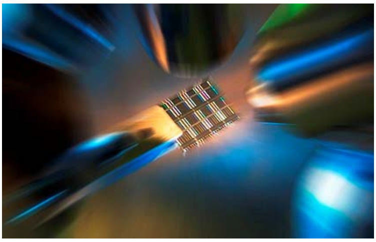
IOP Institute of Physics
Materials and Characterisation Group

NEWSLETTER 18 December 2011

Q What has HMS Warrior to do with the group
A See page 13

Inside This Issue



UKSAF Meeting
11 January 2012
details on page 11

About the Group

The Materials and Characterisation Group is one of 51 groups at the Institute of Physics. We are interested in the properties and application of materials, old and new, the manufacture, modification, acquisition and extraction of materials and all types of materials characterisation including physical, electrical, optical and elemental. We aim to provide coverage of the many materials and techniques of importance to the physics community and to reflect areas of growing interest and importance. Thus our aim is "to foster activities in the fields of materials and materials characterisation within the IOP". The focus of the articles in this newsletter is Materials for Energy.

We are keen to encourage new group members and participation of existing ones so please let us know if you have any feedback, suggestions for events, ideas, articles or news items of interest which we can include in future annual newsletters or on the web site. *Ed.*

Chairman's report

By David McPhail (d.mcphail@imperial.ac.uk)

This has been a very active period for the Materials and Characterisation group. Our committee has secured the participation of a number of enthusiastic new members and so the average age of the committee has gone down whilst the female:male ratio has gone up. We have organized, or co-organized, many workshops and conferences, with several more planned for next year. Currently we have 517 members who come from many walks of life, including industry and academia. We are an international group and many of our members are overseas.

Our activities include: arranging conferences, seminars and workshops for our members and others; promoting interaction between physicists working in industry and research, providing opportunities for networking; producing regular newsletters to keep their members in touch with the latest developments in their field; providing information on relevant meetings organized by other bodies; awarding bursaries to help research students attend conferences via the Research Student Conference Fund; awarding prizes in our area.

We ran three "flagship" events last year. "Perspectives in Materials and Technologies for Photovoltaics" (30th June 2011) was a highly successful one day meeting run at the Manchester Conference Centre and organized by Drs Hamid Kheyrandish and Dr Hari Reehal; this meeting attracted 73 delegates. On a rather different vein a fascinating meeting entitled "Cultural Heritage Meets Science, was held at the Mary Rose Trust Museum on 14th September 2011; this was organized by Dr Richard Morris and Dr Alison Crossley and was conducted under the watchful eye of King Henry VIII (or at least a life size replica thereof) so we were all on our very best behavior. Richard proved to be a very successful and assertive chairperson and kept all the speakers to time in a very charming and diplomatic way. Finally one of our new committee members, Dr Annela Seddon, ran an excellent conference for "Recent Appointees in Materials Science (RAMS)" at Bristol University (14th-16th September 2011). All these events were supported by the Conference Office at the IOP and we express our gratitude to them. Next year's highlight include Novel Methods for the Detection of Nuclear and Radioactive Materials on Thursday, 9th February 2012, Advanced Characterisation Techniques for Aerospace Materials on Tuesday, 27th March 2012, Ultrasound Standing Waves - manipulating cells, particles and fluids with sound Monday on 2 July – Friday, 6 July 2012, 8th Photovoltaic Science Application and Technology (PVSAT-8), Monday, 2 April – Wednesday, 4 April 2012.

A listing of all our workshops and conferences, past, present and future may be found at: *http://www.iop.org/activity/groups/subject/mc/calendar/index.html*.

In general the success of the group depends on the energy and enthusiasm of all its members. The Institute is, I know, particularly keen to engage with its overseas members, so we would love to hear from those of you some distance from Portland Place!

My take home message to you, as we approach the New Year is that here is always room for more activity so please don't be backward in coming forward with your ideas for events; you will be pushing at an open door as far as this committee is concerned. The Materials and Characterisation Committee wishes all its members a very successful 2012.

News in Brief

The University of Warwick opened the doors to its new Materials and Analytical Sciences (MAS) building in October 2011, although the official launch is planned for sometime in 2012. This £24M collaboration between the departments of Physics and Chemistry is intended to provide a world class building to house state of the art instrumentation and stimulate world leading analytical science research.

Even the building incorporates a significant amount of modern engineering and science, being designed with energy conservation, efficiency and sustainability as its major driving factors. For example, glass panels are exploited as end walls of laboratories which lead out into the research student write-up areas allowing natural daylight to be used as much as possible. Energy consumption is designed to be as low as is practical, with modern design techniques being employed to minimise heat losses and gains, both through the construction of the building (i.e. its concrete mass) and the mechanical air ventilation and fume extraction /cooling system methodology. The construction and performance detail will be submitted to achieve a BREAM excellent rating.

Inside, the MAS building is designed to provide the required space and environment for four key research areas, namely: Microscopy - Electron, AFM and Optical. Synthetic Chemistry. Mass Spectrometry. X-Ray.

Also located throughout the building are more general laboratories for Physics and Chemistry research along with designated write-up spaces for postgraduate students, academic offices, meeting rooms, and breakout areas.

Spot the Mistake

and find out what amused our chairman when he attended SIMS XVIII

Surfaces and Interfaces of Thin Film Functional Materials for Energy, *A Characterisation Challenge*

By S.J. Skinner, M. Burriel, S. Cook, P.K. Petrov, B. Zou, N.McN. Alford,

Department of Materials, Imperial College London, Prince Consort Road, London SW7 2AZ, UK

Recent interest in the area of thin film functional materials for a variety of energy technologies, from multiferroics through to fast ion conductors, has prompted the development of advanced characterisation techniques to address the challenges of determining interface behaviour on the nanoscale. At Imperial College London we have a complementary suite of advanced characterisation techniques to enable unique insights into surfaces and interfaces to be obtained from the most challenging samples. Key to our approach is the interface of microscopy, spectroscopy and ion scattering, highlighted by the recent commissioning of our low energy ion scattering (LEIS) system, which complements our existing nanoanalytical FEGTEM microscope.

LEIS offers the opportunity to analyse the outermost atomic layers of materials: from single crystals to thin films and even polycrystalline powders. Distribution of the atomic species is obtained through interpretation of elastic collisions of noble metal ions on the surface of interest. This provides a powerful technique to probe both surfaces and interfaces and is of particular value in the development and understanding of surface termination of thin films. Through the unique preparation chamber, our instrument enables direct analysis of gas/solid interactions, of value in interpreting catalytic and surface exchange processes. Combined with the secondary ion mass spectrometry (SIMS) platform, a powerful technique to probe interactions at both surfaces and in the bulk is available. Initial measurements using this technique have provided detailed surface termination information from perovskite related materials, as shown in Figure 1a, whilst the power of the SIMS technique is highlighted in Fig 1b where the distribution of Zr, Ti and O at the interface of a YSZ/STO thin film is presented.

As an example of the power of advanced microscopy in characterizing thin film heterostructures, we show epitaxial (001) oriented $Ba_xSr_{1-x}TiO_3$ (BSTO) films produced by pulsed laser deposition. The desired stoichiometry of the BSTO sample was achieved by altering the thicknesses of the BTO and STO layers in the bi-layer structure. Figure 2 shows a typical STEM image of the $Ba_{0.75}Sr_{0.25}TiO_3$ thin film, clearly demonstrating that a well-defined superlattice structure has been grown, with alternating ~4 nm and ~1 nm thick layers, respectively. In the HAADF image the thicker layers exhibit brighter contrast that the thinner layers which implies that the former are the BTO layers and the latter are the STO layers, which is consistent with the targeted stoichiometry. The alternating composition was further confirmed by EDX analysis along the line indicated by an arrow in Figure 2 showing that the minima of the Ba profile corresponds to the maxima of Sr profile extracted from the EDX spectra.

Full details of the Materials Characterisation Facilities available in the Department of Materials at Imperial College London can be obtained from Dr Stephen Skinner, s.skinner@imperal.ac.uk

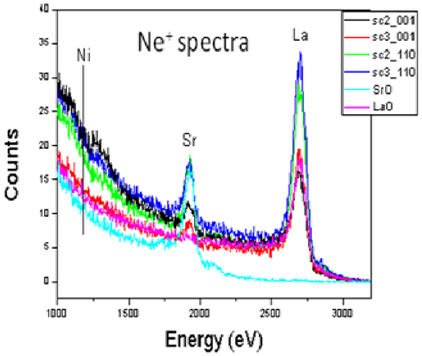


Figure 1a – LEIS data obtained from a sample of La2-xSrxNiO4, highlighting the surface termination as La-O and Sr-O dominated. Further data processing will produce the La:Sr ratio.

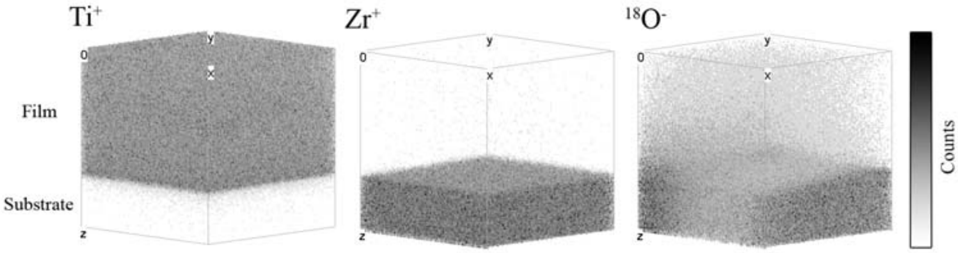


Figure 1b – 3D reconstruction of the interface of a YSZ/STO thin film sample, isotopically labeled with $^{18}O_2$. Overall thickness is approx. 120nm. Analysis area is 100 m^2

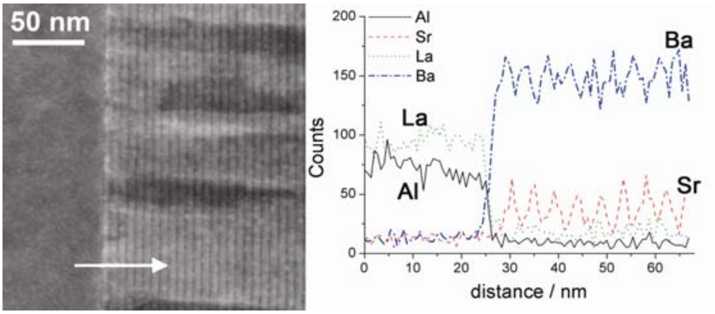


Fig. 2. STEM-HAADF image of the STO/BTO multi-layer structure showing the $LaAlO_3$ substrate and BTO/STO multilayers. Contrast is due to the atomic number difference between Ba and Sr with Ba layers appearing brighter. EDX line profile position is shown as an arrow on the image.

Next generation solar cells for enhanced performance

By *IM Dharmadasa, Materials and Engineering Research Institute, Faculty of Arts Computing Engineering and Sciences, Sheffield Hallam University, Sheffield S1 1WB, UK.*

Most of the solar cells used for direct conversion of photons into electricity (photovoltaic conversion) utilise well known p-n, p-i-n or hetero-junctions. These devices have limiting capabilities for harvesting major parts of the photons available, due to the presence of just one or two materials with specific energy bandgaps.

In order to absorb UV, Visible and IR radiation, all within one device, a graded bandgap multi-layer structure has been designed and shown in Figure 1(a) [1,2]. The main features of this design include the use of a wide bandgap p-type semiconductor as the window material, gradual reduction of the energy bandgap and gradual conversion from p-type to n-type electrical conduction from the front to the back of the device. The smallest bandgap material limits the value of V_{oc} achievable and therefore it is sensible to keep this value at about 1.43 eV (bandgap of GaAs). The large bandgap in the front of the solar cell helps in creating a steep slope (strong internal electric field) in the solar cell structure in order to effectively separate photo-generated charge carriers. The low-resistive ohmic contacts to p-type semiconductor in the front and the n-type semiconductor at the back provide effective collection of charge carriers and allow efficient passage through an external load creating useful DC power. Furthermore, in order to spread the depletion region throughout the device width, the doping concentration of the end materials should be as low as ~10^{15} cm^{-3}[3]. Then the whole device becomes PV active with a steep slope or a strong internal electric field present through out the width of the device.

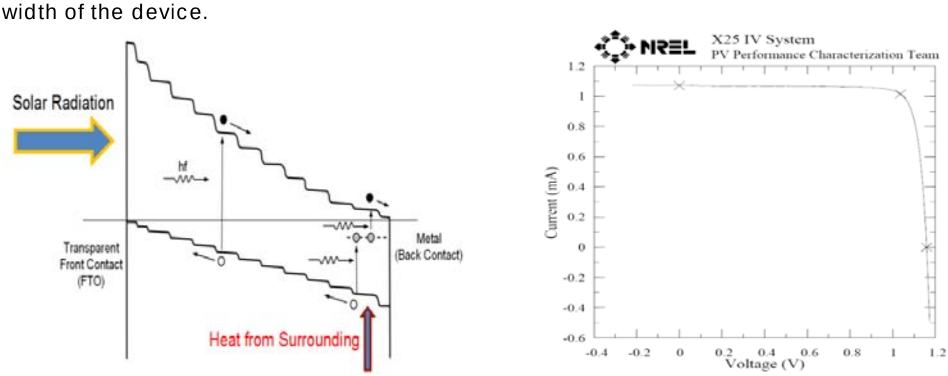


Figure 1. (a) Energy band diagram of the graded bandgap multi-layer solar cell and (b) the current-voltage characteristics of this device fabricated with GaAs/$Al_xGa_{(1-x)}As$

The new design has been experimentally tested with well researched GaAs/$Al_xGa_{(1-x)}As$ materials grown by MOVPE method. This well established growth method and the material system are used mainly to test the validity of this design and the physics behind the new device structure. The advantages of this structure was shown by the first experimental test [2,4]. The parameters observed for the first fabrication (see Figure 1b) were:

V_{oc} ~ 1175 mV, J_{sc} ~ (11 - 12) $mAcm^{-2}$, FF ~ (0.82 - 0.87) and η = (10-12)%

The observation of highest reported V_{oc}~1175 mV for a single device with maximum possible Fill Factor (FF) values in mid 80%, shows the high potential of this new device structure. Although two parameters, V_{oc} and FF reached their highest values, the J_{sc} was comparatively low for this material system. SIMS experiments carried out on these structures showed that the p-type doping at the front with carbon and the n-type doping at the back of the device with silicon was high in excess of 10^{18} cm^{-3}. This created almost flat band conditions at both ends creating a thinner depletion region as estimated by EBIC, causing loss in both blue and red end of the spectrum [4].

The second MOVPE growth reducing the n-type doping concentration (Si) at the back of the device from ~10^{18} to ~10^{15} cm^{-3} gave the following overall improved device performance:

V_{oc} ~ 900 mV, J_{sc} ~ (22 - 26) $mAcm^{-2}$, FF ~ (0.82 - 0.87) and η = (18-20)%

The optimisation of the silicon doping at the back of the device improved the collection from red-end as shown in Figure 2, increasing the efficiency to ~20%, but the MOVPE technique cannot reduce the p-type doping concentration in the front due to presence of excessive background carbon in the reactor.

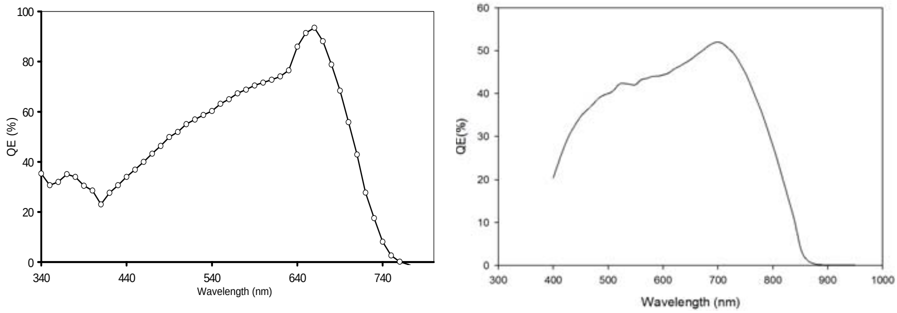


Figure 2: Typical spectral responses of devices from the first growth and the second growth. Note the improvement of the red-end after improving Si doping at the back of the device.

This work using well established MOVPE grown materials is to test the validity of the physics behind this new device. Although these devices have direct applications in concentrated PV systems, the ultimate aim is to fabricate such devices using low-cost and large area compatible techniques like electroplating, to produce low-cost and high efficiency next generation solar cells. The work is progressing to optimise the doping concentration in the front layers to improve these devices further.

References:

[1] Third Generation Multi-layer Tandem Solar Cells for Achieving High Conversion Efficiencies. IM Dharmadasa, Solar Energy Materials & Solar Cells 85 (2005) pp293-300.

[2] The reproducibility, Uniformity and Scalability of Multi-layer Graded Bandgap solar cell structures based on GaAs/AlGaAs System, IM Dharmadasa, GJ Tolan, JS Roberts, G Hill, S Ito, P Liska and M Grätzel, Proc. of 21st EU photovoltaic conference, Dresden Germany, June-2006, pp 257-262.

[3] SM Sze (1981) Physics of Semiconductor Devices, 2nd Edition, John Wiley & Sons.

[4] Advances in Thin Film Solar Cells, IM Dharmadasa, Pan Stanford Publishing Ltd, 2011.

The Growth and Characterisation of Pure and Al-Doped ZnO Nanorods by Pulsed Laser Deposition as a contact for thin film solar cells.

By Haridas Kumarakuru and David Cherns. H.H. Wills Physics Laboratory, Tyndall Avenue, University of Bristol, BS8 1TL, Bristol, UK. E-mail: phxkh@bristol.ac.uk

The Micro and Nano-Materials Research Group is one of the larger research groups in the School of Physics, University of Bristol. The group works on nano materials, nano device fabrications and nano technology, especially in designing sensors, renewable energy sources, and low voltage touch panel displays. Nanostructured materials have several potential advantages for renewable energy sources like solar cells. There has been considerable interest in the use of nanostructured ZnO films as electrodes for solar cells.

As well as being transparent to visible light (ZnO is a wide band gap semiconductor, with band gap ~3.37eV), ZnO can be grown in a variety of nanostructured forms with high crystal perfection. This opens up the prospect of electrodes with high surface area, good conduction paths and potential benefits from quantum confinement of carriers. In a current project we are investigating the use of vertically aligned periodic arrays of pure and doped ZnO nanorods, grown by the Pulsed Laser Deposition Technique-PLD, as a contact for thin film solar cells. The cell electrical properties will be characterised and correlated with structural information from optical, electron and scanning probe microscopies. This information will be used to improve theoretical understanding of the factors limiting cellefficiency and thereby, to optimise cell design. Here, we examine the growth of ZnO and doped ZnO films by PLD under conditions which lead to the growth of nanorod arrays. PLD has been used to compare the growth of ZnO nanorod (ZO), Aluminium doped ZnO nanorods (AZO) and pure ZnO nanorods on the top of an Al-doped ZnO seeding layer (AZO: ZO) on 'c- axis' sapphire.

The structure of the films has been studied by scanning (JEOL JSM 6330F) and transmission electron microscopy (JEOL 2010 and EM 430). The properties of the films have been examined by four point probe conductivity measurements and photoluminescence, and photocurrent measurements have been used to examine their potential solar cell performance. The electrical resistivities of Al-doped ZnO films were in the range 5-7X10-3 Ocm which is close to commonly-used indium tin oxide (ITO) where material availability, cost and toxicity are significant drawbacks. The present challenge for improving the conductivity is to know where this aluminium is incorporated with in the ZnO material and this remains uncertain. Figure 1(a) shows a TEM image of an AZO: ZO film which reveals that arrays of nanorodsgrow out of a continuous Al-doped ZnO layer. The reason for this bi-modal growth islinked to the growth of grains with opposite polarities, as explained previously [1].

It was found that the deposition parameters required to grow nanorod structures, namely substrate temperature, background oxygen pressure, target – substrate distance, deposition time and laser pulse energy are different for ZO, AZO and AZO: ZO, with aspect ratios of the nanorods being generally lower for AZO films which is shown in figure 1(b). This suggests that the diffusion of atoms along the nanorods differs when Al is present [2].

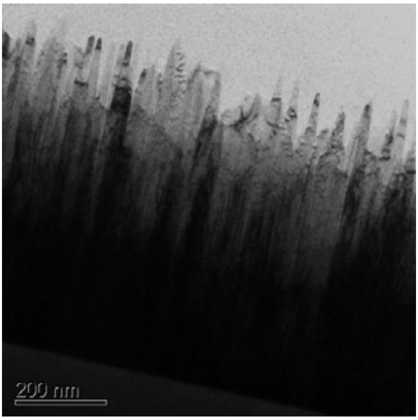


Figure 1: (A) AZO: ZO Nanorods

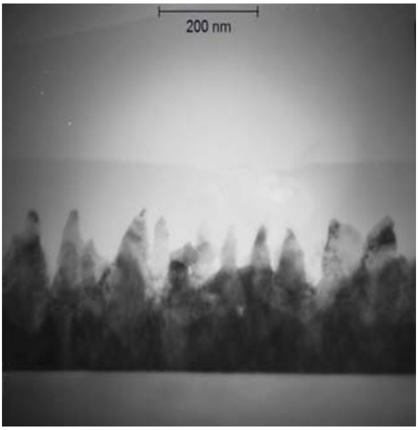


Figure 1 (B) AZO nanorods grown under similar conditions and showing different morphologies.

References

[1] D.Cherns and Y.Sun, Applied Physics Letter. 92 (2008) 051909.

[2] H.Kumarakuru, D.Cherns and G.M.Fuge, Surface & Coatings Technology. 205 (21-22), (August 2011), pg. 5083-5087

About the Committee

The current committee members are listed below. We are always keen to hear from potential new committee members who feel they would like to contribute to the Materials and Characterisation Group – contact d.mcphail@imperial.ac.uk. In addition, the Chair, Secretary and Treasurer will be coming to the end of their term of office next year and so elections will need to take place for their replacements. Look out for the AGM notification and officer nominee forms.

Chair:

Dr David McPhail (Department of Materials, Imperial College, London)

Interactions between the environment and materials, primarily using secondary ion mass spectroscopy (SIMS). David's interests are in surface phenomenon such as corrosion, oxidation, diffusion and segregation, with applications ranging from aerospace materials to museum conservation.

Hon. Secretary:

Dr Jonathan Painter (Department of Engineering and Applied Science, Cranfield University)

Jon has a background in deposition and characterisation of thin film materials, and surfaces of bulk materials with a recent emphasis on use of microscopy, both optical and electron, for materials analysis.

Hon. Treasurer:

Dr Hamid Kheyrandish Aystorm Scientific Ltd.

Expertise in materials characterisation methods, especially in ion beam analysis methods including secondary ion mass spectrometry (SIMS) and Rutherford backscattering (RBS), with interests in semiconductors, photovoltaics, optical coatings and related technologies.

Members:

Dr Alison Crossley Editor Newsletter (Department of Materials, University of Oxford, Oxford)

Alison is a member of the Royal Microscopical Society and the Royal Society for Chemistry, and is the manager of Oxford Materials Characterisation Services with wide expertise in the application of surface science to a variety of materials.

Dr Richard Day (School of Science & Technology, Glyndŵr University, Wrexham)

Expertise in processing, mechanical and physical properties, of composites and polymers.

Professor Richard Dewhurst (School of Chemical Engineering & Analytical Science, University of Manchester, Manchester)

Wide experience of optical methods for materials characterisation and non-destructive testing, and special expertise in remote optical detection of ultrasound.

Dr Sarah Fearn (Department of Materials, Imperial College)

Near surface analysis of SOFCs and ionic conductivity measurements on nano-engineered structures

Dr Matthew Healy (Department of Engineering and Applied Science, Cranfield University)
Expertise in ion beam analysis techniques applied to materials characterisation, with a recent focus on wider security related materials problems.

Dr David Keeble (Division of Electronic Engineering and Physics, University of Dundee, Dundee)
Local probe spectroscopy for materials characterisation, specifically electron magnetic resonance methods and positron annihilation techniques. Interests in point defect identification in materials, with particular experience in ferroelastic oxide materials and interests in various inorganic semiconductors and insulators and organic semiconductors.

Dr Richard Morris (Department of Physics, University of Warwick)
Nano-scale material development and analytical characterisation.

Professor Haricharan Reehal (London South Bank University, London)
Growth and characterisation of silicon based materials for solar cells.

PRIZE POSTER

High Performance Thin Film Coatings: *Diamond-like Carbon, hard-wearing, low-friction, biocompatible thin-film material*

Dr Benjamin Jones was awarded the prize for best poster at a recent Nanotechnology KTN meeting on *High Performance Thin Film Coatings: Ensuring Nanoscale Manufacturing Integrity* held at the Institute of Physics in London. Crossing medical, manufacturing and aerospace sectors, Dr Jones' research on diamond-like carbon (DLC) at Brunel University has utilised micro and nanoscale characterisation techniques in order to understand production processes and improve quality and function for the end user. A hard-wearing, low-friction, biocompatible thin-film material, DLC contains both graphitic and diamond-like bonded carbon atoms, and often a significant level of hydrogen. Controlling the balance of the constituents, phases and ordering allows the creation of a material with properties that can be tailored to match requirements, resulting in wide ranging suitability. Application of methods such as electron microscopy, atomic force microscopy and X-ray photoelectron spectroscopy has enabled understanding of the changes in film structure and properties. Presenting the prize, Dr Alison Crossley of the IOP Materials and Characterisation group said that the award recognised both the effective utilisation of surface science techniques and the application to diverse industrial problems. This work has facilitated production of enhanced coatings for medical tools, improved film adhesion by three orders of magnitude and created machining tools with five times improvement in life and 36% reduction in power consumption. An outstanding example of high quality university science with impact for industry.

Forthcoming Events

UKSAF Winter Meeting 2012

Advances in Correlative and Multi-Technique Analysis

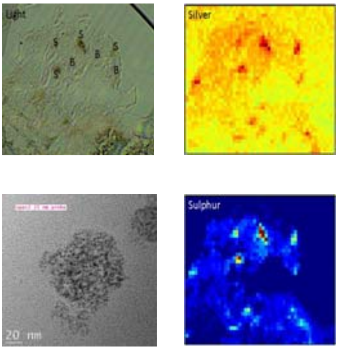
Wednesday 11 Jan 2012 Host: The University of Oxford

Venue: Oxford University Begbroke Science Park

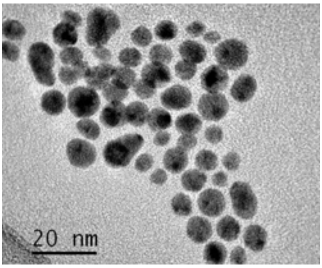
http://www.uksaf.org

Surface analytical techniques are often limited in the information that they provide. By combining information from more than one technique, or different modes of the same technique, new information can be synthesized. The theme of this meeting concentrates on recent advances in the areas of correlative and multi-technique analysis.

Correlated Synchrotron X-ray and TEM images of Ag nanoparticles in tissue *(K.Jurkschat Oxford)*



Diamond Light Source



PVSAT-8

8th Photovoltaic Science Application and Technology Conference and Exhibition

2-4 April 2012

Venue: Northumbria University, Newcastle upon Tyne

PVSAT-8 will provide the opportunity to hear about the latest advances in PV, enjoy the exhibition of the UK PV industry and supporting services to the PV community and interact with colleagues across all PV sectors in the UK. *More details on Page 13*

Calendar 2012

More details: www.iop.org/activity/groups/gd_calendar/index

Novel Methods for the Detection of Nuclear and Radioactive Materials

9 February 2012, Institute of Physics, London

The aim of the meeting is to explore ways to detect radioactive materials from means other than passive alpha, beta, gamma and neutron emissions and therefore to extend the physical range or enhance the capacity to detect radioactive materials. Detection could occur via any of literally dozens of non-traditional signatures, possibly secondary signatures from phenomena such as air fluorescence, or indicators such as muon deflection.

The meeting will draw on many areas of physics, chemistry and engineering, it should highlight interesting phenomena and discuss relevant exploitive technologies that potentially could generate leaps in the capability for detecting radioactive materials.

Advanced Characterisation Techniques for Aerospace Materials

27 March 2012, Institute of Physics, London

The materials used in the aerospace industry face increasingly complex loading and environmental challenges. It is very important, therefore, to use the widest possible range of state-of-the art characterisation techniques and protocols in order to fully understand the mechanisms and kinetics of processes such as oxidation, diffusion, segregation, creep and crack growth. In this meeting we will explore the wide range of approaches available for the characterisation of these materials placing a particular emphasis on some of the nano-scale resolution techniques that have developed over the last decade or so.

8th Photovoltaic Science Application and Technology Conference and Exhibition

2-4 April 2012, Northumbria University, Newcastle upon Tyne

The PVSAT series of conferences is now well established as the premium event for the presentation of leading research in photovoltaics in the UK. The UK is privileged in having a strong R&D community active in most of the major PV fields of devices and applications. The conference is organised by the UK section of the International Solar Energy Society in partnership with EPSRC's PV-Net. The conference will again be held over three days to allow the inclusion of the wide range of papers and posters reflecting this fast moving field of research and development.

Ultrasound Standing Waves – manipulating cells, particles and fluids with sound

2-6 July 2012, Powys

From acoustic basics to designing sophisticated resonant chambers for manipulating cells, particles and fluids.The theoretical and practical instruction of the physics, engineering and biology will be suitable for postgraduates to experienced professionals.

16th International conference on Positron Annihilation (ICPA-16)

19-24 August 2012, Bristol.

This is the triennial meeting of the positron annihilation community. A major theme is the application and development of positron annihilation methods for the study of materials. The call requests contributions in the areas of metallic and semi-conducting solids, characterising both electronic structure and defects, applications to polymers and soft matter, studies of surfaces and interfaces and of porous materials and layered structures.

Cultural Heritage meets Science: *The Interface*

By Richard Morris (Department of Physics, University of Warwick)

This one day event held in Portsmouth in September was designed to bring together those working, or with an interest, in the field of cultural heritage and heritage science. Its main objective was to introduce and discuss the blend of cutting edge and traditional science behind the preservation of the moveable heritage, and the ethical framework which shapes its experiments.

The Mary Rose Trust in Portsmouth was chosen as the host venue because it is not only a heritage site but has a strong ongoing heritage science activity. Professor Mark Jones from the Trust started proceedings with an excellent talk about the application of x-ray beams for studying archaeological artefacts recovered from the Tudor warship the Mary Rose. Dr Lyn Wilson of The Scottish Ten project, Historic Scotland Conservation group then both entertained and informed the audience with a wonderful visual display demonstrating a new 3D laser scanning technology being used by the project to document artefacts, buildings and iconic monuments. The morning session was brought to a conclusion by Mr Richard Smith Director of the Tank Museum, Bovington and his collaborators from Bournemouth University **(**Mark Hadfield and Zulfiqar Khan**)** who outlined and discussed the financial management and scientific challenges faced by museums, using the tank museum as an excellent example as they strive to preserve and maintain the full operation of their historic vehicles and maintain visitor numbers.

The afternoon session started with Mr David Watkinson, Cardiff University giving an interesting presentation about the preservation of iron which is an important area of current heritage science. To conclude the talks Professor May Cassar, UCL discussed the potential outlook for heritage science in the UK, and more importantly, its future funding.

The day finished with the delegates having the opportunity to take a tour behind the scenes at the Mary Rose Trust to see their facilities and ongoing research while others opted for a tour of the ship “HMS Warrior 1860”, seeing firsthand the science and preservation work that has gone into restoring this iconic ship. Overall it was felt by the organising committee that the day was a huge success thanks to the range of topics covered and the level of science and heritage content covered.

Other meeting reports can be found on page the group website

The Institute of Physics, 76 Portland Place, W1B 1NT, UK.
Tel: 020 7470 4800
Fax: 020 7470 4848