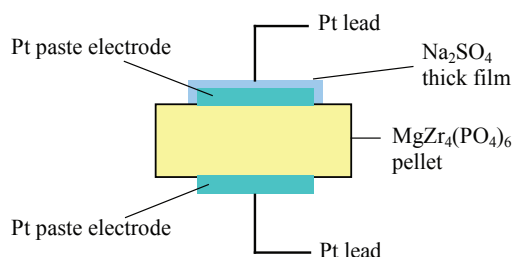


Research meets reality in chemical sensing

Over two decades the use of lambda sensors to monitor the concentration of oxygen in vehicle exhaust gases in order to control the combustion conditions has led to a substantial reduction of noxious emissions world-wide. New research to identify materials to act as sensors for other chemical species is being tackled through interface engineering, surface modification, ionic transport and electrochemicals (the study of phenomena occurring at the surface of electrodes, particularly charge-transfer reactions).

World-class research based on innovative approaches to chemical sensing using solid-state ionic materials and electrochemical measurements, carried out individually and jointly by Derek Fray and Vasant Kumar, has led to successful industrial usage of novel sensors. In one example, a sensor has been operated in an active mode such that ionic transport at two different rates is used to give chemical information at higher accuracy with a faster response. This system is also self-cleaning due to the cyclic oxidation-reaction at the surface and has a built-in on-board diagnostic (OBD) feature due to the availability of on-line impedance monitoring during measurement. While this approach is significant for all solid-state ionic sensing, Derek and Vasant have found it particularly valuable for perovskite protonic conductors in hydrogen sensing. These specially doped perovskites, prized for their high-temperature protonic conductivity, can change between oxygen- and hole- type conductivity depending on the environmental chemistry and time of usage. The OBD feature can readily report this change, thus avoiding spurious analysis of data.



A planar perovskite-based sensor for SO_2 (schematic)

Their group, which includes research students, post-docs and visiting scientists, has also pioneered the use of electrochemical chains by interfacing several solid-state ionic systems in series or parallel for responding to many different molecular species. On-going research is expected to create sensors that can self-actuate and self-tune with applications in a wide range of contexts. For further information, please contact Dr Vasant Kumar rvk10@cam.ac.uk.

Editorial: fund raising for a Cottrell Chair

This issue of *Material Eyes* marks the launch of the Department's campaign to establish a professorship in honour of Sir Alan Cottrell. It is a pleasure to report that Sir Alan himself is thriving; indeed his latest scientific paper (a commentary on a bridge from electron theory to the theory of lattice defects*) has just beaten this issue to the press. Sir Alan, Goldsmiths' Professor and Head of Department 1958-66, is the foremost academic metallurgist that the UK has produced. He has served with great distinction in many rôles, not least as Chief Scientific Adviser at the Cabinet Office, as Master of Jesus College, and as Vice-Chancellor of the University. The Sir Alan Cottrell Professorship of Materials Science will recognise his eminence, complement our existing named Chair, the Goldsmiths' Professorship, and strengthen the Department. The new chair is a priority for the Department within the University's 800th Campaign.

A fund-raising committee has been set up under the chairmanship of Sir Graeme Davies. Currently Vice-Chancellor of the University of London, Graeme worked in our Department (1962-76), and has held a series of important posts, including Chief Executive of the University Funding Council and Vice-Chancellor of the University of Glasgow. He writes that Sir Alan "was the reason I came to the UK, when he offered me a Research Fellowship to work on the then very new field of composites – my PhD in New Zealand had made me very familiar with his work and to join him in the Cambridge Department was a goal I had not expected to fulfil." The Department is immensely grateful that Graeme is leading the fund-raising effort. Initial donations have already been secured, making a start on raising the necessary £2M. Those wishing to find out more, or to contribute to the Cottrell Chair, should contact me on alg13@cam.ac.uk.

Professor Lindsay Greer
Head of Department

Phil. Mag. Lett.* **87 (2007) 1.

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New bone for old

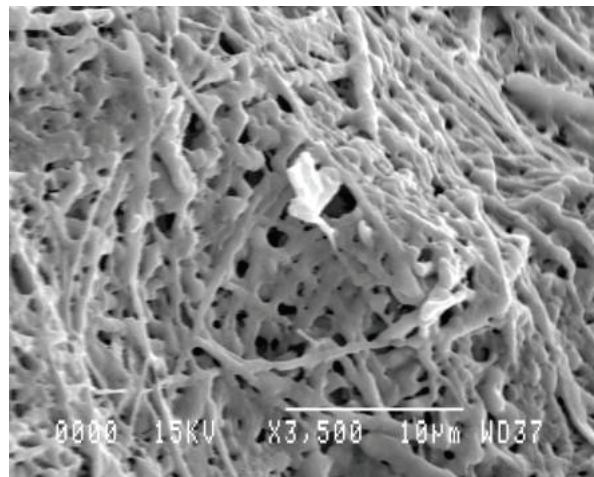
Research in the Department on biomedical materials, especially on bone, was featured in Issue 9 of *Material Eyes* just over six years ago. One of the challenges highlighted was that a conventional metallic or ceramic implant in a bone does not stimulate bone growth over time and so a physical link between the natural bone and the implant does not form, leading to deleterious consequences. The research then in progress, to develop a range of bioactive materials to overcome such problems by more closely mimicking the tissue they are replacing, has continued apace. Dr Serena Best and Dr Ruth Cameron have taken over responsibility for this area following the formal retirement of Professor Bill Bonfield, although Bill still maintains a very active interest, while collaboration with others within and outside the Department, especially the Orthopaedic Research Unit (headed by Professor Neil Rushton) at Addenbrooke's Hospital, remains an important part of the programme.

Bone may be thought of as a nanocomposite of hydroxyapatite (a crystalline mineral) in a matrix of collagen. By adjusting the composition of synthetic hydroxyapatite through the incorporation of small proportions of various ionic species (e.g. silicon) it is possible to make a biological substitute for bone that is accepted by the body and speeds up the process of bone integration.

Research on the development of materials for practical applications is underpinned by work aimed at understanding the relevant fundamental processes that occur in the body. For example, thin films are currently under investigation for studies focusing on the basic science of the interaction of osteoblast-like cells with hydroxyapatites of various compositions (an osteoblast cell is a bone-making cell), biodegradable polymers and composites are also under development, while elsewhere in the Department the effectiveness of magnetic fields in stimulating bone growth is being examined.

With applications explicitly in mind, current research includes developing suitable physical forms of selected materials to optimise natural bone growth into the requisite regions in the body. Two distinct physical forms that have been shown to be successful in appropriate contexts are surface treatment of an implant with hydroxyapatite prior to implantation and the formation of porous scaffolds based on hydroxyapatite into which natural bone will grow. Several commercial methods of coating metallic implants with hydroxyapatite are available, one of the most common being plasma-spraying. Materials Science progresses through developing an understanding of the structure-property relations of materials and the field of biomedical materials is no different in that respect, so one theme of current research involves characterising plasma-sprayed hydroxyapatite-coated implants by high-resolution electron microscopy, concentrating especially on the nanoscale interfacial properties. Work in the area of bioactive coatings is being carried out by Dr Serena Best in collaboration with Professor Bill Clyne, Drs Bill Clegg and Zoe Barber. In principle, porous scaffolds form an attractive option for encouraging bone-growth where it is required but unfortunately the mechanical weakness of hydroxyapatite on its own means that it usually has to be combined with other materials,

preferably ones that will interfere as little as possible with the desired biological activity. One example (illustrated below), based entirely on hydroxyapatite, is the use of porous scaffolds constructed by a foaming method from a mixture of single-crystal fibres of silicon-substituted hydroxyapatite and a silicon-substituted hydroxyapatite gel. In another approach research led by Ruth Cameron, in a project funded jointly by DTI, EPSRC and the Finnish company Inion, seeks to develop novel bioactive biodegradable nanocomposites of ceramics and resorbable polymers for bone-replacement materials.



Silicon-substituted hydroxyapatite scaffold

Building on this research, commercial opportunities are being pursued. With Andrew Lynn, who previously worked in the Department as a graduate student and then as a post-doc, as its CEO OrthoMimetics, the first spin-out company based on work carried out under the auspices of CMI (the Cambridge-



MIT Institute), has been established and has now succeeded in raising £5M of financing.

Ortho-Mimetics will provide a range of products designed to improve the quality of tissue repair at the sites most relevant to orthopaedic surgery. The first of these products "ChondroMimetic", which can be shaped with a scalpel, implanted without special tools, and which bonds directly to the site of injury without sutures or glue, is designed to improve the effectiveness of existing surgical procedures for the repair of articular - cartilage injury. Two preclinical trials of ChondroMimetic have been completed successfully and the results will shortly be published in peer-reviewed journals. Closely following ChondroMimetic there are further products in OrthoMimetics' development pipeline.

For further information see:

<http://www.msm.cam.ac.uk/ccmm/>

<http://www.orthomimetics.com/index.asp>

http://www.inion.com/press/news2005/en_GB/Cambridge_agreement/



The rôle of the Senior Class Technician

Frank Clarke outlines his job in the following terms. When describing the job to people at interview I use the metaphor of the factory, in that a Class technician's job is similar to that of somebody on a production line: if you get the timing wrong you won't get a second go at the task and everybody misses out.

My rôle and that of my colleagues has changed over the last 4 years. At one stage the Class technician's task was viewed as that of somebody who simply set up and then cleared away the undergraduate experiments. With the growing use of computers, the technicians are now expected to be familiar with IT and how computers interface with the increasing use of instrumentation in materials testing and analysis.

The end of the academic year may be the best place to start, as this is the time when we have a chance to reflect on the past year and to plan what needs to be put in place before the next onrush. An essential task in the summer is replacing the consumables used in the year, repairing existing equipment and planning for any new experiments we have prior knowledge of, often as a result of my participation in meetings of the Teaching Committee. If we get this right we are in good shape for the Michaelmas Term when the IA and IB people come to us. Each week we set-up and subsequently take down three experiments and run 10 practical sessions for undergraduates as well as two briefings for demonstrators, so we need to be quick footed and well prepared, as there is little time between practicals to clear away and set up again.

Recently we have completed a number of projects in the summer, such as the development of the Part IA Mini Project described in the previous issue of *Material Eyes*, the installation of digital cameras on some of the optical microscopes, and the reorganisation of Lab 301 (known to past generations of students as the Part II Lab) to include a student study area and a characterisation suite, which now includes an EDX unit on the Class SEM and a new AFM.



Frank and students in refurbished Lab 301

Other schemes completed this year are the installation of new visualisers, which replace the old OHPs but have greater flexibility and offer the facility to interact with the new Smartboard, which has been fitted in the tower lecture room,

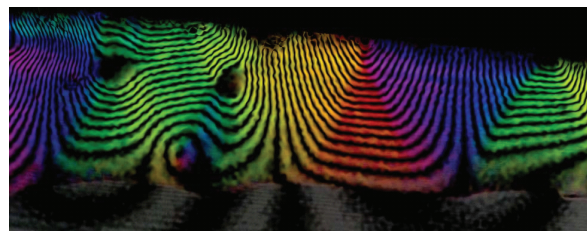
and computerisation of the tensometers, replacing the "string and sealing wax" method of data collection with data loggers and shaft encoders, as well as fitting new software developed by the Electronics section. We are now looking at the possibility of purchasing a number of microscopes and of renewing some of the IB practical set-ups.

Other areas where I have an input are in the use of the metallographic facilities and hardness testing. I'm also involved in teaching MPhil students, undergraduates and occasional visitors how to use equipment especially the SEM+EDX already mentioned.

Signing off the year, we are tasked with supervising the written exams held in the Department (practical exams have all been replaced by assessed coursework). Making sure we have everything in place for this event is the final proof that we have met our objectives. In the words of Van Morrison "the meaning of success is delivering what is needed and delivering on time"; the same principle applies to the tasks of the Class technicians.

Jubilee celebrations of links with India

In this year when India celebrates sixty years of independence, it is a pleasure to record that our Department has many active links with Indian scientists and engineers. These links span the range of our activities, from Harry Bhadeshia's work supported by Tata Steel, to Judith Driscoll's collaborations with Neeraj Khare (IIT Delhi) on magnetic semiconducting oxides for spintronic applications and with SK Agarwal (NPL, New Delhi) on transport studies in superconducting MgB_2 . Our picture comes from the work of Parameswaran (Indira Gandhi Centre for Atomic Res) who recently spent three months here with Rafal Dunin-Borkowski on a Royal Society Study Visit. The objectives during his stay were to apply the Department's state-of-the-art transmission electron microscopy, in particular electron tomography and holography, to the characterization of ferritic steel containing nanoscale carbide particles.



Magnetic domains interacting with carbide particles

Our Department has many distinguished alumni working in India. Prominent among these is Srinivasa Ranganathan, under whose guidance close links have been maintained over many years with the Metallurgy Department at the Indian Institute of Science (IISc), Bangalore, where he was HoD. In the present academic year, the IISc Department also celebrates sixty years, and is marking this not only with a change of name to Department of Materials Engineering but also with Diamond Jubilee Lectures. In January 2007 the third lecture in this commemorative series was given by Lindsay Greer, who spoke on "The glassy state: novel properties and applications exploiting non-crystallinity". Lindsay and the present IISc HoD Kamanio Chattopadhyay look forward to further fruitful links.



Dr JP Chilton, 1929 - 2006

John Chilton came up to Cambridge in 1947, graduating in Metallurgy in 1950, and gaining a half-blue for lacrosse. He then went on to a PhD, completed in 1955, under the supervision of the world's greatest expert on corrosion at the time, Dr UR Evans. Evans had been seeking to explain the relatively slow rate of corrosion in wrought iron produced by the puddling, forging and piling process, as compared to a low-carbon iron produced through normal steelmaking methods. The answer, revealed by John Chilton, lay in the surface zones of more noble metal enrichment produced by iron oxidation during heating. In the subsequent repeated folding and reheating during forging, these zones of copper, nickel and tin enrichment became elongated and dispersed throughout the body of the wrought iron, giving electrochemical conditions which arrested corrosion of the iron. These zones of enrichment were revealed by painstaking progressive machining and then analysing the layers removed chemically. Nowadays, of course, the segregation zones can be much more easily revealed by electron-probe microanalysis.

Whilst the original research may now seem out-of-date in view of the very small interest in commercial wrought iron, the recognition of the segregation occurring in piled and forged iron and steel products is central to the understanding of the microstructural development in archaeological and historical artefacts, and the work lives on.

John was a Demonstrator from 1957-62, having spent a year at the University of Texas 1956-57. Appointed Lecturer in 1962 he became established in the department as a superb teacher, this at the time when good teaching was considered to be the prime objective. Research under his guidance focused initially on solidification studies and then moved back again to electrochemical aspects of corrosion in later years, but he never led a major group as Evans and Hoar had done before him. His Royal Society of Chemistry booklet on *Principles of Metallic Corrosion* served many generations of students very well. Although outside his main field of interest he gave a well-received course on glasses and ceramics when other than metallic materials came to be studied in the transition to Materials Science. John retired in 1989.

John and his wife Christine were lovers of classical music, particularly opera, and keen supporters of Kettle's Yard Museum, reflecting their joint interest in contemporary art.

ACUA and the Department

The Association of Cambridge University Assistants, generally referred to by its acronym ACUA, is one of the organisations representing the staff of the University; indeed it was the first such organisation within the University, being established in 1893 as the New Museums Club. Many members of the technical, secretarial and other assistant staff of the Department belong to ACUA and some hold important posts in it. Both the current President and General Secretary work in the Department. Having served on a variety of ACUA committees over a period of ten years, Carol Best was elected President in 2004. Carol is widely known in the

Department as half of the long-serving Photographic team, who have helped so many of us to illustrate all manner of



things including papers and lectures and handouts, and have seen their working methods dramatically changed by the move from film to digital photography.

Andrew Moss has been General Secretary since 2000. He too was elected after a decade or so of committee service. Through his duties as the technician with day-to-day responsibility for the X-ray facilities, he too comes into contact with many people working in the Department. Those duties involve not only ensuring that the equipment produces reliable data but also, equally importantly, that it is running safely. No doubt it was that latter function that led to his appointment as a member of the Joint Union Statutory Health and Safety Representatives Committee and also the University Sub-committee for Ionising and Non-Ionising Radiation. In this context it is interesting to reflect on the fact that, in 1920, the President of the New Museums Club, the predecessor of ACUA, was JHV Charles of the Department of Biochemistry and the Pathology Laboratory. His son, Jim Charles, formerly a Reader in this Department, has recently written his biography.

“Materials to save the planet?” - a date for your diary

Tuesday 12 June 2007 is the day, the Babbage Lecture Theatre on the New Museums Site the place, the Armourers & Brasiers' Cambridge Forum the event. This year's Forum will focus on the crucial issues of energy and sustainability, and in particular on the rôle that materials research can play in reducing CO₂ emissions and in reducing energy consumption. The Forum starts with registration at 1.30 pm and after a series of talks on topics including hydrogen-storage materials, fuel cells, solar cells, gas-turbine materials and nuclear materials, culminates in the Kelly lecture at 5.30 pm. This year's Kelly lecture, the ninth in the series, will be given by the world-renowned materials engineer Professor Mike Ashby from Cambridge University's Engineering Department. For information on this year's programme as it develops, see: <http://www.msm.cam.ac.uk/forum/>

The Armourers & Brasiers' Cambridge Forum is hosted annually at the Department and aims to raise the profile of materials science in the UK academic and industrial communities while being international in scope. It attracts high-level involvement from industry, the research councils and other influential bodies. The Department is grateful to all the sponsors for supporting the event, especially the Armourers & Brasiers' Livery Company who help with the organisation.



**Louise Makin,
Chief Executive Officer of BTG plc**



Louise Makin joined BTG as Chief Executive Officer in October 2004 since when, under her leadership, the company has focused increasingly on developing and commercialising medical innovations in a number of fields including neuroscience, oncology and ageing. Additionally the company is actively seeking to identify new uses for established drugs or drug combinations; one advantage of this “drug repositioning” is that many aspects of the safe usage of the drugs involved are already well known. So what led a materials scientist to such a position?

Louise and her brother were the first members of their family to go to university. Entering Newnham in 1979 as a Natural Scientist, Louise gradually found herself attracted to Materials Science by the breadth of the subject and by the aim of trying to understand useful and potentially useful materials. She recalls her Part II Class as a memorable, sociable and mutually very supportive group whilst her Part II project with Ian Hutchings on a tribological topic turned out some years later to have provided important background for her work on lubricants in one of her jobs. Electing to remain in Cambridge as a graduate student and having a well established interest in rowing she transferred to St John’s, which had then very recently begun to admit women, with an ambition – soon realised – of becoming Women’s Captain of the Lady Margaret Boat Club (LMBC). She embarked on a PhD supervised initially by Brian Ralph and then, following Brian’s move to Cardiff, by Mike Stobbs, obtaining her PhD in 1986 for work on recrystallisation in aluminium-lithium alloys, which were then attracting a lot of attention because of their reduced density and good stiffness.

Her PhD research had brought her into contact with Alcan where she gained exposure to the excitement of working on developing technology where there was a clear commercial pull (in this case from the aero industry). After leaving Cambridge she joined ICI, initially on the commercial side, but soon returned to research and development where, amongst other things, she learnt “how technology happens”, observing important differences between the UK, the USA, and Japan. Louise soon found herself responsible for running

a business within ICI, although then not yet 30. Evidently someone able to recognise, absorb and apply the lessons continuing experience brings, she quickly learnt to distinguish between two responses to a challenge: “can we (ever) do it?” *versus* “can we do it on time and on budget?”. After rising steadily in ICI she moved briefly to ECC International before joining Baxter Healthcare in 2000 as Head of Strategy and Business Development, before becoming, a year later, European President, Biopharmaceuticals Europe. Four years later, and keen to be in a position where she could set her own priorities in a business, she accepted the opportunity of moving to her current post at BTG. As is readily apparent from this summary, she has always chosen work combining a strong science base with opportunities to bring commercial sense to that science base.

In addition to running BTG and sharing with husband Tim (St John’s 80-83) responsibility for looking after their two daughters, Sarah (13) and Katie (11), Louise has other noteworthy commitments including being a Non-Executive Director of Premier Foods plc, chairing the Advisory Board of the Lancaster University Management School, and acting as a trustee of the Engineering Development Trust. Louise is always keen to seize opportunities that emphasise the value of a scientific education and to support and encourage upcoming leaders. Those who recall Louise’s successes in the world of rowing in Cambridge and beyond during her student days will not have been surprised by this recent photograph. An experienced mountain marathon runner she also regularly participates with husband Tim, a contemporary stalwart of the LMBC, in the activities of “JourneyMaker”, which raises money for charity through participation in the Three Peaks Yacht Race, a gruelling challenge that includes running up and down Snowdon, Scafell Pike and Ben Nevis and sailing between them whatever the weather. You can follow their progress for this year’s event at: www.journeymaker.co.uk

Asked to offer advice to current students, she would urge undergraduates to follow their developing interests by making good use of the variety of subjects available in the Natural Sciences Tripos, while graduate students should recognise that working for a PhD provides invaluable experience of learning self-management and of enhancing self-confidence. Both groups should note the wealth of opportunities that exist to use a scientific education in business not only as a scientist but in so many other ways too. As she says, there is a huge need for scientifically literate people who understand both the scientific side and the managerial side of the business. <http://www.btgplc.com/index2.cfm>

2006 Tripos Prizes

Part II

The Armourers & Brasiers’ Prize & Medal David Lloyd, JN
The CEBG Prize Andrew Bennett, DOW
ICI Prizes Tom Pomfrett, SE, and Jeremy Smith, SE

Part III

The Goldsmith’s Prize and medal Richard Darby, SE
The Armourers & Brasiers’ Prize & Medal Joo Chua, R
The Institute of Materials Prize Andrew Whyte, CAI
ICI Prizes Helen Griffiths, SE, and Sarah Parker, F



Back to the world of superalloys

– a profile of Dr Howard Stone



Howard Stone rejoined the Department in April 2006 to take up the post of Assistant Director of Research in the Rolls-Royce University Technology Partnership. He returned to the Department seven years after completing his PhD with Roger Reed and to the group in which he did it. His career to date has been diverse. Following his PhD he worked as a management consultant in London before securing a position with an internet shopping portal during the dot-com boom. Whilst both positions offered fascinating and challenging experiences, he made the decision to return to academia rather than continue a business career. On his return, he sought to explore new areas of research and has held posts studying: crystallography of mineral systems at high temperatures and pressures, and the time-resolved characterisation of phase transformations in steels by neutron and synchrotron diffraction. More recently, he has been granted a Fellowship from the Worshipful Company of Armourers and Brasiers and, with his return to the Department, his principal research interests have now returned to their roots – nickel-base superalloys. The Rolls-Royce University Technology Partnership focuses on the study of these alloys and other advanced high-temperature materials used in the hottest sections of gas-turbine aero-engines. The group operates in close collaboration with research staff in Rolls-Royce plc and conducts a range of research activities including: developing new alloys for turbine blade and turbine disc applications; exploring methods by which these materials may be protected from the harsh environment in which they are required to work; and obtaining detailed understandings of the behaviour of these materials during their manufacture and service.

Howard is married to Heather and they have two young children, Edward and Matthew. Once a keen sportsman, he now limits his activities to cycling and jogging with his dogs, although both he and Heather are eagerly awaiting the time when their boys are old enough to be taken skiing and they can return to the slopes as a family.

Editorial team: Dr John Leake, Prof Lindsay Greer and Dr Rachel Hobson. Comments to: rjh24@msm.cam.ac.uk

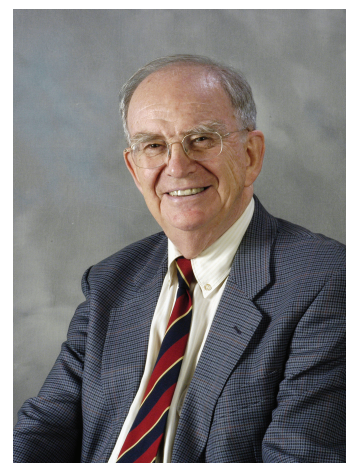
Congratulations to:

Tim Burstein, UR Evans Award of the Institute of Corrosion (UK) and HH Uhlig Award of the Electrochemical Society (USA).

Sir John Meurig Thomas, Honorary Professorship at Jilin University, Changchun, China and Honorary Foreign Fellowship of the European Academy of Sciences.

Harry Bhadeshia, the THERMEC Distinguished Award 2006, Vancouver.

Bill Bonfield, Honorary Membership of the European Society for Biomaterials.



Derek Fray and Vasant Kumar, Honorary Professorships at Hebei University, China.

Ian Kinloch, Lectureship at University of Manchester.

Gavin Burnell, Lectureship at University of Leeds and an EPSRC Advanced Fellowship.

Athina Markaki, Research Fellowship, Robinson College and, from October 2007, Lectureship in the Department of Engineering, University of Cambridge.

Howard Stone, Armourers and Brasiers' Company Research Fellowship.

Casey Israel, Junior Research Fellowship, Wolfson College.

John Durrell, Research Fellowship, Hughes Hall.

Jin-Chong Tan, Junior Research Fellowship, Wolfson College.

Lukas Schmidt-Mende, Royal Society University Research Fellowship and Non-stipendiary Fellowship, St Edmund's College.

Stéphanie Lacour, Research Fellowship, King's College.

Rachel Oliver, Royal Society University Research Fellowship.

Dominik Eder, APART Fellowship, the Austrian Academy of Sciences.

Ashley White, winner of the regional heat of the IoM³ lecture competition and Fellowship from the National Science Foundation (USA).

Kamal Tripuraneni, first Prize in the Robert A Heinlein *Flight into the Future* contest for his project entitled "A greater viability of space travel by the lunar generation of oxygen via the FFC Process".

Michelle Moram, Young Scientist of the Year Award from the British Association of Crystal Growth, and Research Fellowship, Hughes Hall.

Jonathan Hollander, third prize for a film in the amateur category at the MRS Inaugural Materials Film Festival. His film was called "Material Combat".

