IMPACTING LIVES

The University of Surrey Impact Acceleration Account

2016/17 review

IoT Egg
Learning to build Smart Cities

How am I driving?
Video analysis to help understand driver behaviour

Safer power
Improving the earthquake resistance of future power plants

Compact EEG monitoring for sleep

EPSRC
Pioneering research and skills

UNIVERSITY OF SURREY

SURREY CENTRE FOR CYBER SECURITY (SCCS)

The Surrey Centre for Cyber Security (SCCS) is one of 13 Academic Centres of Excellence in Cyber Security Research (ACEs-CSR) recognised by GCHQ and the Engineering and Physical Sciences Research Council (EPSRC).

These centres are based within UK universities conducting world-class research in the field of cyber security. Primarily formed from academics and researchers from the Department of Computer Science and the Institute for Communication Systems (home of the 5G Innovation Centre), the SCCS also brings in expertise from other departments including Mathematics, Surrey Business School, Sociology, Psychology and Law to focus upon six principal themes:

- TRUSTED COMPUTING
- HARDWARE SECURITY
- PRIVACY AND AUTHENTICATION
- SECURE COMMUNICATIONS
- MULTIMEDIA SECURITY AND FORENSICS
- HUMAN FACTORS

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The University of Surrey's research philosophy represents a commitment to engaged, applied work, improving the world we live in through technological innovation, commercial and social enterprise and driving forward policy and professional practice.

Collaboration with industry and user partners is a key element in enabling research that is relevant and can be applied quickly. Over the last five years, the Impact Acceleration Account at Surrey has enabled over 70 pieces of collaborative work with SMEs, start-ups, large corporations, hospitals and other organisations to bring research closer to implementation.

The projects have addressed key industry and societal challenges, providing an interdisciplinary approach to developing solutions, from new methods of disease diagnosis to novel nanoscale materials. A key selection criterion for all IAA funded activities is to maximise the impact of the investment.

We are pleased that the success of this research has been recognised by the award of a new programme of Impact Acceleration Account funding from EPSRC for three years from April 2017.

The new IAA programme will continue to provide short-term support to bridge the funding gap between research and potential commercialisation or adoption. One of the purposes of extending the programme is to allow researchers to explore the wider application areas of their work - finding new exploitation partners and understanding their requirements, leading to projects scoped to fit with further development pathways and funding schemes. This new funding gives Surrey the opportunity to further build our pipeline for creating impact from research, through discovery through to innovation.

Professor Michael J Kearney

Provost and Executive Vice-President
University of Surrey

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‘Canary in a coal mine’ sensor

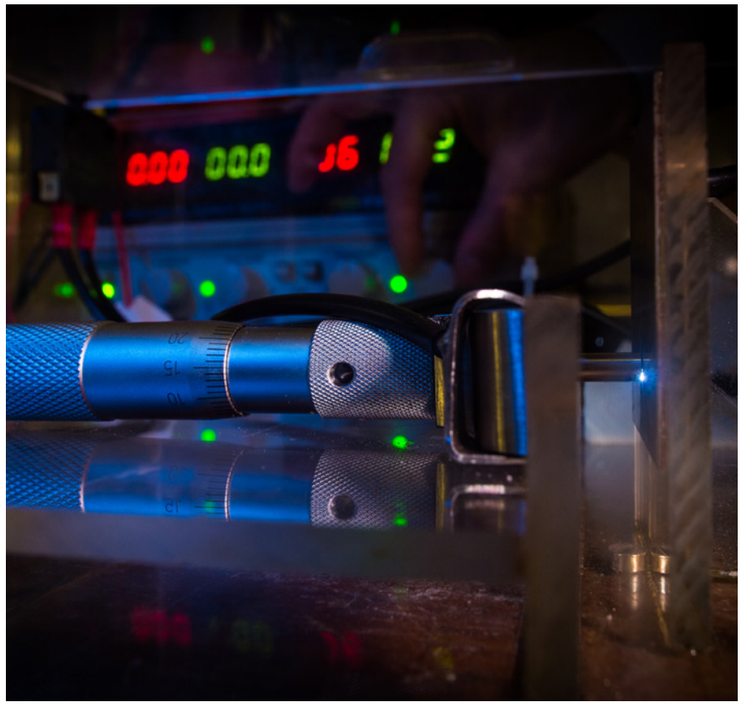
Development of a prototype low-cost air quality sensor system

Academic: *Dr David Birch*

Fluid sensor researchers at Surrey have exploited the physical and electrical properties of gases to develop the low-cost ‘Barozap’ sensor, which can rapidly detect the presence of contaminants in a gas – paving the way for solutions in environmental monitoring and the diagnosis of lung disease.

While there are a number of gas concentration detectors on the market – usually tuned to specific gases and used in clusters – these tend to be fairly expensive and relatively slow, taking up to 30 seconds to respond. They are also unable to indicate the presence of a gas which is not being looked for. The Barozap, which uses high voltage to convert a sample of gas into plasma, and measures its electrical characteristics, can detect when a foreign gas or other contaminant is introduced into the air, and could be used in conjunction with existing sensors to give a more complete picture.

In the IAA project, which has been a collaboration between Surrey’s Centre for Aerodynamics and Environmental Flow and University spin-out company Surrey Sensors Ltd, researchers have succeeded in demonstrating the sensor’s ability to detect concentrations down to 100 parts per million in the air (which is comparable to existing process control equipment). In the near future, the team expects to reduce this to one part per million, while they also plan to miniaturise the system to the size of a whiteboard marker.

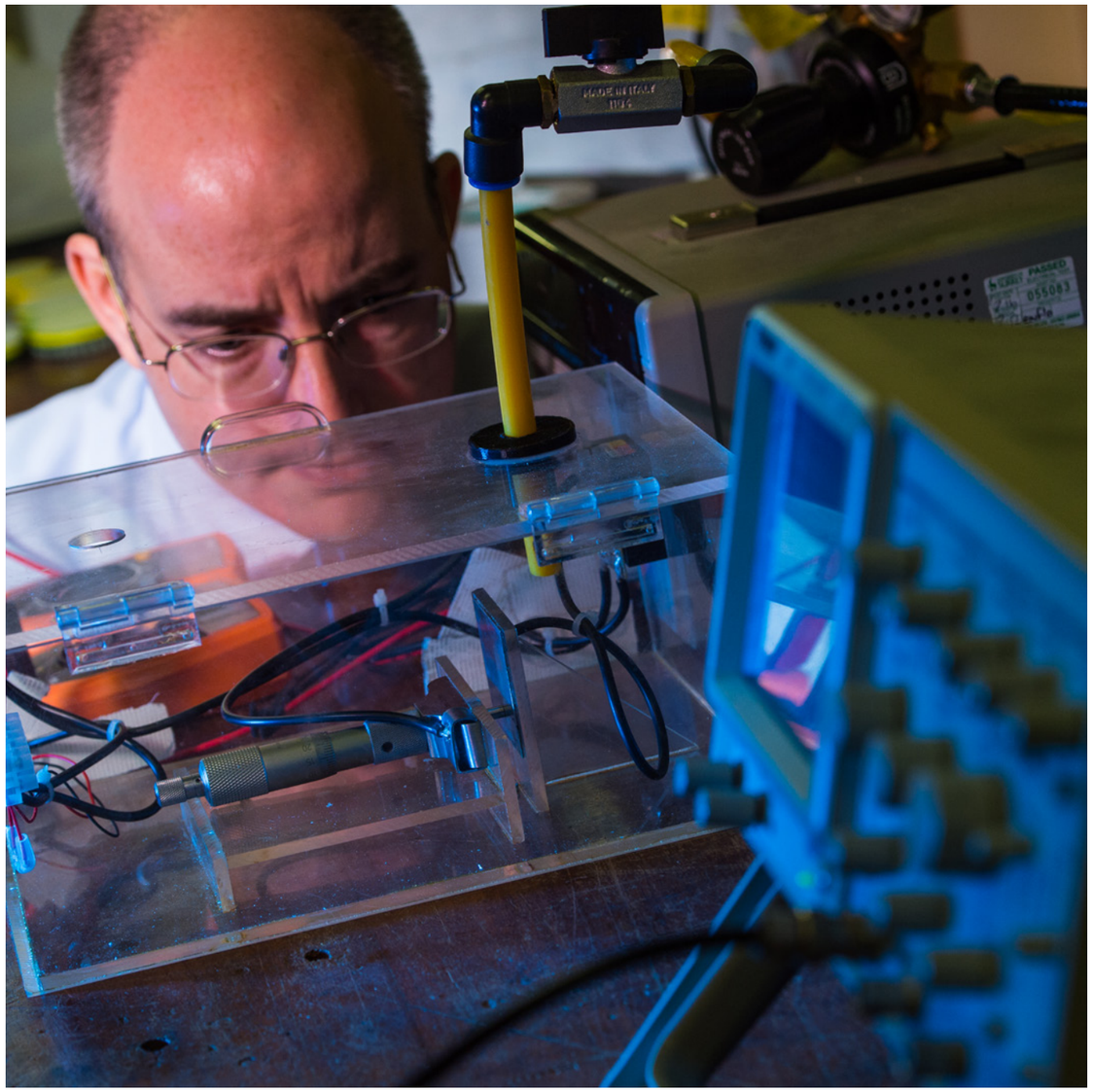


The prototype Barozap sensor

The Barozap sensor has already attracted interest from manufacturers of air quality sensing equipment and also the healthcare profession – where there is currently no simple technology to measure how gas exchange works within the lungs. Since it responds to the presence of contaminants almost instantly, the new sensor can tell doctors how well gas exchange is working within a patient’s lungs during a single breath, and even during each part of each breath.

Joe Braitch, managing director of Surrey Sensors Ltd, says: “This much needed air quality monitoring system can detect a wide variety of air-borne threats, ringing alarm bells to alert watchers to investigate unexpected changes in the air we breathe. It’s the modern equivalent of the ‘canary in a coal mine’.”

The project follows on from Dr Birch’s previous IAA project to develop the ‘sneezometer’, a highly sensitive spirometer currently being trialled with SEHTA (the South East Health Technologies Alliance). He says: “This project is yet another example of innovative and valuable new technology emerging from fundamental research, which could not possibly have been anticipated at the time we wrote the original proposal. The IAA grant provided that extra little push needed to turn the idea into a product, and get it out on the market.”



Dr David Birch demonstrates the technology

“This project is yet another example of innovative and valuable new technology emerging from fundamental research, which could not possibly have been anticipated at the time we wrote the original proposal.”

Dr David Birch

Researchers have succeeded in demonstrating the sensor’s ability to detect concentrations down to 100 parts per million in the air

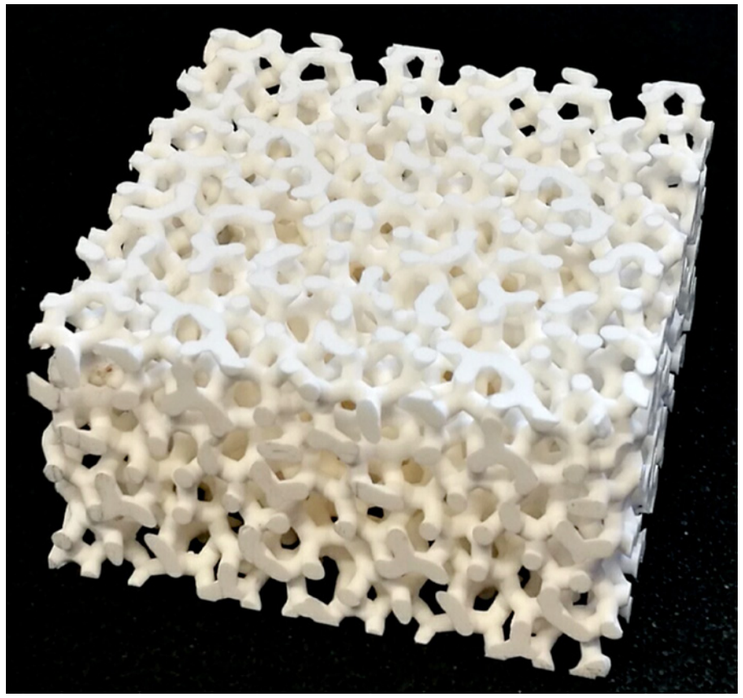
New materials throw light on energy challenges

Lambertian Uniform Absorbers

Academic: *Dr Marian Florescu*

A new class of amorphous photonic materials with a range of exceptional properties, discovered by Surrey's Advanced Technology Institute thanks to IAA funding, could lead to more energy-efficient computers and data centres.

The new materials are based on in-depth research into the physics behind photonic band gaps (energy differences within materials). Researchers in Surrey's Advanced Technology Institute (ATI) and Department of Physics have worked in close collaboration with San Francisco State University to devise a new way of characterising the internal structures of natural materials and replicating their interaction with light. The internal structure of these new materials dictates their ability to diffuse, absorb, reflect and transmit light. Subsequently they developed, and made using a 3D ceramic printer, the first ever amorphous gyroid (triamond) structure with band gaps, which is similar to the structuring found in some butterfly wings.



Fabricated amorphous network made out of aluminium oxide

One of the key outcomes of the IAA project was demonstrating how the materials could be exploited industrially through the development of photonic integrated circuits. This capability could have widespread impact by answering the energy and sustainability challenges posed by emerging information technologies. Computers, consumer electronics, network equipment and data centres consume a significant fraction of total electricity production, and this is predicted to grow dramatically in the future.

Since the materials can be tuned to reflect and absorb different light and heat wavelengths, they could also pave the way for applications such as heat-rejecting window films and paints to improve the energy efficiency of buildings and vehicles. Surrey's wider research on structured photonic materials was recently published in *Nature*.

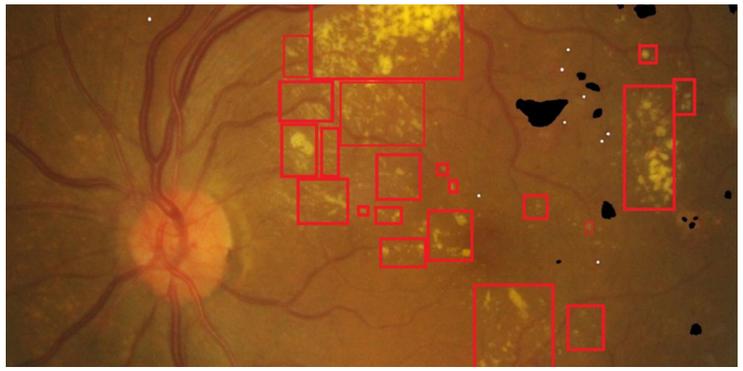
Dr Florescu said: "Our recent research could enable a two times reduction in the amount of material used for photonic devices, and help us to realise a new generation of strong, lightweight materials. The publications and IP we have established puts us at the forefront of both scientific research and commercial exploitation in this exciting area."

Crowdsourcing solution to tackle eye disease

Automated crowdsourcing tool for diabetes retinopathy annotation

Academic: *Dr Lilian Tang*

With limited funding available to progress a large scale diabetes retinopathy screening programme, researchers have taken an innovative approach – turning to crowdsourcing as a way of gathering data.



Retinal image highlighting lesions

Daphne has so far evaluated over 100,000 patients' images from countries across Europe, Asia and Africa

Diabetic retinopathy, a complication of diabetes which can cause blindness if left untreated, affects many of the world's 415 million diabetics, particularly in countries with no screening system in place. There is therefore an urgent need for a diabetic retinal screening system that can operate economically on a large scale.

In this IAA project, the University of Surrey and Moorfields Eye Hospital have designed a web-based software system to train the general public to spot potential eye conditions on retinal images. The aim of this is not only to promote public awareness of eye disease, but also to enable a large-scale evaluation of 'Daphne', an automated system developed by Surrey and Moorfields under a previous EPSRC-funded project. Daphne detects eye diseases from digital images and has so far been used to evaluate over 100,000 patients' images from countries across Europe, Asia and Africa.

The research team believes that crowdsourcing is the key to generating the large amounts of data needed to consolidate Daphne's performance, enabling it to be recognised by the NHS and healthcare providers worldwide. The intuitive interface they have developed will enable members of the public to understand and annotate retinal images. By integrating this data into Daphne, the system will 'learn' to recognise diseases from images taken from different ethnic groups, for example, or on mobile phones which offer varying image quality.

Dr Lilian Tang, a Senior Lecturer in Computer Science at Surrey, said: "Using crowdsourcing in conjunction with the Daphne system will enable regular eye check-ups at low cost, which could prevent delays in the treatment of sight-threatening conditions. It also opens the door to tele-health programmes in developing countries by enabling mobile cameras to be used for capturing retinal images."

Dr Danny Mitry (FRCOphth PhD, Moorfields Eye Hospital), added:

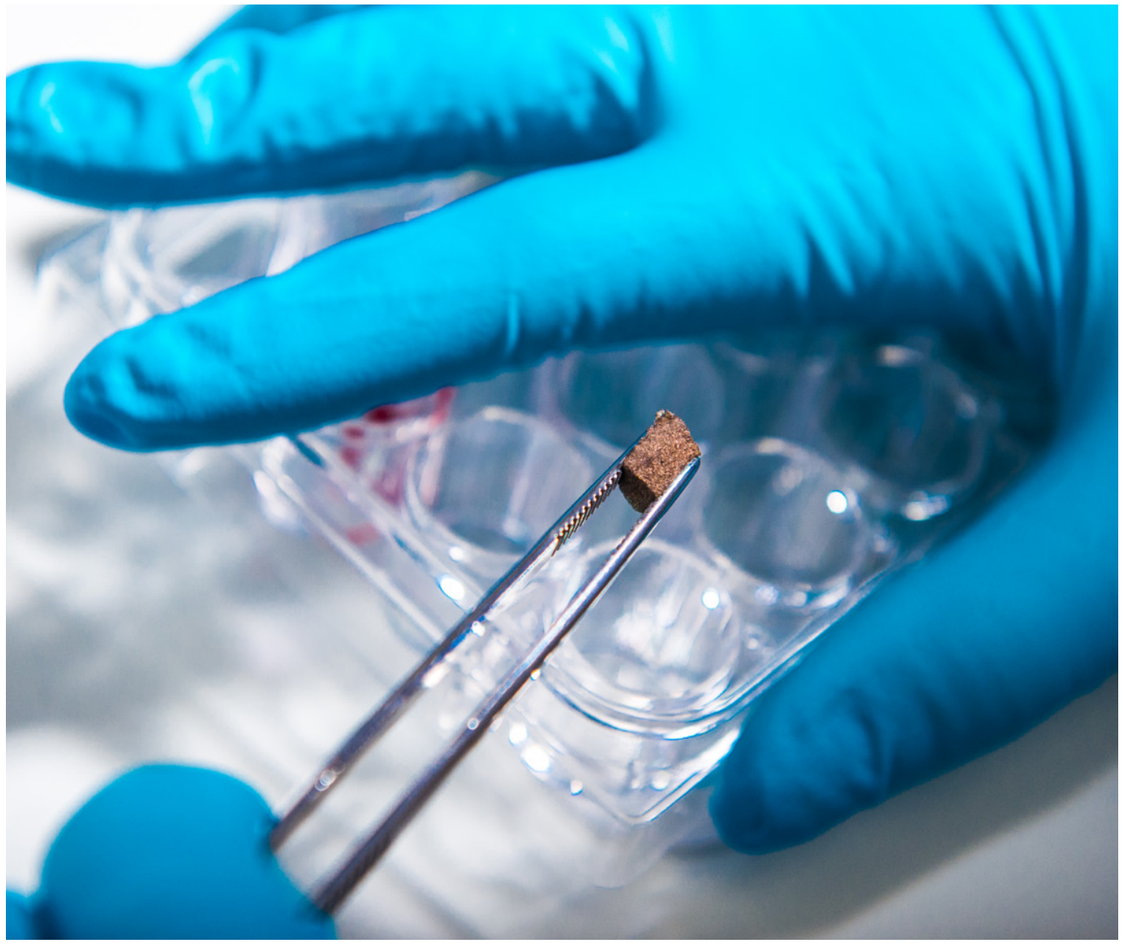
"Initial studies have demonstrated that accurate crowdsourced retinal image reading could cut costs and reduce the time between having an image taken and interpreted. This can have a significant and almost immediate impact in medium and low income countries where access to expert graders is costly and difficult. In our future studies, we hope to expand and develop our training modules and test multiple retinal imaging techniques."

Cancer cells in 3D

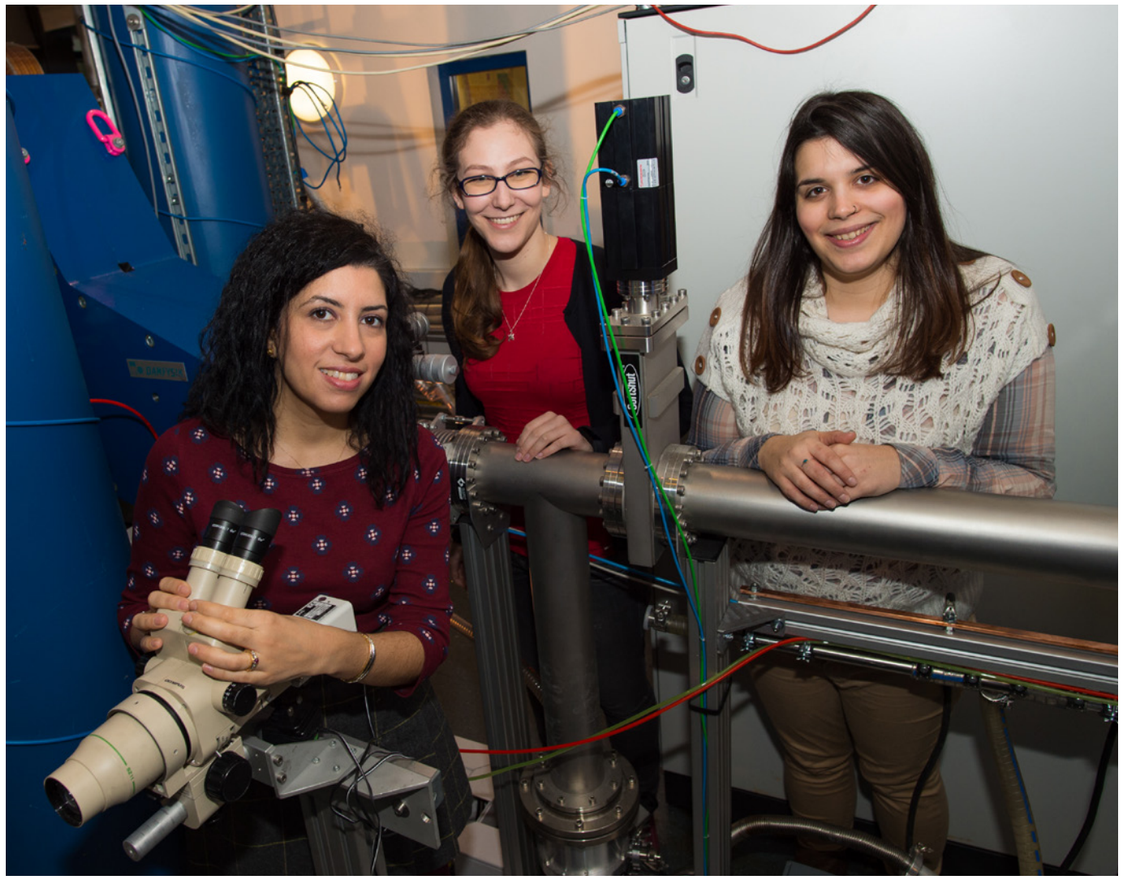
In vitro model system for treatment trials of pancreatic cancer

Academic: *Dr Eirini Velliou*

Pancreatic cancer is a deadly disease with a high fatality rate, partly due to the cancer's resistance to treatment. Advanced materials such as carbon nanotubes enable the development of 3D systems that reproduce features of an actual body tumour – which could improve patient outcomes by enabling fast analysis of the effectiveness of cancer treatments.



Preparing a 3D structure



Dr Eirini Velliou, Katie Costello and Stella Totti

Cells react differently when they are exposed to 'non-optimal' environments (environments they are not used to), often finding ways to adapt themselves to stressful factors. In humans with cancer, cells around a tumour will be less oxygenated than normal tissue and may show local 'starvation' areas because of the high proliferation of cells nearby. These differences can be captured more systematically in 3D culture systems.

The IAA project, which was a collaboration between the University of Surrey and Professor Andy Nisbet of the Royal Surrey County Hospital, focused on developing innovative 3D material structures that mimic features of real human tissues, enabling more accurate studies of pancreatic cancer. The structures developed are based on carbon nanotubes (CNTs) which help to force the cells to interact closely, potentially allowing clinicians to understand why a patient's tissue is resistant to certain drugs.

This 3D cancer platform offers major benefits over traditional 2D flask experiments. Not only could it lead to far more personalised delivery of chemotherapy and radiotherapy, it also offers a much quicker route for testing new cancer drugs (as lab results are much more reliable).

Having demonstrated the viability of growing cancer cells on the 3D CNT-based platform, the next stage for researchers Dr Eirini Velliou (Principal Investigator) and Dr Izabela Jurewicz will be to improve its accuracy by co-culturing on the platform healthy cells (pancreatic stem cells & fibroblasts) and investigating their interaction with cancer cells.

Dr Velliou commented: "This is a very exciting piece of research which could allow life-saving drugs to move 'from bench to bed' far more rapidly, reducing ethical issues around animal and human testing. While we have focused on pancreatic cancer cells in this project, the versatile platform we've developed could be adapted for other types of cancer treatment screening."

The University of Surrey and Professor Andy Nisbet of the Royal Surrey County Hospital, focused on developing innovative 3D material structures that mimic features of real human tissues

Stress in a heartbeat

Pilot study for multi-scale modelling of biological time for health at work

Academic: *Dr David Plans*

Stress causes the loss of over 10 million working days in the UK alone, but until now it has been difficult for occupational health departments to monitor employees at risk. New analysis techniques developed in this IAA project, on data collected by wearable technologies, offers a stress management tool which could transform corporate wellness.

Wellbeing analysis at a glance

A collaboration between Surrey's Centre for the Digital Economy (CODE) with Microsoft, AXA PPP healthcare and Surrey spin-off company Biobeats, the IAA project has successfully developed software which monitors the user's heart rate variability (HRV) – a major indicator of stress.

Principal Investigator Dr David Plans explained: "When we are stressed, the distance between our heartbeats is very uniform because our autonomous system kicks in and goes on auto-pilot, whereas when we're relaxed our heart beats only when it needs to, in a more efficient and complex way. The difference between the two modes over time helps us monitor stress resilience. The software we've developed, which monitors users' HRV, is now ready to be deployed in bands and other wearable technology."

As part of the project, the research team conducted a study with staff in a financial services company, in collaboration with AXA, the results of which have been published in *Frontiers of Human Neuroscience*. The study found that people who perceived themselves as stressed had lower levels of HRV and were less able to regulate emotional thoughts about work during their spare time.

"The software we've developed, which monitors users' HRV, is now ready to be deployed in bands and other wearable technology."

Dr David Plans

The software is now set to become part of a corporate wellness solution capable not only of monitoring employees' stress but also helping them to understand the triggers and patterns that cause stress, and learn how to manage stress with simple interventions such as breathing techniques and listening to music.

"From an employer's point of view, the tool is invaluable in being able to quantify employees' happiness at work, alerting occupational health or HR departments to people who are at high risk of stress and enabling them to intervene before the problem escalates," said Dr Plans.

Analysing complex challenges

Complex Control Tool (CCTool) Analysis & Testing

Academics: *Dr Sotiris Moschoyiannis, Dr Alex Penn*

Drawing on expertise in computer science, sociology and risk management, this IAA project has developed an innovative software-based tool that can help decision makers to analyse complex challenges.

The world is increasingly being managed by interconnected systems consisting of many different components which continuously adapt and change. This means that in areas such as global or regional economies, large organisations, industrial networks, cities and agricultural ecosystems, decision-makers are faced with a difficult task when it comes to managing complexity and uncertainty.

CCTool is based on a workshopping technique first developed in the EPSRC-funded ERIE (Evolution and Resilience of Industrial Ecosystems) project. It enables users to create simple but broad causal models of whole systems and explore the key 'leverage points' and vulnerabilities across social, environmental and economic factors.

The IAA project – a collaboration between computer science and sociology researchers at the University of Surrey and independent consultants Risk Solutions – has focused on creating a user-friendly interface and trialling it on data from real situations. One task has been to re-examine an existing Environment Agency causal model of its flood risk management activities, and to identify new insights that were not revealed by the original analysis.

Computer Science Lecturer, Dr Sotiris Moschoyiannis commented: "It's exciting to use mathematics and formal methods to get a handle on real world problems that come with high degrees of uncertainty and complexity. CCTool is built using state-of-the-art web technologies that enable all the processing to happen inside the browser, which means the tool is accessible from anywhere, at any time, using any device with an internet connection."

Dr Alex Penn of Surrey's Department of Sociology added: "The unique thing about the tool is that it combines information on the probability of scenarios with network analysis of complex causal structure, providing diverse inputs for decision-making. The web-based user interface enables multiple stakeholders to have input, collaborate and develop shared insight, without having to meet in person, which is a big advantage over other related modelling tools."

"By drawing on Risk Solutions' advanced expertise in quantitative analysis we've been able to develop a solution that could be applied to a vast range of areas. It could even, for example, enable individuals to manage their mental health in collaboration with their doctors and supporting agencies."

The ERIE project used the Humber region as a case study

Going with the flow

Feasibility study into new generic powder flowability tester

Academic: *Professor Charley Wu*

Measuring how a powder will flow in a production process is key to optimising many manufacturing operations. An IAA funded project at Surrey has set out to develop a new generic powder flowability tester that could lead to greater efficiencies in the pharmaceutical, food, agricultural and petrochemical sectors.

While a number of methods exist to assess how well a powder will flow in bulk material processing and handling, these cannot be adapted to different applications – so cannot reveal how well powders will flow in actual applications, nor in environments with different temperatures or levels of humidity.

In this IAA project, chemical engineer Professor Charley Wu of the University of Surrey conducted a feasibility study with sustainable technology leader Johnson Matthey to explore whether a laboratory scale die filling system developed at Surrey could be transformed into a generic flowability tester.

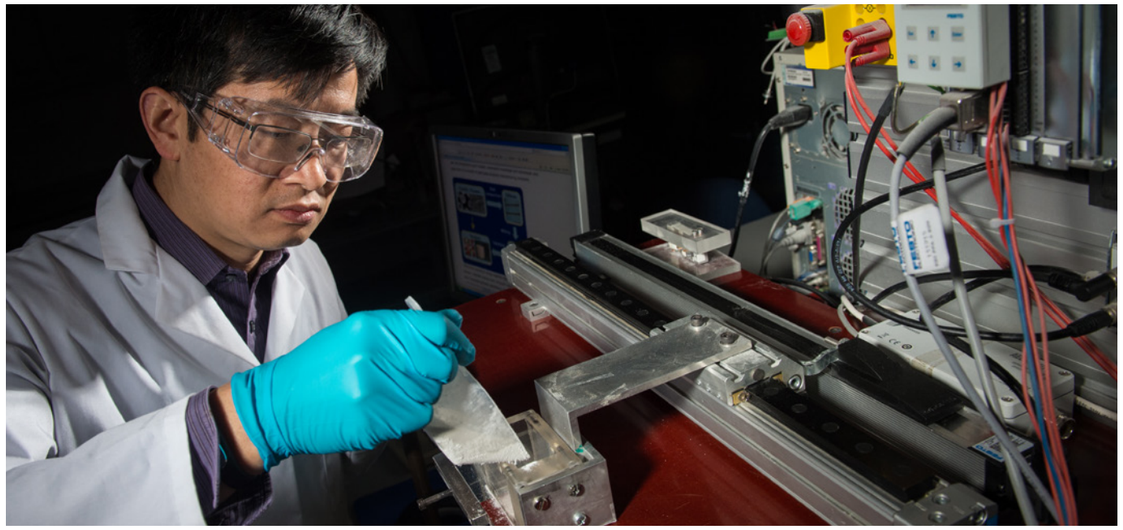
Extensive market research with 33 companies across a range of sectors demonstrated the need for a measurement method that reflects the actual application – particularly when manufacturing particulate products such as tablets, pellets and metal or ceramic components. The study also tested how well the laboratory-based system could characterise materials in different process environments, benchmarking the system against other commercially-available solutions.

Professor Wu commented: "This IAA project has enabled us to identify the industrial need and demonstrate the applicability of the laboratory system for materials being processed at various relative humidities. By providing manufacturers with the data to optimise their production lines, the system could ultimately reduce manufacturing costs and lead to medicines, for instance, becoming cheaper and more accessible."

In the feasibility study, respondents said:

"The first consideration is how much the result can represent the actual performance of the powder/granules. If the specific application can be simulated during the tests, it would be great.

"Flowability measurement is just a way to characterise powder behaviour. The real question is how and how well can we predict the behaviour of powder in the real process using these flowability tests."



Prof Charley Wu demonstrates the system

Compact EEG monitoring for sleep

Validating a new compact EEG system for measurements in sleep

Academic: *Professor Annette Sterr*

Studying brain function through EEG (electroencephalography) with conventional methods is burdensome, expensive and best-suited to specialised laboratory settings. A new mobile phone-based EEG system, combined with a super-thin 3D-printed grid electrode, resolves these problems, allowing the recording of brain activity – for example for the study of sleep or the monitoring of epilepsy at home – in a much more natural way.

Traditionally EEG recordings require the connecting of individual electrodes to the head, often using a cap embedded with the electrodes. This is a particular problem when a person needs to be monitored for a prolonged period, such as during sleep or over several days. Traditional EEG systems require specialist technicians to connect the electrodes, and the electrodes themselves, which make the participant look rather like a Christmas tree, are not very comfortable for sleeping.

The cEEGrid system (www.ceegrid.com), originally developed by Professors Debener (Oldenburg) and deVos (Oxford) together with the Serbia-based manufacturer mBrainTrain, features electrodes which are printed using a 3D printer and therefore much thinner than conventional ones. Easy to apply, cEEGrid fits neatly behind the user's ear, allows for natural sleeping positions, and is comfortable to wear for many hours. Moreover, the system is much more 'invisible' than traditional EEG electrodes and fully mobile. This makes it particularly suitable to brain studies in the home environment, and when participants are out and about.

Building on an existing Erasmus-funded relationship between the Universities of Oldenburg and Surrey, the IAA project examines the suitability of cEEGrid for polysomnography. Linking with previous work that validated new mobile sleep monitoring devices provided under an EPSRC Equipment Grant, the project is focused on modelling the system with users to optimise elements such as amplifier connectors and battery life,

University of Surrey Psychology PhD student James Ebajemito, demonstrating the cEEGrid

and validating cEEGrid against internationally accepted standards of polysomnography (sleep study based on EEG monitoring).

Professor Annette Sterr, principal academic on the project, said: "Through the Surrey Clinical Research Centre, which has extensive expertise in gold standard monitoring of sleep, we have a unique opportunity to test the suitability of cEEGrid for sleep specifically, and brain monitoring more generally. There are many scenarios where mobile monitoring of brain activity is desirable – for example this technology could enable the diagnosis of childhood epilepsy while the child remains at school, or the long term recording of sleep-wake cycles in people at risk of brain disease."

"With the emergence of e-health solutions, we believe that cEEGrid has the potential to develop novel ways of providing community-based neurological services. This is relevant not only for the UK but also for underdeveloped countries where mobile phones, but not traditional neurology laboratories, are highly available."

Professor Annette Sterr

Solar cell learning

Solar cell characterisation kit for schools

Academic: *Professor Craig Underwood*

The opportunity to fly test solar cells on the UK Space Agency's AlSat-1N CubeSat has inspired a more down-to-earth idea: a solar cell characterisation kit that will enable school and university students to conduct their own investigations.

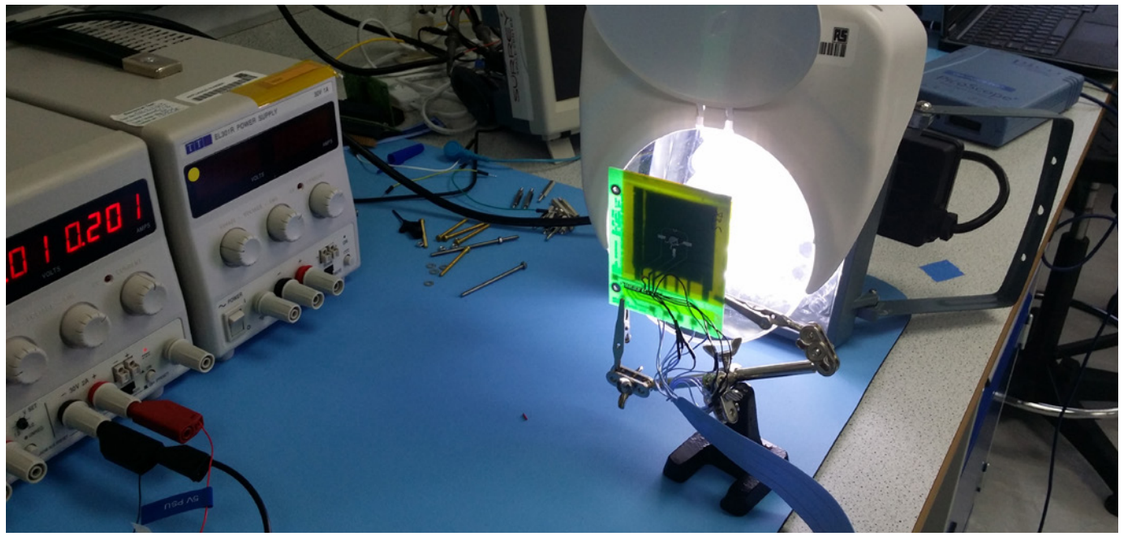
The opportunity to measure the performance of solar cells under different conditions is not only a great way of learning about this important renewable energy source, but also enables students to understand key aspects of physics and electronics. However, to date, learning about solar cells has been very limited due to the lack of cost-effective full characterisation kits available.

In this IAA-funded project, academics from the University of Surrey's Surrey Space Centre (SSC) and the Centre for Solar Energy Research (CSER) at Swansea University have produced a solar cell I-V characterisation kit that is fully compatible with a mobile phone or laptop. The kit is designed to enable students from GCSE level upwards to investigate the effects of illumination, temperature, angle of incidence, location and other factors on the current, voltage and amount of power solar cells can generate.

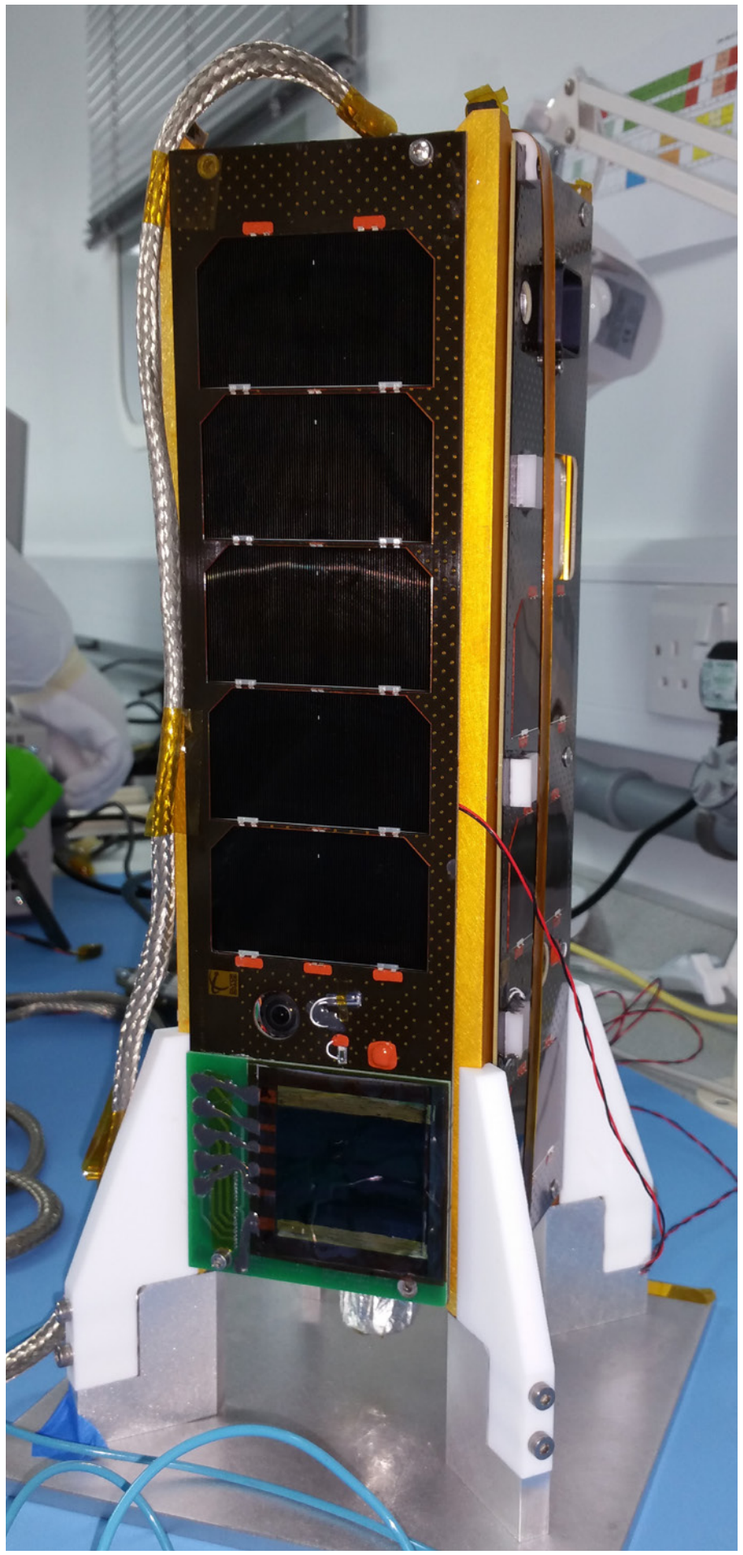
The kit is based on the Thin Film Solar Cell (TFSC) Experiment operating on the AlSat-1N CubeSat, launched into orbit last September, in which a new type of low mass, low cost, highly efficient thin-film solar cell is being tested. The terrestrial version enables students to carry out identical tests, replicating the analysis of data being sent to Earth from the payload in space.

Professor Craig Underwood, Head of Surrey's Space Environments & Instrumentation Group, explained: "While there are a few solar cell educational kits available in the US with these capabilities, they are very expensive and aimed at undergraduate level, so we wanted to develop a low-cost, very accessible kit that could be used in schools. The 'magic' thing – which has not usually been taught in schools – is that you have to set the cell loading conditions very carefully to maximise the power it delivers, and this changes with the illumination level and temperature."

Eight units have initially been produced, which will be used with visiting schools by the University of Surrey's schools liaison team, with the longer-term aim of rolling the kit out to a wider audience.



Testing the prototype solar cells



AlSAT-1N undergoing final testing

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AlSAT-1N is a joint Algerian-UK space mission funded by the Algerian Space Agency (ASAL) and the UK Space Agency (UKSA). The TFSC Experiment is one of three UK technology payloads flown on the mission under the sponsorship of UKSA.

The development of the thin film solar cell was funded by the Engineering and Physical Science Research Council (EPSRC, Grant Ref. EP/K019597/1).

Learning to build Smart Cities

IoT Egg

Academic: *Professor Klaus Moessner*

An innovative 'IoT Egg' has been developed to enable students and researchers to understand the complex requirements of Smart City technologies, helping them to design the solutions which will improve urban life.

Making cities 'smart' is one of our best hopes for resolving many of the problems we face today such as resource management, congestion and pollution. Installing sensor and actuator technologies throughout a city will enable planners and administrators to obtain the necessary data to make informed decisions about addressing these challenges as – or even before – they arise.

However the technology behind Smart Cities is very complex, encompassing numerous concepts from a range of different disciplines. In this IAA-funded project, researchers in the University of Surrey's 5G Innovation Centre (5GIC) have worked with software provider Flexeye India to develop the IoT Egg, a self-contained device which promises to help students and researchers to understand Smart City and Internet of Things (IoT) technologies.

While a previous incarnation of the IoT Egg was developed for the EPSRC-funded REDUCE project, the driving force for this IAA project was the need for a device which looks elegant in a workplace or residential setting, as well as incorporating the right functionality.

The IoT Egg incorporates an array of built-in sensors and actuators, along with several wireless communication modules, which allow the user to gather data and learn about concepts such as Big Data, security, interoperability, data fusion and analytics. In the immediate future, the new device will be used by students on the University of Surrey's Smart Cities short course and a distance learning course facilitated by Flexeye India.

Another key challenge addressed by the IoT Egg is the lack of research support tools available in the field of IoT. A portion of the 400 units produced in the IAA project will be rolled out throughout the 5GIC where researchers will use them to help develop a 'federation of IoT testbeds' as part of the FIESTA-IoT project. This project, which brings together mobile communications experts from 15 universities and research institutions across Europe, aims to provide a blueprint experimental infrastructure which will enable IoT testbed operators to interconnect their facilities in an interoperable way.

The devices will also be used by researchers in Surrey's Centre for Research in Social Simulation (CRESS), under the HomeSense project, to understand how people interact with IoT technologies, and where energy is being wasted in the home.

Professor Klaus Moessner said: "The IAA funding has given us the opportunity to create a robust – yet attractive – sensing solution which can be used in a large number of ways, including teaching and research in different domains."

Flexeye India commented:

"We are very pleased with the progress and results of the IoT Egg development project. This simple, yet powerful, platform can certainly contribute to the pedagogy of IoT concepts and methodologies.

The IoT Egg

How am I driving?

Extracting information from video for the insurance market

Academic: *Professor Richard Bowden*

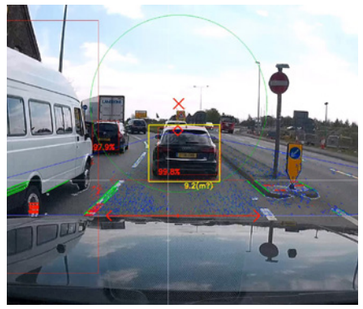
Technology is already being used by insurers to automatically process images of vehicles and documentation, and drivers are increasingly using 'dash cams' to capture videos of driving for occasions when accidents do happen. Now researchers have taken this a stage further by developing a demonstration system that extracts detailed data about how an individual is driving from this footage.

The IAA project – a collaboration between Surrey's robotics researchers and cloud-based image processing solutions company Vzzual – was aimed at using IP developed under a previous EPSRC project to improve dashboard camera tracking software used in the insurance industry.

The outcome has been a demonstration system which can identify how fast a person is driving, their distance from the car in front, and their position within a lane. This information is of huge interest to the insurance industry as it will allow for more sophisticated and accurate accident predictions, and could also be used following an accident to analyse the incident. The technology has the potential to improve road safety by incentivising better driver behaviour.

Professor Richard Bowden explained:

"This technology could provide much richer information on drivers' behaviour, which addresses an immediate need in the insurance industry, but it also has far longer-term implications. As we move towards commercialisation of autonomous vehicles, the ability to gather huge amounts of data about how drivers behave in different scenarios will be key in enabling us to 'teach' these robotic vehicles how to drive."

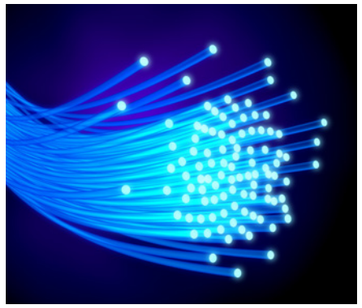


Efficient lasers

Next generation high speed, high efficiency lasers for communications

Academic: *Professor Stephen Sweeney*

Massive growth in video streaming and connected devices means that optical fibre communications need to become more efficient. The challenge addressed by this project was to develop photonic devices that offer high bandwidth performance while using less energy.



Optical fibre communications form the backbone of the internet and are fundamental to maintaining the rapid growth of internet communications and delivering the Internet of Things. However semiconductor crystal-based lasers currently used for optical fibre communications are relatively inefficient (losing up to 80 per cent of their energy through heat) and can only operate in a temperature-controlled environment, requiring even higher energy use. This also impacts the speed at which they can send data, which degrades as the lasers warm up.

At the same time, there is now significantly more data traffic via optical fibre-based MANs (Metropolitan Area Networks) which operate within a city or between cities, due to the growth of cloud-based servers and the way content is shared.

This IAA project built on research conducted by Professor Stephen Sweeney under a £1m EPSRC Leadership Fellowship to develop advanced semiconductor lasers for the telecoms and data communication sectors. Working in collaboration with CIP Technologies (a subsidiary of Huawei Technologies UK), the project team worked on the development of new approaches to laser design to deliver high speed communications while operating at high temperatures. Removing the need for active cooling, this could lead to significant energy savings.

Professor Sweeney said:

"The IAA funding has been instrumental in allowing us to work with a major international company to develop very important communications technology that minimises the energy burden. There is a growing need to enable data communication for many societal reasons, but not at the expense of the environment."

"In this project we have been able to take our EPSRC funded research in semiconductor material and device physics, and put that directly into a commercial application."

Safer power

Novel soil testing for seismic Nuclear Power Plant design

Academic: *Professor Suby Bhattacharya*

In the wake of the Fukushima disaster, new regulations state that design of future nuclear power plants should consider the likelihood of a seismic event – however miniscule. An IAA project has developed a soil testing apparatus capable of predicting the risk of soil movement and settling – as happened at Fukushima.

The 2011 Fukushima Nuclear Power Plant disaster in Japan, which was the result of multiple cascading hazards due to earthquake, liquefaction and tsunami, necessitated a clean-up operation that will cost an estimated £30bn and last around 30 years. This has led the world's nuclear regulation authorities to rule that power plants need to be designed for a likelihood of a seismic event of 1 in 10,000 years.

Understanding the stiffness and damping properties of soil is fundamental to predicting the response of structures to seismic events because the nature of the ground affects how seismic waves are emitted by faults rupture buried many kilometres underground.

In this IAA project, experts in geomechanics at the University of Surrey have worked with VJTech, a soil testing apparatus manufacturer, to develop a proof of concept seismic soil testing system with input from potential end-users (large energy and building companies). The prototype is based on the principle of resonating a column of soil until it vibrates, and collecting data which is then used to compute the stiffness of the soil.

Since the IAA project, a workshop has been held – bringing together industry and academic experts in the field from the UK, China and India – to discuss and further refine the prototype before the process of commercialisation begins.

Professor Suby Bhattacharya, Chair in Geomechanics at Surrey, said:

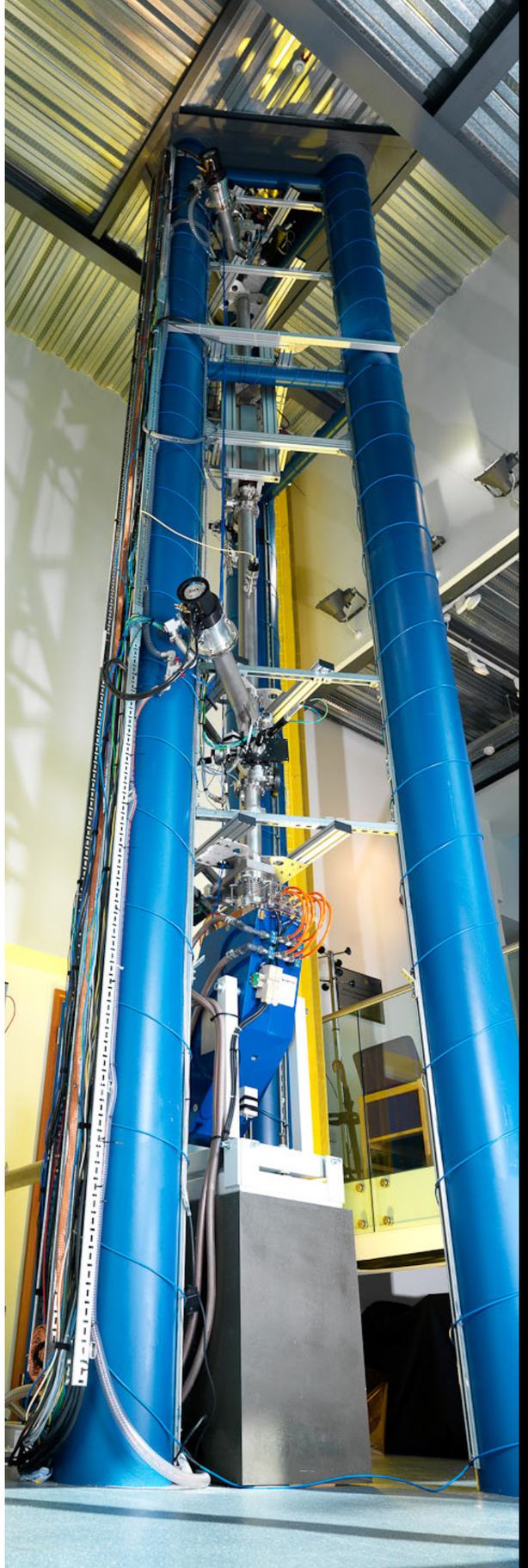
"With demand for energy increasing in line with the world's population, nuclear power plants are providing energy which meets a significant proportion of our energy needs. By ensuring the safety of future plants, this project could benefit the UK economy and provide vital data to countries such as India and China – which are situated in seismically active regions."

In addition to new nuclear power stations, the equipment could also be used to test soil foundations for other large infrastructure projects such as offshore wind turbines and high-speed railway lines.

"By ensuring the safety of future plants, this project could benefit the UK economy and provide vital data to countries such as India and China – which are situated in seismically active regions."

Professor Suby Bhattacharya

Dr Mehdi Rouholamin and George Nikitas



Advanced facilities at the University of Surrey

Our Guildford campus hosts a number of world-class research facilities, funded or supported by the Engineering and Physical Sciences Research Council (EPSRC), which are available for use by other researchers, industrial companies and external organisations:

THE ION BEAM CENTRE (IBC) is a National Facility endorsed by EPSRC. The IBC aims to promote and facilitate world-class research in the field of ion beam applications for the UK academic and industrial communities. It allows users to undertake a wide variety of research using ion implantation, ion beam analysis (IBA) and microbeam analysis. The IBC also has extensive processing and characterisation facilities that can be made available to customers. Applications have included: developing new semiconductor materials, counting atoms in thin-film materials, measuring soap distribution in hair, and testing the paint on works-of-art.

DAPNE (DIRECT ANALYTE PROBED NANO EXTRACTION) SYSTEM – Only recently developed in the US and not available elsewhere, DAPNe is a tool that allows a minute quantity of a material to be extracted from a point on a surface and its chemical constituents analysed by mass spectrometry. The equipment can be used by biochemistry and veterinary researchers to identify and quantify drugs within cells. It will help chemists to understand the reactions inside complex structures (for example within the membranes used in fuel cells), and enable material scientists to study the details of composites (for example those based on carbon fibre which are used in aerospace and automotive applications).

INTEGRATED PLASMA SOURCE FOCUSED ION BEAM (FIB) WITH SCANNING ELECTRON MICROSCOPE (SEM) – One of only two machines of its kind in the UK, this equipment is able to look at pieces of material in 3D at the nanometre to 0.1 millimetre scale. The FIB 'mills' away material with nanometer precision whilst the SEM images the newly exposed surface, thus creating a detailed three-dimensional map of the structure of the material. This will enable state-of-the-art development of novel electronic and functional devices, as well as characterisation of structural materials from wood to next generation titanium composites. The new equipment will enable new developments in fields including advanced structural aerospace materials, additive manufacture, and materials performance and degradation, as well as quantum devices.

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