

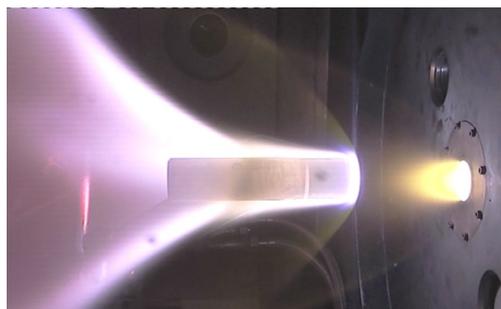
# Material Systems for Extreme Environments, XMat

## XMat Newsletter – July 2013

The first newsletter updating the ceramics community on news and progress of an EPSRC programme grant on Ceramics and Ceramic Composites

### EPSRC GRANT OF £4.2M

The development of next-generation ceramic materials is vital for enabling the operation of machinery in extreme conditions, such as severe chemical and radioactive environments. An EPSRC research project (£4.2M) was launched in February 2013 to meet this challenge. Led by Loughborough University, and working with Imperial College London and Queen Mary University, the project will use, as its foundation, cutting edge, composite based materials developed at these institutions for hypersonic vehicle applications.



The three research groups will work together initially to develop and characterise MAX phase and other selective, ultra high temperature ceramic (UHTC) materials using techniques such as FIB, TEM, mechanical and thermal testing. The research also integrates hierarchical and predictive modelling capability for simulating experiments that are extremely difficult and expensive.

### Developing dense fibre composites

Professor Jon Binner (Dean of the School of Aeronautical, Automotive, Chemical and Materials Engineering at Loughborough University (LU)) is the project's principal investigator. Anish Paul, worked with Jon as a postdoc in a DSTL project developing UHTCs and will be applying his skills and experience, to the development of dense fibre reinforced, UHTC based composites using a microwave assisted chemical vapour infiltration (CVI) technique. He then plans to conduct oxidation studies on the developed materials.



### MAX phase materials

Professor Bill Lee, Director of the Centre for Nuclear Engineering in the Department of Materials at Imperial College London (ICL) will lead the materials processing and characterisation research. Doni Daniel, who has been working with Bill in developing materials for thermal protection systems for hypersonic applications will now develop MAX phase materials such as Zr-Al-C, Hf-Al-C and other ternary carbides such as Hf-Ta-C. In collaboration with the project's other research groups, he will use a range of sintering techniques to optimise the mechanical and thermal properties of the developed materials.



### Novelty in Spark Plasma Sintering

The research team based at Queen Mary University London (QMUL) is led by Prof Mike Reece, Head of the functional nanomaterials group (School of Engineering and Materials Science). His post doc Salvatore Grasso, who has extensive experience of spark plasma sintering (SPS), will now work on extending the current SPS sintering facility's capacity to 100 MPa at 2000°C using carbon dies and to 300 MPa at 1600°C using SiC dies. He will also study electromagnetic field assisted densification, investigating the fields' contribution to spark plasma sintering and comparing the sintering behaviour of SPS materials with those made by, variously, vacuum hot pressing at ICL and flash sintering (electric field up to 1kV/cm) at LU.



## Developing model system

The materials developed will be used as input to the models developed by theory and modelling group by another research team at ICL. Professor Mike Finnis (Chair in Theory and Simulation of Materials) will be leading the theory and simulation activities at Imperial College. Joining him soon as a postdoc will be Andrew Duff, who did his PhD in Bristol and comes to us in August from the Max-Planck-Institut für Eisenforschung in Düsseldorf, where he worked on developing interatomic potentials, density functional calculations, and models involving carbon, including ferrite. Theresa Davey, who obviously has a taste for extreme conditions (she is currently completing a masters in Shock Physics), will join us to start a PhD in October. Andrew will be concentrating on the atomistic calculation of the high temperature properties of defects in carbides and borides, while Theresa will work on the implementation of this information in the calculation of phase stability.



## New appointees....

Amutha Devaraj joined XMat as the Technical Manager in the Department of Materials at ICL in April 2013. She is involved in administrative, financial and managing the project progress. Prior to this she worked as a Team Leader (Quality and Materials) at Novacem, a carbon negative sustainable material development company. She also has experience working on the development of wide range of materials including ceramics, glass and polymer for industrial applications. Since April 1<sup>st</sup> 2013, Christina Kokoroscou has taken on the role of Research Administrator for the XMat programme in LU. She has an extensive administrative work experience at the LU students' union and the research student office and was the only UK RA on an EU Framework 6 project involving eight European partners; she managed all aspects of the UK side of the research and administration.

## Elastic modulus measures up to 1750°C

All material processing equipment (hot press, SPS) for this project is already available to use at ICL and QMUL. An ultrasonic modulus unit has just been purchased in this project and is now installed at ICL. This Resonance Frequency and Damping Analyser (RFDA) uses the natural elastic vibration of materials to determine their stiffness (Young's Modulus), Shear Modulus and Poisson's ratio. Inert gas atmospheres are possible and the maximum temperature of operation is 1750°C. A microwave-heated Chemical Vapour Infiltration (m-CVI) system is being purchased and will be installed soon at LU.



## Meetings

- XMat Launch Meeting was held 14<sup>th</sup> March at Imperial College London
- First Steering Committee Meeting was held 18<sup>th</sup> June at Queen Mary University London
- First annual meeting will be held on 17-18 October 2013 at Imperial College London

## Mike at Schloss Ringberg

Prof Mike Finnis participated in the Unary Workshop at Schloss Ringberg, 24-29 March 2013, one of a CALPHAD series, organised this time by Tilman Hickel (MPI Düsseldorf) and Suzana Fries (ICAMS, Bochum). The output of this will be a volume of papers, partially of a review nature, and MWF is co-author of the one entitled Perspectives on Point Defect Thermodynamics.

## Bill and Doni at AFRL

Prof Bill Lee and Dr Doni Daniel visited the US Air Force Research Lab (AFRL), Dayton, Ohio 6-7 June 2013 and gave presentations on "UHTC research at Imperial College" and "Development of multilayered UHTC composites", respectively.

## Contacts

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