September 2022

Advanced Technology Institute Newsletter
Faculty of Engineering and Physical Sciences

News

THE ADVANCED TECHNOLOGY INSTITUTE (ATI) TURNS 20

The ATI celebrates 20 years of research on the **16th of September 2022**.

The ATI was founded in 2002 as the premier multidisciplinary research centre of the University. Join us in celebrating our achievements over the past 20 years and in looking to the future of quantum, energy, and nanoscale technologies. The day will feature talks from successful ATI alumni and distinguished guests as well as from the current crop of young scientists training as future leaders in the field. Tours of our facilities and a buffet lunch will support technical discussions and collaboration opportunities.

For more information, please contact Nicole Steward via email on n.steward@surrey.ac.uk

IN THIS ISSUE

SOLAR ENERGY MEANS THE SUN'LL COME OUT TOMORROW FOR COST-EFFECTIVE DECARBONISATION, SURREY EXPERT DEMONSTRATES

Solar energy is one of the most cost-effective ways to generate electricity, cheaper even than existing coal-fired power stations, says environmental and technology expert **Professor Ravi Silva**, Director of the **Advanced Technology Institute** at the University of Surrey.

In his latest editorial article for the peer-reviewed academic journal **Energy and Environmental Materials**, of which he is Editor-in-Chief, Professor Silva urges policy makers and energy companies to move quickly towards decarbonisation and to maintain the momentum gathered in COP26 last year.

He cites data published by IRENA, the International Renewable Energy Agency, which estimates that 61% of coal capacity in the United States costs more to operate than building new renewable energy plants. Retiring these coal plants and replacing them with renewables would save US$5.6 billion in costs and 332 million tons of CO_2 per year. In India, 70% of coal capacity is more expensive to run than building new renewables; in Germany it is 100%.

SURREY'S NEW FLEXIBLE AND STRETCHY SUPERCAPACITORS COULD BOOST "BATTERY" LIFE FOR INTERNET OF THINGS

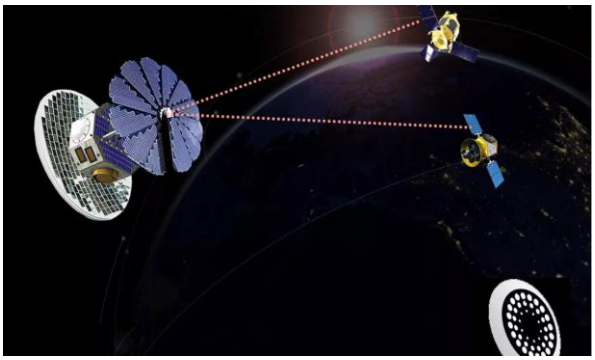
Smartwatches, fitness trackers and other Internet of Things devices could get a significant boost to their "battery" life thanks to new, environmentally friendly energy research from the University of Surrey's **Advanced Technology Institute (ATI)** and the Federal University of Pelotas (UFPel), Brazil.

Professor Ravi Silva, Director of the ATI and Head of the Nano-Electronics Centre at the University of Surrey, said: "Supercapacitors are key to ensuring that 5G and 6G technologies reach their full potential. While supercapacitors can certainly boost the lifespan of wearable consumer technologies, they have the potential to be revolutionary when you think about their role in autonomous vehicles and AI-assisted smart sensors that could help us all conserve energy. This is why it's important that we create a low cost and environmentally friendly way to produce this incredibly promising energy storage technology. The future is certainly bright for supercapacitors."

In the paper, the research team describe a new procedure for the development of flexible supercapacitors based on carbon nanomaterials. This method, which is cheaper and less time-consuming to fabricate, involves transferring aligned carbon nanotube (CNT) arrays from a silicon wafer to a polydimethylsiloxane (PDMS) matrix. This is then coated in a material called polyaniline (PANI), which stores energy through a mechanism known as "pseudocapacitance," offering outstanding energy storage properties with exceptional mechanical integrity.

SURREY RESEARCHERS WORKING WITH SPACE POWER TO REVOLUTIONISE SATELLITE POWER USING LASER BEAMING

The University of Surrey and Space Power are tackling the problem of powering satellites in Low Earth Orbit (LEO) during their eclipse period when they cannot see the sun. Wireless power beaming is a critical and disruptive technology for space infrastructure and will provide auxiliary power to increase the baseline efficiency of small satellites in LEO. The technical side of the project will use the highly specialised laser laboratories and optical systems developed at the University of Surrey's Department of Physics and **Advanced Technology Institute**, which are world leaders in the development and implementation of laser and photovoltaic-based technologies. The first Space Power product will be designed as a plug-and-play system for satellite manufacturers to include in their offering to their LEO constellation customers.

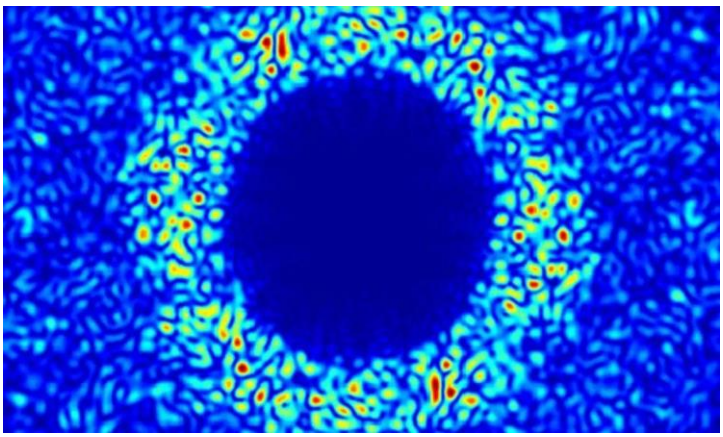


SPRINT provides unprecedented access to university space expertise and facilities and helps businesses through the commercial exploitation of space data and technologies. The power beaming prototype work follows on from an initial feasibility study by Space Power and the University of Surrey on laser transmission funded through the SME Innovation Voucher scheme. Now, the team will investigate and verify the efficiency benefits of laser-based power beaming, develop the new technology, and obtain data to enable them to design a prototype for small satellites in space.

Professor Stephen Sweeney, Professor of Physics at the University of Surrey, said: "The University of Surrey has a long track record in photonics and space research and brings unique expertise in both high-power lasers and photovoltaics technologies. We have many years of experience in optical wireless power and are delighted to work with Space Power to help develop such technologies for space-based applications.

SCIENTISTS ACHIEVE RECORD EFFICIENCY FOR ULTRA-THIN SOLAR PANELS

A team co-led team by the University of Surrey has successfully increased the levels of energy absorbed by wafer-thin photovoltaic panels by 25%.In a paper published in the American Chemical Society's Photonics journal, the team detail how they used characteristics of sunlight to design a disordered honeycomb layer which lies on top of a wafer of silicon. Their approach is echoed in nature in the design of butterfly wings and bird eyes. The innovative honeycomb design enables light absorption from any angle and traps light inside the solar cell, enabling more energy to be generated**.**



Dr Marian Florescu from the University of Surrey's **Advanced Technology Institute (ATI)** said, "One of the challenges of working with silicon is that nearly a third of light bounces straight off it without being absorbed and the energy harnessed. A textured layer across the silicon helps tackle this and our disordered, yet hyperuniform, honeycomb design is particularly successful."

NANOPARTICLES THAT MIMIC PLANT PIGMENT TO DELIVER BETTER SOLAR PANELS

Researchers have taken inspiration from the world of plants to develop innovative and efficient nanoparticles that could be used to build the solar panels of the future.

A team of engineers and biologists from the University of Surrey have synthesised nanoparticles that mimic what chlorophyll (the green pigment in most plants) does in nature – absorb light and convert it to usable energy with high efficiency. Past approaches have not been able to match what nature achieves; the efficiency of light-absorbing pigments drops when tightly packed. In the study, Surrey's researchers detail how they developed a unique synthetic pigment that keeps its fluorescent intensity longer.

Michael Spencer, lead author of the study and PhD student at the University of Surrey, said:

"Mother Nature can teach us so much as we all think of ways to nurse our planet back to health. In this study, we looked at how light is absorbed, enhanced, and utilised in biological systems, and we have incorporated those mechanisms into our own hybrid devices. "The performance of our device gives us hope that the solar panels of the future can ditch the use of toxic materials currently used to maintain their intensity."

The research paper was published in Cell Reports Physical Science, and the study was funded by the Leverhulme Trust. The work was produced by the University of Surrey's Advanced Technology Institute and Quantum Biology Doctoral Training Centre. The paper is available via this **link.**

LIFESPAN OF SOLID-STATE LITHIUM BATTERIES EXTENDED BY SURREY RESEARCHERS

Researchers have successfully increased the lifespan and stability of solid-state lithium-ion batteries, creating a viable approach for future widespread usage.

Dr Yunlong Zhao from the **Advanced Technology Institute**, the University of Surrey, explained:

"We have all heard horror stories of lithium-ion batteries in transport settings, usually down to issues around cracked casing caused by exposure to stressful environments, such as extreme temperature changes. Our research proves that it is possible to produce more robust solid-state lithium-ion batteries, which should provide a promising approach for high-energy and safe future models to be used in real-life examples such as electric vehicles."

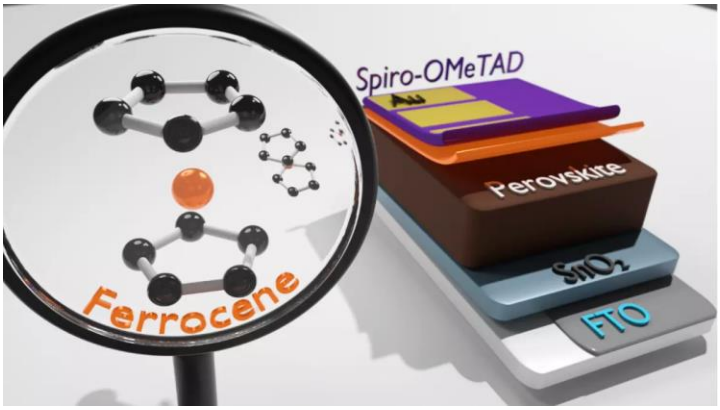
Dr Nianhua Peng, co-author of the study from the University of Surrey, said:

"We are living in a world that is far more aware of the damage humans are causing to the environment. We hope that our battery and approach will help boost the scientific development of high-energy batteries to eventually move us into a more sustainable future."

The full paper published in Small was led by Dr Yunlong Zhao and Dr Nianhua Peng from the Advanced Technology Institute and UK National Ion Beam Centre using the University of Surrey's Ion Beam Centre and can be accessed **here.**

A FOCUS ON CHEMISTRY, NOT ELECTRONICS, COULD SEE FUTURE SOLAR PANELS REACH THEIR POTENTIAL

A material that has been heralded as the key to producing more efficient next-generation solar panels could soon be ready for mass production, thanks to a new method developed by researchers at the University of Surrey.



The Surrey team found that fusing perovskite materials with an element called Ferrocene dramatically increases the efficiency of perovskite-based solar panels. The team found that this focus on the chemistry of solar panels, rather than other approaches that looked at mechanical and electrical components, produced the intended breakthrough.

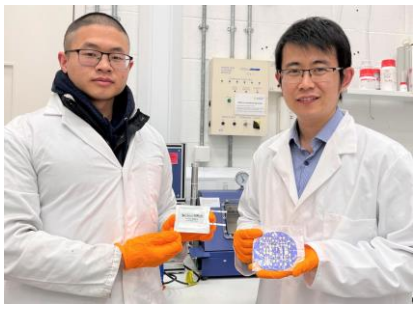
Perovskite materials are widely considered to be the successor to silicon because they are lightweight and far cheaper to produce. However, the promise of perovskite has yet to be realised because of the difficulty of replicating lab results in mass production.

Dr Wei Zhang, the primary supervisor of the research and project lead from the University of Surrey, said: "Silicon cells are efficient but costly to produce; perovskite materials are without a doubt the next generation of photovoltaic technologies. There is still a long way to go to ensure these can be implemented on a mass scale, but with these results, we are a generous step closer to making this a reality."

The project has been produced in collaboration with Imperial College London, the University of Nottingham, London Southbank University, University College London, and Fluxim AG. The research was published in Advanced Energy Materials.

NEW LITHIUM-CO2 BATTERIES ARE BEING MANUFACTURED AT SURREY, WITH POTENTIAL TO REVOLUTIONISE ENERGY STORAGE

Lithium-based batteries capable of capturing carbon dioxide to help store energy are being designed and manufactured by the University of Surrey, thanks to support from the Faraday Institute.



Yunlong Zhao (right) and **Kai Yang** (left) showing on-chip and single layer pouch cell Li-CO2 battery

These lithium-CO2 batteries have a theoretical energy density of 1800 Wh/kg, which is substantially higher than that of lithium-ion battery systems on the market today – meaning lighter batteries or more capacity for the same weight, with potential benefits across industrial applications. **Dr Yunlong Zhao**, project lead from the University of Surrey, said: "We are incredibly excited about lithium-CO2 battery technology, which has the potential to revolutionise the energy storage industry and move us ever closer to reaching net-zero emissions. With the help of our bespoke fabrication platform, we can design and manufacture practical lithium–CO2 pouch cells that eliminate the problems these batteries have faced in the past."

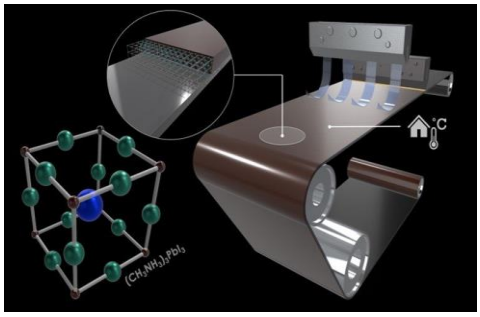
This work to improve batteries is part of Surrey's wider research to tackle the challenge of sustainable energy generation. The huge variety of the University's work in this field includes research into supercapacitors, next-generation solar panels, wearable nanogenerators, biofuels, nuclear fusion and more.

SURREY UNVEILS ENERGY-HARVESTING WEARABLE DEVICE MADE FROM RECYCLED WASTE

Scientists have unveiled a wrist device made from discarded paper wipes and plastic cups that runs on energy harvested by the wearer's movements.

Dr Bhaskar Dudem, project lead and Research Fellow at the University of Surrey's **Advanced Technology Institute (ATI)**, said: "It won't be long until we have to ask ourselves which of the items we own are not connected to the internet. However, the current internet-of-things (IoT) revolution highlights the simple fact that our planet doesn't have the raw resources to continue to make these devices which are in such high demand. "Our research demonstrates that there is a path to creating sustainable technology that runs on electricity powered by us, the users of that technology." Surrey's device is 'self-powered' thanks to materials that become electrically charged after they come into contact with one another. The research was published in ACS Applied Materials & Interfaces.

A RETHINK OF THE BUILDING BLOCKS FOR SOLAR PANELS COULD HELP MASS PRODUCTION



In the paper published in Scientific Reports, **Dr Ehsan Rezaee**, a post-doctoral fellow of the **Advanced Technology Institute (ATI)** at the University of Surrey, explains his research: "The objective is simply to produce solar cell building blocks out of perovskite ink. Whilst perovskite ink is not a new technology, current inks do not guarantee seamless transitions on an industrial scale, as the manufacturing process needs to be highly controlled and optimised.
"Our perovskite ink produces a fast and reproducible way to reliably fabricate these solar cell building blocks on a mass scale, paving the way for its use in commercial markets." Perovskite solar cells are a low-cost, lightweight solution and can be built either rigid or flexible, with more possibilities to easily transport and install. The new study examines the foundation blocks of solar cells made of perovskite rather than the traditional silicon, as perovskite cells harvest light through the visible part of the solar spectrum, which has more energy. **Professor Ravi Silva**, Director of the **ATI** at the University of Surrey, said: "The University of Surrey has always believed in the potential of solar panels to be a critical research area which will, in time, allow us to move away from dangerous old energy sources." The work can be found **here.**

PhD News

Welcome - The ATI welcomes: **Vinura Wickrama Appuhamilage, Leena Abusin, Joshua Bird and Chloe Howard** who joined our July 2022 cohort. We wish them well in their research.

Staff News

Welcome – The ATI welcomes **Felix Wong** as the new ATI Cleanroom Technician.

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The Advanced Technology Institute