Cambridge
materialeyes

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Part III Silver Jubilee

This year marked the graduation of the Department's 25th Part III cohort, which was celebrated with our annual Part III dinner, held at St Catharine's College. We were joined by Peter Mason, a dear friend of the Department who generously sponsors the dinner and a number of undergraduate summer research projects every year. The Part III course was introduced for the 1998-99 academic year and, since then, nearly 500 students have graduated with an MSci degree. The course is continually evolving to cover state-of-the-art research in a wide variety of areas of materials science, including structural, functional and biomedical materials, soft matter, and materials characterization. The course includes an individual research project, which has developed to allow each student to be embedded within one of our research groups across two terms.

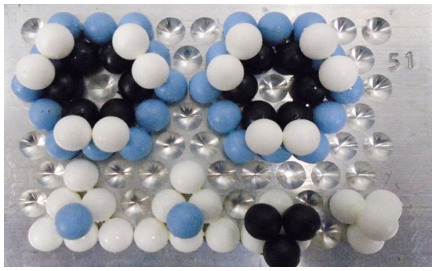
Since the introduction of Part III, the rest of our course has also evolved. For example, Part II now includes a group Alloy Design project, in which students design, process, and characterize alloys to meet specified criteria, such as targets for microstructural stability, oxidation resistance, and high strength over extended periods at high temperature. However, some things remain constant, such as the 1st-year practical in which students stick together polystyrene spheres to demonstrate close-packed structures!

Changes in the Teaching Office

In December 2022, we were excited to welcome Dr Peiyu Chen as a new Teaching Associate. Peiyu graduated from Part III in 2014, before completing a DPhil at Oxford. She carried out postdoctoral research at the other place, and subsequently worked as a teaching-focused lecturer at Sheffield, before returning to Cambridge to work closely with Jess Gwynne and Rob Thompson to help coordinate and deliver our undergraduate course. We are also pleased to welcome to the Teaching Office team Peter Brindle, who has recently joined Stephen Mitchell and Lianne Sallows as a new administrator.

New Teaching-focused career pathway

The University recently introduced a new and long-awaited Teaching and Scholarship career pathway for teaching-focused academics, and we were absolutely thrilled that both Jess and Rob were successful in the first round of promotions: Jess becoming the Department's first Teaching Professor; and Rob being promoted to Associate Teaching Professor.



Editorial

As we dive into the latest edition of Material Eyes, we can't help but marvel at the vibrant tapestry that is the Department of Materials Science & Metallurgy. It's not just a department, it's a community of innovators, learners, and trailblazers.

Heartfelt congratulations to our 25th Part III cohort. Your journey over the last few (very) challenging years has been inspiring, and your graduation marks a milestone in the legacy of our Department. Speaking of legacy, we were delighted to have a chance, at last, to celebrate the many contributions of some of our recent retirees at a special dinner held at Madingley Hall in November. We look forward to continuing to benefit from their wisdom for many years to come!

In the spirit of growth, fresh perspectives have been added to our dynamic teaching team, as we welcome several new members. Our commitment to a teaching-focused career pathway remains unwavering, ensuring a nurturing environment for both educators, researchers and students alike.

This year's Armourers & Brasiers' Forum again exemplified our dedication to fostering connections and knowledge exchange. It's where new ideas are forged and collaborations sparked, embodying the essence of our academic pursuits.

And finally, we're thrilled to announce the appointment of Howard Stone to the Tata Steel Professorship of Metallurgy. His expertise, along with that of David Collins (recently appointed as Mike Ashby Associate Professor in Materials Science) will further elevate our standing in the realm of metallurgy. Looking ahead, we expect to be issuing further calls for more pioneers to join us on our exciting journey early in the New Year.

Wishing you all the best for a Happy 2024.

James, Ruth and Jason

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ABC Forum 2023

A large audience was treated to some fascinating talks and presentations during the afternoon of 20th June. Proceedings began with a welcome from Mr Mike Goulette, Past Master of the Armourers & Brasiers, and current Chair of the A&B Materials Science Committee, followed by a beautifully illustrated presentation on Crystallization-Driven Self-Assembly, from Prof. Rachel O'Reilly, FRS, Head of the School of Chemistry at Birmingham University. Her group has worked on the fabrication of well-defined assemblies of anisotropic polymer-based nanoparticles, such as 2D platelets or cylinders: their shape, size distribution, and surface properties can be precisely controlled through the balance of hydrophilic and hydrophobic regions. Applications include catalysis, and drug delivery.

Prof. Richard Harrison, Head of the Earth Sciences Department here in Cambridge, then described his quest for radical new routes to the creation of environmentally friendly, sustainable permanent-magnet materials. These are important in achieving net-zero carbon emissions through 'green' energy generation and transport, which currently are largely reliant upon rare-earths and other elements with significant environmental and geopolitical supply issues. Lessons are being learnt from the natural formation of FeNi-based magnetic minerals within meteorites. Whilst the slow-cooled environment of a meteorite (of order 1 K / Myr!) cannot be reproduced in the lab., detailed structural characterization using synchrotron-based methods is leading to the identification of pathways to novel, hard, and stable magnetic materials formed from widely available elements.

L to R: Dr Markus Hellenbrand, winner of the A&B Postdoctoral Prize, with Prof. Ruth Cameron, Joint Head of Department, and Mike Goulette, Chair of the A&B Materials Science Committee.

Prof. Julian Jones, from the Department of Materials, Imperial College London, introduced us to the huge importance of glass, and its incredible versatility in many, many areas of life. In particular, he described the applications of *Bioglass* for bone regeneration, healing of chronic wounds, and for fighting infection and antimicrobial resistance. A recent development is borate-based 'Bouncy Bioglass', which is self-healing, 3D-printable, and can be used to produce tough, biodegradable scaffolds for high-quality cartilage regeneration.

Professor Victoire de Margerie

Attendees at the Forum are never disappointed by the *Brief Encounters* session. This year included nine, thoroughly entertaining, 3-minute presentations from PhD students and postdoctoral researchers on topics ranging from machine-learning for materials prediction, to multi-dimensional electron diffraction, and light-triggered molecule release; covering aspects of semiconductors, bulk metallic glasses, granular materials, electrochemical actuators, and ferroelectric polymers. The slick performance and professionalism of all presenters must be highly commended.

Prof. Xavier Moya, of our own Department, reported on scientific advances in barocaloric materials, with applications as solid-state heat-pumps for zero-carbon heating and cooling. Xavier is founder and director of a spin-out company, Barocal Ltd. This talk was followed by the presentation of the *2023 A&B Materials Science Venture Prize*, by the Master of the Company, Mr Jonathan Hale, to *BindEthics Ltd*. Co-founder and CEO, Maria Garcia, gave us a brief introduction to their technology: innovative bio-adhesives derived from food waste that can be used to manufacture low-cost, scalable, low carbon-footprint engineered wood products.

The 24th Kelly Lecture, *Materials Science: Key opportunities and challenges by 2035*, was delivered by Prof. Victoire de Margerie, the founder and Vice-Chairman of the *World Materials Forum*, which promotes international collaboration to find 'innovative and impactful solutions to use materials smarter, less and longer'. She emphasized the need for clear, focused thinking when considering optimal steps towards sustainable economic growth. Examples were given of targeted materials breakthrough technologies that must be rapidly scaled up.

The Department is immensely grateful to the Armourers and Brasiers' Company for their support, as well as AWE, the Henry Royce Institute, the Institute of Materials Minerals & Mining, the Materials Processing Institute, and Rolls-Royce for their generous sponsorship of this event.

Save the date for the next ABC Forum to be held on 18th June 2024.

Henry Royce Battery Suite

Cambridge University is a founding partner in the *Henry Royce Institute*, the UK national institute for advanced materials research and innovation, headquartered at Manchester University. *Royce@Cambridge* (headed by Goldsmiths' Professor, Manish Chhowalla, see Material Eyes 36) provides open access to an interdepartmental network of materials deposition, fabrication, and characterization facilities. Adding to this is the Battery Suite, opened in the Materials Department on 31st October, to enable scalable manufacturing and processing of battery materials. The facilities will accelerate novel materials to battery applications, and bridge the gap between innovation in the lab and industrial collaboration.

The equipment available includes a glove box, vacuum oven, planetary mixer, centrifuge, freeze dryer, shear mixer, reactor synthesis, digestion reactor, and rotary evaporator. This comprehensive suite will accommodate a variety of materials and overcome difficult processing operations including synthesis, digestion, separation, drying, purifying, mixing, and washing.

The formal opening included a Battery Symposium with speakers from academia and industry including *Cornish Lithium, Nyobolt, Echion Technologies, Sigma Lithium*, and *Anaphite*.

Prof. Anne Ferguson-Smith, Pro VC for Research, with Prof. Chhowalla and Prof. Tony Horner, CTO of the Henry Royce Institute, at the opening of the Battery Suite.

For further information email: royce@maxwell.cam.ac.uk

Map of a Career

Professor Michael Ashby, FRS, FREng, CBE, is known for his development of a systematic approach to materials selection for engineering design, and of materials and mechanism "maps" – methods of presenting large bodies of information to give a broad overview. He has honorary doctorates, honours and awards from many UK and international universities and societies, which recognize his major contributions to materials science, engineering, design, sustainability, and pedagogy.

Left to right, Prof. Ashby with David Collins, newly appointed Mike Ashby Associate Professor, and Prof. James Elliott, Joint Head of Department.

Born in Bristol in 1935, Mike attended schools in Sydney, Manchester, and Belfast. After a year at Queen's University, Belfast, he was encouraged to apply to Queens' College, Cambridge for a Natural Sciences degree. He started Part II in organic chemistry but, just in time, discovered the attractions of the Metallurgy Department "with a workshop, where you could make things". He graduated with a 1st class degree in 1957 and stayed on for a PhD, supervised by Gerry Smith, exploiting and developing the still-fresh capabilities opened up by transmission electron microscopy. The Department was a hub of innovation, with its new Head, Alan Cottrell, bringing his pioneering work on dislocation theory and fracture mechanics, and initiating research on superconductivity and field-ion microscopy. Stimulating international links included visiting researchers from commercial laboratories in the US.

Recognizing the importance of experiencing other environments, Mike followed a brief post-doctoral position in Cambridge with a move to the Institut für Metallphysik in (war-damaged) Göttingen. This was a fascinating place: post-war European science was recovering and expanding, with Peter Haasen in Göttingen and Alfred Seeger in Stuttgart combining new ideas from the US with the long-established excellence in physics that had been the hallmark of science teaching in pre-war Germany. Mike and his wife learnt German, and he gained teaching experience.

From Germany, Mike moved to the Division of Engineering and Applied Physics at Harvard, working first with Professors Bruce Chalmers and David Turnbull. At that time the US Government, in response to the perceived superiority of the Russian space programme, established a set of ARPA-funded Materials Research Laboratories (MRLs). These were remarkable in bringing together metallurgy, ceramic science, polymer science, and applied physics to form the first true Materials Science groups. They were successful (many of them still exist) and they generated industrial interest and support, making them a stimulating environment for a young researcher. Harvard had successfully bid for an MRL, and it was this that Mike joined. His research projects on deformation mechanisms, sintering and creep fitted well under the MRL umbrella, leading to his promotion to Full Professor. When Bruce Chalmers, the long-time editor of a newly founded (in 1953) journal *Acta Metallurgica* (now *Acta Materialia*) retired, he asked Mike to take his place, a post he held for 20 years.

Returning to Cambridge (UK) in 1974, Mike took up a position in the Engineering Department, with a remit to rethink the teaching of Materials to engineering students. In striving to connect materials education with other fields of engineering, he began to develop Selection Maps, or Ashby Charts, which so many use today. Collaboration with David Cebon led to development of software for systematic materials selection (the *Cambridge Engineering Selector, CES*) as part of a wider development of computer-aided teaching in the Department. The success of *CES* and its increasing industrial use led to the founding, in 1994, of a small company, *Granta Design Ltd*. to develop it further, leading to the suite of tools known as the *Granta EduPack* (education), *Granta Materials Selector* (adapted for industry), and *Granta MI* (an enterprise-wide system for sharing materials information), and creation of a set of consortia to work with industrial clients to develop software to meet their materials-related needs. Granta Design grew to ~180 employees, with premises in Cambridge, offices in the US, France, Germany and Poland, and short courses running all over the world.

In response to a Research Council initiative, Mike, together with Professor David Newland and Ken Wallace, negotiated a 10-year grant to establish the *Cambridge Engineering Design Centre* which has recently celebrated its 25th anniversary, now with over 60 staff and students undertaking 'fundamental and applied research to generate knowledge that improves the design process'. Mike is the author of books on *Cellular Solids* (with Lorna Gibson), *Engineering Materials* (with David Jones, Hugh Shercliff and David Cebon), *Materials and Industrial Design* (with Kara Johnson), *Materials Selection in Mechanical Design, Materials and the Environment,* and *Materials and Sustainable Development*. Arising from his interest in industrial design, he held the post of Royal Academy Visiting Professor at the Royal College of Art for two years. Mike's other interests include music (for many years he was a member of a wind quintet) and watercolour painting.

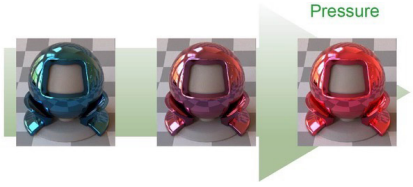
He considers himself to have been lucky in the evolution of his career, which was not planned out, but more a set of accidents. His advice to those just starting out? Seize opportunities as they come, don't agonize about whether they were the right choices – just make them work. The key asset is education, something that the Department provided for him and for which he remains indebted. To help others along the same path, Mike has, this year, endowed the Mike Ashby Associate Professorship in Materials Science, through which dedication to the highest quality of Materials research and teaching can be perpetuated.

The Colour of Superconductors?

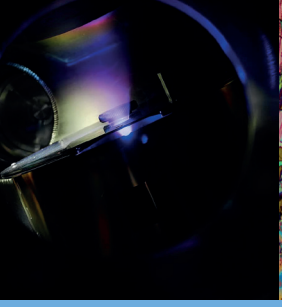
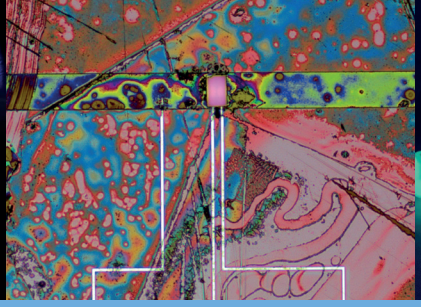
This past year has seen two remarkable claims of room-temperature superconductivity, the first in a hydrogen-rich compound by an American team and the second in a material based on lead apatite by a Korean team. If confirmed, a room-temperature superconductor would change our lives: from affordable MRI machines in hospitals to higher-temperature quantum computers and possibly back-to-the-future-type hoverboards and levitating trains.

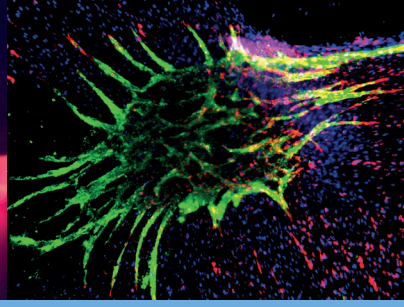
Notably, the proposed hydride superconductor undergoes dramatic colour changes from blue to pink to red as a function of pressure. To assess these claims, a team led by Prof. Bartomeu Monserrat and Dr Sun-Woo Kim in our Department has built computer models of the material. The results can explain the origin of the colour changes (see figure below), but also demonstrate that it is, unfortunately, not superconducting. The models used to calculate these colour changes could be extended to other materials, and an area very relevant to friends of the Department, including the Goldsmiths' Company, is the colour of noble metals and alloys.

Ongoing work by the team (and others internationally) also suggests that the lead apatite compound is not superconducting.



Photorealistic rendering of the modelled hydride, shown surrounding a grey ball with an opening in the centre



Memory Metal Shapes the Future

The young Nick Jones enjoyed building structures, was good at science and maths at school, and thought of continuing into Engineering. Fortuitously, he discovered the fascinating concept of a Shape Memory spring in one of his Physics A-level modules, and this led to his interest in Materials Science. Following graduation from Imperial College, with an MEng in Materials Science & Engineering (2005), he stayed on for a PhD, working on a new titanium alloy for landing gear in the Airbus A380. For him this was an optimal mix of science and engineering, with potential applications in other fields. His research also gave him access to synchrotron-based characterization techniques, and he enjoyed studying deformation and transformation mechanisms in real time, including a return to Shape Memory Alloys and the phenomenon of super-elasticity. Post-doctoral positions at Imperial, and then here in Cambridge, led on to a Fellowship in the Department, before he was appointed to a Lectureship (2016).

Now Professor of Metallurgy, based in the Rolls-Royce University Technology Centre, Nick is enthusiastic to ensure that the next generations are exposed to science, engineering and, particularly, Materials Science, since this had shaped his career choices. He leads the Department's contributions to the Cambridge Science Festival and, recognising that it is essential to inspire both teachers and pupils, is involved with many more outreach initiatives: *Discover Materials* (a collaboration between UK universities that offer Materials-based courses); *The Big Bang*, inspiring young people in STEM; and a collaboration with Oxford University and Imperial College called *Making Materials Matter*, aimed at increasing awareness of Materials Science in state schools.

Nick's current research includes continued work on super-elasticity in titanium alloys: a deeper new understanding has rationalised previous discrepancies in the literature, and there is much commercial interest, from aeroengine design to biomedical applications. Having been taught by him at Imperial, it was poignant to recently be awarded the IOM3 Harvey Flower Titanium Prize. He is also using advanced neutron- and synchrotron-based characterization tools for the study of novel materials for high-temperature applications.

Away from work Nick once did much scuba diving, particularly enjoying surveying under-sea wrecks – but Cambridge is a little too far from good sites for this! He sings regularly in the Ely Consort Choir and is kept busy, through his two children, with under-7's football coaching.

Class of '82 Reunion

Ten Met. & Mat. Sci. alumni from the graduation class of '82 gathered in Cambridge last September for a 40-year reunion. Meeting for lunch at the West Hub Café gave us a chance to recognise each other (many of us had not met since we did our finals) and catch up on families and careers, as well as reminisce about our undergraduate days – including the hours spent polishing specimens, casting aluminium ash trays, our Goldsmiths' industrial tour to Bristol in the cold winter of 1981, and an outing to Clacton-on-Sea during the Long Vac. term. Zoe Barber arranged a tour of the "new" department and we all enjoyed seeing the modern facilities, chatting with some of the staff and researchers and realising how much things had changed in 40 years. We were also delighted to finish off our reunion afternoon in the tearoom, in the company of Rob Wallach, John Leake, Ian Hutchings, Tim Burstein and Harry Bhadeshia who had taught us back in the day. Many thanks to the Department for hosting us and we look forward to returning again!

Nuna Staniaszek (née Turska)

Congratulations

Georgie Burgoyne-Morris, won the UK final of the IOM3 Young Persons' Lecture Competition 2023

Ruth Cameron, Fellow of the Royal Academy of Engineering

Manish Chhowalla, Fellow of the Royal Academy of Engineering

Rachel Evans, Fellow of the Learned Society of Wales

Bea Jones, awarded the Roscoe Medal (Gold prize) for Chemistry at the 2023 STEM for Britain

Nick Jones, IOM3 2022 Harvey Flower Titanium Prize (Retrospective)

Sohini Kar-Narayan, awarded the RSC Peter Day Prize, whilst spinout company, Artiosense (of which she is co-founder and director) was awarded the Institute of Physics Lee Lucas Business Award

Bartomeu Monserrat, The Royal Spanish Society of Physics and BBVA Foundation award

Rachel Oliver, RAEng Chair in Emerging Technologies

Ismail Sami, winner of Chris Abell Postdoc Prize

Joanna Symonowicz, winner of the 2022 Engineering Integrity Society (EIS) Peter Watson Prize

Promotions

Professor Sohini Kar-Narayan (Professor, Grade 12)
Professor Thomas Bennett (Professor, Grade 11)
Professor Jessica Gwynne (Teaching Professor, Grade 11)
Professor Bartomeu Monserrat (Professor, Grade 11)
Professor Xavier Moya (Professor, Grade 11)
Dr Giuliana Di Martino (Associate Professor, Grade 10)
Dr Rob Thompson (Associate Teaching Professor, Grade 9)

Editorial team: Zoe Barber, James Elliott, Lindsay Greer, Nalin Patel and Lianne Sallows
Comments to: alumni@msm.cam.ac.uk. DMSM is also on *Linkedin, Twitter* and *Facebook*. If you would prefer to receive your copy of *Material Eyes* electronically please email alumni@msm.cam.ac.uk.

Figures at top from left to right: Plasma laser deposition of lithium for solid state batteries, Adam Lovett, Dried solvent deposits on an in situ TEM chip, Jedrzej Morzy, Luminescent solar concentrators for solar-harvesting, Morton Lyu, Structures created by human dermal microvascular endothelial cells co-cultured with primary human osteoblasts, Nima Meyer.