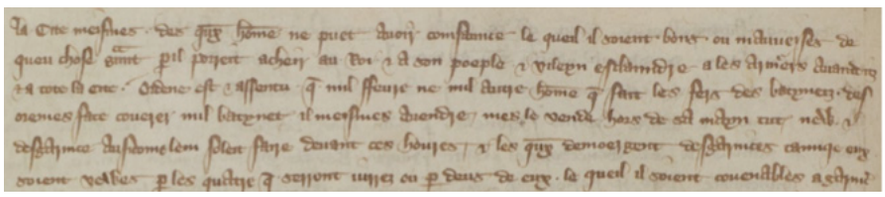
Cambridge materialeyes

Autumn 2022 Issue 38

700th anniversary



The Armourers' Company earliest record, 25 January 1322. London's Court of Common Pleas records the authorization granted to 27 armourers. The grant is concerned mainly with quality control in manufacture and sale. The Norman French inscription on vellum is notable for the naming of individuals with names revealing their métier/mistory (le heumier, helmet maker; le heauberger, mail maker), or their diverse places of origin.

The Armourers & Brasiers' Cambridge Forum on 21st June was a special event, as 2022 marks the 700th anniversary of the Worshipful Company. Peter Bateman, Clerk of the Company, described its origins and history, the charmed life of its Hall (surviving the great fire and the Blitz), the development of a philanthropic and educational focus, and the Company's role today in making the UK the best place to study, research, and practise Materials Science.

In subsequent presentations we learnt how cutting-edge materials science contributes to vital technological advances. Prof. Tom Scott (Bristol University) reported on radiovoltaics: carbon-14 enriched diamond micro-power diode devices that can maintain a constant trickle of electricity over 1000s of years! Such ultra-long-life cells could power devices for the Internet-of-Things, satellites, and sensors in extreme and/or inaccessible locations. Prof. Philippa Reed (Southampton University) described the optimization of materials microstructure for the high-temperature / high-stress environment of turbine engines. Work on the evolution of fatigue damage is leading to aeroengines that can run hotter, and hence more efficiently. The always-entertaining Brief Encounters session, in which nine early-career Cambridge materials scientists presented their work, led the audience through an impressive array of current research – all in under 30 minutes!

We also learnt about two start-up companies built on research within the Department. Prof. Rachel Oliver presented the story behind *Porotech*: the (accidental) discovery that porosification of doped GaN by electrochemical etching can occur through an undoped (and hence non-porous) capping layer, has led to the production of high/low-refractive-index multilayers that act as wavelength-specific mirrors. Success in the Camb. Univ. Business Plan Competition brought business training and contacts, together with seed funding through Cambridge Enterprise. This technology is now set to revolutionize the micro-LED display industry.

The Armourers and Brasiers' Venture Prize was presented by Mrs Nicola Davies, Master of the Company, to this year's competition winner: *ArtioSense* (see page 3). Prof. Sohini Kar-Narayan outlined the technology of their novel surgical device, and Mr Vikas Khanduja, consultant orthopaedic surgeon at Addenbrooke's Hospital, highlighted the impact it will have on implant surgery.

L to R: Bill Bonfield (Chair, A&B Materials Science Committee), Vikas, Nicola, Sohini, and Jehangir Cama, of ArtioSense.

Editorial

Welcome to *Material Eyes*, with a celebration of the 700th anniversary of the Armourers and Brasiers' Company.

This summer, the results of the Research Excellence Framework (REF) recognized the global impact of Cambridge's research in Materials Science. In REF 2021, for the first time, our Department was included together with the Department of Chemical Engineering & Biotechnology, and the Department of Engineering in Cambridge. The excellence of the combined results reflects the close collaborative relationships amongst the Departments, and with other Departments in the Schools of Technology and the Physical and Biological Sciences, and externally, both nationally and internationally. 99% of the outputs within the combined submission were rated as 'world leading' or 'internationally excellent', demonstrating the major impact that researchers in our departments are making every day.

Since our last issue of *Material Eyes*, we have seen the retirements of two long-standing members of our academic staff, Kevin Knowles and Vasant Kumar. They have both contributed hugely to our Department and the wider University over many years and we look forward to a continuing relationship with them as Department Distinguished Research Fellows. We wish them all the best for the future.

Finally, our *Student Opportunity Fund*, launched in commemoration of our centenary, is enabling us to provide further ongoing support to our students – please do consider making a donation at the link on the back page.

We hope that you enjoy this issue of *Material Eyes*.

Ruth Cameron, Jason Robinson and James Elliott, Office of Head of Department

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Inside:

The day was rounded off with the 23rd Kelly Lecture: *Towards a Zero-Carbon Future*, delivered by Prof. Emily Shuckburgh, OBE, Director of *Cambridge Zero*. The urgent need for transformational changes across the sectors of energy supply and storage, transport, building materials, and agriculture is clear; but we must surely be optimistic about the myriad opportunities available. Earlier talks, directly related to such opportunities, illustrate that materials science is making a huge contribution to the science and technology behind a zero-carbon future.

At the Armourers and Brasiers' Forum dinner in Sidney Sussex College, Prof. Lindsay Greer was presented with a statue of St. George in combat with a dragon. St. George represents a figure of great significance to the Company, and this award to Lindsay, who has been the principal driving force behind the Forum since its inception in 2004, marks the deep gratitude held for his major contributions.

Materials Testing

Following retirement from his University post, Prof. Bill Clyne has not been taking it easy. He is Chief Scientific Officer at *Plastometrex* (https://plastometrex.com/), with premises on Cambridge Science Park. The company was founded in late 2018 by Bill and three colleagues who obtained PhDs and held post-doctoral fellowships in his group: James Dean, Jimmy Campbell and Max Burley. *Plastometrex* manufactures and markets a unique benchtop indentation system, which has been designed and developed in-house. This can output the stress-strain curve of a metal via analysis of a measured indent shape. It is an impressive stand-alone device, able to operate without any specific environmental control, little sample preparation, and giving immediate results.

Systems have been sold to both industry and academia, and sales are set to increase as word gets out and new applications arise. A hot stage will be available later this year, and then a smaller, portable version, suitable for use 'in the field' (literally!) for assessment of the mechanical properties of pipelines.

Plastometrex currently has a workforce of around 15 people, many with links to the Department, and is set to expand further. Students have been employed on summer internships, and the company is an enjoyable destination for undergraduate industrial visits.

MSM Centenary Dinner

On Tuesday 19th October 2021 a Materials Science and Metallurgy Centenary Dinner took place in the grand setting of the Goldsmiths' Hall in London, marking the end of the Department's centenary year and celebrating its achievements. The event also served to honour the contributions of all academic and research staff, and to thank the Department's many supporters and sponsors. Attendees, including present and former staff, students, colleagues, benefactors, friends, and members of the Goldsmiths' Company, were treated to a champagne reception, and had the opportunity to look around the glittering surroundings. Once seated in the Livery Hall, guests were welcomed by the Prime Warden of the Company, Dame Lynne Brindley.

Following the dinner, a lively panel discussion was led by Prof. Lindsay Greer. Current and past Goldsmiths' Profs. (Manish Chhowalla and Sir Colin Humphreys, respectively) reflected upon the change and innovation that has accompanied research in the department over the years, and the vital input from industrial partners and collaborators. The influence of Sir Alan Cottrell, another former Goldsmiths' Professor who has been described as 'the father of modern materials science', was also remembered. Dame Julia King, Baroness Brown of Cambridge (Chair of the Carbon Trust, and a recent Vice-Chair of the UK Committee on Climate Change), emphasised the huge importance of materials science in its many contributions to scientific and technological solutions of current global challenges. The Department at Cambridge continues to make these essential scientific contributions, and has demonstrated over the years that it is also a key training ground for materials specialists, and for international leaders.

Sir Graeme Davies
(7 April 1937–30 August 2022)

New Zealander Graeme Davies joined the Department in 1966 (and St Catharine's College in 1967) with a PhD from the University of Auckland. He led a thriving research group, focused on texture and solidification, and his students were enlivened and enriched by his scientific guidance, and by the social environment that he fostered.

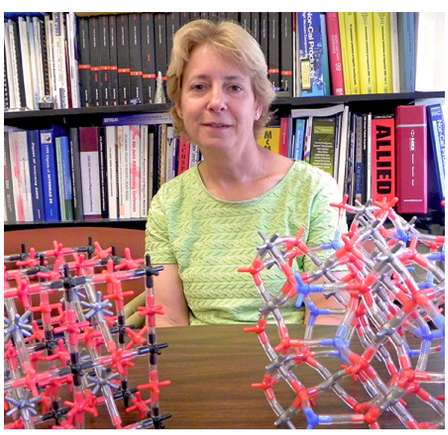
He moved to a Chair at the University of Sheffield (1977); became Vice-Chancellor of the University of Liverpool (1986); Chief Executive of the Higher Education Funding Council for England (1991); Principal and Vice-Chancellor of the University of Glasgow (1995); and Vice-Chancellor and President of the federal University of London (2003-2010).

Graeme held visiting professorships on four continents, received 13 Honorary Degrees, was elected to Fellowships of the Royal Academy of Engineering, the Royal Society of Edinburgh, and of New Zealand, and was knighted in 1996. He was a trustee of many charities and a member, or chairman, of internationally significant institutes, foundations, and advisory boards.

Entertaining and highly likeable, he forged long-lasting friendships, and many across the world cherish fond memories of a remarkable man.

Cambridge UK – Cambridge MA

Caroline Ross, Toyota Professor of Materials Science and Engineering at MIT, Cambridge MA, kicked off her scientific career with a Natural Sciences degree here at Cambridge UK. She didn't have long-term plans while at school, but took science because she found it fun. Like many, she wasn't completely sure which science to go for at university – chemistry ran in the family, as well as gemstones, so she had early experience of playing with chemicals, crystal growth, and an interest in the shapes of minerals. She hadn't been aware of Materials Science as a potential degree course, but enjoyed 1st-year Crystalline Materials, and followed that with Metallurgy & Materials Science at Part II. Her first taste of research, working on a Part II research project (on mass analysis using laser ablation), was very enjoyable, and she chose to continue in the Department with a PhD project on electromigration in thin films, supervised by Jan Evetts.



Having completed her PhD (in 1988), Caroline moved to Harvard University, Cambridge MA, to work with Prof. Frans Spaepen on interdiffusion in amorphous electrodeposited multilayers, using X-ray diffraction to track diffusion in alternating NiP layers with varying P levels. Whilst this research represented fundamental science, it turned out to be very opportune, since amorphous NiP was then being used by the rapidly expanding hard-disk industry, as an exceptionally smooth underlayer for complex layered hard-disk structures. With her experience in the fabrication and properties of this material, she was taken on by a major hard-disk manufacturing company (*Komag*) in Silicon Valley, California, where she spent 6 years in research & development. Besides contributions to a better understanding of electroless plating for NiP production, she also gained an interest in tribology, and in other methods of film deposition which could be used for the many layers required in hard-disks and read-heads. Her expertise proved particularly valuable when assessing the different fabrication techniques used by competitor companies.

In 1997 Caroline moved back to Cambridge MA, this time to MIT as an assistant professor, where she set up her own research group. Beginning with projects inspired by her experiences in industry (e.g. magnetic orientation in thin-film Co-alloys), her research broadened into more general magnetization studies, and the fabrication of very small magnetic features and single-domain structures. Her current research encompasses magnetic, magneto-optical, ferroelectric, and multiferroic materials, nanocomposites, and devices, as well as the self-assembly of block copolymers. At MIT she took on teaching as well, and learnt on the job as she was asked to deliver a range of courses, sometimes in less familiar areas. Having rapidly achieved the coveted goal of Full Professor with tenure at MIT, Caroline is now also Associate Head of the Department of Materials Science and Engineering.

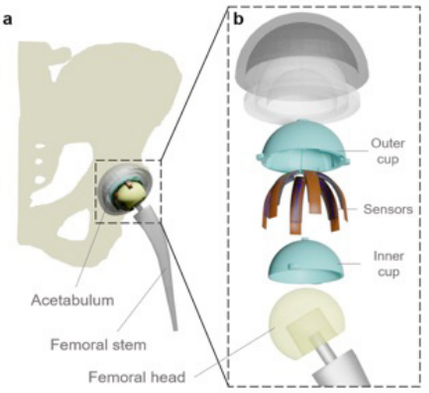
The elder of her two children is just about to embark on a degree course at MIT, probably in Mathematics, but Caroline is a fan of the US system where options remain open, and subject choices can be made later in a degree programme. Her philosophy is that it is just fine not to have a 'grand plan' early on – life is about exploring and gaining experience, and it is impossible to know what you'll most enjoy without that experience. And, whilst the UK education system is more focused than that in the US, and opportunities are often limited, the Natural Sciences course at Cambridge (UK!) does keep options open, and certainly worked for her.

Readers may refer to Issue 37 for mention of Caroline's twin sister, Prof. Frances Ross, also currently at MIT

A step forward for hip replacement

An ingenious method for assisting surgical joint replacement has been developed in Prof. Sohini Kar-Narayan's group, and an ERC Proof of Concept grant (of €150,000) has been awarded to assist in its commercialization. This novel device is based around conformable microfluidic sensors, which give direct quantitative read-out of the forces at different points around the implant. Monitoring and balancing these forces during the replacement surgery leads to greatly improved implant longevity, through optimal positioning. Sensors have been fabricated by a combination of 3D and aerosol-jet printing, and the design of a complete device for use during the trialling stage of hip implant surgery has been optimized using finite -element modelling. With ever increasing demand for the replacement of weight-bearing joints, this represents a very powerful new surgical tool.

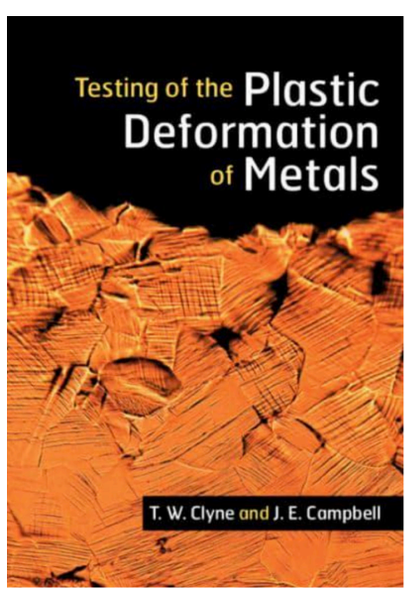
This is reported in: *Conformable and robust microfluidic force sensors to enable precision joint replacement surgery*, L. Ives, A. Pace, F. Bor, Q. Jing, T. Wade, J. Cama, V. Khanduja and S. Kar-Narayan, *Materials & Design* **219** (2022) 110747.



(a) Hip implant: the cup containing the sensors is incorporated into the polymer part of the implant's acetabular cup. (b) Additions to the implant, during the trial stage, consist of an outer cup, the sensors, which lie in the grooves of the outer cup, and the inner cup to act as an articulating surface with the femoral head.

Plastic Deformation of Metals

On 15th April 2021, Harry Bhadeshia hosted *One Hundred Years of Books*, available on YouTube (www.msm.cam.ac.uk/100-years/100-years-books). We are pleased to report that the bibliogenerative powers of the Department's staff and associates are undiminished. A recent addition to the DMSM canon is *Testing of the Plastic Deformation of Metals* by T.W. Clyne and J.E. Campbell. This covers a topic central to our field, namely the deformation of metals, and how that can be characterized. One of our colleagues has noted that this new book offers particularly clear explanations, so that it was the citation of choice when, in work just published on a novel material, they were trying to explain Considère's construction. (Alumni and followers of DoITPoMS will, of course, recall that Considère was concerned with the onset of necking in the tensile plastic deformation of materials, usually metals.) Influence on our field, in teaching and research, depends strongly on such scholarly output.



Calm support on the battle-front!

Jeanne Estabel, who hails from Lyon, has recently taken on the role of Departmental Administrator. Jeanne gained a PhD in Developmental Biology from The École Practique des Hautes Études (Paris, Sorbonne) in 2004 and then came to live in Newmarket with her partner, who was pursuing his own PhD, and their 2-year-old daughter. Her PhD research experience proved invaluable in her search for a post nearby, and she took on the role of animal technician at the Wellcome Trust Sanger Institute at Hinxton, looking after frogs and fish, and learning about mouse-husbandry.

Sometime later, when the major Mouse Genomes Project (https://www.sanger.ac.uk/data/mouse-genomes-project/) was being set up at the Sanger, Jeanne's Developmental Biology background, plus experience with histology and tissue banks, led to her being invited to join the team. Here she remained for about 9 years, playing a central role in the start of the *International Mouse Phenotyping Consortium*: setting up laboratories, recruiting staff and acting as scientific manager. This was followed by the post of Principal Technician at the University's Wellcome-MRC Stem Cell Institute where, amongst many other things, she enjoyed being involved in the design of the new building on the Addenbrooke's site. And whilst at the Stem Cell Institute, Jeanne stood in as acting Departmental Administrator for a period. This experience led to her subsequent roles, first as D.A. in the Psychology Department, then Biochemistry, and now in Materials Science.

One of Jeanne's most fascinating hobbies is battle re-enactment, which the whole family has been enjoying over the years. This consists of travelling to sites around the UK, setting up camp, and re-enacting, for example, Napoleonic and American Civil War battles. Jeanne keeps away from the battle-field itself, preferring a support role, and she very much enjoys talking to public onlookers and teaching them about the history and background to the battles. (During a Napoleonic re-enactment, she was very amused to receive compliments on her incredibly realistic French accent!) At the end of the day, all sides get together in peace, to enjoy chat and music around the camp fire.

Living in Newmarket, Jeanne enjoys getting away to more hilly surroundings, for example, the Lake District and Scotland for hiking with friends, as well as visiting family and friends back in France as often as possible. Away from historic battle sites, she relieves the stresses of everyday life with yoga and meditation.

Sir Harry Bhadeshia

Sixty colleagues and friends enjoyed an excellent dinner, hosted by Prof. Sir Harry Bhadeshia at Darwin College on 25th November 2021, to mark his retirement from the Department.

Materials Science & Metallurgy has been greatly enhanced by Harry's contributions and innovations, in both research and teaching, over the years. He will always be remembered affectionately by the many, many students he has taught and influenced during his long career in Cambridge, and he continues to interact with an extensive catalogue of illustrious collaborators from all around the world.

Student Opportunity Fund

The funds will be used to provide on-going support for undergraduate and graduate students in the Department.

For more information or to make a donation visit: https://www.philanthropy.cam.ac.uk/give-to-cambridge/materials-science-metallurgy-student-opportunity-fund

Congratulations

Tom Bennett, Royal Society of Chemistry *Chemical Communications Emerging Investigator Lecturership 2021*

Rachel Evans, SCI/RSC McBain Medal 2022

Maruf Sarkar, UK Nitrides Consortium, best student poster

Abi Collins, Silver medal, Chemistry category at *STEM for Britain*

Rachel Oliver, FDM Everywoman in Technology 2022 Award; Co-Founder of Porotech who have raised $20M Series A funding

Sohini Kar-Narayan, Cambridge SU Student-led Teaching Award for Innovative Teaching

Louise Hirst, Promoted to Professsor

Emilie Ringe, Promoted to Professsor

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.