October 2023

Advanced Technology Institute Newsletter
Faculty of Engineering and Physical Sciences

News

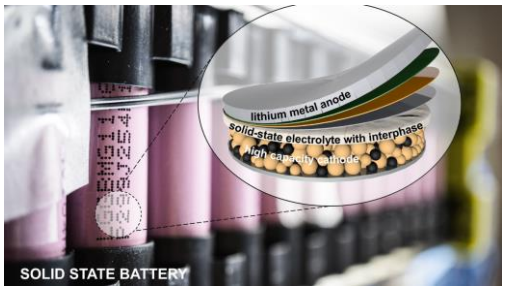
UNIVERSITY HOSTS DR JITENDRA SINGH, INDIAN MINISTER OF STATE OF THE MINISTRY OF SCIENCE AND TECHNOLOGY

The setting up of semiconductor research and development and widening research collaboration with India was the focus of a visit to the University of Surrey by Dr Jitendra Singh. The visit, which took place in the **Advanced Technology Institute (ATI) and Ion Beam Centre (IBC),** was also joined by Mr Sanjeev Kumar Varshney (Adviser & Head, International Bilateral Cooperation Division, Department of Science & Technology) and Dr Rama Bansal (Head, CSIR).

The focal point of the visit was developing semiconductor research and development that can help spur the whole ecosystem to enable the next generation of technologies and industries to cater for integrated chips (IC) that are at the heart of all electronic equipment and enable AI to function suitably. Semiconductor chips are integral to the evolution of the modern world, enabling technology in homes, offices, factories, and transport networks to function efficiently, sustainably and in a secure and safe environment. The meeting concluded with a round table discussion with representatives from leading UK universities, industry and government departments on future semi-conductor research and development in the two countries.

Professor Ravi Silva, Director of the Advanced Technology Institute and Head of the Nano-Electronics Centre said: “As this visit demonstrates, the importance of building the entire semiconductor supply chain to contribute to technology and society has never been greater. “With recent announcements by the UK Prime Minister Rishi Sunak on support to semiconductors in excess of £1bn last week, and the willingness of the Indian government to invest in the field in similar measures, there is no better time to progress a Memorandum of Understanding. “Ahead of the King’s coronation, discussions about a new MoU represent a new dawn in the advancement of semiconductor research and development at the heart of the Commonwealth.”

NEW 'SMART LAYER' COULD ENHANCE THE DURABILITY AND EFFICIENCY OF SOLID-STATE BATTERIES



A new technique to make solid-state electrolytes safer and more efficient for solid-state batteries has been developed by researchers from the University of Surrey, the National Physical Laboratory and the University College London. This research could enhance the energy storage capabilities of batteries for use in electric vehicles and mobile devices.

The researchers found a way to manipulate the internal flow of electrons within the battery to prevent a common problem called "lithium dendrite growth". This problem occurs when small bits of lithium metal form in a way that can cause the battery to short-circuit or lose power. To fix this, the team created a special layer between the solid-state electrolyte and lithium metal anode that stops unwanted electrons from entering the electrolyte and causing problems.

Dr Xuhui Yao, the first author of the paper from the University of Surrey and the National Physical Laboratory, said: "We have developed a solution to address the dendrite growth problem in solid-state batteries, where dendrites can cause the complete failure of the battery. Our approach involves creating a barrier layer that allows the battery to function normally but slows down dendrite growth and promotes their quick elimination, thus making the battery safer and more reliable." **Dr Yunlong Zhao**, Senior Lecturer and the project leader from the Advanced Technology Institute, and the National Physical Laboratory, added: "The scientific community must continue to innovate quicker if the world is to develop energy storage solutions that help the UK and the world transition to net zero." The full paper, "Rectifying Interphase for Preventing Li Dendrite Propagation in Solid-State Electrolytes", has been published in Energy & Environmental Science. (DOI: https://pubs.rsc.org/en/content/articlelanding/2023/EE/D2EE04006A)

PEROVSKITE SOLAR CELLS' INSTABILITY MUST BE ADDRESSED FOR GLOBAL ADOPTION, SAY SURREY RESEARCHERS

Mass adoption of perovskite solar cells will never be commercially viable unless the technology overcomes several key challenges, according to researchers from the University of Surrey. Perovskite-based cells are widely believed to be the next evolution of solar energy to meet the growing demand for clean energy. However, they are not as stable as traditional solar silicon-based cells.

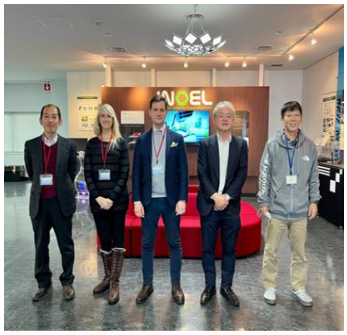
Dr Xueping Liu, the first author at the **Advanced Technology Institute**, said: "Perovskite solar cells are not yet as reliable as traditional solar cells, even though they are more efficient at converting sunlight into electricity. To make these cells more reliable, it is important to understand why they are unstable and to find ways to control how they are made to prevent them from breaking down over time. This research aims to do just that by better understanding the cells' stability and how to improve their design. By doing this, perovskite solar cells could be used on a larger scale, helping to provide more clean energy for everyone."

Dr Wei Zhang, the corresponding author from the University of Surrey, said: "The scientific community will have to work on breaking through the stability bottleneck of perovskite materials. Revisiting scientific mechanisms of phase instability and seek opportunities derived from light harvesting material will potentially trigger the evolution of the next generation perovskite PVs. "The study has been published in **Nature Reviews Chemistry**.

(DOI: https://www.nature.com/articles/s41570-023-00492-z)

EXPANDING UK-JAPAN COLLABORATIONS IN EMERGING THIN-FILM TRANSISTOR AND SENSOR TECHNOLOGY

Dr Radu Sporea and **Dr Eva Bestelink** have returned from visiting several institutes in Japan in January 2023, engaging in several activities including delivering seminars and making visits at Kochi University of Technology (KIT), Nara Institute of Science and Technology (NAIST), and Yamagata University. Planning is underway with Prof Furuta from KIT for future collaborations in optimising thin-film transistor operation, while PhD student Pongsakorn Sihapitak from NAIST is visiting the **Advanced Technology Institute** and performing a series of experiments during February and March 2023.



The many years of fruitful collaborations with Prof Tokito and Prof Matsui at Yamagata University have strengthened ties with the institution and further projects discussed above and beyond the current studies on organic transistors and sensor arrays.

The trip culminated with a visit to the Innovation Centre for Organic electronics (INOEL), at Yamagata University Smart Future House and discussed capabilities, industrial priorities, and routes to manufacturing for large area electronics.

ATI PGR SPREADING THE JOY OF SCIENCE IN THE COMMUNITY

Advanced Technology (ATI) PGR, **Aimee Sweeney,** was invited to Felton fleet School to give a talk to a group of year 6 students about her project and PhD. She discussed her academic journey from when she first showed an interest in science to how she came to study a Quantum Biology PhD. She spoke on the interaction of light with matter and how the absorption and reflection of different wavelengths results in objects being the different colours we see.

This led to a discussion on the structure of the eye and how she is using different pigments from different fruits and vegetables to create an artificial retina. Aimee says, ‘The students were a pleasure to talk to and seemed to be very engaged in the science we are doing’.

THE OPENING OF A NEW RESEARCH FACILITY, THE SCALED PRINTING LABORATORY

The Scaled Printing Laboratory (SPL) is a cutting-edge research facility enabling the fabrication of various opto-electronic devices. It is a research hub for the screening and development of novel materials, devices, and concepts. **Dr Dimitar Kutsarov**, who joined the ATI after spending many years working in the industry, is a lead researcher and responsible for the design, set-up, and running of the new facility. He adds: “The SPL is a unique R&D environment open for researchers across the globe. It contains equipment allowing for the complete fabrication cycle of various printed electronic devices. It is amazing how many tools fit into such a small footprint and how well they complement each other.”

Organic and perovskite-based solar cells as well as light emitting diodes, sensors, antennas, batteries, super capacitors, and many more functional devices can be made in the SPL. Initial research and development activities in the laboratory are carried out on glass or plastic substrates with dimensions of up to 100 cm². This tool allows for the deposition of functional layers with various thicknesses ranging from few nm to tens of µm on plastic foils with a length of up to 100 m. It is also possible to screen-print A4 sized structures in the SPL and use a picosecond laser to scribe various materials with a registration accuracy below 30 µm. At the end of the fabrication cycle, an encapsulation step of the product can be carried out in the in the SPL to protect any device from degradation. For further information please contact Dr Dimitar Kutsarov: d.i.kutsarov@surrey.ac.uk or visit the SPL online https://www.surrey.ac.uk/advanced-technology-institute/facilities/scaled-printing-laboratory.

MULTI-LAYERED ‘SPACE SKIN’ CAN HELP FUTURE SATELLITES AND SPACECRAFT HARVEST ENERGY

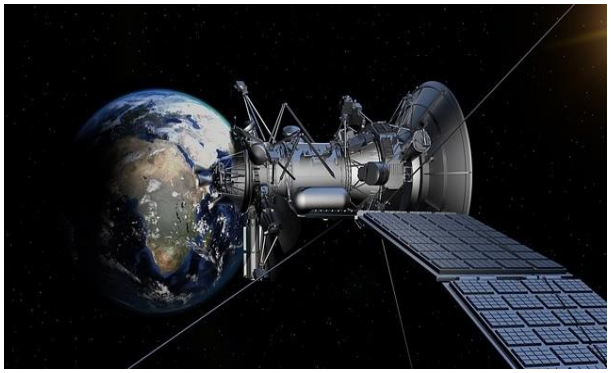
A 'space skin' could help protect spacecraft and satellites from harsh solar radiation while also harvesting energy for future use in the craft's mission, according to a study from the University of Surrey and Airbus Defence and Space. The research team has shown their innovative nano-coating, called the Multifunctional Nanobarrier Structure (MFNS), can reduce the operating temperatures of space-qualified structures from 120°C to 60°C.

Professor Ravi Silva, corresponding author of the study and Director of the **Advanced Technology Institute** said "Space is a wondrous but dangerous place for us humans and other human-made structures. While solutions already on the market offer protection, they are bulky and can be restrictive when it comes to thermal control. "Our new nano barrier is able to not only provide radiation and thermal protection but also harvest energy for use at a later date." The MSFN consists of a buffer layer made of poly(p-xylylene) and a diamond-like-carbon superlattice layer to give it a mechanically and environmentally ultra-stable platform. This means that the MSFN can protect a craft from Atomic Oxygen (AO) and UV radiation. Its dielectric nature (transparent across a wide range of radio frequencies) means it can also be coated on highly sensitive payloads without interfering significantly with performance. The team found it is possible to modify how much AO and UV a craft can absorb and harvest while a craft is in low-earth orbit.

(DOI: https://pubs.acs.org/doi/10.1021/acsnano.2c09737#)

ULTRA-LIGHTWEIGHT MULTIFUNCTIONAL SPACE SKIN CREATED TO WITHSTAND EXTREME CONDITIONS IN SPACE

A new nano-barrier coating could help protect ultra-lightweight carbon composite materials from extreme conditions in space, according to a study from the University of Surrey and Airbus Defence and Space. The new functionality added to previously developed 'space skin' structures add a layer of protection to help maintain space payloads while travelling in space, like having its very own robust ultralight protective jacket.



The research team has shown that their innovative nano-barrier would help drastically increase the stability of carbon fibre materials, while reducing radiation damage.

Professor Ravi Silva, corresponding author of the study and Director of the **Advanced Technology Institute (ATI**) at the University of Surrey, said:

"Current aluminium shielding is not thermally stable or fully conformal, and therefore usually undesired for stable structures. Not to mention that aluminium shielding contributes to the mass and cost of satellites. Our nano-barrier addresses these issues and is a promising upgrade to the industry standard which could become a key accessory to all space and aircraft structures that are both mobile and static." The coating is a highly dense superlattice structure applied to carbon fibre materials at room temperature which does not add over 1 µm of thickness, therefore keeping the materials lightweight. The study has been published in Science Advances. (DOI: https://www.science.org/doi/10.1126/sciadv.add6947)

RECENT ATI PUBLISHED PAPERS

Ravi Silva

- Lithium-Sulfur Batteries Meet Electrospinning: Recent Advances and the Key Parameters for High Gravimetric and Volume Energy Density
- (DOI: https://onlinelibrary.wiley.com/doi/full/10.1002/advs.202103879)
- A route towards the fabrication of large-scale and high-quality perovskite films for optoelectronic devices. (DOI: https://www.nature.com/articles/s41598-022-10790-z#citeas)

Radu Sporea

- The Secret Ingredient for Exceptional Contact-Controlled Transistors (DOI: https://onlinelibrary.wiley.com/doi/full/10.1002/aelm.202101101)

Maxim Shkunov

- Development of polymeric blue prosthetic retina photoreceptors (DOI: https://link.springer.com/article/10.1557/s43580-023-00525-1)

Michal Delkowski

- Radiation and electrostatic resistance for ultra-stable polymer composites reinforced with carbon fibres, Science Advances (DOI: https://www.science.org/doi/10.1126/sciadv.add6947)
- Multifunctional nanostructures with controllable bandgap giving highly stable infrared emissivity for smart thermal management (DOI: https://pubs.acs.org/doi/10.1021/acsnano.2c09737)
- Nature Research Highlights, A gem of a material could provide a shield for spacecraft (DOI: https://www.nature.com/articles/d41586-023-00834-3)

Hashini Perera

- Modification of Hydrophobic Self-Assembled Monolayers with Nanoparticles for Improved Wettability and Enhanced Carrier Lifetimes Over Large Areas in Perovskite Solar Cells (DOI: https://onlinelibrary.wiley.com/doi/10.1002/solr.202300388)

HOUSEHOLDS INVESTING IN SOLAR PANELS COULD REACH BREAK-EVEN POINT SOONER THAN EXPECTED

New research suggests that many households could break even on their solar panel investments as early as 2027, as solar electricity becomes a more competitive electricity source, according to scientists at the University of Surrey. Surrey scientists have found that there has been a steady decline over the last decade in the cost outlay and return on investment of solar panel systems, regardless of the size of the system, which includes individual homeowners. In 2021 large-scale photovoltaic systems were cheaper than wholesale electricity with prices at £51 / MWh, versus £149 / MWh for smaller systems.

Professor Ravi Silva, Director of the Advanced Technology Institute, University of Surrey said: "The findings of this study will aid the UK's focus on reaching its net-zero targets by 2050 for many parties including homeowners, solar developers, the construction industry and Government offices. The promise of these investments breaking even or making electricity 40-50% cheaper by 2035 is something that can't be ignored."
Despite an abundance of solar resources available, a figure from 2019 suggests solar electricity only accounts for 3% of the market globally due to high installation costs.
Dr Filip Mandys, Research Institute for Labour and Social Affairs (RILSA) commented:
"As the cost-of-living increases and the world focus is on climate change and decarbonisation, it is great news for many to hear a once costly investment will not only help deliver greener energy, but also at a lower cost. By offering more supportive initiatives, solar energy can grow more competitively and address the UK's energy needs while providing a promising sustainable and affordable electricity solution."

The University is committed to improving its own resource efficiency on its estate and being a sector leader, aiming to be carbon neutral by 2030. A focus on research that makes a difference to the world has contributed to Surrey being ranked 55th in the world in the Times Higher Education (THE) University Impact Rankings 2022, which assesses more than 1,400 universities' performance against the United Nations' Sustainable Development Goals (SDGs).

(DOI: https://doi.org/10.1016/j.patter.2023.100735)

SCALABLE AND ROBUST QUANTUM COMPUTING ON QUBIT ARRAYS WITH FIXED COUPLING

Quantum computers need to perform many operations which involve changing the internal states of single qubits (basic quantum memory units) and pairs of qubits in each step of the computation. To target specific qubits and specific pairs of qubits, it is important to isolate them from all the other qubits and this adds complexity both to the hardware and to the control, making it difficult to scale-up the quantum processor. We invented a protocol to implement these operations without the need to physically isolate the qubits, and in a scalable way.

Dr Nguyen Le, who was a former researcher in the group, was the driving force behind this project. A paper was written describing the method and a patent submitted as well. **Dr William Mortimore** from the University's Innovation team has been supporting us in the IP generation process and we received additional funding to continue the development of the invention towards a proven technology from the university (IAA) as well as from external sources (EPSRC's Quantum Computing hub and UUKi), and our team **Dr Max Cykiert** and **Dr Elena Lupo** are now developing this project. (DOI: https://www.nature.com/articles/s41534-022-00668-3)

PhD NEWS

Welcome - The ATI welcomes: **Sam Eserin, Oscar Lloyd-Willard, Alex Meek, Ilaria Francescon, Ali Vafa and Guangpeng Zhang** who joined our October 2022 cohort. **Guan-You Lin, Walter Stroud, Jamie Neil, Gagan Sharma and Darshana Chatterjee** who joined our January 2023 cohort and **Yunke Wang** who joined our April cohort. **Mark Ludlow, Spencer Skinner, Ezrah Miriam, Sajib Roy, Anthony Abraham, Kyriakos Almpanidis and Callum Mcaleese** who joined our October cohort. We wish them well in their research.

ATI COMMONWEALTH STUDENTSHIPS

The Advanced Technology Institute (ATI) welcomed two scholars from India who were awarded a prestigious commonwealth studentship to undertake research for 12 months. PGR students, Gagan Sharma and Darshana Chatterjee joined the ATI in February of this year.

Darshana recently attended a residential workshop on "Maximizing Your Impact: Training for Development" which included scholars from different Commonwealth Countries and diverse research areas. Darshana was selected to present her poster which focuses on Sensor fabrication for forensic toxicological applications which addresses to the sustainable development goal (SDG-3).

Gagan recently delivered a contributory talk titled "Two-dimensional MXene ($Ti_3C_2T_x$) decorated MoS_2 nanohybrid films for printable high-performance flexible Supercapacitors" at a conference "IOP PGS Printing for the Future" conducted on June 1, 2023, held at Institute of Physics, London, UK. Moreover, he attended a 3-day residential workshop, "Maximising Your Impact: Training for Development", held at Cumberland Lodge, Windsor Great Park, from June 2 to 4, 2023, organised by Commonwealth Scholarship Commission in the UK.

As a Commonwealth Scholar, Mr. Gagan is working on lead-free and environmentally friendly energy storage technology for next generation storage. One of the primary goals of his research on green energy is to benefit every section of human civilisation. He is further optimising several nanohybrid materials for better capacitive properties, which will contribute to solving the world's current energy crisis.

ATI LAURETTE AWARDS 2022

Dongtao Liu for his contribution to research in high impact publications
Dr Yunlong Zhao for his contribution to research in high impact publications and collaborative projects
Dr Wei Zhang for his contribution to research in high impact publications and collaborative projects
Dr Steve Clowes for his contribution to research in RAISIN project
Dr Michal Delkowski for his contribution to research in high impact publications
Dr Holly Lewis for her contribution to research in high impact publications
Dr Jae Yun for his contribution to research in high impact publications
Dr Bowei Li for his contribution to research in high impact publications
Dr Prabodhi Nanayakkara for her contributions to high impact paper
Dr Mateus Masteghin for high impact collaboration with internal and external collaborators

ATI AWAY DAY 2023

It was wonderful to see a great turnout for the ATI strategy day in June this year. In addition to team building activities, much time was spent on reviewing past success and performance with a view to enhancing output and delivery of impact in the coming year. Progress was also made on identifying core strengths and opportunities. Thank you all for your participation and contributions.