

Advanced High Temperature Materials for Core and Novel Energy Engineering

Report on EU-Eastern Partnership Countries
Experts Workshop

EUROPEAN COMMISSION

Directorate-General for Research and Innovation
Directorate G - Industrial Technologies
Unit G.3 - Materials

Contact: Achilleas STALIOS

*European Commission
Office CDMA 04/158
B-1049 Brussels*

*Tel. (32-2) 29-95303
Fax (32-2) 29-60550*

E-mail: Achilleas.Stalios@ec.europa.eu

Advanced High Temperature Materials for Core and Novel Energy Engineering

Report on
EU-Eastern Partnership
Countries Experts Workshop

25-26 November 2010
State Committee of Ukraine on Science,
Innovation and Informatization
16, T. Shevchenko Blvd, Kyiv, 01601, Ukraine.

Edited by

Dr. Achilleas Stalios
DG Research and Innovation



***EUROPE DIRECT is a service to help you find answers
to your questions about the European Union***

Freephone number (*):
00 800 6 7 8 9 10 11

(*) Certain mobile telephone operators do not allow access to 00 800 numbers
or these calls may be billed

LEGAL NOTICE:

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission.

More information on the European Union is available on the Internet (<http://europa.eu>).

Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2011

ISBN 978-92-79-19322-4

doi 10.2777/45129

© European Union, 2011

Reproduction is authorised provided the source is acknowledged.

Pictures © Shutterstock, 2011 (*unless otherwise specified*)

Printed in Belgium

PRINTED ON TOTALLY CHLORINE-FREE BLEACHED PAPER (TCF)

Contents

- 4** Introduction
- 5** Workshop Opening
- 6** Workshop Presentations
- 11** Round Table Discussion
- 14** Proposed Common Ground for Possible Future Cooperation
- 15** Conclusions

Annexes

- 16** Agenda of the Workshop
- 19** List of participants

1. Introduction

The workshop was convened as part of the dialogue being conducted between the European Commission and the Eastern Partnership, EaP, countries with a view to establishing more co-operation and collaboration in the fields of research and development. The specific focus of the workshop was set out in the title and the main objectives were to

- Share information between EU experts and EaP experts on the current state-of-the-art in materials research in selection of applications in the energy domain,
- Identify some common ground of research interest targeting stronger future research collaboration under EU Framework Programme research calls.

The workshop selected the following materials applications domains for the information sharing:

1. Solid oxide and molten carbonate fuel cells (SOFCs and MCFCs, respectively)
2. Turbine and power plants (exclude nuclear)
3. Boilers
4. Heat exchangers -refractory ceramics and others
5. Nuclear applications
6. Modelling

Experts from each of the domains from the EU and the EaP countries contributed extensively to the workshop.

The following report is a summary of this extensive presentation and exchange of information.



2. Workshop Opening

The workshop was co-chaired by Prof. Borys Grynyov, First Deputy Head of the State Committee on Science, Innovations and Informatization of Ukraine and Dr Achilleas Stalios, EC official from DG RTD-Directorate G –Unit G3 added value materials.

The workshop was opened by **Prof. Borys Grynyov**, welcoming the experts from the EU and the EaP countries, Prof. Grynyov pointed out that this was the first event of this type to be held between the groups and he expected it to contribute ideas that would lead to systemic solutions that would assist competitiveness. He stressed that concrete proposals were needed when the conclusions of the discussions were being prepared at the end of the workshop. He wished the participants well in their endeavour and requested constructive and dynamic work from all.

Dr. Achilleas Stalios, on behalf of the European Commission, welcomed the participants and repeated the call for focus in identifying the common ground for possible research between the groups in the important field of high temperature materials. He stressed that the aim of the ongoing process, of which this workshop was a key part, was to promote EU and Eastern Partnership Countries co-operation.

He explained that he would lead the summarisation at the end of the workshop and wished all a fruitful meeting.

Prof. Anatoliy Zagorodny, Principal Scientific Secretary of the National Academy of Sciences in Ukraine, also welcomed the participants and stressed that this meeting was important to the Ukrainian Scientific community and that they were looking forward to increasing co-operation with the EU. He also wished the participants well in their work.

3. Workshop Presentations:

The first domain presented was that of Fuel Cells. From the EU side **Prof. Constaninos Charitidis**, Director of Material Science and Engineering Section of the School of Chemical Engineering at National Technical University of Athens presented a review of the key issues facing material science in the development of Solid Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells (MCFC). His presentation outlined the existing type of fuel cells being developed, the range of applications for fuel cells, the necessity for developing fuel cells that can operate at elevated temperatures and the challenges in the field of materials to ensure the requisite levels of reliability and durability of high temperature fuel cells. He also indicated how the EU and the US were cooperating on this field.

The second presentation in this domain was made by **Prof. Valerii Skorokhod**, Director of the I.M. Frantsevych Inst. for Problems in Material Science, Ukraine. The presentation outlined the research activity at IPMS with Solid Oxide Fuel Cells, in particular work on the superior conductivity achieved for ceramic electrolyte films, influence of additives on cathode and anode conductivity, newly developed SOFC stack using combination of various technologies. The SOFC represents important energy-conversion system uniting ceramic and metallic components the best compositions of which are under development yet. Other areas covered in the presentation were:

- Development of ceramic flame tubes for coal-fired boiler burners in power stations aimed at development of high melting high strength ceramic flame tube for power plants operating in aggressive media at temperature of 1500 oC and higher. The combined burner/flame tube technical solution allows efficiency increasing for electricity generation. The materials science of high-temperature ceramics problem for this solution has been emphasized to be developed under international cooperation.
- Ultra-high temperature radiation-resistant boride-based ceramics for nuclear reactors and related applications.
- Prof. Skorokhod has also shown a wide-range of international collaboration activities of IPMS

The full presentation by Prof. Skorokhod is reproduced in Appendix 1.

The second domain covered was Turbine and Power Plants. From the EU side **Prof. Robert Vassen**, Head of Power Plant Materials Department Forschungszentrum, Jülich, Germany, outlined some future developments in fossil fuel power plants involving the use of membrane coatings for CO₂ capture and Thermal Barrier coatings for allowing higher efficiency from higher temperature operations. These developments have outstanding materials issues that need to be resolved.

The next presentation in this domain was made by **Prof. Tatiana Talako**, National Academy of Sciences of Belarus. In a wide ranging presentation that outlined the scope of research being conducted in Belarus Prof. Talako put forward information relating to the Turbine and Power Plant domain suggesting the following areas of interest:

- Composite Abradable sealings for steam and gas turbines. Compositions: Nichrome + 8...10% NB. Operating temperature up to 750 °C. Technology: Powder blending, high explosive pressing, sintering, machining
- Mechanochemically alloyed superalloys. Operating temperature up to 1200 °C. Technology: mechanochemical alloying, cold isostatic pressing, hot extruding, machining.
- Mechanochemically alloyed Nb-alumina superalloy. Operating temperature up to 1500 °C. Technology: as for i.2.
- Composite material SiC-nanocarbon. Operating temperature up to 1900 °C. Technology: making nanopowders, blending, synthesis at high pressure & temperature

Other aspects of Prof. Talako's presentation covered some of the other domains.

- Solar energy harvesting and conversion using open-cell foam solar receivers, a research area where her institute collaborated with an institute in Minsk.
- Multicomponent SHS powders for elevated and high temperature corrosion and corrosion-erosion protection of boilers.
- High-performance HVOF-coatings against corrosion-erosion in boilers.
- Porous metal supported multilayer composites for the hydrogen production and fuel cells:

- Multilayer ceramic membranes with the mixed ionic-electronic conductivity (MIEC)
- Intermediate temperature thin-film SOFCs

A presentation was then made by **Prof. Edwin Gevorkyan**, State Railway Academy of Ukraine and **Prof A. Kharatian**, State Engineering University, Yerevan. His presentation covered the development of new technology for creating ceramic blades using nano-powders of refractory compounds for advanced gas turbine engines. These developments are being undertaken at emergency conditions and involve hot pressing and plasma baking. In addition to gas turbine engine components for aircraft the materials are also good for cutting tools. Electrochemical processing is also being developed to control micro cracking.

At this point in the workshop **Prof. Anatolii Belous**, V.I. Vernadsky Inst. of General and Inorganic Chemistry, National Academy of Sciences, Ukraine made a presentation on Li-conducting perovskites and their potential applications. Lithium fast ion conductors are of great interest for their potential use as electrolyte of full solid-state batteries and in other electrochemical devices substituting conventional liquid phase lithium batteries. High lithium-ion conductivity, especially at room temperature, and chemical stability against reducing lithiated negative electrodes are two main requirements for a solid electrolyte in an all solid-state lithium battery. The presentation outlined the experiments carried out in Ukraine on development of solid electrolytes for thin film batteries based on $\text{La}_{2/3-x}\text{Li}_{3x}\text{TiO}_3$ - LIPON. These were aimed at providing both high conductivity of electrolyte and its chemical stability with the metallic lithium. The wide range of applications for stable thin film batteries was also listed. Novel solid-state lithium batteries represent advanced energy storage systems.

The third domain addressed was that of Boilers. From the EU side **Dr Jerzy Pasternak**, RAFAKO SA a large boiler making company in Poland, outlined the characteristics of the Polish Power Generation Sector and the operating parameters, efficiency and environmental impact of boilers. The presentation outlined the research programme for the development of suitable steels for the high temperature environments emerging. The presentation dealt extensively with the improvements needed for steels to meet the new conditions and also the weldability characteristics and mechanical properties of the new materials. Particular emphasis was laid on creep resistance. The priority of maintaining a role for coal as a fuel for power generation places stringent demands on materials used.

Reference has been made above to the elements of Prof. Talako's presentation that referred to this domain particularly in relation to corrosion and erosion resistance in boilers.

The fourth domain addressed was that of heat exchangers. For the EaP group **Prof. Sergii Ladokhin**, Head of Department, Physical and Technological Institute of Metals and Alloys, National Academy of Sciences Ukraine presented details of research into the following:

- Heat exchangers for sulphuric acid manufacturing
- Technology of making heat-exchange cooling plates for blast furnaces
- Heat-resistant, high temperature, thermo-stable corrosive resistant steels with nitride strengthening for heat and power engineering

The presentation also outlined the following area of activity appropriate to the nuclear applications domain:

- Electron beam technologies and equipment for zirconium tube billets casting for nuclear fuel pipes manufacture.

For the EU **Prof. Geoff Gibson**, School of Mechanical and Systems Engineering, University of Newcastle, UK, focused on high temperature ceramics and heat exchanger materials plus heat shields. The presentation outlined that ceramic matrix composites offered opportunities for improvements in the field but that little systematic study of these materials had been carried out to date. The opportunities lay with advanced composites, which could improve the range of shapes possible, produce lower cost high strength fibers and reduce the carbon footprint of existing processes. The presentation suggested that the following be included in the study:

- Low temperature hydrateable cementitious systems and others that can be processed by advanced composites technology.
- Polymer matrices with transformable components and additives

The presentation by **Prof. Giorgi Tavadze**, Director of Ferdinand Tavadze Institute of Metallurgy and Material Science, Georgia, outlined the research priorities of the Georgian institute, which focused on

- Complex reprocessing of the metal-containing ores, wastes of metallurgical production, obtaining and processing of metal materials – new methods and technologies.
- Obtaining, research and perspectives of application of functional and nano-crystalline materials, powders and coatings.

Applications in the area of turbine components were presented. The institute also developed high temperature ceramic and metal ceramic composite materials using its technology of self-propagating high-temperature synthesis combined with compaction. Radiation resistant materials using composite materials with variable porosity have also been developed.

The main developments concern energy conversion systems.

The fifth domain addressed was that of Nuclear Applications. For the EU **Prof. Philippe Billot**, Programme Manager, Nuclear Energy Directorate, CEA, France presented an outline of Materials R&D for nuclear applications. In dealing with the requirements for materials in future nuclear applications, the presentation focused on extended lifetime to 60 years, fast neutron damage in fuel and core materials high temperature and corrosion resistance.

For future sodium fast reactors, gas fast reactors and very high temperature reactors a long term research programme for developing appropriate materials is either under way or is needed. This will include new martensitic steels with improved creep resistance and new ceramics both for fuel and structural components. Finally multiscale modelling of mechanical behaviour bridging the gap between macroscopic mechanics and atomic scale physics will be needed.

For the EaP countries **Dr. Mykola Odeychuk**, Chief of Laboratory of Nuclear Materials & Export Controls, National Science Centre ‘Kharkiv Institute of Physics and Technology’, (NSC KIPT). National Academy of Sciences Ukraine, presented his institute’s work on high temperature materials for energy engineering. He outlined that the work of the institute centred on development of fuel and core components for high temperature gas reactors such as fuel elements, absorbing elements, control rods, reflector blocks and discharging tubes. The main difference in CVI methods of carbon-graphite material production in NSC KIPT from other technologies is the use as a binder of low-temperature pyrocarbon. The presentation described the process for producing multilayered fuel and absorbing elements using carbon and carbon-carbon composite matrix materials for protective barriers.

In addition to a range of technologies based on nuclear applications the presentation suggested that future applications might include technology of brake disks for automobiles and planes, thermal shields and auxiliary equipment and medical products from CCCM.

The final presentation was that of **Prof. Vladimir Berzan**, Director, Power Engineering Institute, Academy of Sciences Moldova. The presentation discussed the following topics:

- Mathematical modeling of dynamic behaviors of thin-wall constructions.

A mathematical model was proposed for calculation of unsymmetrical deformation of a construction with added masses and local weaknesses. This is particularly applicable to weakness of a thin shell created by an elliptical hole in thin film materials in nuclear applications.

- Superconducting MgB₂ films for technical applications,
- Electromagnetic processes in non-homogenous lines with superconducting compounds,
- Microwire resistive divider for high voltage measurement of alternating current of 6.3-35 kV.

4. Round Table Discussion

The Round Table discussion was chaired by **Dr. Achilleas Stalios and Prof. Andriy Ragulya**, Deputy Director of I.M. Frantsevych Institute of Problems in Material Science, National Academy of Sciences, Ukraine.

In endeavouring to define some common ground between the EU experience and the Eastern partnership countries it was suggested that the areas of high temperature materials for energy engineering be grouped into three strands:

- Ceramic composites & coatings
- Metals and alloys
- Fuel cells

It was further suggested that modelling was an area of mutual interest and should be included in any future co-operative activity. Prof. Ragulya put

forward a strong case for including solid oxide fuel cell technology as a topic of interest for many parties as there was already co-operation in the area between the EaP countries and the EU.

The field of Silicon Carbide - based composites was also an area of considerable interest to the EaP countries, particularly in nano-composites. Energy conversion high temperature facilities need numerous parts made from silicon carbide and related materials. This was an attractive area as there was nearly 40 years experience in the EaP countries to work with SiC-based ceramics.

The field of filters and membranes for high temperature energy applications was also put forward as being of interest to EaP researchers. New developments in nano-fibres and new developments of silicon carbide strengthened with diamond clusters for nuclear applications can be supported by experience and expertise in the EaP Scientific community. Prof. Ragulya stressed that co-operation with EU researchers would be very attractive to the researchers in the EaP countries.

Another area suggested was ionic conductors as they had a significant role to play in the future development of low- and high-temperature ionic batteries. Problems in the area had been studied since the 1960s but they offered a promising hybrid solution for vehicles and automotive applications representing large-scale segment of the market. A further application in super capacitors was outlined where a Ukrainian company is a world leader in development of supercaps. Ionic conductors based on intercalated graphite are currently working but solid state ionic conductors could be the way forward. This would have a considerable impact on the industrial programme keeping in mind powerful electrochemical institutions e.g. in Ukraine, Belarus, Germany, United Kingdom, Belgium and other countries working over these hybrid solutions.

There should be a substantial coincidence of interests in the area of high temperature materials for nuclear energy engineering taking into account powerful Kharkiv Institute of Physics and Technology and CEA in France. Finally, Prof. Ragulya mentioned an existing successful co-operation between UK, Georgia and other EU countries in the field of novel steels focused on the important problem of energy saving.

Prof. Skorokhod suggested that energy conservation based on the science of heating solid was an area of great interest and the understanding of the thermal and physical properties of materials was important to co-operate in. Thermal-insulating materials presented by Prof. Gibbson are of great perspectives in various applications. Natural and synthetic mineral materials

like basalts and composites on their base represent rapidly growing market, which needs new developments.

Prof. Berzan suggested the field of technology on superconducting materials, particularly based on boron would be an appropriate inclusion in any programme as there was already co-operation with institutes in Germany in the field. He was also interested in enlarging solid oxide fuel cells and the area of hydrogen capture and storage.

Upon request about how FP topics are defined, Dr. Stalios explained that the Commission drafts a proposal document and presents it to the programme committee, composed of representatives of the administrations of the Member States. The number and breadth of the various topics depend upon the budget available. The topics chosen insist on quality work, innovation and breakthrough research. Evaluation rules are defined and posted on the web.

Prof. Vassen recommended that any chosen topic should be specified on the basis of a problem to be solved. He gave as an example solving degradation. Alternatively the specification could focus on particular applications, such as, thin electrolytes or on material types, such, as ceramic high temperature materials.

Prof. Tavadze observed that it was easier to join a topic when it is specified and accepted that a concrete topic would be needed. He asked how the EaP countries could participate.

Dr. Stalios and Dr. Dzubinsky recalled that FP7 is open to the participation of researchers from EaP countries. In addition to that **Dr. Dzubinsky** gave a short presentation of the FP7 work programme participation rules.

Dr. Odeychuk put forward for consideration in drafting the common ground that radiation resistant materials, particularly of graphite should be included.

5. Proposed Common Ground for Possible Future Cooperation

Following the Round Table discussion it was concluded that there was common ground between the experts on both sides in terms of possible in co-operation research in the technological area of the present workshop. The fields to be addressed are Materials for Energy Conversion, Energy Transfer and Energy Storage.

The Materials of particular interest are:

- Metals and Alloys
- Non Metallic Materials (incl. Ceramics, Composites and mineral based materials such as graphite, basalt)

The Applications will be exclusively High Temperature applications and will include:

- Solid State Ionic Conductors
- Refractories
- Coatings and Joints
- Thermoelectricity
- Fuel Cells
- Fossil fuelled Power Plants
- Structural Materials for Nuclear Applications

Properties to be addressed can include:

- Radiation Resistance (Nuclear Applications)
- Reliability and Durability
- Ionic Conductivity
- Corrosion, Erosion Resistance
- Mechanical Properties

This list of the areas, which should guide the development of any topic, was reach following a further round of discussions between the experts of both groups.

Conclusions

In all the workshop was very successful and it was clear from the presentations by the EaP countries participants that there is a substantial and impressive reservoir of research skills, competence and experience available in those countries.

There is also a significant research infrastructure in terms of laboratories and facilities to support the skills. Research co-operation between the EU and EaP countries would be mutually beneficial.

AGENDA

Thursday, 25th of November, 2010

- 08:45 – 09:00** Registration
- 09:00 – 09:10** Welcoming addresses
- Prof. Borys GRYNIOV**, First Deputy Head, SCSII
Dr. Achilleas STALIOS,
Materials Unit, DG RTD, European Commission
- 09:10 – 09:25** Introducing the experts: *tour de table*
- 09:25 – 10:45** **EU - EaP countries experts' presentations**
- 9.25 – 9.40** Solid Oxide Fuel Cells
Prof. C. CHARITIDIS,
National Technical University of Athens, GR
- 9.45 – 10.00** Advanced High Temperature Ceramics and Solid Oxide Fuel Cells
Prof. V. SKOROKHOD,
Inst. Problems in Materials Science Kiev, UA
- 10.00 – 10.15** Turbine and Power plants
Prof. R. VASSEN, Forschungszentrum, Julich, DE
- 10.15 – 10.30** Advanced High Temperature Materials for Core and Novel
Energy Engineering
Prof. P. VITYAZ,
National Academy of Sciences of Belarus, Minsk, BY
- 10.30 – 10.45** Development of new technology of creating ceramic blades with
use of nano-powders of refractory compounds for original
diskless turbine of advanced gas- turbine engines
Prof. E. GEVORKYAN,
State Railway Academy of Ukraine, Kharkov, UA
- 10:45 – 11:00** **Coffee break**
- 11:00 – 12:30** **EU - EaP countries experts' presentations**
- 11.00 – 11.15** Li-conducting perovskites and their potential applications
Prof. A. BELOUS,
Institute of General and Inorganic Chemistry, Kiev, UA

- 11.15 – 11.30** Boilers
Dr. J. PASTERNAK, Rafako Boilers, PL
- 11.30 - 11.45** Advanced High Temperature Materials for Core and Novel Energy Engineering
Prof. V. BERZAN, Institute of Energy, Chisinau, MD
- 11.45 – 12.00** Materials and Technologies for Novel Heat Exchangers
Prof. S. LADOKHIN,
Physics-Technology Institute of Metals and Alloys, Kiev, UA
- 12.00 – 12.15** Heat exchangers - refractory ceramics
Prof. G. GIBSON, FIMMM, UK
- 12.15-12.30** Advanced High Temperature Materials for Core and Novel Energy Engineering
Prof. G. TAVADZE,
Institute of Metallurgy and Materials Science, Tbiliso, GE
- 12:30 – 14:00** **Free time**
- 14:00 – 15:00** **EU - EaP countries experts' presentations**
- 14.00 – 14.15** Nuclear Applications
Prof. P. BILLOT, CEA-FR
- 14.10 – 14.30** Advanced High Temperature Materials for Core and Novel Energy Engineering
Dr Mykola Odeychuk,
Kharkov Institute of Physics & Technology, Kharkov, UA
- 14:50 – 16:00** Round table discussions
Exploration of possible common interests
- 16.00 – 16.15** Break
- 16:15 – 17:30** Recommendations from the experts to the public authorities, concluding remarks
- 20:00** Fourchet

Friday, 26th of November, 2010

- 09:00 – 12:30** Summarising discussions

Annex 2

LIST OF PARTICIPANTS

| | | Name | Title / Position / Institution | Title of Presentation |
|----|--------------------------------|--------------------------------|---|---|
| 1. | ARMENIA | Prof. Edwin GEVORKYAN | State Railway Academy of Ukraine - Kharkiv, Ukraine Director of scientific and manufacturing company "Cermet-Ukraine" | Development of new technology of creating ceramic blades with use of nano-powders of refractory compounds for original diskless turbine of advanced gas-turbine engines |
| 2. | REPUBLIC OF AZERBAIJAN | Prof. Vagif FARZALIEV | Academician-Secretary of National Academy of Sciences | Republic of Azerbaijan |
| 3. | BELARUS | Prof. Peter VITIAZ' | Academician Vice-President of National Academy of Sciences | Advanced High Temperature Materials for Core and Novel Energy Engineering |
| 4. | BELARUS | Prof. Tatiana TALAKO | National Academy of Sciences | |
| 5. | FRANCE | Dr. Philippe BILLOT | Program Manager "R & D for the Generation II and III reactors" at the Nuclear Energy Directorate, CEA/Saclay, France | Outlines of materials R&D program for nuclear applications |
| 6. | GEORGIA | Prof. Giorgi F. TAVADZE | Corresponding Member of National Academy of Sciences; Director of Ferdinand Tavadze Institute of Metallurgy and Material Science | The IMM scientific developments for inclusion into the EC Seventh Framework Program |
| 7. | GEORGIA | Dr. Dementiy L. GABUNIA | Deputy Head of Scientific Council, Ferdinand Tavadze Institute of Metallurgy and Material Science | |
| 8. | GERMAN FEDERAL REPUBLIC | Prof. Robert VAßEN | Head of the Power Plant Materials Department, Forschungszentrum Jülich | Turbine and power plants - focus coatings |

| | | Name | Title / Position / Institution | Title of Presentation |
|-----|---|---|---|--|
| 9. | GREECE | Dr. Constantinos CHARITIDIS | Associate Professor, Dr Director of Material Science and Engineering Section, School of Chemical Engineering National Technical University of Athens (NTUA) | Solid Oxide Fuel Cells & Molten Carbonate Fuel Cells (SOFCs & MCFCs) |
| 10. | MOLDOVA | Prof. Vladimir BERZAN | Director of Power Engineering Institute, Academy of Sciences | Nuclear applications |
| 11. | POLAND | Dr. Jerzy PASTERNAK | Boiler Engineering Company "RAFAKO SA", Racibórz | Boilers |
| 12. | THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND | Prof. Arthur Geoffrey GIBSON | Fellow of the Institute of Materials, Minerals and Mining (FIMMM); School of Mechanical and Systems Engineering, University of Newcastle | High Temperature Ceramics and Heat Exchanger Materials |
| 13. | EUROPEAN COMMISSION | Dr. Achilleas D. STALIOS | EC Official, DG RTD, Directorate G - Industrial Technologies – Value Added Materials | |
| 14. | EUROPEAN COMMISSION | Dr. E. CAHILL | Rapporteur | |
| 15. | EUROPEAN COMMISSION | Dr. Mykola DŽUBINSKI | EC Official , DG RTD, Directorate K- Energy- Fission | FP7 work programme participation rules |
| 16. | UKRAINE | Prof. Borys GRYNIOV | Academician First Deputy Head of State Committee on Science, Innovations and Informatization | |
| 17. | UKRAINE | Dr. Marina GOROKHOVATSKAYA | Scientific Secretary, Division of Science Management, Presidium of National Academy of Sciences | |

| | | Name | Title / Position / Institution | Title of Presentation |
|-----|----------------|--|---|---|
| 18. | UKRAINE | Prof. Anatoliy G. ZAGORODNY | Academician Principal Scientific Secretary of National Academy of Sciences | |
| 19. | UKRAINE | Prof. Valeriy V. SKOROKHOD | Academician Director of I.M. Frantsevych Institute of Problems in Material Science, National Academy of Sciences | Advanced High Temperature Ceramics and Solid Oxide Fuel Cells |
| 20. | UKRAINE | Prof. Anatolii G. BELOUS | Academician V.I. Vernadsky Institute of General and Inorganic Chemistry, National Academy of Sciences | Li-conducting perovskites and their potential applications |
| 21. | UKRAINE | Prof. Volodymyr L. NAYDEK | Academician Director of Physical and Technological Institute of Metals and Alloys, National Academy of Sciences | |
| 22. | UKRAINE | Prof. Andriy RAGULYA | Deputy Director of I.M. Frantsevych Institute of Problems in Material Science, National Academy of Sciences | Moderator |
| 23. | UKRAINE | Dr. Anatoliy M. VERKHOVLYUK | Deputy Director of Physical and Technological Institute of Metals and Alloys, National Academy of Sciences | |
| 24. | UKRAINE | Dr. Mykola P. ODEYCHUK | Chief of Laboratory of Nuclear Materials & Export Controls, National Science Center 'Kharkiv Institute of Physics and Technology', National Academy of Sciences | High temperature materials for energy engineering |
| 25. | UKRAINE | Prof. Sergii V. LADOKHIN | Head of Department, Physical and Technological Institute of Metals and Alloys, National Academy of Sciences | Materials and Technologies for Novel Heat Exchangers |
| 26. | UKRAINE | Dr. Svyatoclav V. GNYLOSKURENKO | Head of Department, Physical and Technological Institute of Metals and Alloys, National Academy of Sciences | |

| | | Name | Title / Position / Institution | Title of Presentation |
|-----|----------------|---------------------------------|---|------------------------------|
| 27. | UKRAINE | Prof. Oleksandr VASYLIEV | Head of Department, I.M. Frantsevych Institute of Problems in Material Science, National Academy of Sciences | |
| 28. | UKRAINE | Dr. Borys V. BORTS | Head of Laboratory, National Science Center 'Kharkiv Institute of Physics and Technology', National Academy of Sciences | |
| 29. | UKRAINE | Ms. Olena KOVAL | Director of National Information Centre for Ukraine-Eu S&T Co-operation | |
| 30. | UKRAINE | Mr. Maksym VDOVYCHENKO | Adviser of First Vice-President of National Academy of Sciences | |
| 31. | UKRAINE | Mr. Dmytro KOZORIZ | Deputy Head of Department of International Co-operation, State Committee on Science, Innovations and Informatization | |
| 32. | UKRAINE | Ms. Maria BURTSEVA | Chief Expert, Department of International Co-operation, State Committee on Science, Innovations and Informatization | |

European Commission

**Advanced High Temperature Materials for Core and Novel Energy Engineering - Report
on EU-Eastern Partnership Countries Experts Workshop**

Luxembourg: Publications Office of the European Union

2011 — 28 pp. — 17,6 x 25,0 cm

ISBN 978-92-79-19322-4

doi 10.2777/45129

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- via EU Bookshop (<http://bookshop.europa.eu>);
- at the European Union's representations or delegations. You can obtain their contact details on the Internet (<http://ec.europa.eu>) or by sending a fax to +352 2929-42758.

Priced publications:

- via EU Bookshop (<http://bookshop.europa.eu>).

Priced subscriptions (e.g. annual series of the Official Journal of the European Union and reports of cases before the Court of Justice of the European Union):

- via one of the sales agents of the Publications Office of the European Union (http://publications.europa.eu/others/agents/index_en.htm).

The workshop was convened as part of the dialogue being conducted between the European Commission (DG Research - Industrial Technologies Directorate - Materials Unit with the assistance of Energy Directorate - Fission Unit) and the Eastern Partnership, EaP, countries with a view to establishing more co-operation and collaboration in the fields of research and development. The workshop gathered 15 distinguished experts from EU member states and EaP countries. The specific focus was on advanced high temperature materials for core and novel energy engineering. The main objectives were to share information between EU and EaP experts on the current state-of-the-art in materials research and applications in the energy domain and identify some common ground of research interest targeting stronger future research co-operation. The workshop selected, solid oxide and molten carbonate fuel cells (SOFCs and MCFCs, respectively), turbine and power plants (exclude nuclear), boilers, heat exchangers -refractory ceramics and others, nuclear applications and modelling as materials applications domains for the information sharing.

The common ground was identified to be in the fields of materials for energy conversion, energy transfer and energy storage. Materials of mutual interest, their applications and properties to be addressed were commonly agreed and accepted.

