Cambridge
materialeyes

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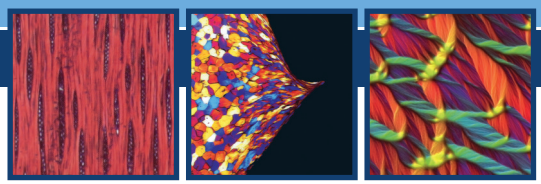

From around the Babbage Lecture Theatre to Charles Babbage Road

After years of planning and several months spent dismantling, moving and reassembling equipment and filling, moving and unpacking thousands of crates (to say nothing of filling rubbish skips!) the Department is now at home in its new building on the West Cambridge Science and Technology Campus. Admittedly some work remains to be completed to get all the equipment fully re-commissioned and to deal with those snags that have an annoying habit of remaining hidden until a building is brought fully into use. Happily the teaching areas were ready for the start of term and, despite concerns that the long journey to the west might deter some undergraduates, numbers have held up very well; indeed the number in the first year is the highest for some years. Forming a prominent landmark on the West Cambridge campus, our new building unites all the Department under one roof for the first time. It contains 31% more laboratory space than the previous facilities and will allow the Department to continue to thrive and grow.

No such move is complete without an official opening ceremony. So from mid-morning on Friday 4 October some 250 people — present members of the Department, some notable past members and guests from around the University — assembled in the new Common Room. They were joined by the official party, whose members had already enjoyed a brief tour of the building. At 11.30am the Vice-Chancellor opened the proceedings with praise for the work of the Department and for Lindsay Greer's leadership of the project through to completion. Lindsay then introduced Professor David Delpy, Chief Executive of the EPSRC, who commented generously on the work of the Department. David mentioned not only some research projects, but also the Department's very important contribution to the education and training of materials scientists. The Chancellor of the University, Lord Sainsbury of Turville, followed and, after noting the Department's world-leading position in Materials Science, formally declared the building open. Lindsay rounded off the formal proceedings by thanking the Chancellor for opening the building and the other speakers for their kind words. He expressed the Department's great gratitude to the benefactors whose contributions, on top of the funding by the University, had significantly enhanced the facilities in the building (more details of these are given on page 2). He then encouraged all present to inspect the displays and join the tours of the building, and to enjoy the reception in the Common Room. Much animated conversation continued there for another hour or more as old friendships were renewed and new ones made.

Pictured L-R: David Delpy, CEO of EPSRC; The Vice-Chancellor; Professor Lindsay Greer, outgoing Head of Department; The Chancellor

More information about the opening ceremony is available on the University's news website; details of the building are provided in the illustrated booklet distributed at the opening. Both can be accessed from **msm.cam.ac.uk/news/index.php**

Editorial

As is evident from this issue, the Department has just undergone the biggest transformation in its history. Not only do we have a new building, three miles away from our previous site, but we also have a new Head of Department and two (rather than one) Deputies. The move itself has been a period of massive upheaval for all members of the Department, but everyone has worked together to get things up and running as quickly as possible. This is particularly true of all our support staff, who have managed not only to cope with the period when we were simultaneously occupying both sites but have sought to make the new labs and social spaces as vibrant and functional as possible.

Beneath all this excitement, the normal work of the Department has had to continue: our submission to the Research Excellence Framework (REF), the catchily-titled successor to the Research Assessment Exercise (RAE), is almost complete and the results, when they are announced in a year's time, will hopefully show that this continues to be one of the leading departments in Cambridge and the UK.

Professor Mark Blamire,
Head of Department

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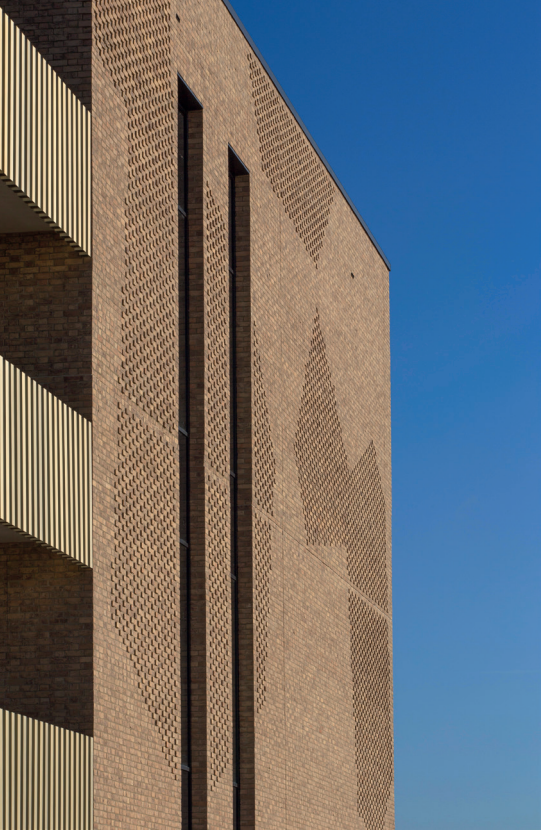
Inside:

In and out of the new building	2	*ABC Forum 2013*	3
Changes at the top	2	*Age of Enlightenment*	3
A sad note	2	*Film Buff – Zoe Barber*	4
Microscopic observations	2	*Congratulations*	4



In and out of the new building

Teaching is central to the Department's mission. The Teaching Suite endowed by The Worshipful Company of Goldsmiths is used for undergraduate third- and fourth-year and MPhil lectures as well as research seminars, which are at the heart of the intellectual life of the Department. The Ann D Foundation Teaching Laboratories ensure that practical skills remain at the heart of the Department's undergraduate training; their co-location with the Department's research laboratories is consistent with our view that cutting-edge research should directly inform teaching.

As technology rapidly develops, research is increasingly driven and streamlined by advanced computer modelling at length-scales from the atomistic to the macroscopic. The Glover IT Suite provides top-quality computing facilities, accelerating research progress and enabling students to learn these increasingly important skills.

Meetings of all kinds are integral to an active, cross-disciplinary research community. The Armourers & Brasiers' Room provides adaptable, effective space for such meetings in a prominent location at the top of the building.

Amongst the building's most advanced features is the Wolfson Electron Microscopy Suite described in the accompanying article.

The building incorporates a number of impressive and unusual features to reduce its energy and water consumption, including: a sophisticated mixed-mode ventilation system that provides natural ventilation to non-laboratory areas; a large photovoltaic array at roof level that will provide 3% of the total energy use of the building; a green roof planted with wild flowers covering the EM Suite; and rain-water harvesting at roof level.

Externally the building is also striking. Through ingenious and skilful brick-laying the brickwork has been made to give an impression of polygonal 'grains' as seen in a microstructural section, reminding us all of the importance of microstructure in our subject.

(*Photograph by Morley von Sternberg, courtesy Architects NBBJ*).

Changes at the top

At the end of September Lindsay Greer and Bill Clyne completed their stints as Head of Department and Deputy Head. Mark Blamire is now Head, assisted by two Deputies: Serena Best looking after research and Zoe Barber focusing on teaching. At the same time David Duke retired after many years service, the last 21 as Principal Technician. He is succeeded by Nathan Cliff. We thank Lindsay, Bill and David most warmly for their great efforts on behalf of the Department and offer best wishes to Mark, Serena, Zoe and Nathan at this very important time.

A sad note

Derek Starnell, remembered by many who worked in the Department in the second half of the twentieth century, died in September at the age of 85. Derek's University service started in the 1940s in the Cavendish, was interrupted by a spell in the Navy, and resumed in our Department, as an electron-microscope technician. He became Principal Technician in succession to Brian Goshawk, retiring at the end of 1992.

Microscopic observations

A thriving research topic, and key underpinning technique for much of materials science, electron microscopy (EM) has been a cornerstone of the Department for many years. The move has provided an opportunity to design and build a bespoke EM facility with the highest world-class specifications and sufficient flexibility to accommodate not just today's electron microscopes but those likely in the future. The Wolfson Electron Microscopy Suite offers facilities from the simplest scanning electron microscopy imaging to the most sophisticated atomic resolution transmission electron microscopy and spectroscopy. The Suite is used by nearly all our groups and by users from 10 other University Departments.

Many of the design team visited key EM facilities in Europe and Australia to garner best practice, good ideas and key design elements for the new suite. In the final design all the factors that could seriously impact on performance were minimised.

Pre-eminent in the design of the Suite's foundation was the need to achieve maximum vibration attenuation. The foundation comprises a massive single slab of steel-reinforced concrete, 2m deep, separated from the foundation of the main building. The concrete was specially formulated to avoid cracking and the whole concrete foundation was laid as a single continuous pour lasting 12 hours, involving 200 lorries from 5 cement factories.The massive slab ensures minimal transfer of vibrations at critical frequencies from outside but microscopes need water chillers and other equipment with motors, fans, pumps etc. These are housed in a dedicated service room, the floor of which is supported by springs to attenuate the relatively high frequencies generated.

To minimise stray magnetic fields individual steel rebars in the concrete foundation were electrically isolated to minimise earth loops and the wiring in the suite has a radial design. In addition the uninterruptible power supply (UPS) room was magnetically shielded from the rest of the building, as was the main cable from the UPS to the individual microscope rooms. A complete magnetic shield was formed using four layers of 2mm low carbon steel sheet (18 tonnes in total) for the room housing the Titan aberration-corrected microscope, giving a high degree of attenuation enabling the fields in the room to be well below the 10 nT target.

Fluctuations in temperature can lead to excessive sample drift when analysing at the sub-angstrom level. Very stringent temperature stability criteria were met through room capacity (large rooms provide thermal inertia), the use of chilled panels to remove heat and very low velocity fresh air replacement. The room environment was modelled using computational fluid dynamics and thoroughly tested over a period of several weeks to ensure temperature stability throughout the suite

Acoustics is the final factor. Each microscope room on the slab is in essence a separate 'box'. The walls and ceiling of each microscope room are not connected to those of its neighbours so as to minimise any possible acoustic or vibration cross-talk. The walls and ceilings incorporate a wooden structure, which, as well as being strong, provides a degree of acoustic attenuation. There are also acoustic panels on the walls and ceiling in each microscope room.

Vital to the success of the EM Suite are the technical and support staff, whose skill and dedication will ensure a very bright future indeed for materials electron microscopy here.

(*Paul Midgley and John Leake*)

ABC Forum 2013

Opening the Forum, Bill Bonfield, a Past Master of the Armourers and Brasiers' Company, thanked the sponsors, whose generosity enables participants to attend without charge, and Lindsay Greer, for his contributions to the success of each Forum.

Daan Frenkel (Cambridge) reviewed the challenges in designing complex 3D structures that can assemble themselves from colloids. He led us painlessly through some important thermodynamic arguments and some interesting history to recent computer simulations and experiments using DNA mixtures. He noted that complex self-assembly is difficult because it seeks to create non-equilibrium structures. He concluded that "Entropy is even more important than we thought".

Peter Lee (Manchester and RAL) uses synchrotron X-ray sources for "4D imaging" (3D images with real-time changes) to provide data for "integrated computational materials engineering" (ICME), which can improve product design, processing and performance. Examples included nucleation and growth of β Al_5FeSi in aluminium re-melted from impure scrap, the formation of ice lenses that cause heaving of permafrost and freckle defects in superalloy castings.

Alison Davenport (Birmingham) uses X-ray imaging to study corrosion, knowledge of which is essential for life-time prediction models. Imaging and point-by-point current density measurements have been used to follow the formation of "lacy-top" pits by localised wet corrosion of a steel; a ferric chloride layer at the bottom of the pits was detected by X-ray diffraction. Other examples included atmospheric corrosion of airframes, and corrosion and wear of titanium in body fluids. The care needed in using ionising radiation to study ionic processes was noted.

Karen Scrivener (Lausanne) explained that, although, per tonne made, concrete is environmentally friendly, so much is produced that ways must be found to reduce the total CO_2 emission, 60% of which arises chemically. There are very few possible alternative materials that form space-filling hydrates on setting. Instead partial substitution of the CaO is preferable but all blends have a lower rate of strength development. Understanding the hydration process is essential; nuclear magnetic resonance is used to investigate the nanoscale structure and computer modelling has been developed.

Oliver Gutfleisch (Darmstadt) reviewed critical aspects of permanent magnet and magnetocaloric materials. A material's importance has to be judged against supply risks for its constituents and its ease of recycling. We must reduce rare earth content while retaining properties and use key elements as efficiently as possible, e.g. diffuse dysprosium into Nd-Fe-B to concentrate it on grain boundaries. Magnetocaloric materials using both structural and magnetic transitions (e.g. Ni-Mn-In-Co Heusler alloys) are more efficient than traditional refrigeration.

The Rt. Hon. Viscount Lifford, Master of the Armourers and Brasiers' Company presented the Company's *Materials Science Venture Prize* to Robert Hill, Natalia Karpukhina and David Gillam of Queen Mary, University of London to assist them, with input from Pushkar Wadke of Queen Mary Innovations Ltd, to develop a prototype "remineralising" toothpaste by extending their work on novel bioactive particles that enter and repair holes in teeth. Robert Hill spoke briefly about the project, pointing out that the classification of toothpaste as a "cosmetic" rather than a "medical" product has advantages!

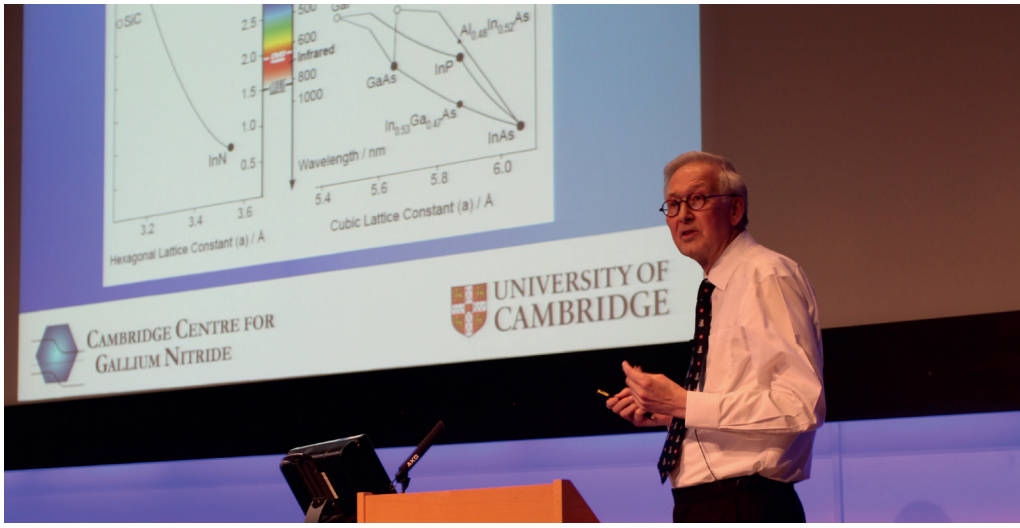
Age of Enlightenment

Starting the 15th Kelly Lecture, *Lighting the Future*, Colin Humphreys noted that worship of *Ra*, the Egyptian sun god, and *Sin,* the Babylonian moon god almost 5000 years ago, illustrated the importance long attached to lighting by the human race. He highlighted the world problem of the demand for energy, now (almost certainly) growing more rapidly than ever before. He cited the Bruntland definition '*sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*', pointing out that it omits cost. Incandescent lighting is very inefficient and compact fluorescent lights are slow to power up, only 20% efficient and contain mercury. Energy efficiency is a top priority and GaN is the key to large energy savings. "GaN" means materials in the AlN-GaN-InN system, which can be grown as quantum well structures with a wide range of emission wavelengths depending on composition, although there remains a "green gap". Commercial white LEDs use phosphors to create a satisfactory spectrum; white emission from a single chip is an aim. Commercial white GaN LEDs are now 30% efficient and 60% efficiency has been achieved in the laboratory. Lighting uses about 20% of all electricity so a switch to efficient LED lights could save the UK £2bn annually.

Colin demonstrated some of the range of GaN lights available and the quality of the colour rendering with examples from UK-based PhotonStar and Forge Europa, albeit based on expensive imported LEDs. One reason for the high cost is that the LEDs were grown on small diameter sapphire or SiC wafers. Colin's group has developed a process to grow them on large diameter silicon wafers, reducing the substrate costs by 90%, and aims to process them in a 6" silicon foundry. Deposition of AlN, AlGaN and holey SiN or ScN layers beneath the active layer is necessary. The total thickness of all the layers of their devices is about 2.5 μm (competitors require 5 μm) and the growth rate is comparable to that of grass! Commercial development has involved acquisition of his spin-out company *CamGaN* by *Plessey*. Looking forward, Colin anticipates specific designs for LED lights (not imitations of traditional forms), phosphor-free LEDs and a solution to the "green gap" problem.

Once perfected, LED systems emitting a colour spectrum close to that of natural light should bring health benefits including the generation of vitamin D, resetting circadian rhythms to overcome jet-lag and boosting serotonin levels; use in hospitals could be particularly beneficial. LEDs with deep UV emissions could be used to purify water and LED light could be used as the carrier for WiFi or in electronics.

In the vote of thanks, Anthony Kelly also started with some history, telling us of the prediction by Mendeleev and subsequent finding and naming of several elements, including gallium, which was discovered by a Frenchman called Lecoq. *Gallia* is the Latin name for France so a natural choice for the name - but *gallus* is Latin for *coq* so had he named it after himself? He thanked Colin Humphreys most warmly for the informative and clear explanations of matters historical and scientific.



Film Buff – Zoe Barber

The deposition of thin films of materials, and combinations of materials, has long been a significant activity in the Department, and has played a major role in Zoe Barber's life since she embarked on her PhD after completing Part II in 1982. Originally based on sputter-deposition, the facilities have expanded to include other techniques, such as pulsed-laser deposition. Zoe is now in overall charge and, after successive steps up the academic ladder, is now a Reader and one of two Deputy Heads of Department.

At the moment everyone's focus is on settling into the new building. After many years working from a basement office in the Annexe, Zoe welcomes having everyone in one building and the view from her new office is an added bonus! Moving the deposition equipment went smoothly, although returning all the systems to full working order has understandably taken time. Now the many projects supported by these systems can continue. The facilities form a key component of the Device Materials Group, but Zoe also enjoys collaborating with a broad range of researchers, including others within the Department: for example, Gallium Nitride (Colin Humphreys), Medical Materials (Serena Best) and the Gordon Laboratory (Bill Clegg and Bill Clyne); other Cambridge Departments, such as Electrical Engineering; as well as other universities, and local companies.

Zoe's departmental role as Deputy Head, with responsibility for teaching, now fills a substantial amount of her time. With the development of post-graduate MPhil courses, the introduction of EPSRC "Doctoral Training Centres" and the advent of the *Master of Advanced Study* degree (for graduates of other universities who come to Cambridge to take our Part III course), the Department's teaching responsibilities are now far wider than they were in the past! She has also been involved from the start with the on-line teaching resources project *DoITPoMS*. She has been a Teaching Fellow of Downing since 2000 and is Director of Studies for first-year Physical Natural Scientists as well as President of the Downing Students' Science Society.

With all that, some relaxation is essential! Daily cycling to and from the new building helps. When time permits, holidays are decidedly more adventurous, for example, the Alaskan wilderness and an expedition into Monument Valley at dawn with a Navajo guide. And she always hopes to find more time for musical activities, singing and playing the piano.

Congratulations

Mark Blamire, Head of Department from 1st October 2013
Neil Mathur, Personal Professorship from 1st October 2013
Cate Ducati, Readership from 1st October 2013
Rachel Oliver, Readership from 1st October 2013
Nathan Cliff, Principal Technician from 1st June 2013
Colin Humphreys, Platinum Award, IOM^3
Pedro Rivera, Vanadium Award, IOM^3
Sir John Meurig Thomas, Foreign Member, Swedish Royal Academy of Science
Xavier Moya, University Research Fellowship, The Royal Society
Tom Bennett, Junior Research Fellowship, Trinity Hall
Howard Stone, Department Teaching Prize
James Curran and Lianne Sallows, Department prizes for Contributions to Teaching
Kylie Beasley, Fabian Massabuau, **Maya Shinozaki** Departmental Demonstrator Prizes
Pierre Burdet, 1st Poster Prize, European Microbeam Analysis Society
John Davenport, 2nd Poster Prize, ECI Conference, Germany
Emma Pewsey, Access to Understanding Award, Europe Pubmed Central

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The Department has networking groups on *LinkedIn* and *Facebook*.
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