Cambridge material eyes

Spring 2009 Issue 18

Endowment of a Chair in Metallurgy

The Tata Steel Group has made a substantial donation to establish a Professorship of Metallurgy in the Department. The inaugural holder of the chair is Harry Bhadeshia FRS, FREng, FNAS, whose research on the development of steel microstructures is world-renowned. Harry writes "I will do my utmost to promote education and creativity in steel. I am particularly delighted that this endowment will provide a long-lasting source of funds for in-depth research into this most wonderful of materials." In a joint statement, Mr B. Muthuraman (Managing Director, Tata Steel) and Mr Philippe Varin (CEO, Corus) note "In this partnership we are fortunate to have found a combination of passion, inspiration and dedication towards the further development of steel … the continuing efforts of Professor Bhadeshia in this field will highlight the exciting opportunities this industry makes available to young people in their career choices." The donation, made within the University's 800th Campaign, provides the Department with only its second endowed chair (after the long-established Goldsmiths' Professorship). The Department records its gratitude to the Tata Steel Group, and applauds the foresight of investing in the future in these testing times. The new chair will help to maintain our strong record of contributions in materials science and metallurgy.

At Queens' College Old Hall on 24 November 2008 when the establishment of the Tata Steel Professorship was formally announced: (L to R) Lindsay Greer (Head of Department), Harry Bhadeshia (Tata Steel Professor) Tridibesh Mukherjee (Director, Tata Group), Philippe Varin (CEO, Corus).

A Quality Profile

The Research Assessment Exercise is of close interest to the UK academic world as it can make or break the reputation of a department. The peer-reviewed rating is crucial, subject-by-subject, in determining research-related government funding coming to universities. The results of RAE 2008 (based on data from the period 2001-07) were published on 18 December 2008. These show Cambridge ranked first in quality in the Metallurgy and Materials category, and our department emerges as one of the highest ranked in any discipline.

The 2008 results are presented differently from previous RAEs. Each department has a Quality Profile, giving the fraction (to the nearest 5%) of research activity meeting the following standards: 4* (world-leading in terms of originality, significance and rigour), 3* (internationally excellent), 2* (recognised internationally), and 1* (recognised nationally). The full results are available at http://www.rae.ac.uk/

The Cambridge Materials Department is rated 40% 4*, 55% 3* and 5% 2* giving a grade point average (GPA) of 3.35. Ranked by GPA, we are ahead of other materials departments in the UK, our nearest rivals scoring 3.05. Indeed, we are in the group of top 4 science and engineering departments (3 of them in Cambridge, 1 at Imperial) across the country all with the same GPA. Across all disciplines, no department exceeded our 95% fraction in the 3* and 4* categories, and only 5 matched it.

The RAE performance owes everything to the outstanding efforts of all members of the Department, and it is wonderful that those efforts have been recognised in this clear way.

Editorial

In the face of concerns about the financial situation and its implications for education and research, it is pleasing to be able to report that our Department has much to celebrate in the University's 800th year. We can count the inauguration of the Tata Chair, the recognition of our research excellence in RAE 2008, the spectacular London launch of the Cottrell Appeal (see insert) and the many achievements of individuals over the past few months (p. 6). The article by Srinivasa Ranganathan (p. 4) brings to mind our alumni, whose distinguished contributions we look forward to celebrating at our Alumni Symposium on 25 September 2009.

Professor Lindsay Greer, Head of Department

Contents:

The Tata Steel Professor of Metallurgy shares his thoughts with us —

For three decades, we have been working on quantitative methods that allow the solid-state transformations in steels to be treated without disrespecting their complexity. Occasional successes have been published, patented and produced, but on this occasion I would like to focus on some irksome problems preventing creativity in the technology of steels, although I imagine that the problems are generic.

Despite much research on the mechanical behaviour of metals, from dislocation theory to the characteristics of large-scale structures, I would challenge anyone in the world to make a prediction of phenomena such as formability, fatigue, creep, oxidation, corrosion, toughness, given a complete description of every level of the structure, composition and processing of the metal. This is a major field that we intend to develop. A glance into the future is that we will soon reveal a method allowing the fatigue crack growth rate to be estimated for any metallic material; blind tests have already been conducted which have given us a warm feeling. So this kind of work is not impossible, but the task is enormous and should be regarded as covering the next three decades.

Steels are produced in vast quantities and the processing is so rapid that it cannot be controlled directly by humans; indeed, these days it is hard to find humans on production lines. However, there is now the possibility of amazing properties at a low cost, if the manufacturing process can be arranged to allow for long heat-treatments at very low homologous temperatures. This would require adventure on the part of industry to build plant capable of maintaining a high output but with an intervening heat-treatment that takes several days or weeks. Imagination needed is on the scale of the Tata Nano, India's and the world's most inexpensive car.

All of these activities must be in concert with the education of individuals who are able to understand the challenging principles of metallurgy and who become capable of changing, for the better, the ratio between perspiration and inspiration. We continue to create openly available teaching resources to help this process.

Professor Harry Bhadeshia

Cambridge Materials Science Alumni Seminar

Marking the 800th anniversary of the University, a seminar celebrating the many and varied achievements of the Department's alumni will be held on Friday 25 September, as part of the Alumni Weekend 2009. Twelve distinguished alumni/ae from around the world, representing cross-sections of ages and walks of life, will speak at the event, which will also feature displays of current work in the Department. A very interesting and stimulating day is in prospect!

The seminar will start at 10.00 am with coffee. A buffet lunch will be provided by the Department. The day will end with a formal dinner for alumni and their guests (at a cost of £52 per head). Alumni and other interested parties will be most welcome to all or part of the Symposium and are asked to register provisionally on-line to help us gauge numbers. See: http://www.msm.cam.ac.uk/alumni/800event

Belvedere Professor

In recognition of his contribution to the science and applications of superconductors, Bartek Głowacki receives the award of the title of Professor from the Chief of the President's Office, Piotr Kownacki, on 14 January 2009 in the Belvedere Palace, Warsaw.

Bartek, Reader in Applied Superconductivity, received his MSc in Physics from the University of Wrocław and his PhD from the Polish Academy of Sciences, but was nominated for this latest award by the University of Lublin in consideration of the scope and impact of his research. Bartek has more than 200 publications (attracting more than 1600 citations) and 10 patents, and he has led national and international projects researching superconducting generators, cables, fault current limiters, MRI and NMR, fusion, liquid hydrogen, photocatalysts, fuel cells and electrolysers for energy applications.

This prestigious title enhances his profile internationally and strengthens his activities in promoting interaction between research institutes in Poland and the UK in the fields of energy development and policy.

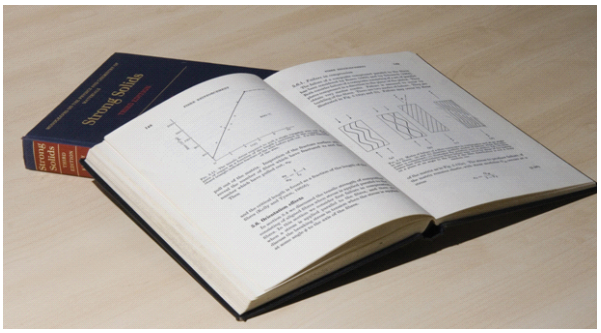
Bartek leads the department's Applied Superconductivity and Cryoscience Group http://www.msm.cam.ac.uk/ascg/, which has a broad, multidisciplinary research programme focused on the development and application of high- and low-temperature superconductivity, blending physics with heavy industry. Bartek is currently engaged in three high-profile collaborative projects, with major UK and EU universities and companies, in superconductivity, ink-jet printing of electroceramics, hydrogen generation and liquefaction, and energy storage. He is also interested in biomagnetic applications, where the combination of superconducting and magnetic materials can be beneficial for cancer treatment. He lectures on superconductivity and nanomaterials.

Bartek has devoted much time in recent years to developing educational resources, particularly filming and editing the *Lectures on Superconductivity*, an extensive series of videos (which can be viewed on-line or downloaded from http://www.msm.cam.ac.uk/ascg/lectures/), featuring inter-views with almost 200 leading international experts.

In what free time remains, Bartek can be found on the slopes indulging a particular liking for "freestyle" skiing or introducing his grandson Oskar to the properties of helium.

Strong Solids

No matter what property is of primary importance in a potential application of a material, that material is unlikely to be useful if its structural integrity cannot be guaranteed. So, the mechanical properties are always relevant and, of course, are sometimes crucial in applications. The Department has long been involved in seeking to understand mechanical properties and to optimize them in different contexts. One important aspect is the development of strong solids, whether for use on their own or as constituents in, or on, some other material. Some have to withstand steady tensile stresses while others may to resist compressive impacts from varying directions. Some also have to operate in extreme environments. The first edition of Tony Kelly's seminal book *Strong Solids*, a milestone in the field and shown below, was written in 1965 when he was a Lecturer in the



Department. Subsequent editions, the third shared with Norman Macmillan, have continued to influence the development of the subject. In parallel with the Department's on-going involvement with strong solids, that topic also formed the theme of the Gordon Seminars and tenth Kelly Lecture at the Armourers & Brasiers' Cambridge Forum in June 2008.

The Forum was opened by Rear Admiral Patrick Middleton, Chairman of the Materials Science Committee of the A&B Company. The first Gordon Seminar was delivered by Milo Shaffer (Imperial College) who described developments in the production of carbon nanotubes and limitations of their impressively high fracture stress (perhaps 9 GPa in practice). He speculated on the possibilities of exploiting that strength to build a "space elevator", as suggested by NASA. Then Fritz Vollrath (Oxford) took us into the realm of natural strong materials with a study of the properties of spiders' silk in order to develop equivalent materials that can be spun from synthetic biopolymers and then have potential applications within the human body. In the following talk Ian Bond (Bristol) also talked about developments inspired by natural systems, this time to provide a means for self-healing of fibre-reinforced composites. The simplest system involves incorporating in the composite some hollow glass fibres containing uncured "healing" resin, which can leak out into regions where the material is damaged and be cured to effect a repair. A more advanced system involves a vascular network feeding uncured resin to damaged areas. The centuries-old involvement of the A&B Company with armour was particularly evident in the next two talks. In the first, Colin Roberson (Advanced Defence Materials Ltd) described ceramics (e.g. boron carbide, silicon carbide, or alumina) that can be used for an outer "disrupter" layer on another material or, in some cases, can be made into transparent armour. In the final seminar Peter Brown (DSTL), acknowledging Harry Bhadeshia's essential involvement especially through the development of predictive models, described the progress of "superbainite" steels to tonnage production and practical testing. These steels are currently undergoing ballistic testing. Interestingly he pointed out that armour need not be continuous; in the right context, armour containing an array of holes can be very effective. He closed with some remarks about the attractive prospects for steels with twinning-induced plasticity (TWIP).

In the opening remarks of his Kelly Lecture "Materials by Design: Frankensteels driving innovation in research and education" Greg Olson (Northwestern) reminded us that Tony Kelly, a Faculty member at the time, had been involved in the creation of the Materials Science Department at Northwestern some 50 years ago. The power of modelling in the design of materials was prominently demonstrated throughout this lecture. The integration of the models applicable to different length-scales from atomic to continuum was explained and the requirement for some experimental testing noted. Successful applications were described, as was the need for further work, for example to be able to predict toughness as reliably as can already be achieved for fracture stress. By no means least, the successful use of these techniques in undergraduate education was outlined.

The Forum, having encompassed a wide range of types of material, concluding with steels, allowed Tony Kelly, in a characteristically entertaining vote of thanks, to remind us of the theme of Kipling's poem *Cold Iron*, " ... But Iron – Cold Iron – is master of them all".

Of course strong solids feature in the Department's research programme and not just in Harry Bhadeshia's work on ultra-high-strength steels. Cathie Rae, Howard Stone and colleagues in the Rolls Royce UTP are developing new materials for the discs of aeroengine gas turbines. The stresses, which can rise as high as 1 GPa, and the operating temperatures vary significantly across a disc so high strength and good resistance to fatigue and creep are all required in varying degrees. At ambient temperatures, bulk metallic glasses, studied by Lindsay Greer, are the strongest known metallic materials. And moving away from bulk metals to surface coatings, Bill Clyne and colleagues are developing strongly adherent, hard, dense and wear-resistant oxide coatings on metals such as aluminium and magnesium using the plasma electrolytic oxide (PEO) process.

See www.msm.cam.ac.uk/forum/ for details of this year's Forum featuring Professor CNR Rao FRS as Kelly Lecturer.

To see a World in Cambridge

The English winter of 1962-63 was one of the most severe. The river Cam froze and water pipes burst. But I was fascinated by seeing the beautiful snowflakes falling on the lawns of Peterhouse. I had been welcomed by this College with a Research Studentship of £485 per annum − a princely sum in those days. I had also received a travel grant from the J.N. Tata Endowment for the Higher Education of Indians. I became conscious of the age of my college, when I was told that the sexcentenary club was not what I took it to be! Then I saw with envy Fellows walking across the lawns. This turned into pride as two of them – Max Perutz and John Kendrew won the Nobel Prize in Chemistry in 1962. That I belonged to the same college, breathed the same air and dined in the same hall was an impression that transformed my life.

Earlier in the spring of 1962 I was completing my Bachelor's degree in Metallurgy at the Indian Institute of Science, Bangalore. Following my student predecessors, I had applied and secured admission and financial assistantships at several universities in the USA including MIT, Columbia University and the University of California, Berkeley. One of my teachers, Professor K P Abraham, persuaded me to apply to Professor Alan Cottrell at the University of Cambridge. Professor Cottrell readily accepted me for doctoral studies and even prescribed in his letter that I should study the structure of grain boundaries using field-ion microscopy. Professor T R Anantharaman gave his good wishes that I should make my mark though it may not be easy in a place where Srinivasa Ramanujan, S Chandrasekhar and Homi Bhabha had set the standards.

It was intellectually most exciting and rewarding to do research in the Department of Metallurgy in the early sixties. I was guided by David Brandon during the first year. The group was pioneering in its application of field-ion microscopy to metallurgical problems. The close interactions in the octagonal room in what is now the Annexe was an important ingredient. Mike Wald, Mike Southon, Brian Ralph, Kelvin Bowkett and M A Fortes all became close friends and taught me not just about metallurgy but also to cope with the nuances of British culture. Joseph Reich was the technical assistant to the group and became a close friend transcending several barriers. It is from my group members and from the encounters at coffee time with others, that my thinking was moulded. I learned about bar billiards and "bird and bottle" parties. While the first reaction to the satire in the BBC show *That Was The Week That Was (TW3)* was one of shock, I learned to appreciate many subtleties of the British ways. A poignant moment came very recently when I contributed a paper on grain shapes to the memorial issue of *Philosophical Magazine Letters* dedicated to M A Fortes. We both shared a love for geometry.

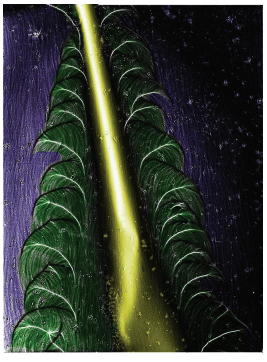
The ambience at Cambridge was incredible. The world's leading metallurgists came to Cambridge almost on pilgrimage. I could write to H S M Coxeter on compound tessellations, discuss with F C Frank crystal rotations, and with Nevill Mott the structure of grain boundaries. The first paper of mine in *Acta Metallurgica* co-authored with Brandon, Ralph and Wald – with the authors arranged in alphabetical order after some arguments(!) – became a citation classic. Professor Cottrell used two of my micrographs in his classic books. This made me more known across the globe than all my other endeavours.

I left Cambridge in 1965 to spend two years at the Lawrence Radiation Laboratory, Berkeley, California with Professor Gareth Thomas and then returned to India in 1967 to join the faculty at Banaras Hindu University – an act considered at that time as foolhardy. I moved to the Indian Institute of Science, Bangalore in 1981. Through all these years the intellectual luminosity I experienced at Cambridge has remained a guiding light.

My wife and I (pictured above with Sir Alan Cottrell) returned this summer after more than four decades. Much has changed. Much has remained the same. Cambridge is celebrating its octocentenary, while the IISc is celebrating its centenary. The Tata Trust may give more endowments than just travel assistance to a metallurgy student from India. Excellence and warmth have remained amidst the changes.

S Ranganathan (Rangu)

Professor S Ranganathan, FASc, FNA, FNAE, FNASc, FTWAS, is INAE Distinguished Professor Indian Institute of Science (IISc), and is also affiliated with the Jawaharlal Nehru Centre for Advanced Research and National Institute of Advanced Studies in Bangalore and Harbin Institute of Technology, China. He is the author or co-author of many papers and a number of books, and has received several notable awards. In addition to research on nanostructured materials, metallic glasses and quasicrystals he has a substantial interest in the metallurgical heritage of India. His most recent books are *India's Legendary Wootz Steel* (2004, with Sharada Srinivasan) and *New Geometries for New Materials* (2006, with E A Lord and A L Mackay). He was Chairman of the Department of Metallurgy (now Materials Engineering) in the IISc from 1981 to 1988 and President of the Indian Institute of Metals in 1999.



Christmas 2008

The 2008 Materials Science and Metallurgy Department Christmas card featured a Lorentz micrograph of magnetic domain structure in Permalloy.

This image was supplied by Professor Paul Midgley.

Our very own MCC

Cricket has long played a major rôle in Departmental life. Matches between staff and students have been held in most years for over 50. This photograph, which appeared in *Light*

Blue Materials, shows the 1956 staff team and features some (to be) famous names including: (standing, from left, 4th) Gareth Thomas, *inter alia* founder and Scientific Director, National Center for Electron Microscopy, Lawrence National Laboratory, USA; (5th) John Coiley, first Keeper, National Railway Museum, York; (8th) Jack Nutting, Head of Department, Leeds; and (squatting, right) Gerry Smith, for decades a mainstay of the Department and Pembroke College. May their present-day successors emulate their success!

In the 1970s success of the Metallurgy Cricket Club was particularly memorable, thanks especially to the enthusiasm of Graeme (now Sir Graeme) Davies. A keen participant from those days, Paul Howell, now Professor of Metallurgy at Penn State, has kindly sent these reminiscences.

"My memories of Departmental cricket are some of the fondest I have of my time in Cambridge. My first exposure to twenty-over cricket came in 1970 when Graeme Davies asked me if I would like to try out for the team. As a fresh-faced new graduate student I stood in awe of Graeme and Jeff Edington, two of the younger faculty members who anchored the team. We played of an evening on College grounds and from my none-too-perfect memory, had a good season, finishing runners-up in both league and cup competitions. However, my most indelible memories were forged "après-cricket" in various locals, when faculty, students and staff alike, relaxed together, played darts and socialized with our wives, girlfriends and our competition; thus over the years I forged many long-term friendships. The next year, 1971, was truly memorable; we had a good team and even better camaraderie. We won both the league and cup competitions. Amongst those who contributed to our success I must mention Pete Hull, our wicketkeeper who fielded all bowlers with equal aplomb; and Jim Tolley, our most talented cricketer; a lively fast-medium bowler and a sometimes dour, but always dependable and productive batsman. And of course there was Graeme Davies, who could bowl a few frugal overs of medium-pace cutters from a three-step run and was a prodigious hitter of the ball. Yet Graeme's overwhelming contribution to the team stemmed from his friendly but firm leadership that brought out the best in a motley crew. Graeme was a great competitor and he reasoned that if we could compete successfully in an evening league, could we not compete in other arenas? So was born the Materialists touring club that for several years toured northern Germany each summer. The first tour was in 1972; a total of twelve brave souls spent a week in Germany playing cricket against a variety of RAF bases. We were hosted by RAF Rheindahlen, ate in the mess and drank in the sergeant's club. The composition of the touring team was eclectic; as long as you were connected to the Department, even loosely, you were welcome. Typically half were from the Department and half were personal friends who elevated the ability of the team to a level competitive with our hosts. Again there are too many names and too many memorable moments to rehearse but I will never forget David Williams chasing after a ball driven through the covers, catching up, turning - and throwing his shoulder out! David's arm proved more resistant to re-setting than it did to dislocating and a nurse had to kneel on his chest to accomplish the task. In 1977, this era came to an end when Graeme was awarded a Chair at the University of Sheffield and the Materialists toured no more. Yet thirty years later, Graeme and I would meet once again - to celebrate David's inauguration as President of the University of Alabama in Huntsville."

Noel Rutter, now Departmental Teaching Fellow, takes up the story with a more recent golden era. "In the new millennium the club continued to thrive; a new cap was designed and regular match reports ensured that lift-goers were entertained. The Farrer Cup was dusted off and some high-tech joining techniques employed in its repair so that it could again be awarded at the annual dinner. On the field there have been many memorable achievements, including an outstanding contribution of 123 from James Wescott in 2000. Having failed to mount a serious challenge on any silverware for some time, our progress was finally rewarded in 2001 with MCC, under the captaincy of Adam Lister, crowned league champions. The annual match between staff and students has continued and the 2007 fixture produced a remarkable finish. Both Andy Rayment and Pete Cherns hit centuries for their respective teams, the latter taking the students to within a whisker of victory, then having to watch from the non-striker's end as my "occasional" bowling produced a hat-trick to secure a Staff win by just one run."

This year the staff-student match was replaced by one against the Department of Materials at Imperial College. This innovative match was played with 12 on each side and with most players bowling at least one over! Cambridge, captained by Noel Rutter, batted first and amassed 143 runs, aided by a generous number of wides. Imperial then mounted a spirited pursuit led by skipper Julian Jones, whose score of 56 was easily the highest of the day, but their innings closed at 104 leaving Cambridge clear winners of the specially created trophy. As ever the day was admirably supported by the efforts of Dave Duke and his helpers, not least in running the barbecue.

Postgrads, potatoes and pirouettes —
A profile of Dr Rosie Ward

Every year many new graduate students join the Department to work towards a PhD and yet others embark on the MPhil course. At just over sixty, this year's postgraduate intake is the largest ever, and nearly forty countries have been represented in recent years. To cope with this, someone has to climb an administrative mountain; that someone is our Academic Secretary Dr Rosie Ward. Working between the prospective students, the academic staff and the Board of Graduate Studies to coordinate graduate admissions is the most visible but far from the only task to fill Rosie's desk and computer screen. Her responsibilities include other aspects of the graduate school and assisting the Head of Department with general administration, not least the various forms of external scrutiny that now impose major burdens. Top of the pile recently was the Research Assessment Exercise 2008 (p. 1) where Rosie played a crucial rôle in compiling the Department's submission. Even more fulfilling, she feels, and undoubtedly very important, is the help and advice she provides to individuals, perhaps someone from overseas about settling into this country, or someone whose financial support is causing concern, or someone anxious about adapting to postgraduate work. She finds it immensely rewarding to see the students complete their degrees successfully, particularly so for those who have found it a challenge. Rosie also takes her turn providing assistance with the General Board's programme of teaching and learning reviews of other Departments.

Rosie's previous experience has prepared her well for her present post. She gained her first degree (in Zoology) from The Queen's University, Belfast and then a PhD in London on immune resistance to the tropical disease bilharzia (schistosomiasis). She then acquired professional qualifications in personnel management and moved into administration for the Medical Research Council, first in central London, then in 1991 in Cambridge as Personnel Officer, before joining the Department in September 1996.

But what of life outside the Department? Rosie lives locally, manages without a car and positively enjoys cycling, despite the hazards. She maintains a biological interest by sharing with neighbours a prize-winning allotment growing vegetables, flowers and fruit. Even more energetically she is a dedicated amateur ballet dancer, studying the Russian style to advanced level and taking part in examinations and local performances. As she points out, this brings us back to materials science: these days some pointe shoes incorporate a carbon-fibre shank. Away from Cambridge, Rosie may be found visiting Hay-on-Wye or exploring ancient monuments on "small, cold islands" and pursuing an as yet unrequited quest to see the Northern Lights.

Congratulations to:

Harry Bhadeshia Tata Steel Professorship of Metallurgy from December 2008

Promotions from October 2008: **Judith Driscoll** to a Professorship; and **Neil Mathur** to a Readership

Karl Sandeman Lectureship in Physics, Imperial College from April 2009

Krzysztof Koziol Royal Society University Research Fellowship from October 2008

Stuart Wimbush Leverhulme Early Career Fellowship from October 2008

Cathie Rae Royal Society Industrial Fellowship with Rolls-Royce from April 2009

Bill Clyne Fellowship of the Royal Academy of Engineering

Bartek Glowacki title of Professor from the President of Poland (Belvedere Professor), September 2008

Tony Cheetham 2008 Royal Society Leverhulme Medal and the Staudinger-Durrer Lecture at ETH, Zurich, October 2008

Paul Midgley President of the European Microscopy Society from August 2008

Sir John Meurig Thomas Monchot Prize Research Professorship, spring term 2009 at the Technische Universität, Munich.

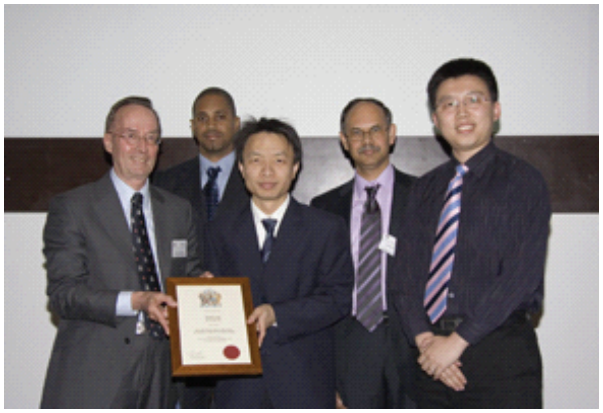
Bill Bonfield Honorary Professorship, UCL and Honorary Fellowship, Queen Mary, London

Lindsay Greer Lee Hsun Lecture 2008, Institute of Metal Research, Chinese Academy of Sciences

IoM^3 awards for finals in 2008: **Sonya Pemberton** Royal Charter Prize for Best Materials Graduate; **Caroline Humphrey** A T Green Award for Best Ceramics Graduate**.**

Marcus Weigand IoP Superconductivity Group AGM Poster Prize

Vasant Kumar and Green PB pictured below receiving the inaugural 2008 Armourers & Brasiers' Materials Science Venture Prize from Prof Bill Bonfield, Master of the Armourers & Brasiers' Company



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