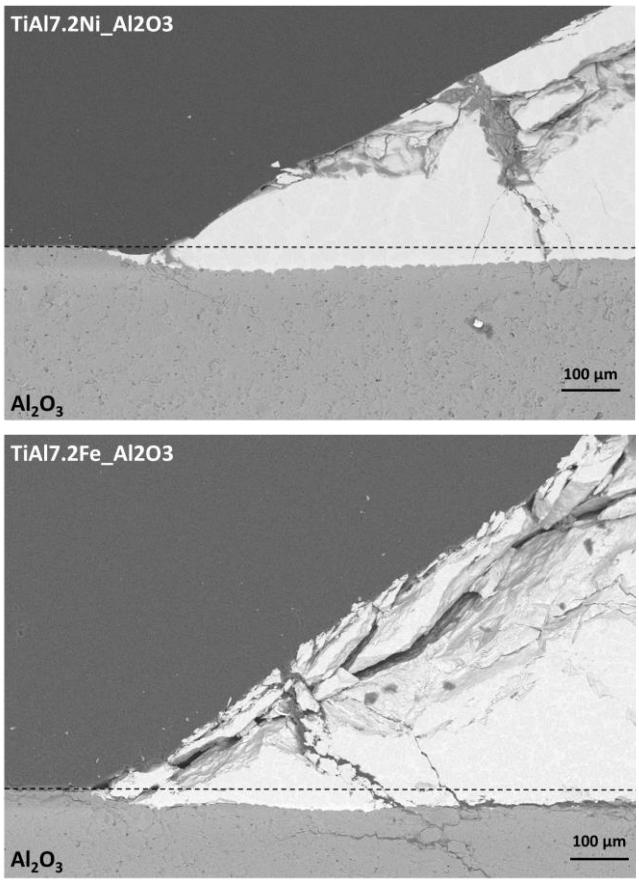


***Fig. 1**. Microscopic images of the interaction of TiAl braze and alumina, slight shift of the ceramic surface level indicates chemical interaction, no additional reaction products are found because of similar chemical system Ti-Al and Al-O (courtesy FRAUNHOFER-IKTS)*

There might be a chemical interaction between the alloy and the alumina substrate. This interaction most probably promotes the bonding of the braze alloy onto the ceramic surface. The results have been communicated between the partners. The results show that TiAl alloys are promising braze alloys for joining alumina ceramics. The TiAl-braze can be applied for high temperature environments up to > 1000 °C. The addition of third components like Fe or Ni promotes wetting on alumina ceramics. The project generated a good starting position for further projects in the future and will be closed at the current state of achievements.

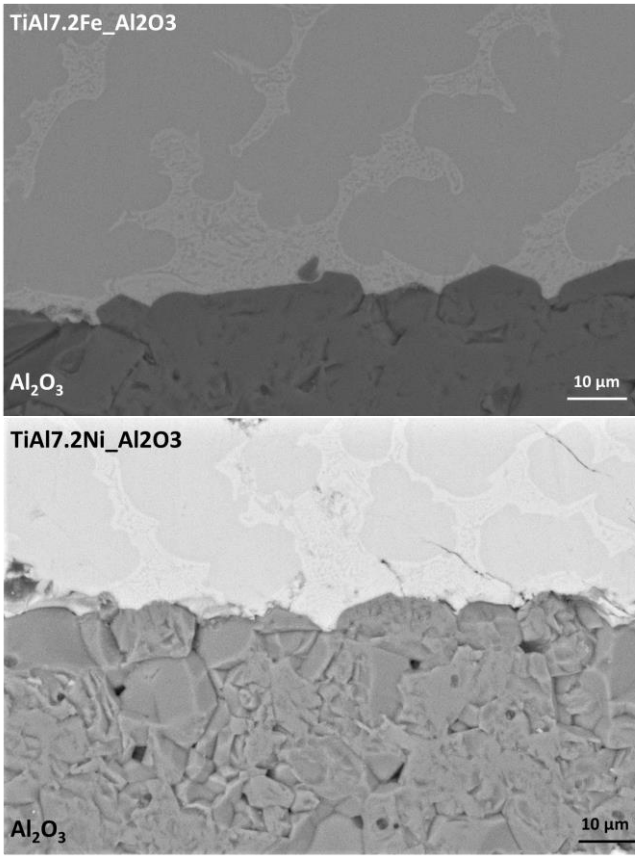


***Fig. 2**. Microscopic structure of Ti-Al braze alloys with Fe or Ni addition on alumina substrates, clearly to recognize a very similar eutectic microstructure of both braze alloys (courtesy FRAUNHOFER-IKTS).*

2. Effect of various severe plastic deformation parameters on grain refinement and mechanical properties of aluminum-based composites

At the beginning of 2019 a new bilateral project entitled "Effect of various severe plastic deformation parameters on grain refinement and mechanical properties of aluminium based composites" has started between IMIM Kraków (Wojciech Maziarz) and VSB TU Ostrava (Miroslav Greger). The project obtained financial support for travel expenses and short visits in the frame of the NAWA programme from the Polish side and Mobility programme from the Czech side. The aim of this two-year project is to determine the influence of severe plastic deformation (SPD) process using a new construction of the ECAP-TC angular channel with helical exit geometry (intensifying deformation) on changes in the microstructure and mechanical properties of cast composites based on aluminum-silicon alloys with the addition of SiC and Al_2O_3 submicron particles. Optimization of the deformation process of cast composites on the aluminium matrix will be carried out through the selection of technological parameters in the ECAP-TW process such as: process temperatures, strain rates, channel geometry and the number of passes. Fig. 3

presents the set-up for ECAP process installed at Department of Mechanical Technology of VSB TU Ostrava in the research group of Stanislav Rusz, also involved in the project. In Fig. 4 construction of new geometry of ECAP channel and photographs of typical sample after different number of passes are presented. This geometry should ensure a higher plastic deformation level during one pass what has a positive effect on the process efficiency.

***Fig. 3**. Innovated workplace for ECAP process installed in Department of Mechanical Technology of VSB TU Ostrava (courtesy of IMIM).*

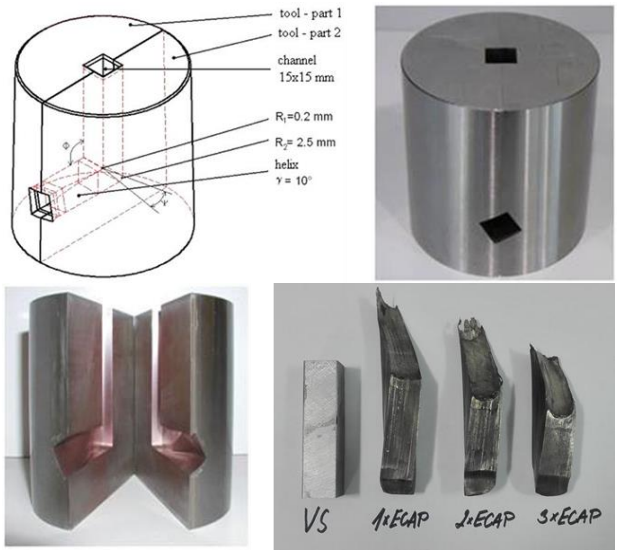


***Fig. 4**. Construction of new geometry of ECAP channel and photographs of typical sample after different number of passes (courtesy of IMIM).*

Experimental work is directly connected with the application of ECAP process for AlSi/TiC composites. Analysis of the microstructure using scanning and transmission electron microscopy (SEM, TEM), mechanical properties and wear resistance is performed at IMIM. First obtained results are very promising. Successful ECAP-TW process was conducted in VSB TU Ostrava for AlSi/TiC composite applying a different temperature of the process. Fig. 5 shows AlSi/TiC composite samples after one pass of ECAP-TW process performed at 350, 400 and 450°C. Samples were cut in different places in order to examine the homogeneity of plastic deformation by microscopic observations. Preliminary microscopy studies performed at IMIM have revealed significant differences between composite samples without and after ECAP-TW process. Also, differences in microstructure were observed for samples plastically deformed at different temperatures as well as taken out from different places as shown in Fig. 6. AlSi/2%SiC composite was obtained by high pressure die casting assisted by ultrasonic mixing.

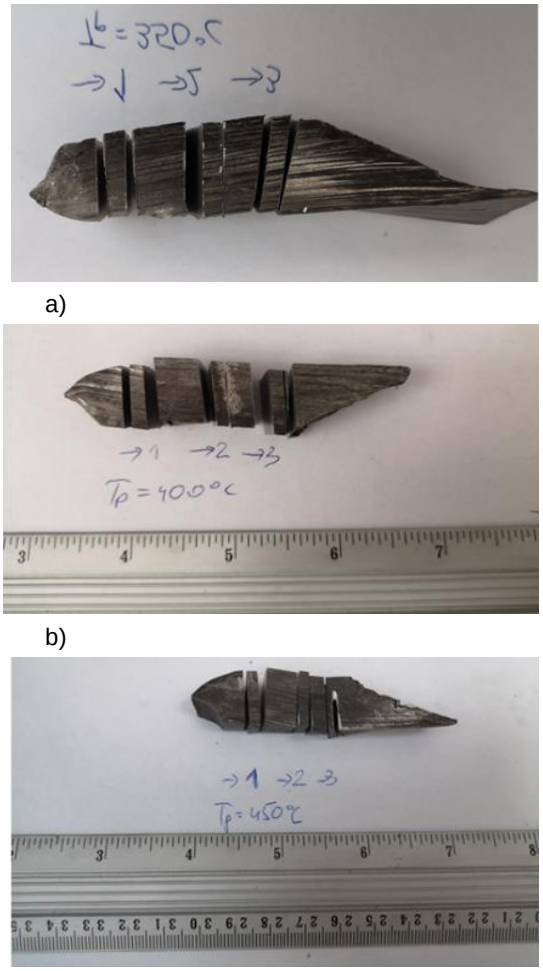


***Fig. 5.** AlSi/TiC composite samples after one pass of ECAP-TW at a) 350°C, b) 400°C and c) 450°C (courtesy of IMIM).*

Generally, the ECAP–TW process caused a more uniformed distribution of SiC particles and change of shape and size of α(Al)+β(Si) eutectic present in the matrix of composite. An example of the microstructures of composites as cast and after one pass of ECAP-TW performed in different temperatures is shown in Fig. 6.

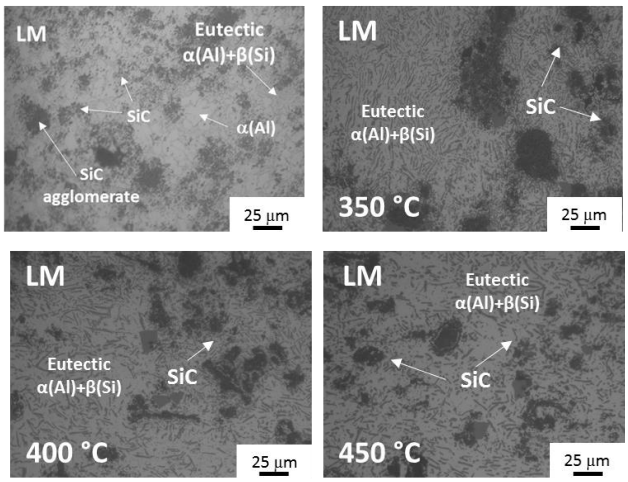


***Fig. 6.** Microstructure of as cast and after one pass of ECAP-TW performed in different temperatures (courtesy of IMIM).*

Preliminary results of mechanical properties obtained in the tensile test revealed interesting behaviour of an increase of plasticity in the investigated composite maintaining a relatively good strength. These phenomena will be explained in the future through detailed microscopy investigations by TEM and EBSD. Also, the mechanical properties in elevated temperatures and wear resistance will be investigated.

Wojciech Maziarz, IMIM
w.maziarz@imim.pl

3. Development of new aluminium and magnesium based particulate reinforced composites with the help of ultrasound probes to disperse ceramic particulates

TECNALIA has produced new samples of pure aluminium and Al-Si7Mg0.6 samples reinforced with TiC particulates applying the semisolid stir casting process and ultrasound wave to the composite melt before the casting step in order to improve the dispersion of the reinforcements. The produced samples have a final content of 0.1-0.2 wt.% of submicron sized particulates. Small specimens have been sent to IMIM for further HRSEM and TEM analyses.

The following images (Figs 7, 8) show the results of the study carried out by IMIM with the pure aluminium based material. Further tasks within this project related to the production of samples with higher content of TiC particulates and the analysis of the Al-Si7Mg0.6 based samples are ongoing. The project will continue in 2020 where the incorporation of nanosized (average 80nm) TiC and alumina particulates will be used to reinforce the alloys and the feasibility of producing magnesium-based nanocomposites will be approached.

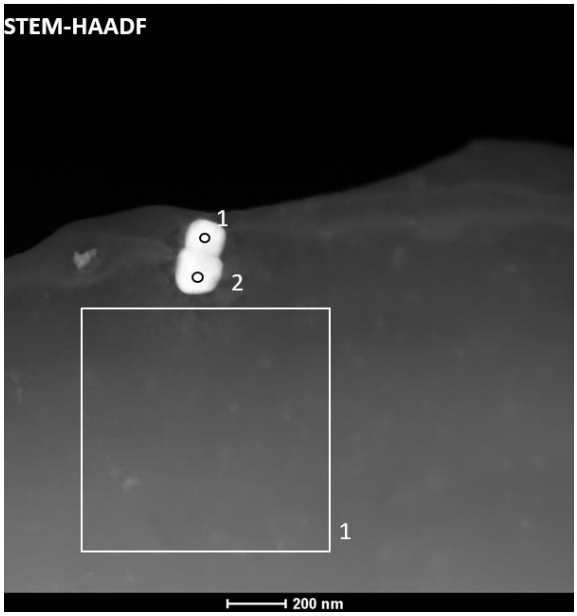


Fig. 7. *STEM-HAADF image at two points (titanium carbides) and marked area of matrix (courtesy of IMIM).*

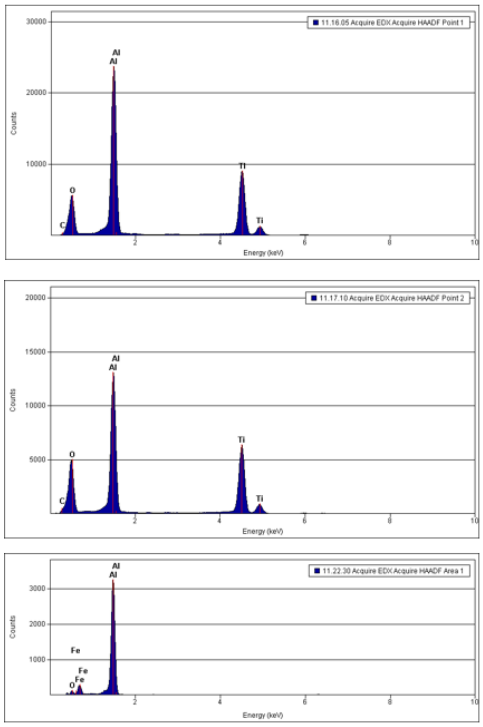


Fig. 8. *EDS analyses at two points (titanium carbides) and marked area of matrix. A significant amount of oxygen inside the carbide can be seen but not in matrix (courtesy of IMIM).*

News from IPPT

Bending of composite microcantilever beams

Micromechanical bending experiments (Fig. 9) and numerical modeling of deformation and fracture of microcantilever beams made of chromium(rhenium)-alumina sintered composites targeted for valve seats application had been carried out several years ago within two KMM-VIN Research Fellowships (K. Bochenek from IPPT at MCL, and P. Pitchai from POLIMI at IPPT). This research has been continued until recently and its resuts will be presented in a joint publication [1].

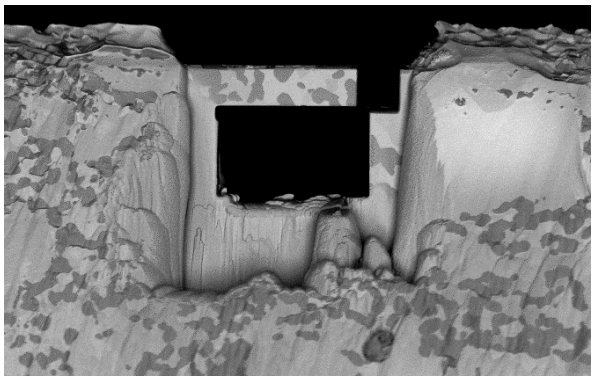


Fig. 9*. SEM micrograph of a FIB-milled cantilever used in micromechanical bending experiments (courtesy of MCL / IPPT)*

A particular focus of this collaborative research was on determining the *in situ* failure properties of the interfaces between chromium(rhenium) and alumina in the 95vol.%(75vol.%Cr/25%vol.Al_2O_3)+5vol.%Re bulk

composite. Brittle cracking along chromium(rhenium)-alumina interfaces was the main fracture mode of the composite microcantilevers loaded through a nanoindenter. The interface characteristics were determined through a reverse approach, i.e. a selected force-displacement curve was reproduced numerically for a set of values of the interface cohesive strength and fracture energy giving the best fit with the experiment (Fig. 10).

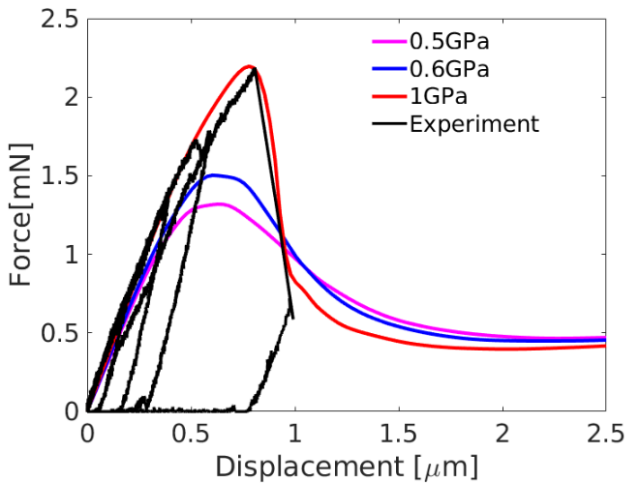


Fig. 10. *Load displacement curves of chromium(rhenium)-alumina composite in Mode I for same values of interface fracture energy and different values of the cohesive strength (courtesy of POLIMI / IPPT).*

Using this approach the in situ values of the interface cohesive strength and fracture energy of the investigated composite were estimated.

[1] W. Węglewski, P. Pitchai, K. Bochenek, G. Bolzon, R. Konetschnik, B. Sartory, R. Ebner, D. Kiener, M. Basista, Experimental and numerical investigation of the deformation and fracture mode of micro cantilever beams made of Cr(Re)/Al_2O_3 Metal-Matrix Composite (*under review*)

Michał Basista, IPPT
mbasista@ippt.pan.pl

News from AGH-UST

Precipitation of TCP phases in the EBW dissimilar Inconel 718/ATI 718Plus® joint during high-temperature exposure

Precipitation strengthened Ni-based superalloys such as Inconel 718 and ATI 718Plus® are widely used materials in aircraft and land-based gas turbine engines due to their excellent high temperature properties. Electron beam welding process causes changes of microstructure that can lead to loss of high temperature resistance. Moreover, high temperature exposure of dissimilar joint could result in far evolution of microstructure of above-mentioned region.

In the present work, the microstructural changes within the fusion zone of electron beam welded joint isothermally held at 760 °C for 500 h were investigated. Microstructural studies were performed using Zeiss Axio Imager M1m light microscope and Zeiss Merlin Gemini II scanning electron microscope supported by energy dispersive X-ray spectroscopy. Furthermore, to exemplify the spatial distribution of precipitates present in the interdendritic regions of the fusion zone (γ', δ, η, μ, σ, Laves phase), the FIB-SEM tomography using Zeiss Neon CrossBeam 40EsB scanning electron microscope equipped with focused ion beam was performed.

Fig. 11 shows the complex structure of precipitates present in the interdendritic regions of the fusion zone. In the above-mentioned regions, after high-temperature exposure, the formation of TCP phases enriched in Mo, W and Cr (Figs. Xa-d) occurred. The precipitates of the σ phase are enriched in Mo and Cr, whereas the μ phase contains Mo and W. Furthermore, the nucleation of plate-like precipitates of η/δ phases on surfaces of Laves phase precipitates were observed.

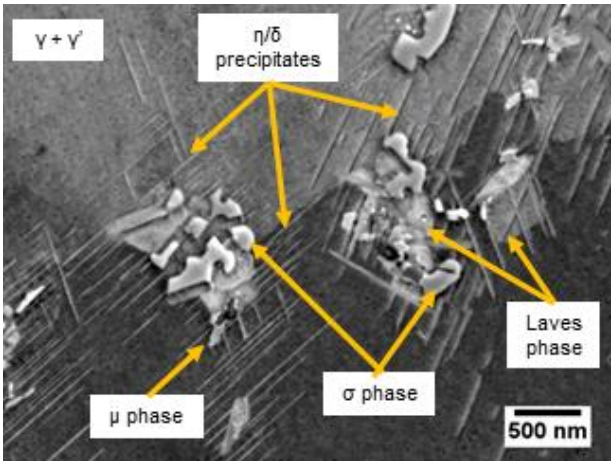


Fig. 11*. SEM-SE image of the fusion zone's interdendritic region after isothermal holding (760 °C/500 h). (Courtesy of AGH-UST)*

Three-dimensional visualizations of FIB-SEM volumes of the fusion zone are shown in Fig. 12a-c. Fig. 13a shows the complex cluster of precipitates with η/δ plate-like precipitates located in the interdendritic regions, surrounded by γ' precipitates present mainly in the dendrites of fusion zone. The arrangement of η/δ phases precipitates shown in Fig. 13b suggests their grow takes place on specified crystallographic planes. The 3D visualization of the complex cluster of precipitates formed as a result of transformation of Laves phase during high-temperature exposure is presented in Fig. 13c. Future work will focus on selected area electron diffraction investigations in order to unequivocal identification of TCP phases.

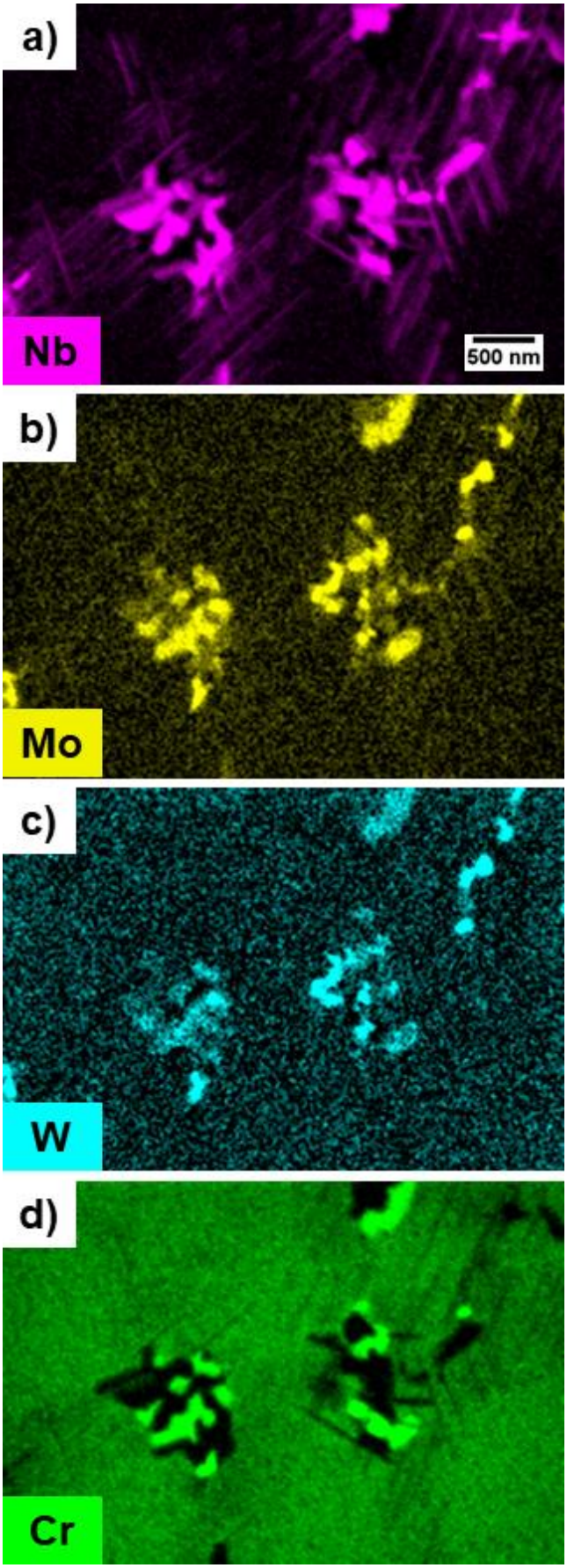


Fig. 12. *SEM/EDX maps of selected elements, a) Nb, b) Mo, c) W, d) Cr (courtesy of AGH-UST).*

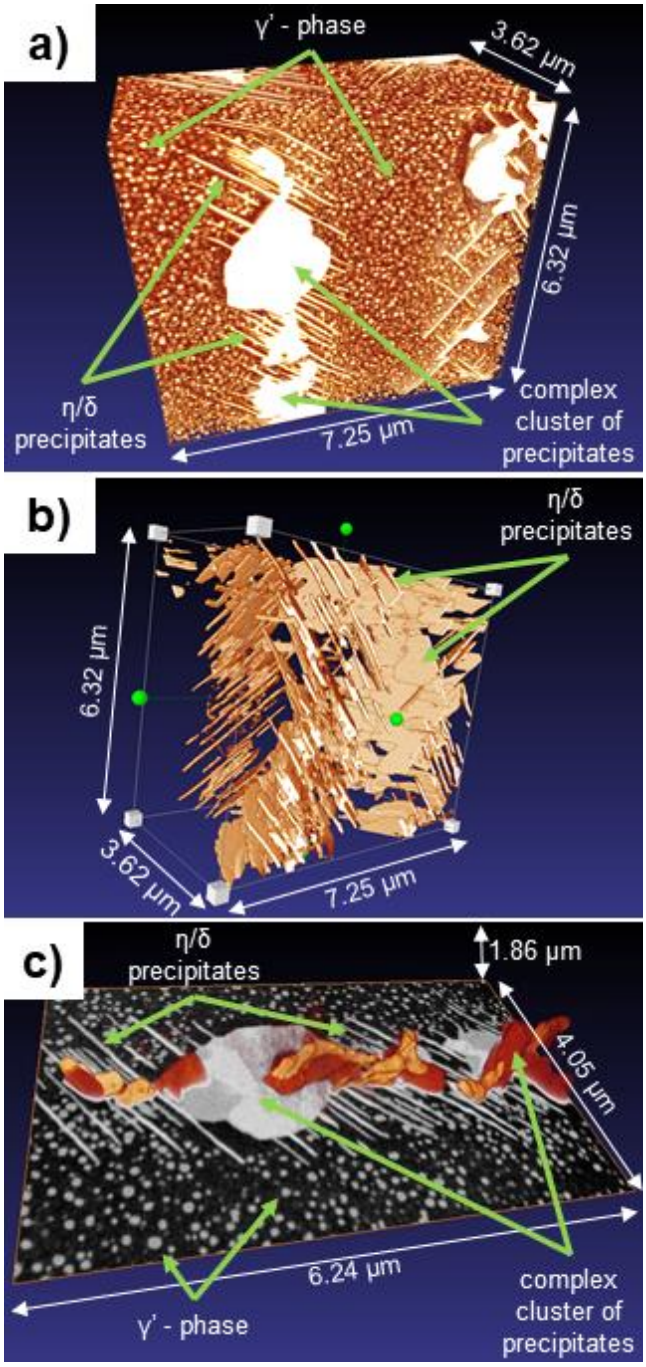


Fig. 13 *a) 3D visualization of the fusion zone microstructure, b) tomographic reconstruction of η/δ phases precipitates, c) 3D visualization of the complex cluster of precipitates (courtesy of AGH-UST).*

News from FRAUNHOFER-IKTS

New Braze-alloys for high temperature stable ceramic – ceramic junctions

Ceramic materials open up the range of extremely high temperatures, lead to significantly longer life times of components or offer superior chemical resistance in comparison to conventional materials. The successful use of ceramic components is always dependent from the integration concept of the overall system. The increasing demand on ceramic functions and reliability of specific components requires the development of innovative joining procedures and new brazes also for very high application temperatures.

Aluminium oxide Al_2O_3, silicon carbide SiC and zirconium oxide ZrO_2 were joined with a new vanadium based braze alloy, which was developed by TU Dresden and FRAUNHOFER-IKTS. This vanadium alloy, which consists of V-Si-Ti components, has a melting point above 1900 °C and was prepared via alloying by arc melting. Brazing was done by laser heating and in a high temperature vacuum furnace to compare the effect of process conditions on the properties. High bending strength and ductility are some of the characteristic achievements of this cost-effective high-temperature brazing process for ceramic-ceramic and ceramic-metal composites. The obtained samples were characterized via SEM/EDX, XRD and Thermoanlaysis. 4-point bending strength up to 160 MPa was obtained for ZrO–ZrO_2 joints. Measurements of high temperature 4-point bending strength up to 1500 °C has been done as shown by Fig. 14. The phase formation during joining depends on the ceramics which are joined with each other (Fig. 15). Both laser brazing and furnace brazing result in strong high temperature stable joints.

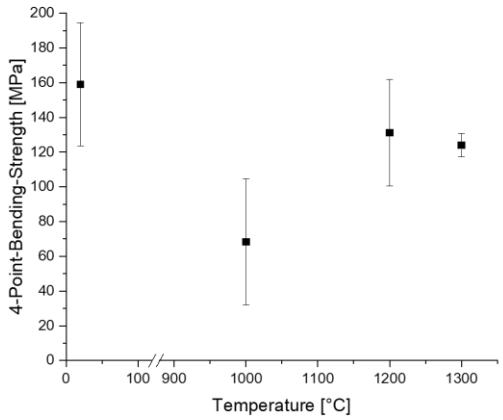


***Fig. 14**. 4-point bending strength of zirconia sample depending on test temperature (courtesy of IKTS).*

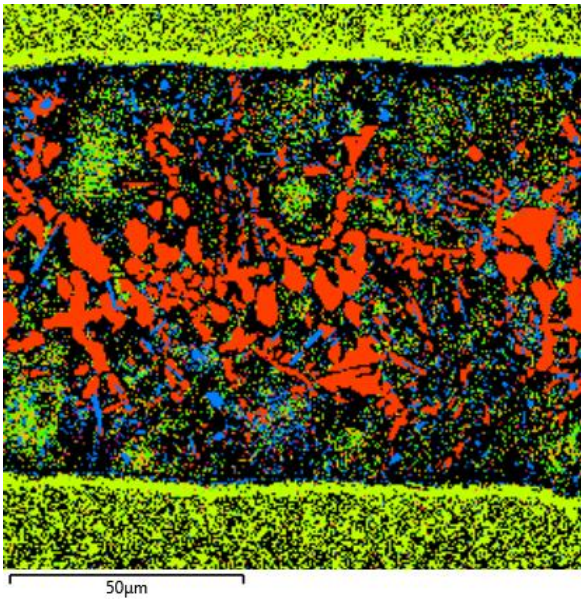


***Fig. 15**: EBDS image of joining zone of zirconia sample, detecting V_3Si, VSi_2 and Ti as metallic phases in the braze layer (courtesy of IKTS).*

News from IMIM

The project entitled "Development of high-efficiency and waste-free technology for the manufacture of magnetically soft nanocomposites for high-frequency high-power processing" is funded by the National Center for Research and Development in Poland. Main aim of the project is to develop high-efficiency and waste-free technology for the production of high-inductance and low-loss soft magnetic nanocomposites for high-frequency high-power conversion which can be applied in novel electro-mobile industry. The project has been implemented in a collaboration between five Polish scientific institutions and two companies.

The scope of the research includes fabrication of the Fe-based materials showing optimal soft magnetic properties (high permeability and narrow coercivity) and their multiscale characterization. One of the research tasks concerning TEM investigation on the Fe-based materials is carried out at IMIM in Krakow. It gives important information about the microstructure of materials which directly influence their magnetic properties. It is well known that the microstructure features such as size, volume fraction and distribution of nanocrystals in the amorphous matrix are important factors affecting the soft magnetic behavior of nanocomposites. Microstructure of ribbons can be controlled not only by chemical composition but also processing including fabrication of amorphous ribbons by melt-spinning and heat treatment allowing for the crystallization of α-Fe crystals in the amorphous matrix which was found to be promising [1,2].

Our work is divided into two parts: (i) examination of the structure and microstructure of both melt-spun and heat-treated ribbons using conventional TEM modes (bright field, dark field, high resolution and electron diffraction) and (ii) in-situ heating investigation showing the crystallization process details. The second route is quite interesting and intensively studied since the discovery of an ultra-fast annealing being beneficial comparing to traditional heat treatment.

Here, alloys with the chemical compositions of Fe67Co20B13 and Fe66Cu1Co20B13 were fabricated by melt-spinning technique which ensures high cooling rates and consequently amorphous structure of the ribbons. Then, transmission electron microscopy (TEM) observations were performed by G2 operating at 200 kV equipped with an energy dispersive X-ray (EDX) microanalyser and high angle annular dark field detector (HAADF). Thin foils were prepared with with TenuPol-5 double jet electropolisher using an electrolyte of perchloric acid (20 %) and methanol (80 %) at temperature of about 253 K followed by ion milling using ion polishing system.

We selected two heating rates of 20 and 200 °C/min and the maximum temperature above the first crystallization peak (selected based on the DSC measurements). The first results obtained for the ternary ribbon heated up with the heating rate of 20 °C/min showed that the first nuclei of α-Fe crystallites appear 20°C below the onset of the crystallization

peak. Then, the number of crystallites increases rapidly and finally they grow. The crystallization process of the ribbon heated with the heating rates of 200 °C/min occurs similarly, however, the α-Fe crystallites are three times smaller comparing to the ribbon which was slowly heated (see Fig. 16).

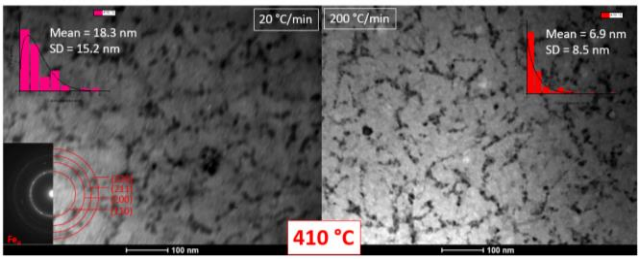


***Fig. 16**. BF and SADP images for $Fe_{67}Co_{20}B_{13}$ ribbons in-situ heated with heating rates of 20 and 200 °C/min; the crystallite size distribution (courtesy of IMIM).*

Thus, it was proven that higher heating rates assure fine and homogenous microstructure. Moreover, we have examined the influence of chemical composition of ribbons on the size of crystallites. It can be concluded that Cu addition leads to smaller crystallite size than in ribbons without Cu after heating with heating rates of 20 °C/min.

To sum up, we have shown that TEM investigation is key in the studies of soft magnetic materials. However, to complete the results **we are looking for someone who can perform APT measurements**, which will allow us to develop appropriate heat treatment conditions.

This work has been carried out within the frame of project TECHMATSTRATEG/347200/11/NCBR/2017 funded by National Centre for Research and Development (Poland).

[1] G. Herzer, *Acta Mater.* 61, 718-734, 2013
[2] P. Sharma, X. Zhang Y. Zhang, A. Makino, *Scripta Mater.* 95, 3–6, 2015.

Anna Wójcik, IMIM
a.wojcik@imim.pl

News from TECNALIA

End of ALNANAL project.

The project, carried out in the period of May 2018-September 2019 and entitled "Nanoreinforced aluminium alloys to approach the technological challenges of electric mobility", has been funded by the regional entity *Gipuzkoako Foru Aldundia.* Its main objective was to develop a robust process for the incorporation of ceramic submicron sized and nanoparticulates into aluminium alloys for future transport applications (Fig. 17).

At the end of the project a methodology to produce small batches of reinforced alloys has been achieved that presents a yield of 40-50% in the incorporation rate and an improvement of 10-30% of mechanical properties with only 0.1-0.2 wt. % of TiC particulates.

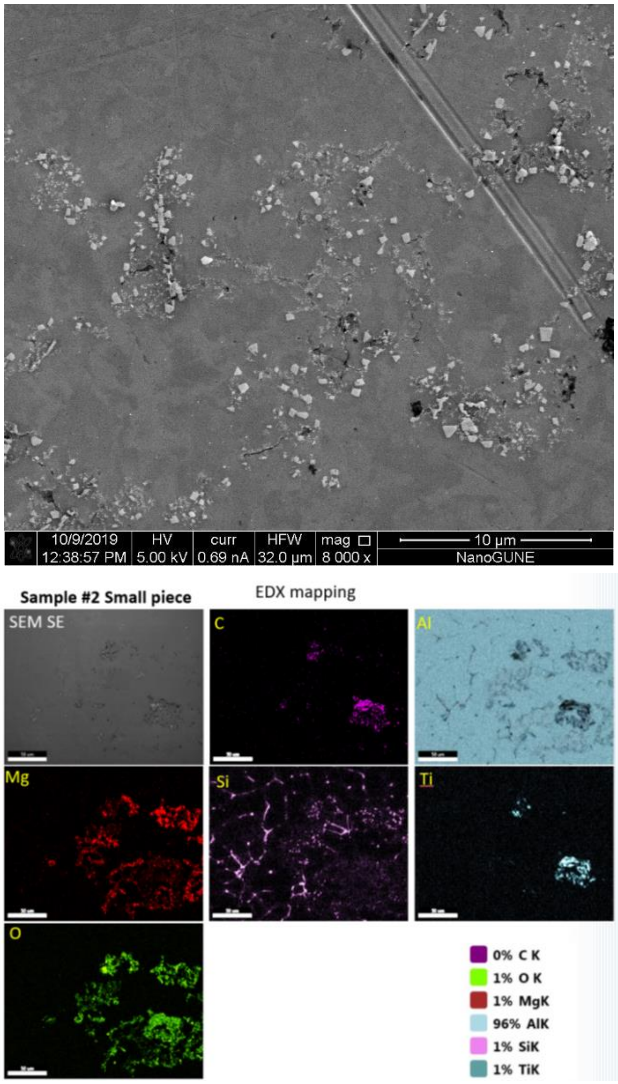


***Fig. 17**. HRSEM images and EDX mapping of a Al-Si7Mg0.6 alloy reinforced with submicron sized TiC particulates (courtesy of CIC-Nanogune).*

Start of OASIS project (https://project-oasis.eu)

The Kick-off meeting of the OASIS "Open access single entry point for scale-up innovative lightweight smart composite materials and components" project was held in San Sebastian in March 2019 hosted by TECNALIA (project coordinator). OASIS was funded by the EC in the frame of the NMBP-01-2018 call under the topic of Open-innovation test beds for lightweight, nano-enabled multifunctional composite materials and components with GRANT Agreement ID 814581 and will run for 42 months up to August 2022. Its main objective is to boost the use of nanoenabled multifunctional lightweight composites, both polymer and aluminium based The OASIS project aims at fulfilling market potential of multifunctional lightweight composites with both polymer and aluminium matrices. The structure is divided into 12 pilot lines that will be developed and upgraded for the industrial production of nano-enabled components as well as the corresponding complementary technical and market-oriented services.

The final aim is to eventually offer these services to companies that may have difficulties to access such technologies and equipment through the service of a single-entry point. The project in its initial 18 month phase will develop and upgrade up to 12 different pilot-lines and the technologies will be demonstrated by 6 industrial showcases, namely SC#1 “Nanoenabled pultrusion for lightweight construction”, SC#2 Structural nanoreinforced Al castings, SC#3 Bus roof, SC#4 Smart battery casting in nanocomposite for aeronautic applications, SC#5 Multifunctional nanobased layer for aeronautical structure and SC#6 Energy storage in prefabricated walls.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 814581

Pedro Egizabal, TECNALIA
pedro.egizabal@tecnalia.com

NEWS FROM WG2: MATERIALS FOR ENERGY

Collaborative research in WG2 is being conducted within two thematic subgroups: “EMEP” and “non-EMEP”. The EMEP partners follow the work model and research programme of the former COST proposal “Engineered Micro- and nanostructures for Enhanced long-term high-temperature materials Performance” (EMEP).

News from TUG

3D printing with the ORLAS CREATOR

Since October 2019, IMAT at TU Graz is the proud owner of a new SLM machine. The ORLAS CREATOR (Fig. 18) is a high- performance 3D printer for the production of small, high resolution objects that is capable of operating with both reactive and non-reactive metallic powders. There are a wide range of printing parameters that can be varied which makes the machine an optimal choice for high- quality research.

Planned research topics will be:

- Printing of titanium parts used in aviation, which will be joined with associated 3D printed polymer parts by ultrasonic joining
- 3D printing of AlNiCo magnets to obtain rare-earth free magnetic parts with the possibility to produce complex shapes.
- Selective laser sintering of steel samples, suitable for SHPB testing according to ASTM Standard F2971.
- Improvement of printing parameters for a new generation stainless steel powder

More topics are planned to be launched in the future. Collaboration and joint projects in the network are very welcome !

Fig. 18. *High-performance 3D printer ORLAS CREATOR installed at IMAT (courtesy of TUG).*

3D printing of AlNiCo permanent magnets

With an increasing need for renewable energy sources, e.g. wind turbines and recent advancements in electromotive driving, the ability to produce high coercivity permanent magnets has become crucial. Traditionally, rare earth containing magnets like FeNdB or SmCo have been used. However, with an increasing demand for rare earth metals, the call for rare earth free alternatives has become louder.

A very promising alternative material is AlNiCo which has a good temperature stability and a high Curie-temperature. Theoretical calculations have shown, that an increase in coercivity by a factor of 2-3 is possible.

For this goal to achieve, a smaller grain size and a more defined phase structure than currently possible to produce with conventional methods is necessary. Here, 3D printing is a promising method to achieve these goals due to high cooling rates and the possibility for directional anisotropic printing.

Christof Sommitsch, TUG
christof.sommitsch@tugraz.at

News from FRAUNHOFER-IKTS

Thin-film photovoltaics on technical textiles

With the help of new textile-based solar cells, marquees, slats and sun sails may not only protect against the sun, but also generate electrical power. Besides semitrailers could soon be producing their own electricity needed to power cooling systems or other onboard equipment. As part of the “PhotoTex” project, FRAUNHOFER-IKTS is working with partners to equip flexible technical textiles with photovoltaic layers (Fig. 19). This is done by combining thin- and thick-film technologies with textile technology.

A prerequisite for applying thin-film solar cells on textile surfaces is that the textiles can withstand the coating temperatures of around 200 °C. In a first step, a layer is applied that levels out the peaks and troughs on the surface of the fabric. Then, the two electrodes – which are made of electrically conductive polymer – and the photovoltaic layer are applied by means of the common roll-to-roll method. The voltage collectors were connected with adhesive bonding, low temperature soldering and textile industry compatible rivet assembly concepts. Finally, hermetic sealing using a film lamination process enables stable, long-term operation.

In order to evaluate the performance and long-term stability of the layer systems, a small series with active cell surfaces of up to 250 mm² was built on glass fiber textiles. The efficiency was characterized in the solar spectrum AM 1.5. The "PhotoTex" modules achieved efficiencies of 0.1 to 0.3 %. The project consortium expects an increase to 2-5% through further development of the technology. Thus, an economic use of solar-active sun protection textiles seems possible in the near future.

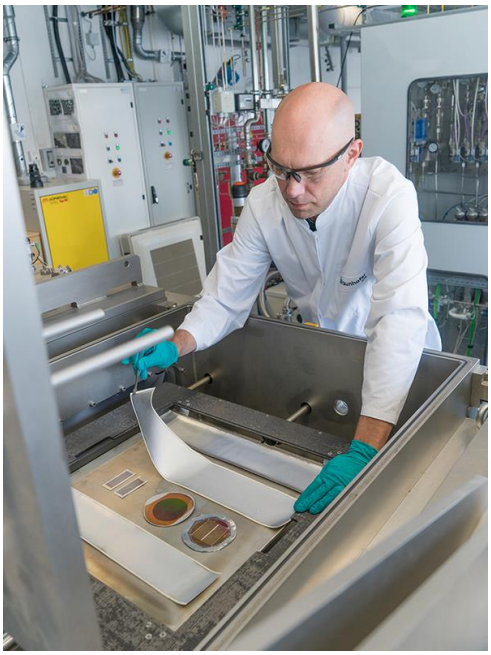


Fig. 19. *CVD coating plant for the functionalization of textile fabrics (courtesy of FRAUNHOFER-IKTS).*

cerenergy® battery module with largest existing $NaNiCl_2$ cells

Stationary energy storage is one of the most promising growth markets in Germany, Europe, and globally. In connection with this trend, solutions beyond lithium-ion and lead-acid technologies are especially interesting, because they provide high security at low acquisition and operating costs. Sodium technology is set to make a comeback in a new form, ready to face the energy storage challenges of the future.

cerenergy® is the FRAUNHOFER-IKTS technology platform for ceramic-based high-temperature batteries (Fig. 20). The idea is based on the "re-development" of $Na/NiCl_2$ and Na/S batteries with the proviso that cells and systems are produced as cost-efficient as possible. For this purpose, cell and system design, used materials and production technologies are considered. A cost-effective extrusion process was established for the production of the core element of the high-temperature battery, the solid electrolyte. In combination with a new cell layout, this has made upscaling possible.

Numerous offset recipes and ceramic-metal bonding options had to be tested and optimized during development. The sealing technology turned out to be another technological challenge; it needs to show long-term stability under a sodium vapor atmosphere. As a result of the development work, 100 Ah cells could now be realized for the first time, instead of the 38 Ah cells typically available on the market. The world's largest $NaNiCl_2$ cell in terms of capacity has already been successfully tested in stationary battery modules.

Fig. 20. *cerenergy® battery module under test (courtesy of FRAUNHOFER-IKTS).*

Hans-Peter Martin, FRAUNHOFER-IKTS
Hans-Peter.Martin@ikts.fraunhofer.de

News from AGH-UST

Metastable phases in metal-semiconductor nanosized alloys

Nowadays, there is a quest for novel materials and hybrid structures for energy-related applications, and nanomaterials have a great promise in that. In particular, the size effects, which are featured to nanomaterials, promote the formation of phases that never existed or are metastable in bulk materials. Mixing of insoluble chemical elements via reduction of their size is an example of nanophase engineering. The properties of such phases (both equilibrium and metastable) promise new performance and functionality, e.g. in thermoelectric and nanophotonic applications. Thus, the doping of semiconductor nanoparticles with metal to concentrations much beyond the equilibrium one in bulk, provides control over free electron density and enables tuning of the plasmon resonance frequency. Furthermore, tuning the electrical and thermal properties of Ge and Si films via dopant concentrations resulting in oversaturated solid solutions and metastable crystalline phases is a promising approach in semiconductor-based thermoelectric.

AGH UST in scientific collaboration with V.N. Karazin National University, Ukraine and Iberian International Institute of Nanotechnology, Portugal has conducted proof-of-concept study of the formation of metastable phases in Ag-Ge nanosized alloys. Alloying of Ag nanoparticle and amorphous Ge has been performed inside of a transmission electron microscope operated at 200kV fitted with a MEMS-based *in situ* heating holder. Fig. 21 shows the initial stages of the alloying process at 300°C. Nuclei of a new phase were formed under and at the edge of Ag nanoparticle (Fig. 21a).

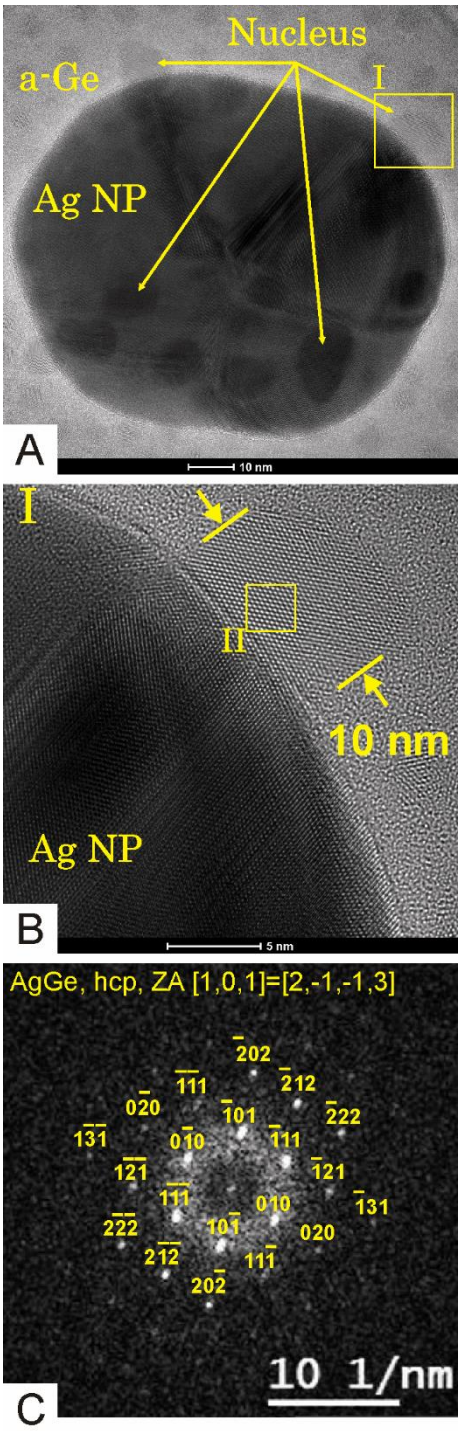


Fig. 21. *TEM images of a parent Ag nanoparticle (NP) on amorphous Ge film (a-Ge) at 300°C (a, b) and FFT spectrum (c) of Ag-Ge nucleus from the region I in (a). (Courtesy of AGH-UST)*

High-resolution imaging of these nucleus and image Fourier spectrum analysis showed that at least some of them possessed a hexagonal (hcp) crystalline structure. Fcc Ag and hcp Ag-Ge compound have similar diffraction patterns in many crystallographic orientations, therefore extensive image analysis and simulations of high-resolution TEM images have been performed (Fig. 22) for unambiguous identification of phases. Intermetallic Ag-Ge hcp phase in bulk alloys is known as a metastable one; it is typically found in high-pressure and melt quenching experiments, but not at elevated temperatures. Formation, temperature stability of this phase in nanosized alloys, as well as its thermo-physical and optical properties, will be addressed in the future work.

This work was performed in the frame of the Polish National Science Centre research project no. 2016/23/B/ST8/00537.

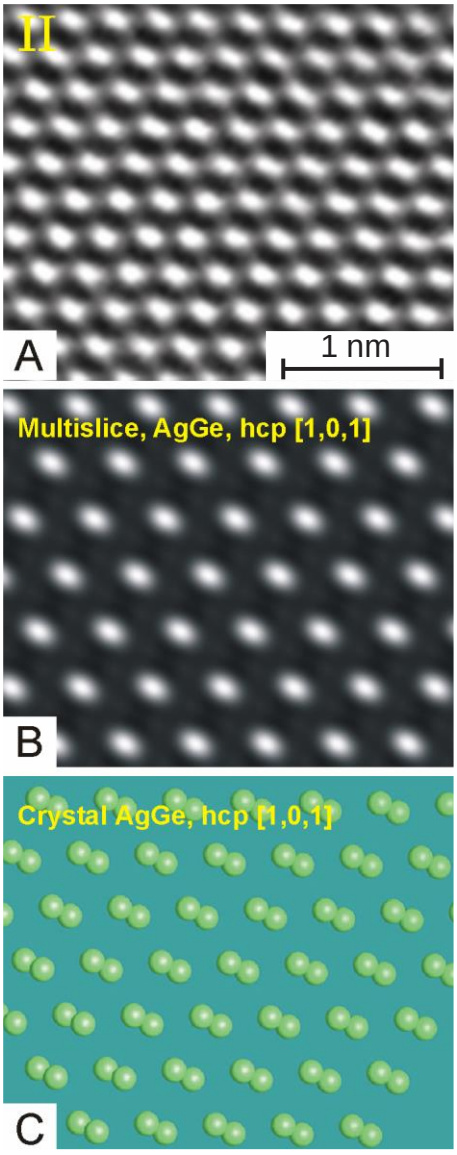


Fig. 22. *Enlarged image of region II in Fig. 21b, simulated with multislice method image of hcp Ag-Ge compound (b) and projection of Ag-Ge hcp crystal structure in [101] orientation (c). (Courtesy of AGH-UST)*

Oleksandr Kryshtal, AGH-UST
kryshtal@agh.edu.pl

Evolution of oxide scale formed on ATI 718Plus superalloy studied by FIB-SEM tomography

ATI 718Plus (718Plus) is a polycrystalline nickel-based superalloy designed to replace in some applications the widely used Inconel 718 superalloy. Due to excellent mechanical properties combined with oxidation resistance, 718Plus is considered as a material for critical rotating components in gas turbines used in aircraft and energy industry.

The factor affecting the heat and oxidation resistance of superalloys is the ability to form a protective oxide scale, usually Cr_2O_3 or Al_2O_3. However, the extensive chemical composition of nickel-based superalloys causes the formation of much more complex multi-layered systems, where chromia and/or alumina are only microstructural elements of the full oxide scale. Moreover, these multi-layered systems are built from several different phases, where the size and shape of phases may rapidly change. For that reason, two-dimensional analysis may be sometimes insufficient to describe the oxide scales in detail, therefore a three-dimensional (3D) description is necessary.

In our study, we investigated the evolution of the oxide scale formed on ATI 718Plus superalloy, during oxidation at 850 °C up to 4000 hours. We used an original approach, combining analytical electron microscopy with FIB-SEM tomography to not only identify, but also to show a 3D distribution of phases formed in the near-surface area, during oxidation. Results of the FIB-SEM tomographic reconstruction of 718Plus oxidized for 120 hours at 850 °C in synthetic air are shown in Fig. 23.

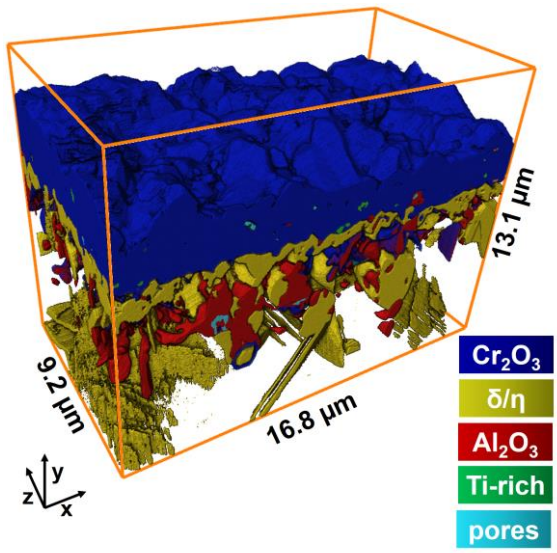


***Fig. 23**. The 3D visualization of the oxide scale formed on 718Plus after oxidation at 850 °C for 120 hours in synthetic air (courtesy of AGH-UST).*

Figure 24 shows the evolution of alumina at the grain boundaries in the internal oxidation zone of 718Plus. More information about this study may be found in recent publications [1,2].

It is worth mentioning, that all these publications are the result of Sebastian Lech research fellowship at INTA, supervised by Alina Agüero and granted by KMM-VIN within the 2016 Research Fellowship call.

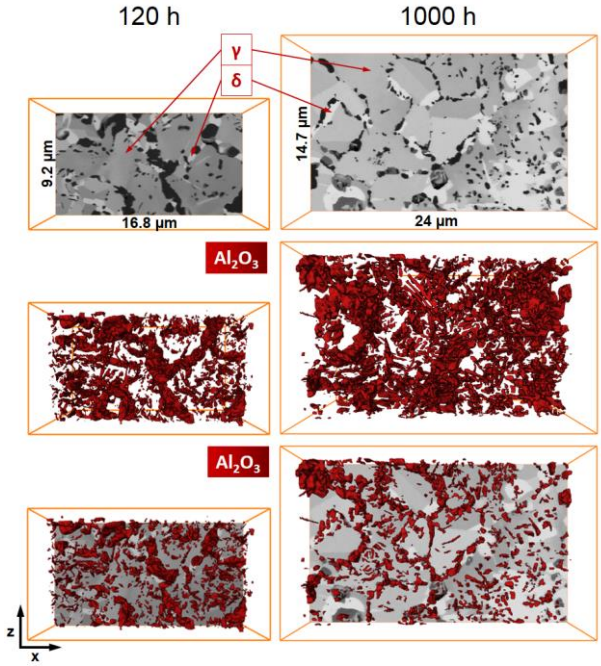


***Fig. 24**. The 3D tomographic reconstruction of Al_2O_3 phase formed in the internal oxidation zone of 718Plus after 120 and 1000 hours of oxidation at 850 °C in synthetic air (courtesy of AGH-UST).*

Sebastian Lech, AGH-UST
slech@agh.edu.pl

News from POLITO

New equipment at J-TECH@POLITO

A variety of powerful characterization tools are now available at J-TECH@POLITO, Advanced Joining Technology at Politecnico di Torino (http://www.j-tech.polito.it/). Below some photos of the just received equipment and more details about their characteristics are given. For more information about cooperation options please contact:

luca.goglio@polito.it
monica.ferraris@polito.it

Fig. 25. *Torsion tests up to 700°C and Impulse Excitation technique up to 1200°C (courtesy of POLITO).*

Fig. 26. *Universal tensile/compression machine up to 1200°C and furnace up to 1850° (courtesy of POLITO).*

List of available equipment:

- **Electron Microscopy FESEM: Phenom XL (Phenom World)**

Max Magnification: 80 – 100.000 X
Resolution: < 20 nm
Electron source: CeB_6
Backscatter detector
Equipped with Energy Dispersive X-ray Spectroscopy
Detectable Elements: From Boron (B) to Americium (Am)

- **Universal tensile/compression machine: Z050 THW (ZwickRoell)**

T test range: room temperature to 1200 °C
Equipped with laser extensometer
Max tensile force 100 kN.

- **Torsion test equipment (Test Resources)**

Torsion Test System Designed for High Temperature Tests.
Max torque 500 Nm, max temperature 800 °C

- **IET [Impulse Excitation Technique] HT1600 (IMCE)**

It can be used to:

- measure elastic properties: Young's modulus, shear modulus, Poisson's ratio and internal friction/damping (ASTM C 1259, ASTM E 1876);
- investigate the material crystal structure (phase transformations, point defects, dislocations, etc.);
- measure deterioration of mechanical properties due to irradiation, fatigue, thermal shock cycles, etc.
- determine a "fingerprint" of frequencies and their damping complex part;
- act as a *quality control tool* by comparing resonant frequencies;
- act as a *dilatometer*: range 5 mm, resolution LVDT 100 nm, temperature resolution 0.1 °C, force 0.65 – 0.8 N.

T_{max}: 1600 °C.

- **Furnace Gero (Carbolite)**

High Temperature Furnace, air, up to 1850 °C

Equipment available by the end of 2020:

- **Tomography CT SCAN: Custom built by Fraunhofer-Institut für Keramische Technologien und Systeme IKTS)**

300 kV X-ray tube
Resolution: > 2 µm
Chamber size 100 X 100 X 100 cm^3
in situ Tensile test machine, Maximum load: 10kN
Possibility of *in situ* heating up to ~ 500 °C
Possible adaptation for tensile, compression, and bending tests

- **Vacuum furnace (XVAC Series)**

High Temperature Furnace System up to 1700 °C
Working Atmosphere: Inert gas / Vacuum
Minimum Pressure (vacuum): 5 x 10^{-6} mbar

More information about available facilities within J-TECH@POLITO and associated laboratories:

http://www.j-tech.polito.it/
http://www.composites.polito.it
https://www.polito.it/ricerca/infrastrutture/dynlab4jmat/

From POLITO to AGH-UST

(KMM-VIN Research Fellowship, call 2019)

During this fellowship, Elham Sharifikolouei (POLITO) has performed a research projects at the Academic Centre for Materials and Nanotechnology ACMIN-AGH (Piotr Bala's group) for development of a technique to

fabricate metal microfibers with superior mechanical properties based on melt-spinning technique. The project focus was therefore divided into two main areas: (i) fabrication development stage (ii) fabricated microfiber characterization.

Microfiber fabrication was performed using 25µm BN slit nozzle, controlling the melt-spinning parameters (applied pressure, distance between slit nozzle and the copper wheel, and ejection temperature) for optimum results. Three types of alloys were characterized at ACMIN for their microstructure, mechanical and magnetic properties using XRD, SEM, TEM, VSM and Nanoindentation. Some results are shown in Figures 27 and 28. This activity and collaboration is still ongoing and a paper based on this activity is under preparation.

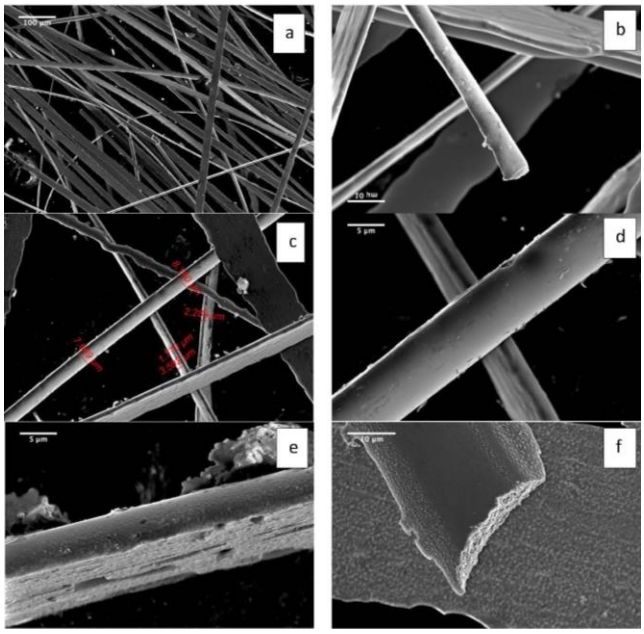


***Fig. 27**. SEM pictures of microfibers: a & b) $Co_{66}Fe_4Mo_2Si_{16}B_{12}$ alloy. c & d) $Fe_{40}Ni_{40}B_{20}$ alloy e & F) 316 stainless steel (courtesy of POLITO)*

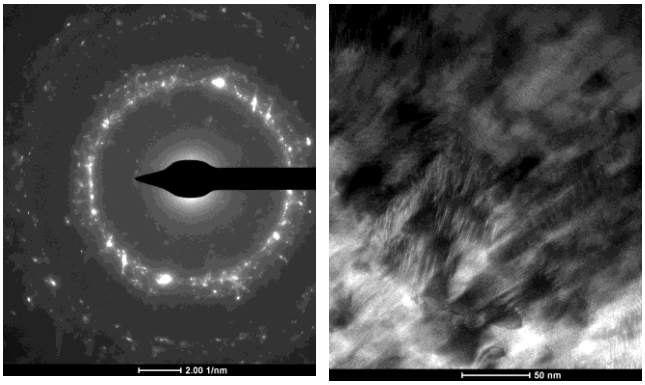


***Fig. 28**. TEM pictures of annealed 316-stainless steel microfibers prepared by focused ion beam (FIB) (courtesy of POLITO).*

Elham Sharifikolouei, POLITO
elham.sharifikolouei@polito.it

NEWS FROM WG3: BIOMATERIALS

News from FAU

New Polish-German (AGH-FAU) research collaboration on biomedical coatings

A new collaborative research project in the field of biomedical coatings has been selected for funding in the framework of the "BEETHOVEN CLASSIC 3" Polish-German Funding Initiative of the joint National Science Centre Poland (NCN) and the German Research Foundation (DFG) (call 2018-2019). The Institute of Biomaterials, University of Erlangen-Nuremberg, FAU, Germany, led by Aldo R. Boccaccini, and Faculty of Metals Engineering and Industrial Computer Science, AGH University of Science and Technology, (AGH UST), Kraków, Poland, research team led by Tomasz Moskalewicz, will collaborate in the project entitled: "Development of electrophoretic co-deposition of bioactive and antibacterial ceramics with biodegradable polymers to produce novel composite coatings for biomedical applications". The project, which has attracted funding of more than Euro 500 000, will start in 2020, and it has a duration of 36 months. The project will involve fundamental and applied research in the field of electrophoretic deposition of polymer-bioactive ceramic combinations to obtain multifunctional coatings with bone bonding and antimicrobial capability (Fig. 29). The project will exploit the expertise of the KMM-VIN partners FAU and AGH-UST in the biomaterials processing and characterization fields, based on a research collaboration between the two groups which started more than 10 years ago and has already led to joint publications (e.g. [1]).

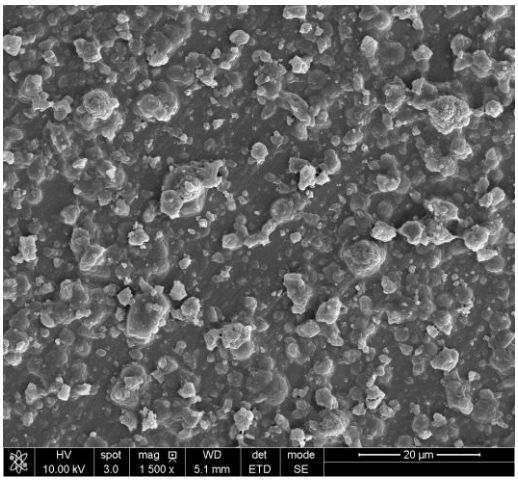


***Fig. 29.** SEM image of a bioactive sol-gel glass/chitosan coating obtained by electrophoretic deposition on a Ti-13Nb-13Zr alloy substrate (courtesy of FAU).*

[1] N. S. Radda'a et al., Electrophoretic deposition of tetracycline hydrochloride loaded halloysite nanotubes chitosan/bioactive glass composite coatings for orthopedic implants, *Surf. Coat. Technol.* 327, 146-157, 2017.

Aldo R. Boccaccini, FAU
aldo.boccaccini@ww.uni-erlangen.de

International Symposium at the FAU Institute of Biomaterials

The „10 Year Anniversary“ International Symposium to celebrate the 10 years of the Institute of Biomaterials, University of Erlangen-Nuremberg, was held on November 29, 2019 at Friedrich-Alexander-University of Erlangen-Nürnberg (FAU). Over 120 participants attended the symposium, which featured a high quality scientific program of invited speakers, all of them collaborators of the Institute, coming from Italy, Spain, UK, USA, Poland, France, Thailand, Malaysia, Finland, Austria, Portugal, Switzerland, and Germany.

Particularly significant was the participation of numerous alumni of the Institute. In his introduction, Aldo R. Boccaccini highlighted the achievements of the Institute since its establishment in October 2009, including the publication of more than 500 research papers, many in collaboration with research groups worldwide, acquisition of substantial extramural funding and the high number of Bachelor and Master students (more than 350).

Aldo R. Boccaccini also remarked that 31 doctoral theses have been completed and more than 150 visiting students and researchers have carried out research at the Institute since 2009.

KMM-VIN partners Christian Hellmich (TUW), Agnieszka Witecka (IPPT) and Federico Smeacetto (POLITO) were invited speakers at the symposium.

The celebration finalized with a dinner attended by more than 100 guests, including alumni, friends, collaborators, a the current members of the Institute, all expressed their wish to come back to Erlangen to celebrate the next 10 years of the Institute !

Aldo R. Boccaccini, FAU
aldo.boccaccini@ww.uni-erlangen.de

News from AGH-UST

Imaging of cell - material interactions for tissue engineering studies

In tissue engineering one of the well-studied topics is the role of interfaces interactions of cells with tissue scaffolds. In our group we focus on electrospun polymer fibers used as a substrate for cell culture studies. We control the surface and bulk properties of fibers via electrospinning parameters, mainly by adjusting voltage polarities at the nozzle to control surface chemistry. The controlling of surface potential on electrospun scaffolds has a direct effect on cells and tissue regeneration [1-2].

We use the state-of-the-art nanoscale microscopy characterization to exploit the structure-properties relationship in materials and cells responses. The examples of cells wrapping polymer fibers by extended filopodia are presented in Fig. 30. Currently, we have two projects funded by National Science Center in Poland on cell-material investigations: 1. ‘Interfaces studies of cell-biomaterial interactions in 3D” led by Joanna Karbowniczek, 2. “Cell responses to electrospun polymer fibers with controlled surface potential, conductivity and stiffness for tissue engineering applications” led by Urszula Stachewicz.

Fig. 30. *Bone cells (osteoblasts) attached to electrospun polymer scaffolds. On the left, front cover from paper [1], on the right - inside cover from paper [2], both published in 2019 (courtesy of AGH-UST).*

[1] P. K. Szewczyk, S. Metwally, J. Karbowniczek, M. Marzec, E. Stodolak-Zych, A. Gruszczyński, A. Bernasik, U. Stachewicz, “Surface potential controlled cells proliferation and collagen mineralization on electrospun PVDF fibers scaffolds for bone regeneration”, *ACS Biomaterials Science & Engineering*, Vol. 5 (2), 582–593, 2019

[2] S. Metwally, J.E. Karbowniczek, P.K. Szewczyk, M.M. Marzec, A. Gruszczyński, A. Bernasik, U. Stachewicz, “Single-step approach to tailor surface chemistry and potential on electrospun PCL fibers for tissue engineering application”, *Advanced Materials and Interfaces*, 1801211, 2019.

Urszula Stachewicz, AGH-UST
ustachew@agh.edu.pl

NEWS FROM WG4: MATERIALS MODELLING AND SIMULATION

10th KMM-VIN Industrial Workshop on "Design and modeling of innovative biomaterials and bioinspired materials for industrial applications"

This is to remind all KMM-VIN partners that the IW10 will be held at the Technical University of **Vienna** from **18th to 19th January 2021.**

Co-chairs: Christian Hellmich (TUW, IW10 local organiser), Katarzyna Kowalczyk-Gajewska (IPPT), Andrés Díaz Lantada (UPC).

The workshop is the tenth in a series of industrially oriented workshops organized by KMM-VIN in collaboration with leading research centres and industries. The most recent advances in material science and technology with high industrial potential are presented in this series. These workshops provide a unique opportunity to start and intensify the communication and cooperation between scientists and engineers for reshaping several industrial sectors with the help of knowledge-based multifunctional materials.

The 10th KMM-VIN Industrial Workshop will cover the following topics:

- Design and modeling of biomaterials for medical devices and other biomedical applications.
- Design and modeling of bioinspired materials for industrial applications.
- Multi-scale / multi-physical modeling of the synthesis, processing and application of biomaterials and bioinspired materials.
- Modelling methods of microstructure-property relationship for hierarchical materials.
- Artificial intelligence-aided design of innovative biomaterials and bioinspired materials.
- Manufacturing hierarchical biomaterials and bioinspired materials towards final applications
- Promotion of knowledge-based biomaterials and bioinspired materials for enhanced industrial performance.
- Cases of success in different industrial sectors: health, energy, transport, space, construction and

All participants are invited to present a poster or oral presentation to show and discuss their work on materials modelling and process simulation. Invited keynote speakers will present research directions and recent breakthroughs in the aforementioned topics.

If you plan to present a poster or oral presentation please contact Andrés Díaz Lantada.

Contact: adiaz@etsii.upm.es

News from IPPT

IPPT-FAU collaboration on solution mapping in Finite Element Method

The collaboration between Karol Frydrych and Katarzyna Kowalczyk-Gajewska (IPPT) with Arun Prakash (FAU, currently at TU Freiberg) was firmly established with the aid of KMM-VIN Research Fellowship grant. The problem attacked was proper accounting of the model variables after changing the finite element mesh (remeshing), or simply speaking, proper solution mapping. Long-term cooperation resulted in the implementation and validation of three different solution mapping schemes, namely the closest point projection (CPP), sequential spherical linear interpolation (SSLERP) and weighted spherical interpolation (WSA). First method is the simplest one, as it assigns the closest integration point from the old mesh to each integration point of the new one. The second one developed in the team consists in sequential application of the Spherical Linear intERPpolation (SLERP) algorithm. The last one is based on the weighted spherical averages. Both the SLERP and WSA concepts seem to be well known in the computer graphics community. Here they were modified and applied in the context of crystal plasticity finite element method. Recently published paper [1] reports on the implementation, validation and simulations of two passes of the Equal Channel Angular Pressing (ECAP) process. The process was modelled using the simple shear approximation applied to a cubic volume element (Fig. 31.a). The resulting textures after two passes simulated using each of the three implemented methods are presented as pole figures in Fig. 31. b-d.

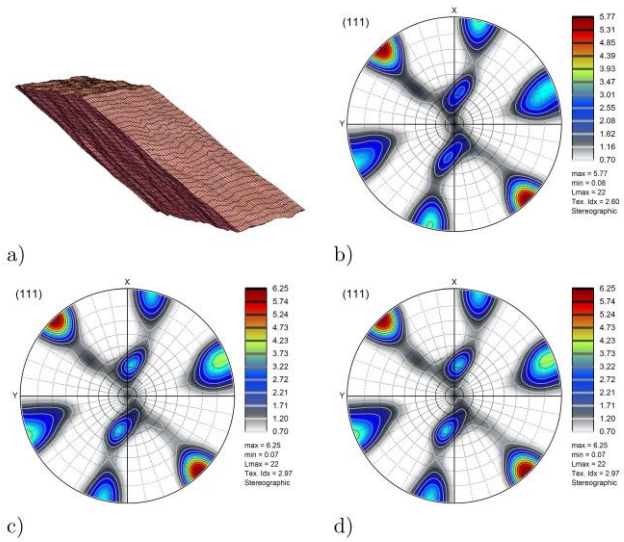


***Fig 31**. The deformed FE mesh (a). Simulated textures obtained using different solution mapping schemes: b) closest point projection (b), sequential spherical linear interpolation (c), weighted spherical interpolation (d) (courtesy of IPPT)*

Further research on how to use the developed procedures in the full-scale ECAP simulations is ongoing (Fig. 32), although still some numerical

difficulties have to be overcome. First of all, the billet to die contact has to be properly taken into account, which is not trivial when the material model is based on the crystal plasticity theory.

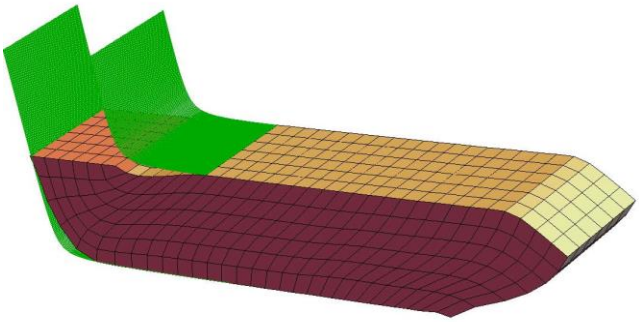


***Fig. 32**. The deformed mesh after passing through the angular channel obtained in the in the initial study. The material model in the studied example was macroscopic J2 plasticity (courtesy of IPPT).*

[1] Frydrych K., Kowalczyk-Gajewska K., Prakash A, On solution mapping and remeshing in crystal plasticity finite element simulations: application to equal channel angular pressing, *Modelling and Simulation in Materials Science and Engineering*, Vol.27(7), 075001-1-27, 2019

Multiscale modelling of heterogeneous materials: description of microstructure evolution and scale effects

This project funded by the National Science Centre (Poland) was led by Katrzyna Kowalczyk-Gajewska (IPPT). It was focused on texture and twinning-induced anisotropy of the yield stress and hardening of AZ31B extruded rods. Magnesium alloys belong to the class of high specific strength materials and find application in automotive and biomedical industries. The main issue which hinders their wider use is reduced ductility and fracture toughness related to the plastic anisotropy, insufficient number of easy slip systems and, in general, strong sensitivity of properties to the material microstructure. The goal of this research was twofold. Firstly, the multidirectional compression tests, involving strain path changes after uinitial preloading, have been performed in order to: i. assess which slip and twinning systems are active in the polycrystalline sample with a strong texture, ii. analyze the influence of the preliminary deformation upon twin formation, iii. observe the resulting change of the mechanical response. The schematic of the performed compression tests and some selected results are demonstrated in Fig. 33. The set of tests has been designed with a goal to activate different set of slip and twinning systems in the polycrystalline sample with the strong texture. Mechanical testing was supplemented by microstructure analysis. As-received AZ31B extruded rodes were pre-heated at T=350° (2h) prior to loading. Intital texture of the material as well as textures after compression in different directions were measured. The undeformed material has strong texture, where the extrusion direction (ED) is nearly parallel to the most of the basal planes.

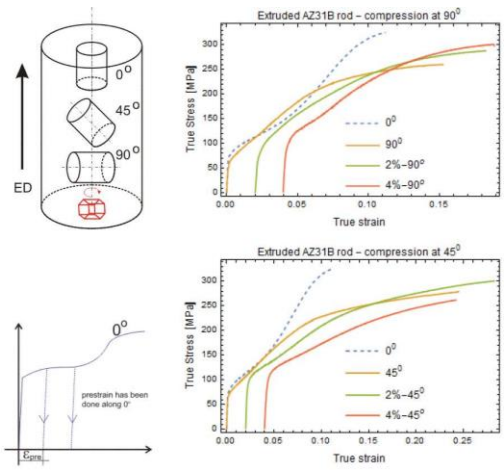


***Fig. 33.** Schematic of uniaxial compression tests involving the strain path changes performed for the samples cut from the extruded AZ31B rod and their selected results; DIC technique was used (courtesy of IPPT).*

The texture only slightly deviates from the expected axial symmetry related to the extrusion process. EBSD microstructure analysis of samples preloaded by compression along ED confirmed an important activity of twinning (see Fig. 34).

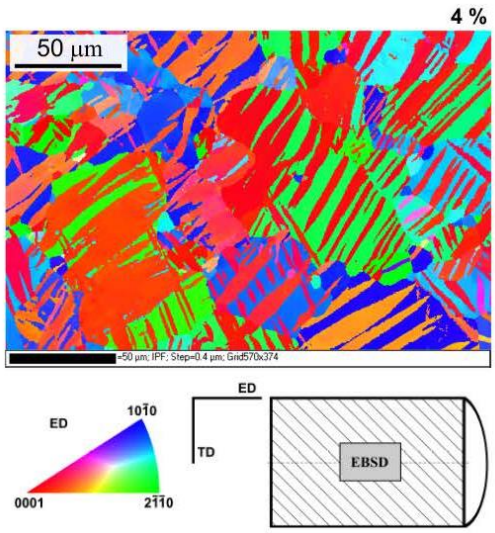


***Fig. 34.** The orientations maps obtained from the EBSD analysis on the cross-section for sample deformed up to 4% of plastic strain by compression in ED direction (courtesy of IPPT).*

Secondly, experimental observations were used to validate the proposed crystal plasticity model accounting for twinning when it is combined with the viscoplastic self-consistent scheme (Fig. 35). To this end the results of numerical simulations were used to confirm an advocated interpretation of experimental findings. Parameters of the model were identified using the procedure based on the evolutionary algorithm. The experimental and numerical results were also discussed with respect to the theoretical study of slip and twinning activity on the basis of the generalized Schmid criterion. It was concluded that twinning activity influences the mechanical response predominantly by the texture change and to lesser extent by modification of strain hardening due to slip-twin interactions.

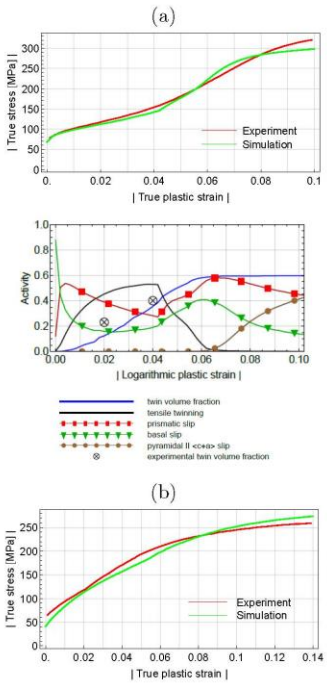


Fig. 35 *True stress-logarithmic plastic strain curves obtained in experiment and simulation for samples cut from AZ31B extruded rod: (a) ED compression with predicted activity of deformation modes and increase of twin volume fraction, (b) compression perpendicularly to ED (courtesy of IPPT).*

Although the proposed computationally efficient two-scale approach provides the predictions of satisfactory agreement with experimental outcomes, the observed discrepancies for the tests involving the strain path changes have indicated that the component of the model related to the modification of material parameters of the re-oriented grains requires further elaboration. In this respect **IPPT is open for collaboration with interested partners from KMM-VIN**.

[1] K. Frydrych, M. Maj, L. Urbański and K. Kowalczyk-Gajewska, Twinning-induced anisotropy of mechanical response of AZ31B extruded rods, *Mater. Sci. & Eng. A*, Vol. 771, 138610, 2020doi.org/10.1016/j.msea.2019.138610.

Katarzyna Kowalczyk-Gajewska, IPPT
kkowalcz@ippt.pan.pl

NEWS FROM WG5: GRAPHENE / 2D MATERIALS

We currently have 14 KMM-VIN member organisations in WG5 and hope to add another new KMM and WG5 member soon. Partners have been active in exchanging materials for evaluation, publishing papers, launching new products and assembling new H2020 projects. To help support the activities of the group, Antonios Kanellopoulos from the University of Hertfordshire (UH), UK has kindly agreed to co-lead WG5 graphene/2D materials with me. Antonios has been an enthusiastic member of the WG since it was formed a couple of years ago and will be a great help to me in growing the activities of this group.

The breadth of topics covered in WG5 includes:

- Hall effect sensors
- polymer matrix composite material pilot lines
- lubricants
- sports equipment
- lightning strike protection and deicing of aircraft
- concrete
- asphalt

New members of the group are always welcome.

Peter Hansen
peter.hansen@kmm-vin.eu

News from UH

Graphene enriched cement-based composites: A brave new world

Reinforced concrete (RC) is the dominant construction material and the key element in the vast majority of infrastructure assets. However, concrete's manufacture is extremely energy and resource intensive: >4Billion tonnes of cement produced annually, accounting to ~8% of global anthropogenic CO_2 and resulting to an annual production of ~2 tonnes of concrete for every person on the planet [1]. Despite the huge environmental impact, concrete and the related cement-based materials are the construction industry's favourites for a variety of reasons: (i) ease and cost of construction compared to alternatives (e.g. steel); (ii) robustness for a variety of exposure scenarios; (iii) ability to construct a large variety of complex geometries and (iv) excellent mechanical performance.

The exposure of cement-based infrastructure to a vast number of degrading environments throughout their service life cannot be prevented. The integrity of concrete and cement related materials largely depends on their ability to withstand mechanical and environmental weathering. It is the coupled effect of phenomena such as impact, service loading, chloride/CO_2 concentration, pressure/thermal differentials, freeze-thaw and sulphates that can cause severe damage, hence reducing functionality. Damage can manifest itself by localised weakening of the material and can progress in the form of microcracks that gradually reduce the integrity of structures and elements. Under continuous mechanical and environmental stress these microdefects coalesce and expand compromising the mechanical properties of materials. In addition, the microcracks lead to the rapid rise of corrosion of the steel reinforcement by creating paths for oxidising species. The corrosion related costs are a major problem worldwide with an annual budget of 2.2 trillion US dollars. In the UK alone the annual cost of corrosion comes to a total of £70 billion [2] where currently between 35 and 40% [3] of all construction spending is on repair and maintenance of civil infrastructure.

The design codes consider the degradation of concrete as inevitable and as such they prescribe a very strict set of rules and factors. Although cracking cannot be totally prevented, in fact design codes permit and allow cracking levels up to a certain extent, degradation of materials and components can. In concrete and cement-based materials it is the structure of the pore network that will define the permeation properties of the material. These properties affect the way water soluble and/or air-borne deleterious species can permeate and/or diffuse into the material. Chlorides, carbon dioxide and sulphates are the most important species which when they penetrate the material gradually lead to material weakening, crack formation and eventually to the oxidation and corrosion of the steel reinforcement.

The electronic properties of graphene have initially caught the interest of scientists and engineers, but extensive research showed that graphene has other important properties as well such as improved stiffness and strength, thermal conductivity, impermeability to liquid and gaseous molecules. In the recent years, the properties of graphene have been exploited for applications that do not necessarily require the use of monolayers on substrates. The incorporation of large quantities of graphene in bulk materials such as polymers has revealed a sea of new applications [4]. Concrete is a nanostructured composite material that consists of various amorphous and crystalline phases ranging from nanometer to micrometer. At the nanoscale, concrete is polymorphic network of molecular clusters, chemical bonds and surfaces that continuously interact through intermolecular forces and chemical reactions. These complex processes are dynamic, evolve with time, depend on the exposure conditions and ultimately define the quality and the properties of concrete itself [5].

At the University of Hertfordshire, a major part of our research activities in the division of Civil Engineering & Built Environment focuses on the development of innovative construction material for the future infrastructure. Our work involves compounds from the graphene family (e.g. graphene platelets, graphene oxide, reduced graphene oxide), other 2D materials (e.g. 2D silica) and nano-graphite. These compounds are being introduced into the cement-based matrix to considerably improve its properties and alleviate its naturally occurring weaknesses. Our main areas of work currently are:

- The development of impermeable barriers in cement-based composites to yield ultra-high durability (project funded by the Royal Society).
- Conductive construction materials for sensing and energy related applications.
- Nano-reinforcement of the cementitious matrix for slender concrete structural members.

Our facilities included state-of-the-art SEM, XRD, TEM, AFM, TGA, DSC in addition to the latest technology assessing mechanical and durability properties of construction materials. Our array of equipment can go test samples from as low as 15 kN to as high as 5000 kN. Our mechanical testing capabilities are being complemented by a nano-indentation suite and a dynamic mechanical analyser. In terms of durability assessments, our labs are equipped with climatic chambers, rapid-chloride diffusion cells, air-permeability cells, rapid corrosion suite, etc.

In our immediate plans is to expand our work on the use of graphene-based materials as anticorrosive compounds in structural steel. From the KMM network, currently we have an established collaboration with the Institute of Electronic Materials Technology in Poland. We very keen in expanding our collaborations and explore new opportunities for joint projects within the KMM-VIN network.

[1] P.P. Beng, The carbon footprint of reinforced concrete, *Adv. Cem. Res*. 25 (2013) 362–368. doi:http://dx.doi.org/10.1680/adcr.13.00013

[2] Building Research Establishment, Residual Life Models for Concrete Repair - Assessment of the Concrete Repair Process, 2003. doi:10.1002/yd.20038

[3] Office for National Statistics, Construction output in Great Britain: May 2016, *Off. Natl. Stat.* (2016) 5–9. http://www.ons.gov.uk/businessindustryandtrade/constructionindustry/bulletins/constructionoutputingreatbritain/may2016

[4] A.C. Ferrari, et al. Science and technology roadmap for graphene, related two-dimensional crystals, and hybrid systems, *Nanoscale*. 7 (2015) 4598–4810. doi:10.1039/C4NR01600A.

[5] H.M. Jennings, J.W. Bullard, J.J. Thomas, J.E. Andrade, J.J. Chen, G.W. Scherer, Characterization and Modeling of Pores and Surfaces in Cement Paste, *J. Adv. Concr. Technol.* 6 (2008) 5–29. doi:10.3151/jact.6.5.

Antonios Kanellopoulos, UH
a.kanellopoulos@herts.ac.uk

News from ITME

The ongoing intensive activities dedicated to graphene applications have led to new findings, including the thermally-activated double carrier transport in epitaxial graphene on high-purity semi-insulating 4H-SiC(0001).

New research results

Industry-supported validation of graphene-based Hall effect sensors enters new stage. Sensors are scheduled for dynamic verification in simulated environment of a brushless motor. Planned conditions include rotating static magnet and alternating magnetic field of an electromagnet.

Awards

1. International Warsaw Invention Show 2019: Silver Medal for Graphene Magnetic Field Sensor for Extreme Temperatures

2. Seoul International Invention Fair 2019: Gold Medal for Graphene Magnetic Field Sensor for Extreme Temperatures.

Papers published

1. T. Ciuk, B. Stanczyk, K. Przyborowska, D. Czolak, A. Dobrowolski, J. Jagiello, W. Kaszub, M. Kozubal, R. Kozlowski, P. Kaminski, *„High-temperature Hall effect sensor based on epitaxial graphene on high-purity semiinsulating*

4H-SiC", IEEE Transactions of Electron Devices 66(7), 3134-3138, 2019).

2. K. Grodecki, J. Jagiello, A. Dobrowolski, D. Czolak, I. Jozwik, T. Ciuk, Enhanced Raman spectra of hydrogen-intercalated quasi-free-standing monolayer graphene on 4H-SiC(0001), *Physica E Low-dimensional Systems and Nanostructures* 117, 113746, 2019.

Tymoteusz Ciuk, ITME
tymoteusz.ciuk@itme.edu.pl

News from IK4-TEKNIKER

Graphene oxide as catalyst of chemical reaction

TEKNIKER is studying the influence of graphene oxide (GO) and reduced graphene oxide (rGO) in the chemical reaction of epoxy amine groups during the preparation of epoxy nanocomposites. The epoxy monomer was a difunctional diglycidyl ether of bisphenol A (DGEBA), and the curing agent was 4,4-diaminodiphenylmethane (DDM). Loading of GO in epoxy–amine systems resulted in a decrease of peak exotherm temperature and a reduction in the curing times, indicating a significant enhancement of curing reaction. The use of rGO instead of GO resulted in a slight acceleration reaction rate due to a reduced presence of oxidation groups in rGO. The kinetic parameters of the curing processes in these systems have been determined by a Kamal and Sourour phenomenological model expanded by a diffusion factor. The predicted curves determined using the kinetic parameters fit quite well with the isothermal DSC thermograms, except for the systems with higher GO contents (Fig. 36).

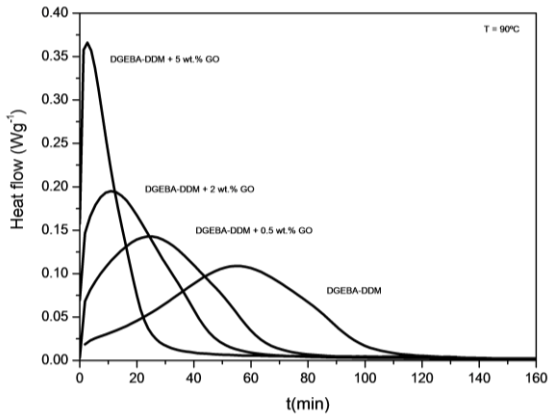
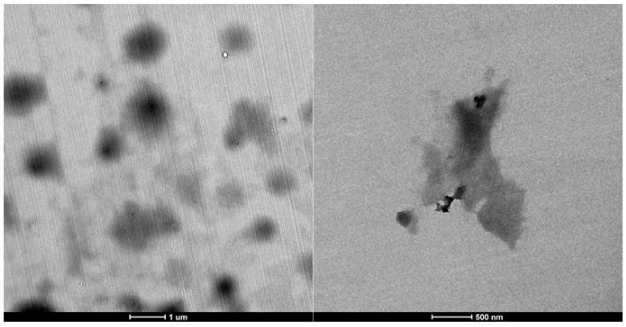
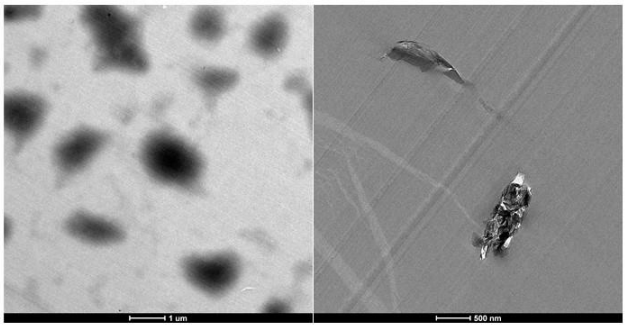


***Fig. 36**. Isothermal DSC thermograms at 90 ºC for neat DGEBA-DDMand systems with 0.5, 2, and 5 wt % GO (courtesy TEKNIKER).*

Comparison of the activation energies and rate constants suggest that the curing mechanisms of the neat DGEBA-DDM and systems modified with rGO are similar. However, for systems modified with GO, the system cure mechanisms passes from being controlled by the autocatalytic contribution to be controlled by a non-autocatalytic contribution. This change is more noticeable for systems with increased GO contents and is ascribed to the presence of a high concentration of carboxylic and hydroxyl groups on GO surface which can form complexes with the epoxy and the amine groups increasing the noncatalytic contribution in the reaction mechanism (Fig. 37).



(a)



(b)

***Fig. 37**. TEM images of epoxy/graphene composites with 0.5 wt % of: (a) GO and (b) rGO (courtesy TEKNIKER)*

Publications:

https://onlinelibrary.wiley.com/doi/full/10.1002/app.44803
https://www.mdpi.com/2073-4360/9/9/449/htm

Cristina Monteserín, IK4-TEKNIKER
cristina.monteserin@tekniker.es

KMM PROJECTS

In several EU projects two or more KMM-VIN members are currently involved as partners, which is a form of integration stemming from their collaboration within KMM-VIN. Some ongoing projects and recent project proposals are presented below.

BIONECA COST Action "Biomaterials and advanced physical techniques for regenerative cardiology and neurology" (2016-2020). This COST action involves three KMM-VIN members: UNIVPM (coordinator), AGH-UST and TUW as project partners.

i-TRIBOMAT – "Intelligent Open Test Bed for Materials Tribological Characterisation Services", a new H2020 project with two KMM-VIN members TEKNIKER and VTT as project partners has started in 2019 (https://www.i-tribomat.eu).

NICRRE – "Innovative Ni-Cr-Re coatings with enhanced corrosion and erosion resistance for high temperature applications in power generation industry" (2017-2021). This MERA-Net consortium is composed of four KMM-VIN members: ITME (coordinator), IPPT, WUT and IMRSAS as project partners.

BIO-kIller - a MANUNET project "Antibiopollutant coating for reusable biofiller" with POLITO and TECNALIA among project partners. This cooperation and project idea started during the KMM-VIN meeting in 2018.

REXMETS - a project proposal has been submitted under the H2020 Call WIDESPREAD-5-2020 Twinning. In case it is successful it will be coordinated by the associate member of KMM-VIN IMSETHC from Bulgaria with the participation of two core members of KMM-VIN: TEKNIKER from Spain and POLITO from Italy. It aims at enhancing networking activities between the participants and strengthening the research capacity of the Bulgarian Institute.

COOPERATION

European Technology Platform for Advanced Engineering Materials and Technologies (EuMaT)

KMM-VIN members: Amaya Igartua (TEKNIKER) Pedro Egizabal (TECNALIA), Arnaldo Moreno (ITC) and Michal Basista (IPPT) are members of the EuMaT Steering Committee (SC). Amaya also serves as the co-secretary of EuMaT ETP.

KMM-VIN supported the EUMAT event on Materials for Circular Economy organized on September 17, 2019 within the EMRS Fall Meeting in Warsaw. The activities of KMM-VIN were addressed at the European Aluminium Alloys Conference on October 2, 2019 within the presentation of EUMAT agenda related to light materials.

Alliance for Materials (**A4M**)

This is an informal network composed of 6 European Technology Platforms (EuMaT, SusChem, Manufuture, FTC-TEXTILE, ESTEP and SMR, two large European materials societies (E-MRS and FEMS) and Energy Materials Industrial Research Initiative (EMIRI). The goal of A4M is to develop, verify and implement effective coordination schemes of materials research across different sectors in the frame of the EU research and innovation programmes.

In 2019 KMM-VIN has signed the Alliance for Materials Memorandum and the Alliance for Materials Position Paper (see www.eumat.eu).

KMM-VIN RESEARCH FELLOWSHIPS, COURSES and TRAININGS

One of the ways to boost research integration among KMM-VIN members are the KMM-VIN Research Fellowships offered on a competitive basis for PhD students and early stage researchers (less than 10 years after obtaining the PhD degree). The grants are on average of a 1 month duration supported with a lump sum of 1500 €/month. Both the grantee and the host must be from the KMM-VIN network.

The **12th Call** for KMM-VIN Research Fellowships will be opened shortly after the General Assembly 2020 (scheduled on February 25, 2020) and will be closed on March 31, 2020. Joint publications by the fellowship holder and the host are expected as a result of the KMM-VIN Research Fellowship within 12 months after the research stay completion. The up-to-date list of published papers resulting from KMM-VIN RF stays is available at http://kmm-vin.eu/fellowships/

KMM-VIN Specialized Courses offered by Members

KMM-VIN offers customer-tailored Specialized Courses in the fields of materials design, processing technologies, fundamentals of chemical and physical processes, thermodynamics of complex materials, characterization of materials microstructure and properties, modelling of material properties and response to in-service conditions. The courses entail lectures, practices and case studies. They can be delivered at company's premises, at KMM-VIN members' location, or as e-learning.

These courses are designed for experienced staff members, who want to improve their skills in a selected field, but also for non-experienced employees, who would like to gain basic knowledge in the field. The courses are offered on a continuous basis upon individual arrangement with the interested parties. The fees depend on the type and extent of the course and and can be agreed upon with the customers on case by case basis. More information on the courses can be found on KMM-VIN webpage using the following link:

http://kmm-vin.eu/for_industry/courses_and_trainings/

Interested companies can contact the coordinator of KMM-VIN trainings:

Arnaldo Moreno Berto, amoreno@itc.uji.es

Current offer of Specialised Courses

MATERIALS

- Adhesive bonding (LU)
- Biomaterials (FAU)
- Development and applications of micro-structured and micro-textured materials (UPM)
- Light alloys and composites (IOD)
- Materials for energy systems and advanced steam power plants (AGH-UST)
- Materials for aeronautics & aerospace (AGH-UST)
- Materials science and technology (POLITO)
- Nanomaterials for biomedical applications (FAU)
- Nickel based superalloys (AGH-UST)
- Sustainable use of materials (LU)

PRODUCTION PROCESSES

- Automotive body materials (UH)
- Colloidal processing (FAU)
- Electrophoretic deposition (FAU)
- Foundry (TECNALIA)
- Heat treatment of welded joints (ISPL)
- International / European Welding Engineer / Technologist / Specialist (ISPL)
- International welder (ISPL)
- Plastics processing technology (LU)
- Rubber compounding and processing (LU)

CHARACTERIZATION TECHNIQUES

- Joining of dissimilar materials and mechanical tests of joints (POLITO)
- Electron microscopy (AGH-UST)
- High-temperature materials characterization in liquid and semi-liquid states (IOD)
- Material characterization via depth sensing indentation tests (IMBAS)
- Microstructural analysis and characterization by microscopy and tomography (AGH-UST and TECNALIA)
- Stress analysis of texturized materials by X-ray diffraction technique (IMIM)
- Testing methods for materials at high temperature and in aggressive environments (IOD)

MODELLING TOOLS

- Advanced multiphase and multi-scale material modelling (IMBAS)
- Design and modelling of micro-structured and micro-textured materials (UPM)
- Fracture mechanics of piezoelectric composites (IMBAS)
- Modelling and numerical simulations of multiphase composites (IMBAS)
- Sintering of metal-ceramic composites: modelling of the process, measurement and prediction of residual stresses and properties (IPPT)
- Tissue engineering: biomaterials and cardiovascular systems (BIOIRC)

RISK MANAGEMENT

- Risks in Industry (R-TECH)
- Asset/plant Oriented Risk Management (R-TECH)
- Health, Safety, Security and Environment (R-TECH)
- Risk Governance (R-TECH)
- Risk Based Inspection R-TECH)

PERSONALIA

Peter Mayr has been appointed as Full Professor of Materials Engineering of Additive Manufacturing at Technical University of Munich (TUM).

The past 8 years he was Professor of Welding Engineering at Chemnitz University of Technology (TUC) and now continues his research at TUM. The focus of his research will be put on the investigation of structure-process-property relationships for challenging metallic materials and advanced manufacturing processes. With industrial partners Oerlikon, Linde and GE Additive, TUM forms the Bavarian Additive Manufacturing Cluster located in Garching close to Munich. Together they will tackle the challenges in establishing metal AM as an additional advanced manufacturing technology. The webpage of the lab can be found at: https://www.mw.tum.de/mat

Marek Janas (prof. emeritus, IPPT) the editor of KMM-VIN Newsletter since 2009, celebrated his 85th Anniversary in Oct. 2019. We congratulate Marek and thank him very much for his effort and commitment to KMM-VIN network.

Amaya Igartua (IK4-TEKNIKER) has been nominated Vice-President for Spain of the International Tribology Council.

Milena Salvo and **Enrica Vernè** have been promoted to full Professors at Politecnico di Torino (POLITO).

KMM-VIN Core Members

Institutions

1. **AGH-UST** AGH-University of Science and Technology, Krakow, Poland
2. **BioIRC** Bioengineering Research and Developing Centre, Kragujevac**,** Serbia
3. **CISM Lab** Centro Internazionale di Scienze Meccaniche Spin-off, Udine, Italy
4. **FAU** Friedrich-Alexander Universität Erlangen-Nürnberg, Germany
5. **FRAUNHOFER** Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V., Germany
   - **- IFAM** Fraunhofer Institute for Manufacturing and Advanced Materials, Bremen,
   - **- IFAM-DD** Fraunhofer Institute for Manufacturing and Advanced Materials, Dresden,
   - **- IWM** Fraunhofer Institute for Mechanics of Materials, Freiburg
   - **- IKTS** Fraunhofer Institute for Ceramic Technologies and Systems, Dresden,
6. **IK4-TEKNIKER** Foundación TEKNIKER, Eibar, Spain
7. **IMBAS** Institute of Mechanics, Bulgarian Academy of Sciences, Sophia, Bulgaria
8. **IMIM** Institute of Metallurgy and Materials Science, Polish Academy of Sciences, Krakow, Poland
9. **IMRSAS** Institute of Materials Research, Slovak Academy of Sciences, Kosice, Slovakia
10. **INTA** Instituto Nacional de Técnica Aeroespacial, Torrejón de Ardoz, Spain
11. **IOD** Foundry Research Institute, Krakow, Poland
12. **IPM** Institute of Physics of Materials, Brno, Czech Republic
13. **IPPT** Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland
14. **ITC** Instituto de Tecnología Cerámica - AICE, Castellón, Spain
15. **ITME** Institute of Electronic Materials Technology, Warsaw, Poland
16. **MCL** Werkstoff-Kompetenzzentrum-Leoben Forschungsgesellschaft m.b.H. (Materials Centre Leoben), Leoben, Austria
17. **POLITO** Politecnico di Torino, Torino, Italy
18. **R-TECH** Steinbeis Advanced Risk Technologies GmbH, Stuttgart, Germany
19. **TECNALIA** Fundación Tecnalia, Donostia-San Sebastian, Spain
20. **TUD** Technische Universität Darmstadt, Darmstadt, Germany
21. **TUG** Graz University of Technology, Graz, Austria
22. **TUW** Technische Universität Wien, Wien, Austria
23. **UH** University of Hertfordshire, Hatfield, Herts, UK
24. **UNIVPM** Università Politecnica delle Marche, Ancona, Italy
25. **UPM** Universidad Politécnica de Madrid, Madrid, Spain
26. **WRUT** Wroclaw University of Technology, Wroclaw, Poland
27. **WUT** Warsaw University of Technology, Warsaw, Poland

Individual members

1. **Katarzyna Pietrzak** Warsaw, Poland
2. **Michał Basista** Warsaw, Poland
3. **Krzysztof Doliński** Warsaw, Poland
4. **Michał Urzynicok** Koszęcin, Poland
5. **Peter Hansen** Ammanford, UK

KMM-VIN Associate Members

Institutions

1. **BEG** Böhler Edelstahl GmbH & Co KG, Kapfenberg, Austria
2. **BSGA** Böhler Schweißtechnik Austria GmbH, Kapfenberg, Austria
3. **CSM** Centro Sviluppo Materiali S.p.A., Rome, Italy
4. **GE Power** General Electric Power Ltd, Rugby, UK
5. **UNIPER** Uniper Technologies Limited., Coventry, UK
6. **ETE** Energietechnik Essen GmbH, Essen, Germany
7. **EU-VRi** European Virtual Institute for Integrated Risk Management, Stuttgart, Germany
8. **GSCLtd** Goodwin Steel Castings Ltd, Hanley, UK
9. **IMSETHC** Institute of Metal Science, Equipment and Technologies with HydroAerodynamics Centre of the Bulgarian Academy of Sciences, Sofia, Bulgaria
10. **IS** Instytut Spawalnictwa, Gliwice, Poland
11. **LU** Loughborough University, Loughborough, UK
12. **MPA** Materialprüfungsanstalt Universität Stuttgart, Germany
13. **NOMASICO** Nomasico Ltd, Nikosia, Cyprus
14. **NUIG** National University of Ireland, Galway, Ireland
15. **NTUA** National Technical University of Athens, Athens, Greece
16. **SIEMENS** Siemens AG, München, Germany
17. **SSF** Saarschmiede GmbH Freiformschmiede, Völklingen, Germany
18. **SWG** Schmiedewerke Gröditz GmbH, Gröditz, Germany
19. **TUC** Chemnitz University of Technology, Chemnitz, Germany
20. **TUBAF** TU Bergakademie Freiberg, Germany
21. **UCM** Universidad Complutense de Madrid, Spain
22. **UL** University of Limerick, Limerick, Ireland
23. **UNIPAD** Università degli Studi di Padova, Padova, Italy
24. **VAGL** Voestalpine Giesserei Linz GmbH, Linz, Austria
25. **V&MD** Vallourec & Mannesmann Tubes, V&M Deutschland GmbH, Düsseldorf, Germany
26. **VTT** VTT Technical Research Centre of Finland, Espoo, Finland
27. **VZU** Výzkumný a zkušební ústav Plzeň s.r.o., Plzeň, Czech Republic

Individual members

1. **Fabrizio Valenza** Genova, Italy

European Virtual Institute on Knowledge-based Multifunctional Materials (KMM-VIN AISBL)
rue du Trône 98, 1050 Brussels, Belgium
Phone: +32 2 213 4160, +48 668 160 300
Fax: +32 2 791 5536
Email: office@kmm-vin.eu
http://www.kmm-vin.eu

KMM-VIN Branch Poland
Pawińskiego 5 B, 02-106 Warsaw, Poland
Phone: +48 22 122 8528
Fax: +32 2 791 5536

Newsletter Editor: Marek Janas
Marek.Janas@kmm-vin.eu
http://kmm-vin.eu/newsletter/