# CAFMaD

Centre for Advanced Functional Materials and Devices

Partneriaeth Ymchwil a Menter
Research and Enterprise Partnership

Prifysgol Aberystwyth a Phrifysgol Bangor
Aberystwyth University and Bangor University

# Newsletter Autumn '09

## CAFMaD

The £2.9M Centre for Advanced Functional Materials and Devices (CAFMaD) is part of the Aberystwyth University and Bangor University Research & Enterprise Partnership. The Partnership was awarded HEFCW funding of £10.9M from 2007 to 2011 to provide research and entrepreneurship support and to create four internationally recognised research Centres. CAFMaD is one of these centres, bringing together leading academics from the Institute of Mathematics and Physics (IMAPS) and the Welsh Visualisation Centre at Aberystwyth, and the College of Physical and Applied Sciences at Bangor, which includes the School of Chemistry, the School of Electronic Engineering and the School of Computer Science.

CAFMaD's Vision is to be an international centre of excellence for the development, characterisation and application of advanced materials and devices, and its Mission is to be an international centre of research excellence based on pure science and capable of delivering sustainable economic growth in Wales, the UK and beyond.

CAFMaD's strengths are in materials, sensors, mathematics, space physics, synthesis and catalysis, molecular modelling, visualisation, image recognition, characterisation, photovoltaics, biological chemistry, optoelectronics and high performance computing. Aberystwyth leads in glasses and ceramics, semiconductor surfaces and interfaces, advanced characterisation techniques and stereo reconstruction and modelling of solids and surfaces. Bangor leads developments in optoelectronics and solar cell technology, materials synthesis and catalysis, polymer processing, polymer electronics, micro-nano-fabrication and molecular modelling.

The executive group that manages the Centre is Chaired by Gary Reed, Head of the Partnership Office and includes the Co-Directors, Professor Neville Greaves and Professor Geoff Ashwel. This group meets every two months, and a management group consisting of all CAFMaD members meets every six months. The External Advisory Board (EAB) is drawn from leading Physics, Chemistry and Engineering Institutes across the UK, with representation from the Welsh Assembly Government and industry. Its Chair is Professor Mike Scott from IQE Plc.


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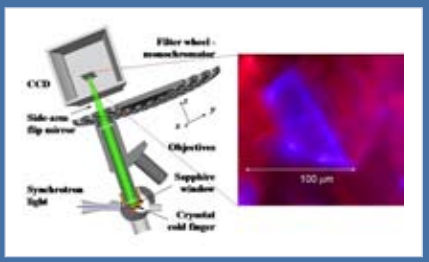
## In this Newsletter...







# CAFMaD at ICMAT Singapore conference & the British Council

14 CAFMaD delegates attended the biennial ICMAT conference in Singapore. The delegates were Dr. Edwin Flikkema, Prof. Neville Greaves , Dr. David Langstaff, Mr. Owain Roberts and Mr. Gruffudd Williams from Aberystwyth, and Prof. Geoff Ashwell, Miss Susan Barnes, Dr. Gregory Chasse, Dr. Mohammed Mabrook, Dr. Benjamin Robinson, Prof. Martin Taylor, Dr. Barbara Urasinska-Wojcik, Mr. Colin Watson, and Mr. Aled Williams from Bangor. The delegates delivered oral contributions and presented posters.

Partly overlapping with the conference the British Council International Young Scientist Conference (INYS) meeting on Advanced Materials and Devices also took place in Singapore, organised by young CAFMaD scientists from Aberystwyth and Bangor Universities, and the National University Singapore, Nanyang Technological University, and the Singapore Synchrotron Light Source. The organizers were Dr Krzysztof and Dr Agnieszka Banas, Dr Gregory Chasse, Dr Chen Wei, Dr Andrew Grimsdale, Dr Florian Kargl, and Dr Justin Lawrence, supported by senior organisers Prof Neville Greaves and Prof Herbert Moser. The British Council and CAFMaD sponsored the meeting, supporting the attendance of 15 UK scientists.

The meeting attracted 50 scientists from the organizing universities and research centres and was hosted by ICMAT on Thursday (poster session) and Friday (oral sessions), and subsequently by NUS (oral sessions and joint project planning). INYS delegates attended the ICMAT banquet on Thursday. INYS poster prizes were presented by the President of NUS, Prof TAN Chorh Chuan.

The programme focused on five main areas, of which four aligned well with CAFMaD research strands, and also led to an invitation from Professor Chowdari, Chair of the ICMAT series, to organize a Young Scientists symposium during the next conference, to be held in 2011.

The main aim of the INYS meeting was to facilitate the planning of collaboration between young scientists. This led to the identification of four possible projects between Singapore and CAFMaD, which might develop into longer term projects with possibilities for exchange of graduate students and postdoctoral researchers.

Whilst attending the conferences a CAFMaD delegation visited the fabrication facility of MBE Technology Pte Ltd to see if the characterisation techniques being developed at Aberystwyth and Bangor universities could be applied to improve production.


A group of INYS delegates at the Singapore Synchrotron Light source.

CAFMaD delegation visiting MBE Technologies Pte Ltd.

# The white heat of science helps unlock the secrets of liquids

Finely detailed and advanced work into the behaviour of liquids, undertaken by an international team of researchers, led by the University of Aberystwyth working alongside scientists at the Science and Technology Facilities Council's (STFC) Daresbury Laboratory in Warrington, Cheshire, is likely to have a wide-ranging impact in a variety of fields and could affect the lives of millions of people.

The findings of the team will help in developing a new understanding of the physics and chemistry of both liquid and solid states under conditions of variable temperature and pressure.

Using a special laser heated furnace at temperatures approaching the surface of the sun, the team of scientists from the UK, US and France melted aluminium and yttrium oxides to form drops that were floated on a stream of gas. When intense X-rays were fired at these shimmering spheres, the scattered radiation revealed the liquids separating and then reforming as the temperature dropped below the melting point. The X-rays enabled the team to measure the different states of the same liquid at the

atomic level and the different capacities of each to hold heat.

The research techniques carried out by the team enabled the distances between atoms and between groups of atoms on the nanoscale to be measured as the temperature was varied. The experiments also recorded the density and internal heat at ultra high temperatures, and for the first time, instantaneous changes in structure and density could be seen in the liquid state.

Team leader, Professor Neville Greaves of Aberystwyth University said: "What we have discovered at these colossal temperatures will have profound implications for understanding liquids in general. Most of our body mass is water and it is likely that dissolved enzymes and proteins adopt different water states depending on their operation."

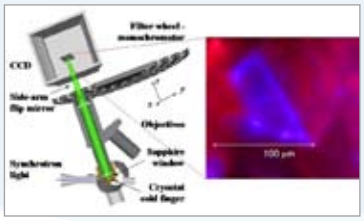
Tracey Turner of STFC said: "These are significant findings that could have applications in many fields, including the development of new high performance materials and the significantly improved fabrication of YAG laser hosts, essential in the fields of ophthalmology, dentistry, cosmetic surgery and manufacturing."

The team is now moving on to look at other liquids where liquid unmixing has been speculated, for instance in liquid metals, in water and in solutions.

# New luminescence imaging and spectroscopy facilities for optoelectronic materials at Aberystwyth

Studying the luminescence emission properties of materials can be richly rewarding in terms of understanding the processes that give rise to light emission, providing a wealth of information concerning the presence and nature of defects that may be present within the material matrix.

Dr Nigel Poolton of the STFC Daresbury Laboratory has pioneered characterisation techniques for optoelectronics materials through optical detection and x-ray irradiation.



Professor Andy Evans and Dr Dave Langstaff at the Institute of Mathematics and Physics at Aberystwyth University are now applying these techniques to light-emitting organic thin films – polymers and small molecules fabricated at Aberystwyth and Bangor - and to wide-gap inorganic semiconductors.

As part of a £350k investment in this work, two spectrometers have been installed in a new imaging and microscopy suite at the CAFMaD Materials Characterisation Laboratory at Aberystwyth, together with a new facility in optically-detected electron spin resonance.

Additional EPSRC funding of over £500k in collaboration with the universities of Manchester and Delft has financed a new spin resonance spectrometer and the upgrading of one of the existing luminescence imaging spectrometers (CLASSIX) to provide portable user facilities for UK researchers keen to exploit their unique x-ray optical luminescence imaging facilities.

# Pen Profiles

Dr Hongyun Tai

Dr Tai's scientific background is extensive and she has accumulated substantial research and industrial experience and expertise. Her research interests currently focus on the development and applications of functional biomaterials for tissue engineering and drug delivery, particularly on the design, synthesis characterizations and in-vitro evaluations of novel synthetic biomacromolecules.

The ultimate goal of her research is to develop injectable scaffolds for tissue repair and wound healing. One of the challenging issues for the development of injectable scaffolds is to find suitable materials which can solidify in-situ to form 3-D scaffolds.

Having gained degrees at Shanghai Jiao Tong University in China, Dr Tai was awarded a Doctor of Philosophy at the University of Nottingham in 2005, and now works as a Lecturer in Chemistry/Life Science Interface and EPSRC Life Science Interface Postdoctoral Research Fellow at the School of Chemistry at Bangor University.

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Dr Mohammed Mabrook

Dr Mabrook, who has over ten years experience in microelectronic engineering, gained degrees from Basra University in Iraq and Bradford University and was awarded a PhD from Sheffield Hallam University in 2000 for work on the fabrication and characterization of porous silicon.

Before joining Bangor University as a lecturer in 2009 he was Senior Research Associate at the Durham Centre for Molecular and Nanoscale Electronics.

His current research interests include work on organic memory devices, inkjet printing of organic materials, chemical sensors, food quality sensors, semiconductor thin film device fabrication and characterisation and nanotechnology.

Dr Mabrook has co-authored over 35 papers and presented his work in more than 15 international conferences and meetings. He submitted two British patents on food quality control and gas sensors using inkjet printing technology, and was awarded the Durham and Darlington Justice Award 2008 for his voluntary work with the criminal justice board as independent advisor.

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# Ground-breaking science helped by an old photographic trick

While the work done by CAFMaD scientists is at the cutting edge of their disciplines, using the latest technologies and equipment and pushing boundaries in their fields, one project at the Institute of Mathematical and Physical Sciences at Aberystwyth University led by Tudor Jenkins and Matthew Gunn is looking way back into the past for help with their project on imaging ellipsometry.

Ellipsometry is a powerful technique and is used principally to determine the optical properties and thickness of thin films on surfaces, such as oxide films on silicon. It has sensitivity down to submonolayer coverage on a surface, and it works by determining the change in polarisation state of light reflected from the surface of the system being investigated.

In conventional systems, the optical properties averaged over the area of the light beam are measured, but, by introducing a CCD camera into the detection arm, ellipsometry can be used in an imaging mode. However, the method calls for high angles of incidence (typically around 75° for silicon dioxide on silicon) and therefore the images obtained suffer from poor focus and perspective-induced distortion. This can be overcome by scanning through the focus and compiling a composite image from the in focus strips of many sub images. However, this introduces unwanted mechanical movements during the measurements and makes the data collection slow and inefficient.

The Aberystwyth scientists have come up with an alternative and more efficient method of correcting the focus and distortion. By applying a one hundred year old photographic trick known as Scheimpflug's principle with suitable constraints, images can be rendered in focus and almost free of distortion. This has the potential for the development of a new generation of high resolution, real-time imaging ellipsometers which would be ideally suited to optical readout of biosensors, for example. The potential increase in speed in these instruments compared with their predecessors would make them ideal for studying reaction kinetics as well as for mass screening of biological interactions, and a patent application is pending for this technique.

It's worth noting that while scientists are always seeking new frontiers and methods in their work, this project shows that it's also valuable to remember lessons learnt in the past.