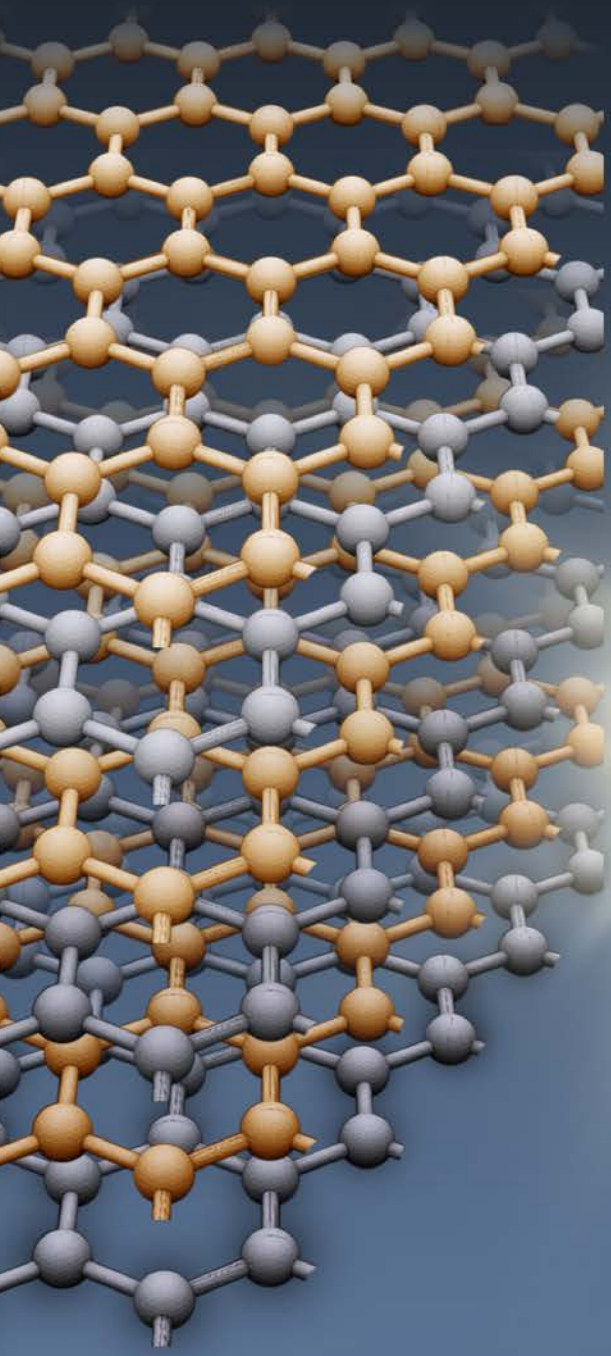
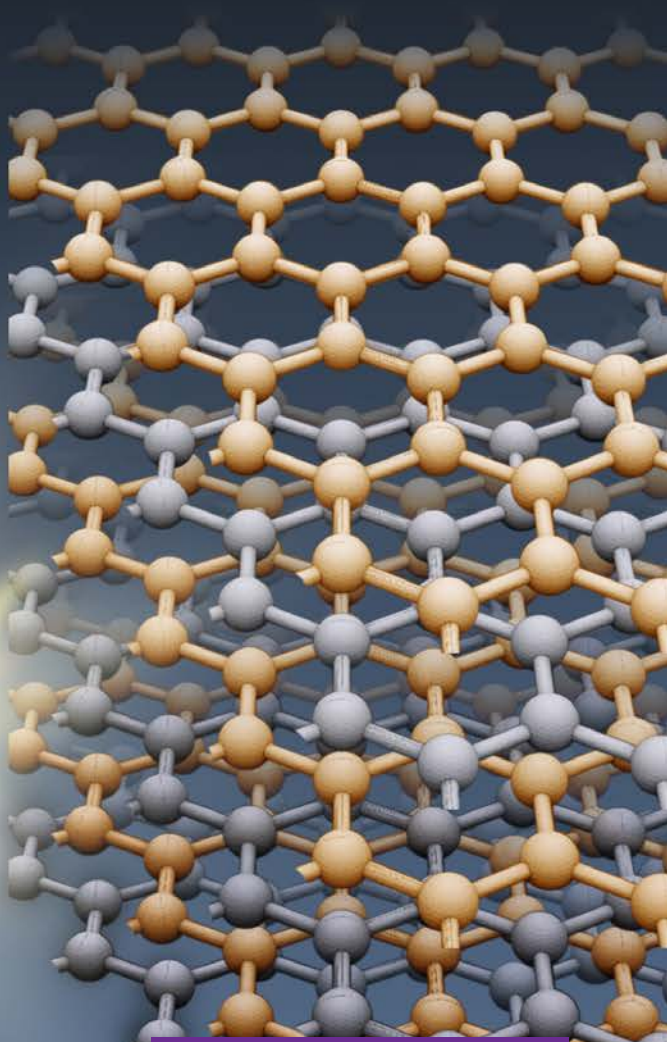
MANCHESTER 1824
The University of Manchester

ENGINEERING & PHYSICAL SCIENCES NEWS

WORLD-LEADING RESEARCH
INNOVATION & COLLABORATION

AUTUMN 2012





Grappling with Graphene

ALSO INSIDE

CONTENTS

EPS PEOPLE

The Faculty is led by the **Vice-President and Dean, Professor Colin Bailey**, and comprises **nine academic Schools** and **four Research Institutes**. The Faculty Leadership Team also includes **six Associate Deans** who support key areas of activity, including **Research, Teaching and Learning, Graduate Education**, **Social Responsibility, Internationalisation** and **Business Engagement**, and the **Head of Faculty Administration**, who is responsible for leading the administration across the Faculty.

School of Chemical Engineering and Analytical Science
Head of School, Professor Mike Sutcliffe

School of Chemistry
Head of School, Professor Christopher Whitehead

School of Computer Science
Head of School, Professor Jim Miles

School of Earth, Atmospheric and Environmental Sciences
Head of School, Professor Hugh Coe

School of Electrical and Electronic Engineering
Acting Head of School, Professor Tony Brown

School of Materials
Acting Head of School, Professor Paul O'Brien

School of Mathematics
Head of School, Professor Peter Duck

School of Mechanical, Aerospace and Civil Engineering
Acting Head of School, Professor Andy Gibson

School of Physics and Astronomy
Head of School, Professor Stephen Watts

Dalton Nuclear Institute
Director, Professor Andrew Sherry

Manchester Interdisciplinary Biocentre
Director, Professor Nigel Scrutton

Photon Science Institute
Director, Professor Richard Winpenny

University of Manchester Aerospace Research Institute (UMARI)
Director, Professor Costas Soutis

Associate Dean (Research)
Professor Hugh McCann

Acting Associate Dean (Teaching and Learning)
Dr Danielle George

Associate Dean (Graduate Education)
Dr Ann Webb

Associate Dean (Social Responsibility)
Dr Tim O'Brien

Acting Associate Dean (Business Engagement)
Professor Mike Sutcliffe

Acting Associate Dean (Internationalisation)
Professor Stephen Flint

Head of Faculty Administration
Rachel Brealey

The front cover shows how a beam of ions digs a trench through the surface of graphene. See page 11

Welcome from the Vice-President and Dean

Welcome to the Faculty of Engineering and Physical Sciences newsletter. I hope you find the contents interesting and that the presented articles provide you with an indication of the wide range of work and activities we are involved in.

It had been a very exciting six months since our last newsletter. The strength of our world leading capabilities in materials and our track record of delivering breakthrough research and engineering applications were recognised through the recent announcement by BP to establish a $100 million BP International Research Centre for Advanced Materials (BP-ICAM) here in Manchester.

The BP-ICAM will be modelled on a "hub and spoke" structure, with the 'hub' located within The University of Manchester's Faculty of Engineering and Physical Sciences, which has core strengths in materials, engineering, characterisation, and collaborative working. The "spokes" and other founder members, all world-class academic institutions, are the University of Cambridge, Imperial College London, and the University of Illinois at Urbana-Champaign. The BP-ICAM will carry out research into areas of direct interest to industry; structural materials, smart coatings, functional materials, catalysis, membranes, energy storage and energy harvesting. This will allow BP to change the way it builds, operates and maintains its equipment, and manufacture cleaner and more efficient products.

As the need to create cleaner energy using much more efficient methods intensifies, we've presented an update on some of the work our experts have been involved in across the faculty. Professor Ian Kinloch talks about how we could all have longer lasting batteries in laptops and electric cars thanks to Graphene, whilst we look at smart electricity systems as power networks of the future.

We were greatly saddened in August with the news of the death of Sir Bernard Lovell. He was Emeritus Professor of Radioastronomy and the founder and first director of the University's Jodrell Bank Observatory. Jodrell Bank is dominated by the 76 metre Lovell Telescope which has become an icon of British science and engineering. Sir Bernard's legacy is immense, extending from his pioneering work developing H2S radar during the Second World War to his dedication to education and public engagement with scientific research. He will be sadly missed.

We are very proud of our commitment to social responsibility and contributing to global issues. One of the biggest challenges in the world is the need to provide clean drinking water in the developing world. A unique project involving staff in the School of Materials, funded by the Bill and Melinda Gates Foundation is aiming to create a prototype device for harvesting energy and clean water from human waste. The research project brings together expertise from across a number of universities in the UK creating an interdisciplinary team to reach a common goal.

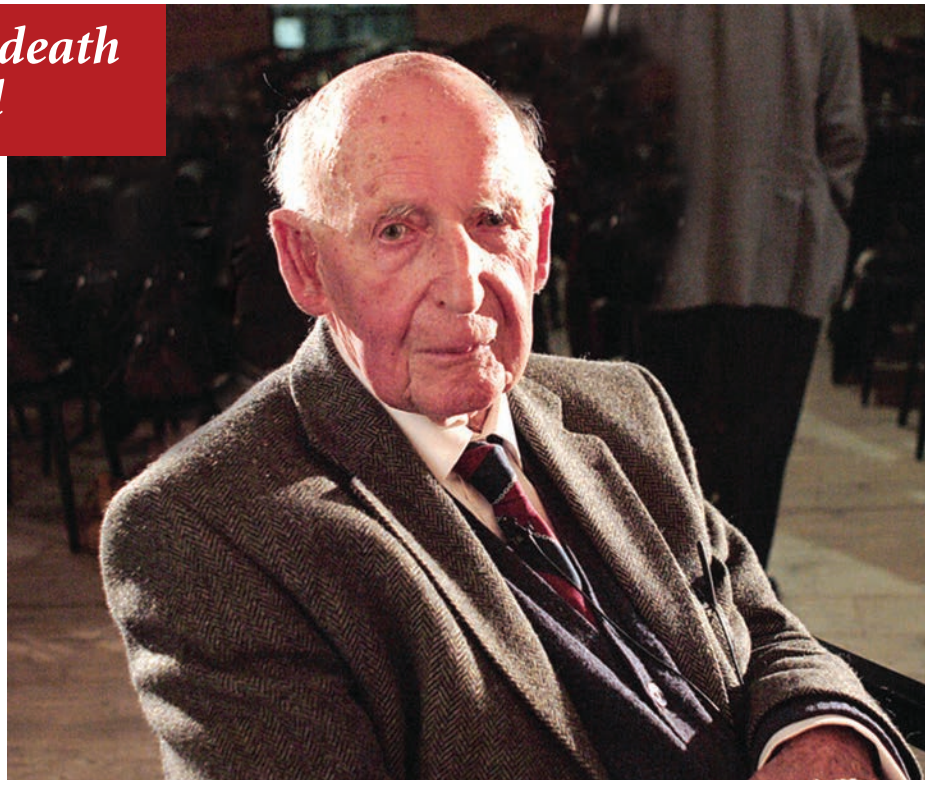
Every summer we host a number of summer schools and residential courses for 14 / 15 year olds and this year we hosted a four day Nuclear Residential Course for schoolchildren from across the UK who are considering Nuclear Engineering as a career. Participants took part in small groups on projects such as developing a method of pumping toxic radioactive sludge from Sellafield ponds, and then delivering Dragons' Den style pitches to sell their ideas.

I hope you enjoy this magazine – please let us know what you think, particularly if there are any specific areas of activity that interest you and you would like to hear more about. If you have colleagues who would like to be added to our circulation list please get in touch.

Professor Colin Bailey
Vice-President and Dean
Faculty of Engineering & Physical Sciences

0161 306 9111
colin.bailey@manchester.ac.uk

Great sadness at the death of Sir Bernard Lovell



Sir Bernard Lovell at the University

Sir Bernard Lovell, Emeritus Professor of Radioastronomy, died on 6 August aged 98. He was the founder and first Director of The University of Manchester's Jodrell Bank Observatory in Cheshire.

Born in 1913 in Oldland Common, Gloucestershire, Sir Bernard studied at the University of Bristol before coming to Manchester to work in the Department of Physics in 1936. During the Second World War, Sir Bernard led the team that developed H2S radar, work for which he was later awarded the OBE.

Sir Bernard returned to the Manchester Physics Department in 1945 and began work on cosmic rays using ex-military radar equipment. He brought this equipment to a University botany site at Jodrell Bank in late 1945, founding the world-famous Observatory.

Jodrell Bank is dominated by the 76-metre Lovell Telescope, conceived by Sir Bernard. He worked with engineer Sir Charles Husband to build the telescope which has become an icon of British science and engineering, and a landmark in the Cheshire countryside.

A hugely ambitious project, the telescope was by far the world's largest when it was completed in 1957 and within days tracked the rocket that carried Sputnik 1 into orbit, marking the dawn of the space age. It is still the third largest steerable telescope in the world and a series of upgrades mean it is now more capable than ever, observing phenomena undreamt of when it was first conceived.

Today the Lovell Telescope plays a key role in world-leading research on pulsars, testing our understanding of extreme physics including Einstein's General Theory of Relativity.

In person, Sir Bernard was warm and generous. He is survived by four of his five children, 14 grandchildren and 14 great-grandchildren. He retained a keen interest in the development of science at Jodrell Bank and beyond. Indeed he continued to come in to work at the Observatory until quite recently, when ill health intervened

Outside the world of science he was an accomplished musician, playing the organ at the Swettenham Church for many years. He was also a keen cricketer, captain of the Chelford Cricket Club and past President of the Lancashire County Cricket Club. He was also renowned internationally for his passion for arboriculture, creating arboretums at both The Quinta and Jodrell Bank itself.

Sir Bernard's legacy is immense, extending from his wartime work to his pioneering contributions to radio astronomy, and including his dedication to education and public engagement with scientific research. A great man, he will be sorely missed.

President and Vice-Chancellor of The University of Manchester, Professor Dame Nancy Rothwell, said: "We are all greatly saddened by Sir Bernard's death. He was a towering figure, not just in Manchester or the UK, but globally. Sir Bernard leaves a fantastic legacy at the University's Jodrell Bank Observatory which is a world class centre for astronomy research, an iconic science monument, and a centre that attracts thousands of visitors and inspires scientists of the future".

A book of condolence was opened at the Jodrell Bank Discovery Centre in August, and an online version is also available at **www.manchester.ac.uk/bookofcondolence.**

BP International Research Centre for Advanced Materials

President and Vice-Chancellor Professor Nancy Rothwell with Chancellor of the Exchequer, George Osborne, and Bob Dudley, BP Group Chief Executive, at the BP-ICAM launch

BP is to establish a $100 million international research centre, known as the *BP International Centre for Advanced Materials*, or BP-ICAM. This centre will lead research aimed at advancing the fundamental understanding and use of materials across a variety of industrial applications.

The BP-ICAM will be modelled on a "hub and spoke" structure, with the 'hub' located within The University of Manchester's Faculty of Engineering and Physical Sciences, which has core strengths in materials, engineering, characterisation, collaborative working, and a track record of delivering breakthrough research and engineering applications that can be deployed in the real world. The "spokes" and other founder members, all world-class academic institutions, are the University of Cambridge, Imperial College London, and the University of Illinois at Urbana-Champaign.

BP's investment programme will span ten years, and will support around 25 new academic posts alongside 100 postgraduate researchers and 80 postdoctoral fellows.

The BP-ICAM will carry out research into areas of direct interest to industry; structural materials, smart coatings, functional materials, catalysis, membranes, energy storage and energy harvesting. Initially its work will focus on:

- Structural materials, such as new metal alloys and composites for deepwater production, and high pressure/high temperature reservoirs;
- Smart coatings, for increased protection from the elements and improving a structure's usable life, protecting pipelines and offshore platforms from corrosion;
- Membranes and other structures, for separation, filtration and purification of oil and gas, water and chemicals in production, refining and biofuels processes and petrochemicals.

This will allow BP to change the way it builds, operates and maintains its equipment; manufacture cleaner and more efficient products; develop imaginative energy sources and then store that energy for when it is needed most; and increase the use of lighter metals and composites for structures and products.

The UK Chancellor of the Exchequer, George Osborne, said: "This coalition Government is committed to putting innovation and research at the very heart of its growth agenda. We are ensuring the UK maintains it competitive edge in science and we are creating an environment where innovation can flourish. That's why top businesses such as BP are investing in the UK and supporting our world-leading universities in delivering cutting edge research. And as an MP for the North West of England I particularly welcome the fact that BP's International Centre for Advanced Materials will be based at Manchester University."

Bob Dudley, BP Group Chief Executive, said: "Advanced materials and coatings will be vital in finding, producing and processing energy safely and efficiently in the years ahead, as energy producers work at unprecedented depths, pressures and temperatures, and as refineries, manufacturing plants and pipeline operators seek ever better ways to combat corrosion and deploy new materials to improve their operations.

"Manchester has world-leading capabilities and facilities in materials and was chosen after a global search to act as the 'hub' of the centre, working with other world-class university departments. We look forward to deepening further the very productive partnership that already exists between our professionals in BP and the academic team at Manchester."

BP's Chief Scientist, Ellen Williams said: "We're very excited by the vision of taking advanced tools that were developed for fundamental research to the real-world application of materials used for energy production. Our engagement with these four Universities demonstrates the importance both of research and of the innovation which can lead to advanced technologies."

Colin Bailey, Vice President and Dean of the Faculty of Engineering and Physical Sciences said "I am really pleased that BP has chosen The University of Manchester to be the Hub for the new BP-ICAM following a rigorous global review of expertise. The work we do on advanced materials underpins all our activities in engineering and science, covering all sectors. What makes Manchester distinctive is that we seamlessly work across disciplines, bringing together the skills and resources needed to address the challenges facing industry and society at large."

SCHOOL OF MATERIALS' DESIGN STUDENTS HAVE COMMERCIAL EDGE

This year's School of Materials annual Design Show has showcased students' final year projects, which they had created over the last year.
The students' work was judged by Nick Barber, Head of Design at Manchester-based fashion brand Bench, who described the work as being of such a high standard that a number of pieces could have been produced professionally.

Nick was present to give out several awards to the Textile and Retail Design and the Fashion Management BSc cohort, and said: "I've been to many of these events in my time and usually you can pick out the best students just by looking at the work.

"It's been difficult because the standard of work has been excellent. The students talked me through their projects and there have been one or two things that I could take right into our business straight away. The standard really is that high."

Right: Hang Nguen, Jason Li, Jeslyn Chan, Lin Chen, Qiao Liang, Yawei Chen, Yawei Chen, and Zhuoru Niu with the concession they created for Mango.

Lin said: "Now that I've finished my degree I'm going to go back to China and work for a fashion magazine. I've really enjoyed working in a team and I've developed so many skills – designing, market research, garment production – it's been fantastic."

Left: Ami Sibsick and Rebecca Williamson from the Textile Design and Design Management BSc with their collection of printed scarves inspired by the film Drowning by Numbers, directed by Peter Greenway.

Ami, who completed an internship with a bespoke men's tailor over Easter, said: "One of my favourite things on this course has been getting to know people. There are 21 girls on our course and we've just become so close. It's nice to know about each others lives and we've got on really well and helped each other out along the way. "

Textiles Lecturer, Ms Victoria Wheeler, explained: "In the final year students specialise and refine the skills they have gained. They choose a particular market and use their insights into the production of fabric alongside their knowledge of the creative processes.

"This has been a fantastic year. We've had some really experimental work.
I'm really pleased with how hard they've all worked."

N8 LEADS THE WAY IN HIGH PERFORMANCE COMPUTING

A new £3.25m Centre of Excellence for High Performance Computing is bringing together the best academic expertise in the N8 Research Partnership.

The new Regional Centre, funded by the Engineering and Physical Sciences Research Council (EPSRC), will provide a shared facility for high performance computing (HPC) for the universities of Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York - an established partnership of research-intensive universities that collectively form the N8 collaboration.

The facility which is based at the University of Leeds, and will be run jointly with The University of Manchester, is of a scale currently not readily available to the partners.

The Centre of Excellence will provide a major boost to world-class research in the partner institutions, allowing researchers to build more realistic computational models and undertake more complex analyses in fields as diverse as healthcare (e.g. modelling organs and their interactions, discovering causal patterns in health data), sustainable energy (e.g. modelling wave energy conversion), and aerospace (e.g. large-scale simulation for developing green air transport).

The shared facility will make it easier for institutions to collaborate on research and will create opportunities to engage more effectively with business and the community.

Professor Chris Taylor will be providing academic leadership for the Centre, alongside Professor David Hogg, Pro-Vice-Chancellor Research and Innovation at the University of Leeds. He said: "This development provides an exciting opportunity for the N8 universities to boost internationally-leading research that has significant real-world impact".

Professor Hogg said: "This is a good example of the N8 universities working together to share research assets, combine research strengths, and engage more effectively with industry and the community".

The N8 partnership has recently published a report into the potential for sharing research assets across the universities in the North, with a view to encouraging greater collaboration and industry links.

Professor David Delpy, EPSRC's Chief Executive, said: "Having access to high performance computing facilities is becoming increasingly essential to many branches of science, to investigate new theories and model more complex problems in greater detail. Collaborations such as the N8 Research Partnership can provide these vital tools and help UK institutions build on their existing strengths."

N8 Research Partnership

UNIVERSITY ASTRONOMERS DISCOVER SANDSTORMS IN SPACE

Astronomers at The University of Manchester believe they have found the answer to the mystery of a powerful 'superwind' which causes the death of stars.

University researchers formed part of a team of researchers that have used new techniques to allow them to look into the atmospheres of distant, dying stars; research findings recently published in *Nature*. The team, lead by Barnaby Norris from the University of Sydney in Australia, includes scientists from the universities of Manchester, Paris-Diderot, Oxford and Macquarie University, New South Wales, and used the Very Large Telescope in Chile, operated by the European Southern Observatory.

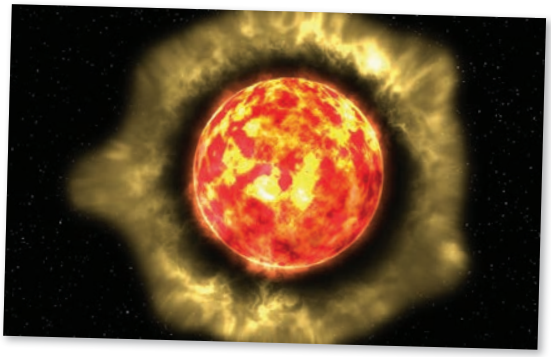
At the resolution used by the scientists one could, from the UK, distinguish two headlights on a car in Australia, and this extreme resolution made it possible to resolve the red giant stars, and see winds of gas and dust coming off the star. Stars like the Sun end their lives with a 'superwind', 100 million times stronger than the solar wind. This wind occurs over a period of 10,000 years, and removes as much as half the mass of the star. At the end, only a dying and fading remnant of the star will be left. The Sun will begin to throw out these gases in around five billion years.

Scientists have assumed that superwinds are driven by minute dust grains, which form in the atmosphere of the star and absorb its light. The star light pushes the dust grains (silicates) away from the star. However, models have shown that this mechanism does not work well.

Scientists have now discovered that the grains grow to much larger sizes than had previously been thought. The team found sizes of almost a micrometer – as small as dust, but huge for stellar winds.

Grains of this size behave like mirrors, and reflect starlight, rather than absorbing it. This leaves the grains cool, and the star light can push them out without destroying them. This may be the solution to the mystery of the superwind.

The large grains are driven out by the star light at speeds of 10 kilometres per second, or 20 thousand miles per hour – the speed of a rocket. The effect is similar to a sandstorm. Compared to grains of sands, the silicates in the stellar winds are still tiny.



An artist's impression of the sand storm surrounding the star W Hya.Image: Anna Mayal

Professor Albert Zijlstra, from The University of Manchester's Jodrell Bank Observatory, said: "The breakthrough changes our view of these superwinds; for the first time, we begin to understand how the superwinds work, and how stars (including, in the distant future, our Sun) die.

"The dust and sand in the superwind will survive the star, and later become part of the clouds in space from which new stars form. The sand grains at that time become the building blocks of planets. Our own Earth has formed from star dust. We are now a big step further in understanding this cycle of life and death."

DUAL SITE FOR SQUARE KILOMETRE ARRAY

An agreement on the dual site solution for the SKA has been reached, marking a crucial step towards the development of the world's largest and most sensitive radio telescope.

Scientists, engineers, and industry partners from around the world are participating in the SKA project which is driving technology development in antennae, data transport, software and computing, and power. The design, construction and operation of the SKA project which has its headquarters at The University of Manchester. The project has the potential to impact skills development, employment and economic growth in science, engineering and associated industries globally.

The ASKAP and MeerKAT precursor dishes will be incorporated into Phase I of the SKA which will deliver more science and will maximise on investments already made by both Australia and South Africa.

The majority of SKA dishes in Phase I will be built in South Africa combined with MeerKAT. Further SKA dishes will be added to the ASKAP array in Australia. All the dishes and the mid frequency aperture arrays for Phase II of the SKA will be built in Southern Africa while the low frequency aperture array antennas for Phase I and II will be built in Australia.

Minister for Universities and Science, David Willetts, said: "The decision for a dual site maximises the use of the investments already made in both locations. It also ensures that all the great experience already gained can be put to best use designing and delivering the next phase of the project, in which UK scientists will play a key role.

Richard Schilizzi, Professor of radio astronomy and Head of the SKA Group in the University of Manchester, added: "The SKA will be one of the top global science projects of the 21st century. The findings of this project will benefit many other areas, such as information and communication technologies (ICT), wireless communication, sensor technology and renewable energy."

The Science and Technology Facilities Council (STFC) is providing funding for the UK's involvement in the project's detailed design phase, enabling UK institutes (Universities of Cambridge, Oxford and Manchester) and industry to participate in the international work collaborations needed to progress SKA to construction readiness. STFC also provides funding to support operation of the SKA Project Office, based at Jodrell Bank Observatory at The University of Manchester.

CHANGING CITIES

'A change from above'
– a rooftop garden in Manchester

Photo courtesy of Andrew Speak

The University of Manchester and Bruntwood- a leading property company- hosted the symposium 'Adapting the City' during the summer, the culmination of a project to explore how cities can adapt to ongoing and projected future changes in weather and climate.

Content for the symposium was developed through extensive research by EcoCities- a joint initiative led by The University and funded by Bruntwood- which focuses on the response of cities to the impacts of climate change.

EcoCities draws on the knowledge and capabilities of the University's Manchester Architecture Research Centre and Centre for Urban and Regional Ecology. The key findings of the project are on a webpage – www.adaptingmanchester.co.uk – and are targeted at supporting adaptation strategy and action in Greater Manchester and beyond.

Greater Manchester has been the case study for the EcoCities project which has found that the city is already seeing changes in its weather and climate, with more significant shifts projected for the coming decades.

The Adapting the City symposium addressed three key themes for climate adaptation in our cities: boosting future prosperity- flooding will cost millions and extreme heat will hit productivity; protecting vulnerable communities- groups such as the elderly will be most at risk from rising temperatures, some poorer areas face higher exposure to flood risk; and improving the resilience of infrastructure- transport, utilities, data, public services and green spaces must adapt to the changing climate .

The summit hoped to stimulate the process to find practical and economically viable solutions of how climate adaptation can, and should, happen at a number of levels: individual building, local community, and strategic city-level region.

Kevin Anderson, Professor of Energy and Climate Change and Director of the Tyndall Energy Programme commented: "Evidently there is real drive and commitment to bring about change at the city level – both from within the academic community and the city council. However, whilst this is certainly to be welcomed, we are now in 2012 and unfortunately Manchester is not isolated from the global failure to respond to the challenges of climate change.

"Despite several years of economic downturn and upheaval for many industrialised nations, global carbon dioxide emissions in 2011 rose 3.2% on the 2010 figure, which itself was up almost 6% on 2009. It is against such a backdrop of significant and escalating growth in emissions, that the mitigation and adaptation efforts of Manchester and other cities need to be considered. The challenges we face now, twenty years on from the first Rio Earth Summit, are an order of magnitude more demanding both in scale and urgency.

"The EcoCities project and conference demonstrated we have the ingenuity and wherewithal to meet these challenges. What we need to bring about action is the audacity to think differently about the future, the courage to push through difficult policies and a commitment not to buckle under pressure from short-term self interest. Put these together – and the prospect for a sustainable and socially prosperous future for our cities (and beyond) is within our grasp."

2012 RSC HARRISON-MELDOLA PRIZE FOR DR MIKE INGLESON

Dr Mike Ingleson, from the School of Chemistry, has been awarded the prestigious 2012 RSC Harrison- Meldola Prize for his innovative work in borocation chemistry, particularly the borylation of arenes.

Mike heads a research group focused on using main group and organometallic chemistry to solve key challenges defined by pharmaceutical/organic materials industry and facing society in general.

A key aspect of the research is the ability to facilely access boronic acids and boronic esters more economically (in one step, at room temperature, without halogenated intermediates), which will prove valuable to academia and industry. Furthermore this route also provides access to new boronics ester/acids that were previously difficult or impossible to access. The importance of boronics is predominantly (though not exclusively) in the Suzuki Miyaura reaction which is pervasive in academia and used in industry on a large scale.

Dr Ingelson commented, "Some compounds we've made by this method are already commercially available through fine chemical catalogue companies and have indeed sold out, with companies currently negotiating options to obtain more (through licensing with an intermediary custom synthesis company).

"This prize is important as it raises the profile of our work, and awareness of this chemistry, and furthermore it's recognition of the great work carried out by my first couple of students/PDRAs."

Dr Mike Ingleson

ROYAL ACADEMY ROLE FOR COLIN BAILEY

Professor Colin Bailey, Vice-President and Dean of the Faculty of Engineering and Physical Sciences, has been elected a Fellow of the Royal Academy of Engineering.

Professor Bailey is internationally renowned in the field of structural fire engineering, and was the lead expert in reviewing the structural fire design of iconic buildings in London, such as The Shard, The Pinnacle, Heron Tower and Leadenhall. He has also been an expert on a number of other projects, including explaining the collapse of the World Trade Centre following the terrorist attack in 2001.

In addition he has published 99 research papers and 11 design guides and has been awarded eight prizes for his work. He has developed the 'Bailey/BRE' design method, which utilises membrane action of floorplates to allow the optimum specification of protection to steel beams, within the fire safety design of buildings. The method has been used on a number of projects, with its use growing throughout the industry. The method was first presented in a research paper in 2000 and is now presented in industrial guides.

He has served on the Joint Board of Moderators, where he has contributed in a number of ways including being Chairman of the working group who developed guidelines covering the teaching of design on all university degree programmes. He has been external examiner at a number of universities where he has provided overall curriculum advice. He serves on a number of committees, including currently being the only academic on the Standing Committee on Structural Safety.

Professor Bailey entered academia from industry at the age of 35, when he was offered a chair in Structural Engineering. He has provided strategic leadership in the area of engineering in various roles. In his current role, as Vice President and Dean of The Faculty of Engineering and Physical Sciences, he is responsible for 1,913 staff, 10,477 students and an income of over £200 million. He has been responsible for turning an operating deficit of £14.6 million into a £6.9 million surplus within two years, whilst providing leadership to increase the quality of engineering and science across the board. One of his major strengths is his understanding of all disciplines allowing him to bring together expertise to address the grand challenges facing society and the ever-changing needs of industry.

Professor Colin Bailey

Dr Sarah Haigh

ENERGY FROM HUMAN WASTE

Researchers at The University of Manchester are working on a prototype device for harvesting energy and clean drinking water for human waste, thanks to funding from the Bill and Melinda Gates Foundation.

They formed a team with researchers from Imperial College London and Durham University, beating more than 2,000 other proposals to receive $100,000 (over £62,000) funding to develop the prototype system.

The technology could provide an inexpensive device for use in the developing world to generate clean water and energy from waste and a sustainable source of hydrogen energy that could be used to power homes in developed countries. The device will be portable, allowing installation in homes and remote locations.

The technology is based on a porous scaffold that holds bacteria and metal nano-particles. When faecal sludge is filtered through the scaffolding these particles will react with the waste matter to generate recycled resources. These can either be used immediately or stored for later use. Bacteria in the device will form part of a process to extract energy and clean water from human faecal waste.

The first stage of the project will see the team developing a stand-alone sanitation device, making it easier and cheaper for people in developing countries to adopt the technology where large sewage networks may not exist.

In the long-term, the researchers aim to further develop their device into a 'pick and mix' series of recycling units that can extract the types of resources most useful for users such as: electrolytes, used for generating electricity; methane, for energy; and ammonia, which is a widely used fertiliser. The team says their device would be an advantage over other systems currently on the market that can only recover one or two resources at most.

Dr Sarah Haigh, from the School of Materials at The University of Manchester, said: "The phrase 'off to spend a penny' is used in polite society to refer to a visit to the lavatory. We plan to turn this essential everyday outgoing into an investment by developing novel materials that convert natural waste into a useable resource.

"This technology will be particularly important for remote locations in developing countries and will have the added benefits of reduced pollution and lower waste disposal costs. It is exciting to be working in this interdisciplinary team and demonstrates the importance of combining different expertise to reach a common goal."

The researchers plan to have a prototype ready to demonstrate by 2013. The project team and the concept were a product of a recent Engineering and Physical Sciences Research Council "Inspire in the Physical Sciences" workshop.

ROYAL SOCIETY HONOURS UNIVERSITY OF MANCHESTER ACADEMIC

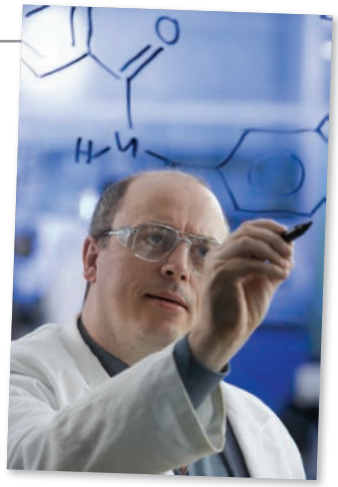
Professor David Leigh FRS, has been selected to give the Bakerian Lecture – one of the most highly regarded lectures in physical sciences. The lecture, which is accompanied by a medal and a gift of £1,000, is delivered annually and is one of the oldest scientific lectures in the world – first given in 1775.

David Leigh, Professor of Organic Chemistry, is a world leader in the field of synthetic molecular motors, machines and nanotechnology. His work has been rewarded with several awards and international prizes, including the EU Descartes Prize for Research and the US Feynman Prize for Nanotechnology, both in 2007. He was elected Fellow of the Royal Society in 2009.

Speaking about the Bakerian Lecture and his work at Manchester, Professor Leigh said: "It's great when our group's work is recognised by prizes, of course. The Bakerian Lecture is one of the premier awards of the Royal Society and I was both surprised and honoured when the Royal Society asked me to give the 2013 Lecture."

Sir Paul Nurse, President of the Royal Society, said: "The recipients of the Society's awards and medals this year represent the best of the best in science yet again. Science can improve our health and quality of life, help solve the world's biggest problems, and support sustainability.

"These outstanding scientists work across a range of disciplines and their research could have real impact. We're very pleased to be able to recognise them in this way and highlight the important work they are doing."



Professor David Leigh

The full list of recipients of Awards, Medals and Prize Lectures for 2012 is available at **www.royalsociety.org/news/top-scientists-2012**

Professor Andrew Sherry, Director of the Dalton Nuclear Institute at the House of Commons

CELEBRATION DAY FOR QUEEN'S ANNIVERSARY PRIZE

Industry leaders, Government officials and academics from The University of Manchester came together at the House of Commons during the summer to celebrate the award of a Queen's Anniversary Prize for Higher and Further Education for the Dalton Nuclear Institute.

The Queen's Anniversary Prizes are the UK's most prestigious form of national recognition open to a UK academic or vocational institution. The winning entries range from individual departments or research groups to major international development projects and community schemes delivering cutting-edge research. The prize recognises and celebrates the outstanding work within UK higher and further education institutions and the impact that they have on society.

The House of Commons celebratory event was hosted by The Rt Hon the Lord Jenkin of Roding, and recognised the University's success in nuclear research and training. Charles Hendry MP, then Minister of State for the Department of Energy and Climate Change, gave an address about opportunities for growth in the nuclear sector, and attendees were able to learn more about the Dalton Nuclear Institute and its ground-breaking research and facilities, as well as to discuss future nuclear research and development needs for the UK.

The Rt Hon the Lord Jenkin of Roding highlighted the recent House of Lords Report on nuclear R&D, which has led to a renewed focus on the UK nuclear research capability, as a means to deliver the technology and skills needed for low carbon nuclear power to contribute significantly to the future UK energy mix.

Colin Bailey, Vice President and Dean of the Faculty of Engineering and Physical Sciences at The University of Manchester spoke about how the University established the Dalton Nuclear Institute in 2005, and its rise to be a world-leading centre for nuclear research.

Mr Hendry described the major opportunities for nuclear research and development to contribute significantly to growth in the UK and highlighted the positive on business opportunities which the Electricity Market Reform bill will bring. Mr Hendry said: "The Dalton Nuclear Institute is a world-leading centre of expertise and fully deserves this recognition through the Queen's Anniversary Prize. With the country on the cusp of a nuclear renaissance, research and development in the nuclear sector can be a significant driver of our future economic growth."

Professor Andrew Sherry, Director of the Dalton Nuclear Institute, concluded the speeches, highlighting the continued need for nuclear R&D to address seven grand challenges including reactor operation, decommissioning and waste management. He also highlighted the opportunity for the UK to re-engage in international programmes, to establish a network of nuclear research facilities, and to contribute to the national and international skills agenda.

Professor Sherry said: "It was wonderful to celebrate the Diamond Jubilee Queen's Anniversary Prize with those who have worked with the University in developing the nuclear R&D capability".

EDF AND THE UNIVERSITY OF MANCHESTER RENEW COLLABORATION AGREEMENT

EDF, the leading electricity producer in Europe, has renewed a collaborative framework agreement with The University of Manchester which will see the continued partnership between EDF R&D and the University's Dalton Nuclear Institute's world-leading research centres.

The agreement covers the development of a mutually beneficial research strategy, the outline structure of research contracts and support for doctoral students, the re-affirmation of the Chair funding, as well as funding for a research fellow for the Modelling and Simulation Centre (MaSC).

The collaboration will involve sharing knowledge, technical expertise and common research across the energy sectors. Fields of interest will be overseen by a strategy committee from schools across the Faculty of Physical and Engineering Sciences at the University, including the Schools of Electrical and Electronic Engineering, Materials, and Mechanical, Aerospace and Civil Engineering.

Professor Andrew Sherry, Director of the University's Dalton Nuclear Institute, said: "We value our relationship with EDF highly and are delighted with the opportunity to extend the strategic collaboration further to work across a range of relevant research areas in new innovative projects."

Professor John Yates of MaSC at The University of Manchester, said: "I'm delighted to renew the collaboration agreement with EDF R&D. The University of Manchester has a long-standing relationship with EDF, particularly in the area of computation of fluid dynamics and materials performance, and we're looking forward to expanding this into solid mechanics and materials modelling with some exciting new ideas on the horizon".

Professor Stéphane Andrieux, Scientific Director of EDF R&D, commented: "This collaboration is set at the international scientific level which has come to be expected from The University of Manchester and is a continuation of what was achieved in the CFD domain for years. We are very happy to share with the Dalton Nuclear Institute and the School of MACE the great ambitions that are necessary to deal with the full range of challenges in energy over the next few decades".

Pierre-Louis Viollet of EDF R&D (left) and Peter Stansby of The University of Manchester sign the collaboration agreement

Green revolutions grappling with graphene

Science and environment journalist Myc Riggulsford talks to The University of Manchester's Professor Ian Kinloch about the future for Britain's strangest and strongest material

More effective electric cars and longer lasting laptops could be coming our way soon if the investment in turning graphene, The University of Manchester's wonder material, into everyday products pays off.

"The key problem with electric cars is exactly the same as the problem with modern mobile phones – how do you make the batteries lighter, but last longer?", says Professor of Materials Science Ian Kinloch. "Batteries store power and give it back over a long period. For a car, you also need a boost of energy for acceleration and this power could come from supercapacitors".

In a car, or mobile phone, or laptop, the battery is crucial for the power and performance. In an electric vehicle it has to be able to deliver a continuous electrical charge for as long as possible. It does this by reacting chemical ions at two electrodes, both of which need as large a surface area as possible for the lightest weight. The supercapacitors store positive and negative charges at their electrodes, which can then release the electrical energy in a short burst.

"The power depends on the surface area of the plates. The more conductive and the thinner they can be, the more we can fit into the space for the same weight. Which is where graphene comes in", says Professor Kinloch.

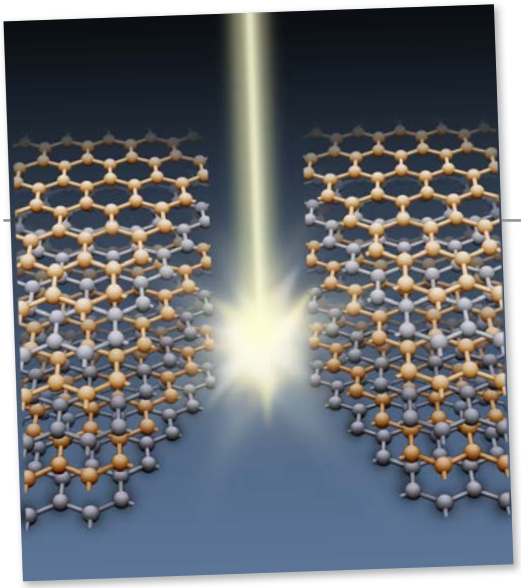
"At the moment electric cars have a limited range due to their batteries, and the latest mobile phones need recharging regularly. The storage capacity of the batteries also deteriorates each time you charge them, and eventually they hardly hold a charge at all. Our job is to see if we can use graphene to improve their performance", he says.

Graphene is the strongest and lightest material in the world, with extraordinary electrical conducting properties – It is a million times better as a conductor than copper wire. It is a one atom thick layer of carbon, arranged in a hexagonal, honeycomb-like lattice, giving it a massive surface area for its weight.

"Graphene could improve the cycle life of electric or hybrid car batteries in at least three ways, charging them up faster, giving them more storage capacity - making them last longer on each trip, and giving them a longer overall life", says Professor Kinloch.

So when you see an electric car driving along the street in a few years' time, the chances are it will have a graphene-based battery or supercapacitor giving it a better mileage range and acceleration. It could also have lighter body panels made of graphene composites. Graphene-based photovoltaic panels could charge the car as it moves or parks. And its internal touch screens and displays will use the transparent properties of one of nature's weirdest and most useful materials.

For more information about the commercial development of graphene composites, fuel cells and energy storage contact Professor Ian Kinloch, Materials Science Centre, University of Manchester, email ian.kinloch@manchester.ac.uk



A beam of ions digs a trench through the surface of graphene

VISUALISING GRAPHENE

Researchers at Manchester have demonstrated that graphene can be used as a building block to create new 3D crystal structures which are not confined by what nature can produce.

The latest discovery for the wonder material was reported in *Nature Materials*, and involved sandwiching individual graphene sheets between insulating layers in order to produce electrical devices with unique new properties. It is thought that this new method could pave the way for a new dimension of physics research.

Researchers showed that a new side-view imaging technique can be used to visualise the individual atomic layers of graphene within the devices they have built. They found that the structures were almost perfect even when more than ten different layers were used to build the stack.

This surprising result indicates that the latest techniques for isolating graphene could be a huge leap forward for engineering at the atomic level, and gives more weight to graphene's suitability as a major component in the next generation of computer chips.

The researchers' side-view imaging approach works by first extracting a thin slice from the centre of the device. By using a beam of ions to cut into the surface of the graphene and dig a trench on either side of the section they wanted to isolate, they were able to remove a thin slice of the device.

Dr Sarah Haigh, from The University of Manchester's School of Materials, said: "The difference is that our slices are only around 100 atoms thick and this allows us to visualise the individual atomic layers of graphene in projection.

"We have found that the observed roughness of the graphene is correlated with their conductivity. Of course we have to make all our electrical measurements before cutting into the device. We were also able to observe that the layers were perfectly clean and that any debris left over from production segregated into isolated pockets and so did not affect device performance.

"We plan to use this new side view imaging approach to improve the performance of our graphene devices."

MENDING HOLES

In more graphene news, scientists at the University, alongside colleagues at the SuperSTEM facility at STFC's Daresbury Laboratory, have discovered that graphene undergoes a self repairing process to mend holes.

Published in *Nano Letters*, this new research may mark a breakthrough in realising graphene's potential for use in fields from electronics to medicine.

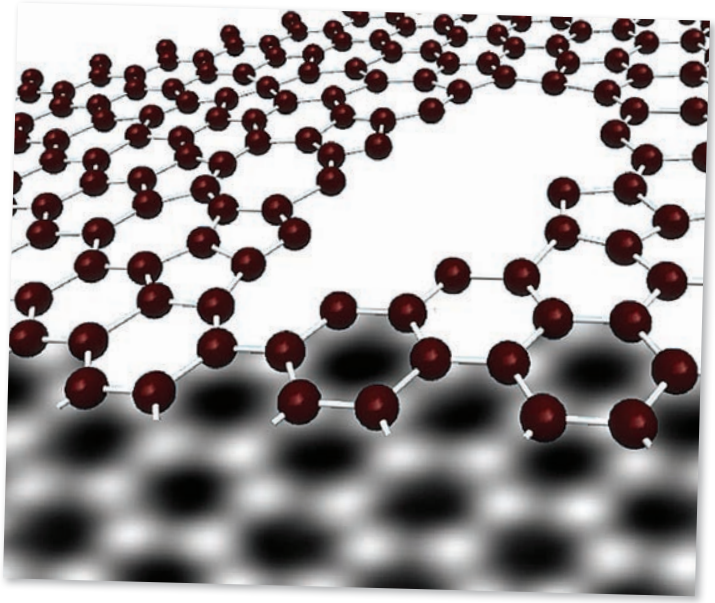
Led by Nobel Prize winner Professor Kostya Novoselov, the team looked to gain a deeper understanding into how metals interact with graphene, essential if it is to be integrated into practical electronic devices in the future.

Having demonstrated that metals can initiate the formation of holes in the graphene sheet, which could be hugely detrimental to the properties of any graphene-based device, the team used a powerful electron microscope at the SuperSTEM Laboratory at Daresbury, allowing them to study the properties of materials one atom at a time.

The results showed that some of the holes that had been created during this process were spontaneously mending themselves using nearby loose carbon atoms to re-knit the graphene structure.

Dr Quentin Ramasse, Scientific Director at SuperSTEM said: "This was a very exciting and unexpected result. The fact that graphene can heal itself under the right conditions may be the difference between a working device and a proof of concept without any real application. We may now have a way of not only drilling through graphene in a controlled fashion to sculpt it at the atomic level, but also to grow it back in new shapes. This adds a lot of flexibility to our nanotechnology toolbox and could pave the way to future technological applications".

www.graphene.manchester.ac.uk



Self-healing graphene can repair holes in the structure

A forest fire in southern Rondonia taken from the window of the research aircraft
Photo: Will Morgan

SOUTH AMERICAN BIOMASS BURNING ANALYSIS (SAMBBA)

Professor Hugh Coe of the School of Earth, Atmospheric and Environmental Sciences is leading a £3.7M Natural Environment Research Council Consortium to investigate the impact tiny particles, less than a micron in size, emitted by forest fires across Amazonia, are having on the region's weather, air quality and climate. The South American Biomass Burning Analysis (SAMBBA) programme involves seven UK universities and is in collaboration with the Met Office, the Brazilian Space Agency, INPE, and the University of Sao Paulo.

Currently, around 7000 square km of Amazonian rainforest in Brazil is cleared to develop the land for farming. The vast majority of this clearance is by burning, giving rise to very large emissions of small particles into the atmosphere. As a result, the atmosphere above southern Amazonia during August through October is extremely hazy and visibility is very poor. The particles, typically less a micron in size can scatter light from the sun back to space, cooling the underlying surface, but as they contain soot they can also absorb solar radiation leading to atmospheric heating. These changes to the heat balance can affect regional weather by reducing convection and hence affect cloud formation and rainfall. Convective clouds are common over Amazonia and the biomass burning particles can significantly influence their properties, affecting the distribution of rain across the region. In addition, the large and increasing population is exposed to such high concentrations which have a major impact on human health, especially when weather systems move the pollution to the major cities in south east Brazil. The problem is that current weather and climate models do not include these detailed interactions. The SAMBBA project seeks to improve our knowledge of these basic processes, to develop improved descriptions of them in computer models and to test these models using a highly detailed set of observations. Better air quality and meteorological forecasts will be developed as a result of this work, this is the reason the Sao Paulo Research Foundation (FAPESP) are supporting our Brazilian partners.

The team have recently returned from Brazil after spending September sampling fire plumes and the dense regional haze across the region using the UK's leading atmospheric research aircraft, a four engine jet converted to be a flying laboratory. The team of 50 scientists, pilots, engineers, and support staff flew over 75 hours in 21 days to deliver the most detailed characterisation of biomass burning aerosol and its effects ever made over the Amazon. This is a truly unique data set that will provide the basis for testing our models and has played a leading role in bringing UK and Brazilian atmospheric scientists together to solve some important global problems.

'MAGIC CARPET' COULD HELP PREVENT FALLS

A 'magic carpet' which can immediately detect when someone has fallen and can help to predict mobility problems has been demonstrated by University of Manchester scientists.

Plastic optical fibres, laid on the underlay of a carpet, bend when anyone treads on it and map, in real-time, their walking patterns.

Tiny electronics at the edges act as sensors and relay signals to a computer. These signals can then be analysed to show the image of the footprint and identify gradual changes in walking behaviour or a sudden incident such as a fall or trip. They can also show a steady deterioration or change in walking habits, possibly predicting a dramatic episode such as a fall.

Falling is the most serious and frequent accident in the home and accounts for 50% of hospital admissions in the over 65s.

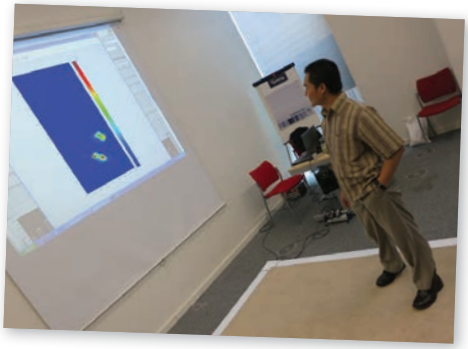
Presenting their research to the Photon conference, the scientists believe the technology could be used to fit smart carpets in care homes or hospital wards, as well as being fitted in people's homes if necessary. Physiotherapists could also use the carpet to map changes and improvements in a person's gait.

The interdisciplinary team, from the Schools of Chemical Engineering and Analytical Science, Electrical and Electronic Engineering and Nursing, Midwifery and Social Work along with the Photon Science Institute used a novel tomographic technique similar to hospital scanners. It maps 2D images by using light propagating under the surface of the smart carpet.

One of the team, Dr Patricia Scully from The University of Manchester's School of Chemical Engineering and Analytical Science, said: "The carpet can gather a wide range of information about a person's condition; from biomechanical to chemical sensing of body fluids, enabling holistic sensing to provide an environment that detects and responds to changes in patient condition.

"The carpet can be retrofitted at low cost, to allow living space to adapt as the occupiers' needs evolve – particularly relevant with an aging population and for those with long term disabilities – and incorporated non-intrusively into any living space."

Professor Krikor Ozanyan from the School of Electrical and Electronic Engineering added: "We pioneered this new kind of tomography here at The University of Manchester in 2005. Now we are delighted to show how achievements in maths, science and engineering can bring together this exciting new application in healthcare."



£1 BILLION CAMPUS MASTER PLAN TO INCLUDE A NEW ENGINEERING CAMPUS

The new campus will be located around the new James Chadwick building

The University of Manchester is to invest £1 billion over the next ten years to create a world-class campus for our staff and students.

The Estates Master Plan, which was approved by the University's Board of Governors in October will create a single campus and will involve the construction of new teaching and research buildings, student facilities and major improvements to the public realm.

The first phase of the plan, costing around £700 million, will be delivered over the next six years. It includes the building of a new engineering campus, as well as new centres for the School of Law and Manchester Business School, a major refurbishment of the University Library, a bigger and better Students' Union and a new Medical School for our students in Dover Street. There would also be investment in a Combined Heat and Power Facility, as well as a new car park and the refurbishment of the telescope at Jodrell Bank.

The University will also spend several million pounds to improve the University's public realm and landscaping in order to capitalise on the future improvements to Oxford Road, which will see wider pavements, tree-lined boulevards and the removal of all cars during 2015. Students will benefit from major IT upgrades, a new teaching block, refurbishments of several teaching rooms and extension to the Students' Union Building.

Outline plans have been drawn up for a second phase which is expected to cost a further £300 million and would begin in 2018 and end in 2022. This second includes refurbishments in the Schools of Computer Science, Earth, Atmospheric and Environmental Sciences, Mathematics and Chemistry.

Director of Estates and Facilities Diana Hampson said: "Since the merger of the two universities in 2004, it has been our ambition to bring all of the academic activity together on a single site south of the Mancunian Way, which will improve efficiency, improve the student experience and reduce the University's carbon footprint.

"This visionary building programme will give us one of the most modern campuses in the world, where the vast majority of our students will be studying in brand new or refurbished buildings."

The new investment is in addition to the £750 million spent since 2004 which has already seen the completion of ten new buildings and many large scale refurbishments.

The completion of Phase One of the Master Plan will see the University moving out of most of the buildings on the North Campus, although it will retain some of the buildings to the west of Sackville Street, including the Manchester Interdisciplinary Biocentre. The University is already working with partners from the City Council and New Economy to identify a suitable use for the buildings on the North Campus, which will be vacated by 2018.

The majority of schools will not move out of their present base on the North Campus until the new engineering campus is completed in 2018 and the University will continue to invest in and maintain the North Campus to a high standard, with significant investment over the next six years.

President and Vice-Chancellor of The University of Manchester, Professor Dame Nancy Rothwell, said: "For the first time, we will deliver a single site for The University of Manchester, where engineering, arts, biomedicine, business and all of our other activities live side by side, and our students will be at the real heart of a campus.

"Our long-term aim, as restated in our Manchester 2020 Vision, has been to create a world leading university that would compete with the best universities in the world and would occupy a single, outstanding campus, where some of our beautiful old buildings would stand alongside the very best in modern facilities for our research and our students."

TEENAGERS TAKE OVER THE UNIVERSITY FOR NUCLEAR RESIDENTIAL COURSE

Forty six Year 10 and 11 pupils were let loose at the University during a Nuclear Residential Course, which was organised by the Smallpeice Trust. The Trust is an independent educational charity that runs hands-on Science, Technology, Engineering and Maths (STEM) activities for schoolchildren across the UK, as well as engineering courses for pupils in Years 6-12.

The University hosted a four-day residential course for schoolchildren from across the UK who are considering Nuclear Engineering as a career, and they were able to take part in project work, talks, laboratory visits and social events.

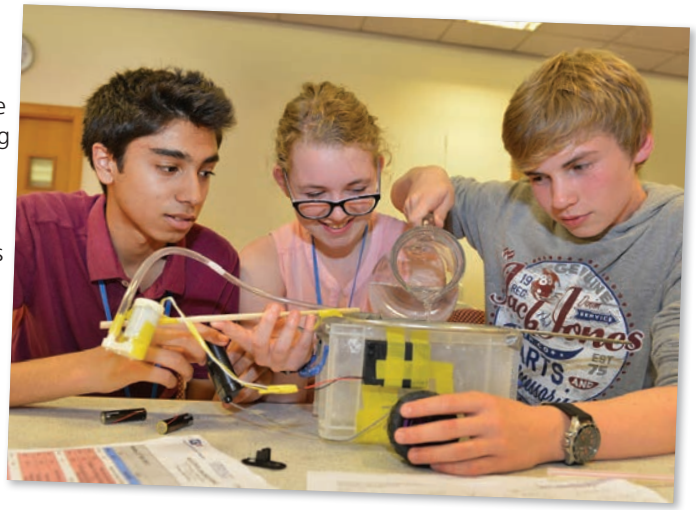
The pupils worked in small groups on projects such as developing a method of pumping toxic radioactive sludge from Sellafield ponds and to obtaining funds by developing saleable IP from the design and testing of a system, and creation of posters, trials, posters and a Dragon's Den-style presentation to sell their idea.

They were able to attend several talks including one that featured a shower of mini Mars bars explaining radioactive decay, the nuclear fuel cycle, Fukishima, and the UK's waste, sessions to listen to University researchers talk about their research, as well as have talks on the facilities at the University. They were also given career advice with access to University staff for a session on choosing a degree, and career case studies.

The pupils took part in a one hour Question Time-style discussion with a panel of opinionated experts, which included Jean Llewellyn, OBE, Director of the National Skills Academy for Nuclear.

As well as having the opportunity to learn more about nuclear engineering the pupils were treated to a formal dinner, disco, film screenings and were able to take part in sports on campus.

The event was coordinated by the Smallpeice Trust, and was organised by National Nuclear laboratory staff. Financial support was provided by the Nuclear Fuels Company, URENCO and The University of Manchester. Feedback for the course was extremely positive with 100% of the 46 selecting excellent or good for the overall assessment. Pupil comments about the residential were overwhelmingly positive, from praise for the interesting subjects covered in talks, and the level of understanding they gained from projects on the nuclear fuel cycle, to the knowledge and friendliness of the University staff.



SCIENCE AND ENGINEERING COMES TO LIFE

National Science and Engineering Week takes place each year across the UK, and aims to bring science alive for the next generation of scientists. The event is the UK's widest grassroots celebration of all things science and engineering, and this year more than 4,500 events took place across the country.

The University takes part each year to showcase how science, engineering, technology and maths impact on our everyday lives, and shape our daily decisions. Pupils get up close and personal with some of the cutting-edge research going on at The University of Manchester, and take part in a range of activities designed to inspire and motivate them to becoming the scientists of the future.

This year's three-day event featured a science fair with interactive displays from 19 different research groups, workshops delivered by PG students, and engaging guest lectures from leading academics Frank Mair (Chemistry) Joao Quinta da Fonseca (Materials Science) and Matthew Cobb (Faculty of Life Sciences).

Emma Lewis, who works in the Undergraduate Recruitment and Widening Participation team, as an Academic Enrichment Officer for Science, Technology, Engineering and Mathematics, commented "Events like this are key to open up the minds of young people to the breadth and importance of STEM subjects in our everyday lives. Meeting academics and researchers from the University and learning about their work is a great way to inspire many young people to study science and engineering to A-level and beyond. We were delighted to have so many colleagues involved, and the enthusiasm of staff certainty rubbed off on the young people who attended – one visitor commented that they "enjoyed listening to someone who was an expert in science" and that they found the lecture very interesting.

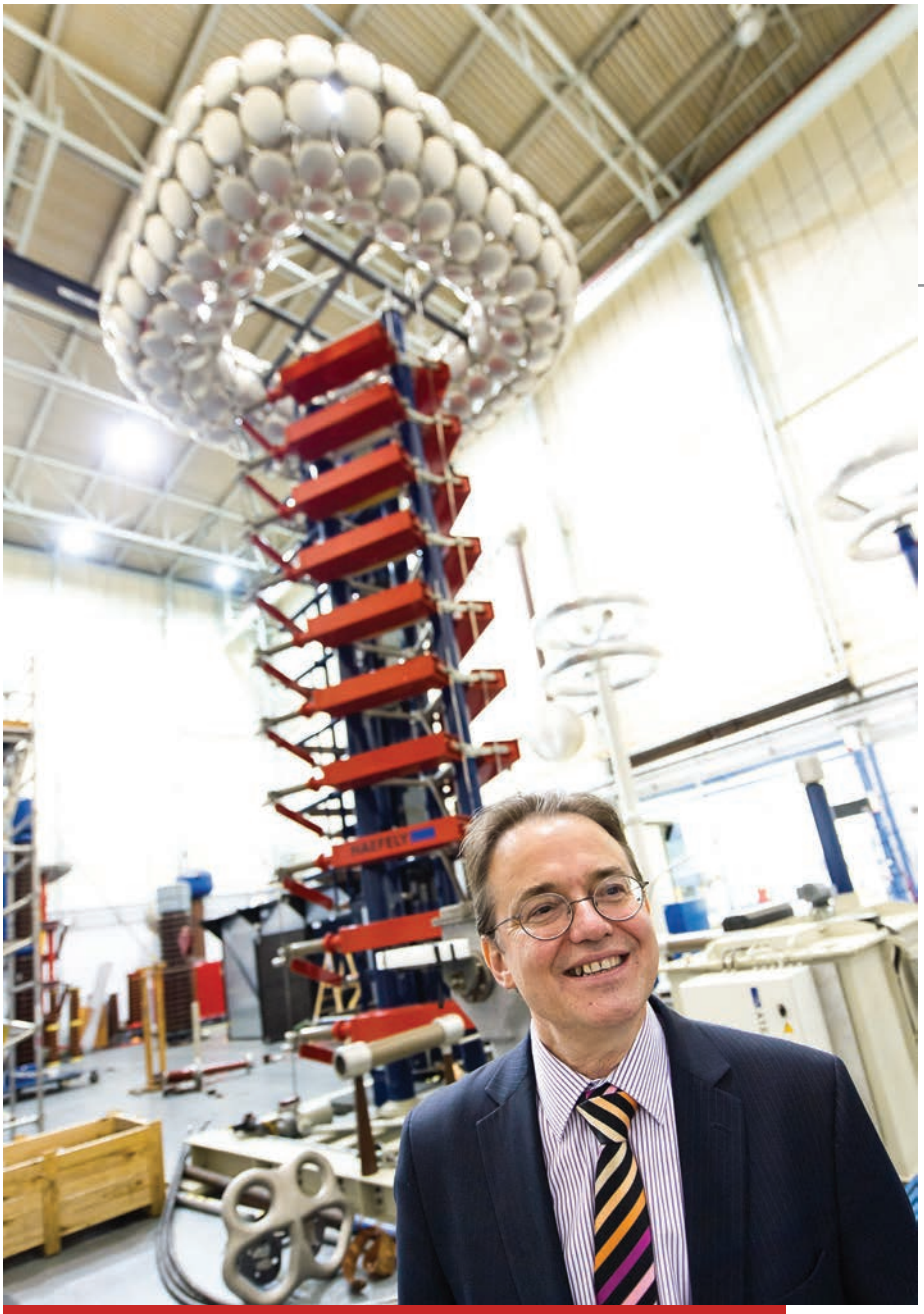
Eleanor Morris is a Speech and Language Therapy student at the University, and worked as a student ambassador at National Science and Engineering Week.

" During National Science and Engineering Week I was a student ambassador, helping out with activities. I was helping out at the science fair, which saw more than 700 high school students from around the Manchester area over three days. Busy busy!

The fair itself had lots of stalls and interesting exhibits on different science and engineering subjects and it was a lot of fun! From making model DNA from pipe cleaners, creepy crawlies under microscopes, infrared cameras, balancing robots and recycling-based dance mats, there was a stall about everything.

There were also workshops on things like boomerang making and giant biology board games. Each day was finished with a lecture about a specific area of science or engineering, which were amazing.

I don't know a lot about science (I tried Chemistry AS level and didn't do too well!) but it was all really interesting. The children seemed to think so too, and all three days were a great success. Hopefully it has inspired some to consider choosing a career in science and engineering!"



Smartening up the system - smart people, smart grids, smart homes

Science and environment journalist Myc Riggulsford talks to The University of Manchester's Professor Peter Crossley about cutting our bills and his smart plans for power systems

We rely on prehistoric power, locked up in ancient deposits of oil, coal and gas, to run our busy modern lives. But environmental science is increasingly telling us that we have to decarbonise our economies if we don't want to trigger even more dangerous climate change.

At exactly the same time that we are being told we must change, all our extra heat is melting Arctic ice to the record lows seen this summer, opening up some of the world's largest and untapped fossil fuel deposits to our giant oil exploration companies, and new technologies are trying to tap into shale gas locked in the rocks beneath our feet. This clash of ideologies is our society's next big test.

Smart electricity systems could transform the power grid, delivering cheap and reliable electricity to the places it is needed. And smart homes could tap into the system, powering up domestic appliances, heating systems and even our cars, at times when other demand is low, prices are cheap, but power is still pouring into the system from modern low-carbon generators such as wind farms, and in the future, wave and tidal power.

The urgent political juggling act is to find a way to cut carbon emissions, meeting our legal international obligations; keeping our household bills down to a manageable level as our working families and whole economy struggles; and finding the funds to invest in replacing our ageing national electricity grid and nuclear, coal, gas and oil fired power stations.

"We've taken millions of years of carbon and burnt it in just 200 years. We are now discussing and exploring methods to reduce our reliance on prehistoric solar energy stored in fossil fuels and exploiting real-time energy available in wind, waves, photovoltaics, solar thermal, biomass and hydro systems", says Prof Peter Crossley, head of electrical energy and power systems at The University of Manchester.

"To incorporate these green but often intermittent energy resources, electricity networks will have to become smarter. Real time information will have to be communicated between the suppliers and consumers of electricity, the local and national energy stores, and the operators of the transmission and distribution grids", he says.

A combination of rising world population and the much faster rising standards of living in developing countries mean that global carbon emissions are already approaching four tonnes of carbon per person per year. But that could leap to Europe's nine tonnes of carbon per person per year as China, India, Brazil and other large countries' economies strengthen. Environmental scientists say that the world cannot sustain the 15 tonnes per person emitted in countries like the USA and Australia, if everyone adopts a developed world lifestyle.

According to Peter Crossley, historically Britain is the second worst polluting country in the world, after the USA, bigger even than China in our overall emissions in spite of our much smaller population. We were the first country to industrialise, and it could be argued that we have a responsibility to the world to cut our emissions today. Our industrialisation was built on coal and coal gas. If the rest of the world did the same, earth would become uninhabitable.

Left and right, Professor Peter Crossley pictured with student Xi Chen in the High Voltage Lab in the Ferranti Building

But changing our patterns of electricity generation and consumption mean that we need some extra capabilities, such as storing energy when supplies are plentiful and some way of recovering the power when needed. If you were acting financially sensibly, and counting the cost of each unit, you would buy power when it's cheap and sell your stored electricity when the price rockets. But storage is only part of the solution. You also need energy management systems.

"Smart homes will be able to receive information from the supply system, telling our appliances when the price is about to go high, and telling them that unless absolutely necessary they should not operate. This reduces demand by automatically shifting the use of white goods to periods when the wind is blowing, energy use is low, or the local network infrastructure isn't heavily loaded".

Linking smart homes to a smart grid will cut costs for the whole country, since it would mean that our ageing power plants can continue to operate reliably well beyond their original life expectancy. Household bills could come down in spite of rising electricity prices. Meanwhile our renewable energy resources will get fully used, recharging our energy stores whenever supply exceeds demand.

"At the moment we have a legacy transmission network, designed 60 years ago around the centralised coal fired power stations in the midlands of England. Peak winter demand is fairly stable at around 55GW, and we have a national power generation capability of up to 80GW, or 80,000,000 one bar electric fires switched on at once, so just now we do have sufficient reserves in the system", says Peter Crossley.

"However we are expecting 12.GW of old coal stations and 7.5GW worth of nuclear power plants to reach the end of their lives and close completely by the year 2020, so we have to do something. Another 21GW of offshore windfarms and 11GW of onshore turbines will come on line by 2020 and need new grid connections. We might also see 3GW of new nuclear, 11GW of gas and 3GW of new coal plants fitted with carbon capture and storage capabilities to cut their carbon emissions".

"Offshore wind farms are the challenge and the opportunity. Britain is small and we don't have enough land to put up enough wind farms onshore. We don't want new overhead power transmission lines with pylons, so we're going to have to build new links around the coast. If we didn't have public opposition the network operating companies would build more pylons because it's the cheapest way of delivering the energy and they are the easiest to maintain".

The new generation plants will require new grid connections across the UK allowing generators and suppliers to even out and balance Britain's needs and capabilities.

"The new network, or smart grid would let smaller more dispersed generators such as wind farms feed into the national grid much more cheaply. It would reduce transmission and distribution losses and would help us to look for new ways of storing electricity at times of low demand but surplus generation, without putting a strain on the network. And it would prepare the way for electric and hydrogen fuelled vehicles, and new types of domestic power generation, combined heat and power plants, next generation photo-voltaic and domestic wind turbines", says Peter Crossley.

Britain is a world leader in research, development, and engineering expertise for these new green renewables and smart electricity systems thanks to our universities and well developed industries. But we are lagging at number eight in the world, behind countries such as Brazil, China, the USA, and even cash strapped economies like Spain, for investment in a smart power grid.

"We need to look east to countries like Korea and Japan, whose systems are much more like Britain than those of the United States. Japan was generating 35% of its electricity from nuclear before the Fukishima accident, now it's down to 5%, but they are still running the economy, and they are making a huge investment in their smart grid".

And as for fitting smart meters into homes, we have hardly started. "At the moment your utility company expects to deliver an average of 800 watts of electricity to your home, but this can peak at about 10kW. What happens if it is a cold dark morning and the wind is not blowing? How do the supply companies keep your lights on? In an average 24 hour period a typical family will use 20kW hours of power, costing about £2, giving you an electricity bill for the month of about £60", says Peter Crossley.

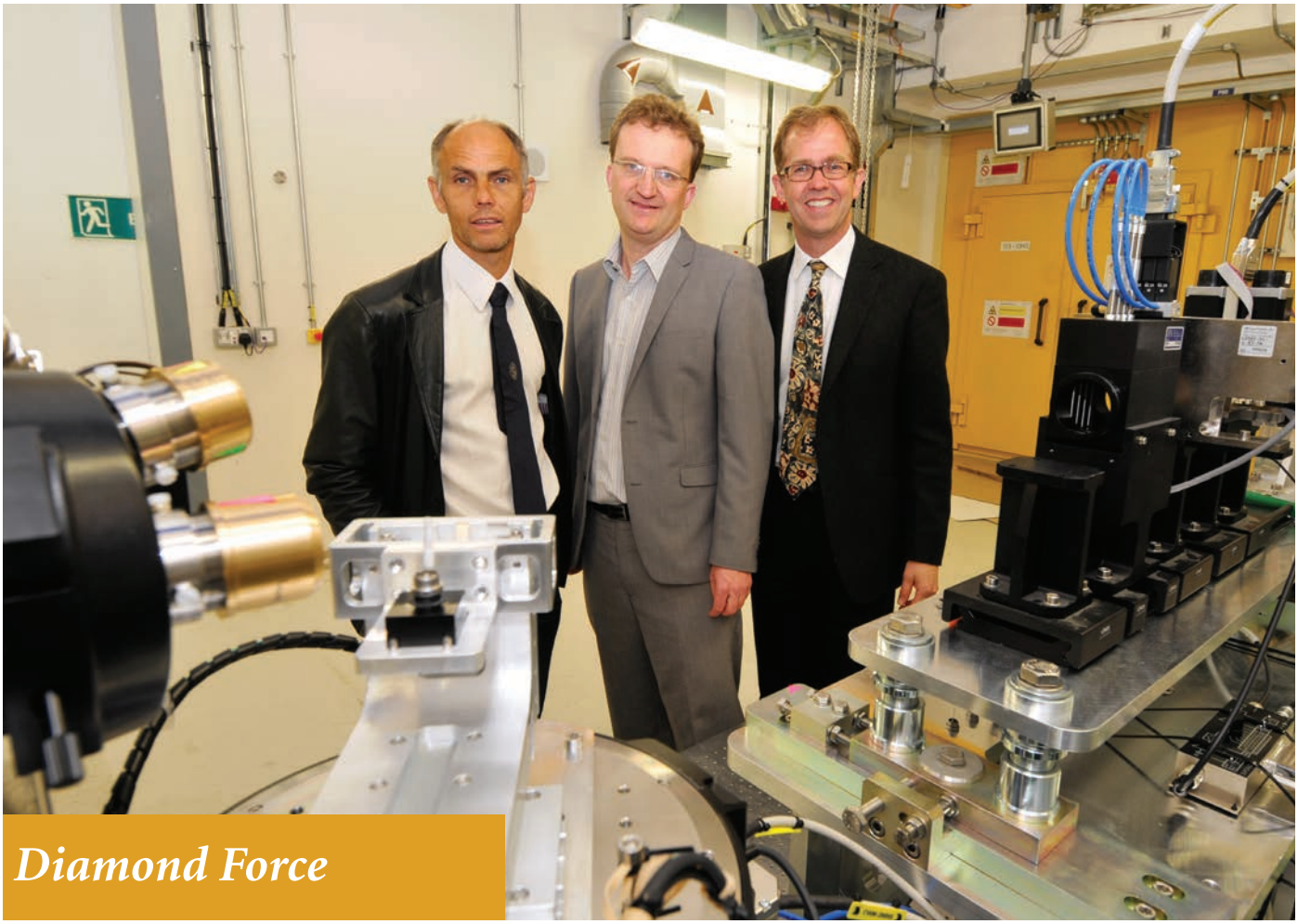
"With the next generation of smart meters and home computer systems you could shift your load away from the peaks and store electricity for heat when the price drops below 10p per unit. The computer could tell your washing machine to wait", says Peter Crossley. "A few years ago we moved to instant hot water heating, instead of having a hot water tank in every home. Actually heating water when the electricity prices are low is quite a sensible idea".

"You could imagine in future having a huge well-insulated hot water tank in the house, or even under your house, so any heat lost would warm your floor. You could store heat in it when the cost of electricity is low. You might even be able to heat it up in summer using solar thermal panels, and store the heat for weeks or months into the winter, a bit like the reverse of those grand old country houses which had ice stores underground", he says.

Storing electricity is a bit trickier. Battery storage is still a very expensive technology, but in future everyone expects it to get cheaper, and more reliable. At present batteries are damaged by being repeatedly charged up and discharged again, shortening their lives.

"Once the technology improves, at times when electricity costs are low you could also recharge storage batteries in your home, and in your car at night. Store it when the price drops below 6p per unit; and recover some power from your batteries whenever the price rises above 18p per unit", says Peter Crossley. "It would be possible to nearly halve your domestic electricity costs with the same basic usage. But the system needs communications, storage, sensors, intelligence and public acceptance first".

For more information about smart grids and electricity management contact Professor Peter Crossley, School of Electrical and Electronic Engineering, University of Manchester, email peter.crossley@manchester.ac.uk



Diamond Force

Diamond Light Source, the UK's national synchrotron facility, has recently signed a formal seven year collaboration agreement with The University of Manchester to develop a world-leading x-ray imaging capability for ultra-high resolution 3D images that are also time resolved, termed 4D imaging.

The collaboration began in May 2010 with significant funding contributions by both the University and Diamond, allowing the building of a new imaging branchline.

The University has additionally co-located a new Imaging Facility at the Research Complex at Harwell (RC@H) adjacent to Diamond Light Source (Diamond)) to further strengthen its capabilities for advanced research.

Both new sites augment Manchester's existing capability in the School of Materials (the Henry Moseley X-ray Imaging Facility), a state-of-the-art computed tomography (CT) facility within the Materials Science Centre. In 2011 all three activities were joined to form the Manchester X-ray Imaging Facility, or MXIF.

We met with Professor Peter Lee, Co-Director of the Manchester X-ray Imaging Facility, to find out more about the pioneering research and applications of imaging and image-based modelling techniques that are addressing scientific and industrial challenges.

"One example application is designing a new generation of joint replacement implants. At Manchester we are working on new manufacturing methods that are similar to rapid prototyping (termed additive manufacturing) which allow an engineered fine structure which bone can grow into, with a goal of providing a seamless transition in properties. However, the structure is so fine that a traditional CAT scan or radiograph cannot resolve it.

"These new facilities allow x-ray tomography with unprecedented resolution that lets you see if the bone is growing and interlocked, and if a healthy network of blood vessels have developed to feed that growth. Once we have these images, we can directly convert them into computer simulations, termed image-based modelling, helping to predict how new structures will behave, accelerating the design of this new generation of implants.

"These new facilities allow x-ray tomography with unprecedented resolution."

"The facilities are equally applicable to engineering applications such as developing more efficient jet engines to new alloys that are more easily recycled – we can see inside components whilst they are being made or in operation, allowing us to improve their internal structure to increase their performance."

Six years ago Professors Phil Withers, Lee and colleagues put forward a proposal for the Henry Moseley X-Ray Imaging Facility, receiving funding from EPSRC,

Left: first users of the facility, left to right, Phil Withers, Christopher Rau and Peter Lee

Right: Aerial view of Diamond Light Source with the Imaging and Coherence beamline, the Imaging branchline can be seen in the foreground

the University and industry. This facility, which formed the nucleus of the MXIF, has already generated more than 250 scholarly publications, with researchers addressing a wide range of problems from improved batteries for energy storage, to novel bioactive tissue replacements, to improved materials processing for jet engines.

Professor Lee continues "With the Diamond-Manchester beamline, we're able to zoom in to look inside objects as small as a human hair (~20 microns in diameter) and resolve internal features almost one thousandth of this size. Quantifying internal structures in 3D is important in many fields. For example, in energy applications, we have developed rigs which let us melt and then solidify metals whilst obtaining 3D images of their internal structure, with a goal upscaling the techniques used to grow small aeroengine blades as single crystal, to the metre long blades required for power plants. This would allow them to run hotter and hence more efficiently. Another recent energy application has been the examination of natural gas extraction from shale, which have a nanoscale structure; potentially allowing more controlled and efficient extraction techniques."

With the addition of time (4D imaging), the behaviour of objects can be observed in the same environment they are manufactured or used in, measuring how their structure changes with temperature, pressure, or exposure to liquids or gases. For example, you can't see the initiation of a crack unless you apply a load, operating temperature, or corrosive atmosphere that the component might be exposed to. To do this the team develops special rigs that replicate a range of environments while imaging in the lab or synchrotron x-ray beam.

"A group led by Dr O'Sullivan at Imperial College wanted to examine the behaviour of soils, and at Manchester we designed a rig to freeze and thaw soils permeated with water whilst the pressures found below grown were applied. It allowed us to obtain new insights into how ice lens form, the structure that makes ground heave or collapse, destroying buildings and causing failure in pipelines. It also allowed image-based modelling calculations of gas release from these soils, which is important as the melting of permafrost is a potentially huge source of greenhouse gases.

> "Projects include scientists from many disciplines; engineers, bio material researchers, medics, mathematicians and computer scientists."

"It's not enough to know that something consists of fibres and crystals; we need to know the sizes and orientations. Trying to break a fibre along its length is very different to doing so across its width, so we're working with colleagues in mathematics to develop algorithms to put quantifiable numbers on the astounding range of 3D shapes we're observing in the different materials both nature and humans produce."

Projects include scientists from many disciplines; engineers, bio material researchers, medics, mathematicians and computer scientists, who are joining forces to image, quantify and model how materials and structures work, with an end goal of designing better implants, jet engines, or just improving manufacturing methods to make them more competitive both from cost and environmental impact perspectives.

ABOUT DIAMOND LIGHT SOURCE

Diamond Light Source is funded by the UK Government via the Science and Technology Facilities Council (STFC) and by the Wellcome Trust.

Diamond generates extremely intense pin-point beams of synchrotron light of exceptional quality ranging from X-rays, ultra-violet and infrared. For example Diamond's X-rays are around 100 billion times brighter than a standard hospital X-ray machine.

Many of our everyday commodities that we take for granted, from food manufacturing to cosmetics, from revolutionary drugs to surgical tools, from computers to mobile phones, have all been developed or improved using synchrotron light.

For more information about Diamond visit www.diamond.ac.uk

continues on the next page...

The cross-discipline angle of work is critical. A team is assembled for each project; people who understand the x-ray physics, the mathematics of turning a series of individual x-rays into a 3D image, scientists who can take that information and build an environment; engineers, computational algorithm experts who can incorporate that data into a model. As Professor Lee notes "The academics are not just working together, we're very much trying to work with the best people across the UK and beyond, whether in academia, industry or government labs. Having part of the MXIF based at the Harwell Oxford Campusin Oxfordshire (also the site of Diamond Light Source), has facilitated these interactions, with more than 200 visitors in the past year, evenly split between academia and industry.

Although laboratory sources at the University are cutting edge, they have their limitations. In order to achieve high resolution they magnify the image in a similar way to a pin-hole camera; the object is placed close to a point source and the expanding x-ray 'shadow' is magnified by placing the detector far away. The small size of the source limits the flux of x-rays. Synchrotrons like Diamond work differently- they generate x-rays by bending a beam of electrons that has been accelerated to almost the speed of light. This creates a much brighter source of x-rays that can be focused.

"With a lab source we can take a 3D image every few minutes, but using a synchrotron means we can obtain a full 3D image many times in a second, so we can capture the kinetics of processes. Both speeds have their applications; when quantifying long-term corrosion a lab source can be ideal, but when analysing flows, fast deformations, or phase transformation a synchrotron is required, so the techniques are highly complementary."

Manchester was visionary in making the investment to build jointly a branchline with Diamond Light Source, as it gives Manchester academics priority access for research.

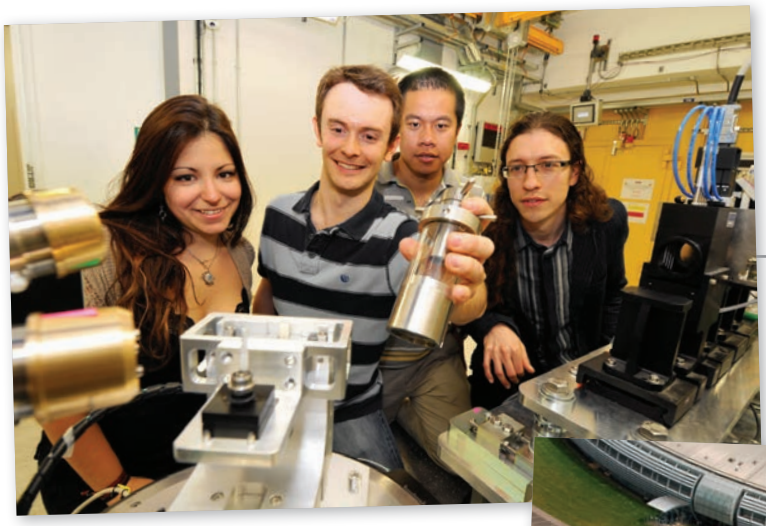
Professor Lee is clear on the benefits for society of this type of research "We're currently working with a biomedical company which has developed a new rapid manufacturing method for producing implants that can be tailored to an individual. The company needed to determine if the complex 3D structures that they had designed were being produced accurately, and if they had the desired results. We devised methods for obtaining the high resolution images, and then mathematical algorithms to quantify them. Our work allows industry to test processes and design with unprecedented spatial and temporal accuracy, optimising the process before it goes into service.

> **"Our work allows industry to test processes and design with unprecedented spatial and temporal accuracy, optimising the process before it goes into service."**

"We're also developing methods of understanding what happens during the failure of materials. Cracks can initiate inside an object, accelerated by corrosion or oxidation. Our new techniques simulate conditions ranging from those experienced by your knees as you walk, to the inner workings of a power plant, all the while measuring features in 3D, such as crack growth, stress states and methods of mitigating failure. Led by Phil Withers, we're carrying out work with a group in Holland to produce a new set of materials called self-healing ceramics. These are not fully oxidised so as a crack opens it takes on oxygen, forming new ceramic and healing the crack. We're currently discussing the applications and requirements with industry.

"We're also looking at the recycling of alloys. For example, as aluminium alloys are recycled, the amount of iron in them increases, melted in from many sources such as steel nuts and bolts that have not been removed. As the iron level increases, it is more prone to form large needle-like intermetallics which are brittle and can initiate fatigue cracks and corrosion; hence recycled alloys are not used in high performance applications. Our observations are being used to develop new models of this process, with an end goal of developing methods to turn the needle-like phases into more rounded or finer phases that strengthen the product rather than weakening it."
This would have a huge impact on industry and society, as recycling aluminium alloys generates less than 1/10th of the CO2 emissions as compared to primary production.

What's the future for research? "Future projects include a project led by the European Space Agency to apply additive manufacturing (as we've used for implants) to the production of aerospace components. As only a few parts are needed each year, using a technique that directly produces bespoke components from CAD drawings, is very cost effective, and 4D x-ray imaging promises to be an effective way to ensure component quality both on the outside, and in. This allows the inside of components, which often are non-load bearing, to be hollow or replaced with a webbing, enabling efficiencies in manufacturing and in use, reducing emissions in aerospace applications, and perhaps even reach automotive applications at some stage.



All images courtesy of Diamond Light Source

"We're also looking at trying to understand how to develop the next generation lithium batteries. We're working on a large project together with STFC, UCL and 20 major UK, US and European research centres, including Oakridge, the Swiss PSI Institute and the European Synchrotron Radiation Facility, bringing together scientists from across disciplines and institutions to overcome tomorrow's scientific challenges."

Find out more at
www.mxif.manchester.ac.uk
www.diamond.ac.uk
www.rc-harwell.ac.uk

The Research Complex at Harwell (RCaH) adjacent to Diamond where the University has its new Imaging Facility

ABOUT THE MANCHESTER-DIAMOND COLLABORATION

A formal collaboration between The University of Manchester and Diamond Light Source was set-up in May 2010. Through this collaboration, The University of Manchester agreed to financially contribute to the Imaging branchline. By Manchester's substantial contribution, Diamond was able to secure additional funding required to accelerate the branchline's completion and make this additional facility available to the benefit of the wider user community. Manchester have, in turn, secured themselves regular access to beamtime at Diamond. Once the branchline becomes fully operational, Manchester will benefit from a beamtime allocation at the branchline based on 50% of User beamtime available, although in practice this will mean that Manchester can get 35% user beamtime on the branchline with the remaining 15% to be other beamlines they select at Diamond.
Manchester are establishing their own peer review panel to ensure that the highest quality science is being undertaken to reflect Diamond's standard academic access.

Their funding has contributed towards both capital, core beamline staff, and to ongoing operational costs over the seven year term of the collaboration agreement. Diamond owns and has overall responsibility for this branchline and will provide all other funding necessary to ensure the beamline is world leading and maintain the operational status of the beamline.

As a result of the collaboration, The University of Manchester has additionally co-located their new Imaging facility at the Research Complex at Harwell adjacent to the Diamond synchrotron to further strengthen their capabilities for advanced research.

Diamond and Manchester will work together to develop imaging instrumentation that will discover, explore and exploit new science whilst making full use of Diamond's brightness. Whilst Manchester's initial interest lies in the field of materials sciences, the collaboration includes applications to other fields ranging from engineering to biology, biomedical research, and geology.

Hydrocarbon Futures: Manchester's Petroleum Revolution

Oil and gas are the major source of global energy and will likely remain so for the short to medium term. However, the exploration for and development of new and existing hydrocarbon resources is becoming increasingly challenging as industry steps into deeper water, higher subsurface pressures and temperatures, and the production of more unconventional resources such as shale gas.

Reducing uncertainty and risk is high on the agenda for oil companies, both financially and in terms of finding hydrocarbons economically and safely. At the same time there is the challenge of no damage to the environment and minimising the footprint caused by these activities. Research and training at The University of Manchester is focussed on helping industry in all of these areas, and also in training the future capability through its undergraduate and Master's programmes.

All of this requires higher levels of technical skill and new research driven technologies. The Petroleum Geosciences and Basins research team at the University is playing a key role in each of these areas, taking applied research, technology and skills development to the next level. Recent staff arrivals such as Professors Steve Flint, Kevin Taylor, Mike Bowman and Dr's Cathy Hollis and Stephan Schroeder have significantly added to the team's capability and industrial expertise. These clearly show the ambitions of the University to create excellence in Research and Teaching and also make the Manchester team one of the top Petroleum Geoscience Research and Teaching groups in Europe.

Additionally, researchers in the team are active in the leadership of international professional and academic societies (e.g. PESGB, SEPM), and the University is hosting the Annual European Meeting of the International Association of Sedimentology in September 2013.

Professor Jonathan Redfern, Chair of Petroleum Geosciences at the University, talked to us about the work being carried out in this area, and the great strides the team is making towards helping industry meet its challenges, and in creating a safe, secure and environmentally responsible future in hydrocarbon resources

"Our breadth of expertise gives us a very broad research capability. We are involved in a huge range of projects covering everything from seismic imaging of the subsurface to evaluating major oil producing basins, through research into new areas such as the exploration and development of shale gas and other unconventional resources, to recovering hydrocarbons more efficiently from existing fields and reservoirs. We also have strong and distinctive research capabilities in the latest techniques and technology for finding and recovering oil and gas such as digital outcrop analysis to inform reservoir models.

"We have a large integrated team of geoscientists and also draw on collaborative links within the University, with equally powerful schools such as Chemical Engineering, Mathematics, and Material Science, making our output truly interdisciplinary".

The quality of the team at Manchester has also attracted high calibre and expert practitioners and researchers from industry such as Shell and BP – thus making the University attractive to external industry funding and collaboration.

The team's strength lies in the breadth and depth of its knowledge, expertise and experience that enables the integrated and collaborative work it carries out. Fifteen members of staff work on projects that

Spectacular outcrops in fine-grained submarine fan systems, Karoo Basin, South Africa

are truly global, working on data that's collected and provided by sponsors from across the world. For example, the team have researchers working on frontier exploration related projects in Australia, West Africa, and South America and in the development and production of existing resources in major oil and gas fields in such areas as Trinidad, the North Sea and the Middle East.

Professor Redfern's own North Africa Research Group regularly sends teams of geologists into the field to collect new data, often to remote areas such as the Sahara and North Africa. "Our teams collect huge amounts of data and return to Manchester to use it to build models that industry can use as analogues for their subsurface exploration; when companies drill wells, the data they collect is limited."

The group's international standing has led to collaboration with many of the major players in the oil industry. Professor Redfern explains "We have strong links with many major independent and national oil companies, who provide us with newly acquired subsurface data which is often worth many millions of pounds. They send it to us so that we can help them to better understand challenges of exploration and production. We look at issues such as the regional petroleum system, basin evolution, and fluid flow, and carry out detailed analysis of key hydrocarbon reservoir, source and seals.

"Just recently we were the first research institution outside of the USA to receive a major Gulf of Mexico offshore data set from BP. We are also working collaboratively with BG and Petrobras in Brazil and Pemex and Mexican research institutions on subsurface data sets and basins. Our research and technology enables companies to better target their exploration, and focus where they should drill for hydrocarbons and then increase the efficiency of recovery from reservoirs and fields."

Two major developments and appointments highlight the ambition and growth of petroleum research in the University. Professor Kevin Taylor has recently joined the team and together with Professors Ernie Rutter in SEAES and Peter Lee in the School of Materials have a major research focus on the characterisation on gas-bearing and oil-bearing shale reservoirs using state-of-the art geological, mineralogical and multi-scale imaging. The latter of these involved work being done in the Henry Moseley X-Ray Imaging Facility (MXIF) investigating shale reservoirs right down to the nano-scale. The team is applying knowledge gained in these techniques to inform the development of new scientific techniques to help us more effectively and safely develop and recover these new and challenging unconventional resources.

The second development is the arrival of The Stratigraphy Group (STRAT) to Manchester, headed by Professor Steve Flint, which brings together a huge amount of expertise in field geology, building regional depositional models and understanding the process of reservoir generation and deposition, which all complements existing capabilities. The research in the STRAT Group, funded by a large industry consortium, has been instrumental in the development of depositional and reservoir analogue models in marine, both shallow and deepwater, settings through groundbreaking outcrop analogue studies in South Africa and the USA. This group is home to post doctoral researchers and PhD students, and makes Manchester one of the largest petroleum research groups in the UK.

How groundbreaking is the work the Group carries out? "In many areas, particularly digital analysis of outcrop data, we are the first people to carry out such research, so we're genuinely pushing the boundaries of what's possible. Dr David Hodgetts, Senior Lecturer in Reservoir modelling and Petroleum Geology here at Manchester, has written software that's the first to capture such data and interpret it, allowing us to better understand where to explore for hydrocarbons in a basin and then more efficiently recover discovered resources".

Industrial collaboration is essential to the team, as its research stretches from the understanding of fundamental geological processes, through to applied technology and best practice, all helping meet the challenges the oil industry faces. "Our research ranges from understanding large scale regional oil and gas bearing basins right through to the nano scale of the reservoir pore system, and is targeted to meet the broader demands of industry. This is reflected in the substantial funding we receive from industry, for projects and PhD students. This is exemplified by major Consortia on carbonate reservoir systems and more focused research, such as developing secondary gas reservoirs in offshore Trinidad."

None of this work could be carried out without the ability to attract and retain the right staff. As Professor Redfern notes "The University has supported us to build our capacity in light of demand from industry. Over the last few years we've increased our complement of staff, and we are now one of the largest groups in the UK, and we're competing globally with our research, output and applications."

Attracting the highest calibre students goes hand in hand with research, and the School of Earth and Atmospheric Sciences runs very successful Petroleum Engineering undergraduate and Petroleum Geoscience Masters courses. The Masters can be taken in either exploration or development and production techniques; both feed directly off the research carried out within the School and by the Group. These are taught by active researchers with recent industrial experience, which means content is constantly updated and fit for purpose. "Teaching is as important as research, as we are helping to train the next generation of oil industry experts, and there's a huge demand for skilled geoscientists; both petroleum engineers and geoscientists"

What's next for this group? "There's a huge amount of exploration activity in Brazil, and we are increasing our research activity there, particularly in carbonate systems and source rocks and shales, through building links with Brazilian universities and industry" says Professor Redfern. The team is also undertaking and developing research in other emerging arenas, such as Argentina, South Africa, the far-east and Australia.

Finally, Professor Redfern remarked, "We're not Houston or Dallas, but Manchester's size and the investment we receive from the University and industrial collaborators, is pulling the oil industry to Manchester and is creating Manchester's second industrial revolution".

National facility and service for EPR

In 2011 the University's School of Chemistry, alongside partners at the universities of Oxford and St Andrews, was awarded the contract to run and deliver services in the EPSRC National Facility & Service for EPR spectroscopy (also known as ESR).

EPR provides a method for studying any material containing unpaired electrons, and the Facility is a national centre for a range of techniques that can be used to study magnetic materials and their impact across scientific disciplines.

Housed in the Photon Science Institute- the University's research centre for the study of how light interacts with matter- the Facility has been made possible through £4.1 million funding from EPSRC, and significant contributions from The University of Manchester. Scientific instrument manufacturer Bruker is also a key partner.

We spoke to Eric McInnes and David Collison, both Professors of Inorganic Chemistry and Co-Directors of the EPR Service Centre, about the new Facility and the work they are carrying out.

Professor McInnes begins "In non-magnetic materials electrons tend to go about in pairs, cancelling out their magnetic properties, and this is called diamagnetism. EPR is specifically sensitive to unpaired electrons, which give rise to the property called paramagnetism, and their environment, and is the most sensitive method for studying them.

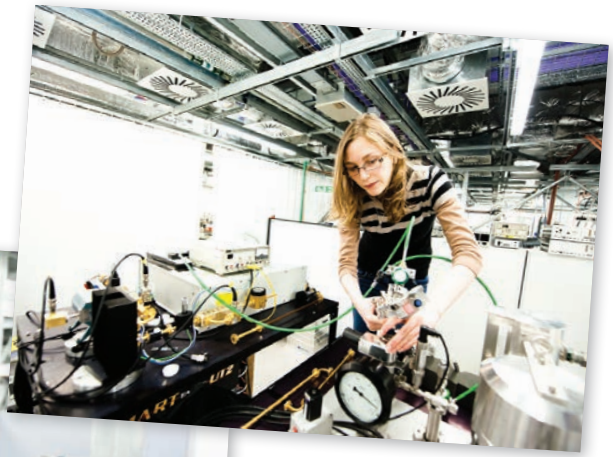
"EPR is not widely taught at undergraduate level, and is often seen as a niche technique; we don't believe it is. It has to be mainstream as so much of the world around us is paramagnetic, and that magnetism is fundamental to how the world operates. Magnetic materials are ubiquitous so understanding how they do what they do, what the influence of the magnetism is, and their properties, is crucial. As it is not widely taught there's generally a lack of expertise, particularly when compared to nuclear magnetic resonance (NMR) - there's not a chemist in the country who doesn't understand how NMR operates."

There are perhaps six large EPR groups in the UK, but Manchester is the national centre of expertise and as such is providing the national applications access for this family of techniques.

Professor McInnes continues "Our Facility and expertise is world-class and we are known globally. There are perhaps only three or four laboratories in the world that can offer the same range of techniques, and one of those is within industry.

"EPR requires expensive equipment and there are a range of techniques that come under its remit, so this model of having a specific centre of expertise makes sense. We have all of the very expensive equipment in one place, and many researchers and scientists can access it for occasional use.

"EPR techniques have wide applications outside of physical sciences, for both medical and life sciences. A major growth area for EPR worldwide is in



Professor David Collison and students photographed at the new EPR facility

structural biology where, even if you don't intrinsically have centres with unpaired electrons, biologists know how to tag materials such as enzymes or a strand of DNA with a paramagnetic label. EPR can then be used to measure distances between these labels, giving structural information even when the sample is amorphous. This is a growing area of interest within biological and medical research."

Interdisciplinary research is an important aspect of the Centre's work. As Professor McInnes explains "We're currently collaborating with a group from the School of Medicine to look at the implications of certain paramagnetic sites for a range of diseases, from Alzheimer's through to diabetes, in an effort to discover how these diseases work.

"The basis of the research is to look at certain therapeutics which may have a major impact in the treatment of these diseases. EPR can in principal specifically look at what the therapeutic agent does, so the question is 'can we understand the mechanism?' It's early days for this research, but it's genuinely exciting." Clinical applications of the technique include blood analysis; looking at free radical content in blood to examine strokes and heart disease.

The groundbreaking research that's taking place within the Facility wouldn't be possible without the highest calibre of staff. EPSRC funds two postdoctoral researchers and a technician, and other staff are funded from additional sources. "The nature of the Facility and our work demands staff with a broad experience as we often have to solve disparate problems from across all areas of science. Retaining our staff is paramount, so we invest heavily in training. We have a strong partnership with Bruker, and that partnership is an important part of the Facility. It is funding the appointment of Dr. Alistair Fielding, who brings with him a wealth of biological EPR experience which will allow us to build our activity in that area. Alistair will be designing new experiments to use the new spectrometers."

Ensuring that students get the best use from the Facility is important to open their eyes to the possibilities, and to ensure they remain interested in the techniques as they pursue their academic or professional careers. As Professor Collison explains "The Facility is a big selling point for undergraduates, and the fact that it's located within one of the UK's best schools of chemistry means that students benefit from world class infrastructure and breadth of expertise.

"The research capabilities of the Facility make it attractive to students from all scientific backgrounds. We are keen to make students more aware of what we can do, and we're pushing our agenda into lectures and laboratories. We also work with sixth formers during the Nuffield summer student scheme, and they come here and see for themselves, working on a variety of projects with our equipment."

The Centre undertakes lots of research to address industrial challenges. As Professor McInnes notes "Industrial collaboration is a very important part of what we do. Historically, collaboration tended to be on small scale projects, but increasingly many industrial manufacturers are finding issues that require EPR, as they realise that free radicals are really rather important! We recently worked with a chemical manufacturer that thought it had free radical poisoning in their chemical processes.

"Our contribution to their problem resulted in major changes on how it went about its manufacturing process. It couldn't have solved its problem without the Facility and our expertise. We are currently negotiating three CDAs with industrialists who have realised the benefit of working with us.

"Industry also benefits from our expertise through teaching; we teach EPR and they develop a knowledgeable workforce able to use new techniques to address industrial challenges."

New projects for the Centre include research into the 'heavy end' of the Periodic Table – the actinides and Professor Collison is excited about this work. "There are fundamental questions yet to be answered about the behaviour of actinides which are fundamental to the nuclear industry. For example, our understanding of the nature of chemical bonding involving actinide ions (which include uranium) lags a long way behind that for transition metal ions despite the fact this is important in, for example, separation methods for actinide mixtures.

"We've begun projects with researchers from the School of Chemistry and the universities of Nottingham and of Edinburgh to look into this in more detail, using the power of modern EPR methods and taking advantage of recent advances in actinide chemistry."

The Centre has recently moved its EPR laboratory from the School of Chemistry to the University's Photon Science Institute. This will allow combining the PSI's state-of-the-art laser facilities to EPR to study light-induced paramagnetic species. This is important in areas such as photosynthesis and solar energy conversion. The move to the PSI will also allow technical developments in the technique through collaboration with physicists and engineers.

www.epr.chemistry.manchester.ac.uk

Focus on Professor Helen Gleeson

In September the Institute of Physics (IOP) reported that nearly half of all state schools in England do not send any girls on to study A-level physics. We talk to Professor of Physics Helen Gleeson about how she got into the science and what life's like for a senior physicist, who happens to be a woman.

You were a student at Manchester, what led you here?

Once I started studying physics in school I enjoyed understanding how the world fits together. My initial ambition was to use the sciences to do medicine, but I quickly realised that I wouldn't cope well if any of my patients died!

These days people can choose their university based all on sorts of information, which just wasn't available then. So I went on reputation, but I also chose Manchester because it has a really good shopping centre!

How did you come to specialise in liquid crystals?

I studied maths and physics and thoroughly enjoyed both, but I particularly enjoyed an optics course I did in the second year. I've always liked physics you can see, so once I'd decided to continue on to do a PhD I set off in that direction.

One of your first post-doctoral roles was in the industrially funded Wolfson Liquid Crystal Unit. How did working with industry early on in your career influence the way you see the relationship between the academic and the commercial?

Being realistic, I knew academic posts were few and far between and that they're incredibly competitive. This was a dream job for me because I was able to do research at the same time as learning about industry and building up industrial collaborations.

I enjoyed seeing how ideas can be translated in to actual products and I've maintained that interaction. It's not driven what I've done, but it's been important.

What are the industrial or commercial applications of your work?

It's more about being aware of the applications rather than being driven by them. We're interested in understanding materials and what they can do and what their optical and electrical properties are.

The most obvious application is liquid crystal displays. There are some excellent displays out there but there's still a need for materials that can go faster, so companies can, for example, develop true 3D television sets.

Occasionally we'll do something that is more focused. We've recently finished a collaboration between physics, chemistry and electrical engineering here at Manchester with Syngenta, working on new materials for sensing devices. The aim was to come up with a way of monitoring the temperature history of perishable goods, because something like 40% of perishable goods that are shipped to supermarkets never make it to the shelves.

We proposed an all-plastic electronically RFID (radio frequency identification) readable tag for the perishable goods chain that was going to cost pennies. We built a prototype device. Now we're waiting for the plastic electronic circuitry part of the technology to catch up with us!

There aren't many women working in your area. What difference has this made to your career?

Although there were other people appointed at a very similar time, I was the first female physics lecturer they'd ever appointed at The Victoria University of Manchester.

Often the issue is one of expectation. Did I expect to get a first class degree? No. Did I expect to get a PhD? No. It was a huge shock to me when I got offered my first lectureship post! That's not unusual in women; to assume that you're not at the top of the class. I'm talking about our own expectations of ourselves, not other people's.

The School of Physics and Astronomy has always been a fantastic place to be though. Well before I was appointed they were running a 'women into physics' programme for young women aged fourteen or fifteen to come and get a taster of physics. So I came in to a very positive environment. I felt very comfortable and welcomed, always have done.

What are you proudest of?

I am proudest of seeing some of the excellent students I've worked with go on and do really good things, and knowing that I've had a part in helping them. As far as awards go, I was lucky enough to get an OBE and I was amazed about that!

…it's not luck is it?

No, I'd get told off by lots of senior women for saying that! I was very proud because it recognised some of the things I'd done for women in physics.

This can mean small things such as changing the policies for sabbatical leave for the faculty so that it was more family friendly. These little things can have a big impact.

Often the list of invited speakers on conference organisation committees doesn't even reflect the demographics of how many women there are in physics. A lot of people don't notice. They don't deliberately say 'we don't want a woman speaker' they just don't notice because they're expecting to see a man – the same is true of other minorities too. The tide is turning, but it's really slow and I'm sorry to say that women still find themselves being discriminated against and they don't know how to best deal with that.

The Institute of Physics and Athena Swan do excellent work in progressing these issues and I've very much enjoyed being part of that. Getting the OBE gives me a very serious responsibility to make sure that I'm still doing what I can to progress that.

How important is it to you to engage with the wider community about science?

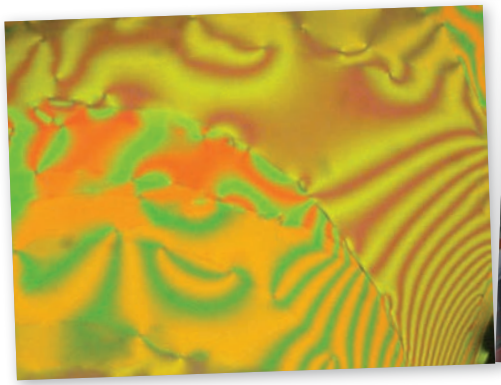
The tax payers pay for a lot of what goes on in the University, so it's important that we can communicate what we do. I do a lot of public lectures, explaining about my research. It's very visual so it comes across very well, it's very good for kids and I really enjoy it. It is important for young people to meet people that don't fit the stereotypical view of a scientist.

Physics has recently become quite cool, with a bit of a celebrity media status. Does this impact on what's actually happening in physics departments? Or is a bit of an irritation?

I think it's really important that people find physics important and interesting. It's a real tragedy that our society thinks it's okay to say 'I'm rubbish at maths' or 'I was never able to do physics'. They wouldn't dream of saying 'I can't read'. It's an ingrained problem in our society that isn't true of other cultures. Anything that makes them want to go and find out about science as a lay person – the same way I read a novel or I get my sketch book out – is great.

The only little niggle from my own research perspective is that there's lots of focus on 'big physics': the LHC, particle physics and astronomy. What I do is 'little physics' but it has a huge impact on society, maybe an even bigger impact. It would be good for people to understand that without the fundamental physics and chemistry that people in the UK have done on liquid crystals they wouldn't have their flat panel TVs, their mobile phones or their laptop computers.

Clockwise from top right: Professor Gleeson at a conference in Bangalore, funded by the Royal Society, with the aim of enhancing links with Indian scientists.
Being awarded the British Liquid Crystal Hilsum Prize by Cyril Hilsum.
Liquid crystal film, viewed using polarized light. "Pictures like this, apart from being really beautiful, allow us to work out a lot about the liquid crystal we're examining. In this case, there is a phase transition between two states in the middle of the picture."
Left: Professor Gleeson with her mother and sister after receiving the OBE.



Pot of Gold

The University celebrates its staff student and alumni's selfless contributions to others through its annual Social Responsibility and Volunteer of the Year Awards scheme. The scheme, which recognises the outstanding volunteer work carried out by members of the University, both home and overseas, aims to encourage greater social responsibility.

Lenox Green, a postgraduate office administrator in the School of Mathematics was this year's winner in the staff category, and his story is inspiring.

"When I was a kid growing up I got involved with local youth work projects and summer clubs, which led me to meet and befriend homeless people, and before I knew it I was inviting them back to my house at the weekend for lunch. Fortunately my mum didn't seem to mind; in fact she was very encouraging! That's the sort of attitude I've always had- reaching out to people in the community and area.

"My experience with helping people detox from drugs started later, after I got married. Again I was fortunate that my wife had the same ideas, so together we began to do outreach work from our home. We started by taking in a family member of a friend and helping her to overcome her drug and alcohol addiction. The local authority wouldn't take her in as she was cross addicted, so we began to support her without any official help. We opened up our home to other addicts, and we managed to help many people overcome their addictions, and benefit from a loving, stable environment in our home at the same time.

"We realised we needed to make our work more official and began to look for a building from which to run our support. We wanted to establish a project centre with youth groups, and the council was very supportive and keen to help us to make a mark on the local community. They tried, on several occasions, to help us identify a suitable building- with their financial support- but each time we found one it was quickly sold to another party. This eventually coincided with the final mortgage payments on our own home, and we thought 'let's go for it'…we remortgaged our house and found and bought a building off Boundary Lane in Hulme.

"When we went to look at the building we saw some kids climbing on the roof. We shouted them to come down, and asked them what they'd like to see happen in the building, to which they responded 'music, youth groups, a place to chill' which gave is some ideas, and so the Rainbow Christian Centre was born.

"That was nine years ago, and we quickly had a youth project and a gym running two days a week, alongside church bible studies and a church group on Sundays. There's something on every evening of the week, as well as a few trips out for the children, and luckily we are able to rely on the help of some fantastic volunteers. We wouldn't have been able to launch and continue to develop the project without the help of the local community.

"Many children we work with are from difficult backgrounds; our community- Hulme- is in the top 25 for social deprivation in the UK, and we hope we provide a welcome and regular break from their difficult lives, as well as providing useful support to them and their families. It's such a shame really, as we are on the doorstep of central Manchester, but a subculture of it."

One of the reasons the Centre is so successful is the people who run it, and the trust they elicit from the community.

As Lenox goes on "The support locally is very strong; people know what we are doing and that their children can come here voluntarily. I'm able to walk into most homes in the area, deal with family issues, and be treated with respect because they know me. I've negotiated and arbitrated between conflicts in the area, and the Centre is sometimes used as a safe base in which to sort out disputes."

The respect with which Lenox is held is in no small part due to the place he has in the community. "I was recently walking one of the children home to ensure she was safe, and she told me she was worried because she had lost her key for home and her mum was out working. I climbed through the bedroom window, and noticed that I was walking over candles. I asked her about the candles, and she said that the electricity had been cut off a while ago- that's what can be going on in some of the homes." If Lenox wasn't so connected to the community there's no doubt he wouldn't find out about some of the issues going on behind closed doors. His involvement allows him to see past what's presented at the Centre.

Clearly a leader in the community, Lenox knows the key to maintaining this standing is to stay safe. As he explains, "The key for us is to remain as neutral as possible. We don't involve the police in issues, and we are not seen as a threat by members of the community so they feel comfortable with our presence. That respect was tested when the Centre was burgled. When members of the community found out they made the burglars return everything!

"We're now concentrating on our current projects, which include a new food distribution service in partnership with Fair Share and local retailers, who redistribute food to organisations like ours. Recently we've noticed an increase in the number of hungry children coming to the Centre, and we have more than 20 families who come to us for food, so this new service is a lifeline for some members of our community."

A remarkable story, made all the more astounding by the fact that Lenox and his wife also work full time. "We don't have much spare time, and we've spent the last few years building the Centre as well as looking after our children."

Future plans for the Centre include bigger premises. "I'd like to run some educational workshops and teach the children about life skills, and I'd also like to open up some of the classes to parents to increase the literacy amongst some of our children by involving their parents. We also have a desire to run another support centre for people with addictions."

The Centre receives very little financial help. "We've been promised local authority funding, but we are waiting to see it! We have some financial help from an independent benefactor who helps us to pay our utility bills, but basically we are self funded and don't collect money from the people who use the Centre so we are always looking for funds."

POETRY IN EPS MOTION

Poetry is not usually teamed with engineering and physical sciences, but a competition organised by Dr Peter Fenn, Senior Lecturer in the School of Mechanical, Aerospace and Civil Engineering, set out to marry the two together, and show the beauty in the creativity and innovation present across the Faculty.

Students from across the Faculty were invited to submit their poems, with the criteria of showcasing the creative and human aspects of science and engineering.

More than 150 entries were received from across every School in the Faculty and judges, Dr Fenn, Dr John McAuliffe, Creative Writing Lecturer, and poets Wendy Cope and Lachlan Mackinnon whittled the competition down to 35 shortlisted poems.

Professor Colin Bailey, Vice President of the University and Dean of the Faculty of Engineering and Physical Sciences, commented: "The art of engineering and science is critical to address the global challenges facing society. It is important that our engineering and science students develop their creativity to obtain the skills to address these challenges.

"This initiative allowed students to express their ideas through the medium of poetry and I was particularly pleased that 166 students decided to enter the competition, with the quality of the poems being extremely high."

Read more of the shortlisted poems at **www.eps.manchester.ac.uk/science-for-all/science-poetry**

THE WINNING POEM

UNTITLED

Peter Thompson, 3rd year undergraduate, Physics with Theoretical Physics

We categorise the agents of our kind,
We grind the lens, bring focus to our fears,
With Feynman lines and spirals map the mind,
Still burning is the flame of that idea,

Once stole in fennel stalk from ancient night,
To read the mind of god beneath its light.

ONE OF THE RUNNERS UP

LIVING VIRTUALLY

Kathryn McCarron, undergraduate Computer Science student

Zuckerberg and Jobs are the names you know.
Not the thousands working away at their desks
that never receive the glory press.

Parents let their children run wild without a second thought -
the same ones who have to be in before dark.
Some are obsessed, they think they're giving
undivided attention. But in this kid's room alone
it's different, now there's a picture of her breasts
on her profile and everybody's out
working away at their desks, too far away to stop it.

Lives are stored on hard drives:
as temperamental as desperate housewives;
one day running without a worry -
the next, the blue screen of death,
calling the children back in a hurry.
They're miles from where you are.

External Relations
Faculty of Engineering &
Physical Sciences
The University of Manchester
B13 Sackville Street Building
Manchester
M13 9PL
United Kingdom

+44 (0)161 306 4045
www.eps.manchester.ac.uk
EPSFaculty@manchester.ac.uk

Royal Charter Number RC00097

Written and designed by coppermedia.co.uk