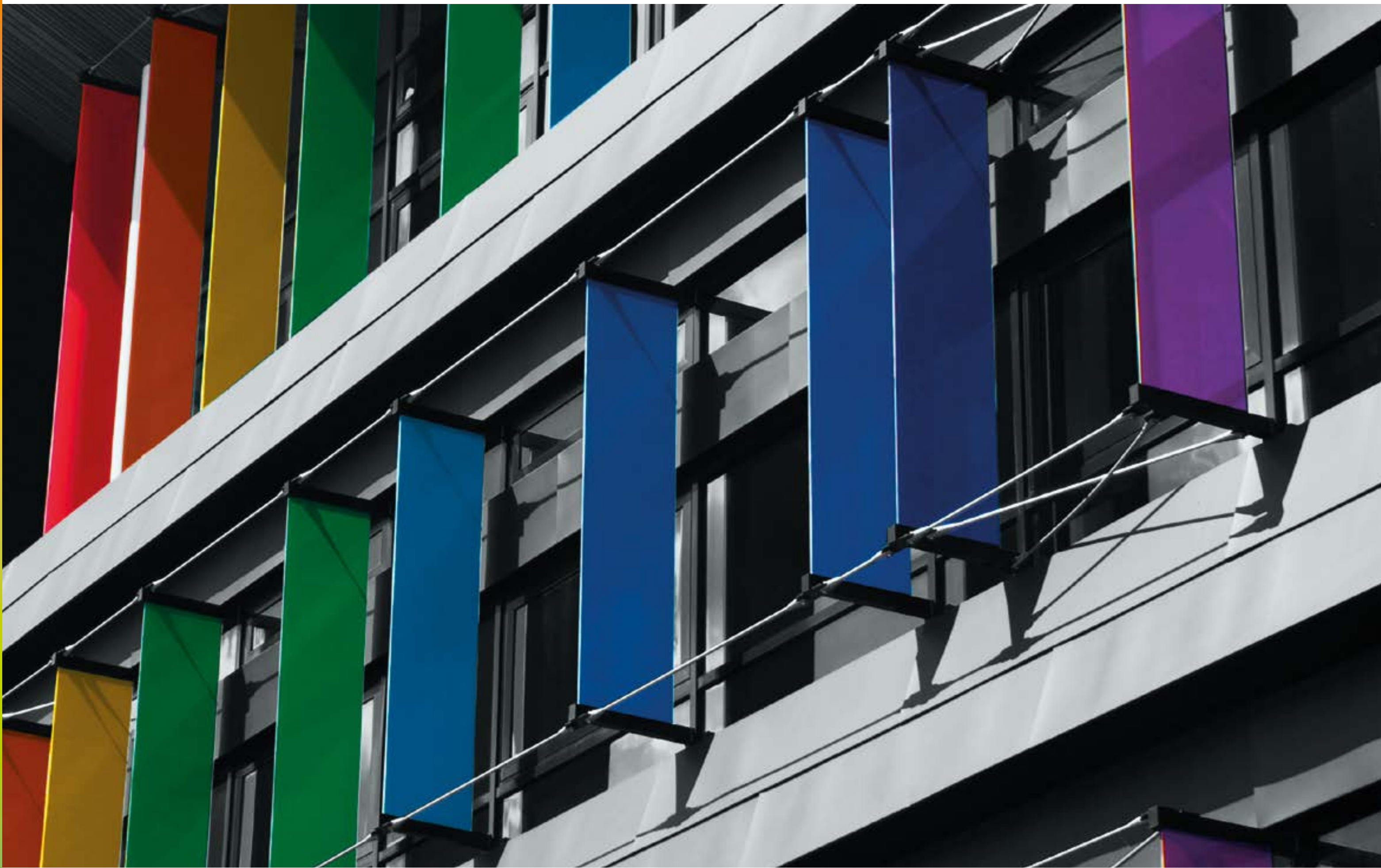
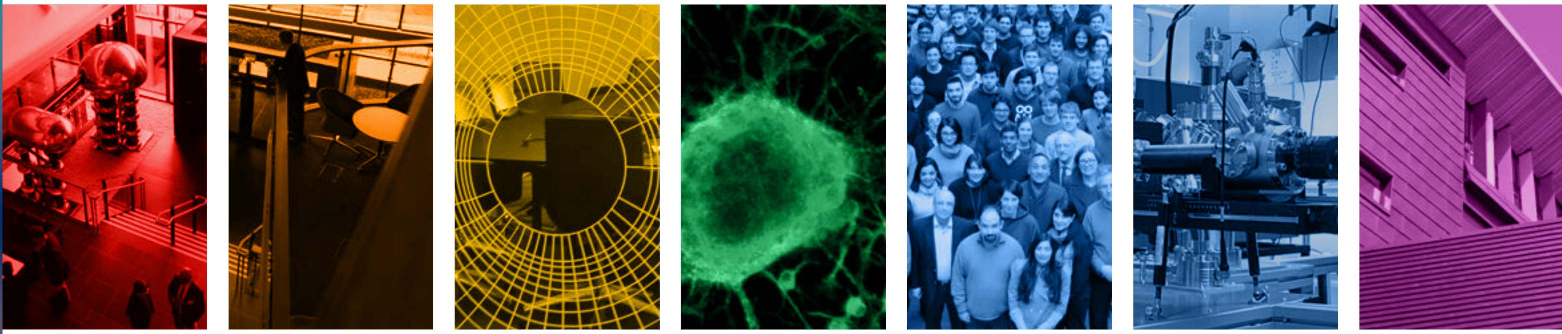


Maxwell Centre Report

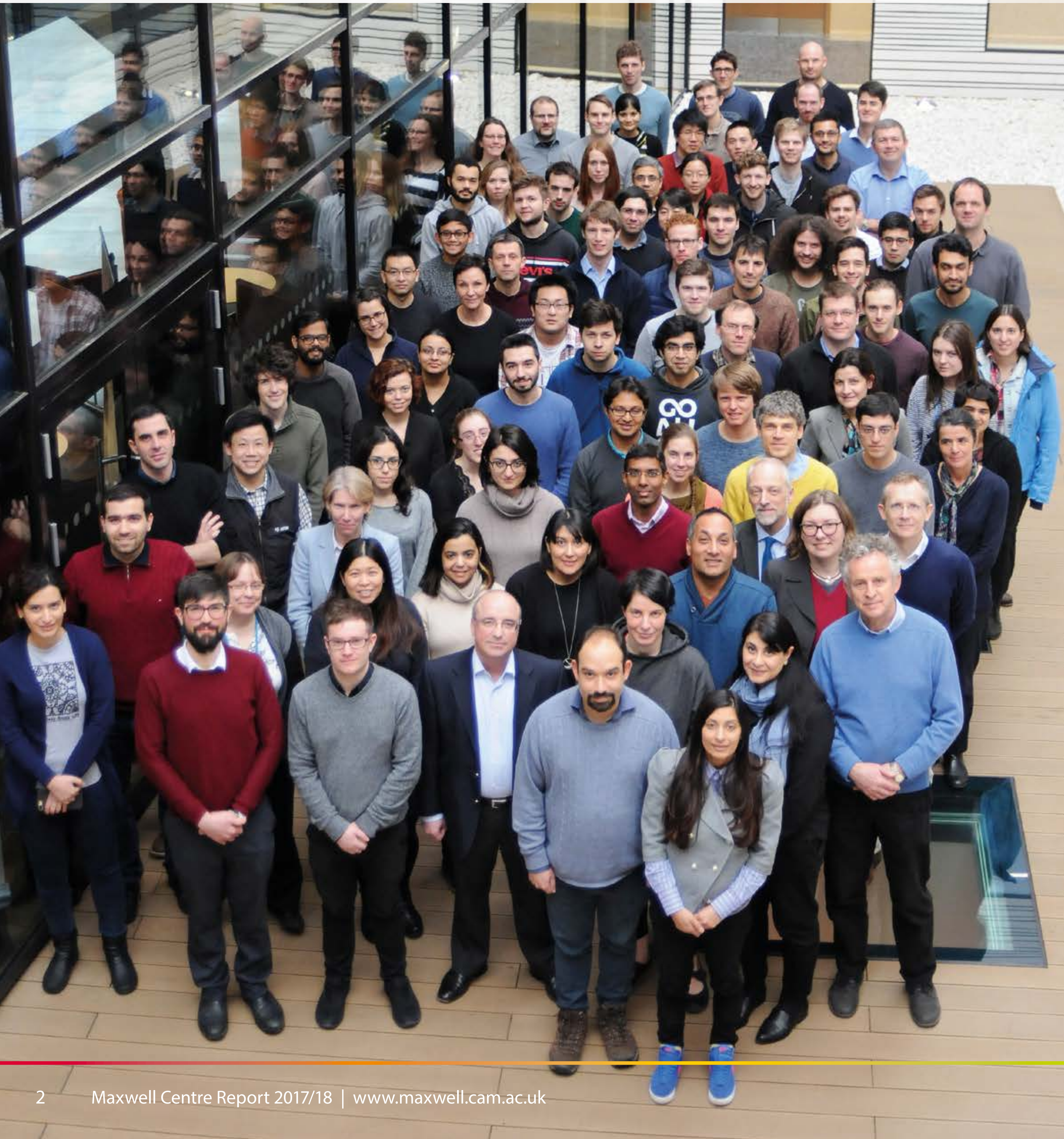
2017/18



UNIVERSITY OF CAMBRIDGE

"The Maxwell Programme seeks to develop partnerships between the University and industry. Capitalising on the University's world class science and research, the Maxwell Programme provides a gateway to University. If you want to learn more about Cambridge, its research and insights, I have no hesitation in recommending Maxwell to you."

Professor Andy Neely, Pro-Vice Chancellor for Enterprise and Business Relations



From the Director

Prof Sir Richard Friend FRS FREng
Cavendish Professor of Physics
Director, Maxwell Centre

The Maxwell Centre is now substantially occupied, by industrial partners, by the Henry Royce Institute for Advanced Materials, by the Winton Programme for the Physics of Sustainability, the Laboratory for Scientific Computing, two EPSRC Centres of Doctoral Training, activities from the Cavendish Bio-Nano-Fluidics research and the Quantum Matter group, and the offices for three of the university's Strategic Research Initiatives/ Interdisciplinary Research Collaborations. This mix of activity, together with the open access we offer to all on the West Cambridge Site and beyond, has brought a real buzz to the building.

Cambridge is one of the partners in the Henry Royce Institute for Advanced Materials, HRI, and this has brought £10M for capital equipment. The HRI is centred at Manchester, and its role is to provide a 'national' set of resources to support academic and industrial research. At Cambridge the HRI is based around the Maxwell Centre and we have been able to locate some substantial new research facilities here, as detailed later in this report. We are pleased that some of these resources will play a big role in supporting the Cambridge part of the national Faraday Institution for Energy Storage Research. Facilities for fabrication of new battery structures, for X-ray photoelectron spectroscopy, X-ray tomography, and electrochemical characterisation are all based here.

The offices for Energy@Cambridge, Cambridge Big Data, and Global Challenges Initiative, and the Centre for Digital Built Britain, bring strong links to research across the whole university, and provide routes to develop larger scale research programmes that naturally span across disciplines. We have a growing list of industry partners in the building, whose interests range from local and specific research links through to larger scale, longer range research challenges. One emerging interest area is the future of fuels and chemical feedstocks when no longer derived from fossil fuels. Opportunities here range from near term (e.g. efficient hydrogen from water electrolysis) to the long term (e.g. new ways to convert sunlight to fuels).

Though the building now feels busy, it is not 'full' and we are very keen to bring in new partners from both academia and industry. Our model for 'shared facilities' allows companies to take offices and laboratories or, at a smaller scale, 'hot desks', and we find this provides the flexibility that our partners want. We are now looking to support external users of the Royce experimental facilities.

This is our second annual report, and it picks out just some of the activities in the Centre and the University. We are presenting more of what happens here at the second annual Research Showcase on 22 March 2018.

Second year at the Maxwell Centre

Dr Aga Iwasiewicz-Wabnig
Maxwell Centre
Programme Manager

Mónica Lucena
Maxwell Centre
Engagement Coordinator

The Maxwell Centre opened in 2016, and its programme has been steadily growing in reach and size ever since. We selected highlights from the first year of its operation in our Maxwell Centre Report 2017/18, available in the electronic format from our website. It presented the role of the Maxwell Centre as a hub for academia-industry interactions at West Cambridge. You will also find there, among other, information about our first industrial residents, ARM and NPL, alongside research highlights from Departments, Winton Programme for the Physics of Sustainability and EPSRC Centre for Doctoral Training in Nanoscience. We further introduced Energy@Cambridge and Cambridge Big Data Strategic Research Initiatives, as well as announced the new arrivals: the Cambridge Henry Royce Institute, the EPSRC Centre of Advanced Materials for Integrated Energy Systems (CAM-IES), and our entrepreneurial training programme, Impulse for tech innovators. The Maxwell Report 2017/18, which you now hold in your hands, presents further research and collaboration highlights selected from among the Maxwell Programme community, including our newest residents – the Centre for Digital Built Britain, and the Global Challenges Initiative.

The Maxwell Centre building currently hosts over 250 people, on full-time and part-time basis. Our state-of-the-art laboratories are being further enhanced with recent additions through the Henry Royce Institute and the Faraday Institution, and we are opening access to a large proportion of equipment to be shared between many Cambridge departments as well as external users, from industry, universities and research institutions. The variety of meeting rooms and communal spaces encourage interaction and the Centre gets really busy on a regular basis. The building may be nearing its nominal capacity, but the Maxwell Centre vision and community extend beyond the building alone, acting as a gateway to Physical Sciences and Technology in West Cambridge. The model agreements which we developed for regulating collaborative industrial presence have proven to work well, and are now available for use more broadly across the university. The Maxwell Programme will therefore continue to grow, expanding across the entire West Cambridge campus.

I would like to mention a few events and highlights of the last year. The Maxwell Centre hosts more and more company visits and collaboration workshops exploring mutual interests and expanding research connections in Cambridge. These are largely customised to the need of each visiting company and the Maxwell Programme works closely with the Strategic Partnerships Office on setting the agendas and follow-ups for these engagements. One recent example is our growing relationship with Magna. Initial exploratory visits and introductions opened a route to new activities. Magna's subsequent participation in a roadmapping workshop led by the IfM resulted in first research involvements, with Engineering. The 'Magna Innovation Day' followed, co-hosted with the Cambridge Network at the Maxwell Centre in December 2017. Further research links are being formed, and we now look forward to welcoming Magna's presence at the Maxwell Centre in near future.

We continue a fruitful partnership with the Cambridge Network in organising termly 'From Discovery Science to Industrial Applications' events aimed at industrial audiences, providing a glimpse into what goes on within the University walls. We invite an academic to speak about their field of work, followed by opportunity for discussion and networking. This format offers a forum for companies to hear about ongoing cutting-edge research and where it may go next. The aim is to communicate the key ideas and opportunities behind the recent research that is ordinarily presented in specialist journals and conferences. The two most recent talks were given by Dr Sohini Kar-Narayan from the Department of Materials Science and Metallurgy on 'Nanogenerators for energy harvesting' and by Dr Laura Torrente from the Department of Chemical Engineering and Biotechnology, on 'Manufacturing of designer nanomaterials'. We have now started filming those events and the video clips will be available online.

The Maxwell Programme has also started a new Innovation Seminar, which we run in collaboration with the NanoDTC and the Impulse programme. Within this diverse series, open to all, we have so far heard from Prof. Ijeoma Uchegbu of Nanometrics (on leading pharmaceutical nanotech), Clive Rich (on becoming better negotiators), Prof Andy Hopper (on entrepreneurial vision and motivation, drawing on his own experiences including the Raspberry Pi), Dr Alex Reid from Artemis Racing (on science behind the Cup of America sailing) and from Dr Lakmal Jayasinghe of Oxford Nanopore Technologies (on chemistry and platform development). More to come!

A broader list of Maxwell events can be found on www.maxwell.cam.ac.uk/past-events. To be kept in the loop about our upcoming events and opportunities please contact our Engagement Coordinator, Mónica Lucena, who is responsible for the Maxwell Centre monthly newsletter and will be delighted to keep you posted (contact email: engagement-coordinator@maxwell.cam.ac.uk).

The idea for celebrating the excellent research and industrial collaborations in the format of an Annual Research Showcase resulted in the first event of its kind in March 2017. We were delighted to welcome over 250 participants, near-equally split between academic and external affiliations. This report is written just ahead of our second Maxwell Centre Annual Research Showcase on 22nd of March 2018, once more celebrating the breadth and quality of Cambridge research in the context of external partnerships, opportunities and collaborations. Programme includes an introduction by Prof Sir Richard Friend, and keynote addresses by Prof Tim Minshall, Professor of Innovation and the Head of the Institute for Manufacturing, as well as by Steve MacManus, Vice-President Engineering at Tesla Motors. We will present case studies from Materials Science, Chemical Engineering and Biotechnology, and 2 minutes' research snapshot talks and posters from all our stakeholder departments and collaborators. We have also introduced a session with industrial perspective where our partners showcase their work and interests in a series of short talks. There will be ample opportunities to explore the Centre, network, make new connections and meet future collaborators.

Being in the Maxwell Centre continues to create non-trivial opportunities. We have welcomed many new industrial residents and visitors in the last year, and new collaborations are starting all the time. You will find accounts of what the Maxwell residence can lead to from the point of view of our industrial partners – this time: Artemis Racing and Silicon Microgravity – further in this report. I would like to encourage all companies interested in expanding their portfolio of collaborative activities to consider using the Maxwell Centre as a gateway to Cambridge research. There is a multitude of ways to work together – some of which are summarised in the article about collaboration models on page 6. If you are interested in joining the community, we welcome new residents and hot-deskers from industry. Please do get in touch and come visit the Centre and we will be delighted to tell you more.

- www.maxwell.cam.ac.uk/programmes
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Access electronic versions of the Maxwell Centre Reports here: www.maxwell.cam.ac.uk/programmes

Models of academia-industry interaction

The Maxwell Centre is the centrepiece for industrial partnerships, providing a gateway to the research and expertise of the University of Cambridge across the Physical Sciences and Technology. Each academia-industry partnership has its own unique characteristics and needs and we welcome the opportunities to collaborate in many different ways.

We work closely with companies to identify the most effective mode of collaboration that adds value and research insights to support our common aims. We cherish this diversity, recognising that serendipity of a random conversation over coffee is often just as important as strategic planning.

Collaborations come in all shapes and sizes and the University has adopted a flexible approach with a broad spectrum of modes of interaction which have already been implemented. The table opposite illustrates twenty different modes of collaboration with industry which have already been established. These range from advice, consultations and one day exploratory workshops to sharing expertise and know-how through strategic partnerships lasting decades. The scale of resource involved also varies considerably between the different models. The table indicates the key advantages of the various approaches, all of which have already been developed with our collaborators. While this selection hopefully captures the diversity of relationships we foster with a wide range of external partners, it does not claim to represent the full range of flavours nor the full extent of any of the existing relationships. We emphasise that these examples are only a subset of a very much larger number of past, current and developing partnerships.

We are constantly on the lookout for new partners and industries - the Maxwell Centre is set up to facilitate and foster these interactions. We strongly welcome new collaborations that involve innovative and ambitious research approaches to solving real-world challenges. The modes of interaction can be matched to the aspirations of both sides. The primary considerations are communality of interests between partners, capacity, resource intensity and expected duration of each project - each case is slightly different. There is a huge range of possibilities, with countless contexts, scenarios and collaboration areas. Each new avenue feels like embarking on a truly exciting voyage of discovery. Therefore, if you feel inspired to give it a try, or have any questions about the interaction models, please feel free to get in touch and let's explore how we can work together!

Programmes currently hosted at the Maxwell Centre:

ARM-Cambridge collaborative partnership

National Physical Laboratory's East of England Hub

Artemis Racing – Artemis Technologies hub

Maxwell Centre Industrial hot-desking scheme

Winton Programme for the Physics of Sustainability

Henry Royce Institute: Materials for Energy Efficient ICT

Centre for Advanced Materials for Integrated Energy Systems

Faraday Institution: Extending Battery Life

Centre for Digital Built Britain

Energy@Cambridge Interdisciplinary Research Centre

Cambridge Big Data Strategic Research Initiative

Global Challenges Strategic Research Initiative

EPSRC CDT in Nanotechnology (NanoDTC)

EPSRC CDT in Computational Methods for Materials Science

MPhil in Scientific Computing

Impulse for Tech Innovators

Several research groups from participating departments

Maxwell Programme and knowledge exchange support

Interaction model	Types of activity
Residence or Hot Desk in the Maxwell Centre	Co-location for direct and ongoing interaction across the University's Physical Science & Technology campus; hub for open innovation; place for planned conversations as well as serendipity; scoping & brokering collaborations.
Strategic Partnership	Relationship of strategic importance to both parties; institutional level agreements enabling a portfolio of activities across the University; developing new areas of joint collaborative research with help of the Strategic Partnerships Office.
Expertise Hub for Knowledge Transfer	Converts blue-skies academic research into disruptive technologies which are transferred across non-competing industries; facilitating step change progress.
Embedded Laboratory	Industrial laboratory embedded long-term within an academic department; sponsored posts & studentships; outputs maximised by bidirectional information flow: joint patents and publications; joint funding from RCUK.
Sharing Expertise and Know-how	Building mutual understanding of the other partner's needs, interest and expertise; direct exchange of knowledge and know-how; regular access to the other partner's facilities; co-application for funding.
Shared Access Equipment	Access to cutting-edge equipment in University laboratories; cost-effective, pay for access when required; optimal use of academic facilities & maximal impact of capital investment.
Pump-Priming Initiatives	Scoping new big ideas to solve difficult problems; small initial commitment can kick-start discussions, de-risk and test waters for larger collaborations.
Industry Engagement Forum	Companies gain insight into how Cambridge research & know-how may be applied to their problems; showcasing industrial challenges to researchers; opportunity to identify areas of common interest and forge links.
Summer or Master Projects	Short-term, focussed research projects carried out by students under academic guidance; work best with well-defined research questions.
University Technology Centre	Long term research generating new knowledge; company-funded academic posts for creatively addressing industrial needs, leading to better products.
Research Collaboration	Funding ground breaking research, for example, by embedded postdoctoral researchers; direct access to novel technologies; close collaboration; research visits.
Spin-outs & IP licensing	Commercialisation of research inventions and ideas aimed at solving society's problems; R&D to make technologies accessible; creating strong links with industry licensees and enabling impact by putting IP to use.
Career Fairs & Recruitment	Access to talent; opportunity to showcase your business; University attracts the best people from all over the world; many graduates and postdocs subsequently look to move to 'real-world' jobs.
Consultancy & Expert Advice	Access to world-leading experts and game-changing ideas; consultants who excel in sound critical assessment and build on their accumulated knowledge and know-how; delivering impact of academic work on society and economy.
iCASE / PhD Studentship	3-4 years graduate research project; PhD student working in an area of relevance to the company; link to a research group; student may visit the company and maintain the link.
CDT: Cohort Interaction	Companies engage with the entire cohort of typically >50 PhD students and the network of their >150 academic supervisors; highly interdisciplinary.
CDT: Directly Sponsored Projects	PhD student projects matched to skills & bespoke training; access to research at several participating departments; highly specialised graduates.
Knowledge Transfer Partnership	Transfer of knowledge and know-how from university to company, RCUK co-funded, and mediated by a specialist Associate.
Mentorship and Co-supervision	Direct interactions with students and postdocs; input into shaping their research, awareness and career choices; providing role models with industry experience.
Consortium for Precompetitive Research	Group of companies with overlapping interests jointly funding new knowledge generation to share risks and benefits at pre-competitive research level.

Artemis Technologies

Iain Percy OBE
CEO

Dave Endean
COO

Simon Watin
Head of Simulation

Artemis Technologies is a world leader in high-performance yacht design, formed from Artemis Racing's 35th America's Cup design and engineering team. With experts from the fields of motor sport, aerospace and yacht design, we utilise world class skills in simulation, lightweight structure engineering, electronics, hydraulics, aerodynamics, and hydrodynamics, to deliver real innovation to our customers through unique solutions and products. The core philosophy of Artemis Technologies is to develop techniques that allow for fast and accurate evaluation and optimization of designs.

"At the end of the America's Cup in Bermuda last summer, we immediately began the process of identifying where to base ourselves. The main driver of our move to the University of Cambridge was to forge links outside the traditional yacht design community to drive innovation in the fields of computational simulation, materials, construction techniques and instrumentation. By housing ourselves within one of the world's premier Universities we also have a number of formal and informal opportunities to expand our knowledge." – Simon Watin, Head of Simulation.

Artemis Technologies is already working on a number of collaborations with the University including:

- 4th year project in the Department of Engineering
- 1st year PhD study in the Department of Maths
- Joint research project on image processing techniques

"Our first six months in the Maxwell Centre have certainly exceeded our expectations. Our group is in regular discussion with Professors from various Departments, and and we are excited to build on our current collaborations with the University by supporting more projects and PhD studies in the near future."

– Iain Percy OBE, CEO, double Olymic and multiple World Champion.

Silicon Microgravity

Paul Vickery
Executive Chairman and Director

Prof Ashwin Seshia
Chief Scientific Officer and Director

Dr Philipp Steinmann
Senior Systems Engineer

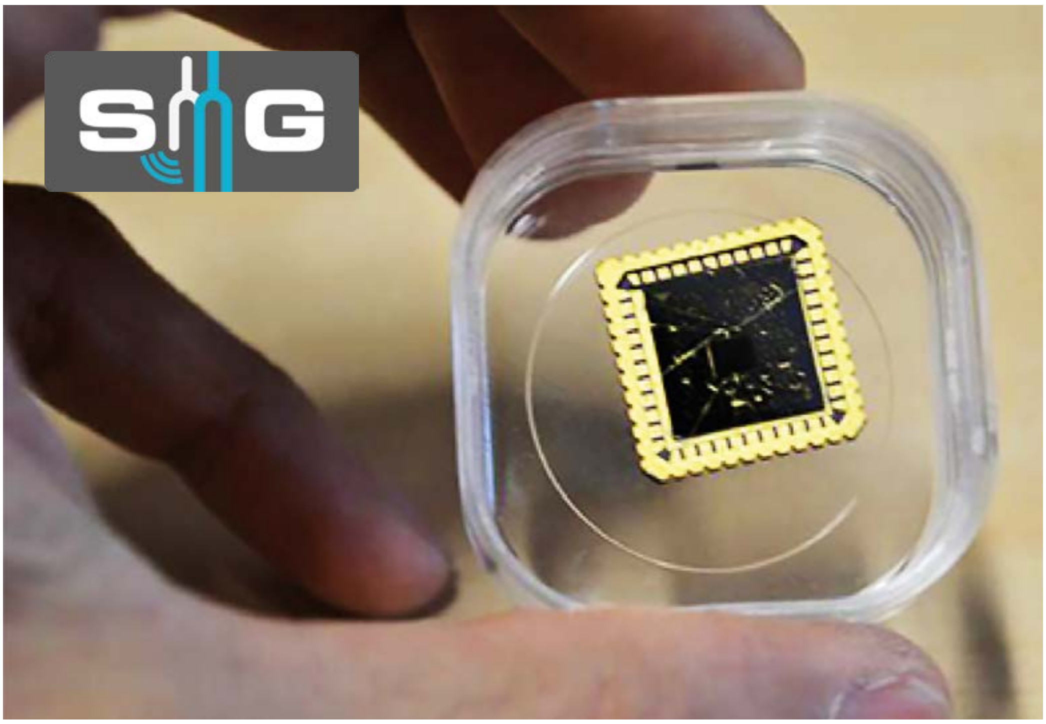
Silicon MicroGravity ("SMG") is a spinout company from the University of Cambridge. The company has developed a high performance microelectromechanical systems (MEMS) accelerometer with a projected resolution of approximately one billionth of the Earth's gravity, while allowing for measurement over a 180 decibel (dB) dynamic range.

The technology has been developed in Cambridge University's Nanoscience Centre primarily funded by BP and Innovate UK. The breakthrough sensors enable the recording of gravity data at very high sensitivities and seismic data at ultra-low frequencies. Both sensing methodologies provide an improved means for oilfield reservoir surveillance. Gravity sensing is a well-established surface exploration technology, however not easily available in the borehole. Changes in gravitational acceleration of the order of one part per billion provide information related to differences in density associated with variations in fluids and geological lithology. Seismic imaging involves the use of seismic sources sending acoustic energy through subsurface geological layers. The reflected energy is sensed as minute vibrations by geophones. Processing these seismic signals provide a subsurface image of the layering and reservoirs.

The Company's MEMS technology is differentiated from other available MEMS technology by using a highly sensitive resonant frequency sensing methodology. This provides improved performance at low frequencies relative to other MEMS seismic sensors based on capacitive or optical sensing. Utilising this technology SMG is actively developing a borehole gravity tool for gravity surveys and has partnered with leading engineering contractors to achieve the first commercial deployment of the tool in 2018.

Since February 2017 Silicon Microgravity has a permanent presence in the Maxwell Centre. Co-location close to the Nanoscience Centre and the academic team, and engagement with the wider research community has enabled SMG to rapidly transition the technology from lab to field.

As SMG grows the Maxwell Centre will continue to provide both the facilities and opportunities for the company to engage with researchers across departments and will likely maintain a permanent presence.



Henry Royce Institute, CAM-IES and Faraday Institution

Prof Clare Grey FRS
Cambridge Faraday Institution and CAM-IES Director

Prof Sir Richard Friend FRS FREng
Royce Academic Champion

Dr Isabelle de Wouters
Director of Scientific Development, Energy@Cambridge

Dr Lata Sahonta
Programme Manager, Cambridge Royce & CAM-IES

The Maxwell Centre was the site of much activity in 2017 with the installation of advanced equipment facilities provided by the Henry Royce Institute (HRI) at the University of Cambridge. These state-of-the-art equipment suites are located primarily at the Maxwell Centre, with some items installed as part of dedicated facilities suites in other laboratories in West Cambridge. The HRI attracts a steadily growing user base of both academic and industrial materials scientists. The Cambridge Royce facilities are focused onresearch within the broad Materials for Energy-Efficient ICT theme. Activities span fabrication, testing and packaging of device materials and systems with reduced consumption of resources and energy, both in their production and use. The Cambridge Royce equipment comprises a range of advanced materials growth and device characterisation tools for applications in efficient energy generation, storage, and use. These goals overlap remarkably well with the aims of other programmes run from the Maxwell Centre, such as the Winton Programme, Impulse, and Energy@Cambridge, and it is expected that the facilities will be vital to driving progress in energy materials research in Cambridge and throughout the UK. The Cambridge Royce has been crucial in attracting further funding to Cambridge for energy materials research.

HENRY ROYCE INSTITUTE | UNIVERSITY OF CAMBRIDGE






A part of the custom Ambient Processing Cluster Tool, being assembled in Munich

In January 2017 the EPSRC awarded £2.1 million networking grant funding to the setting up of the Centre for Advanced Materials for Integrated Energy Systems (CAM-IES), based at the Maxwell Centre and led by Professor Clare Grey. The Maxwell Centre has also recently become the home of the Cambridge-based research activities of the Faraday Institution, a part of the UK government's £246 million investment in making battery technology more accessible and more affordable. The Cambridge-led research into "Extending battery life" involves nine other universities and 10 industry partners, and is due to kick-off with a meeting at the Maxwell Centre in early 2018. Leaders in the field of battery development will explore novel approaches to meet challenges in battery degradation, energy densities and cycle life.

Researchers working both in CAM-IES and the Faraday Institution will be regular users of a range of Royce equipment dedicated to studying electrochemical and interfacial phenomena in battery systems, as well as the growth and deposition of energy storage materials systems. These facilities include the Ambient Processing Cluster Tool, the 3D X-ray CT scanner, and the Energy Storage Test Equipment, all located within the Maxwell Centre. The interactions between these groups of researchers will be vitally important for cutting-edge basic research and novel industrial applications in the energy sector.

The Maxwell Centre is the perfect environment for UK academics and industry to engage with other researchers to develop collaborations, as well as take advantage of excellent shared experimental facilities. It is expected that in 2018 the critical mass reached by activities at the Maxwell Centre will be the nucleus for new collaborations with the UK energy materials community, and will continue making links with key industrial partners.

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- CAM-IES@maxwell.cam.ac.uk
  www.energy.cam.ac.uk/cam-ies

- Faraday@maxwell.cam.ac.uk

Global Challenges Strategic Research Initiative

Prof Alan Blackwell
Director of Research

Dr David Good
Director of Research

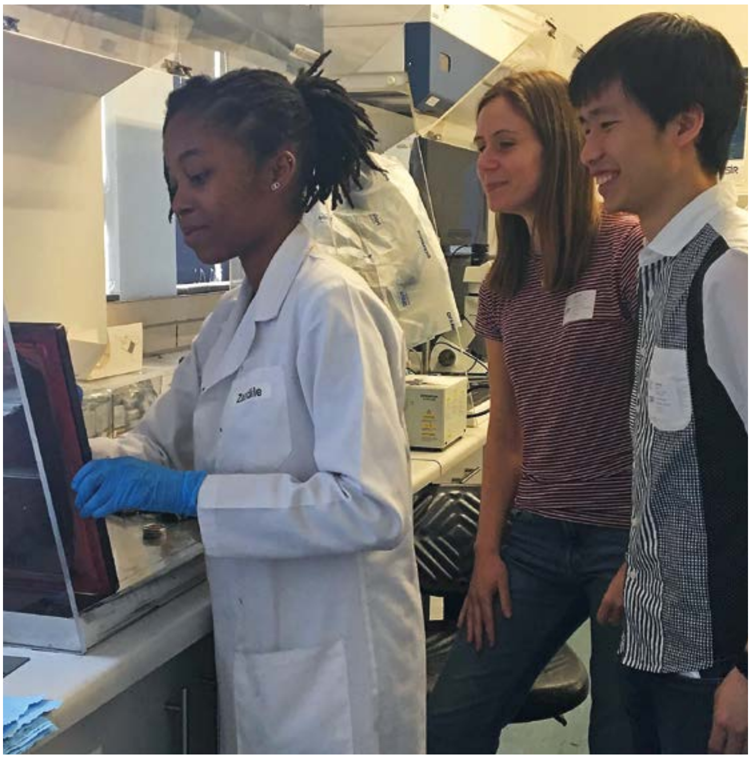
Dr Lara Allen
Director of Implementation & Impact

Dr Sara Serradas Duarte
Coordinator

In October 2017 the Global Challenges Initiative (GCI) Strategic Research Initiative (SRI) moved into the Maxwell Centre. With over 300 members from all six University of Cambridge Schools, GCI advances the contribution of University's research towards addressing global challenges and achieving the United Nations Sustainable Development Goals (SDGs) by 2030.

GCI supports researchers working on global challenges and the SDGs in the following ways:

- Facilitation of dialogue and the co-creation of research agenda with research partners and end-users in the developing world;
- Support of interdisciplinary collaboration between science, technology and medical researchers and those in the arts, humanities and social sciences;
- Enhancement of the contribution of early career researchers to the formulation and implementation of challenge-led research on the SDGs;
- Facilitation of the evolution of cross-disciplinary research agendas on the SDGs leading to the successful submission of substantial funding bids;
- Development of protocols for 'impact chains' connecting research design to implementation.



Over the past year, Maxwell researchers have participated in GCI-led training opportunities of relevance for research for the SDGs – namely around methodologies for co-creation with communities in the Global South – and contributed to the formulation of adequate global challenges-related research agendas.

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sbas2@cam.ac.uk

CamBridgeSens Strategic Research Network

Prof Clemens Kaminski
Director

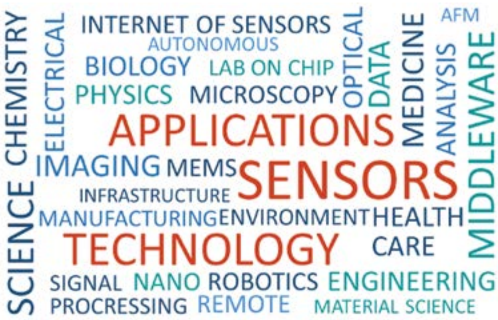
Dr Oliver Hadeler
Programme Manager,
MRes Director

CamBridgeSens is an interdisciplinary network for graduate students, researchers and academics with an interest in sensor research and applications across Cambridge University. The network connects around 300 members from more than 20 departments, including Physics, Engineering, Chemistry, Biology, Chemical Engineering and Biotechnology, Biochemistry, Materials Science, Neuroscience and Clinical Medicine. Expertise ranges from developing new materials for sensing applications to the employment of existing technologies in new areas. CamBridgeSens facilitates the interaction between industry and academia, e.g. by exploring collaborative research opportunities between industry and members of the network.

Sensor innovation thrives through collaboration between researchers from different traditional academic disciplines. Point of care glucose sensors, smart homes or autonomous vehicles are prime examples where interdisciplinary research in sensor technologies has had a significant impact.

Sensing is one of several strategic research areas at the University of Cambridge. CamBridgeSens provides a formal network for all sensor researchers at the University, bridging the gap between traditional academic disciplines and connecting expertise, people and equipment. It provides a gateway for industry to engage with academics in sensor related research, e.g. by matching industry with corresponding academics, often in collaboration with the Research Office and Cambridge Enterprise.

The combined expertise between CamBridgeSens members includes technologies such as micro-electro-mechanical systems, microfluidic and electro-chemical devices, super-resolution optical microscopes and open-source hardware. Sensors for personal health care, environmental monitoring, civil infrastructure sensing, astronomy, robotics and sensor networks



are part of a wide range of application areas covered by the network. Fundamental research by members of CamBridgeSens, such as the development of new sensor materials, the use of artificial intelligence in data visualisation and advancements of manufacturing processes, provides exciting opportunities for future sensor applications.

Workshops, organised by the network, encourage cooperation between researchers from different scientific areas. Recent events include a networking day on “Sensors and Data in Robotics”, which was co-organised with the Big Data Strategic Research Initiative and the British Antarctic Survey. This event brought together delegates from industry and academia from around the UK to explore future challenges and solutions in the field of robotics in harsh environments. The annual Sensors Day conference brings together an international mix of students, academics and industry to share new results and trends in sensor research.

Since 2014 CamBridgeSens runs the Centre for Doctoral Training in Sensor Technologies and Applications (Sensor CDT), funded by EPSRC and industry. The Sensor CDT trains 10-15 graduate students per year across the many sensor areas represented in the University of Cambridge, developing future innovative leaders in the field. A one year Master of Research programme followed by a three year PhD project provides the students with key scientific knowledge and a broad range of research skills, including team working, leadership and research management.

www.sensors.cam.ac.uk
info@sensors.cam.ac.uk

The Winton Programme for the Physics of Sustainability

Dr Nalin Patel
Winton Programme Manager

The Winton Programme for the Physics of Sustainability was set up through a donation of £20M by David Harding, alumnus of the Cavendish Laboratory. The Programme has focussed on attracting and supporting exceptional researchers from different disciplines working on 'blue-skies' research that can have an impact on how we meet the growing global needs for scarce resources.

The Maxwell Centre is home to the majority of the Fellows and Affiliated Lecturers, with access to state-of-the-art laboratory space, much of which has been configured to their specific research requirements. Many of the global challenges that the Programme is addressing require collaborative research across disciplines and interfacing with industrial partners who will eventually commercialise these new technologies. The Maxwell Centre has a unique combination of researchers from across the Physical and Engineering Sciences as well as industrial partners and is therefore an ideal place for the Winton Community to develop the links needed for their research to flourish. In the last year three new Winton Advanced Research Fellows have started and moved their research into the Maxwell.

Dr Chiara Ciccarelli is working on ferromagnetic systems with a view to finding new types of magnetic random access memories that require low levels of energy to read and write. As the demand for computing resources continues to rapidly rise this is becoming a pressing global issue. Chiara along with Dr Hannah Joyce in Engineering are setting up an optical THz facility in the Maxwell Centre which will be able to probe the speed of response of these systems. The set-up will include a 1T electromagnet and a low vibration optical cryostat covering the temperature range 3-500K.

Dr Felix Deschler is exploring how excited state dynamics are connected with local material structure to understand the recombination mechanisms of highly-luminescent materials. He combines expertise in ultrafast spectroscopy with high-resolution microscopy to resolve electronic state and material dynamics. His group is based in the Maxwell Centre, using laser facilities that enable studies down to the femto-second scale. The goal of his research is the discovery of new functionalities and novel material systems for optoelectronic applications.

Dr Alpha Lee is using machine learning techniques to discover functional soft materials such as organic electrolytes and bioactive molecules. His research is linked to a number of applications including accelerating drug discovery and chemical synthesis, as well as finding new materials for energy storage applications. The later is linked to the growing activities in battery research which is being supported by the Faraday Challenge, which is a £250M government research programme for developing batteries in the UK. Batteries were also one of the themes of this year's Winton Symposium on Energy Storage and Distribution.

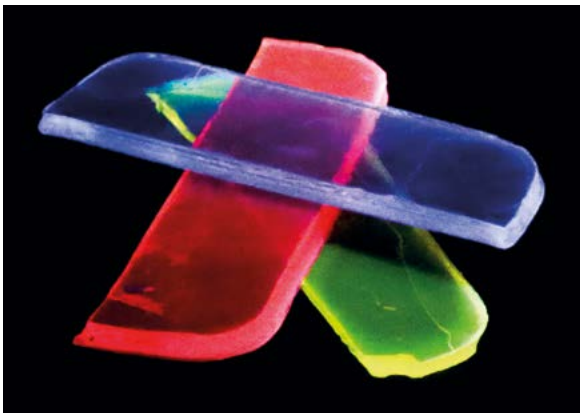
The annual one-day Winton Symposium was held on 9th November 2017 at the Cavendish Laboratory and attracted researchers from across disciplines as well as industrialists to engage in a topic related to sustainability. With the increase in the level of intermittent renewable energy that is coming online, the issue of storage and distribution is becoming critical for the energy network to work efficiently. Much of the technology advances in energy storage are being utilised in the transport economy, with two of the speakers addressing the challenges that need to be overcome to move to low or zero-emission transport. Professor Katsuhiko Hirose, who was involved in Toyota's Mirai hydrogen fuel cell vehicle, presented the opportunities of moving to a hydrogen based economy, and how it is expected to contribute a significant portion to the future total energy mix. The electrification of transport was described by Professor David Greenwood from the Warwick Manufacturing Group, who suggested that vehicles will switch to electric over the next 20 - 30 years. The transition will be supported by research into battery technologies, where there is considerable scope for making batteries smaller, longer-lived and cheaper.

www.winton.phy.cam.ac.uk | winton@phy.cam.ac.uk

THE WINTON PROGRAMME FOR THE
Physics of Sustainability

Dr Akshay Rao
Winton Advanced
Research Fellow

At the Frontiers of Light Matter Interaction in Energy Materials



Understanding and harnessing light-matter interaction in novel nanostructures and semiconductors materials has the potential to open a range of new device functionalities in areas ranging from solar energy harvesting and photocatalysis to spintronic and quantum information science. To fully understand these materials and the phenomena they play host to, it is important to understand the dynamics of the quasiparticles that dominate their physics such as electrons, excitons, polarons and polaritons. Getting a complete picture of these materials can allow us to develop new device with radically enhanced or completely novel functionality. But there are two challenges that need to be overcome first.

Our first challenge, is the traditional tradeoff between spatial and temporal information when studying these systems. While electron microscopy techniques can provide structural information with sub-nm spatial resolution and time-resolved optical spectroscopy techniques can provide sub-10fs temporal information, no technique can provide a real-time picture of the dynamics of the photo-excitations in these systems at the nanoscale. This is because time-resolved spectroscopy is primarily performed at the ensemble level due to the diffraction limit, which is a few hundred nms for visible light. To overcome this challenge, we have developed a new Ultrafast Super-Resolution Microscopy platform. This enables us to study the dynamics of quasiparticles with sub-10 fs temporal resolution and sub-10nm spatial resolution. We are using this unparalleled technique to study the dynamics of a range of systems including 2D semiconductors, quantum dots, molecular semiconductors, hybrid perovskites, organic-polaritons and polariton condensates. By providing a real-time picture of these quaiparticles at the nanoscale, we hope to gain new insights into their physics and pave the way to novel device functionalities.

Our second challenge is to reimagine how to utilise these quasiparticles for applications such as solar energy harvesting and light emission. To take an example, there is a huge worldwide effort to develop new materials for cheaper and more efficient photovoltaics. However, it is clear that simply developing new, cheaper materials is no longer sufficient to drive down the cost of solar energy by say a factor of 10. This is because of the increasingly dominant systems cost to balance within solar installations.

Inspired by natural light harvesting complexes and based on our rapidly evolving understanding of excitons and other quasiparticles, we are working on a new generation of cheap, light weight and flexible structures that can harvest solar photons and concentrate them onto conventional Si solar cells. Via careful control of photon and exciton dynamics these structures could concentrate diffuse light, something that is entropically forbidden in conventional optical systems based on lenses and mirrors, and reach concentration factors above 100. Thus, we hope to use such structures to dramatically reduce both the number of solar panels needed and also the the balance of systems cost. We are working with industrial partners including Eight19 and the NSG group to bring these technologies to market.

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Computational Physics at the Maxwell Centre

Dr Nikolaos Nikiforakis
Head of the Laboratory for Scientific Computing, Director of the MPhil in Scientific Computing

"The industry is continually seeking alternative formulations and the ideal technique to determine this is through computational methods."

– Dr Simon Bittleston, Managing Director, Schlumberger Cambridge Research

Computational physics at the Maxwell Centre is a unique ecosystem of training and research and a genuine two-way partnership of academia and industry. It trains early-stage researchers from Master's level through to PhD and contributes to their continuous professional development by means of short courses and their active engagement with industrial projects.

Research is predominately on complex, multi-physics, multi-scale problems arising in science or technology and is guided and funded by industry and government laboratories, often jointly with EPSRC.

The meaningful interaction between academia and industry significantly accelerates the conversion of blue-skies research into disruptive technology and is considered by the industrial partners to be of profound importance as a key differentiator for their business.

Computational Physics at the Maxwell Centre is an integrated research and teaching activity, comprised of the Laboratory for Scientific Computing (LabSC) and the Academic Programmes of the Centre for Scientific Computing (CSC).

The Laboratory is engaged with UK-National and international strategic research programmes and alliances and is working with automotive, aerospace, manufacturing, oil & gas and defence companies. These include Atomic Weapons Establishment, Boeing Research and Technology, BP Exploration Operating Company, Jaguar Land Rover, Orica Mining Services, QinetiQ, Schlumberger Cambridge Research and Singapore National Laboratories, amongst others.

It is fulfilling the vision of the Maxwell Centre by implementing blue skies activities into research objectives relevant to economic opportunities for industry and society at large and it is facilitating a two-way flow of ideas and researchers.

The core of LabSC's research is on Computational Multiphysics and it has a development and an applied physics element. The development is on numerical algorithms for the simultaneous solution of the complex systems of nonlinear partial differential equations for four states of matter on discrete space, thus allowing researchers to address multi-physics, multi-scale, multi-phase and multi-material problems.

This involves research on applied mathematical aspects of the problem, such as on mixed Riemann problems to account for communication between different materials or states of matter. It is complemented by research on high performance computing methodologies such as hierarchical adaptive mesh refinement to bridge vastly different spatial and temporal scales between processes (multi-scaling). Using these unique numerical tools allows for internationally-leading research on topics of fundamental and applied physics. An example is lightning strike on a composite aerospace material which covers a combustible liquid, commissioned by Boeing Research and Technology. The solution involves a nonlinear interaction of MHD (magnetohydrodynamics), multi-material solid mechanics and reactive, multi-phase fluid dynamics.

Other current projects include the ultrasonic excitation of thin substrates for anti-icing purposes (Boeing R&T), the Programme for Simulation Innovation (Jaguar Land Rover and EPSRC), understanding the properties of complex non-Newtonian fluids (Schlumberger), combustion-induced elastoplastic structural response (JLR, QinetiQ and ORICA) and detonation-induced electromagnetic fields (Singapore National Laboratories).

The cohabitation of these projects under the Maxwell Centre roof facilitates technology transfer across non-competing industries and promotes step change progress.

"This training system is a significant step change in the capabilities of scientific graduates for AWE and UK industry in general." – Professor Peter Roberts OBE, AWE Chief Scientist

Teaching and training

Teaching and training within the Academic Programmes at the Centre for Scientific Computing includes the EPSRC Centre for Doctoral Training in Computational Methods in Materials Science (CMMS) and the MPhil in Scientific Computing. The CDT in CMMS provides training on the development of new mathematical models, algorithms and code, and on the expert use of computational models for materials modelling at atomic and continuum scales (see separate feature in this annual report).

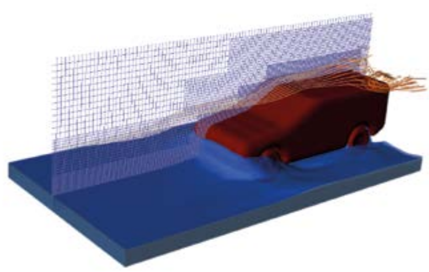
The cornerstone of research and training in computational physics at graduate level at the Maxwell is the MPhil in Scientific Computing, which is a full-time course providing education of the highest quality at Master's level. Covering topics of high-performance scientific computing and advanced modelling methodologies and techniques, it produces graduates with rigorous research and analytical skills, who are formidably well-equipped to proceed to doctoral research or directly into employment in industry, the professions, and the public service. The MPhil has seen a year-on-year increase of very strong applications at a time that similar courses in the UK are experiencing a decline in numbers due to a shift of applicants to CDTs. As a result, the majority of our successful applicants already have Master's level degrees and/or 1st class bachelor degrees. Not surprisingly, every single graduate of this course to date has been offered fully-funded PhD studentships or jobs in the high-tech industry.

Apart from the MPhil and the CDT, the Academic Programmes of CSC also support continuous professional development courses such as the annual two-week Autumn Academy in High Performance Computing and a number of week-long short courses in various topics of computational physics, scientific computing and its applications.

Looking ahead to the future, SC research aims to take the theme of multi-physics and multi-scale simulation to a different level by taking coupled continuum/atomic-level models outside the highly specialised research domain and making them an every-day commodity for academic and industrial research and development. This highly disruptive technology will bring a step-change in academic research and a significant competitive advantage to SC's industrial partners.

- www.csc.cam.ac.uk
  www.lsc.phy.cam.ac.uk

Multiphysics modelling, QinetiQ and ORICA

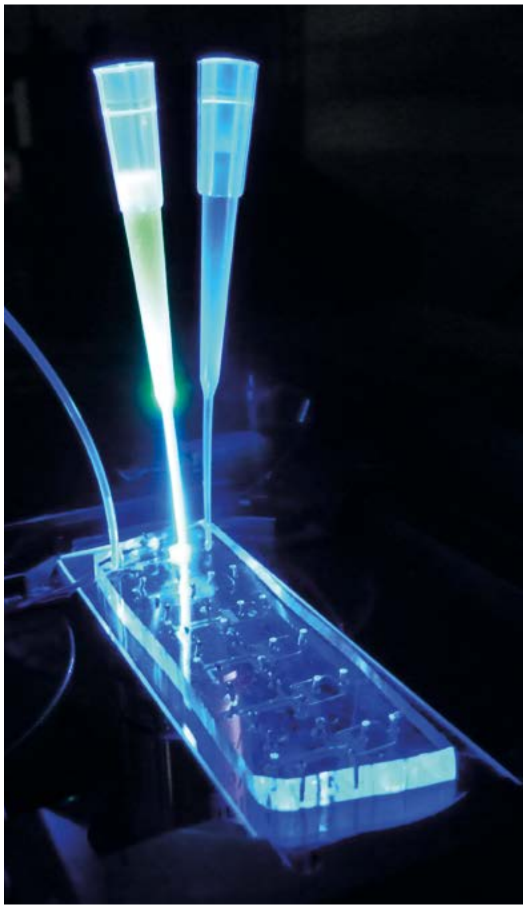


Multiphysics modelling, Jaguar Land Rover

Biophysics and Biophysical Chemistry

Prof Tuomas Knowles
Department of Chemistry

Proteins are the building blocks of life. Nature uses proteins to generate highly sophisticated materials and nanoscale machinery with astonishing performance, yet consumes remarkably little energy and resources in doing so. It has become increasingly apparent that the majority of proteins do not exert their biological actions alone, but rather as part of complexes.



Protein self-assembly, through which proteins find and bind to the correct partner in order to become biologically active, is thus the centrepiece in the molecular basis of life. By contrast, if proteins bind to an incorrect partner, this process can lead to disease. Indeed, it is now apparent that a wide range of disorders, including neurodegenerative diseases such as Alzheimer's and Parkinson's diseases are at the molecular level associated with pathological protein-protein interactions. The focus of our group is to use concepts and approaches from the physical sciences to develop new methods to understand and control protein self-assembly for applications ranging from molecular medicine to the development of new biomaterials.

Protein self-assembly phenomena are at the heart of biological function and malfunction, yet their study has proved to be challenging. Indeed, most existing methods perform best for purified preparations of isolated components rather than the dynamic and heterogeneous complexes that are formed as a result of protein self-assembly. To address this challenge, our group develops and applies new methods and approaches rooted in the physical sciences to find new ways to probe protein systems, and the interactive and interdisciplinary nature of the research environment in the Maxwell Centre provides a stimulating environment for interdisciplinary Physics research which underpins many of our method development activities.

Much of our efforts are focused understanding aberrant protein self-assembly that underlies neurodegenerative disorders such as Alzheimer's and Parkinson's disease, and we conduct this work in the Cambridge Centre for Misfolding Diseases. In particular a major challenge in this area is that the molecular disease mechanisms have been challenging to establish and target in a rational manner. By bringing together newly developed physical methods to probe and understand protein behaviour with the full biological complexity of protein misfolding diseases, we aim to progress together with our collaborators towards finding disease modifying therapies in this challenging yet vitally important area.

We are also interested in controlling the self-assembly of natural proteins to generate new types of functional materials. Many proteins, such as silk, have a level of material performance unrivaled by man-made materials. We are applying physical strategies to control biological self-assembly to generate new types of functional materials from natural biological building blocks.

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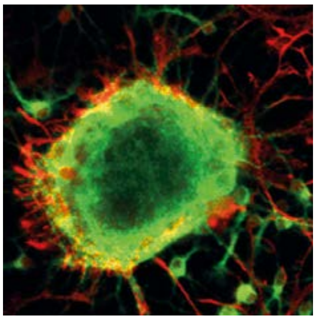
Bioelectronics Systems Technology group

Dr Róisín M. Owens
Department of Chemical Engineering and Biotechnology

The Bioelectronics Systems Technology group has recently relocated to the department of Chemical Engineering and Biotechnology at the University of Cambridge from the south of France. Our research is focused on bioelectronics, interfacing novel electronic devices with cells. We are interested at the fundamental level in understanding how electronic materials act at the interface with biological materials.

Most of our work understanding the fundamentals of the biotic/abiotic interface has centred on the use of organic electronic materials, specifically conducting polymers. For a host of reasons, including better matching of mechanical properties to biological molecules, similarities in terms of chemical composition, and the ability to convert ionic signals to electronic signals, organic electronic materials are emerging as extremely viable alternatives to traditional electronic materials such as silicon or noble metals. This is particularly well illustrated for the generation of metabolite sensors (e.g. glucose, lactate, dopamine) which can benefit from these materials properties for wearable or disposable or more sensitive diagnostics. We have summarised this emerging field in our brand new review published in Trends in Biotechnology (DOI: http://dx.doi.org/10.1016/j.tibtech.2017.10.022).



Confocal microscope image of neurospheres containing neurons (green) and astrocytes (red). J.Pas, et al. "Enhancing electrophysiology recordings with neurospheres via patterned PEDOT:PSS microelectrode arrays". Advanced Biosystems (2017) doi: 10.1002/adbi.201700164

Typically, we integrate our organic electronic materials into devices known as transistors. In terms of interfacing with biological systems, the transistor provides the opportunity to amplify signals that can often be of low magnitude. Our device of choice is the organic electrochemical transistor (OECT) that facilitates intimate coupling of the biological and electronic materials. We work very closely with collaborators in Cambridge (Prof. Malliaras) and internationally (Stanford, KAUST, Northwestern, Linköping) on these devices and have recently collaborated on a comprehensive review on the OECT published in Nature Materials (doi:10.1038/natrevmats.2017.86)

The fundamental understanding we have acquired thus far helps us to design better devices for monitoring and hosting cells in vitro. We are particularly motivated to develop more physiologically relevant biological models that combine the use of human cells, grown in 3-dimensions, as a more accurate representation of human tissues and organs. We are integrating these models with our devices so that we can generate systems to enable drug discovery and reduce our reliance on animal models that are often not predictive of the human situation.

This research is central to a newly funded European Research Council project called 'IMBIBE: Innovative technology solutions to explore effects of the microbiome on intestine and brain pathophysiology'. Alterations in the microbiome have been linked with many disease phenotypes including colorectal cancer, Crohn's disease, obesity, diabetes as well as neuropathologies such as autism spectrum disorder (ASD), stress and anxiety. Animal studies remain one of the sole means of assessing the importance of microbiota on development and well-being, however *in vitro* models have developed at an accelerated pace in the past decade, benefitting from advances in cell culture, increasing the viability of these systems as alternatives to animal testing. We will be the first to develop an in vitro model of the gut-brain axis with microbiota, using engineering and materials science approaches to develop complete (i.e. human and microbe) models to truly capture the human situation. The result from this project will be a platform to study host-microbiome interactions and consequences for the pathophysiology of the GI tract and brain.

The success of the IMBIBE project will rely on our previously developed expertise in 3D models monitored using organic electronic devices.

Going hand in hand with our interest in the microbiome, we are working on a novel OECT-based platform for the screening of antibiotics to answer a growing global crisis caused by a lack of new compounds to treat bacterial infections. Focussing on cell membranes as the primary place of encounter in drug or pathogen interaction with a cell, we have created biomimetic platforms for drug discovery using native membrane components integrated with state of the art devices for characterisation.

www.ceb.cam.ac.uk/research/groups/best | rmo37@cam.ac.uk

Engineering oxides atom by atom to give unprecedented properties

Prof Judith Driscoll
Department of Materials Science and Metallurgy

With properties which span all the way from insulating to superconducting and everything in between (semiconducting, magnetic, multiferroic, ionics, etc), oxides are of interest in a very wide range of devices in energy and electronics. For most applications, thin films are required. Both complex (multicomponent) oxides and more simple binary oxides have important roles to play.

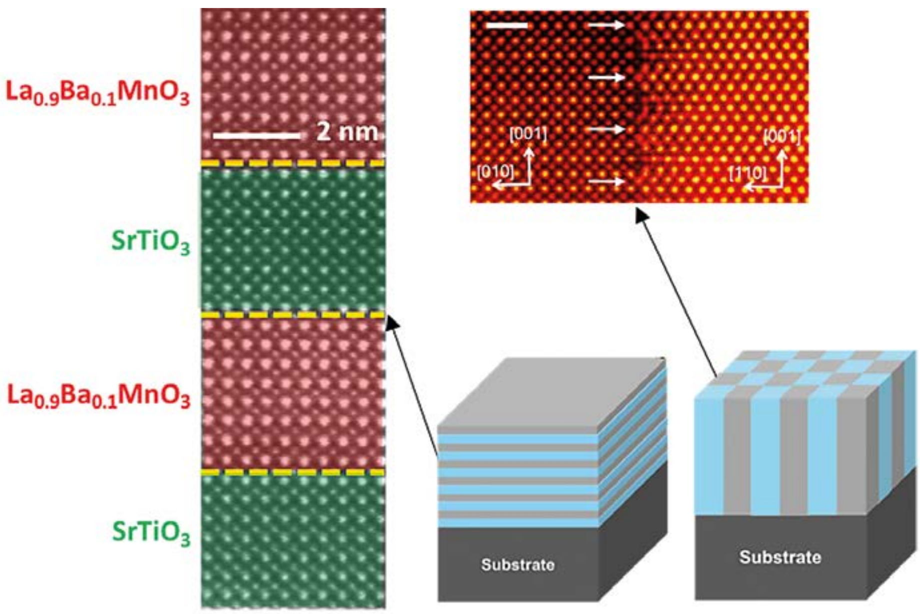
Our work aims to answer the following questions:

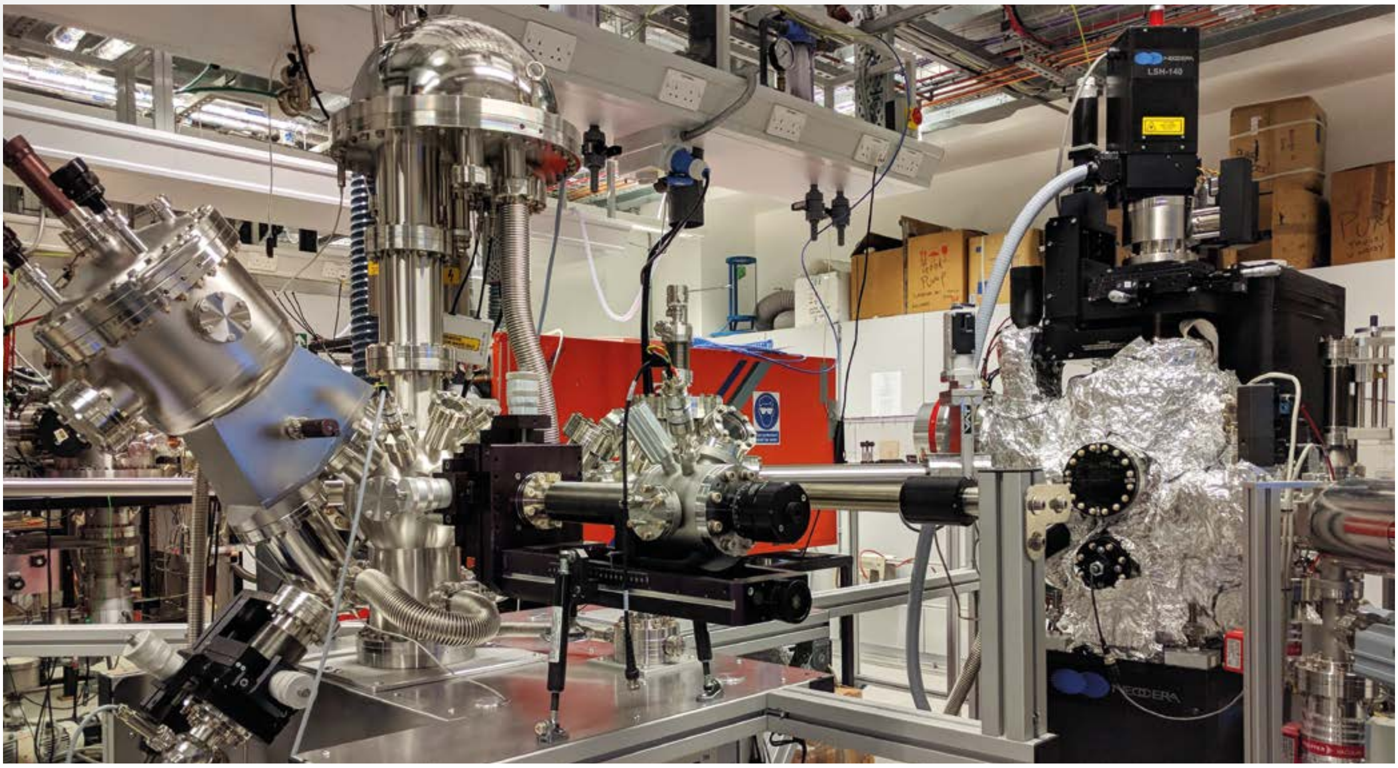
a. How can we dial-in properties at the atomic scale, what new functionalities emerge, and can we improve functional performance?

b. Can we translate the new science learned in a) to practical applications?

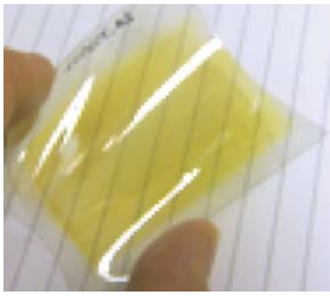
Our work is highly interdisciplinary, linking chemistry, physics and engineering. The first part, (a), involves creating and understanding ideal interfaces between complex oxides. We grow and measure epitaxial horizontal superlattice structures, made atomic layer-by-atomic layer, using advanced pulsed laser deposition (PLD) with reflection high energy electron diffraction. We also study vertical superlattices (a new form of superlattice grown very simply by self-assembly). The vertical structures have perfect interfaces of much higher density than can be made in a standard superlattices, and which do not need complex control of growth as standard superlattices do.

The figure below shows TEM images of horizontal and vertical superlattices. These different superlattice structures give rise to new quantum effects as well as novel emergent interface properties, e.g. the formation of a 2D electron gas, enhanced magnetism, and novel hidden states of matter. Furthermore, strain coupling between the materials and new strain states in the different superlattices gives rise to functionalities which cannot in any other materials forms, e.g. above-room-temperature magnetoelectrics, green ferroelectrics, higher temperature superconductors, oxide ionic conductors with much enhanced ionic conduction, and highly controlled on-off ratios in RRAM devices.





Advanced pulsed laser deposition with in-situ XPS for atomic layer growth and analysis of advanced oxide materials



As well as working on complex oxides, we also explore more simple (in fact less simple than one would like!) binary (or doped binary) oxide semiconductor thin films which are of interest in a wide range of energy devices (e.g. solar cells and energy storage systems) as well as devices for IoT related applications (e.g. flexible logic and memory). The figure alongside shows a simple p-type binary oxide film of Cu_2O grown on a flexible substrate.

Binary oxides have the advantage over complex oxides of being able to be grown at lower temperature than complex oxides (i.e. at <300°C instead of >600°C as for PLD). In order to enhance device performance, we precisely engineer their compositions, defect levels, and band structures.

The second part, (b), of our research involves close interactions with different industries in the UK and across the world. Precision oxides have huge potential in a number of applications. Hence, while we are excited to be able to demonstrate strong property improvements through engineering thin films at the nanoscale, it is also very important that our basic research moves to the next level. This entails thinking about how our lab scale devices can be manufactured using scaleable processing routes, which often requires innovative processing methodologies. We have a strong track-record in translating lab demonstrations to industry and we aim to keep firmly moving along this path.

Current industries we are working with include: Pragmatic (flexible logic and memory), Applied Materials (energy storage), Deregallera (energy storage), Murata (energy storage), Sunam (superconductor wires for several energy applications), Tokomak Energy (superconductors for fusion).

Finally, it is great to see how the Maxwell Centre has provided a strong platform and focal point for research in energy and low power electronic materials. Our interactions with scientists and engineers from across the University has led to new thinking and exciting collaborations. Also, the industry links that Maxwell is fostering is proving to be highly beneficial to many researchers in the University, including me.

JD thanks Ping Lu and Weiwei Li for the superlattice data.

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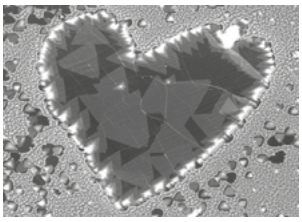
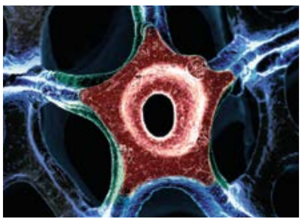
Integrated Crystal Growth of Advanced Nanomaterials

Prof Stephan Hofmann
Department of Engineering

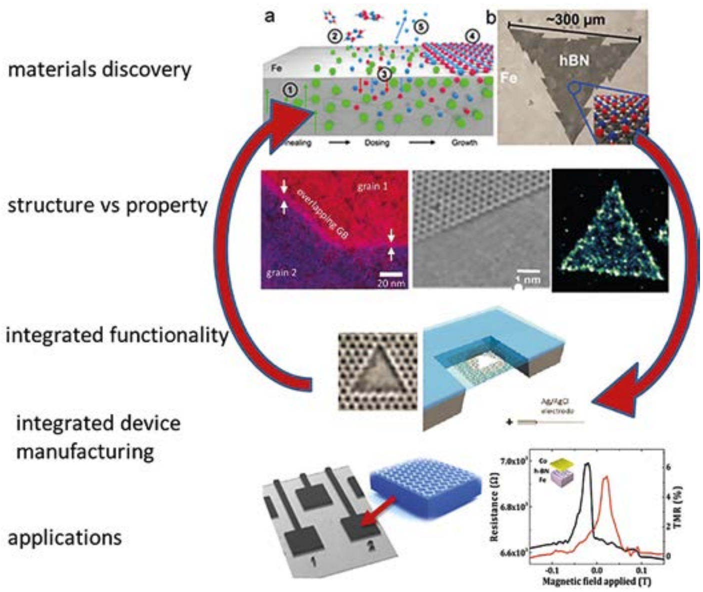


h-BN – S. Caneva from CUED photo competition



Graphene foam – I Aria from CUED photo competition

From new metrology and model systems to integrated manufacturing



Crystal growth and materials integration are at the heart of integrated circuits and systems. This has driven the computer revolution and an ever increasing material portfolio coupled to new device concepts offer a tremendous opportunity for future radical technology changes, many of them driven by energy efficiency.

We focus on materials discovery, and the development, optimisation and characterisation of the materials required to engineer change in applications ranging from information & communication technologies (ICT) to healthcare, energy conversion and storage. Much of the new functionality arises from the ability to combine an increasing diversity of materials and achieve greater structural complexity and more complex device architectures. This necessitates new growth and heterogeneous material integration strategies, and for nanomaterials bottom-up, or self-assembly, approaches are thereby of crucial importance.

Our work bridges from the fundamental understanding of phase behaviour, nucleation and interface dynamics on the nano-scale to developing integrated manufacturing pathways. We employ a range of complementary electron, X-ray and optical in-situ characterisation techniques, to reveal the mechanisms that govern the growth, interfaces and device behaviour of these nanomaterials in realistic process environments. As part of the Royce equipment at Cambridge, we are currently setting up a new high pressure XPS system, that will allow direct probing of "real" surfaces/interfaces at temperatures of up to 1000°C and in reactive gas environments in the mBar range. We are also currently setting up a new SEM system and optical spectroscopy system with similar environmental capabilities.

A focus of our current work is on developing scalable chemical vapor deposition processes for 1D and 2D nanocrystals, specifically semiconductor nanowires and 2D materials like graphene, hexagonal boron nitride and transition-metal dichalcogenides, and related heterostructures. We explore their new functionality in resistive memory devices and magnetic tunnel junctions for new ultra-low power computing architectures. We also explore integrated passive and active photonic components, electrochemical electrodes, sensor arrays and membranes/barrier film applications.

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Impulse Programme for tech innovators

Yupar Myint
Head of Programme

Dr Alexandra Huener
Coordinator

impulse
MaxwellCentre
for tech innovators

An intensive and steep learning curve experience

Impulse serves as a catalyst for entrepreneurship in individuals and organisations.

It engages 80+ experienced innovators from Cambridge to act as role models and to provide guidance to aspiring entrepreneurs with the development of their science and technology ideas and turning them into successful commercial ventures.

"Our vision is to become a focal point of collaborations for innovators and entrepreneurs from a variety of disciplines, industries and countries who are passionate in helping a new generation of science and tech entrepreneurs succeed"

Our advisory board members include:
Prof Chris Abell, Matthew Bullock, Dr David Cleevely, Prof Sir Richard Friend, Dr Debbie Harland, Dr Hermann Hauser, Prof Andy Hopper, Dr Elaine Loukes, Prof Chris Lowe and Prof Florin Udrea.

Programme Overview

Chance encounters make amazing ideas possible

The programme is comprised of two intensive residential modules with individual assignments in between. Its nature allows considerable flexibility in defining aims and workflow. The next Impulse Programme starts on 8 April 2018 at the Maxwell Centre, University of Cambridge.

The first edition of the Impulse programme run in 2017 and attracted a diverse range of projects from various disciplines, including technologies around graphene, green energy, health, machine learning, materials science, medical devices, diagnostic testing, quantum computing, sensors, software/IT, and water tech.

The programme is aimed at:

- PhD students, Post-docs and researchers across the different fields of Physical Sciences and Technology
- Early-stage entrepreneurs
- Researchers/Engineers/Managers from large corporates with innovative ideas

Further information about the programme timetable, mentors, speakers and other contributors, and application procedure can be found on our website.

www.maxwell.cam.ac.uk/programmes/impulse
impulse@maxwell.cam.ac.uk

The University hosts a number of themed Centres for Doctoral Training (CDTs), including EPSRC-funded centres listed here: www.epsrc.group.cam.ac.uk

Spotlight: EPSRC Centre for Doctoral Training in Computational Methods for Materials Science

Prof James Elliott
CMMS CDT Director

Dr Nikolaos Nikiforakis
CMMS CDT Deputy Director

The EPSRC Centre for Doctoral Training in Computational Methods for Materials Science (CMMS) provides training on the development of new mathematical models, algorithms and code, and on the expert use of computational models for materials modelling at atomic, mesoscopic and continuum scales.

The CMMS CDT engages academics from five Departments (Chemistry, Chemical Engineering & Biotechnology, Engineering, Materials Science & Metallurgy and Physics) across the Schools of Physical Sciences and Technology.

It is founded on partnership and active engagement with 20+ industrial partners who have contributed more than one third of the CDT's income and studentships. This combined focus on cutting-edge science and industrial requirements makes the Maxwell Centre for Industrial Engagement the natural home for the CDT. The Maxwell building has been catalytic for the student-led CDT cohort interaction, offering elegant and functional space for initiatives such as informal seminars, social events with other CDTs and coding competitions.

The backbone of training programme in the first year is provided by the MPhil in Scientific Computing, which has a taught and a research element. The taught element has modules on topics of high-performance scientific computing and data science techniques, and advanced topics of electronic, atomistic, coarse-grained and continuum modelling of matter. For the research element students undertake a substantial project which enhances their research capacity and provides them with essential skills for a successful completion of the PhD.

For the remaining three years, the students are based at one of the participating Departments and benefit from a rigorous Continuous Professional Development Programme which includes CPD courses and placements in UK companies and National Laboratories such as Schlumberger, Dassault Systèmes BIOVIA and Los Alamos.

By the end of its current 5 year cycle the Centre will produce nearly 60 outstanding graduates who will be poised to take on leading roles in UK-based software companies, academia, and analytical or modelling roles within UK industry.

The CDT is led by the Director, Professor James Elliott (Materials Science) and Deputy Director, Dr Nikolaos Nikiforakis (Physics), with day-to-day co-ordination by Dr James Dean and administration support by Miss Erica Pramauro and Mrs Louise Mortimer.

www.csc.cam.ac.uk/academic/cdtcompmat

Maxwell Centre

The Centre for Digital Built Britain

Prof Andy Neely
Pro-Vice Chancellor for Enterprise and Business Relations; Director, Centre for Digital Built Britain; Director, Cambridge Service Alliance

Dr Jennifer Schooling
Director, Centre for Smart Infrastructure and Construction; Director, Research Bridgehead, Centre for Digital Built Britain

Alexandra Bolton
Assistant Director, Centre for Digital Built Britain

"We deliberately want a very open system – a network of people involved in thinking about the future of digital built Britain."

The Centre for Digital Built Britain is a partnership between the Department of Business, Energy & Industrial Strategy and the University of Cambridge to deliver a smart digital economy for infrastructure and construction for the future and transform the UK construction industry's approach to the way we plan, build, maintain and use our social and economic infrastructure.

As Director of the new Centre for Digital Built Britain, based at the University of Cambridge's Maxwell Centre, Professor Andy Neely, Pro-Vice-Chancellor for Enterprise and Business Relations, sets out the next stage of the Digital Built Britain programme.

The success of Digital Built Britain (DBB) to date provides strong foundations to develop and deliver the next phase of the UK programme. This will bring together industry, academia and government to progress the digital agenda that will transform infrastructure and construction. The programme has helped to define, among other things, Building Information Modelling (BIM) at levels 1 and 2, and it has facilitated change in the way the public sector thinks about procuring construction and buildings. The impact has been significant and many countries across the world are looking to the UK as the arbiter of BIM and associated standards.

The Centre for Digital Built Britain (CDBB) will drive the next phase.

A key priority for the Centre is to continue and capitalise on the work of the DBB programme and the UK BIM Task Group. The Centre is bringing together industry, academia and government to explore how digital technologies will be used to improve the built environment and deliver value to the economy. This is timely. The UK will spend around £600 billion over the next 10 years on improving the built environment by investing in public and private infrastructure. If we can make the design, construction and, importantly, the on-going operation of that infrastructure more efficient, there will be significant savings for the country.

The Centre will bring focus to what lies ahead and to consider how digital technology will shape the future construction landscape. There are important questions to be asked: what will new technologies enable in the design, build and operation of buildings in the years to come? How does that digital technology play out and where can it create value for society?

Like any complex programme, particularly one looking to the future, the challenges are partly around predicting what that future will hold and how technologies will evolve. To succeed we have to bring people with us. Whether that is individuals or organisations, we need to engage people at large to think about the ways in which technologies can help both the persons that live and work inside the buildings and also the industry that is involved in construction. Bringing all those communities together so they see value in the future application of technology is crucial.

Involving industrial partners at the Centre and working closely with government is vital. We will be running an industrial consortium programme and are open to industrial members who are interested in working with us to explore the ways digital technologies will shape the future of the built environment.

While the Centre is housed at the University of Cambridge, we are open – and running calls and competitions – to involve academics from across the UK and internationally in different programmes, projects and initiatives. We deliberately want a very open system – a network of people involved in thinking about the future of digital built Britain.

This is a fascinating time to be involved in progressing the digital agenda for the sector; the confluence of different technologies and innovations opens up new and unprecedented opportunities to think very differently about the future of construction and infrastructure in the UK – and to be a world leader in this field.

To optimise this opportunity, we need to work together and engage a wide variety of professionals, organisations and communities in open activity. We hope you will join us.

www.cdbb.cam.ac.uk | enquiries@cdbb.cam.ac.uk | @CambridgeCDBB

Industry collaboration

There is a growing number of links with industry, ranging from joint research projects, partnerships with the Centres for Doctoral Training, collaborations between individuals, research groups, and networks, through to established industrial presence in the Maxwell Centre. Several companies and organisations were already mentioned in the report. The companies that interacted with the Maxwell Programme within the last year by taking residence in our building, hot-desking, regular visits, collaborations and events include:

Further industrial relationships within the Maxwell Centre community include:

Aixtron
Algaecytes
Alphasense
Applied Materials
Aston Martin
Astra Zeneca
BAE Systems
Barclays Eagle Labs
Base 4 Technologies
BASF
Boehringer Ingelheim
Boeing
Cambridge Cleantech

Cambridge Crystalographic Data Centre
Cambridge Display Technology
Cambridge Wireless
CPI
Dassault Systèmes Biovia
De La Rue
Deregallera
Digital Catapult
dstl
Dyson
Echion Technologies

Eli Lilly
Fieldfisher
FlexEnable
Flextech
Fluidics
Analytics
Future Cities Catapult
Granta Design
GSK
High Value Manufacturing Catapult
Horizon Discovery
immaterial
Infineum

Infinitus
InfoChem
Janssen Pharmaceutica
Johnson Matthey
Lhasa
MARS
MedImmune
Merck
Microsoft
Mitsubishi
Murata
Mursla
Nanoco Technologies

Nestlé
oe-a
Pfizer
Plastic Logic
Pragmatic
QinetiQ
Renishaw Diagnostics
Rolls-Royce
Royal Society of Chemistry
Satellite Applications Catapult
Sharp

Siemens
Sumitomo Chemical
Sunam
Syngenta
Tata Steel
TeraView
Thales
Tokomak Energy
Toyota
TWI
WaterScope
3M
42 Technology
and more …

Structure and Governance

Maxwell Centre Steering Committee

Prof Lindsay Greer, Head of the School of Physical Sciences, **Chair**

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Prof Pietro Cicuta, Deputy Head of Department of Physics, Finance & Resources

Prof Tim Minshall, Head of the Institute for Manufacturing

Dr Peter Hedges, Head of University Research Office

Dr Tony Raven, Chief Executive, Cambridge Enterprise

Dr Aga Iwasiewicz-Wabnig, Maxwell Centre Programme Manager, **Secretary**

"The Maxwell Centre builds on and extends existing collaborative links between industry and the physical sciences and engineering within Cambridge. It both provides a new and welcome direction for framing research within an academic environment in the 21st Century and widens the scope for industrial participation in research on an international scale."

Prof David Cardwell FREng, Head of Department of Engineering

"The Maxwell Centre is a great place to bring together researchers from industry and academia. It offers a comfortable environment to work and buzzes with activity. Although I have been working here only for a few months, I already attended many exciting events, expanded my network of collaborators and learned a lot about the current University of Cambridge collaborations.

Dr Marina Romanchikova, Principal Research Scientist, Data Science, NPL

"The Maxwell Centre provides an invaluable opportunity for our organisation to collaborate across the university and commercial sectors and access the unique expertise available. It affords LGC a window to the exciting technologies and expertise that a university such as Cambridge is developing and ensures we can develop relevant measurement support for cutting-edge research through our role as the National Measurement Laboratory (NML)."

Dr Jonathan Campbell, Science Leader, Molecular and Cellular Biology, Science and Innovation, LGC

"Having my laboratories in the Maxwell Centre allows us to make the most of the dynamic community and the shared facilities provided by the Henry Royce Institute and the EPSRC advanced materials characterisation suite."

Dr Siân Dutton, University Lecturer, Department of Physics

Get in touch

We welcome more ways of engaging with external partners and industry – the Maxwell Centre is set up to facilitate and foster these interactions. We look forward to new collaborations that involve innovative and ambitious research approaches to solving real world challenges.

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