The Joint Visegrad 4 - Japan Seminar on Technology Transfer: "Nanomaterials for Industrial Use"

The seminar is organized as a joint effort of CzechInvest, the Embassies of the Visegrad 4 countries (V4, the Czech Republic, Poland, Hungary and Slovakia) and the Japan Science and Technology Agency. Its aim is to introduce top research institutes from the V4 countries and their latest findings in the area of "Nanomaterials for Industrial Use" to Japanese scientific and business audience. The representatives of Japanese academia and innovative companies will have the chance to learn about the research results of the V4 top institutes and the available programs for funding joint projects, in order to establish cooperation with them for further research and product development. The seminar will be held in English, materials will be provided in Japanese, the capacity is 80 persons.

PROGRAM

13:30 – 13:40 ***Opening speeches***

- **Mr. Tomáš DUB**, the Ambassador of the Czech Republic in Japan
- **Ms. Mayuko Toyota,** Parliamentary Vice-Minister of Education, Culture, Sports, Science and Technology of Japan
- **Dr. Michinari HAMAGUCHI**, President of the Japan Science and Technology Agency

13:40 - 15:00 ***Block 1: Financial programs for International Science &Technology cooperation projects in Visegrad 4 countries***

- **Dr. Petr OČKO**, Chairman of the Technology Agency of the Czech Republic
  Ms. Agnieszka RATAJCZAK, Head of Unit for International Programmes, Department of Programme Management, National Centre for Research and Development, Poland
- **Dr. Gyula P. SZIGETI,** Vice President for Research and Development at the National Research, Development and Innovation Office of Hungary
- **Dr. Juraj LAPIN**, Member of the Presidium of the Slovak Academy of Sciences
- **Mr. Stijn LAMBRECHT,** Project Manager JEUPISTE, EU-Japan Centre for Industrial Cooperation

15:00 – 15:25 ***Coffee break***

15:15 – 17:15 ***Block 2: Nanomaterials for Industrial Use***

- **Mr. Adam BLAZEK**, Institute for Nanomaterials, Advanced Technology and Innovation, Technical University of Liberec - "***Nanomaterials and their use in practice – Application of nano-fibrous materials and research of technologies for the preparation of micro and nanoparticles and their applications in thin layers on substrate surfaces***"
- **Dr. Lukasz WIERZBICKI**, Faculty of Materials Science and Engineering, Warsaw University of Technology – "***Shear thickening fluids for energy absorbing systems***"
- **Dr. Béla PÉCZ**, Institute of Technical Physics and Materials Science, Centre for Energy Research, Hungarian Academy of Sciences – "***Nanostructures in semiconductors and ceramics***"
- **Dr. Juraj LAPIN**, Institute of Materials & Machine Mechanics Slovak Academy of Sciences ***"Low cost TiAl-based precision cast turbocharger wheels for automotive industry***"

17:15 – 19:00 ***Networking reception***

CZECHINVEST ビジネス・投資開発庁
Embassy of the Czech Republic in Tokyo
Embassy of the Republic of Poland in Tokyo
EMBASSY OF HUNGARY TOKYO
EMBASSY OF THE SLOVAK REPUBLIC IN TOKYO

INFORMATION ABOUT THE SPEAKERS

Block 1: Financial programs for International Science &Technology cooperation projects in Visegrad 4 countries

Topics: The presentations in this block are all dedicated to financial programs for International Science &Technology cooperation projects in each presenting country

Dr. Petr OČKO, Chairman of the Technology Agency of the Czech Republic

The **Technology Agency of the Czech Republic (TACR)** is the main organization which implements the state policy in the sphere of applied research, development and innovations in the Czech Republic. The TACR participates in the conceptual orientation and creating of research environment of the CR, in the preparation of National Policy of Research, Development and Innovations, produces strategic document in the field of applied research, development and innovations and implements key programmes in this field, in particular based on national priorities of oriented research and development.

Ms. Agnieszka RATAJCZAK, Head of Unit for International Programmes, Department of Programme Management, National Centre for Research and Development, Poland

The **National Centre for Research and Development** is a research funding agency supervised by the Minister of Science and Higher Education. Established in 2007 to perform tasks related to science, technology and innovation policies adopted by the Polish government. Its mission is to support a sustainable growth of Poland through commercialisation and transfer of R&D results to economy. NCBR is responsible for the implementation of national strategic R&D programmes as well as sectoral programmes in which industry sectors develop a research agenda for the programme and provide matching funding. The agency has been acting as Programme Operator of the UE's structural funds dedicated to R&D and higher education sectors. In the current financial perspective, NCBR is in charge of 2 such programmes: Smart Growth which aims at increasing the innovation potential of the Polish economy and Human Capital aiming at building capacity and competitiveness of the higher education sector.

Dr. Gyula P. SZIGETI, Vice President for Research and Development at the National Research, Development and Innovation Office of Hungary

The **National Research, Development and Innovation Office (NKFIH)** of Hungary is a national strategic and funding agency for scientific research, development and innovation, the primary source of advice on RDI policy for the Hungarian Government, and the primary RDI funding agency. Its mission is to develop RDI policy and ensure that Hungary adequately invest in RDI by funding excellent research and increase competitiveness supporting innovation. Its mandate is to prepare the RDI strategy of the Hungarian Government, to handle the National Research, Development and Innovation Fund, and represents the Hungarian Government and a Hungarian RDI community in International organizations.

Dr. Juraj LAPIN, Member of the Presidium of the Slovak Academy of Sciences

The **Slovak Academy of Sciences (SAS)** is a national institution which undertakes scientific research in Slovakia as an autonomous non-university research institution which is primarily funded from public finances. Its aim is to undertake basic research in the natural, technical, medical and social sciences as well as in the humanities in areas which are innovative, demanding in terms of personnel and research infrastructure, and which develop innovative technology and diagnostics. In addition to its proportionate role in enhancing knowledge through international cooperation in scientific endeavor, the academy fulfils its social mission through the development of progressive technologies, patents, innovations, expertise and the transfer of knowledge to many areas of practical implementation.

Mr. Stijn LAMBRECHT, JEUPISTE Project Manager EU-Japan Centre for Industrial Cooperation

JEUPISTE (Japan-EU Partnership in Innovation, Science and Technology, FP7 grant agreement no 609585) is an EU funded project for the promotion, enhancement and development of Europe-Japan cooperation in Science, Technology and Innovation (STI). The project is implemented by a consortium of 10 organisations, coordinated by the EU-Japan Centre for Industrial Cooperation (IIST). JEUPISTE is supporting the EU-Japan STI policy dialogues through data collection and analytical reports on the status of the cooperation. It also organises workshops and information days to promote cooperation programmes such as Horizon 2020, the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over 7 years (2014 to 2020), and facilitates partnership building through thematic events. The project furthermore addresses the individual needs of researchers and research organisations by implementing training seminars on Horizon 2020 project management and operates a help desk where any kind of inquiry related to EU-Japan STI cooperation can be addressed.

Block 2: Nanomaterials for Industrial Use

Mr. Adam BLAZEK, Institute for Nanomaterials, Advanced Technology and Innovation, Technical University of Liberec

The **Institute for Nanomaterials, Advanced Technology and Innovation (CxI)** is the most ambitious and expensive project in the nearly sixty-year history of the Technical University of Liberec. It is a new research centre that was established in 2009. The Institute focuses on two research programs: material research and competitive engineering.

In addition to the processing and use of new advanced materials (in particular nanomaterials), the Institute focuses on the development and use of advanced engineering constructions and technology (especially mechatronic systems, propulsion units, etc.). One of its priorities is the application of the results of research and their applicability in practice.

Basic research in this research programme is focused on a complete physical description of the processes that take place in the electrospinning of polymer solutions and melts. The development (technological) part specializes in new process variants and their modifications. The basic research activities will be: electrospinning, preparation of various types of nanosurface treatments and preparation of composites based on nanomaterials.

Applied research of nanomaterials is focused on exploring the properties of nanomaterials and their utilization for specific applications, such as the development of specific products, especially filters, surface treatments in medicine and engineering, and biotechnology materials for water treatment and other sanitation procedures.

Topic: "Nanomaterials and their use in practice – Application of nano-fibrous materials and research of technologies for the preparation of micro and nanoparticles and their applications in thin layers on substrate surfaces"

The main topics of the presentation will be the introduction of activities of selected laboratories at the CxI.

1) The application of nanofiber materials developed at the CXI especially for applications in air and water filtration, bioengineering and acoustics.
2) Application of new progressive methods for remediation and water treatment, applications of nanomaterials in remediation technologies and the environmental protection against potential hazards of nanomaterials. This is essentially a research into the modification of the zero-valent nanoiron.

Main technologies:

Special patented technology for the production of emulsions. This is a film forming impregnation emulsion based on polysiloxane with nano-additives. To increase the useful properties of the emulsion (hydrophobic and antistatic), nanoparticles are part of an emulsion itself.

The fundamental advantage over existing hydrophobic materials which are available on the market is the improved mechanical resistance. Thanks to this quality the protective layer can endure several times longer than existing technology. Together with our industrial partner we started the production of emulsion, which is available on the market for automotive applications. Further development is currently in progress, with results which will find application in the textile industry (smart textiles), glass and construction industries.

Dr. Lukasz WIERZBICKI, Faculty of Materials Science and Engineering, Warsaw University of Technology

The Faculty of Materials Science and Engineering was established in 1991. Nowadays it is one of the leading research & development centres in Poland in the area of materials science and engineering. According to a parametric assessment conducted by the Ministry of Science & Higher Education, the Faculty is a 1st class unit ranked A+ in the classification of units carrying out research in chemistry and materials in Poland.

Studies carried out by the Faculty are linked with the mainstream of contemporary materials science and materials engineering. The interdisciplinary character of research conducted involves problems of physics, chemistry, biology and medicine. Works carried out are particularly focused on links between microstructure and the quality of materials used in different industry sectors e.g. aerospace, clean energy and medicine. Main research areas relevant to the topic include Nanomaterials and nanotechnologies, Smart and functional materials, Materials characterisation, Multiscale modelling.

FME WUT has vast experience in the processing of materials and characterising their microstructure as well as in the testing of rheological, mechanical and magnetic properties of materials, including polymer matrix composites. Since 2003, FME has carried out investigations into smart polymer materials as well as magnetorheological materials based on urethane elastomers and magnetocaloric alloys.

Topic: "Shear thickening fluids for energy absorbing systems"

Shear thickening fluids (STF) belong to the group of non-Newtonian fluids. They have the ability of predictable response to the external stimuli, which classifies them to the group of smart materials that combine functions of a sensor, a processor and an actuator. The shear thickening phenomenon can be explained by a few theories such as clustering theory, Order - Disorder Transition (ODT) and flocculation theory.

The current presentation introduces rheological behaviour of the STF based on nanosized silica suspensions. Depending on the oligomer chemical structure, its molecular weight, as well as volume fraction and type of the solid phase we observe different behaviours under the shear stress. The shear thickening behaviour has focused substantial scientific interest due to its potential applications in many branches of industry including: automotive, sport, transport, telecommunication, construction and liquid body armours. Warsaw University of Technology has, up to now, developed smart passive body armour based on STF and shin protectors for football players. This presentation will introduce some of their main parameters.

Dr. Béla PÉCZ, Institute of Technical Physics and Materials Science, Centre for Energy Research, Hungarian Academy of Sciences

The mission of the **Institute of Technical Physics and Materials Science** is interdisciplinary research on nanometer scale functional materials exploring their physical, chemical and biological properties, as well as the exploitation of these properties in the development of integrated nano/microsystems, sensors, and non-destructive characterisation techniques.

The main research topics of the Institute are: fundamental multidisciplinary research on new sensing principles; novel materials and nanostructures; innovative 3D microfabrication techniques; development, fabrication and functional validation of nano- and microsensors and integrated systems; development of non-destructive magnetic and optical (spectroscopic ellipsometry) material testing methods; investigation and modelling of structure evolution in thin films; growth and microstructure of semiconducting materials; methodology development for electron diffraction; electron structure and conduction properties of 2D materials; optical performance of bioinspired nanoarchitectures; statistical physical analysis of non-equilibrium systems; development and application of label-free optical biosensors.

The technology transfer and the technical support of SMEs are important tasks of the Institute, and also to engage with university education, where the research infrastructure of the Institute can be utilised for the graduate and postgraduate education (BSc, MSc, and PhD) within the scheme of an open access laboratory.

Topic: "**Nanostructures in semiconductors and ceramics**"

The talk will cover the following topics and results:

1) Graphene and other 2D materials

They have more than a decade experience in graphene research. Their focus of attention currently also includes other 2D materials, mainly from the family of transition metal dichalcogenides. Their expertise includes the synthesis, structural characterization down to the atomic scale (mainly based on scanning probe methods), as well as the nanofabrication of these atomically thin crystals. The Scanning Tunneling Microscopy Lithography method developed by them [Nature Nanotech. 3, 397 (2008)] is the most precise (top-down) nanofabrication method of graphene nanostructures, even today. With this method they were able to fully design the electronic and magnetic properties of graphene nanoribbons [Nature 514, 608 (2014)]. Graphene nanoribbons down to 2 nm width, and fully controlled crystallographic edge orientation can be fabricated, and their electronic properties in-situ investigated by tunneling spectroscopy measurements. The technique is suitable to fully engineer the electronic and magnetic properties of graphene nanostructures by controlling their structure with close to atomic precision.

Regarding the novel 2D materials, other than graphene, they have the expertise to fully resolve the atomic scale defect structure of various transition metal dichalcogenide single layers. This is of key importance for understanding their realistic device characteristics, strongly influenced by native defects, as well as for clarifying their air-degradation mechanism at the atomic scale. Furthermore, the fabrication of nanostructures from these novel 2D materials by STM lithography has also been demonstrated. MoS_2 nanoribbons down to about 10 nm width have been achieved.

They have also developed a nanoengineering method of 2D crystals based on Atomic Force Microscopy, which allows the fabrication of strain patterns and nanostructures on insulating substrates. Graphene nanoribbons down to 20 nm width and controlled crystallographic edge orientation can be fabricated and integrated into device configurations, enabling the fabrication and testing of proof-of-concept electronic devices. The AFM lithography is also suitable to define nanostructures of other 2D materials.

Related to 2D materials, the Institute also has expertise in exploring the applications of graphene as nanoscale filler material for improving the mechanical and electrical properties of ceramics composites. Particularly, very promising results have been achieved in reducing the friction coefficient and increasing the wear resistance of graphene reinforced ceramic matrix nanocomposites. This can be achieved by improving the exfoliation degree and dispersion of graphene nanoplatelets using their fully reversible surface modification.

2) Silicon Nitride Composites with Different Nanocarbon Additives

A world-wide interest on ceramic nanocomposites with novel structure and function can be observed. High level of synergism of mechanical, thermal and physical properties is foreseen.

One of the research groups elaborated firstly a processing method for composites with silicon nitride matrix and carbon reinforcing phase (carbon nanotube (CNT), multi-layered graphene (MLG)). They explored the use of a variety of CNT and MLG to impart electrical, thermal conductivity, good friction properties to silicon nitride matrices. A highly efficient attritor mill has also been used for proper dispersion of second phases in the matrix. The spark plasma sintered silicon nitride composites retained the mechanical robustness of the original system. Bending strength as high as 700 MPa was maintained and an electrical conductivity of 10S/m was achieved in the case of 3 wt% CNT addition. MLG addition decreased the friction coefficient of composites.

Recent basic research on the development of graphene containing ceramic composites has shown that it is possible to realize nanocomposites with remarkably increased wear resistance and fracture toughness.

The main objective of this research is to develop tribological systems on the basis of functionalised graphene and ceramic-graphene, ceramic - CNT nanocomposites and their qualification for technical applications e.g. for slide bearings and face seals in aqueous media.

3) GaN (and related materials) grown on SiC and graphene

SAFEMOST project will develop GaN MOSFET transistors grown on SiC by MOCVD. This project is supported by **V4-Japan project** and carried out in cooperation. The role of MFA is transmission electron microscopy and providing feedback on the structure of aluminium oxide thin layers deposited onto GaN transistor structures.

MFA researchers also managed to get high quality GaN grown on patterned graphene/SiC [Advanced Materials Interfaces, DOI: 10.1002/admi.201400230, Vol. 2, Iss. 2, January 21 2015 and Semicond. Sci. Technol. 30 (2015) 114001]. Moreover they started a cooperation supported by FLAG-ERA (GRIFONE project) in which the consortium is going to grow two dimensional AlN and ZnO on graphene/SiC templates.

4) 3D micro- and nanostructures for sensing

MEMS vectorial force sensor: 3D force sensors were developed for robotic applications. The proper design and packaging provides tactile information in the mN-N force range. The Si based sensors operate with piezoresistive transduction principle by measuring the mechanical stress induced signals of the symmetrically arranged four piezoresistors in the deforming membrane. The chip size can be less than 1 mm^2, special 3D fabrication steps have to be integrated into the standard CMOS technology line. The applied deep reactive etching has no practical limitation in membrane geometry and offers the formation of monolith force transfer rod protruding over the chip surface. Device optimization studies are in progress to determine the effect of the various static and dynamic mechanical load to the device as well as to enhance the force sensitivity of the device layout.

Piezoelectric semiconductor nanowire based devices: Free standing vertical crystalline nanowires (NWs) can be formed and integrated on a sensor chip surface. The semiconductor NWs can be electrically contacted individually and by applying a force, the piezoelectricity induced signals are detected between tensed and compressed sides of the nanowires upon bending. As it was found by finite element analysis a nearly constant positive/negative stress is built up in the outer/inner side of the NW upon bending it by a lateral loading force directing to its tip.

The semiconductor nanowires can act as biosensors as well. By functionalization of the NWs surface by properly developed receptor molecules, the changes in the I-V characteristics could be proportional to the concentration of the detected molecules. The corresponding nanofabrication technologies are also developed in order to reach the targeted structure morphology and electrical characteristics of the deposited NWs.

Dr. Juraj LAPIN, Centre for Applied Research of New Materials and Technology Transfer, Institute of Materials & Machine Mechanics Slovak Academy of Sciences

The mission of the **Centre for Applied Research** is to conduct excellent exploratory research focused on key areas of economic and social development of the Slovak Republic. In addition, the Centre has as its mission to conduct applied research which employs application-oriented methodologies. The research focuses on ultra-lightweight structural (metallic) materials, high temperature materials and materials for extreme environments (ceramic materials), composite materials, nanomaterials and materials for electrical engineering. The center focuses on appraisal of inventions and technologies in terms of their possible patenting as well as patenting of inventions, licensing of patented inventions and common marketing of the organizations of the SAS in foreign countries.

Topic: "Low cost TiAl-based precision cast turbocharger wheels for automotive industry"

Low cost precision cast turbocharger wheels were prepared by induction melting of TiAl-based alloy in oxide crucibles and gravity and centrifugal casting into ceramic moulds under argon atmosphere. Two types of melting crucibles were used: (i) pure Y_2O_3 crucibles and (ii) Al_2O_3+SiO_2 based crucibles with inner Y_2O_3 layer. The effect of several processing parameters such as type of melting crucible, ceramic mould temperature and interaction time of the melt with the crucible on surface quality, casting defects, porosity, contamination by oxygen and volume fraction of Y_2O_3 particles is evaluated. Depending on the processing parameters, the oxygen content was found to vary from 1270 to 3080 wtppm, volume fraction of Y_2O_3 particles was measured from 0.4 to 0.8 vol.% and porosity was found to be between 0.5 and 3.5 vol.%. Chemical composition, grain size, interlamellar spacing and volume fraction of coexisting phases are analysed in defined positions ranging from the tip of blades to central part of the wheel. Mechanical properties including Vickers microhardness, tensile properties, compression properties and creep are characterised using samples extracted from cast wheels and compared to those of the ingot material.