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Advanced Technology Institute Newsletter
Faculty of Engineering and Physical Sciences

News

SIMPLIFIED CIRCUIT DESIGN COULD REVOLUTIONISE HOW WEARABLES ARE MANUFACTURED

Researchers have demonstrated the use of a ground-breaking circuit design that could transform manufacturing processes for wearable technology.

Silicon-based electronics have aggressively become smaller and more efficient over a short period of time, leading to major advances in devices such as mobile phones. However, large-area electronics, such as display screens, have not seen similar advances because they rely on a device, thin-film transistor (TFT), which has serious limitations.

In a study published by IEEE Sensors Journal, researchers from the University of Surrey, University of Cambridge and the National Research Institute in Rome have demonstrated the use of a pioneering circuit design that uses an alternative type of device, the source-gated transistor (SGT), to create compact circuit blocks.

Dr Radu Sporea, lead author of the study and Lecturer in Semiconductor Devices at the University of Surrey, said: “We are entering what may be another golden age of electronics, with the arrival of 5G and IoT enabled devices.

Our design offers a much simpler build process than regular thin-film transistors. Source-gated transistor circuits may also be cheaper to manufacture on a large scale because their simplicity means there is less waste in the form of rejected components. This elegant design of large area electronics could result in future phones, fitness tracker or smart sensors that are energy efficient, thinner and far more flexible than the ones we are able to produce today.”

PHOTONICS EXPERT ELECTED FELLOW OF SPIE

Professor Stephen Sweeney has been elected as Fellow of SPIE, the international society for optics and photonics. Professor Sweeney has been given the prestigious honour in recognition of his achievements in leading research into novel semiconductor materials and photonic devices for communications, energy and sensing applications.

Based in Surrey's Department of Physics and **Advanced Technology Institute**, working in the Photonics and Quantum Sciences Group, Professor Sweeney has produced hundreds of journal papers in the field of semiconductor materials for photonic devices, and published over ten patents. He said: "I feel honoured to have been elected as a Fellow of SPIE and to be amongst such esteemed colleagues in the international photonics community.

It is particularly special to be elected in the year that we celebrate the 60th anniversary of the laser and all of the amazing technologies that it has enabled. SPIE was founded in 1955, at a time when the field of optics and photonics was just beginning to grow. The society has a membership of around 20,000, and serves over a quarter of a million people working in photonics in academia and industry and in topics ranging from communications to medical sensing.

SURREY PHD STUDENT PUBLISHES RESEARCH ON CARBON NANOTUBES

One of our top PhD research students, **Mateus Masteghin**, 25, from our **Advanced Technology Institute**, is celebrating having his first research paper published in Applied Physics Letters, which reports on significant new findings in applied physics.

Mateus' research proposes using Field Electron Emission as a complementary technique to assess carbon nanotube (CNT) quality. In a nutshell, his paper advances an alternative – and cheaper and less time-consuming method – that can be used to analyse the structural integrity of CNTs, a material one billionth of a centimetre in size.

"I was studying at Sao Paulo State University, Brazil, then I came to the University of Surrey on a studentship for 10 weeks in 2017 to conduct an experiment for my masters degree," said Mateus.

The University has two key facilities – the Clean Room and the Focused Ion Beam (FIB) microscope – which helped Mateus' research. "After visiting the Surrey campus, I went back to Brazil and completed my masters in June 2018. Then Dr David Cox, who taught me to use the Focused Ion Beam microscope, emailed me asking if I wanted to apply for a PhD at Surrey."

The findings in Mateus' paper could have far-reaching consequences as CNTs are used in the manufacture of transistors and sensors.

BREAKTHROUGH IN CARBON NANOTUBE PATTERNING

ACS: Applied Materials and Interfaces has published research by the University of Surrey's **Dr Simon King** that reports on a faster and more energy efficient method of patterning carbon nanotubes for specific devices. "Carbon nanotubes, or CNTs as they're known, are very small cylindrical graphitic carbon structures, which are now seeing use in metal-free, lightweight and flexible electrical devices," says Dr King, who's a Research Fellow at Surrey's **Advanced Technology Institute** (ATI).

Thanks to research conducted by Dr King, building on research previously conducted by Dr Liam McCafferty, these additional post-processing techniques may soon be redundant. "What we've done is make a multi-purpose precursor solution that can be used to 'grow' CNTs directly in place, in any pattern, for any device," continues Dr King.

Professor Ravi Silva, Director of Surrey's Advanced Technology Institute, said: "The work presented by Simon in this paper is underlined by over two decades of research in nanocarbon materials. It will open a whole new area in wearable and future Internet-of-Things-type technologies that need new solutions for unique problems."

SURREY UNVEILS FAST-CHARGING SUPER-CAPACITOR TECHNOLOGY

In a paper published by the journal Energy and Environmental Materials, researchers from Surrey's **Advanced Technology Institute** (ATI) revealed their new technology which has the potential to revolutionise energy use in electric vehicles and reduce renewable based energy loss in the national grid..

The ATI's super-capacitor technology is based on a material called Polyaniline (PANI), which stores energy through a mechanism known as "pseudocapacitance." This cheap polymer material is conductive and can be used as the electrode in a super-capacitor device. The electrode stores charge by trapping ions within the electrode. It does this by exchanging electrons with the ion, which "dopes" the material. **Ash Stott**, lead scientist on the project and Ph.D student from the University of Surrey, said: "The future of global energy will depend on consumers and industry using and generating energy more efficiently and super-capacitors have already been proven to be one of the leading technologies for intermittent storage as well as high-power delivery."

SURREY TO DEVELOP BATTERY TECHNOLOGY CAPABLE OF CAPTURING CO_2 EMISSIONS

The University of Surrey is to begin work on a new lithium-ion battery technology that is capable of capturing CO_2 emissions, following an award from the Engineering and Physical Sciences Research Council (EPSRC).

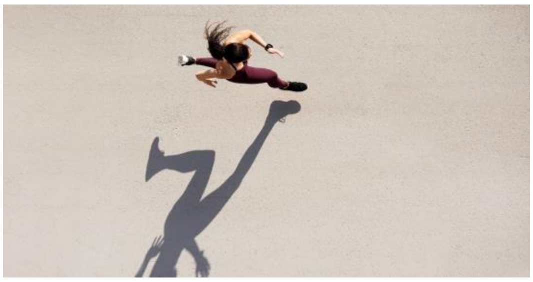
The project, which will be led by **Dr Yunlong Zhao**, will undertake research into state-of-the-art batteries that use Li–CO_2 electrochemical technology. Crucially, the research will look to achieve a breakthrough in efficient CO_2 fixation to store energy.

The EPSRC has bestowed Dr Zhao with its prestigious New Investigator Award. Dr Zhao is Lecturer in Energy Storage and Bioelectronics at Surrey's **Advanced Technology Institute** (ATI) and he is also Senior Research Scientist at the National Physical Laboratory (NPL).

Dr Yunlong Zhao said: "The move to carbon neutral forms of energy supplies is critical to the long-term health of our planet and we are hopeful that our ambitious new project will help to address this need. This project will look at fundamental studies of electrochemical mechanisms through a multimodal in situ characterisation platform developed in collaboration with NPL."

Professor Ravi Silva, Director of ATI at the University of Surrey, said: "At the University of Surrey, we are not afraid of thinking outside of the box and thinking big – because big ideas are often required to tackle grand challenges. We are confident that this incredibly exciting, multidisciplinary project will lead to the fabled fundamental shift in battery technology."

FREE ELECTRICAL ENERGY FROM MOVEMENT TO POWER PORTABLE ELECTRONICS OF THE FUTURE



In a paper published by Nano Energy, researchers detail how they cracked the unreliable nature of previous triboelectric nanogenerators (TENGs) – a type of low cost and lightweight energy generator which can be produced using recyclable materials.

The researchers successfully demonstrated the sustained powering of a number of electronic devices, including LEDs and electronic watches using movements similar to that found in the ambient environment. **Professor Ravi Silva**, Director of the **Advanced Technology Institute** at the University of Surrey, and corresponding author said: "One of our chief ambitions is to make free energy possible for all by 2035 and our breakthrough strongly suggests TENGs technology will be part of the energy mix for mobile applications in that greener future."

The lead scientist of this project, **Dr Ishara Dharmasena**, who is currently working as a Doctoral Prize Fellow at Loughborough University said: "In today's technological context, exploring novel autonomous power sources which can sustainably generate electricity using freely available energy in our surrounding is pivotal to the success of future electronic technologies."

NEXT GENERATION PAPER EXHIBITED AT IDTECHEX

The Next Generation Paper project was exhibited on the NovaCentrix stand at the IDTechEx show on the 20-21st November 2019, in Santa Clara, California, USA.

NovaCentrix, a company based in Austin, Texas, specialise in the development and production of next generation printed electronic devices. They have partnered with the University of Surrey, using their expertise in this area of large-scale fabrication of printed touch sensors and reliable conductive traces to help deliver the hardware-augmented Next Generation Paper functional prototype.

Dr. Radu Sporea, Lecturer in Semiconductor Devices at the University of Surrey and work package leader said, “I am delighted to be able to display the results of our collaboration in such a prestigious venue for printed electronics innovation. Now, with the help of project partner Novacentrix, we have dramatically increased the system’s reliability with the use of custom printed conductive traces with integrated touch sensors. Engineers in Austin and Guildford developed a refined solution in record time.”

Mr George Bairaktaris, a PhD student in Dr Sporea’s group and recent graduate from Surrey’s Electrical and Electronic Engineering BEng programme, implemented the custom printed circuit board and sensor layout design.

CREATING A BETTER SOLAR FUTURE

Bowei Li, a PhD student at Surrey, has researched solar cells that could help create more efficient solar panels. Bowei originally studied material sciences in China before joining the University of Surrey’s **Advanced Technology Institute**, where he studies interface engineering.

“Essentially, creating better connectivity between very thin interfaces in electrical devices can increase their efficiency, performance and stability,” says Bowei. “My research focuses on the connectivity of a material called perovskite, which is used in solar cells. Perovskite solar cells normally have three configurations. What I’ve focused on is optimising one of these by introducing a polymer layer to enhance the structure. Surprisingly, I found this polymer can be applied in different positions in the device and improve its efficiency and stability.”

His recently published paper, *Tailoring Perovskite Adjacent Interfaces by Conjugated Polyelectrolyte for Stable and Efficient Solar Cells*, reports how Bowei has increased the efficiency with which his perovskite solar cell converts solar energy into power by 20.56 per cent.

SURREY PHD STUDENT PUBLISHES AWARD-WINNING WORK ON GRAPHENE

Elizabeth Legge, a PhD student who jointly studies at our **Advanced Technology Institute** (ATI) and the National Physical Laboratory (NPL), has published research that could help manufacturers involved in the multi-million pound graphene market.

“Graphene is a two-dimensional material containing a single layer of carbon atoms in a hexagonal lattice,” explains Elizabeth, whose research won the Infared and Raman Discussion Group (IRDG) Chalmers and Dent Award, and saw her present her findings at a conference in Palm Springs, USA. “A single layer of graphene has a thickness of around 0.34 nanometres. To give some idea of scale, one million nanometres form a millimetre.

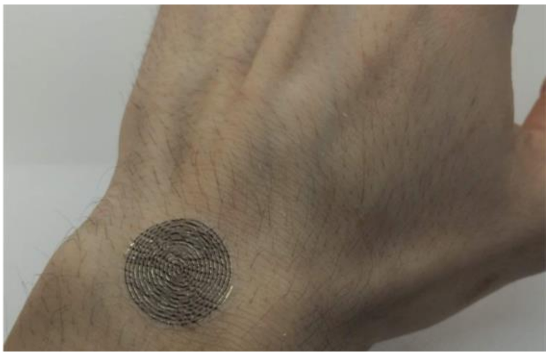
“But it has impressive qualities. It’s the strongest material ever measured, more than 200 times stronger than steel, so it can significantly increase overall strength when just a small amount of graphene is combined with another material.

Professor Ravi Silva, Director of ATI at Surrey, added: “Surrey is pleased to work closely with NPL on this and many other strategic programmes that have given highly impactful output.”

SURREY RESEARCHER WINS PRESTIGIOUS IET AWARD

Pavlos Giannakou, a postgraduate researcher from Surrey’s **Advanced Technology Institute** (ATI), has won the prestigious Institution of Engineering and Technology (IET) Postgraduate Research Award.

Pavlos was recognised for his outstanding work in printed electronics, nanomaterials, and energy storage with flexible micro-supercapacitors, which resulted in ground-breaking work on a ‘tattoo epidermal supercapacitor’. Pavlos explains: “In the future, imagine being able to attach a low-cost activity tracker on your skin in the same casual manner that a child would attach a temporary tattoo sticker.“To enable this technology, we created tattoo epidermal supercapacitors.



The importance of Pavlos’ research, which is part of a collaborative European programme called SURFAS, has been recognised in leading journals. He’s also filed a patent application on supercapacitor nanoparticle inks used to 3D print the devices.

Dr Maxim Shkunov, Pavlos’ PhD supervisor at ATI, adds: “We’re thrilled to see a Surrey student’s hard work being recognised by the IET. Pavlos has an inventive engineering approach, which helped him to develop ultra-flexible, tattoo-like supercapacitors, which provide a step towards wearable self-charging bio- and medical devices.
“This outstanding work is truly inspirational for the future generation of engineers in nanotechnology, physics, material science, electronics and medical devices research.”

PHD STUDENT PUBLISHES RESEARCH ON ECO-FRIENDLY PRINTED ELECTRONICS

Barbara Salonikidou, who is undertaking a PhD in Surrey's **Advanced Technology Institute**, has developed an innovative, cost-effective way of printing electronics which could lead to highly versatile tactile sensors with applications in biomedical devices and

The research, undertaken in collaboration with Yamagata University in Japan, was published by the American Chemical Society and demonstrates a method of inkjet-printing electronics which are versatile, energy efficient and low cost. This differs from conventional fabrication techniques for electronics which involves harsh chemicals and substantial waste of materials.

The project is partly funded by EPSRC, as well as the Royal Society through the International Exchange programme which enabled Barbara to spent four months at Yamagata University, where she was able to draw on the institution's expertise in novel techniques for flexible and printed electronics.

Barbara explained, "Our simple technique produces electronic devices which remember their operating history. These are ideal for applications where you don't need a long-term memory, but rather a processing memory, such as in replicating the complex sense of touch with electronic skin."

Dr Radu Sporea, who is supervising Barbara's PhD, said, "Barbara is methodically spearheading research into printed memristive devices in our team at Surrey, broadening our interest in flexible electronics and placing us in a good position to create elegant, low-power functional sensor systems. Her work is the strongest link yet in our collaboration with Professor Tokito's group at Yamagata University, which is supported by a Royal Society International Exchange Grant."

HELPING PEROVSKITE SOLAR CELLS REACH THEIR POTENTIAL

A new critical review from the University of Surrey has set out a potential roadmap to help the next generation of solar cells reach their full potential.

Perovskite solar cells have emerged as the heir apparent to their silicon-based counterparts because of their high-power energy conversion efficiency, low development cost, and ability to be ultra-lightweight. In the critical review, which has been published by Materials Today, researchers from Surrey's **Advanced Technology Institute (ATI)** and the Institute of Metal Research from the Chinese Academy of Sciences, discuss the current challenges that perovskite solar cells face – particularly flexible solar cells.

Dr. Wei Zhang, Lecturer (Assistant Professor) at the ATI at the University of Surrey, said: "The future applications of flexible perovskite solar cells are not limited to powering up portable electronics and household appliances. They are capable of integrating with exciting technologies such as spacecrafts, E-skin, and the Internet of Things. We are excited to witness the evolution of this emerging field and its journey from lab to fab."

SURREY REVEALS ITS IMPLANTABLE BIOSENSOR THAT OPERATES WITHOUT BATTERIES

Researchers from the University of Surrey have revealed their new biodegradable motion sensor – paving the way for implanted nanotechnology that could help future sports professionals better monitor their movements to aid rapid improvements, or help caregivers remotely monitor people living with dementia.

In a paper published by Nano Energy , a team from **Surrey's Advanced Technology Institute** (ATI), in partnership with Kyung Hee University in South Korea, detail how they developed a nano-biomedical motion sensor which can be paired with AI systems to recognise movements of distinct body parts.

The ATI's technology builds on its previous work around triboelectric nanogenerators (TENG), where researchers used the technology to harness human movements and generate small amounts of electrical energy. Combining the two means self-powered sensors are possible without the need for chemical or wired power sources.

In their new research, the team from ATI developed a flexible, biodegradable and long-lasting TENG from silk cocoon waste. They used a new alcohol treatment technique, which leads to greater durability for the device, even under harsh or humid environments.

Dr Bhaskar Dudem, project lead and Research Fellow at the ATI, said: "We are excited to show the world the immense potential of our durable, silk film based nanogenerator. It's ability to work in severe environments while being able to generate electricity and monitor human movements positions our TENG in a class of its own when it comes to the technology."

ULTRA-SMALL NANOPROBES COULD BE A LEAP FORWARD IN HIGH-RESOLUTION HUMAN-MACHINE INTERFACES

Machine enhanced humans – or cyborgs as they are known in science fiction – could be one step closer to becoming a reality, thanks to new research from the Lieber Group at Harvard University, as well as scientists from the University of Surrey and Yonsei University.

In a paper published by Nature Nanotechnology, scientists from Surrey's **Advanced Technology Institute** (ATI) and Harvard University detail how they produced an array of the ultra-small U-shaped nanowire field-effect transistor probes for intracellular recording.

Dr Yunlong Zhao from the ATI at the University of Surrey said: "If our medical professionals are to continue to understand our physical condition better and help us live longer, it is important that we continue to push the boundaries of modern science in order to give them the best possible tools to do their jobs.

"Our ultra-small, flexible, nanowire probes could be a very powerful tool as they can measure intracellular signals with amplitudes comparable with those measured with patch clamp techniques; with the advantage of the device being scalable, it causes less discomfort and no fatal damage to the cell (cytosol dilation). Through this work, we found clear evidence for how both size and curvature affect device internalisation and intracellular recording signal."

PhD News

Welcome - The ATI welcomes: Yi Gong who joined our July cohort. Adam Burgess, Aneirin Ellis, Hashini Perera, Aimee Sweeney, Le-Yu Bi, Shengan Shi and Alexander Rubenstein will be joining our October cohort. We wish them well in their research.

The **Allan Way Prize for 2020** has been awarded to PhD student Mr **Georgios Bairaktaris**.

Nominations received from students were based on 1:1 support that was provided either with personal tutoring, project supervision, technical or administrative support, laboratory tutoring or pastoral support.

Congratulations to George who was awarded the prize for the support he has shown as a demonstrator in the labs.

Background to the prize:
This is a new prize that was set up this year in the memory of Mr Allan Way. Allan was an academic highly regarded by a number of students who studied in the Department in the 1980s and 1990s. He was known for the support he provided to students as a tutor and project supervisor as well as someone who interacted well in the laboratories. Sadly Allan passed away in 2019 and in his honour we recently sought nominations from undergraduate and postgraduate taught students from the Department for The Allan Way Prize for One to One Student Support.

DAISY SHEARER DISCUSSES THE CHALLENGES AND STRENGTHS OF STUDYING WITH AUTISM

Surrey PhD student **Daisy Shearer** is an experimental physicist working in quantum technology at our **Advanced Technology Institute**. Diagnosed with autism in 2017, she's also a vocal ambassador for neurodivergent people in science, technology, engineering and maths (STEM) subjects.

How has your autism diagnosis affected your life?

“It was empowering. I still struggle with accepting my diagnosis at times. But mostly it's allowed me to recognise that all the little things I got annoyed at myself about and I didn't understand were a reflection of how my brain is wired.

“Now I'm diagnosed, I feel less shame about doing things differently to other people, which is a nice feeling."

What sort of support have you had at Surrey?

“My diagnosis gave me access to Disabled Students' Allowances (DSAs) and the University's amazing Disability and Neurodiversity (D&N) services. I've been working with my specialist D&N mentor since the last semester of my Masters in Physics and I've grown as a person and as a scientist thanks to her help.

Because I was diagnosed quite late in life, I'd inadvertently developed study techniques that worked for me. Seeing my learning support mentor has helped me to hone these. "

How does your autism manifest?

“That’s a big question! Autism looks different in all autistic people and there’s a lot to unpack.

“An example is that being autistic means I process sensory information differently. This often results in an overload and potential autistic ‘meltdown’ or ‘shutdown’, so I have to manage the sensory inputs I encounter to minimise this. I also have some differences with how I communicate with colleagues. I’ll often become non-verbal when under stress. I also need things to be extremely specific to understand what is required of me. I can’t ‘read between the lines’."

Does this affect your research?

“I think my autism is part of why I’m a good researcher and scientist. I can tap into something called ‘hyperfocus’, which is recognised in neurodivergent people with Autistic Spectrum Condition (ASC) and Attention Deficit Hyperactivity Disorder (ADHD).

“This means I can have extreme focus on a task for a long time. My neurotype also means I’m logical and precise, I have great attention to detail, and I analyse things in great depth as well as approaching problems from a unique perspective.”

How do your tutors help?

“My tutors are supportive and they try to understand how best to communicate and work with me.

“Unfortunately, there are many undiagnosed autistic people out there who do not get access to this type of support. Waiting for diagnosis can take several years in some cases or it can be incredibly expensive, so not everyone has access to it.”

What are some key things to know about autism?

“Firstly, autism isn’t a disease. It’s a certain neurotype that means we experience the world differently to most of the population, and we sometimes need extra support to function in a society built for the neurotypical mind.

“Secondly, the best way to support an autistic person is to ask them what their preferences and needs are and work from there.

“Thirdly, autism can look different in different people. For example, autism generally presents differently in females than males. It doesn’t always present in the stereotypical way that the media portrays it, which is skewed towards the experience of a specific type of male autistic.”

Staff News

Welcome - The ATI welcomes: Dr Youngchan Kim, Lecturer in the Leverhulme Quantum Biology Doctoral Training Centre (QB-DTC), as a joint appointment between the Faculty of Health and Medical Sciences and the Faculty of Engineering and Physical Sciences.

We also welcome Koen Buisman, Reader in microwave and mm-wave electronics. Koen will take over the running of the n3M Laboratory in addition to his academic duties.