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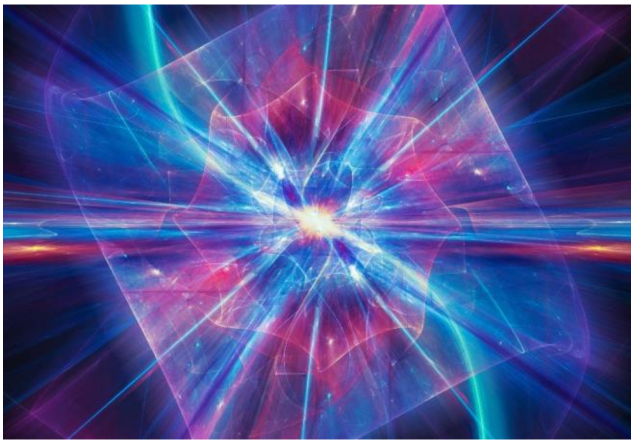
Advanced Technology Institute Newsletter
Faculty of Engineering and Physical Sciences

News

FIRST-EVER OBSERVATION OF MULTI-PHOTON FANO EFFECT COULD LEAD TO BOOST IN QUANTUM COMPUTING



A breakthrough study has confirmed a 50-year-old theory and could boost the development of silicon-based quantum computers. In the first study of its kind, published by Nature Communications, an international team of researchers led by the University of Surrey has proven the existence of the fabled multi-photon Fano effect in an experiment.

Ionisation is when electrons absorb photons to gain enough energy to escape the nucleus' electrical force. Einstein explained in his Nobel Prize-winning theory of the photoelectric effect that there is a threshold for the photon energy required to cause an escape. If a single photon's energy is not enough, there might be a convenient half-way step: ionisation can occur with two photons starting from the lowest energy state.

The team led by the University of Surrey overcame this complication by using impurity atoms where, due to the influence of the semiconductor host material, the electric field that determines the outer electron orbits is significantly reduced and, consequently, much less laser intensity is required to demonstrate the Fano effect. The team used ordinary computer chips that contain phosphorous atoms embedded in a silicon crystal. The team then used powerful laser beams at the free-electron laser facility (FELIX) in Radboud University, Holland, to ionise phosphorus atoms. The outcome of ionisation was estimated by the absorption of a weak beam of light.

Dr Konstantin Litvinenko, co-author and Research Fellow at the University of Surrey, said: "We believe we have taken a very important step towards the implementation of novel and promising applications of ultrafast readout of silicon-based quantum computers; selective isotope-specific ionization; and a variety of new atomic and molecular physics spectroscopies."

BREAKTHROUGH MATERIAL CAN PROTECT SATELLITES FROM ULTRAVIOLET RADIATION AND ATOMIC OXYGEN IN LOW-EARTH ORBIT

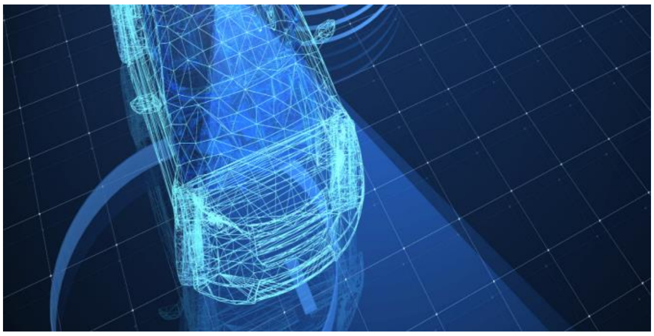
Engineers from the University of Surrey and Airbus have revealed a breakthrough nano-barrier that can protect satellites in low-Earth orbit from ultraviolet radiation and atomic oxygen. Atomic oxygen is created when O2 molecules break apart, a process made easier in space because of the abundance of ultraviolet radiation.

In a paper, published by ACS Applied Materials & Interfaces, the team from Surrey's Advanced Technology Institute and Airbus detail how they developed a nano-barrier and custom-built deposition system that bonds to the surface of polymer or composite materials, protecting them from erosion in low-Earth orbit. This eliminates the risk of contamination and the need to wrap instruments with multi-layer insulation, opening up opportunities to increase satellite performance.

Professor Ravi Silva, Director of the **Advanced Technology Institute** at the University of Surrey, said: "After exhaustive simulation testing and nearly a decade of collaborative research, we are delighted to reveal the most advanced solution yet to protecting satellites and spacecraft. Our nano-scale coating guards against the damaging effects of UV radiation and atomic oxygen that has plagued space travel." The teams from Airbus and Surrey's Advanced Technology Institute are now working on the next stage leading to industrialisation of the coating to enable the first LEO missions to be treated from 2022.

ENERGY-HARVEST TECHNOLOGY TO MAKE ROADS SAFER

An eco-friendly energy-harvesting smart sensor could help make roads safer by identifying potentially dangerous driver behaviour. Triboelectric nanogenerators (TENGs) are an emerging technology that harvests the freely available mechanical energy from daily human activities.



In a study published by Nano Energy, engineers from the University of Surrey reveal how they used recycled plastic cups and silk cocoon waste to develop a soft and skin-friendly self-powered sensor, which can be used to sense human activities. The highly flexible and biocompatible sensor could either be used as a wearable item on clothing or placed within the fabric of the steering wheel, horn, gear stick and brake pedal.

In tests, it provided real-time feedback on the driver's actions, which allowed the AI system to compute performance.

Dr Bhaskar Dudem, principal author of the study and Research Fellow at the University of Surrey's **Advanced Technology Institute**, said: "We are all excited by how AI will influence future consumer electronics, but this future must also be friendly to our planet's environment. Our recycled silk-based smart sensor technology is a hint of what the future holds and, with support from industry, we believe we can soon bring it to market."

SURREY PHYSICS WINS DOUBLE EPSRC FUNDING FOR STRAINED GERMANIUM PHOTONIC CRYSTALS AND NEW NANOTECH IDEA

Two exciting projects from the University of Surrey that will investigate the use of germanium in photonic devices and explore innovative ways to steer and control nanoparticles have been awarded highly competitive grants.

Two research teams from Surrey's Department of Physics have won funding from the Engineering and Physical Sciences Research Council's (EPSRC) New Horizon competition. The nationwide competition attracted more than 1200 proposals of which only 126 (or about 10 per cent) were successful.

Silicon forms the foundation of electronics, but it is limited in terms of its ability to produce light. Therefore, significantly more expensive compound semiconductors are used in photonic devices such as lasers and LEDs. Surrey's new project aims to overcome this fundamental constraint by producing optically efficient, highly strained germanium crystals on silicon using Surrey's recently developed ion-implantation method.

These new devices will have great potential for commercial scale-up and to transform sensors for applications in medical sensing, environmental monitoring and industrial processing.

The principal investigator of the strained germanium project, **Professor Stephen Sweeney**, said: "We are thrilled to have been awarded New Horizons funding in this highly competitive call. I look forward to working with my co-investigators **Dr Steve Clowes** and **Dr David Cox** in the **Advanced Technology Institute** to explore this exciting new method of producing photonics technologies that have wide-ranging potential applications."

PROFESSOR RAVI SILVA AWARDED CBE IN NEW YEAR'S HONOURS

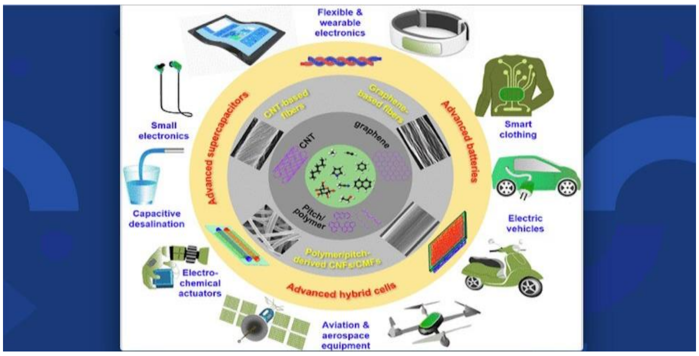
Professor Ravi Silva, Director, **Advanced Technology Institute (ATI)** at the University of Surrey, has been awarded a CBE for his services to Science, Education and Research.

The award is for Professor Silva's outstanding services to Science, Education and Research over the last three decades, with contributions that extend around the world. Professor Silva has conducted major research activities in China, India and Sri Lanka as well as the UK, which have helped to elevate research and the translation of research into useful national products.

Professor Silva was one of the key investigators for the £10m ATI, which was established in 2002 to bring all the solid state electronics and photonics research at Surrey into a dedicated institute, and of which he has been director of since 2005. Professor Silva also helped set up one of the largest carbon nanotechnology laboratories at Surrey and is incredibly passionate about the contributions solar energy can make to drive the world to a Carbon net zero position. He believes that by adopting a solar energy future, solar electricity could become a free energy source within the next two decades.

SURREY ACADEMIC PUBLISHES KEY RESEARCH ON ENERGY STORAGE DEVICES

Professor Huiming Cheng, the Vice-Chancellor's Fellow at the **Advanced Technology Institute (ATI)**, who works on carbon-based materials for energy applications, recently published his work on advanced electrochemical energy storage devices (EESDs) based on carbon nanofibres. EESDs that can store electrical energy efficiently while being miniature, flexible, wearable and load bearing are much needed for various applications.

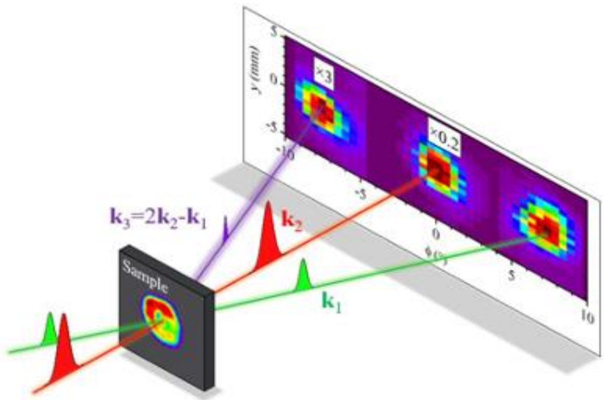


Carbon-based fibres hold great promise in the development of these advanced EESDs and they could be a key material for the creation of energy storage devices such as supercapacitors and batteries. Key reasons for this include the fact they're lightweight, possess high electrical conductivity, excellent mechanical strength and flexibility, and they have tunable electrochemical performance.

In his paper, Carbon-Based Fibers for Advanced Electrochemical Energy Storage Devices, published in Chemical Reviews, a top journal of the American Chemical Society, Professor Cheng and co-workers summarise the fabrication techniques of carbon-based fibres and various strategies for improving their mechanical, electrical, and electrochemical performance.

STUDY SUGGESTS THAT SILICON COULD BE A PHOTONICS GAME-CHANGER

New research from the University of Surrey has shown that silicon could be one of the most powerful materials for photonic informational manipulation – opening up new possibilities for the production of lasers and displays.



Now, in a paper published by *Light: Science and Applications* journal, a Surrey-led international team of scientists has shown that silicon is an outstanding candidate for creating a device that can control multiple light beams.

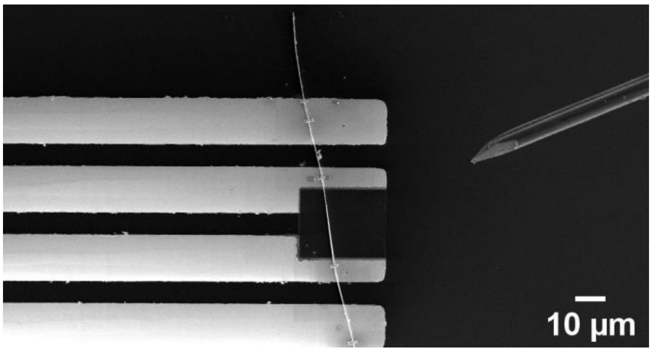
The discovery means that it is now possible to produce silicon processors with built-in abilities for light beams to control other beams.

The researchers found that silicon possesses the strongest nonlinearity of this type ever discovered. Although the study was carried out with the crystal being cooled to very low cryogenic temperatures, such strong nonlinearities mean that extremely weak beams can be used.

Ben Murdin, co-author of the study and Professor of Physics at the University of Surrey, said: "Our finding was lucky because we weren't looking for it. We were trying to understand how a very small number of phosphorus atoms in a silicon crystal could be used for making a quantum computer and how to use light beams to control quantum information stored in the phosphorus atoms. "We were astonished to find that the phosphorus atoms were re-emitting light beams that were almost as bright as the very intense laser we were shining on them. We shelved the data for a couple of years while we thought about proving where the beams were coming from. It's a great example of the way science proceeds by accident, and also how pan-European teams can still work together very effectively.

NANOSTRUCTURED TIN GAS SENSORS COULD HELP THE WORLD TACKLE THE CLIMATE CRISIS

Researchers from the University of Surrey believe that tin-based gas sensors could help track and control harmful nitrogen (NO2) gases that pollute our planet. In a paper published by the Physical Chemistry Chemical Physics (PCCP) journal, researchers from Surrey, in collaboration with colleagues from São Paulo State University (UNESP), Brazil, detail how gas sensor devices can play an important role in the fight against climate change by monitoring emission sources such as nitrogenous gasses.

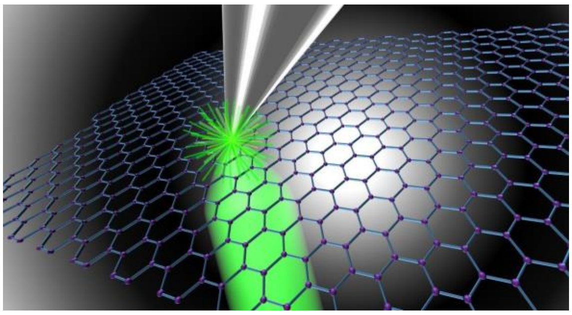


The research team used different combinations of the tin oxide system and constructed two device groups: devices containing a single structure nanofabricated in a Dual Beam Microscope; and a number of them in a “carpet” mode. The two devices configuration allowed the researchers to estimate the materials depletion layer (Debye length), and to propose gas-solid interaction mechanisms between the NO2 and the reduced/stoichiometric surfaces.

Mateus Masteghin, the lead author of the study and PhD student at the University of Surrey, under the supervision of **Dr David Cox** (co-author in the publication), said: “The internship that allowed this work to be done was an opportunity of a lifetime and I am very grateful for that. I was an M.Sc. student in Brazil supervised by Professor Marcelo Orlandi (UNESP) and came to spend about three months at the University of Surrey under the supervision of Professor Ravi Silva. I had the chance to work with amazing researchers at two prestigious universities, from whom I learned so much. We hope that this study furthers the understanding of tin oxide-based NO2 detectors.”

UNIVERSITY OF SURREY DISCOVERS NEW METHOD OF SEEING GRAPHENE GROWING USING A STANDARD ELECTRON MICROSCOPE

Researchers from the University of Surrey have revealed a new method that enables common laboratory scanning electron microscopes to see graphene growing over a microchip surface in real time. This discovery, published in ACS Applied Nano Materials, could create a path to control the growth of graphene in production factories and lead to the reliable production of graphene layers.



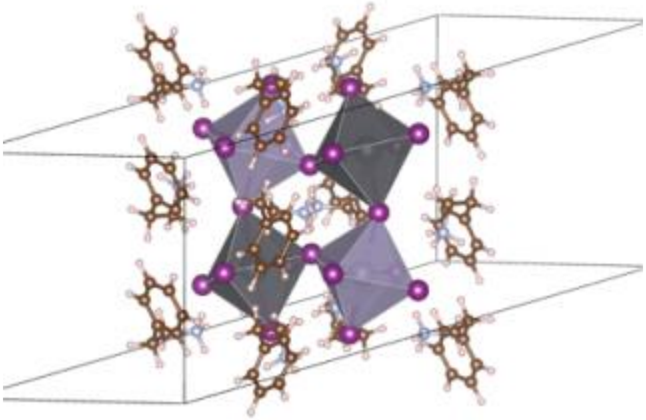
With the use of video imagining, the team from Surrey’s **Advanced Technology Institute (ATI)** have shown graphene growing over an iron catalyst, using a silicon nitride membrane produced within a silicon chip. The membrane is only a few tens of nanometres thin, and heating and cooling can be rapidly controlled by means of modulating an electrical signal that is sent to the iron layer. This acts both as a catalyst and as an electrical resistor to supply the heat. **Professor Ravi Silva**, Director of ATI and Head of the Nano-Electronics Centre at the University of Surrey, commented: “Graphene, the wonder material of the 21st century, has had much written about its unique and remarkable properties over the last decade. It will be widely used if it can be handled expertly and placed easily in applications.”

Dr Jose Anguita, Cleanroom Manager at ATI at the University of Surrey, commented: “Being able to see and control the graphene we are producing in real-time edges us a significant step closer to mass commercialisation and production of graphene for electronic devices.”

NEW ANALYSIS OF 2D PEROVSKITES COULD SHAPE THE FUTURE OF SOLAR CELLS AND LEDS

An innovative analysis of two-dimensional (2D) materials from engineers at the University of Surrey could boost the development of next-generation solar cells and LEDs. Three-dimensional perovskites have proved themselves remarkably successful materials for LED devices and solar panels in the past decade.

In a study published in The Journal of Physical Chemistry Letters, researchers from Surrey's **Advanced Technology Institute (ATI)** detail how to improve the physical properties of 2D perovskite called Ruddlesden-Popper. The study analysed the effects of combining lead with tin inside the Ruddlesden-Popper structure to reduce the toxic lead quantity. This also allows for the tuning of key properties such as the wavelengths of light that the material can absorb or emit at the device level – improving the performance of photovoltaics and light-emitting diodes.



Dr Cameron Underwood, lead author of the research and postdoctoral researcher at the ATI, said: "There is rightly much excitement about the potential of 2D perovskites, as they could inspire a sustainability revolution in many industries. We believe our analysis of strengthening the performance of perovskite can play a role in improving the stability of low-cost solar energy and LEDs."

DOUBLE AWARD WIN FOR ADVANCED TECHNOLOGY INSTITUTE STUDENT

Advanced Technology Institute (ATI) Dr Cameron Underwood has a couple of additional reasons to be full of cheer – thanks to a double award win. Royal Society of Chemistry Award This international conference was originally planned to take place in Moscow, but it was reorganised online due to the Covid-19 pandemic.

The virtual gathering was a huge success, and, in an online presentation, Cameron won the Royal Society of Chemistry Award for Poster Presentation. His poster, Non-linear Band Gap Dependence of Mixed Pb-Sn 2D Ruddlesden-Popper Perovskites, explains his method for understanding the semiconducting or electronic properties of two-dimensional perovskite solar cells.

Second success

A few weeks later, there came another win for Cameron. This time, the same poster claimed the Best ePoster Prize at the International Conference on Perovskites for Energy Harvesting (PERENHAR). “I’m very happy to win these prizes at such prestigious international events,” says Cameron, who’s also one of three Surrey students behind the environmental film series, OurEden. “Online events may not be the same as attending conferences in person, but it’s great we’re still able to present our work and meet with other scientists from around the world in a virtual way.” **Professor Ravi Silva**, the Director of ATI, adds: “I’m delighted to see Cameron being rewarded with these ePoster awards for his theoretical work on mixed perovskite materials for solar cells.”

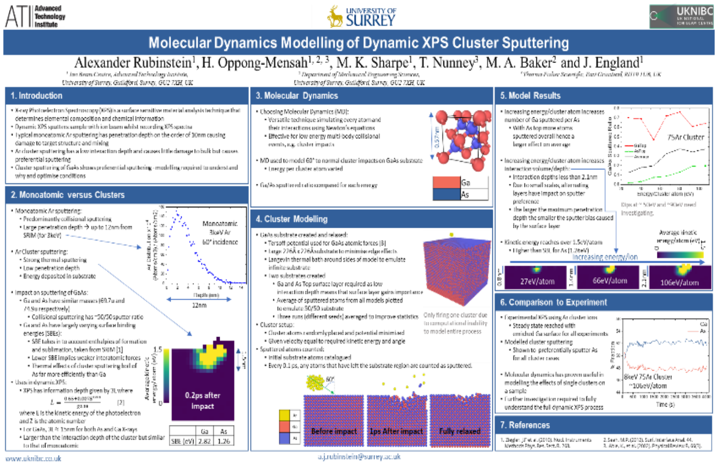
PhD News

Welcome - The ATI welcomes: **Surajit Kar** who joined our January cohort, **Shaoyin Li** who joined our April cohort and **Patryk Golec**, **Alex Teng**, **Toby Hawkins**, **Anthony Balchin**, **Toussaint Gervais** and **Matthew Goodwin** who joined our July cohort. We wish them well in their research.

Well done to **Georgios Bairaktaris** for his publication at the CHI2021 conference, the biggest conference for human computer interactions. The publication can be found here.

Congratulations to **Eva Bestelink** on her win for IET Postgraduate Scholarship for an outstanding researcher. Prior to her BEng degree, Eva was a mature student undergoing a career change. During her MSc in Neuroscience, she discovered mind-controlled prosthetics and decided to pursue a career in robotics. However, without the required STEM degree or relevant A-Levels, particularly mathematics, Eva had to make the decision between a PhD in an unrelated field or start over. Soon after joining, Eva quickly realised that semiconductor devices were her true calling and could see parallels between neural behaviour and unconventional ways of operating transistors. This was the inspiration behind the invention of the multimodal transistor.

Alex Rubinstein wins Best Poster at IoP Plasma Surfaces and Thin Films Meeting.
The Plasma Surfaces and Thin Films Meeting was a one-day meeting organised by the Ion and Plasma Surface interactions Group of the Institute of Physics (IoP) and had around 40 attendees. Under normal circumstances this event would have taken place in London however, this year it was held online. The poster presented, titled “Molecular Dynamics Modelling of Dynamic XPS Cluster Sputtering”, was an overview of molecular dynamics work investigating the mechanisms involved in Ar cluster sputtering.
This project was undertaken with the aim of assisting in experimental work developing the technique of using Ar gas cluster ion beam sources with dynamic XPS.



The researched involved running numerous models and altering parameters such as the energy per cluster atom in order to ascertain the effect on preferential sputtering of the target.
Experimental data was used to glean a general idea of the expected preferential sputtering results.
Alex is in the first year of his PhD working at the Ion Beam Centre.

Staff News

The ATI welcomes **Dr Jae Sung Yun** from September who will be working on powering off-grid portable IoT devices using efficient perovskite solar cells.

Net Zero World

On behalf of RAEng and CESAER, we hosted a very successful two-day meeting on meeting the SDGs in the next 30 years. **Prof. Ravi Silva** hosted the second day session on “Net Zero World in 30 years”. Sir Jim McDonald, Professor Martin Green, Dr. Chad Frischmann from Drawdown etc. spoke at the event which was attended by a virtual audience of over 200. More information and a full recording can be obtained from the web pages link here and here.

An Editorial on meeting the Net Zero energy supply and storage obligations was written by **Prof. Ravi Silva** in the journal Energy and Environmental Materials. He is the Editor in Chief of this quartile one journal which received a recent impact factor of 15.12. For those interested in the Energy Supply trends please examine the following Editorial in full here.