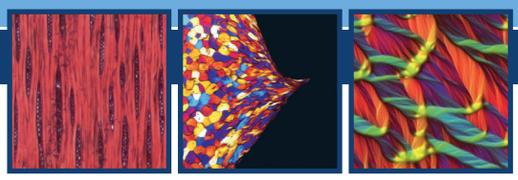
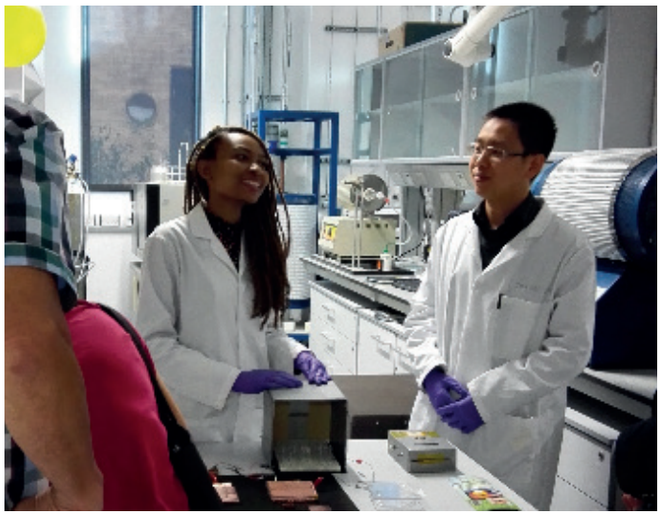
Cambridge
materialeyes

Winter 2017 Issue 30



Open house



On Friday the 23rd September the Department opened its doors to welcome many alumni, past members of staff, sixth formers and visitors from industry. Our guests were treated to a self-guided tour of the building including visiting the new research laboratories, the Wolfson electron microscope suite and the process lab where our current PhDs and post docs were demonstrating or talking about their latest research. This is the first time the Department has held an Open Day in the new building.

We were very pleased to host over 160 visitors and it was lovely to see so many familiar faces of yesteryear including our former Departmental Secretary, Peter Tee, wearing his Goldsmiths tie, Rob Somekh - past member of the Device Materials group, Richard Dolby m1958 (former Research Director of TWI,), John Wood m1971 (former CE of CCLRC), Laura Cohen m1982 (CE of the British Ceramics Confederation) and Bill Welland m1970, former PhD student of Gerry Smith, who came in clutching a cannonball, to name just a few.

One of our alumni, Robin Taunt m1967, kindly summed up the day by saying "So many impressions: what a huge facility you now have, and so much equipment! But the over-riding image I took home with me was of the stunning number of extremely bright and personable young people, who were fully prepared to talk enthusiastically about their work to an old buffer who is many decades out of date." We would like to say that it was a pleasure to see so many attend and we hope to run another event again sometime in the future.

Editorial

Welcome to the 30th issue of Material Eyes. As you will see elsewhere, we have been active in staff recruitment with two new lecturers appointed. We have also organised our first Open Day in our new building which provided an opportunity for us to showcase the huge range of research which is now taking place within it – including the new GaN deposition facilities which were the last major equipment items to be moved into the building.

The teaching resources of the building (and the staff) are being stretched to their limit by our year on year increases in the numbers of undergraduate students choosing to study materials. Although this has created some short-term difficulties, these are "good" problems, particularly given the progressive development of the government's Teaching Excellence Framework (TEF) for which student satisfaction will become a key metric. At least for the moment, the University is being treated by TEF as a single entity, but it's fairly likely that eventually individual departments well be assessed and so it's good that we have already achieved 100% satisfaction in the National Student Survey.

Professor Mark Blamire, Head of Department

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Inside:

David Duke Memorial bench

We are very grateful to all who contributed to the appeal to create a memorial to David Duke, who worked in the Department for 45 years, 16 as Principal Technician (1997-2013). A substantial L-shaped bench was commissioned and was installed on the patio outside the Tea Room on 21 September 2016. It is positioned so that users have a view over the lake. The bench, pictured above, is made of wood from a sustainable source and is inscribed in memory of David.

New Lecturer Appointees

Congratulations to Nick Jones and Rachel Evans on appointment to University Lectureships in the Department.

Rachel will be coming to Cambridge from the School of Chemistry in Trinity College, Dublin. Her research interests are focused on the design and characterization of new photoactive and photoresponsive materials for application in solar energy conversion, optical sensing and stimuli-responsive membranes.

Nick Jones is already a member of the Department, working in the Rolls Royce UTC. His interests focus on developing new materials to improve the overall efficiency of areoengines with the aim of reducing CO2 emissions and noise. This includes novel high temperature metallic systems for engine core applications, functional structural materials for adaptive technologies and the exploration of new alloy concepts, such as High Entropy Alloys.

Greening Lead-acid Batteries

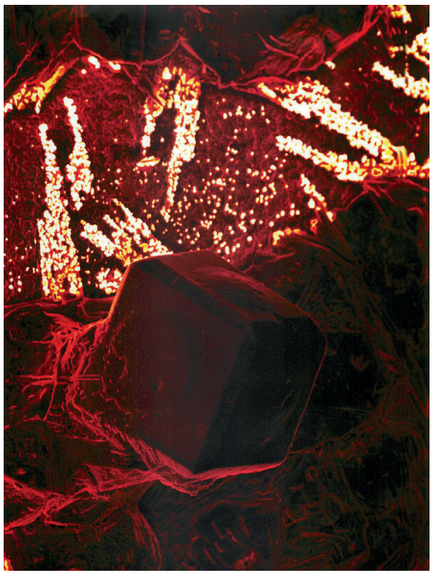
Over several years Vasant Kumar and colleagues have developed a novel recycling technology for the lead and lead oxide paste at the heart of lead-acid batteries. This technology promises to revolutionise battery recycling, an enormous business internationally. It involves substantially lower costs for equipment, very low emissions and a much reduced carbon footprint. Furthermore the resulting paste shows better electrochemical properties than traditional battery paste. Recently this technology has been licensed through Cambridge Enterprise to Aurelius Environmental (AE) in Tipton in the West Midlands. AE expect to commission a pilot plant shortly and anticipate processing over 10,000 tonnes of paste in 2017 with considerable further growth in prospect thereafter.

http://ael.global/battery-recycling

Tata Continuity

Over the last 13 years Harry Bhadeshia has supervised a number of back-to-back PhD students from the Tata Steel Company Research and Development Centre in Jamshedpur in India with two more starting this year.

On a recent visit by Harry to Jamshedpur most of the group were reunited. From the left they are: Saurabh Kundu (2004-07), Ashwin Pandit (2008-11), Subhankar Das Bakshi, (2011-14), Saurabh Chatterjee, (2003-06), Harry and Appa Rao Chintha, (Oct 2016-to date) and Shaumik Lenka, (Apr 2016-to date) – not pictured.



Material Images

Recently the Department held a scientific image competition and the winning entries are shown above.

TOP: "Hell" - SEM image of an organic-inorganic halide perovskite single crystal by Stefania Cacovich.

BOTTOM:"Capillary dance" by Stoyan Smoukov.

13th ABC Forum

Bill Bonfield opened the 2016 Armourers & Brasiers' Cambridge Forum by outlining the long standing support of the Armourers & Brasiers for Materials education and by thanking all the sponsors for their invaluable support.

Leigh Canham (pSiMedica) explained that nanoporous silicon (minimum pore size 1.5 nm) is biocompatible and fully biodegradable in the body making possible implanted transient micro-electronics or providing "sustained release" drug delivery over a year. Other potentially useful properties include luminescence and even ductility. Highly purified silicon is not required for all applications; silicon from bamboo is usable for some.

Judith Driscoll (Cambridge) focused on nanoscale oxides. Multilayer super-conducting wires with successive layers parallel to the substrate have excellent properties dependent on the pinning defects. Other applications require control of the defects. A self-assembled two-phase system of Sm-doped CeO_2 and $SrTiO_3$ grown perpendicular to the substrate shows enhanced oxygen ion transport. Such growth also facilitates microstructural examination.

The nanoporous materials described by Jordi Sort (Barcelona) were made by a variety of techniques, all producing a large surface area to volume ratio, and then doped by chemical or physical methods to give (e.g.) tunable magnetic properties. Two-phase Cu-Ni foams (pore size 20-50 nm) are super-hydrophobic (contact angle > 150°) and ferromagnetic and show promise for application in magnetically actuated micro/nano-electromechanical systems.

Visible light communication underlay Martin Dawson's (Strathclyde) talk. Collaborating with the Cambridge team, nano-composite GaN-based devices were produced: e.g. micro-lasers on ultra-thin glass membranes and micro-LEDs transfer-printed directly onto diamond substrates (the excellent thermal conductivity permits the LEDs to operate at high current-density). The era of "communicating data through a light bulb" dawns.

Andrew Goodwin (Oxford) introduced "frustration" in crystal structures due to incompatibility between the lattice geometry and the ordering interactions between constituents, which leads to correlated disorder with a significant effect on properties, e.g. ice - the disorder influences the melting point. Parallels exist with forms of magnetic ordering, including skyrmions. The chain structures of AuCN, AgCN and $Au_{0.5}Ag_{0.5}CN$ illustrate another class.

Bill Bonfield then reported that 6 previous recipient companies of an Armourers & Brasiers' Venture Prize are still functioning. There were 12 entries this (the 9th) year. The Master, Colonel David Wynne Davies, awarded the 2016 prize to Geraint Williams' team from Swansea University. Work by Patrick Dodds has developed a corrosion inhibitor (aptly named "Hexigone") to replace hexavalent chromate, which is being phased out on safety grounds. Hexigone offers better protection too.

18th Kelly Lecture

Introduced by Howard Stone, Ric Parker (recently retired as Director of R&T for Rolls-Royce) delivered the 18th Kelly Lecture under the title of *Advanced Materials - Flying High*.

He briefly recalled Tony Kelly's many contributions to the Rolls-Royce Materials Board. Then he summarised the dramatic changes in operating conditions and efficiency of aero-engine gas turbines driven by customer requirements (eg cost) and design factors (eg materials). Raising the operating temperature increases the production of nitrogen oxides but new combustion technology shows promise. Bigger fans produce better propulsion efficiency. The main limits imposed by materials are at the back end of the compressor and the first stage of the turbine, where the inlet temperature is 1700°C and the tip speed is around 1,000 mph (giving a load per blade equivalent to the weight of a bus).

He noted engineering developments in the structure of wide chord fan blades where materials based around Ti-Al show promise. Rolls- Royce is supporting work on near net-shape casting of these low-ductility materials.

Nickel-based alloys are reaching their limit. For the disc strength is critical for the hub, creep resistance for the rim. Forging to create a gradient of grain structure helps. The inclusion of Ru and Re is beneficial but both are sourced from less-than-ideal parts of the world so alternative ways of improving the properties are preferable.

Coatings are essential to prevent oxidation and corrosion (a significant problem in regions with polluted air) and to provide a thermal barrier. Good adhesion is vital. Tribological factors become significant in sandy regions. Organic, metal and ceramic matrix composites have potential uses but not yet in rotating parts. Modelling is very useful for designing and optimising alloys but there will always be a need to confirm the results by experiment! Excellent materials are essential but so is the manufacturing technology and associated process modelling. 3D printing is being trialled.

In 1986 Rolls-Royce decided to establish a number of academic partnerships through University Technology (and equivalent) Centres and Advanced Manufacturing Research Centres. Now the "Catapult" high value manufacturing programme helps turn good ideas into manufactured components. Rolls-Royce are also heavily involved in the EPSRC Materials Strategic Partnership, which includes the Department (see *Issue 27*). In short, they seek to develop "Technology through Partnership".

Proposing the vote of thanks and drawing the forum to a close, Harry Bhadeshia congratulated Ric on his impressive survey and for his insights and skills. He supported Ric's views about the need not only for creating materials with good properties but also for turning them into useful components - and also on the importance of experimental verification of the results of computer modelling.

The next Forum will be held on 20 June 2017; **www.msm.cam.ac.uk/forum**

Engineering Atoms - Cathie Rae

Mainstream research in the Rolls-Royce UTC focuses on the materials used in gas turbine engines for components such as blades and discs. Reliable temperature monitoring is essential in this research and also during routine operation of these engines but traditional thermocouples suffer from drift. In parallel with her usual activities, Cathie Rae, with PhD student Michele Scervini, focused successfully on this problem and in October 2016 Cambridge Enterprise announced that it had licensed a "revolutionary thermocouple cable technology" to a US company. The new thermocouple material is also a nickel-based alloy able to operate at very high temperatures.

With this further landmark in her research it is timely to look back at how Cathie's career developed. As a child she became interested in science through accompanying her father on scientific fieldwork visits to sub-Saharan Africa and by the USA vs USSR space race. Subsequently she read Materials at Oxford and remained there for a DPhil on grain boundary migration, work that was strongly influenced by David Smith with additional help from Peter Hazeldine. Subsequently that topic ceased to be of major interest for many years but it has now come to the forefront and underlies another of her current projects.

A number of postdoc posts, including a Rolls-Royce Research Fellowship attached to Girton College followed her DPhil. Then there followed a period away from research; maternity leave for postdocs was not available in those days. Cathie and husband Gareth have three (now grown-up) children. Instead she spent several years with UEA getting most satisfaction out of teaching Physics to students wishing to move into science, some of whom proved very successful. She got her first "permanent" job in 2002 as a Lecturer here, thus escaping from the career structure problems often faced by post-docs, and she has gone from strength to strength, becoming Professor of Superalloys in 2015. Not surprisingly this career path has led her to clear views of the difficulties women face in careers in science as well as keen involve-ment in outreach activities such as the "Engineering Atoms" demonstration in the Royal Society's Summer Science Exhibition in 2015 (see *Issue 28*).

In parallel with her research Cathie has regular teaching duties in the Department and supervises first and second year Engineers in Materials in her College, Emmanuel. On the administrative side of an academic's life her major responsibility is running the EPSRC Centre for Doctoral Training in Structural Metallic Systems for Gas Turbine Applications, although the Principal Investigator is based in Birmingham. On a wider front she was delighted to be involved with the Royal Society Committee for Science Industry and Translation looking into the challenges of recognising exploitable academic ideas and turning them into products of commercial value.

Congratulations

Zoe Barber, promoted to a Personal Chair (Oct 16)

Jason Robinson, promoted to a Readership (Oct 16)

Nick Jones, appointed University lecturer (Oct 16)

Rachel Evans, appointed University lecturer (Jan 17)

Tom Bennett, University Research Fellowship, Royal Society

Sir John Meurig Thomas, 2016 Royal Medal, Royal Society

Lindsay Greer, Leibniz Medal of the IFW, Dresden and the Edward DeMille Campbell Memorial Lectureship, ASM Int.

Anuja Datta, College Research Fellowship, Clare Hall

Paul Coxon, Cambridge University Public engagement award 2016

Fernando Roberto Pereira, PhD student, CISER award for Innovation Technological

Daniel Varley, Part II student, Armourers and Brasiers European Placement Prize

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Department networking groups include *LinkedIn*, *Facebook and Twitter.*
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