EUROPEAN VIRTUAL INSTITUTE ON
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KMM-VIN Newsletter

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EDITORIAL

We are presenting the seventh issue of the Newsletter of the European Virtual Institute on Knowledge-based Multifunctional Materials (KMM-VIN). The Newsletter is published twice a year, as Summer (in July) and Winter (in December) Issues.

KMM-VIN was established in 2007 as the main result of the Network of Excellence KMM-NoE (FP6 project). The legal status of KMM-VIN is Belgian international non-profit association (AISBL). KMM-VIN AISBL is registered in Brussels. It comprises now 69 members from 15 European States. It operates two offices: main office in Brussels and a remote one in Warsaw.

For its members KMM-VIN is providing an organizational framework to conduct jointly basic and applied research comprising materials processing, characterisation and modelling. For external clients KMM-VIN is offering integrated R&D, educational and innovation activities in the field of advanced structural and functional materials with main focus on Transport, Energy and Biomedical sectors.

The Winter Issue of the 2012 Newsletter contains usual columns as listed at the top, commencing as always with "Latest News". The most important part of each KMM-VIN Newsletter are the news from the Working Groups. Recently the Working Groups have been reorganized. In the past they used to be focused on selected groups of advanced materials. Now they are oriented at selected industry sectors acknowledged as target sectors for KMM-VIN research: WG1. Materials for Transport, WG2. Materials for Energy, WG3. Biomaterials and WG4. Modelling (crosscutting group).

In the column "KMM Projects" one can find information from European projects in which KMM-VIN and/or KMM-VIN members are involved. Special attention is given to two running FP7 projects coordinated by KMM-VIN: MATRANS ("Micro and Nanocrystalline Functionally Graded Materials for Transport Applications") and INNVIN ("Innovative materials solutions for Transport, Energy and Biomedical sectors by strengthening integration and enhancing research dynamics of KMM-VIN").

The column "Cooperation" contains updated information on KMM-VIN's activity in the European Technology Platform on Advanced Engineering Materials and Technologies (EuMaT) and in other European initiatives on Materials.

In the column "Research Fellowships and Trainings" information on the 5th Call of KMM-VIN Research Fellowships programme is given.

The list of KMM-VIN members (institutions) is given at the end of the Newsletter. For viewing the details of KMM-VIN members' profiles and information on current events the Readers are requested to visit our webpage www.kmm-vin.eu. The contact details to KMM-VIN Office can be found on the back cover of the Newsletter.

For research communities in Europe the upcoming year will be a year of getting ready to the next framework programme, Horizon 2020, which will be launched on 1st January 2014. The Horizon 2020 programme for research, development and innovation (R&D&I) is proposed to help Europe deal with the present and future challenges through supporting excellent science, technology and innovation.

Importantly, Horizon 2020 will combine different streams of the EU research and innovation funding into a single programme, embracing the current 7th Framework Programme (FP7), innovation activities from the Competitiveness and Innovation Framework Programme, and EU funding to the European Institute of Innovation and Technology (*see also* "Latest News").

Marek Janas, Editor

(B) Diagnostic analysis of masonry structures and of concrete dams by flat-jacks and digital image correlation "full-field" measurements. Such method of "almost non-destructive" "in situ" tests and parameter identification has been recently elaborated in dam engineering. Extension to periodic masonry might represent advantages in civil engineering and for historical building restoration, also for assessments of local properties (bricks, mortar and interface) without specimen extractions.

(C) Identification of residual stresses and of parameters in fracture models by indenters with new shapes.
As a continuation of the research project on inverse analyses based on non-destructive tests by indentation, the following results have to be pursued now: (a) estimation of residual stress tensor using novel optimized "ad hoc" indenters; (b) identification of parameters governing fracture behaviour using novel optimized "double-bicircular" indenter shapes; (c) model calibration of anisotropic elastoplasticity, with "ad hoc" indenter shapes. Such indenters are not yet available on the market.

(D) Identifications of parameters in constitutive models apt to describe the mechanical behaviour of membranes, foils or laminates employed for food-containing boxes.
The experimental techniques at the basis of such inverse analysis procedures are, besides "full-field" measurements of displacements: cruciform biaxial tension tests; "sandwich experiments" with stabilizers for compression and bending tests on multi-layer laminates and/or on specimen containing creases for the production of food containers.

(E) Mechanical characterization of materials and biological tissues at small length scale.
Nanoindentation is a powerful technique which may be successfully applied to this purpose. Bone and cartilage tissues are paradigmatic examples of "materials" in which the characteristic length of its hierarchical structure and the probe size mutually interact, thus providing a fruitful investigation tool. The capability to run experiments in liquid environment, which can replicate the physiological conditions of the working environment of tissues, enables one to expand the investigation of the material response in the time domain where visco-elasticity and poro-elasticity may play relevant roles as dissipation mechanisms.

Small scale investigation of materials can also find a fertile area of research in the field of mechanical behaviour of micro-electronic devices in diverse engineering fields like power electronics or stretchable electronic devices. Research collaborations with foreign institutions and with industrial partners are currently on going and are allowing POLIMI to acquire significant expertise in the field. Collaborations on inverse analysis problems with other teams in the KMM-VIN framework might be highly productive.

The above listed topics on material characterizations by inverse analyses involve activities of several researchers of POLIMI.
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At present interactions and collaborations of POLIMI researchers occur with teams in many universities, as well as with Italian industries, e.g.: Venezia Tecnologie, Marghera (C); Tetrapak, Modena (D); ENI, San Donato, Milan (A); Breda, Cormano, Milan (C); RSE, Milan, and Italian Committee on Large Dams, Rome (A, B); ST Microlectronics (E).

The success of the above projects requires close interactions of practitioners in the industrial area, experimentalists and university researchers. Two years might represent a reasonable period to reach final conclusions on operative procedures and instrument realizations for applications with expected remarkable advantages (and benefits) with respect to the present engineering practice.

PRESENTATIONS

The International Centre of Electron Microscopy for Materials Science (IC-EM) at AGH-UST

The International Centre of Electron Microscopy for Materials Science (www.tem.agh.edu.pl) headed by Prof. Aleksandra Czyrska-Filemonowicz continues over 50 year long tradition of electron microscopy at the AGH University of Science and Technology in Kraków. The Centre was created on 1st June 2010 as the non-faculty unit, acting in co-operation with foreign partners. The lead unit of the Centre at the AGH-UST is the Faculty of Metals Engineering and Industrial Computer Science and the lead foreign partner is the Forschungszentrum Jülich in Germany.

The main activity of the IC-EM is the application and tuning of new methods of electron microscopy to materials investigations, mainly to quantitative characterization of the micro-and nanostructure of innovative materials in order to achieve the desired properties. The main groups of the materials

investigated at IC-EM are materials for energy systems, aeronautics, graded and multilayered materials, biomaterials, nanomaterials, structural and functional materials.

The IC-EM team comprises 10 permanent researchers, 1 (permanent) visiting professor, 2 technicians and several PhD students. Their field of expertise covers quantitative characterization of micro/nanostructure and properties of engineering materials, including structural defect analyses and phase identification in multiphase and multilayered materials down to the nanoscale (even atomic) scale by advanced electron microscopy, electron tomography and electron holography. The IC-EM staff is developing methods for nanophase identification and mapping by coupling fast EDX spectrometry and precession electron diffraction (PED) in the Cs-corrected STEM as well as STEM-EDX tomography.

The Centre has developed its infrastructure to upgrade the expertise in several advanced techniques. The IC-EM is equipped with 4 transmission electron microscopes (TEM) and 2 scanning electron microscopes (SEM). In particular, the third in the world ultimate performance analytical electron microscope, a Titan Cubed G2 60-300 for high resolution analytical microscopy at high (300 kV) and low (60 kV) energy of FEI was installed in 2011. This unique microscope is equipped with ChemiSTEM system consisting of the new X-FEG Schottky high brightness source with a monochromator, a high resolution STEM-HAADF unit with the new dodecapole DCOR probe Cs corrector and the new EDX microanalysis system based on the 4 windowless Silicon Drift Detectors (SDD) technology with enhanced acquisition efficiency (0.7 sr) and speed for low dose, high spatial (atomic) resolution and fast chemical mapping. The other unique equipment of the Titan Cubed G2 60-300 microscope includes EELS GIF Quantum 693 spectrometer for edge shifts/fine structure (using monochromator and probe Cs-corrector), new FEI PED precession electron diffraction, dual-axis tomography holder, Lorentz lens, rotatable biprism for off-axis electron holography and TARO for full remote access operation. Fig. 2 shows STEM-EDX elemental maps of CMSX-4 single crystal superalloy used for aero engine turbine blades acquired with Titan Cubed G2 60-300 with ChemiSTEM technology.

The second transmission electron microscope installed in 2011 is Tecnai G20 Twin with LaB6 cathode, equipped with DigiStar precession diffraction and ASTAR for orientation and phase mapping as well as STEM-HAADF and EDX microanalysis system (TIA/EDAX).

Other two TEMs – Jeol JEM-2010ARP and JEM-200CX - are the workhorse microscopes for defect analysis and intermediate resolution phase identification for engineering materials.

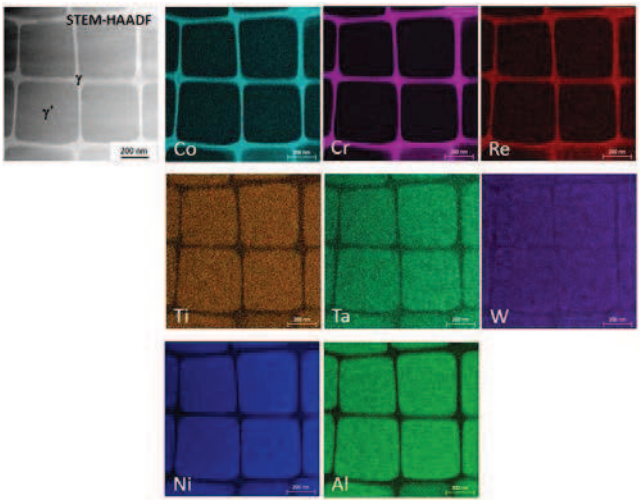

Fig 6. HRSTEM-EDX elemental maps of CMSX-4 single crystal superalloy used for aero engine turbine blade acquired with Titan Cubed G2 60-300 with ChemiSTEM technology.

The Centre possesses two SEM microscopes. Installed in 2009 the FIB-SEM dual beam NEON 40 EsB CrossBeam of Zeiss with EDX microanalysis system Quantax 200 (30mm^2 SDD) of Bruker system, FEG SEM column, SE and BSE modes is used for SEM investigation as well as TEM sample preparation and FIB-SEM tomography. Recently, in summer 2012, the IC-EM has launched the new SEM, a Merlin Gemini II equipped beside several detectors, with FEG, EDX microanalysis system Quantax 800 and EBSD Quantax CrystAlign 400.

The remaining scientific facilities of the Centre include a scanning probe microscope Dimension 3100 SPM, advanced light microscopes Axio Imager M1m and Stereo Discovery of Zeiss, computer-aided image analysis laboratory with several programs and mechanical properties testing equipment.

The comprehensive TEM sample preparation laboratory is mainly dedicated to metals, alloys, ceramics, composites and coatings. The laboratory is equipped with two low temperature electropolishing Tenupols of Struers, two room and LN2 temperature PIPS (Gatan) ion mill with low voltage (100V) and CCD camera for careful final polishing as well as the new ultra-low energy ion beam mill NanoMill 1040 of Fischione for post-processing of FIB lamellae for ultra-thin, clean samples required for advanced TEM analyses.

The IC-EM team is very active in collaboration with research and industrial partners. The team was involved in more than 150 scientific projects. At present, the IC-EM acts as a TEM training site for Central and Eastern Europe and collaborates with many research partners. Within ESTEEM2 project (http://esteem2.eu), the IC-EM provides the transnational access to its facilities for scientists who do not have such modern research instruments and infrastructure.