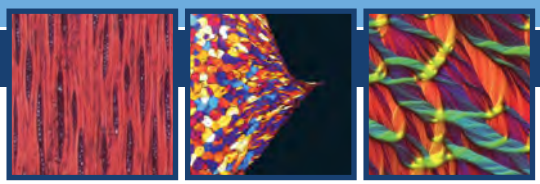
Cambridge
materialeyes

Autumn 2017 Issue 31



African endeavour

Links of many sorts between Cambridge University and parts of Africa have existed for many years; a few links to our Department were described in Issue 24 and, indeed, the Centre for African Studies is now over 50 years old. An introduction to the current picture is available at www.cambridge-africa.cam.ac.uk. Here we look at two materials projects, one - broadly educational with superalloy aspects - centred in Namibia and one - on ceramic insulators - in Ghana. The former involves Cathie Rae, the latter Kevin Knowles.

Funded by the Royal Academy of Engineering, the Namibian project focuses on the Faculty of Engineering and Information Technology of the University of Namibia as "hub" with several institutions in other African countries as "spokes". Local industries will also be involved. The primary aim is to enhance engineering education and research. The ambitious programme involves many aspects to improve university-industry interactions including staff secondment and professional development workshops. In addition second supervisors from the UK will be identified for MSc and PhD students in those institutions. Cathie will contribute expertise on recent developments in superalloys and on experience with university-industry collaboration as exemplified by our Rolls-Royce UTC. Cathie recently returned from a spell in the "hub" in Windhoek where there is an impressive new engineering faculty; amongst other things she was particularly interested to observe their participation rates for women. Pictured above are Cathie and the Dean, Dr Petrina Johannes.

Kevin's involvement has been with a project designed to help solve a specific problem: the frequency of electrical power outages in Ghana (a problem not restricted to Ghana). Dr Abu Yaya, Head of the Department of Materials Science and Engineering at the University of Ghana, realised that a significant cause of such outages was the lack of satisfactory, cheap electroporcelain insulators for the country's distribution grid. This was frustrating because the necessary raw materials are readily available locally. After starting work on this project he was awarded a six-month Fellowship, funded by the Cambridge-Africa Partnership for Research Excellence (CAPREx) and the ALBORADA Trust, to come to Cambridge and collaborate with Kevin on making electroporcelain with a suitable microstructure. Kaolin from two sources in Ghana have been investigated with one being shown to be suitable for electrical insulators (picture below after firing). In addition, he established a connection with Almath Crucibles (based near Cambridge) to continue to improve the process. Throughout, it was necessary to bear in mind the climatic conditions that affect insulators in the Ghanaian grid. The process developed is being patented through the University of Ghana.

Editorial

As you will see in this issue, the Department is continuing to recruit academic staff, with recent appointments to two joint lectureships with other Departments. This is a bold change from the standard Cambridge way of doing things but we are optimistic both that the two appointments will be highly successful and that it is likely to be a template for future expansions recruitment. As we go to press, we are also reaching the final stages of the appointment process for the next Goldsmiths' Professor of Materials Science. This is the Department's longest-established Chair and the appointee will take over from Tony Cheetham who retired at the end of September before moving to Singapore.

Following the success of our Open Day last year we are also thinking of launching an alumni group for those who would like to be more closely involved with the Department and more fully informed about developments. The next issue will contain more details, but in the meantime if there are any people, ideally living in the Cambridge area, who would be interested in helping set-up such a group please email me (mb52@cam.ac.uk).

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Inside:

Winning Grants

To start or continue lines of research has always been a challenge and the structure of the grant system keeps evolving. For some time the Department has enjoyed considerable success in gaining grants from the EU, latterly from the European Research Council (ERC). Funding also comes from sources in the UK, especially the Engineering and Physical Sciences Research Council (EPSRC). At present "Programme Grants" are one important part of the EPSRC system and Fellowships are another. Here we look briefly at some recent successes and then explore a Programme Grant and a (uniquely-structured) Fellowship in a little more detail.

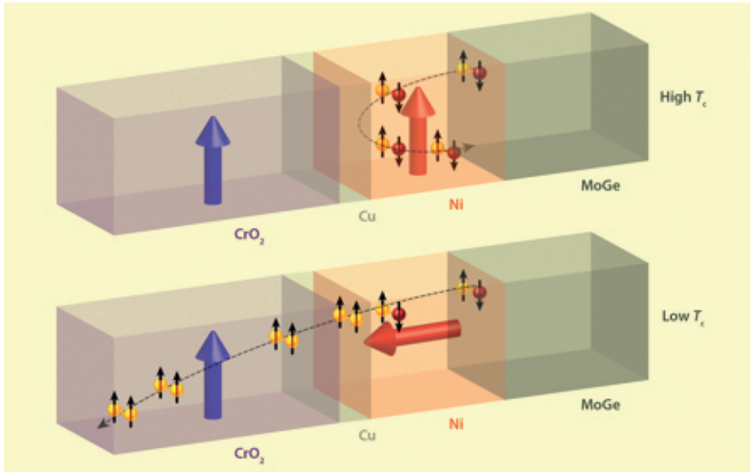
Programme Grants provide a flexible means of supporting world-leading research involving several threads linked to one strategic theme. Each grant usually runs for five years with several million pounds distributed around the participating organisations. Each theme is led by a Principal Investigator (PI), typically in partnership with other senior investigators and a number of academic institutions, industrial companies or international research facilities. Research areas covered so far include: superconducting spintronics (Blamire and Robinson), skyrmions (Midgley), hard-soft matter interfaces (Elliott), and two different aspects of gallium nitride electronics (Humphreys and Oliver).

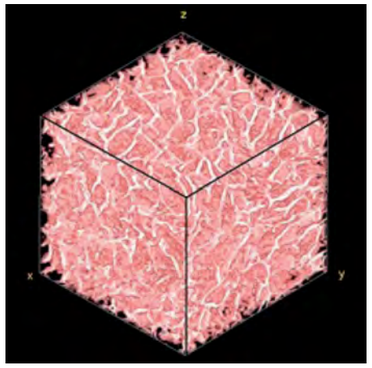
For a specific example, Mark Blamire is PI of the spintronics grant with other investigators and "project partners" including Jason Robinson and others elsewhere in the UK and Europe, as well as China, Israel and the USA. But what is meant by "Superconducting Spintronics"? Happily an explanatory article by Tom Kirk describing Mark's and Jason's research in this area has very recently appeared in the University's "*Research Horizons*" magazine (Issue 33). The semiconductor electronics currently used for computing is power-hungry, consuming an appreciable proportion of the output of the world's generating capacity and ultimately turning a lot of it into heat. Making use of the electron's spin rather than its charge and, especially, using superconductors holds promise of greatly reducing the power consumption but how would it work?

As shown below, the heart of a conventional spin valve consists of three thin layers, each 10 or so atoms thick, two layers of (possibly different) ferromagnetic materials separated by a layer of a non-magnetic material. Typically these layers are deposited on a suitable substrate by magnetron sputtering. Switching the directions of magnetisation of the ferromagnetic layers between parallel and anti-parallel leads to a substantial change in the resistances to the flow of spin-up or spin-down electrons crossing the intermediate layer. This is the "giant magneto-resistance" effect, which enables such a structure to act as a spin valve, easily passing electrons of one spin state while resisting passage of the others, thus forming the essential basis of "spintronics".

For many years conventional wisdom held that magnetism and superconductivity were incompatible but Jason disproved this seven years ago opening the way for a spin valve in which the intermediate layer consists of a (low temperature) superconductor, thus underpinning the application that led to the award of this grant (also, in a separate strand of research Jason and his team have recently demonstrated superconductivity in graphene but whether that will also play a role in this project remains to be seen).

The first paper from this grant was published last year on-line in *Nature Materials* (DOI:10.1038/NMAT4753) and describes a phenomenon by which the magnetic state of the ferromagnetic layers can be controlled by changes in the superconducting layer. This involves an effective quantum mechanical exchange interaction fundamentally different from those previously observed, although proposed over 40 years ago. Much challenging materials development and basic physics lies ahead in achieving the aim of the project: to create proof-of-concept logic and memory devices based on superconducting spintronics by 2021. Needless to say, from there to commercial exploitation will require very substantial investment.





With the title "'Patching up' a broken heart" and a picture on the front cover the same issue of "*Research Horizons*" research involving the Cambridge Centre for Medical Materials, led by Ruth Cameron and Serena Best is also highlighted. As reported briefly in *ME Issue 29,* the continuation of their work on biomedical scaffolds is being supported by a jointly-held EPSRC "Established Career Fellowship", the most senior of the three categories of Fellowship. EPSRC's website makes clear its "Family Friendly" approach to applications for Fellowships but two people sharing one Fellowship is a first. Funding for Established Career Fellowships covers not only each Fellow's salary costs for the portion of their time spent on the project but also all those other aspects associated with major grants.

Guiding the growth of biological tissue to take up the correct structure to repair parts of the body (e.g. heart muscle) generally requires a scaffold, often formed of collagen. Serena, Ruth and their collaborators have developed an effective method by freezing an aqueous solution of collagen and selected biological molecules. As the ice crystals form the other molecules segregate to the boundaries, the ice crystals are then vaporised by reducing the pressure so as to leave a complex but controllable porous structure (cube of side 1mm pictured [J Ashworth]). Such structures have already proved successful as biomedical scaffolds on which the desired tissues can be grown but many challenges remain. In the period of the Fellowship the aim is to optimise the processing for tissues to be used for a variety of purposes such as cardiovascular devices and nerve guidance.

In conclusion, whilst writing grant proposals remains challenging, for those who are ultimately successful support lasts for five years and there can be a measure of flexibility in the approach to achieving the aims. At the same time collaborations around the world are strongly encouraged.

Joint Appointments

Not long ago universities functioned more-or-less in isolation from one another and, within a university, departments generally had an insular outlook. No more! In Cambridge, Interdisciplinary Research Centres have encouraged inter-departmental collaboration, and funding mechanisms have brought universities together on an international scale. However, with rare exceptions, individuals in Cambridge have remained attached to just one department. Now the University's School of the Physical Sciences has approved the creation of two joint University Lectureships involving our Department; one with Earth Sciences, focusing on imaging of natural and synthetic materials and one with Physics, on semiconductor materials. Emilie Ringe has been appointed to the former and Louise Hirst to the latter. In addition to their research Emilie and Louise will teach at undergraduate and graduate levels in both their Departments.

Emilie (pictured on the left) gained her undergraduate and doctoral degrees from McGill and Northwestern Universities in North America. She held a Royal Society Newton International Research Fellowship and a Research Fellowship at Trinity Hall, working in our Electron microscopy group before taking up an Assistant Professorship at Rice University. While here her research included atomic resolution and 3d elemental mapping of alloy nanoparticles. Emilie is also noted for her considerable involvement in in scientific activities.

Louise (pictured on the right) studied Physics, specialising in optics and photonics, at Imperial College, where she gained a PhD working on hot-carrier solar cells. Subsequently she won a National Research Council Associateship in the Optoelectronics and Radiation Effects Branch of the US Naval Research Laboratory where she became a Karles Fellow. Her research now focuses on novel device concepts and materials for photovoltaics, in particular nanostructured III-V materials and integrated light management architectures

Emilie and Louise will take up their posts in early 2018.

CAMatNet Kicks off

The first CAMatNet (Cambridge Advanced Materials Network) symposium was held in March 2017 organised by Professors Ruth Cameron and Serena Best. This was the first of a planned series of interdisciplinary "networking" meetings in the field of Materials Science, designed not only to report on current collaborations but also to explore ways forward for further partnerships in the future. On this occasion, those with a common interest in collagen research came together. There were 10 speakers from eight Departments ranging from Engineering to Haematology and the event attracted over 50 delegates. Attendees were able to make good use of the opportunities for networking and discussions over lunch and during breaks, to make new connections and to catch up with existing collaborators. It was heartening to see how many links already exist between Materials and other Departments across the University. The next CAMatNet meeting is planned for later this year on the subject of materials modelling. **www.msm.cam.ac.uk/news-and-events/events**

Out-of-the-blue donation

Following the Open Day last September, the Department was delighted when one of our visitors Dr Bill Welland made a generous donation to provide flexible funds for Judith Driscoll's group. Judith's initial thought was to use the funds to support summer students to do proof-of-concept research, for which funding would otherwise be very hard to obtain, but since then the need to have secure funding for a very promising EU student has become the first priority.

Pocket Power Plant

Research by Sohini Narayan and her colleagues was featured in *Issue 28*. In March this year she and her team (pictured) participated in one of the Royal Society + Science Museum "Lates" events. Sohini reports that the event was great fun: "We really enjoyed stepping out of the lab and showcasing our research directly to the public. There were more than 4,000 visitors and the atmosphere was electric! We had several hands-on demos showing how heat and motion could be converted into electricity using piezoelectric, triboelectric and thermoelectric nanomaterials and devices. The event was highly interactive and our team did an excellent job in conveying our passion and enthusiasm

for research, and the resulting benefits to society. It lasted till 10.30pm and we were all exhausted, but still smiling."

Evidently their efforts were greatly appreciated because they were subsequently invited to showcase their demonstrations at the opening night of the Royal Society Summer Science Exhibition in July.

Cambridge Science Festival

An annual highlight in the Cambridge outreach calendar is Science Week (actually 10 days) in March, in which the Department regularly participates. Demonstrated by a team coordinated by Judith Driscoll, one very popular and dramatic contribution is an unusual but effective method for the production of ice cream. This involves the use of liquid N_2 - and gloves and goggles, of course. The date for the 2018 festival is 12–25 March.

www.sciencefestival.cam.ac.uk

New Departmental website

The Department Computer Committee has recently overseen a substantial revision of the Department's website, bringing it into line with the latest University style. Alex Eggeman, Tony Gledhill and Lianne Sallows have spent a great deal of time on the architecture and content of the site, ably assisted for a period by students Will Grant (PhD) and Adina Wineman (Part IB). The new look website should improve usability on tablets and other mobile devices. Feedback is welcomed.

Jess Gwynne – Bumper Crop

Our students' satisfaction with the Department's courses and the great increase in their numbers over recent years owe much to many but especially to the vital activities of Noel Rutter and Jess Gwynne. Noel featured in *Issue 22* five years ago; here we turn the spotlight onto Jess, whose appointment as Departmental Teaching Fellow coincided with the move into the new building in 2013. Amongst other things that required a major effort was adapting the sequence of practicals to the restructured timetables dictated by the need for undergraduates to travel to the new location.

The visible aspects of the Department's teaching include lectures, practicals, projects and supervisions (for third and fourth years). Lots of work behind the scenes is required for these to run smoothly and much of that falls to Jess and Noel. In addition to several lecture courses, Jess's current responsibilities include Head of Year for Part IA and Head of Class for several Part IA and IB practicals, administering much of the Parts II and III courses and acting as Senior Examiner for Part III. She is also involved with Bill Clyne in the CaMPUS scheme (Cambridge Materials Placements for Undergraduates in the Summer), which allocates placements in UK industry, in Europe and in the Department.

Jess joined Robinson College in 2000 to read Natural Sciences. She developed an interest in teaching early on and began contributing in summer 2002 when she joined the group creating content for the DoITPoMS project. This interest continued in parallel with her research throughout her time as a PhD student and then postdoc with Ruth Cameron and Serena Best, focusing initially on materials for spinal disc replacements and subsequently on bone-regeneration scaffolds. It was no surprise when teaching proved the stronger interest and she gained her current appointments in the Department and, more recently, in St Catharine's College, where she looks after the Materials teaching and acts as a graduate tutor.

After long days in Cambridge, Jess heads west to join her husband Phillip at home in Cambourne where their allotment helps maintain the supply of fruit and vegetables. Greater relaxation may involve ballroom dancing or visiting her maternal grandmother in Bavaria. However their routine (if "routine" is a fair description!) now faces major change; son Charlie was born on 24 July. Given current flexibility in such matters, the plan is for Jess to take the first six months of parental leave, thus missing the Michaelmas Term, and for Phillip to take the following six months off from his job at the Royal Society of Chemistry. The Department wishes them well and looks forward to welcoming Jess back after Christmas.

Congratulations

Serena Best, CBE in the Queen's Birthday Honours for services to biomaterials engineering

James Elliott, Personal Chair from Oct 17

Howard Stone, promoted to a Readership from Oct 17

Emilie Ringe, appointed University lecturer jointly with Earth Sciences

Louise Hirst, appointed University lecturer jointly with Physics

Krzysztof Koziol, Chair in Composites Engineering, Cranfield University

Pedro Rivera, Chair, Lancaster University

Alex Eggeman, Lectureship at the School of Materials, Manchester University

Rowan Leary, Tata University Research Fellowship, Royal Society

Ruth Cameron, UK Society for Biomaterials President's Prize 2017

Judith Driscoll, IEEE James Wong Award for Applied Superconductivity Materials Technology 2017

Rachel Evans, Dillwyn medal for STEMM, the Learned Society of Wales

Sean Collins, Cambridge Philosophical Society Henslow Research Fellowship hosted by Girton College

Xavier Moya, Emerging Talent Award 2017, Spanish Society of Researcher in the UK and Santander Bank Foundation

Chunlei Pei, Young Researcher Award from IChemE

Editorial team: John Leake, Mark Blamire and Rachel Hobson **Comments to:** rjh24@cam.ac.uk

We have networking groups on *Linkedin, Twitter and Facebook*
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