JULY 2026 | VOL.46 NO.1
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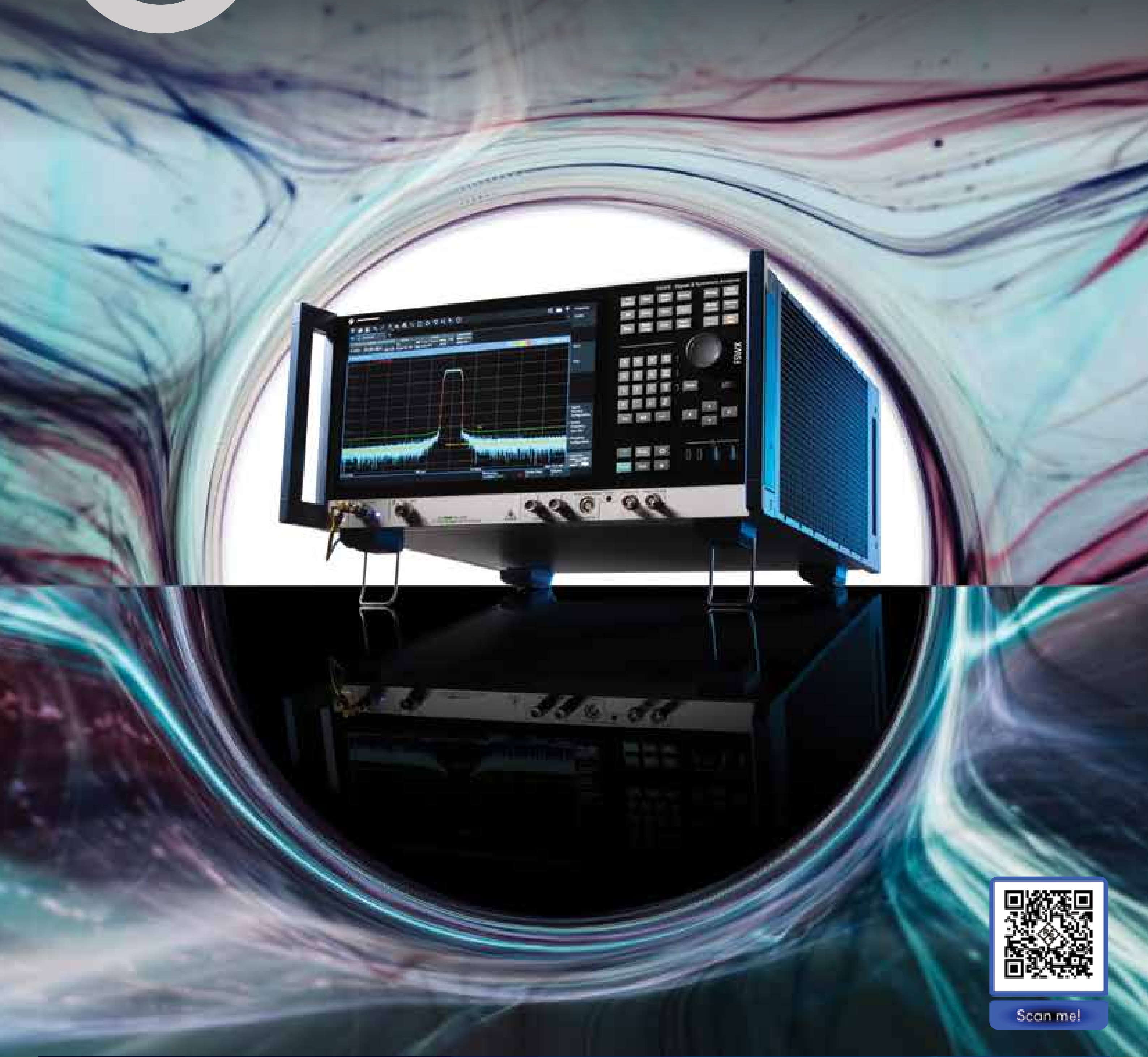
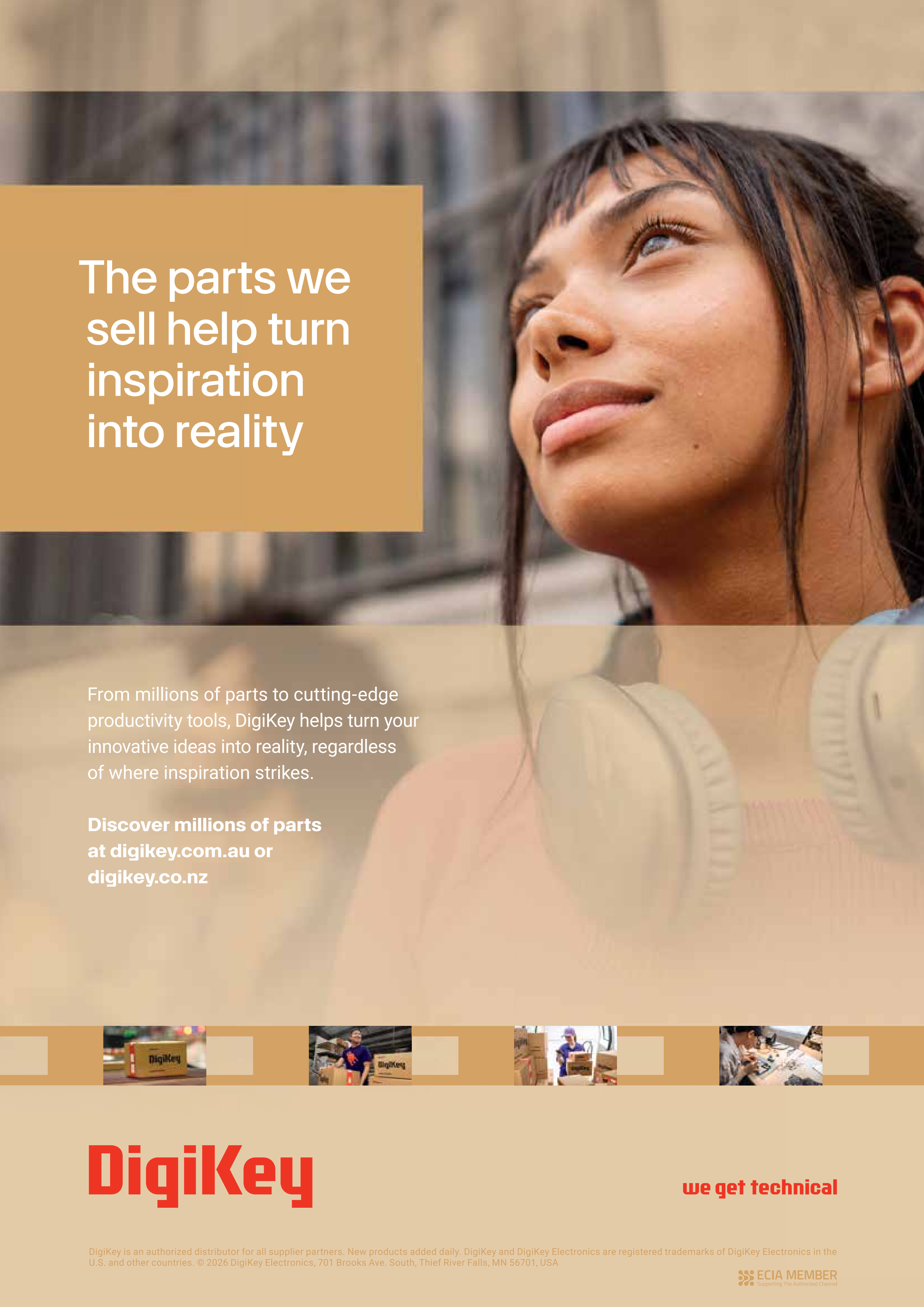
WHAT'S NEW IN ELECTRONICS

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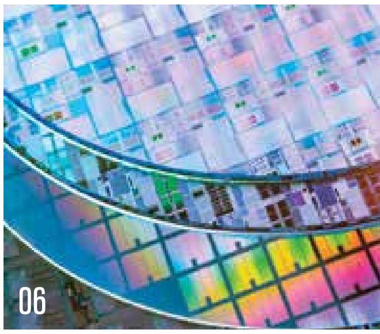

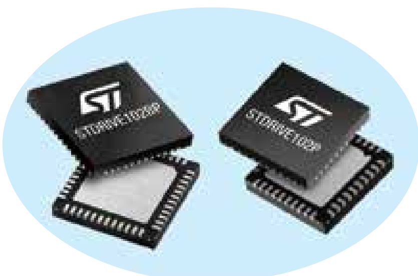

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cover story

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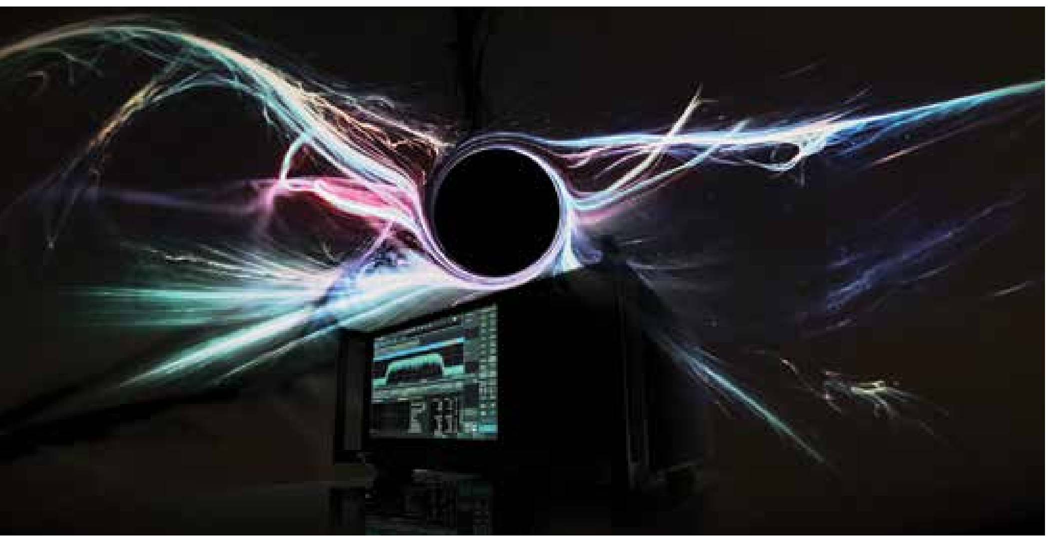
In today's fast-paced technological landscape, it is crucial to have a reliable and efficient signal analysis solution that can transcend limits and overcome the limitations of traditional measurement methods. The cutting-edge, two-path FSWX architecture makes a new level of performance and precision in signal analysis a reality.

The FSWX advanced signal analysis solution shows the real performance of a device under test (DUT) like never before. The FSWX introduces a groundbreaking concept in signal and spectrum analysis. Designed for wide bandwidths, it is not a classic heterodyne receiver. Signal and spectrum analysis use the same signal path and the same broadband A/D converter. The signal is down-converted via a maximum of one mixer stage and most of the analysis is performed in the powerful digital backend. Additionally, a dual-channel version supports both 26.5 GHz and 44 GHz.

This innovative concept enables multichannel measurements, cross-correlation, high sweep speed and unrivalled precision. It is now possible to analyse signals at the lowest levels and capture critical details to ensure that no important information goes unnoticed.



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Printed and bound by Dynamite Printing
Print Post Approved PP100007394
ISSN No. 0728-3873

Machine learning advances semiconductor materials research

New research using an artificial intelligence (AI) system is helping to develop new gallium-based semiconductor materials faster than traditional methods.

The international study, led by Flinders University in collaboration with Khalifa University UAE, built the machine-learning platform to act like a “smart materials discovery engine”, which is capable of reducing the time spent on complex computer or lab experiments to test and find new materials for future semiconductors.

“The challenge is that there are millions of possible material combinations, and testing them one by one in the laboratory or with complex computer simulations is extremely slow and expensive,” said Professor Vi- Khanh Truong, lead author of a new article in *ACS Materials Letters*.

“Instead of randomly searching for materials, the AI we developed learns the hidden chemical rules that control how gallium-based materials behave and then predicts entirely new material compositions with desired electronic properties.”

Gallium is one of 31 critical minerals sourced in Australia, and has a wide range of uses. It is commonly used in electronics but it has gained attention recently for its efficiency in computer chip technology. Gallium arsenide, the primary chemical compound of gallium in electronics, is used in microwave circuits, high-speed switching circuits and infrared circuits.

The AI system was trained using thousands of known semiconductor materials from international materials databases. It then used Bayesian optimisation, a form of intelligent decision-making, to continuously search for promising new gallium-containing materials while avoiding chemically impossible combinations.

“Importantly, the system does not simply generate random formulas. It checks whether the proposed materials are chemically realistic and physically stable before recommending them. This significantly reduces wasted effort and accelerates the pathway toward experimental validation,” said Truong.

“The study successfully generated multiple, completely new gallium-based semiconductor candidates that were not present in existing databases.” said Truong.

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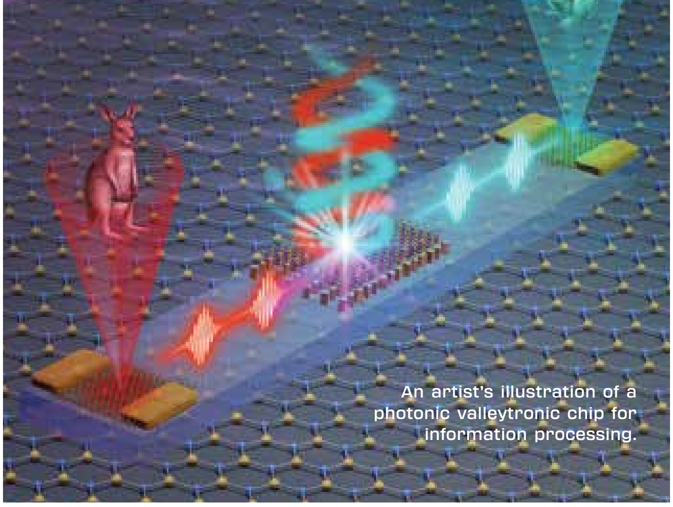
Monash team demonstrates room-temperature photonic circuit



An artist’s illustration of a photonic valleytronic chip for information processing.

Image credit: Chi Li.

Researchers from Monash University have developed a nanoscale circuit that can generate, direct and read light-based information, all on a single chip.

The new technology, brings together cutting-edge materials and nanotechnology to overcome a longstanding challenge in “valleytronics”, an emerging field that could underpin faster, more energy-efficient computing and quantum technologies.

The researchers have demonstrated a fully integrated system that can generate special light signals, guide them in precise directions, and convert them into electrical signals, all within a compact, chip-based device.

These light signals carry information using a property known as the “valley degree of freedom”, a quantum characteristic of materials that can be harnessed to encode and process data in entirely new ways.

Lead author of the study published in ***Nature Photonics*** Dr Chi Li said the development solves a key bottleneck that has limited the field for years.

“Until now, we could generate or detect these signals, but not do everything in one integrated device. What we’ve built is a complete on-chip system that can create, route and read this information with very high precision,” Li said.

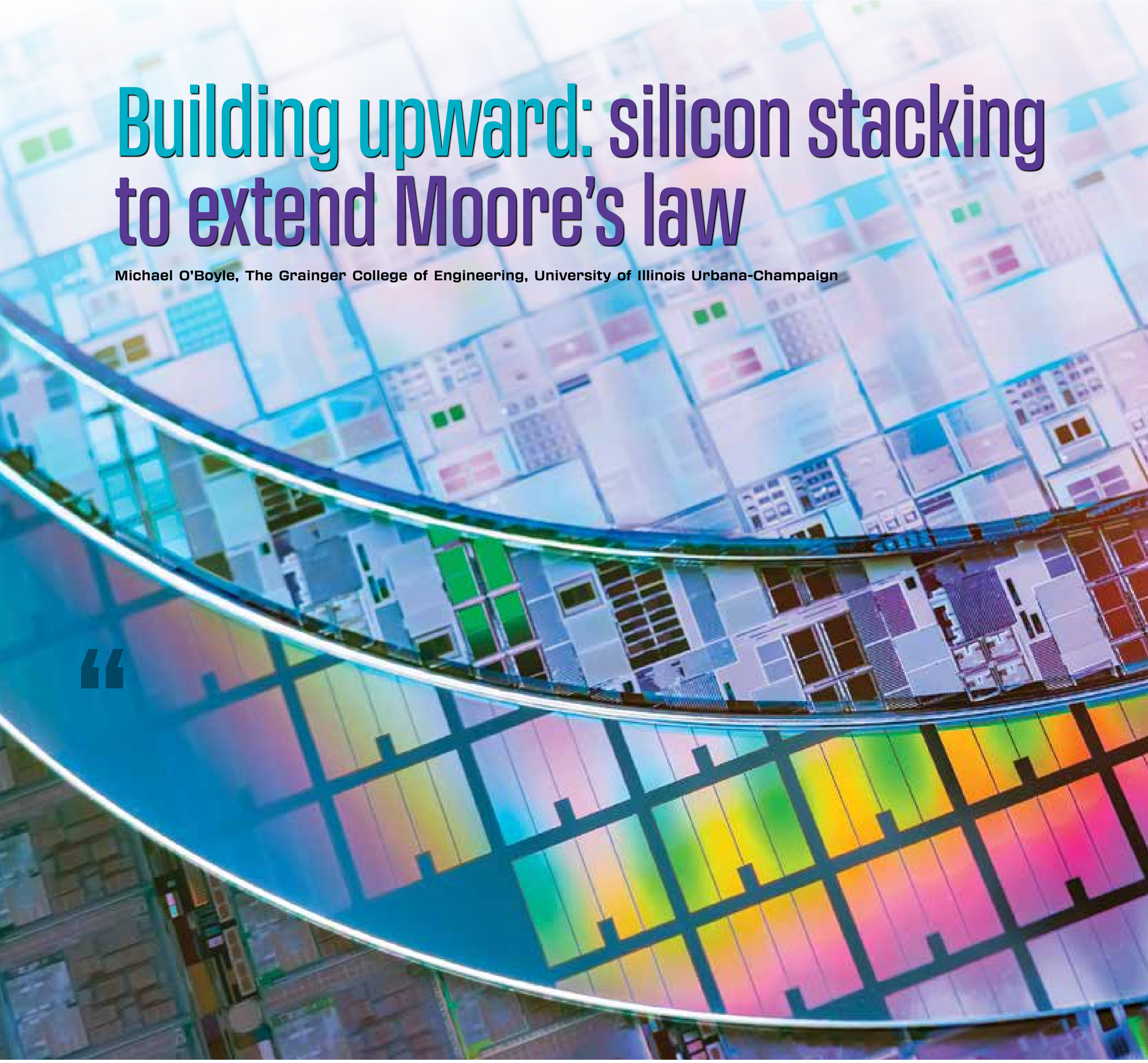
Dr Kaijian Xing, co-first author, said the device works by using ultra-thin materials, just a few atoms thick, combined with specially designed nanostructures that control how light behaves at extremely small scales.

“We employ a straightforward stacking approach to integrate ultra-thin materials with metasurfaces, overcoming the technical challenges of direct material growth on photonic structures, and enabling further advances in valleytronics,” Xing said.

Importantly, the system operates at room temperature, making it far more practical than many quantum technologies that require extreme cooling.

Senior author Dr Haoran Ren said the work opens the door to a new class of compact, programmable photonic devices, and could enable faster and more energy-efficient computing systems, as well as new approaches to secure communications and data processing.

“This is a significant step toward scalable, chip-based technologies that use light instead of electricity to process information,” Ren said.



Building upward: silicon stacking to extend Moore's law

Michael O'Boyle, The Grainger College of Engineering, University of Illinois Urbana-Champaign

RESEARCHERS LED BY ILLINOIS GRAINGER ENGINEERING PROFESSOR QING CAO HAVE DEMONSTRATED A SCALABLE WAY TO DIRECTLY AND SEQUENTIALLY STACK HIGH-PERFORMANCE SILICON CIRCUITS. THIS ADVANCE MARKS A CRITICAL STEP TOWARDS REALISING THE FULL POTENTIAL OF THREE-DIMENSIONAL CHIPS THAT COULD CARRY COMPUTING BEYOND THE LIMITS OF TRADITIONAL SCALING.

For more than half a century, the power of computers has grown by shrinking transistors and packing them more tightly onto flat chips. It worked too well. Devices are now becoming so small that they start to be fundamentally limited by atomic dimensions and quantum effects.

The next leap can come from adding a new dimension: building upward. By vertically stacking layers of silicon circuits, chipmakers can dramatically increase computing density and speed while reducing energy use, offering a promising route to extend Moore's law without shrinking transistors any further.

Illinois Grainger Engineering materials science and engineering professor Qing Cao said, "Take something as simple as static random-access memory, which is universal in CPUs and GPUs. Today it takes six microelectronic devices called transistors on a single plane to store one bit of information. With vertical integration, you can distribute them across multiple layers. It's like replacing a sprawling suburb with high-rises: you get the same functionality, but the spatial footprint is reduced while making communication between layers faster and more efficient."

The most efficient approach, known as monolithic three-dimensional integration, builds each layer directly on top of the previous one to maximise interlayer connectivity. However, achieving this has been a longstanding technical challenge. Preparing high-quality silicon and fabricating high-performance devices normally require processes operating at 1000°C, hot enough to destroy the metal wiring. For upper layers beyond the first, the temperature constraint, or 'thermal budget', is strictly set to 400°C.

A team of Illinois Grainger Engineering researchers led by Cao has now shown that it is possible to stay within that limit while still achieving high device performance across multiple tiers. Their newly invented process uses single-crystalline silicon — the main semiconductor used in industry — and has demonstrated device yields of 98–100%, even in an academic laboratory cleanroom setting, indicating strong potential for industrial adoption.

"Vertical integration is already starting to make its way into commercial devices, particularly in specialised AI hardware, but monolithic integration is what unlocks the full promise of 3D chips," Cao said. "For the first time, we have met the thermal budget of monolithic 3D integration using standard single-crystalline silicon and delivered unprecedented performance."

This study appears in ***Nature*** as one of the journal's rare research articles focused on silicon microelectronics.

The work was conducted within Illinois Grainger Engineering's Center for Advanced Semiconductor Chips with Accelerated Performance, which counts IBM, Intel and the Taiwan Semiconductor Manufacturing Company, among its industry partners. The team is now preparing to translate their process to an industrial semiconductor foundry.

Building circuits in three dimensions

Microelectronics manufacturing has been driven for the past 60 years by Moore's law, which states that the density of transistors on a chip should double every two years. The electronics industry has adopted this principle as a production goal to increase the power and efficiency of computer processors. It has proven successful and steady for decades, but there are signs that the trend is starting to stall.

"In a sense, we're hitting a limit imposed by physics," Cao said. "If you look at the actual size of transistors, they're not getting smaller, especially in terms of their contacted gate pitch. This is because we're becoming limited by the intrinsic material properties of silicon and the fundamental rules of quantum mechanics. If we're going to keep up the trend of increasing processing power of our microprocessors, we have to start thinking beyond just squeezing more devices on a single surface."

Many experts believe that the way forward will be building upward to vertically integrate devices. It gives room for expansion without further shrinking individual devices. It also shortens the needed length of wiring, reducing parasitic capacitance while dramatically increasing the communication bandwidth between devices and circuit blocks. These features offer a crucial advantage for artificial intelligence and other forms of data-intensive computing.

>

The promise of monolithic integration

Current commercial three-dimensional chips are made by fabricating semiconductor devices on separate wafer substrates first and then bonding those wafers or dies together. While this approach has enabled successful products such as high-bandwidth memory and 3D V-Cache chips, it comes with substantial limitations. The alignment between layers is necessarily coarse, and the micron-scale vertical connections between layers called through-silicon via (TSV) are relatively large and sparse.

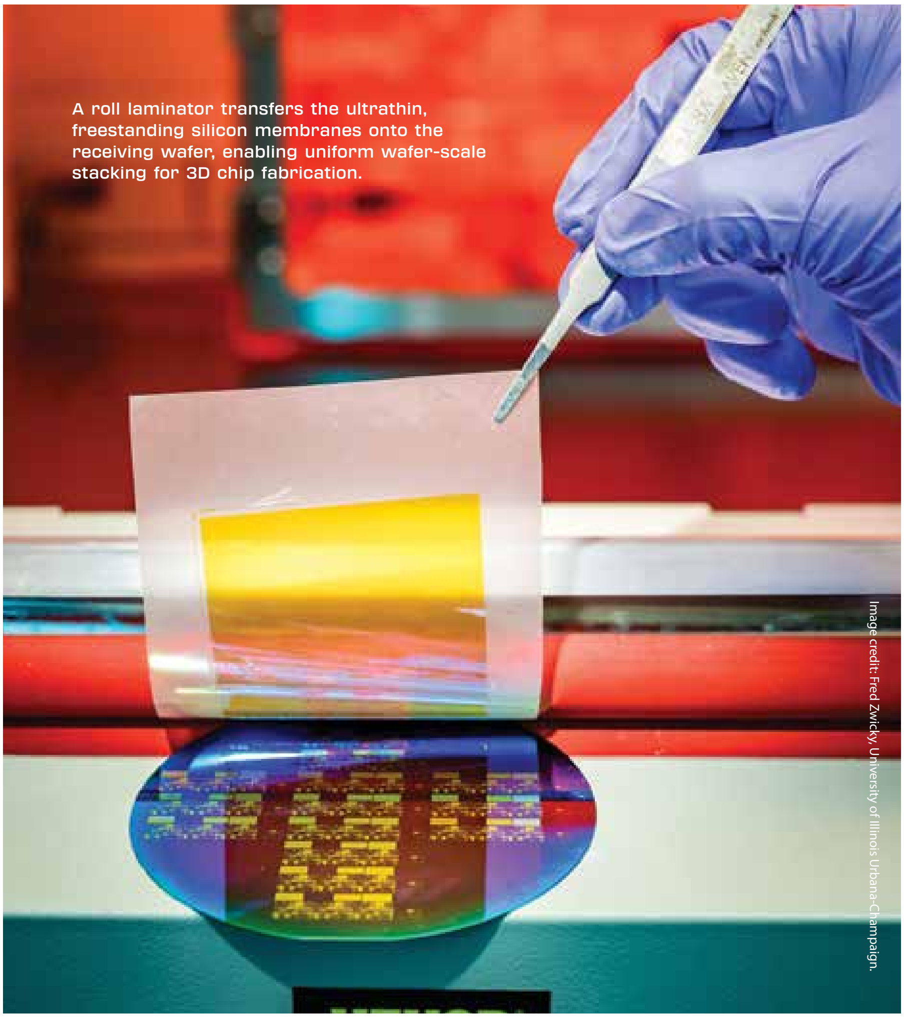
In contrast, monolithic three-dimensional integration takes a fundamentally different approach. Instead of stacking complete wafers, each device layer is sequentially built directly on top of the previous one during fabrication. This procedure allows for much (10–100 times) denser interlayer vertical connections, smaller separations between layers, and precise interlayer alignment with nanometre-scale accuracy.

The main barrier to a practical realisation of this process is temperature. Forming high-quality crystalline silicon and then fabricating high-performance semiconductor devices both require temperatures close to 1000°C, while the metal interconnects used to communicate between devices melt far below that point.

"Generally, the industry accepts that once the first layer of circuits is complete, the thermal budget limit for any additional layers is 400°C," Cao said. "Researchers in both academia and industry have tried to get around this by working with semiconductor materials other than single-crystalline silicon for the upper layers. But the resulting devices all inevitably suffer from issues with performance and reliability."

The alternatives that have been explored include polycrystalline silicon, amorphous or nanocrystalline metal oxides, and nanomaterials such as carbon nanotubes and two-dimensional semiconductors. They all have limitations originating in either intrinsic material properties or extrinsic defects introduced during processing, creating a mismatch between the bottom layer of silicon transistors built on the starting silicon wafer substrate and those upper layers.

The Illinois Grainger Engineering team devised a process that achieves monolithic three-dimensional integration using standard single-crystal silicon. The method starts with creating ultrathin, freestanding silicon nanomembranes from a donor wafer, and these membranes are then transferred onto the receiving substrate that already contains completed bottom-layer circuits using a roll laminator. The process requires no more than 200°C to generate a strong bond between the substrate and the transferred layer. As a result, high performance and reliability were maintained with the high crystalline quality of the silicon films while the process stayed well within the thermal budget.



A roll laminator transfers the ultrathin, freestanding silicon membranes onto the receiving wafer, enabling uniform wafer-scale stacking for 3D chip fabrication.

Image credit: Fred Zwicky, University of Illinois Urbana-Champaign.

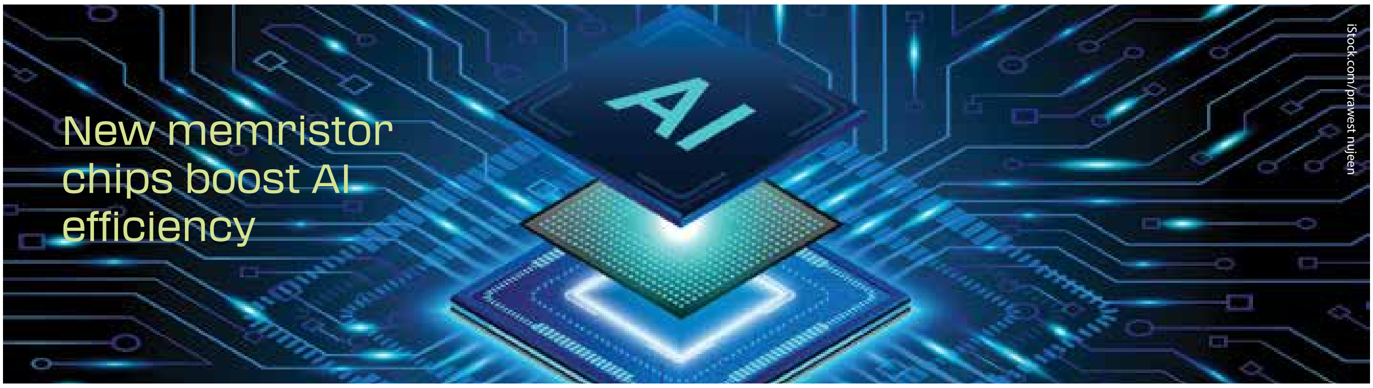
"Our method is not only easier to implement with lower cost, but it has several advantages over previous approaches to stack silicon wafers," Cao said. "The membranes we transferred are only 10 nanometres thick or less, compared to the 500 to 700 micrometres thickness of a typical wafer. Because they are thin, these membranes are mechanically flexible to conform to the underlying surface. This conformality helps avoid interfacial defects like voids, which are common when trying to force two rigid wafers together via wafer bonding."

The team also needed to rethink transistor design and fabrication. Conventional transistor fabrication requires a process known as 'doping' to introduce impurities to the silicon to control its electrical properties. This is a high-temperature process typically exceeding 600°C, and different regions of the device need to be doped differently. To avoid this, the researchers used devices called 'junctionless transistors' in which the silicon is uniformly and heavily doped before the layering step. Because the films are extremely thin, the gate can still control the channel effectively, while the high doping level reduces parasitic contact resistance.

Using this process, the team built three stacked layers, each containing 625 transistors, with good yield and uniformity. The output current densities of these transistors were comparable to that of standard silicon transistors fabricated on bulk wafers under a much higher temperature and at least three to four times greater than those of monolithic devices made from alternative materials, indicating a substantial improvement in performance. By connecting the layers with vertical metal lines, the researchers demonstrated three-dimensional integrated logic circuits and static random-access memory cells.

"But most importantly, we've shown that this process is scalable," Cao said. "You can keep stacking layers beyond the three we demonstrated. And the process will yield high-performing transistors with high yield and low variability. We now have a strong foundation for transferring this technology and demonstrating its immediate promise in an industrial semiconductor foundry."

SHORT CIRCUITS



New memristor chips boost AI efficiency

An Oregon State University College of Engineering researcher has helped develop a new artificial intelligence chip that could improve energy efficiency six times over the current industry standard.

As the use of artificial intelligence soars, so does the amount of energy it requires. Projections show artificial intelligence accounting for half a percent of global energy consumption by 2027.

Sieun Chae, assistant professor of electrical engineering and computer science, is working to help shrink the technology's electricity footprint. She is researching chips, based on a novel material platform, that allow for both computation and data storage, mimicking the way biological neural networks handle information storage and processing.

Findings from her research were published in *Nature Electronics*.

"With the emergence of AI, computers are forced to rapidly process and store large amounts of data," Chae said. "AI chips are designed to compute tasks in memory, which minimises the shuttling of data between memory and processor; thus, they can perform AI tasks more energy-efficiently."

The chips feature components called memristors — short for memory resistors. Most memristors are made from a simple material system composed of two elements, but the ones in this study feature a new material system known as entropy-stabilised oxides, or ESOs. More than a half-dozen elements comprise the ESOs, allowing their memory capabilities to be finely tuned.

Memristors are similar to biological neural networks in that neither has an external memory source — thus no energy is lost to moving data from the inside to the outside and back. By optimising the ESO composition that works best for specific AI jobs, ESO-based chips can perform tasks with far less energy than a computer's central processing unit, Chae said.

Another upshot is that artificial neural networks would be able to process information that's time-dependent, such as data for audio and video, thanks to tuning the ESOs' composition so the device can work on a varied time scale.

Funded by the National Science Foundation, the study was led by researchers at the University of Michigan; Chae participated as a doctoral student at Michigan before joining the faculty at Oregon State.

Battery study explores safer rapid-charging methods

Researchers at Adelaide University have discovered a promising new strategy which could deliver fast battery charging.

The team, led by Professor Shi-Zhang Qiao, an ARC Industry Laureate Fellow in the University's School of Chemical Engineering, created pouch battery cells using interfacial anion-reduction catalysis to record a charge of more than 85% after six minutes.

The cells also provided about 240.4 watt-hours per kilogram after less than six minutes of charging.

Fast-charging capabilities are essential for accelerating the adoption of electric vehicles. Qiao said current models of high-capacity batteries, like those of silicon and lithium, are fast, but their capacities fade rapidly.

"Current models also increase heat generation during fast charging, which can exacerbate battery degradation and safety risks. Until now, achieving more than 90% charge within 10 minutes without sacrificing energy density and cycle life has been a formidable challenge," Qiao said.

Qiao and his team, which included researchers from Imperial College London, researched the capabilities of a cell using interfacial anion-reduction catalysis.

"The catalytic sites on the electrode surface attract anions to the battery interface and promote the formation of a robust inorganic protective layer, which is critical for fast charging and long-term stability," he said.

"Unlike traditional electrolyte engineering, which often affects the entire electrolyte system, this strategy regulates reactions only at the interface, allowing fast charging without sacrificing ionic conductivity."

Qiao added that the discovery provides a new strategy for developing practical fast-charging lithium-ion batteries.

"Our test cell exhibited excellent performance, achieving about 76% capacity retention after 500, six-minute cycles. The cells also exhibited excellent stability at 10 minutes of charging. The discovery could help enable electric vehicles that charge in minutes without sacrificing battery life or energy density," Qiao said.

The findings have been published in the journal *Nature Energy*.

The team will now focus on scaling up the technology and testing its long-term performance under practical operating conditions.

Comau and Omron Robotics to expand industrial automation solutions

Omron Robotics has signed a strategic collaboration agreement with Comau, an automation solutions company, to speed the adoption and deployment of advanced industrial automation solutions for manufacturers worldwide.

The partnership will focus on high-growth sectors including electronics, semiconductors, medical manufacturing and light industrial intralogistics. It comes in response, the companies said, to a rising customer need for scalable, adaptable automation solutions that can be integrated into existing production lines as well as next-generation manufacturing environments.

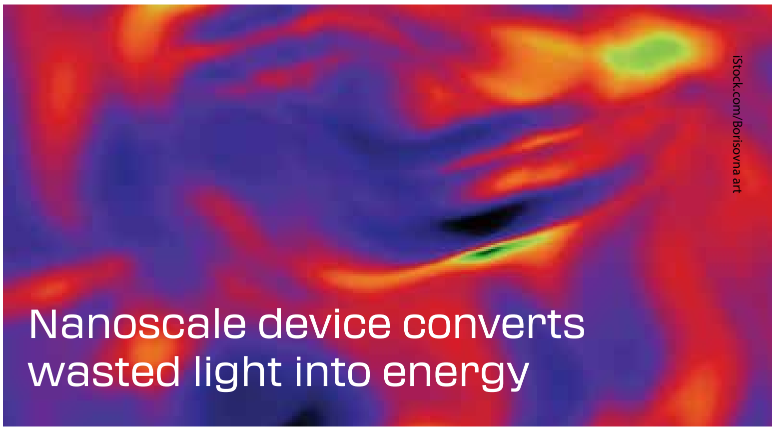
"By combining Comau's robotics expertise with Omron's complementary technologies and software capabilities, we enable the delivery of solutions that are easier to deploy, highly adaptable and future-ready," said Pietro Gorlier, CEO of Comau.

Olivier Welker, CEO of Omron Robotics, added: "By aligning our expertise in robotics, applications, advanced control and intelligent automation technologies, we can help manufacturers respond faster to changing market demands.

"Together, this new collaboration will allow us to deliver more flexible, connected and sustainable production systems that support long-term growth for our customers."

Image: Supplied

Omron CEO Olivier Welker with Pietro Gorlier, CEO of Comau.



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Nanoscale device converts wasted light into energy

UNSW Sydney scientists have addressed a longstanding problem in photonics: how to stop energy from being lost before it can be used.

The researchers managed to create a nanoscale device that converts low-energy infrared and red light into higher-energy visible light. The device achieved photon conversion efficiencies of 8.2% — among the strongest reported for this type of architecture, according to UNSW.

"This work demonstrates a big step forward," said the study's lead author, UNSW researcher Dr Thilini Ishwara.

"Achieving high efficiencies in films is difficult in these ultrathin molecular systems — good light absorption is needed and energy loss needs to be minimised."

The breakthrough has implications for industries looking to recover or reuse wasted infrared light, such as solar panel manufacturing. In solar energy systems, large amounts of low-energy light pass straight through conventional silicon cells unused; converting some of that light into visible wavelengths could improve overall performance.

The researchers said the approach may also be relevant to infrared sensing, photocatalysis, optical communications and next-generation additive manufacturing technologies such as volumetric 3D printing.

Importantly, the system operates in a solid-state structure compatible with semiconductor-style manufacturing, making it more commercially practical than earlier liquid-based approaches.

"We are keen to commercialise our technology," Ishwara said.

"It could be used for a range of techniques such as tumour treatment with deeper tissue penetration, cheap water purification, night vision and 3D printing."

The study has been published in *Nature Photonics*.

Dendrites tied to Li-ion battery failures

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SCIENTISTS FROM THE NEW JERSEY INSTITUTE OF TECHNOLOGY HAVE OBSERVED HOW TINY METAL 'THORNS' CALLED DENDRITES SPROUT INSIDE LITHIUM-ION BATTERIES, WHICH CAN CAUSE THE BATTERIES TO SHORT-CIRCUIT. THEIR FINDINGS, PUBLISHED IN THE JOURNAL *SCIENCE*, SHED LIGHT ON PREVIOUSLY UNKNOWN MECHANICAL PROPERTIES OF LITHIUM DENDRITES AS THEY GROW.

Scientists have long studied lithium dendrites, but did not fully understand how these structures behave inside batteries. Dendrites form at the nanoscale; their growth is challenging to observe in the closed system of a working battery, but has been linked to battery decline and failure.

The new study, an international collaboration between researchers from universities in the US and Singapore, combined experiments and simulations to provide a first glimpse of how dendrites crystallise, according to co-lead author Xing Liu, an assistant professor of mechanical and industrial engineering at New Jersey Institute of Technology.

"This work reflects a close collaboration between experimental and computational mechanics and could help improve battery safety," Liu said.

Co-lead author Qing Ai, a former research scientist at Rice University, added, "Despite decades of study, the fundamental nanomechanical properties of lithium dendrites remained a mystery — until now."

Customised platforms

Measuring about 100 times smaller than the width of a human hair, lithium dendrites (from the Greek word for "tree-like") grow from anodes — negative terminals in lithium-ion batteries. Dendrites' branches can penetrate into a lithium cell's electrolyte; if dendrites extend from the negatively charged anode to the positively charged cathode, they can short out the battery.

"Lithium dendrites are widely recognised as one of the biggest obstacles to the commercialisation of lithium-metal batteries," Liu said. "During battery operation, lithium dendrites can form, break and become electrically isolated from the lithium metal anode, creating what is known as 'dead lithium'. This process leads to a gradual loss of battery capacity over time. In addition, dendrites can penetrate the separator and create an internal short circuit between the anode and cathode. Both capacity loss and short-circuit risks associated with dendrites are commonly observed in lab studies."

What's more, lithium dendrites are near-impossible to remove from a battery once they form.

"At present, there is no practical method to 'clear' dendrites from a working battery cell," Liu said.

For the new study, researchers at Rice University and collaborators at Georgia Institute of Technology, the University of Houston and the Nanyang Technological University in Singapore harvested dendrites from working batteries to test their mechanical strength.

"To enable the quantitative study of lithium dendrites, we developed customised sample preparation and mechanical characterisation platforms for such delicate work," said Boyu Zhang, co-lead author on the study.

Co-corresponding author Jun Lou led a team at the Nanomaterials, Nanomechanics and Nanodevices lab in directly probing the mechanical behaviour of dendrites as they formed in real batteries. Ai and Zhang, both former members of Lou's lab, performed the delicate experiments with support from study co-corresponding author Hua Guo and co-author Wenhua Guo of the Rice University Shared Equipment Authority.

To conduct the experiments, they constructed airtight platforms for preparing and studying samples, as lithium is highly reactive and undergoes chemical and structural changes when exposed to even small quantities of air. High-resolution electron microscopy then revealed how individual dendrites deform in response to controlled stresses.

Lithium in bulk is supple and squishy; lithium dendrites were therefore expected to be similarly pliant. However, the experiments showed otherwise. The researchers observed dendrites breaking in real time during battery operation, providing evidence for dendrite brittleness in both liquid and solid electrolyte systems.

"Lithium dendrites have long been assumed to be soft and ductile, like Play-Doh," Liu said. "But our observations suggest that they may instead be strong and brittle — snapping more like dry spaghetti."

Teams at NJIT and Georgia Tech then contributed modelling and theoretical analysis of data from the observations.

"We conducted scale-bridging simulations to explain why lithium dendrites behave differently from previously thought," Liu said.

They found that as dendrites form in a battery cell, a thin layer of solid electrolyte interphase, or SEI, encases them. The SEI coating makes dendrites rigid and needle-like, capable of piercing battery cells' separators and electrolytes and prone to snapping under stress, accumulating in the battery cell as fragments of dead lithium and contributing to battery failure.

"Understanding the underlying physics provides new insights into how to make dendrites less prone to brittle fracture — for example, by using lithium alloy anodes," Liu said. For researchers who study computational mechanics, mechanisms such as those observed in the study — how structures deform and what makes them shatter and fail — are like musical notes which can be incorporated into a 'symphony' of high-performance materials and high-energy storage systems.

"The strengthening mechanism we identified in lithium dendrites adds a new note to this composition," Liu said.

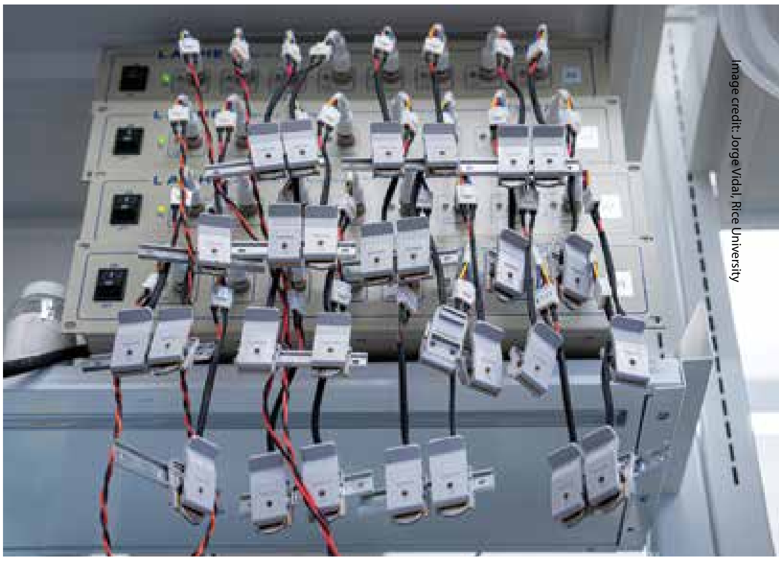
Image credit: Jorge Vidal, Rice University

Integrated drive system

The FAULHABER BXI integrated drive system is designed to meet the demanding requirements of next-generation robotics, where precision, force and dynamic response must work together. Designed for human-like motion — from delicate gripping to powerful joint actuation — the BXI delivers a compact solution for advanced robotic systems.

The system combines a motor, integrated planetary gearhead and high-resolution encoder into a single unit, enabling maximum performance within minimal space. This integrated architecture reduces complexity while improving thermal management and overall system efficiency.

With torque capability of up to 20 Nm and a compact installation length of approximately 34 mm, the system achieves high power density and fast response times, making it suitable for space-constrained robotic joints and precision motion systems.

The integrated absolute encoder supports precise positioning and stable control, even in environments where accuracy and repeatability are critical. Combined with FAULHABER motion controllers, the BXI system forms a complete, optimised drive solution for complex motion tasks.

Typical applications include humanoid robotics, cobots and advanced automation systems where compact size, high torque and smooth, controlled motion are essential.

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Compact module

Advantech has introduced the SOM-6820, a COM Express Compact Type 6 module powered by Qualcomm Snapdragon X-Elite and X Plus series processors. Featuring up to 12 cores, a 45 W TDP and an integrated Hexagon NPU delivering up to 45 TOPS of AI performance, the module offers enhanced AI processing while achieving up to 65% greater power efficiency than comparable platforms.

Designed for demanding edge AI applications, the module supports up to 64 GB of LPDDR5x memory and 256 GB of onboard UFS 3.1 storage for fast data processing. Its flexible I/O includes 14 PCIe lanes, 4 USB 3.0 ports, 4 SATA3 ports and GbE LAN, enabling connectivity for a wide range of peripherals. With an operating temperature range of -40 to 85°C, it is designed to perform in harsh industrial environments.

The integrated Adreno GPU provides up to 4.6 TFLOPS of graphics performance, while the Hexagon NPU accelerates AI inference for applications such as medical imaging, machine vision, mission-critical systems and humanoid robotics. Improved AI efficiency also reduces reliance on external graphics cards, lowering system cost and space requirements.

The compact module also incorporates Advantech's Quadro Flow Cooling System (QFCS), enabling quiet operation under demanding workloads. Comprehensive software support, including Windows 11, UEFI BIOS and the Advantech Edge AI SDK, simplifies cross-platform migration and accelerates AI development and deployment. Backed by a 10-year product lifecycle, the SOM-6820 provides a powerful solution for next-generation embedded AI applications.

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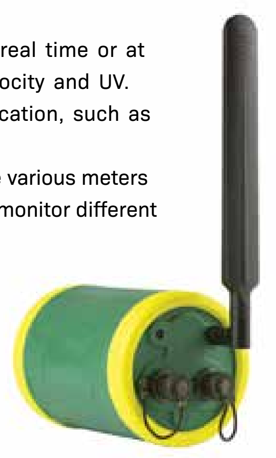
Wireless data logger

Wireless data loggers are the evolution of wired devices for monitoring and recording measurements, in real time or at set intervals, of various physical and chemical quantities such as temperature, humidity, pressure, air velocity and UV. The ISOIL MV155 wireless data loggers from AMS Instrumentation can be used in multiple fields of application, such as measuring and recording data relating to flow, pressure and fluid level.

The data loggers also accept inputs from multiple devices, both analog and digital, recording signals from the various meters by sampling them at regular intervals. By storing data received from multiple instruments, the data loggers can monitor different parameters at the same time, which can then be downloaded to a PC to be read, processed and analysed.



Widely used in civil and industrial fields, data loggers are important tools in applications where monitoring of specified parameters within predetermined thresholds is needed. The MV155 is a multi-parametric data logger that can be powered by lithium or alkaline batteries or by an external source.

Due to its shape, reinforced PA6 Nylon case and MIL connectors, it is suitable for installation outdoors or in harsh environments, where it maintains IP68 protection. The data logger can also be configured with different combinations of digital and analogue inputs, monitoring flow rate, pressure, temperature and fluid level, while providing power to external sensors. It has a high logging capacity which can be downloaded to a PC.

The data logger's 4G connection (with optional DNP3 protocol) enables it to send the stored data via email, SMS or via FTP/S, easily interfacing with AMS Instrumentation's ISOD@M system or with third-party systems. The encrypted data transmission also has an intrusion alarm function with instant alert via SMS and other wireless protocols.

AMS INSTRUMENTATION & CALIBRATION PTY LTD
www.ams-ic.com.au

IGUS DEVELOPS INNOVATIVE ENERGY CHAIN FOR CLEANROOMS

In facilities that manufacture microelectronics, semiconductors or batteries, maximum cleanliness is a necessity. Surroundings must be free from particles while energy and data are conveyed smoothly. This is becoming a real challenge because, as automation increases, the routes for material transport are getting longer.

In modern semiconductor factories, silicon wafers undergo numerous process steps — from lithography to etching to metallisation. Due to strict requirements for cleanliness and freedom from particles, manual transport within the cleanroom is not feasible. Instead, automated systems are being used more and more to transport the wafer cassettes over long distances safely and efficiently.

For example, overhead hoist transport (OHT) is a rail system that moves the cassettes under the ceiling. Although this saves cleanroom space, it presents design engineers with a challenge: supplying the OHT with power and data.

"Busbar systems do not transmit data and require a lot of maintenance. Energy chains usually need a complex extraction device for particles. The demand for a cleanroom-compatible, durable and cost-effective alternative is correspondingly high in the industry," said Kira Weller, Product Manager for e-chains and Cleanroom Expert at igus.

Devising a system that rolls instead of gliding

To solve this problem, igus developed a special guide system called 'e-spin' for its C6 cleanroom energy chain. As with all igus energy chains, its guide wheels are made of tribologically optimised high-performance plastic — that is, plastic that's optimised for friction and wear. The wheels are located between the upper and lower run of the energy chain. As a result, the chain parts roll on top of each other instead of gliding — avoiding further particle emissions. "Thanks to the e-spin system, the energy chains can be used in production within a cleanroom without the need for an extraction unit. This allows design engineers to reduce the complexity of energy supply in transport systems and save costs in the process," Weller said.

The system allows for abrasion-resistant travels over distances of up to 30 metres. Laboratory tests in collaboration with the Fraunhofer IPA resulted in the system achieving the highest cleanroom Class ISO 1 at a speed of 0.5 m/s, igus said.

Treotham Automation Pty Ltd
www.treotham.com.au

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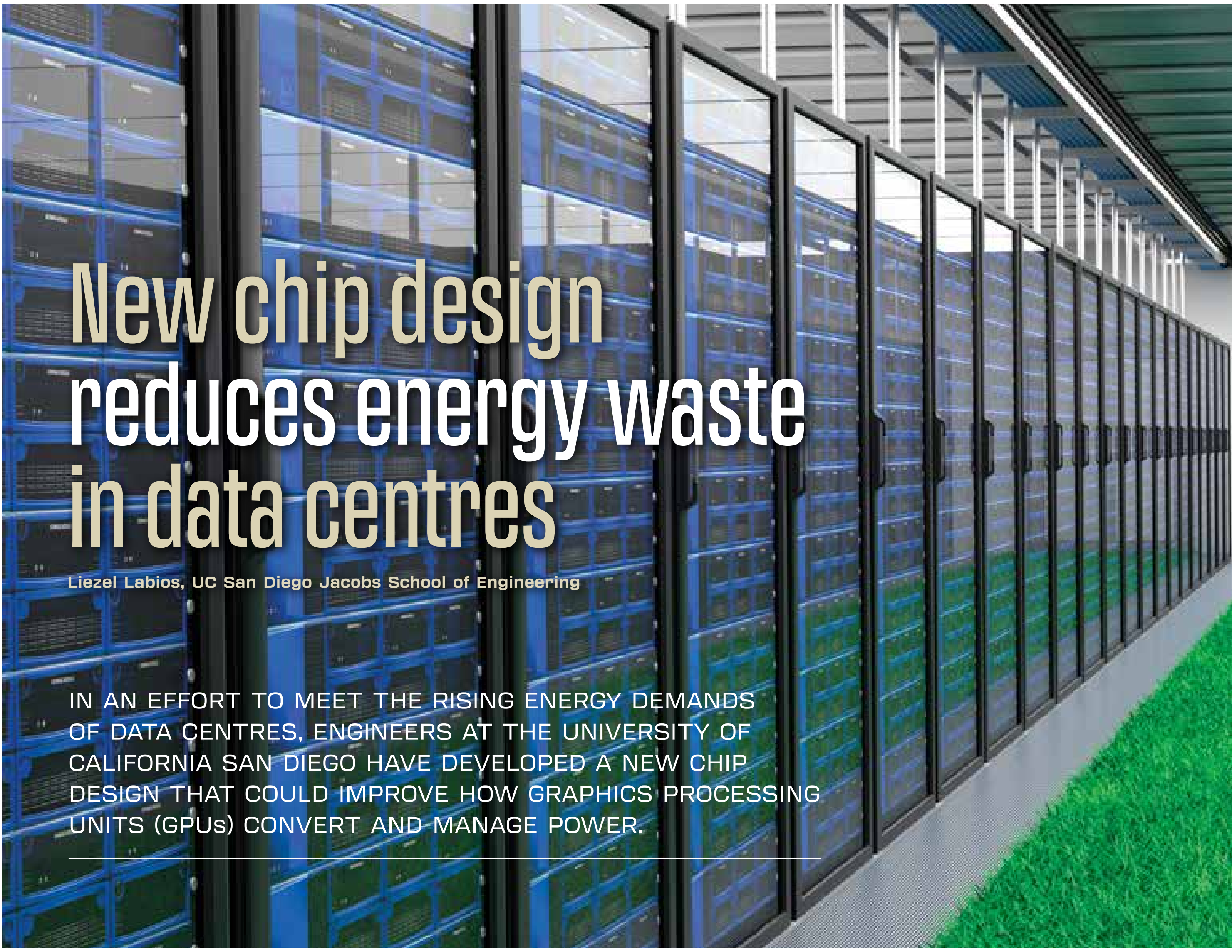


New chip design reduces energy waste in data centres

Liezel Labios, UC San Diego Jacobs School of Engineering

IN AN EFFORT TO MEET THE RISING ENERGY DEMANDS OF DATA CENTRES, ENGINEERS AT THE UNIVERSITY OF CALIFORNIA SAN DIEGO HAVE DEVELOPED A NEW CHIP DESIGN THAT COULD IMPROVE HOW GRAPHICS PROCESSING UNITS (GPUs) CONVERT AND MANAGE POWER.

The technology demonstrates a more efficient way to perform a critical task in electronics: converting high voltages into lower levels required by computing hardware. In lab tests, a prototype chip performed the type of voltage conversion used in modern data centres with high efficiency.

The advance, published in *Nature Communications*, could lead to the development of smaller, more energy-efficient systems for advanced computing.

The chip design offers a new approach to improving the performance of a circuit component known as a DC-DC step-down converter, which is found in nearly all electronics. The step-down converter acts as a protective bridge between power sources and sensitive circuits. It transforms a high input voltage into the lower voltage each component in the circuit precisely needs to operate safely. For example, data centres often distribute power at 48 volts, while processors in GPUs need much lower voltages, typically between 1 and 5 volts.

However, converting between these levels efficiently, and within limited space, has become increasingly difficult as computing demands grow.

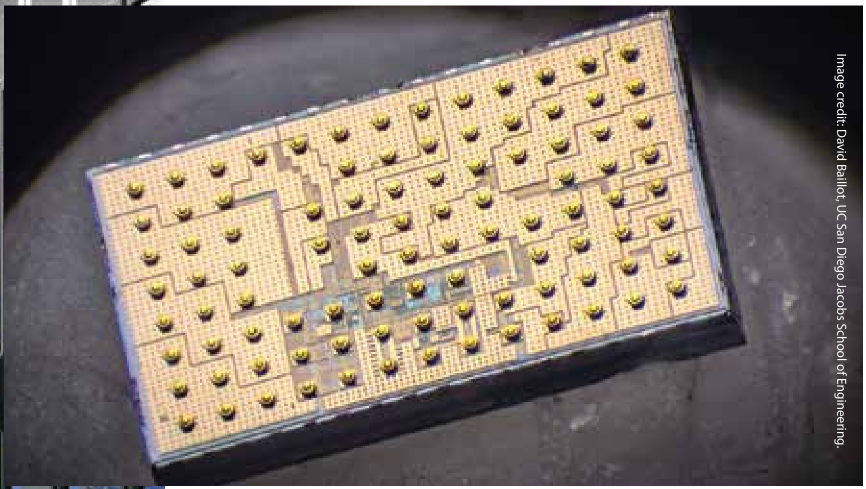
Traditional step-down converters, for instance, lose efficiency and struggle to deliver enough current when the gap between input and output voltage is large. Most step-down converters rely on magnetic components such as inductors, which, while effective, are approaching their physical performance limits and are growing difficult to scale further. “We’ve gotten so good at designing inductive converters that there’s not really much room left to improve them to meet future needs,” said study senior author Patrick Mercier, professor in the Department of Electrical and Computer Engineering at the UC San Diego Jacobs School of Engineering.

To address this challenge, Mercier and members of his research group, including study first author Jae-Young Ko, an electrical and computer engineering PhD student at UC San Diego, explored a promising alternative: piezoelectric resonators, which are tiny devices that store and transfer energy through mechanical vibrations. Piezoelectric-based converters could potentially be smaller, more energy dense, more efficient and easier to manufacture at scale. “They have a lot of room to grow and have the potential to deliver better performance than anything that’s come before them,” Mercier said.

However, early versions of piezoelectric-based converters have struggled to maintain efficiency and deliver enough power when handling large voltage differences.

In this study, the team developed an improved step-down converter that combines a piezoelectric resonator with small, commercially available capacitors arranged in a strategic way. This new circuit design allows the converter to handle larger voltage conversions more effectively. The team implemented the design in a prototype chip. In tests, it converted 48 volts down to 4.8 volts — a level commonly required in data centres — with a peak efficiency of 96.2%. The chip also delivered about four times more output current than earlier piezoelectric-based designs.

There are several advantages with this hybrid circuit design: it creates multiple pathways for power to flow; reduces wasted energy; and eases the workload on the resonator. As a result, it boosts both efficiency and power delivery with only a small increase in size.



A chip designed to convert high voltages into lower levels in electronics — a process known as DC-DC step-down conversion — more efficiently using a piezoelectric resonator.

Although the technology is still in its early stages, the researchers say it represents an important step towards overcoming the limitations of today's power converters. Future work will focus on improving materials, circuit design and packaging. Because piezoelectric resonators physically vibrate, they cannot be soldered onto circuit boards using conventional approaches, and will require different strategies to integrate them into electronic systems, Mercier explained.

"Piezoelectric-based converters aren't quite ready to replace existing power converter technologies yet," Mercier added. "But they offer a trajectory for improvement. We need to continue to improve on multiple areas — materials, circuits and packaging — to make this technology ready for data centre applications."

Network attached storage system

Spectra Defense Technologies' G2 Ultra Rugged microNAS is a compact network attached storage (NAS) system designed to support high-bandwidth sensor data capture and removable mission storage workflows across airborne, maritime, land and autonomous platforms. The system enables simultaneous ingest from multiple sensors within a single rugged enclosure, supporting next-generation intelligence, surveillance and reconnaissance (ISR) and autonomy architectures.

Modern deployed platforms increasingly rely on multiple high-speed sensor streams. However, legacy architectures often require additional switching hardware to manage these data sources. The G2 addresses this challenge by integrating four 10 GbE connections directly into a fully rugged system, allowing simultaneous capture of multiple sensor streams while simplifying system design and reducing integration complexity.

Designed for operation in demanding environments, the G2 Ultra Rugged microNAS features IP66 and IP67 ingress protection and supports removable NVMe storage modules up to 16 TB, enabling rapid mission data offload between deployments. The platform also supports multi-layer full-disk encryption options aligned with Coalition cybersecurity requirements.

The system is suited to a range of SWaP-constrained applications including: unmanned combat aerial vehicles (UCAVs); autonomous ground vehicles; tracked vehicles and optionally manned platforms; ground radar and air defence systems; and distributed intelligence nodes and sensor platforms.

The G2 Ultra Rugged microNAS is now available to customers in Australia and New Zealand from Metromatics, which can provide local engineering support and integration guidance for defence, autonomy and instrumentation applications.

METROMATICS PTY LTD
www.metromatics.com.au

High-performance computers

Advantech has introduced the AIR-410 and AIR-420, its next-generation compact Edge AI high-performance computers (HPCs). Powered by AMD Ryzen 7000/8000/9000 processors, scalable GPU options (up to four PCIe slots), and Advantech's Edge AI SDK, these systems are designed for data-intensive workloads such as LLMs, medical imaging and automated inspection.

By combining hardware and software into a single platform, the high-performance computers are designed to cut expenses in hardware, energy and maintenance, while offering stronger data security than traditional servers. Both models feature compact chassis, advanced thermal design and stable power for edge deployment.

The AIR-410 is a quiet, compact system supporting one 3-slot GPU, including NVIDIA RTX PRO 6000 Blackwell Max-Q, AMD Radeon PRO W7900 and Qualcomm Cloud AI 100 Ultra. It provides up to 96 GB DDR5 RAM, 14 TB storage and rich I/O, making it suitable for semiconductor inspection, medical imaging and on-premise LLM inference.

The AIR-420 is built for demanding GenAI and Vision AI workloads, supporting dual 600 W GPUs within a 28.6 L chassis. With redundant power, optimised CPU/PCIe layout and Advantech tools — aiSSD, aiDAPTIV+ and GenAI Studio — it enables efficient on-premise fine-tuning. GenAI Studio supports both full and parameter-efficient methods (PEFT, LoRA), helping enterprises adapt LLMs for edge applications.

Together, the AIR-410 and AIR-420 deliver compact and scalable solutions, thereby enabling up to 96% savings compared to rack-mounted servers while powering the future of edge AI.

ADVANTECH AUSTRALIA PTY LTD
www.advantech.net.au

Gate-driver integrated circuits

STMicroelectronics has introduced new STDRIVE102 gate-driver ICs for three-phase brushless motors, adding the STDRIVE102P and STDRIVE102BP that feature an SPI interface to simplify configuring the gate current and other settings.

Designed for supply voltages from 6–50 V, the STDRIVE102 series provides high energy efficiency in battery-operated equipment such as power tools and domestic appliances. Able to drive six external N-channel power MOSFETs, the drivers can be programmed to source up to 1 A and sink up to 2 A and provide slew-rate regulation without external resistors. An ultra-low standby current of only 50 nA typ. helps maximise battery life in portable and battery-powered applications.

The STDRIVE102 components integrate an advanced charge pump that enables continuous operation of the high-side driver circuitry, simplifying the design of applications that require a PWM duty cycle of 100%. Integrated 12 and 3.3 V linear regulators (LDOs) power the internal low-side drivers and embedded analog front-end (AFE), and can also be used to supply external components. The STDRIVE102BP includes a configurable AFE with three programmable-gain amplifiers (PGAs) and three comparators for measuring the motor shunt currents.

All STDRIVE102 devices are equipped with a comprehensive set of embedded protection features, including undervoltage lockout (UVLO) to enable gate drivers to operate safely. Drain-source voltage (VDS) monitoring on both the high and low side provides dual-redundant overcurrent protection. The STDRIVE102BP also features a dedicated fault-indicator pin for the main supply voltage.

The EVLDRIVE102P and EVLDRIVE102BP evaluation boards are available now to help explore the performance of the drivers in a three-phase inverter built with ST's STL220N6F7 Power MOSFETs. Both are compatible with a range of Nucleo control boards for developing projects with different STM32 microcontrollers and the STM32 ecosystem, including the X-CUBE-MCSDK motor-control software package.

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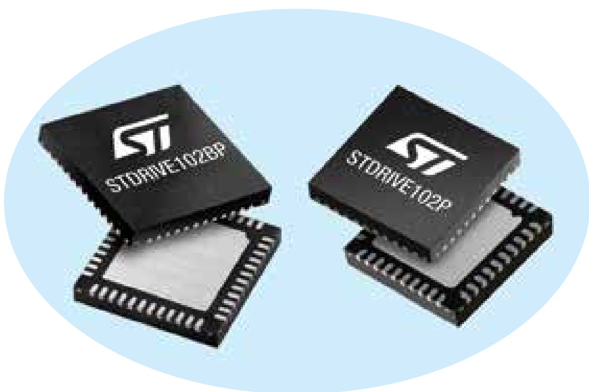

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Architecting a better lithium-ion battery

SINCE THE EARLY 2000s, LITHIUM-ION (LI-ION) BATTERIES HAVE BECOME THE PREDOMINANT RECHARGEABLE POWER SOURCE FOR MANY MOBILE DEVICES, ELECTRIC VEHICLES, RENEWABLE-ENERGY STORAGE GRIDS AND MORE. BUT THE LI-ION BATTERIES IN COMMERCIAL USE CARRY BOTH SAFETY RISKS AND LIMITATIONS.

Julia R. Greer, the Ruben F. and Donna Mettler Professor of Materials Science, Mechanics and Medical Engineering at Caltech, whose lab has been working to improve Li-ion batteries, has established a new path towards making them less dangerous and more environmentally friendly, while also boosting performance.

"We've developed a versatile way to make three-dimensional architected battery electrodes from safer materials," said Yingjin Wang, a graduate student in Greer's lab and first author of a paper published in ***ACS Energy Letters*** that describes the novel electrode. "Using lithium iron phosphate, commonly referred to as LFP, combined with a carbon matrix, we eliminated the use of dangerous cobalt, while improving the mechanical resilience of the battery."

Batteries contain five major parts: anodes, or negative electrodes; cathodes, or positive electrodes; electrolytes, a chemical medium that transports ions between electrodes; a permeable separator between the two electrodes that allows ions to pass through without the electrodes touching; and current collectors, which allow for harvesting the electricity produced via electrochemical ionic exchange.

Greer and Wang's study focused on developing a cathode, with a unique feature: it is 3D architected and produced via additive manufacturing. Most current Li-ion electrodes are planar, or relatively thin and flat; adding a third dimension and shaping the electrode provides efficient ion and electron transport pathways.

"If you make a battery that is 3D architected instead of planar, every lithium ion is going to have an active surface available to it as it's transporting through the electrolyte," Greer said. These surfaces are where chemical energy held in the ions converts into electrical energy. "We think this is advantageous because you can decouple the solid-state versus liquid-state diffusion distance. The electrolyte is liquid, so as it's channelling through this architecture, which is like a labyrinth, it has a solid surface available to it anywhere."

By having less tortuosity, or shorter distances for the ions to follow between the cathode and the separator, the architecture allows for a higher power density, which determines how fast stored energy can be released.

Another major issue with current Li-ion batteries is that many of their cathodes contain cobalt, a metal found in isolated regions of the world where it is often mined using unethical practices. LFP has a much better safety profile than cobalt; if you overcharge it, it is far less likely to catch on fire or short circuit as cobalt cathodes can.

"LFP by itself is not a new material, but using this additive manufacturing, or 3D-printing approach to create an architected electrode that doesn't contain cobalt, is a new thing," Greer said, noting that cobalt is also expensive and hard to recycle, so moving away from its use has many benefits.

The next step is to design a complementary 3D-architected LFP anode to realise a battery with fully 3D-architected electrodes that is both energy dense and power dense.

"Architected LFP electrodes are still a relatively new area of research. The fabrication part is really challenging because there are so many parameters to get right. Ideally, if we can also add a polymer or polymer-based electrolyte to this system, which would make it a real solid-state battery, that would be awesome," Wang said.

Solid-state batteries are the end goal for several reasons, including an increased safety profile and the potential to be extremely lightweight. This would mean they could be utilised to electrify medium- and heavy-duty transportation vehicles such as spacecraft.

"I'm a big fan of solid-state batteries, and I think that eventually we are all going to transition to the solid-state world," Greer said. "Our architected electrode is another stepping stone toward enabling solid-state batteries someday."

This is a modified version of a news item published by the California Institute of Technology (Caltech).

Cabinet cooler systems

The EXAIR Dual Hazardous Location Cabinet Cooler Systems are designed to provide a maintenance-free solution for protecting large electrical enclosures in hazardous environments. Designed for classified areas, including Class I Div 1, Groups A, B, C and D; Class II Div 1, Groups E, F and G; and Class III, these high-capacity cooling systems prevent overheating of sensitive electronics while eliminating the need for costly air conditioners or vortex fans. With cooling capacities up to 5600 Btu/h, the cabinet coolers are suitable for oversized control panels, motor control centres and other electrical enclosures exposed to explosive gas or combustible dust atmospheres.

The cabinet cooler systems use two engineered cabinet coolers working together to evenly distribute cold air throughout large enclosures, maintaining safe operating temperatures for critical electrical components. The systems are UL-tested for hazardous locations and preserve the enclosure's integrity by mounting through standard electrical knockouts. Each system includes an automatic drain filter separator to prevent moisture from entering the enclosure, while optional electronic temperature controls are also available. With no moving parts to wear out and no refrigerants to maintain, the systems provide long-lasting protection in a range of harsh industrial environments.

The Dual Hazardous Location Cooler Systems are part of EXAIR's complete family of Cabinet Cooler Systems, offering solutions for NEMA 12, 4, 4X and ATEX-rated enclosures ranging from 1000 to 5600 Btu/h. Whether cooling a small control panel or a large electrical enclosure in a classified area, EXAIR provides engineered cooling solutions for virtually any enclosure cooling challenge.

COMPRESSED AIR AUSTRALIA PTY LTD
www.caasafety.com.au

Infrared thermal camera

The HJK-MWIR medium-wave cooled infrared thermal camera features a temperature sensitivity of more than 25 mK, a rapid response speed and a high frame rate of up to 1000 Hz in sub-windowing made. This enables the acquisition of the infrared thermal distribution of rapidly changing targets. The infrared thermal camera can also measure temperatures from -10 to 650°C in its standard configuration.

The camera is equipped with fast data interface and comes with professional data analysis software that supports Windows and Linux x85/ARM. The thermal camera is designed to rapidly track changing temperatures and detect small changes in temperature over time.

The HJK-MWIR is available from Applied Infrared Sensing.

APPLIED INFRARED SENSING
www.applied-infrared.com.au

Image credit: Oliver Dietze.

At this year's Hannover Messe, Paul Motzki (left) and his team presented a prototype smart implant that can precisely monitor the fracture healing process and actively support it. Floria Wein (right) is carrying out research into this new technology as part of her degree program.

Robotic micro-actuators power smart healing implants

Claudia Ehrlich, Saarland University

SMART IMPLANTS THAT NOT ONLY STABILISE A FRACTURE BUT ALSO MONITOR THE HEALING PROCESS FROM DAY ONE — AND DELIVER TARGETED SUPPORT WHEN REQUIRED — ARE CURRENTLY BEING DEVELOPED AT SAARLAND UNIVERSITY BY A TEAM OF ENGINEERS, MEDICAL RESEARCHERS AND COMPUTER SCIENTISTS.

The engineering team led by Professor Paul Motzki is contributing shape-memory micro-actuators with integrated sensing capabilities, while Professor Bergita Ganse and her research group provide the medical expertise in fracture healing.

If a fracture is not healing as it should, these novel implants can respond mechanically at the fracture gap by adapting their stiffness or by applying controlled micro-movements to mechanically stimulate tissue and promote bone regeneration.

At present, it usually takes several weeks before clinicians can view the first X-ray image that will tell them whether a fractured bone is healing as it should. Until that time, the healing process remains unmonitored. This is precisely the interval that Saarland University researchers aim to bridge. Medical scientist Ganse is an expert in fracture healing and coordinates the 'Smart Implants' project at Saarland University.

The goal is to develop customised implants that can continuously monitor and visualise in vivo how well, or how

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Medical professor Bergita Ganse is an expert in fracture healing. At Saarland University, she coordinates the "Smart Implants" project, which is funded by the Werner Siemens Foundation.

Image credit: Oliver Dietze.

poorly, a fracture is healing. The implants are also designed to dynamically adapt to the healing process by becoming stiffer or more compliant as required. They can also actively promote bone regeneration by providing micromechanical stimulation of the fracture site.

Motzki and his team are responsible for the technology embedded in the implants. The Saarbrücken engineers are specialists in smart material systems, ie, materials that offer inherent self-sensing and actuation functionalities. Working together with Ganse's group, the engineers have developed several prototypes of intelligent fracture implants, resulting in multiple patents.

Motzki's team has also developed a prototype implant that can precisely monitor the fracture healing process as well as actively support it. First, it can measure whether new bone tissue is forming at the fracture site; the implant detects the minute movements at the fracture edges that are indicative of healthy healing. "As new tissue grows, the stiffness at the fracture site increases — and that progression can be read from the measurement data," Motzki said. The data can also show when movement is harming the healing process, for example if a patient places too much weight on the injured leg. The system enables the permitted load limit to be set individually.

Second, the smart implant makes use of a patented mechanism that enables it to mechanically adapt to the changing situation at the fracture gap. Early on, when the bone fragments need firm support, the implant can stiffen and stabilise the fracture. As the healing process advances, the implant can switch to a more compliant mode. In addition, by coordinating robotic micro-actuators, the smart implant can execute small movements — from gentle contractions to rapid vibrations — designed to specifically trigger growth processes.

"Healing is faster when the fracture gap is subjected to tiny, highly controlled motions and when the tissue at the fracture edges is mechanically stimulated. These miniature oscillating movements with a stroke length of around 100 to 500 micrometres are often enough to initiate tissue growth processes," Ganse said.

How the technology works

At the heart of the smart implant technology are bundles of ultrafine nickel–titanium (nitinol) wires, which serve as both micro-actuators and as built-in position sensors. These wire bundles can contract and thus pull the two sides of the fracture gap closer together, or — when necessary — they can relax to allow the gap to open up slightly. This is made possible by the special properties of nickel–titanium, an alloy renowned for its shape-memory properties.

Nitinol has two phases whose crystal lattices differ in length. When the nickel–titanium wires are heated, the alloy switches from one phase to the other. If an electric current flows through the wires, the material heats up, causing it to adopt a different crystal structure with the result that the wires contract. After cooling, the wires are returned to their starting position. Motzki's team exploits this phase transformation to generate motion — using the wires as actuators.

"Nickel–titanium alloy has the highest energy density of all known drive mechanisms, so by using nitinol, we're able to exert a substantial tensile force in very small spaces," Motzki said.

The researchers use bundles of these ultrafine wires, as more wires mean a greater surface area and therefore faster cooling rates. These shorter cycle times enable rapid movements at high frequencies. The movement of the wires can be controlled very precisely because the material is also self-sensing. This inherent sensing capability arises from the fact that the electrical resistance of the nitinol wires changes as soon as they deform. Each mechanical deformation of the wire can be matched to a specific resistance value.

"We use this measurement data to train neural networks," Motzki said.

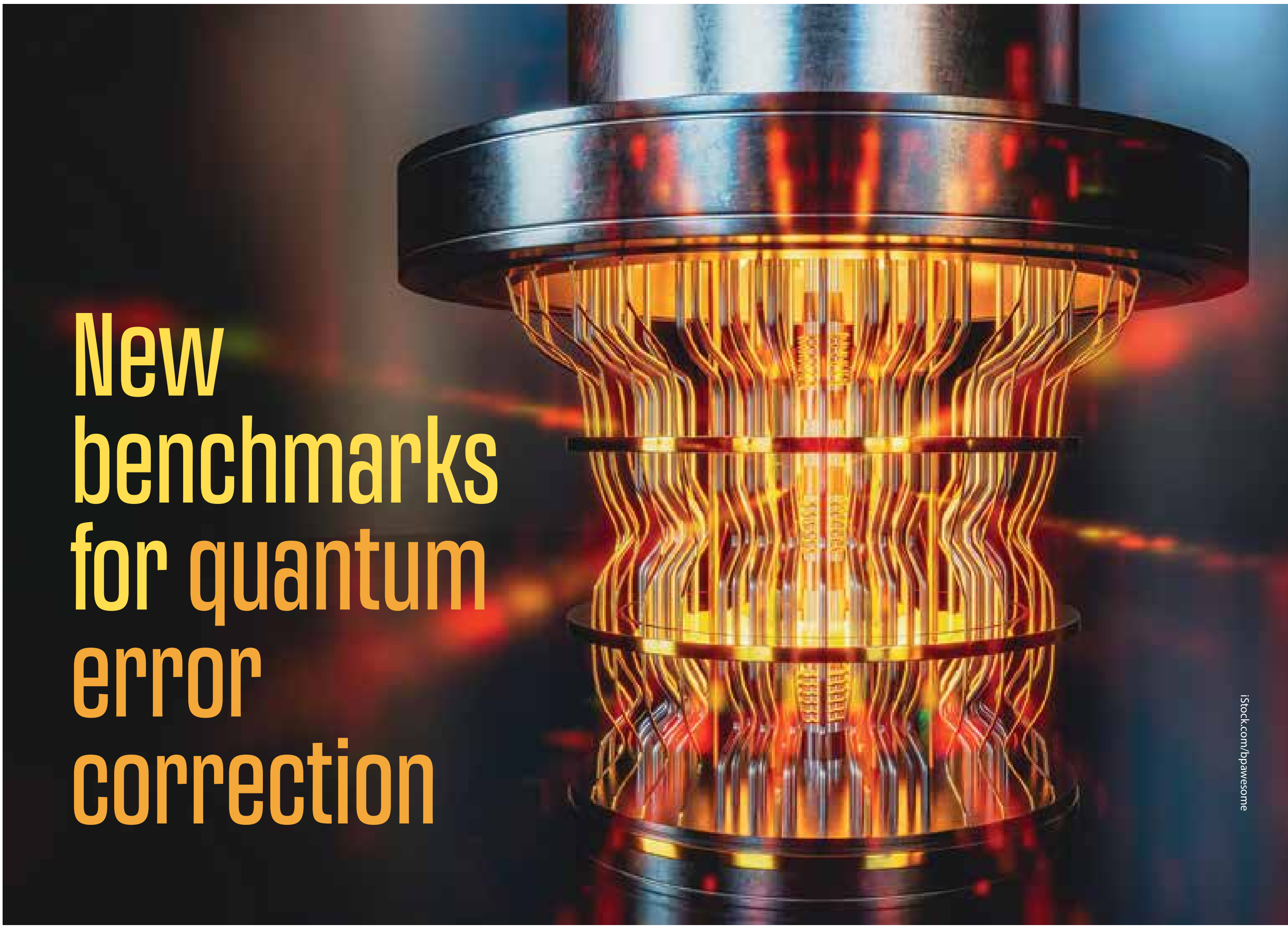
Using large amounts of training data, the artificial neural networks learn to recognise characteristic signal patterns. "Our data-trained neural networks are able to calculate positional information efficiently and accurately even in the face of disruptive influences," Motzki said.

Thanks to the insights that have come from close collaboration with Ganse's team, the combination of smart implant technology and AI-assisted monitoring of the fracture gap is enabling medical teams to assess whether fracture site stiffness is increasing over time — and all without the need for X-ray imaging.

The measurement data also allows the wire bundles to be controlled and moved with high precision. Engineers can model and program specific movement sequences or simply hold the wires in any chosen position. In future clinical use, data from the implant will be transmitted wirelessly to a smartphone and be controlled via the same device.

The Saarbrücken research teams aim to miniaturise their technology even further in the future.

New benchmarks for quantum error correction



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RESEARCHERS FROM THE UNIVERSITY OF SYDNEY, WORKING WITH IBM, HAVE IDENTIFIED AND QUANTIFIED IMPORTANT FACTORS LIMITING THE PERFORMANCE OF QUANTUM COMPUTERS AND DEMONSTRATED WAYS TO OVERCOME THEIR IMPACT.

The findings, which improve our understanding of how errors emerge during quantum computations, could significantly advance the reliability of quantum technology.

The paper has been published in *Nature Communications*.

Project lead Professor Stephen Bartlett from the University of Sydney Nano Institute said quantum computers remain highly susceptible to 'noise', or external interference, and instability, making their scaling-up to useful machines difficult to achieve.

"Quantum computers will become even more useful if we can reliably detect and correct errors while calculations are taking place," said Bartlett, Director of Sydney Nano.

"This joint project with IBM helps us understand which parts of today's quantum hardware are introducing the most problems and where engineering improvements will have the greatest impact."

Quantum computers promise to solve certain classes of problems beyond the reach of conventional computers, including modelling complex chemical systems, designing new materials and pharmaceuticals or potentially improving optimisation problems. But their basic units of information — quantum bits or qubits — are extremely fragile and can lose information through even tiny disturbances introduced by their environments.

To address this, quantum computers use error-correction systems that repeatedly check qubits for mistakes during calculations. This means some of the physical qubits in the system are being used to find errors in the qubits doing the information processing. However, those checks themselves can introduce new errors.

Mid-circuit measurements

To analyse where the errors emerged, the research team looked at the role of mid-circuit measurements. As a quantum system undergoes an operation, specific qubits are measured at intermediate stages of the operation. This measurement collapses those qubits to classical states, while allowing other qubits to maintain their coherence.

Measuring these states gives immediate feedback on how to manage the overall operation.

Bartlett said, "This occurs many, many times during each step of the quantum computation. Each such mid-circuit measurement takes time and everything else in the operation has to 'idle' while the measurement is completed. This is a major stumbling block.

"But we can't get around this step — it is an essential element of quantum error correction. What we have done in this study is pin down quantitatively what kind of performance we need out of these error checks. This is vital to design systems that can scale up and work." >

IBM's Heron r2 quantum processor.

IBM Quantum System Two in Poughkeepsie, New York. The machine was used in the experiments conducted by University of Sydney quantum physicists.

Image credits: IBM.

Using an IBM quantum computer

Using a 156-qubit IBM Quantum Heron r2 superconducting quantum processor, the researchers tested how well different error-correction methods preserved quantum information and enabled quantum logic operations.

Specifically, the team investigated how to reduce the 'idling' noise caused by the mid-circuit measurements.

By redesigning the error-correction circuitry to reduce the idling time, the researchers substantially improved performance. The revised approach increased logical qubit survival rates from below 90% to more than 96% for each error-correction cycle.

The researchers also found that measurement noise is one of the dominant limitations affecting the reliability of quantum logic operations on present-day devices.

Lead author Dr Robin Harper, from Sydney Nano and the School of Physics, said the research focused on understanding why error-corrected quantum operations fail.

"Quantum error correction is essential for building large-scale quantum computers, but it introduces a very complex set of engineering challenges," Harper said.

"We wanted to identify which physical processes were limiting performance on modern quantum devices. What we found is that the act of measuring qubits during a calculation can itself create instability. By redesigning how those measurements are performed, we were able to significantly improve the reliability of the logical qubits."

The work is a direct outcome of the University of Sydney's collaboration with IBM, announced in 2024, to advance quantum error correction and benchmark different approaches to fault-tolerant quantum computing. That collaboration is funded by Intelligence Research Projects Activity (IARPA), a research funding agency of the US Government.

It also builds on an international collaboration and talent exchange program between the University of Sydney and University College London focused on next-generation quantum technologies. Co-author Constance Lainé is a PhD student from UCL who was embedded in the Sydney Nano research group as part of the talent exchange.

Bartlett said the collaboration demonstrated the importance of collaborations between universities and industry in advancing quantum technologies.

"Testing these ideas on advanced quantum hardware allows us to better understand the practical challenges involved in scaling up quantum computing systems. This kind of collaboration is essential if we want to develop quantum technologies that are useful outside the laboratory," Bartlett said.

IBM quantum scientist, co-Principal Investigator on the IARPA grant, and co-author of this research Dr Ben Brown helped design the quantum error correction benchmark that characterised the mid-circuit measurements. Before joining IBM, Brown completed a postdoctoral fellowship at the University of Sydney.

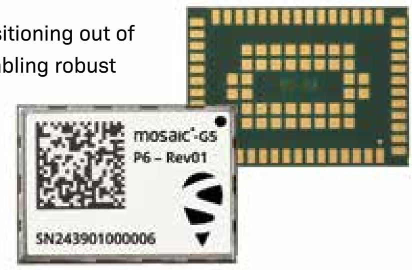
Bartlett said the research highlights Australia's growing role in international quantum technology through collaborations spanning academia, government and industry.

This is a modified version of a news item published by the University of Sydney.

GNSS module

Measuring 23x16 mm and weighing 2.2 grams, the Septentrio mosaic-G5 P6 multi-frequency precise positioning module is designed for commercial UAVs, robots and other size- and power-constrained applications. AIM+ Premium technology protects the receiver from sophisticated intentional or unintentional GNSS jamming and malicious spoofing attacks.

The module provides a high update rate and low latency. In addition to high-accuracy positioning, raw measurements are also available for high-performance sensor fusion.



Mosaic-G5 P6 is compatible with Galileo High Accuracy Service (HAS) for decimetre-level positioning out of the box. Users can choose single or dual antenna configuration for accurate GNSS heading, enabling robust orientation and motion control in industrial automation applications such as autonomous machinery, robotics and precision guidance systems.

The module is compatible with widely used, open-source autopilots like PX4 and ArduPilot as well as ROS, simplifying integration into robotic and drone systems. The mosaic-go G5 P6 evaluation kit simplifies testing with direct autopilot connections, while the free RxTools user interface assists with the setup and evaluation process.

DIGI-KEY ELECTRONICS
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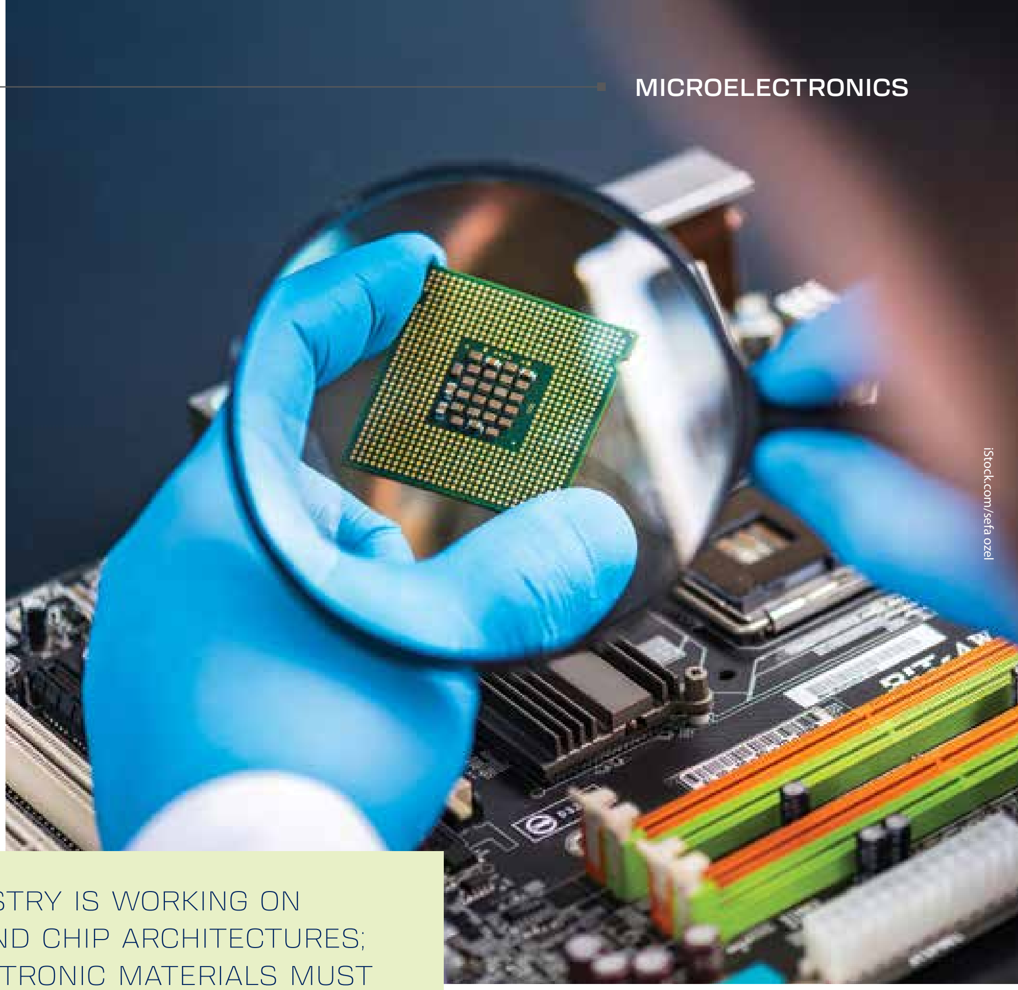
How reliable is your computer chip?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THE MICROELECTRONICS INDUSTRY IS WORKING ON PROMISING NEW MATERIALS AND CHIP ARCHITECTURES; THIS MEANS THAT NOVEL ELECTRONIC MATERIALS MUST BE TESTED CAREFULLY TO ENSURE THAT THEY WILL FUNCTION RELIABLY FOR A LONG TIME DURING OPERATION.

Together with teams from IBM and the National University of Singapore, TU Wien has now shown that tests of novel insulators for semiconductor technology are almost always carried out in a way that does not provide reliable information. However, using a new practical method, suitable measurement data can indeed be used to estimate the actual expected lifetime of electronic components. In research and development, this procedure can therefore help identify the right materials and manufacturing techniques more quickly and with greater confidence.

Measuring until it breaks

The lifetime of a transistor depends crucially on which insulating material is used and at which electrical voltages it is operated. "For thick insulating layers, you can simply apply a voltage, keep increasing it, and measure the voltage at which it breaks down," said Professor Tibor Grasser from the Institute for Microelectronics at TU Wien. "The voltage at which the material fails is then converted accordingly. Roughly speaking: if the insulating layer in the transistor is only one-tenth as thick, one assumes that it will break down at the same field strength, and therefore withstand only one-tenth of the voltage."

For the nanometre-thin layers used in microelectronics, however, this approach is an oversimplification. "The breakdown field strength of thin layers is not simply a material constant; rather, breakdown is a random and time-dependent phenomenon. The failure of the layer therefore depends sensitively on the test conditions," Grasser said.

Breakdown does not occur instantaneously when a certain voltage is reached; instead, it takes a certain amount of time. It therefore matters greatly how quickly the voltage is increased during the measurement. Nor does the layer fail everywhere at once, but rather at specific weak points — locations where the material is not perfectly structured, but contains certain defects.

The temperature and geometry of the sample also have a significant influence on the result: the larger the area, the more weak points can be expected.

"Our experience clearly shows that if one estimates the robustness of materials for electronic components using this oversimplified method, the results are usually completely wrong," Grasser said.

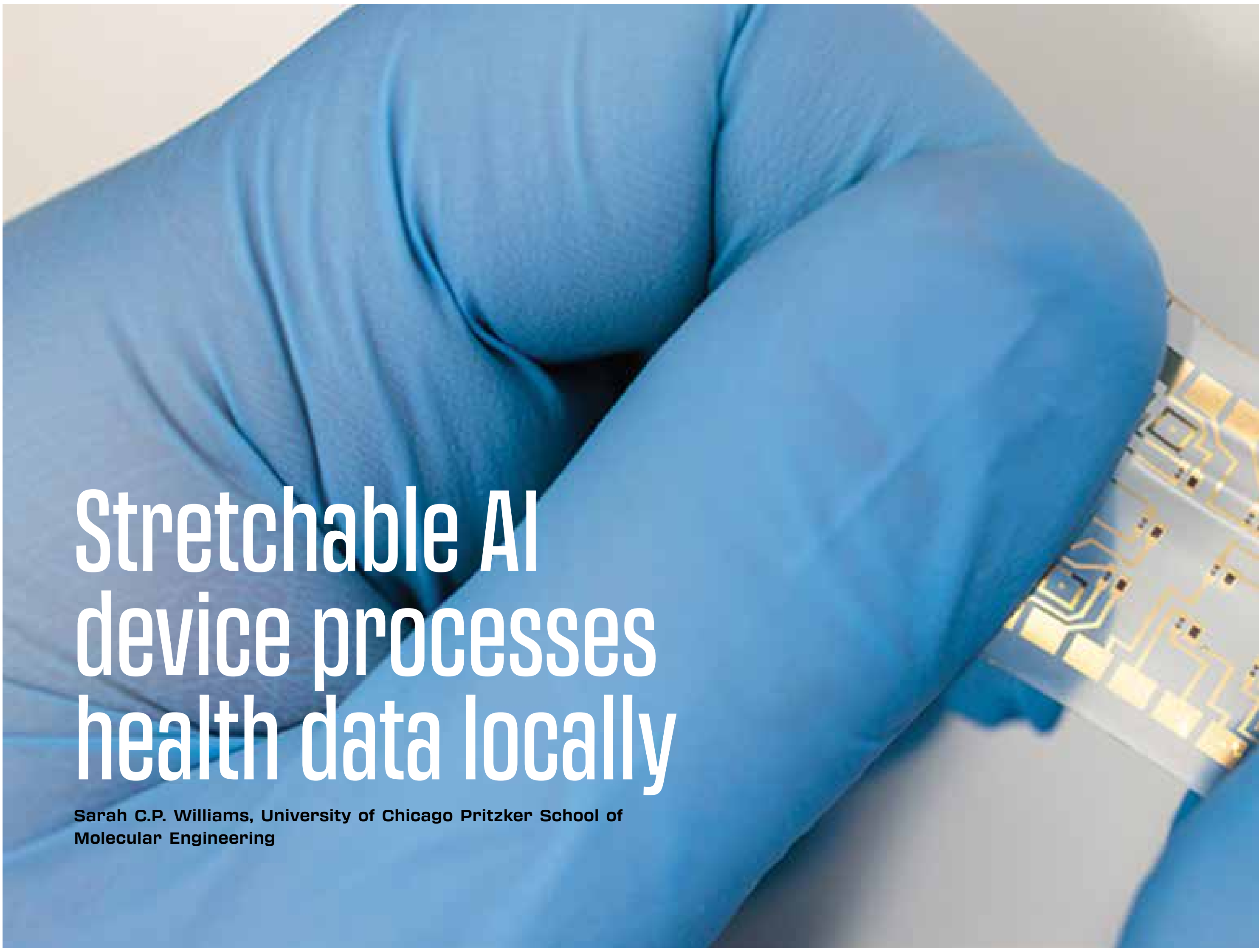
This is precisely what makes the issue so serious for the semiconductor industry: incorrectly estimating failure rates in electronics is unacceptable and leads to enormous economic losses. This is especially true now, when the most suitable insulator for future technologies still needs to be identified. Reliable and rapid lifetime prediction is therefore crucial for material selection.

Until now, the only way to obtain better results was a laborious testing procedure: different constant voltages are applied to material samples of different surface areas, and one waits until the insulators break down. These results can then be evaluated statistically. "With this method, however, it can take months to obtain usable data," Grasser said.

Sophisticated statistical methods

But this does not mean that researchers have to continue groping in the dark. "We propose a more practical method," Grasser said. "We ramp up the voltage in a precisely defined way until the component fails. However, we do not directly transfer the resulting data to electronic components; instead, we use a special statistical procedure. This shows that at least three different voltage ramp rates must be tested. From these, voltage acceleration can then be statistically linked to the probability of failure. In this way, we can calculate from the measurement results exactly the data that matter for industry.

"This allows us to say: what maximum voltage can a certain number of components of a certain area withstand over a certain period of time? That tells us which maximum operating voltage may be used for these components. This makes it possible to compare different materials reliably, without having to fear discovering years later that the wrong materials were used, and that they reach the end of their lifetime sooner than predicted," Grasser said.



Stretchable AI device processes health data locally

Sarah C.P. Williams, University of Chicago Pritzker School of Molecular Engineering

A NEW SKIN-LIKE COMPUTING PATCH DEVELOPED AT THE UNIVERSITY OF CHICAGO PRITZKER SCHOOL OF MOLECULAR ENGINEERING (UCHICAGO PME) CAN ANALYSE HEALTH DATA USING ARTIFICIAL INTELLIGENCE. UNLIKE TODAY'S WEARABLE DEVICES, IT CARRIES OUT ITS AI COMPUTATIONS DIRECTLY ON THE BODY, IN MERE MILLISECONDS, WITHOUT RELYING ON A WIRELESS CONNECTION.

While your current smartwatch may be able to track your heart rate or movements, it doesn't analyse what it finds. The analysis happens elsewhere, after it shuttles data to an external server. In some situations — detecting ventricular fibrillation in the heart, for instance — that few-seconds lag to communicate with the server is too long.

The new device, designed and tested in collaboration with researchers at Argonne National Laboratory, was made possible by the development of manufacturing processes that allow organic electrochemical transistors to be printed onto flexible surfaces.

"The future that we're trying to realise is to make wearable and implantable devices smarter," said Sihong Wang, an associate professor of molecular engineering at UChicago PME and co-senior author of the new study, published in ***Nature Electronics***. "It's helping people have a personal, instantaneous doctor integrated into their devices."

Manufacturing stretchy transistors

For years, Wang's lab has been working to create electronic components that can stretch and bend like human skin, with the ultimate goal of creating smart devices that adhere to human tissues. The group previously developed methods for fabricating stretchable transistor arrays and a stretchable OLED display.

In the new work, Wang and his colleagues set out to build a stretchable neuromorphic computing circuit — a large array of transistors that can run analyses of health data. Earlier work had demonstrated that the concept was theoretically possible with a small number of transistors but hadn't scaled it up to a practical size.

The transistors the team wanted to use, called organic electrochemical transistors, work differently from those inside a standard computer chip. They process information using both electrical current and the movement of ions through a gel-like electrolyte layer. The electrolytes give each transistor a built-in

> "The future that we're trying to realise is to make wearable and implantable devices smarter. - Associate Professor Sihong Wang.

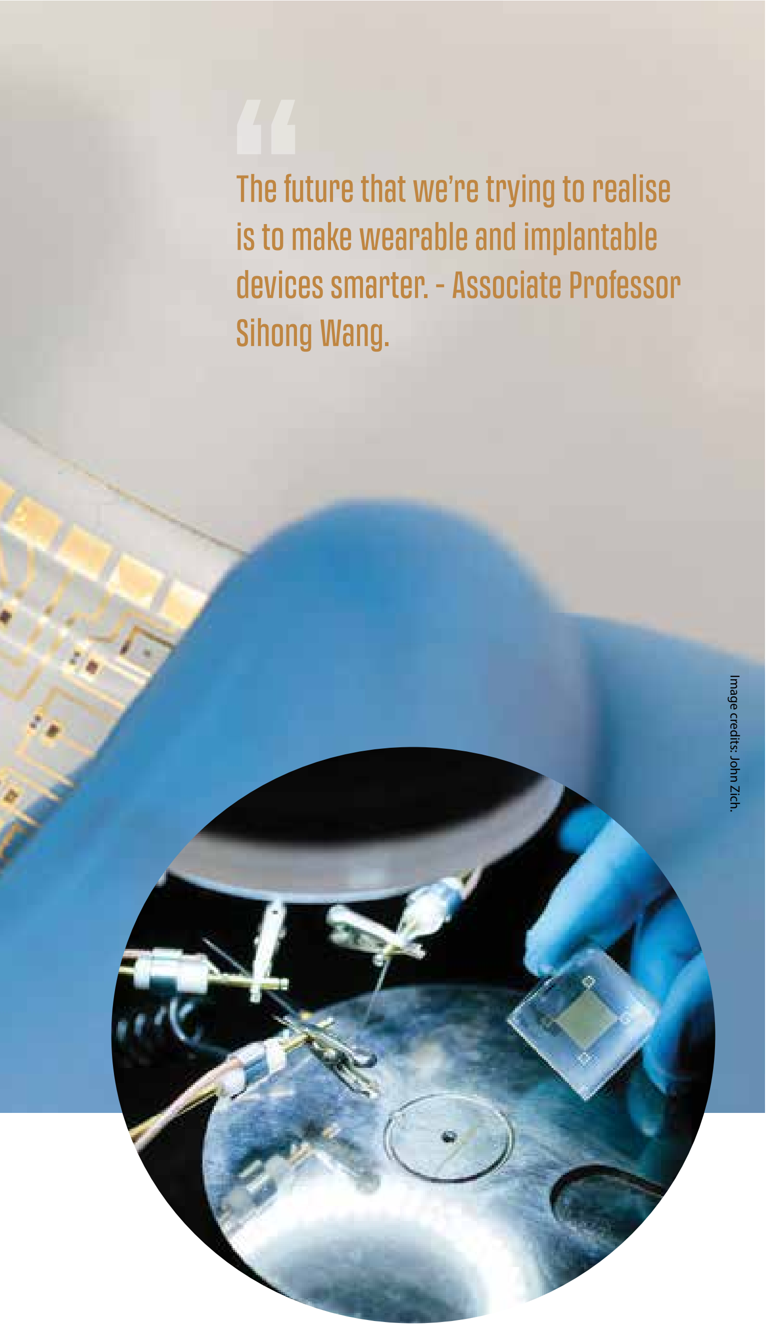


Image credits: John Zich.

A new skin-like computing patch developed at the University of Chicago Pritzker School of Molecular Engineering (UChicago PME) can analyse health data using artificial intelligence in an unprecedented way.


Image credit: John Zich.

Associate Professor Sihong Wang (right) and PhD student Max Weires hold a sample device.

memory, letting them store numerical values stably over time, much the way a synapse in the brain can be strengthened or weakened to encode a learned pattern.

These components, however, presented a manufacturing challenge. The flexible surface layer is sensitive to heat and solvents and so can't be fabricated using standard chip production techniques. At the same time, the gel electrolyte layer has a tendency to move like a liquid, merging with neighbouring devices and causing short circuits.

"What we had to ask was whether we could use or change the properties of these polymers to make them compatible with photolithography — the main patterning method used in the microelectronics industry," Wang said.

The team solved the challenge by engineering a new type of polymer gel that could be hardened into precise patterns through exposure to ultraviolet light. The result is a fabrication method that can produce 10,000 organic electrochemical transistors per square centimetre.

"As computer scientists, we're used to thinking of a neural network weight as just a number," said Zixuan Zhao, a graduate student at UChicago CS and co-first author of the study. "In hardware, it's a material — with variability, history and physical limits. The challenge was to hold those constraints in mind and still compute with enough precision to matter."

Saving lives with speedy computing

To test the utility of the new devices, Wang's team used one of their new stretchable arrays to run a pre-trained algorithm designed to help treat ventricular fibrillation. This dangerous electrical storm in the heart can be fatal and is most often treated with a one-size-fits-all defibrillator shock that delivers a massive jolt of electricity to the entire heart. Researchers have proposed a more precise treatment: mapping abnormal waves of electricity as they move through the heart and delivering small, precise pulses just ahead of them before they can continue.

However, the obstacle has been time. Wavefronts move through the heart so fast that the entire analysis must be completed within milliseconds — far too quickly for data to be transmitted to an external computer and back.

"This is a situation where it's not feasible to have remote computing. It just takes too long," Wang said. "But if you have a computing device that can do the analysis within the body, it could be possible."

Using real cardiac mapping data from a donor human heart, the team showed that the stretchable array could locate wavefront positions with 99.6% accuracy, even while the device was stretched to more than one-and-a-half times its normal length.

In a separate demonstration, a neural network encoded in the array analysed a combination of vital signs and personal health data — including cholesterol levels, blood sugar, maximum heart rate and ECG readings — to assess a patient's risk of heart attack, achieving 83.5% accuracy.

Wang sees this computing array as one component of a fully integrated, body-compatible health platform. His lab is now working to pair the computing array with stretchable wireless communication components and improved sensors, moving towards a system that can sense, analyse and respond to health data as a fully integrated whole.

"Instead of sending data away to a remote server, we can begin making sense of it right where life is happening," said Fangfang Xia, a computer scientist at Argonne National Laboratory and co-senior author of the study.

Simon M. King at the Rice Advanced Materials Institute.

Fast, eco-friendly method recovers critical minerals from batteries

AS GLOBAL DEMAND FOR LITHIUM-ION BATTERIES CONTINUES TO SURGE, A TEAM OF RICE UNIVERSITY RESEARCHERS HAS DEVELOPED A FASTER, MORE ENERGY-EFFICIENT WAY TO RECOVER CRITICAL MINERALS FROM SPENT BATTERIES, POTENTIALLY EASING SUPPLY CHAIN PRESSURES AND REDUCING ENVIRONMENTAL HARM.

In a new study published in *Small*, researchers from Rice's Department of Materials Science and Nanoengineering introduce a class of water-based solutions that can extract valuable metals from battery waste in minutes rather than hours. The work centres on aqueous solutions of 'amino chlorides', which mimic the performance of commonly studied green solvents like deep eutectics, while avoiding their key limitations.

"Traditional recycling methods often rely on harsh acids or slow, energy-intensive processes," said the study's first author, Simon M. King, a sophomore studying chemical and biomolecular engineering who completed this work as a summer research fellow at the Rice Advanced Materials Institute. "What we've shown is that you can achieve rapid, high-efficiency metal recovery using a much simpler, water-based system."

King worked closely with corresponding authors Pulickel Ajayan, the Benjamin M. and Mary Greenwood Anderson Professor of Engineering, and Sohini Bhattacharyya, a research scientist in Ajayan's lab.

Lithium-ion batteries power everything from smartphones to electric vehicles, but recycling them remains a major challenge. Only a small fraction of battery materials, including lithium, cobalt, nickel and manganese, are typically recovered during the recycling process, despite growing demand and limited global reserves.

Hydrometallurgical recycling, which dissolves metals into solution followed by their chemical precipitation, is considered one of the most scalable approaches. However, commonly used solvents can be toxic and proposed green alternatives (DESs) can be inefficient. To address this, the Rice team explored aqueous amino chloride salts as alternative "lixiviants", or leaching agents. Among the candidates tested, a solution based on hydroxylammonium chloride (HACl) delivered standout performance.

"We were surprised by just how fast the reaction occurs, especially

Image credit: Jorge Vidal/Rice University

without the involvement of high temperatures," King said. "Within the first minute, we're already seeing the majority of the metal extraction take place."

The HACl-based solution achieved roughly 65% extraction of key battery metals in just one minute at room temperature with efficiencies climbing above 75% for several metals under slightly longer processing times. And unlike many existing approaches, the process does not require high temperatures or long reaction times — two major drivers of cost and environmental impact.

"A big advantage of this system is that it works under relatively mild conditions," Ajayan said. "That opens the door to more sustainable and scalable recycling technologies."

The team found that replacing traditional organic solvents with water significantly reduced viscosity, allowing faster movement of molecules and improving reaction speed. This shift also simplifies waste handling and lowers environmental risk.

Through a combination of experiments and modelling, the researchers identified why the HACl solution performs so well: while acidity and chloride ions help dissolve metals, the key factor appears to be a built-in redox-active nitrogen centre in HACl that actively participates in the reaction.

"While the rapid metal dissolution is very interesting, what is most exciting is that this highlights the generic chemical properties that are the major drivers for efficient leaching," Bhattacharyya said. "That redox capability gives it a major advantage over other similar systems we tested."

The study also shows that factors like solvent polarity or pH can be outweighed by the presence of reactive chemical groups and efficient mass transport to facilitate rapid leaching.

After extraction, the team demonstrated that the recovered metals could be reprocessed into new battery materials, completing the recycling loop. The findings point to a broader design strategy for next-generation recycling systems: combining low-toxicity solvents with targeted chemical functionality to maximise efficiency.

MXM modules

Advantech has commenced mass production of its SKY-MXM series, powered by the latest NVIDIA RTX PRO Blackwell embedded GPUs. Designed for compact systems, these modules deliver high-performance AI processing, real-time computing and high-resolution graphics, while maintaining low power consumption and long product lifecycles. The initial release targets mainstream applications, with higher-end models to follow, giving developers scalable performance options.

Built on NVIDIA's Blackwell architecture, the SKY-MXM series enhances AI inference and graphics performance with PCIe Gen5 and GDDR7 memory, enabling faster data transfer and support for larger datasets or multiple high-resolution streams. Features such as fifth-generation Tensor Cores, FP4 precision, DLSS 4 and improved FP32 performance accelerate AI model development and deployment. DP2.1a support enables smooth 4K @ 240 Hz output, suitable for broadcast and extended reality applications.

The line-up includes two models: the SKY-MXM-2000B, a mid-tier module powered by the RTX PRO 2000 GPU for demanding AI, 3D rendering and vision-language model applications; and the SKY-MXM-500B, an entry-level option with the RTX PRO 500 GPU, offering efficient AI acceleration and display capabilities for cost-sensitive or compact designs.

Both models share a compact MXM Type A form factor (82x70 mm), low-power design, and flexible integration via carrier boards. Engineered for real-world use, the SKY-MXM series supports applications in medical imaging, security and broadcasting — delivering high-resolution processing and real-time performance in space-constrained environments.

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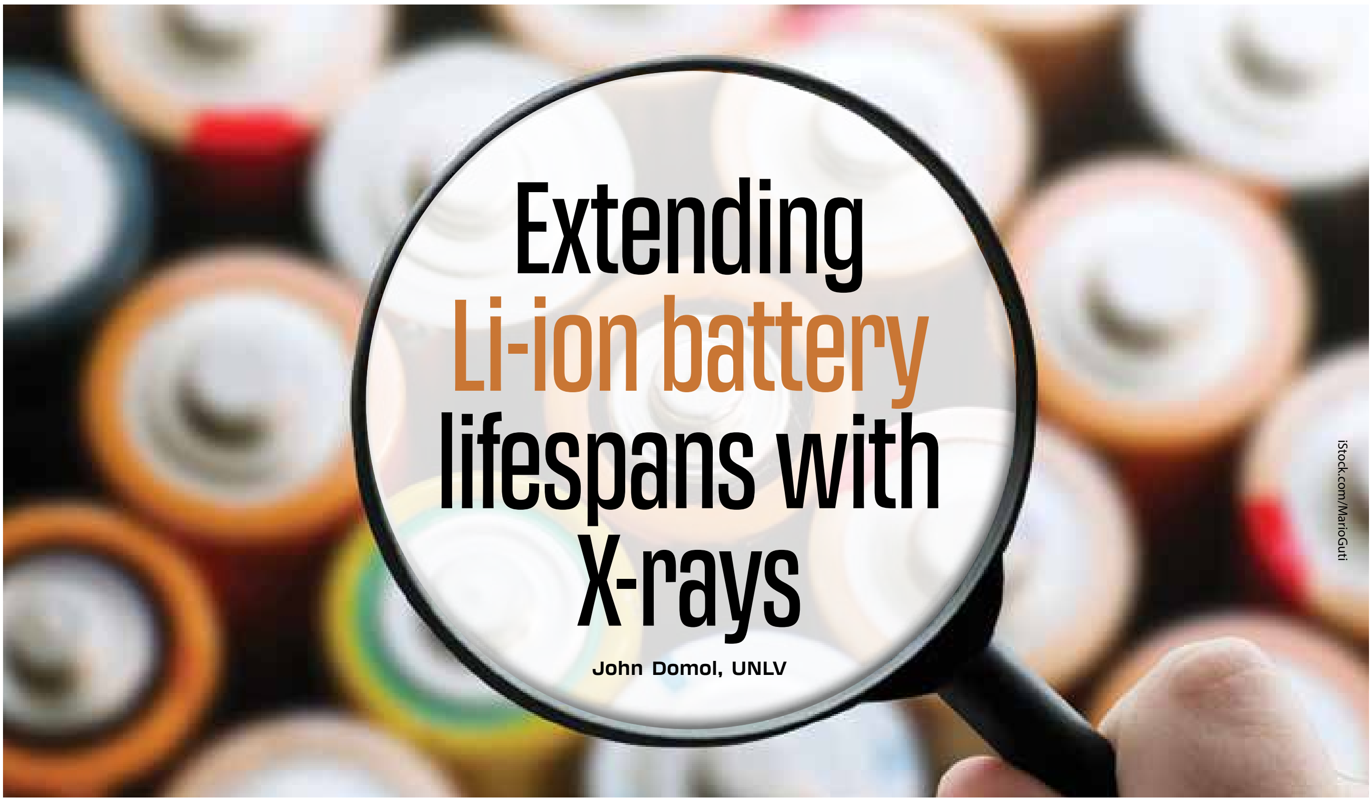

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Extending Li-ion battery lifespans with X-rays

John Domol, UNLV

OPEN THE BATTERY HEALTH TAB ON YOUR PHONE, AND CHANCES ARE PRETTY HIGH THAT YOU'LL BE DISAPPOINTED. AND THE AMOUNT OF TIME SQUEEZED FROM A FULL CHARGE ONLY DECREASES FROM THERE.

That depreciation might seem unstoppable. But new UNLV-led research may prove the contrary, adding years to the lifespan of battery-powered electronic devices.

"A Tesla can drive for on average 340 miles on a full charge, but after a decade, maybe it only goes 200," said Michael Pravica, a professor of physics leading the study. "My lab is trying to regenerate the battery's capacity so that it's basically very close to new and usable for much longer."

The regeneration is applicable to battery packs on electric vehicles, electric trains, power banks used by businesses, cellular phones and any other device dependent on lithium-ion batteries.

"Replacing battery packs on electric vehicles can cost tens of thousands of dollars. Instead of getting 10 years of use from these cars, drivers may now be able to get 15 or 20 years, and save money in the process," Pravica said.

Modern battery technology sees lithium ions move from anode to cathode, or the reverse when recharging. Through repetition of this process, ions become stuck, reducing battery health.

This is where the secret ingredient of this technological breakthrough comes in: X-rays. Typically thought of as medical diagnostic tools, X-rays are a form of highly concentrated light called electromagnetic energy — essentially used as a chisel on the battery.

"We realized that X-rays would be a good way to force out lithium ions that get caught in microscopic fractures as these batteries degrade," Pravica said. "And we would be able to free them back into conduction instead of being stuck and reducing capacity."

Historically, high pressure and temperature are used to bring molecules together and initiate this sort of chemical change. Pravica observed that X-rays are capable of doing the same, and have become a third mechanism for transforming chemicals.

"With X-rays, we can realise novel states of chemistry using very high energy," he said. "As X-rays ionise, they strip electrons from molecules and atoms. But they're so much higher energy that they can access new regions to achieve what we can't through conventional chemistry."

Charging the economy

"The tech will allow electric vehicles and battery-powered products to hold their value for longer. If articulated well to business owners, I think they'll come around to seeing X-ray regeneration as a win-win," Pravica said. "Moreover, regenerating batteries will have enormous environmental impacts because it will delay, if not obviate, the need to dump them into landfills."

The Environmental Protection Agency says that battery dumping can cause intense lead or acid leaks, and there are increasingly more detailed protocols for handling, recycling and disposal as pollution becomes a growing concern.

Pravica says any technology that could potentially slow the replacement of batteries is of high value to both the environment and economy, and he is working with the UNLV Office of Economic Development (OED) to bring it to life.

His lab plans to finish fundamental experiments needed to demonstrate that X-rays have positive effects on battery capacity in the fall. These include toying with the brightness or intensity, and energy of the X-rays to see what changes those factors present to the value proposition of resurrecting batteries.

"There are always going to be hurdles, but to have a feeling that I did something useful for humanity is just priceless," he said. "I'm hoping the tests are all going to work, and that I'm able to make a good contribution to this community soon."

Video: Pravica talks about his upcoming research that could extend the lifespan of your devices.

Video credit: John Domol.


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