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# ENGINEERS SOLVE A MYSTERY ON THE PATH TO SMALLER, LIGHTER BATTERIES

David Chandler, MIT News Office





A discovery by MIT researchers could finally unlock the door to the design of a new kind of rechargeable lithium battery that is more lightweight, more compact and safer than current versions, and that has been pursued by labs around the world for years.

**T**he key to this potential leap in battery technology is replacing the liquid electrolyte that sits between the positive and negative electrodes with a much thinner, lighter layer of solid ceramic material, and replacing one of the electrodes with solid lithium metal. This would greatly reduce the overall size and weight of the battery and remove the safety risk associated with liquid electrolytes, which are flammable. But that quest has been beset with one big problem: dendrites.

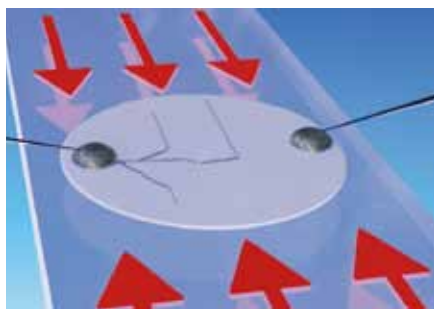
Dendrites, whose name comes from the Latin for branches, are projections of metal that can build up on the lithium surface and penetrate into the solid electrolyte, eventually crossing from one electrode to the other and shorting out the battery cell. Researchers haven't been able to agree on what gives rise to these metal filaments, nor has there been much progress on how to prevent them and thus make lightweight solid-state batteries a practical option.

The new research, published in the journal *Joule* in a paper by MIT Professor Yet-Ming Chiang, graduate student Cole

Fincher and five others at MIT and Brown University, seems to resolve the question of what causes dendrite formation. It also shows how dendrites can be prevented from crossing through the electrolyte.

Chiang said in the group's earlier work, they made a "surprising and unexpected" finding, which was that the hard, solid electrolyte material used for a solid-state battery can be penetrated by lithium, which is a very soft metal, during the process of charging and discharging the battery, as ions of lithium move between the two sides.

This shuttling back and forth of ions causes the volume of the electrodes to change. That inevitably causes stresses in the solid electrolyte, which has to remain fully in contact with both of the electrodes that it is sandwiched between. "To deposit this metal, there has to be an expansion of the volume because you're adding new mass," Chiang said. "So, there's an increase in volume on the side of the cell where the lithium is being deposited. And if there are even microscopic flaws present, this will generate a pressure on those flaws that can cause cracking."



*Researchers solved a problem facing solid-state lithium batteries which can be shorted out by metal filaments called dendrites that cross the gap between metal electrodes. They found that applying a compression force across a solid electrolyte material (grey disk) caused the dendrite (dark line at left) to stop moving from one electrode towards the other (the round metallic patches at each side) and instead veer harmlessly sideways, towards the direction of the force. Image credit: Courtesy of the researchers.*

Those stresses, the team has now shown, use the cracks that allow dendrites to form. The solution to the problem turns out to be more stress, applied in just the right direction and with the right amount of force.

While previously, some researchers thought that dendrites formed by a purely electrochemical process, rather than a mechanical one, the team's experiments demonstrate that it is mechanical stresses that cause the problem.

The process of dendrite formation normally takes place deep within the opaque materials of the battery cell and cannot be observed directly, so Fincher developed a way of making thin cells using a transparent electrolyte, allowing the whole process to be directly seen and recorded. "You can see what happens when you put a compression on the system, and you can see whether or not the dendrites behave in a way that's commensurate with a corrosion process or a fracture process," he said.

The team demonstrated that they could directly manipulate the growth of dendrites simply by applying and releasing pressure, causing the dendrites to zig and zag in perfect alignment with the direction of the force.

Applying mechanical stresses to the solid electrolyte doesn't eliminate the formation of dendrites, but it does control the direction of their growth. This means



THE TEAM DEMONSTRATED THAT THEY COULD DIRECTLY MANIPULATE THE GROWTH OF DENDRITES SIMPLY BY APPLYING AND RELEASING PRESSURE, CAUSING THE DENDRITES TO ZIG AND ZAG IN PERFECT ALIGNMENT WITH THE DIRECTION OF THE FORCE.

they can be directed to remain parallel to the two electrodes and prevented from ever crossing to the other side, and thus rendered harmless.

In their tests, the researchers used pressure induced by bending the material, which was formed into a beam with a weight at one end. But they say that in practice, there could be many different ways of producing the needed stress. For example, the electrolyte could be made with two layers of material that have different amounts of thermal expansion, so that there is an inherent bending of the material, as is done in some thermostats.

Another approach would be to "dope" the material with atoms that would become embedded in it, distorting it and leaving it in a permanently stressed state. This is the same method used to produce the super-hard glass used in the screens of smartphones and tablets, Chiang explained. And the amount of pressure needed is not extreme: the experiments showed that pressures of 150 to 200 megapascals were sufficient to stop the dendrites from crossing the electrolyte.

The required pressure is "commensurate with stresses that are commonly induced in commercial film growth processes and many other manufacturing processes", so should not be difficult to implement in practice, Fincher added.

In fact, a different kind of stress, called stack pressure, is often applied to battery cells, by essentially squishing the material in the direction perpendicular to the battery's plates — somewhat like compressing a sandwich by putting a weight on top of it. It was thought that this might help prevent the layers from separating. But the experiments have now demonstrated that pressure in that direction actually exacerbates dendrite formation. "We showed that this type of stack pres-

sure actually accelerates dendrite-induced failure," Fincher said.

What is needed instead is pressure along the plane of the plates, as if the sandwich were being squeezed from the sides. "What we have shown in this work is that when you apply a compressive force you can force the dendrites to travel in the direction of the compression," Fincher said, and if that direction is along the plane of the plates, the dendrites "will never get to the other side".

That could finally make it practical to produce batteries using solid electrolyte and metallic lithium electrodes. Not only would these pack more energy into a given volume and weight, but they would eliminate the need for liquid electrolytes, which are flammable materials.

Having demonstrated the basic principles involved, the team's next step will be to try to apply these to the creation of a functional prototype battery, Chiang said, and then to figure out exactly what manufacturing processes would be needed to produce such batteries in quantity. Though they have filed for a patent, the researchers don't plan to commercialise the system themselves, he said, as there are already companies working on the development of solid-state batteries. "I would say this is an understanding of failure modes in solid-state batteries that we believe the industry needs to be aware of and try to use in designing better products," he said.

The research team included Christos Athanasiou and Brian Sheldon at Brown University, and Colin Gilgenbach, Michael Wang and W Craig Carter at MIT. The work was supported by the U.S. National Science Foundation, the U.S. Department of Defense, the U.S. Defense Advanced Research Projects Agency and the U.S. Department of Energy.



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## ELECTROLYTE DESIGNED FOR LITHIUM-METAL ANODES IN LI-METAL BATTERIES

Scientists are looking to develop lithium-metal batteries with lithium metal as the anode because these batteries have a much higher charging capacity. However, there are safety issues with lithium-metal batteries because dendrites — spiky, metallic microstructures — form during the charging process. A team of Chinese researchers has designed an electrolyte that suppresses the formation of dendrites in lithium-metal batteries. This electrolyte delivers excellent performance in lithium-metal batteries and offers solutions in the research toward building high-safety, long-life lithium-metal batteries.

While lithium-metal anodes hold potential for high-energy storage batteries, the uncontrollable lithium dendrite growth raises concerns, as it occurs when the lithium ions move and convert to one specific location on the lithium-metal surface. The dendrites cause poor recycling efficiency in the battery and are a severe safety issue.

The researchers addressed the dendrite problem by combining the advantages of conventional electrolytes and high-concentration electrolytes. The high-concentration electrolytes overcome some of the shortcomings of conventional electrolytes, and hold promise for

use in next-generation batteries. The electrolyte the team created is designed to deliver excellent electrochemical performance in lithium-metal batteries and suppresses the formation of dendrites. "Its unique structure not only promotes the uniform conversion of ions on the electrode surface but also ensures the rapid movement of ions in the electrolyte," said Chunpeng Yang, a professor at Tianjin University.

The researchers began their work by running numerical simulations to explore the effect of a negatively charged coating to induce the interfacial high-concentration electrolyte. Then, as a proof-of-concept material, the researchers coated nitrogen- and oxygen-doped carbon nanosheets that have surface negative charges with nickel foam to create the electrode. The positively charged lithium ions are concentrated near the nitrogen- and oxygen-doped carbon electrode that is coated with nickel. This concentration of lithium ions promotes the charge transfer reactions on the electrode, contributing to the outstanding electrochemical cycling performances. The researchers conducted half-cell and full-cell tests on the electrode and found that their electrode performs better than other electrodes based on pure nickel foam.

"This provides a simple principle for suppressing the lithium dendrites by simultaneously taking into account the advantages of conventional electrolyte and high-concentration electrolyte for stable Li-metal anode, which may be applied to other substrates for practical metal batteries," Yang said.

Beyond coating negatively surface-charged materials on the electrode to guide the formation of interfacial high-concentrated electrolytes, the researchers aim to look for other ways to obtain this electrolyte structure as a means to achieving high-performance batteries.

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## TECH PUTS THE BRAKES ON LI-ION BATTERIES TO STOP FIRES

Lithium-ion (Li-ion) batteries can be used to power everything from smart watches to electric vehicles, due to the large amounts of energy they can store. However, when overheated, they can catch fire or even explode. Research published in ACS's *Nano Letters* has offered a possible solution, with new technology that can shut down a Li-ion battery when it gets too hot.

The chemistry found in many batteries is essentially the same: electrons are shuttled through an electronic device in a circuit from one electrode in the battery to another. But in a Li-ion cell, the electrolyte liquid that separates these electrodes can evaporate when it overheats, causing a short circuit. In certain cases, short circuiting can lead to thermal runaway, a process in which a cell heats itself uncontrollably. When multiple Li-ion cells are chained together thermal runaway can spread from one unit to the next, resulting in a large, hard-to-fight fire. To prevent this, some batteries now have fail-safe features, such

as external vents, temperature sensors or flame-retardant electrolytes. But these measures can either kick in too late or harm performance. So, researchers have created a Li-ion battery that can shut itself down quickly, while working just as well as existing technologies.

Yapei Wang, Kai Liu and colleagues used a thermally responsive shape memory polymer covered with a conductive copper spray to create a material that would transmit electrons most of the time, but switch to being an insulator when heated excessively. At around 197°F (91.6°C), a microscopic, 3D pattern programmed into the polymer appeared, breaking apart the copper layer and stopping the flow of operations. This permanently shut down the cell but prevented a potential fire. At this temperature, however, traditional cells kept running, putting them at risk of thermal runaway if they became hot again. Under regular operating temperatures, the battery with the new polymer maintained a high conductivity, low resistivity and similar cycling lifetime to a traditional battery cell. The researchers believe this technology could make Li-ion batteries safer without having to sacrifice their performance.





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## RESEARCHERS DEVELOP BATTERIES THAT USE WATER AS AN ELECTROLYTE

Researchers from the Department of Chemistry and the Division of Advanced Materials Science at POSTECH have developed a stable aqueous zinc-ion battery that uses water as an electrolyte. Lightweight, high-capacity lithium-ion batteries are widely used in mobile phones, laptops and other necessities. However, the organic electrolytes in conventional Li-ion batteries are flammable and can lead to fatal fires or explosions. Professor Soojin Park and Gyujin Song, along with PhD candidate Sangyeop Lee, employed a protective polymer layer in their zinc-ion battery to prevent electrode corrosion and increase the stability of the zinc anode, improving the electrochemical stability of the battery.

The organic-solvent-based electrolyte, which serves as a medium for ions to move inside the typical battery system, is inherently flammable, posing risk of explosion or fire. To address this issue, aqueous electrolyte batteries are being developed as promising replacements. However, the inferior reversibility of the zinc anode in aqueous electrolytes, which are caused by zinc dendrites and surface side reactions, has prevented zinc-ion batteries from being used.

The POSTECH researchers developed a zinc anode coated with a multifunctional protective layer by using a block polymer. This new polymer layer is elastic and stretchable and can ensure expansion during battery charging and discharging. The polymer protective layer is found to induce homogenised ion distribution and suppress dendritic growth, contributing to a long-term zinc anode lifespan. The thin film layer also improves the electrode stability by suppressing unnecessary chemical/electrochemical reactions in the electrolyte on the electrode surface.

Furthermore, the researchers revealed the movement of zinc ions in the coating layer by using time-of-flight secondary ion mass spectrometry (TOF-SIMS) analysis. Imaging the zinc ion movements, which was not successful in previous studies, could prompt further research on the surface properties of battery anodes. The research findings were published in *Cell Reports Physical Science*.

## TACKY TAPE: A NEW SOURCE FOR GENERATING ENERGY?

Researchers are working to harness the energy from static electricity with triboelectric nanogenerators (TENGs) to power everyday devices. Now, in *ACS Omega*, a team of researchers have described an easy way to manufacture these generators out of materials as simple as double-sided store-bought tacky tape that pack in higher energy densities than previously reported versions.

TENGs can transform mechanical energy into electrical energy through the triboelectric effect, which is a form of static electricity. But instead of that static turning into shock, these nanogenerators send it through a circuit to power a device, such as an LED. Based on simple principles, many TENG devices are complicated and expensive to make and only produce a few watts of power. Previous research has shown that simplified TENGs can be made with a combination of tape, plastic and metal, but their lower power densities have prevented them from being used in practical applications. Researchers Gang Wang and colleagues have designed an uncomplicated, easy-to-fabricate TENG that would work as well as more sophisticated designs.

The researchers created a TENG with layers of store-bought double-sided tape and plastic film covered with a thin sheet of aluminium metal. When these two layers were pressed together then disconnected from one another, a small spark formed between them. If more pressure was placed on the layers, they could generate more power, with the TENG able to produce power densities consistent with that of other, more complicated versions. A double-electrode version of the device could even produce a power density of 169.9 watts per square metre — reportedly 47% higher than that previously reported for other devices.

In a series of tests, the researchers put the TENG through its paces. When hooked up to an array of LEDs, the generator could light up over 400 lights simultaneously when someone pressed the layers. Attaching the TENG to the bottom of a shoe could turn on LEDs with the power of a single step. The generator also powered a laser diode, which could pave the way for use in sensors and light-based electronics. The researchers say that this generator design could help meet larger power demands for self-powering electronics with simpler and cheaper materials.

They received funding from the College of Engineering at the University of Alabama in Huntsville and Materials Sciences LLC.





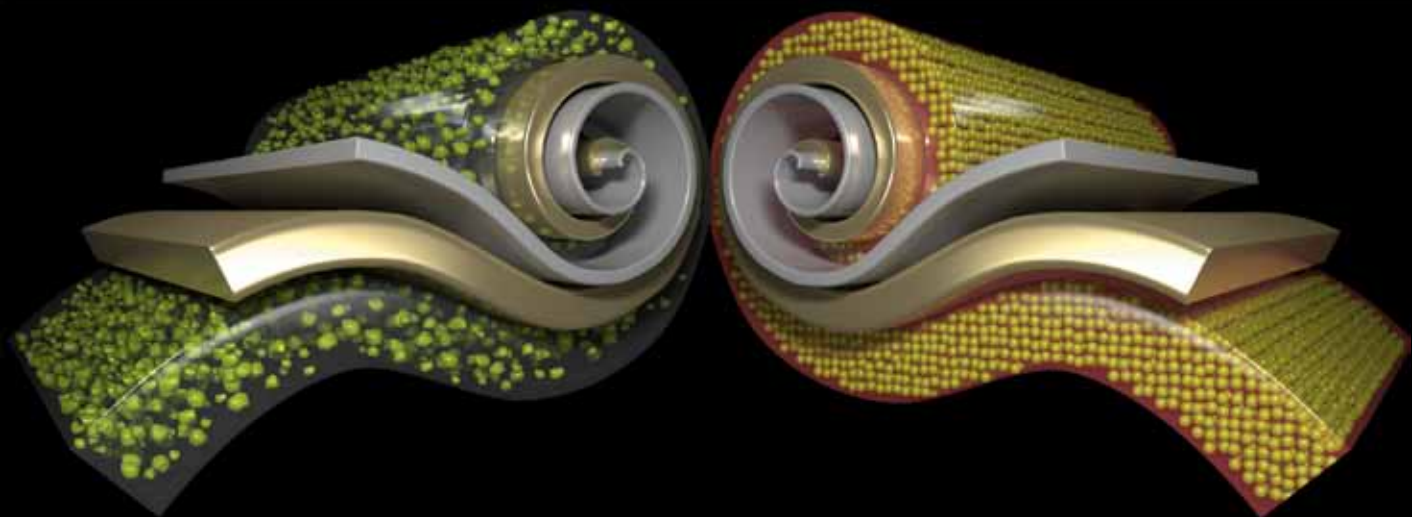


Image credit: Andy Sproles/ORNL, U.S. Dept. of Energy

## MANUFACTURING BETTER, CHEAPER CATHODES FOR LI-ION BATTERIES

Researchers at the US Department of Energy's Oak Ridge National Laboratory (ORNL) have developed a method to produce a key component of lithium-ion batteries, resulting in a more affordable battery from a faster, less wasteful process that uses less toxic material. Lithium-ion batteries — used in products from appliances to cell phones, as well as in most electric vehicles — are composed of a cathode and an anode with an electrolyte in between. Ions move from anode to cathode through the electrolyte in a reaction that converts chemical energy to electrical energy.

The drive toward decarbonisation and the demand for electric cars has increased the focus on sustainably producing energy-dense cathodes. However, traditional processing presents challenges. The first challenge is a dependence on cobalt, a rare metal mined and refined abroad. This dependence on foreign sources poses risks to American manufacturing supply chains and transportation infrastructure. Additionally, the balance of other metals common in cathodes can also make the manufacturing process longer and more hazardous. For example, high nickel

concentration has led to the widespread use of a chemical-mixing method for cathode production that requires large quantities of ammonia for corrosive reactions. Using the toxic chemical increases costs, heightens health and environmental concerns, and wastes large amounts of water to reduce acidity.

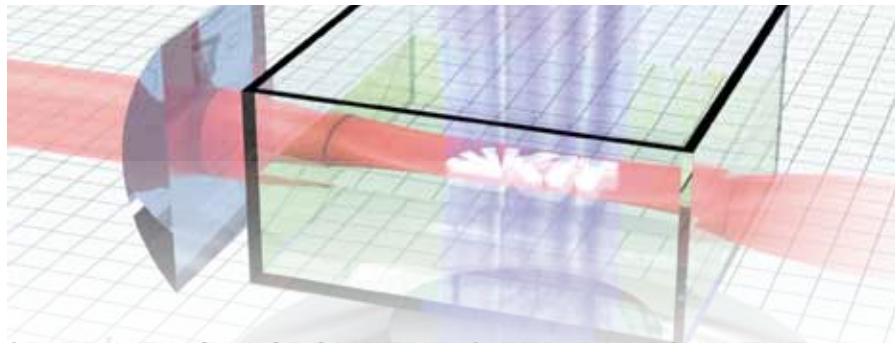
ORNL researchers report in the *Journal of Power Sources* that they have developed a cleaner, cheaper, more efficient method for making a new class of high-capacity cathode material without cobalt. Instead of continuously stirring cathode materials with chemicals in a reactor, their hydrothermal synthesis approach crystallises the cathode using metals dissolved in ethanol. The ethanol is safer to store and handle than ammonia, and afterward it can be distilled and reused. ORNL's Ilias Belharouak, the principal investigator for the project, said the process offers the advantage of moving the cathode industry to cleaner and more cost-competitive production while putting less burden on the environment.

According to ORNL lead researcher Rachid Essehli, the hydrothermal synthesis method is also faster. The time required

to make particles and prepare for the next cathode batch drops from as many as a few days to 12 hours. The material produced has more uniform, round, tightly packed particles that are ideal for a cathode, according to Essehli. Although the ORNL researchers have previously identified other cobalt-free combinations that work, the material developed through this study was better at maintaining stability throughout the battery charge cycle. Because its properties are similar to those of today's cobalt-based cathodes, the new material can be integrated into existing battery manufacturing processes. A patent is pending on the technology, which is ready to be scaled up for commercial production by the industry. "This cathode material can give more energy and decrease the cost of electric car batteries," Essehli said.

The research was funded by the US DOE Office of Energy Efficiency and Renewable Energy's Vehicle Technologies Office. It used resources of ORNL's Center for Nanophase Materials Sciences and the Advanced Photon Source at Argonne National Laboratory. Both are DOE office of Science user facilities.





## 3D PRINTING MICROMETRE-SIZED PARTS IN THE BLINK OF AN EYE

A research team from the Queensland University of Technology (QUT), the Karlsruhe Institute of Technology (KIT), and Heidelberg University have developed a laser printing process that can print micrometre-sized parts precisely and quickly. Stereolithography 3D printing is a popular additive manufacturing process for plastics, both for private and industrial applications. In stereolithography, the layers of a 3D object are projected one by one into a container filled with resin. The resin is cured by UV light. However,

previous stereolithography methods are slow and have too low a resolution. Light-sheet 3D printing, which is used by the QUT researchers, is a fast and high-resolution alternative.

In light-sheet 3D printing, blue light is projected into a container filled with a liquid resin. The blue light pre-activates the resin. In a second stage, a red laser beam provides the additional energy needed to cure the resin. However, 3D printing can only print resins that quickly return from their pre-activated state to their original state.

Only then can the next layer be printed. Consequently, the return time dictates the waiting time between two successive layers and thus the printing speed. First author Vincent Hahn from KIT's Institute of Applied Physics (APH) said that for the resin used by the researchers, the return time was less than 100 microseconds, which allowed for high printing speeds.

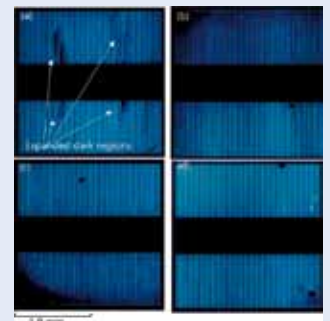
The researchers built a special 3D printer, in which blue laser diodes were used to project images into the liquid resin using a high-resolution display with a high frame rate. The red laser was formed into a thin "light sheet" beam and crossed the blue beam vertically in the resin. With this arrangement, the researchers were able to 3D print micrometre-sized parts in a few hundred milliseconds. However, Professor Martin Wegener of APH said that with more sensitive resins, the researchers could even use LEDs instead of lasers in their 3D printer. "Ultimately, we want to print 3D structures that are centimetres in size, while maintaining micrometre resolution and high printing speeds," Wegener said.

## TECHNIQUE DEVELOPED TO PREVENT BIPOLAR DEGRADATION IN SILICON CARBIDE ELECTRONICS

Silicon carbide (SiC) is a semiconductor material that can outperform pure silicon-based semiconductors in some applications. SiC devices offer benefits such as a high power density and reduced power losses at high frequencies even at high voltages. Although these properties and its relatively low cost make SiC a promising contender in various sectors of the semiconductor market, its poor long-term reliability has been a barrier. A pressing issue with 4H-SiC — a SiC type with superior physical properties — is bipolar degradation. This is caused by the expansion of stacking faults in 4H-SiC crystals. Small dislocations in the crystal structure grow over time into large defects called 'single Shockley stacking faults' that progressively degrade performance and cause the device to fail. Although some methods to mitigate this problem exist, they make the device fabrication process more expensive.

Researchers from Japan, led by Associate Professor Masashi Kato from the Nagoya Institute of Technology, have found a feasible solution for this issue. In their study, they present a fault suppression technique called "proton implantation" that can prevent bipolar degradation in 4H-SiC semiconductor wafers when applied prior to the device fabrication process. "We wanted to help the industry navigate this challenge and find a way for developing reliable SiC devices, and, therefore, decided to investigate this method for eliminating bipolar degradation," Kato said.

Proton implantation involves 'injecting' hydrogen ions into the substrate using a particle accelerator; the idea is to prevent the formation of single Shockley stacking faults by pinning down partial dislocations in the crystal, one of the effects of introducing proton impurities. However, proton implantation itself can damage the 4H-SiC substrate, due to which high-temperature annealing is used as an additional processing step to repair this damage. The research team aimed to verify if proton implantation would be effective when applied before the device fabrication process, which typically includes a high-temperature annealing step. Accordingly, researchers applied proton implantation at different doses on 4H-SiC wafers and used them to fabricate PiN diodes. They then analysed the current-voltage characteristics of these diodes and compared them to those of a regular diode without proton implantation. Finally, they captured electroluminescence images of the diodes to check whether the stacking faults had formed or not.



*Proton implantation prevents the expansion of stacking faults and solves the problem of bipolar degradation. Electroluminescence images of PiN diodes made from silicon carbide after being subjected to electrical stress. In the first diode (a), on which proton implantation was not applied, expanded stacking faults show up as dark regions. The other three diodes (b, c, and d) undergo proton implantation at increasing hydrogen ion doses. Contrary to the first diode, these exhibit no stacking fault expansion and, in turn, bipolar degradation. Image credit: Masashi Kato from Nagoya Institute of Technology.*





## NIST TO PHASE OUT SHA-1 CRYPTOGRAPHIC ALGORITHM BY 2030

The SHA-1 algorithm, a widely used method of protecting electronic information, has reached the end of its useful life, according to security experts at the National Institute of Standards and Technology (NIST). The agency now recommends that IT professionals replace SHA-1, in the situations where it is still used, with newer algorithms that are more secure. SHA-1, whose initials stand for 'secure hash algorithm', has been in use since 1995. It is a modified version of SHA, the first hash function the federal government standardised for widespread use in 1993. NIST has announced

that SHA-1 should be phased out by 31 December 2030, in favour of the more secure SHA-2 and SHA-3 groups of algorithms.

SHA-1 has served as a building block for many security applications, such as validating websites — it secures information by performing a complex math operation on the characters of a message, producing a short string of characters called a hash. It is impossible to reconstruct the original message from the hash alone, but knowing the hash provides an easy way for a recipient to check whether the original message has been compromised, as even a slight change to the message alters the resulting hash dramatically. Today's more powerful computers can create fraudulent messages that result in the same hash as the original, potentially compromising the authentic message. These 'collision' attacks have been used to undermine SHA-1 in recent years, with NIST previously announcing that federal agencies should stop using SHA-1

in situations where collision attacks are a critical threat, such as for the creation of digital signatures.

NIST aims to publish FIPS 180-5 (a revision of FIPS 180) to remove the SHA-1 specification; revise SP 800-131A and other affected NIST publications to reflect the planned withdrawal of SHA-1; and publish a transition strategy for validating cryptographic modules and algorithms.

"Modules that still use SHA-1 after 2030 will not be permitted for purchase by the federal government. Companies have eight years to submit updated modules that no longer use SHA-1. Because there is often a backlog of submissions before a deadline, we recommend that developers submit their updated modules well in advance, so that CMVP has time to respond," said Chris Celi, NIST computer scientist.

More information about the transition is available at the NIST Computer Security Resource Center transition page.

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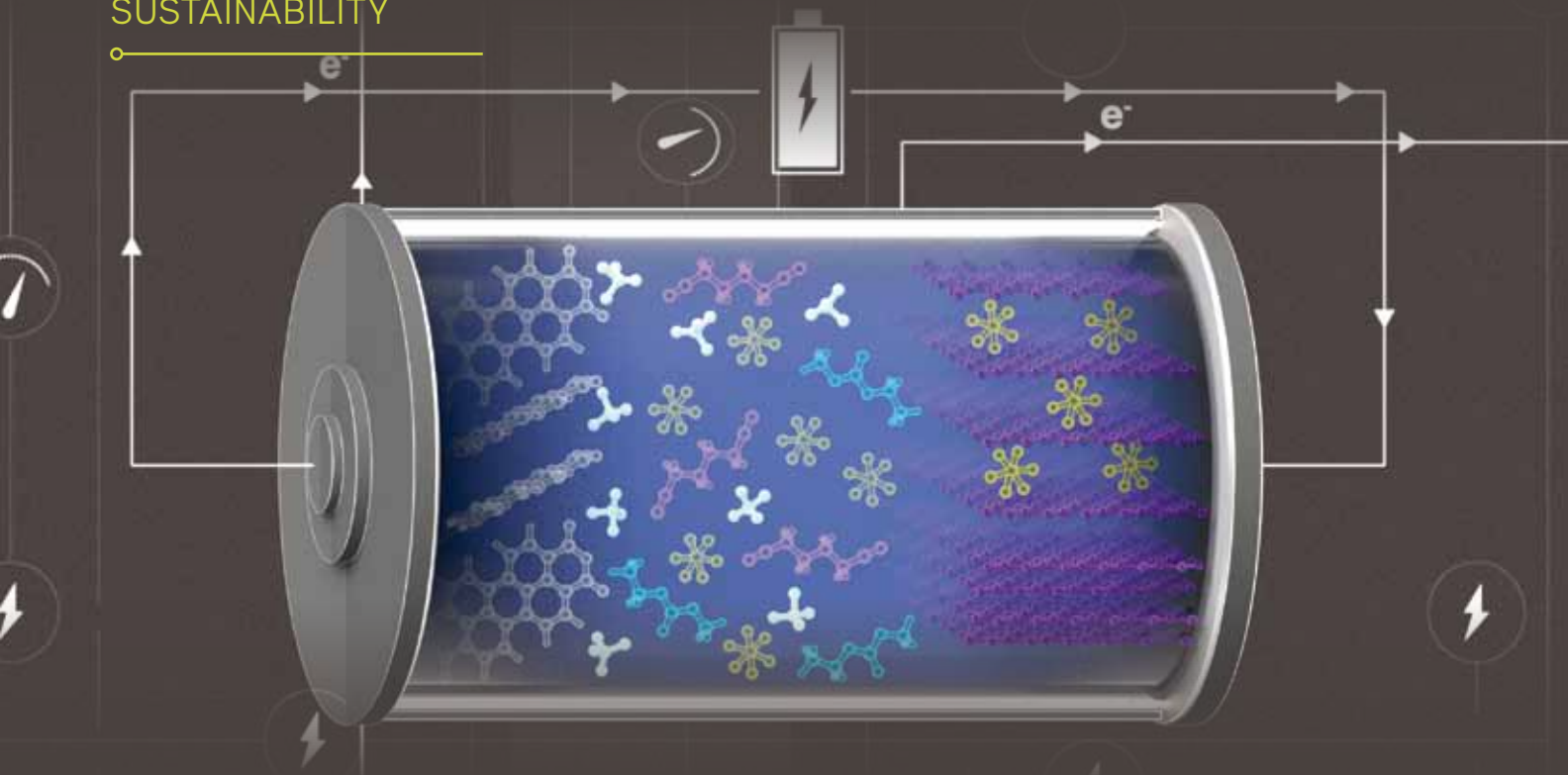


Image credit: Heno Hwang

# METAL-FREE BATTERIES

## RAISE HOPE FOR MORE SUSTAINABLE AND ECONOMICAL GRIDS

Rechargeable batteries that use ammonium cations as charge carriers could provide ecofriendly and sustainable substitutes to metal-ion-based batteries, researchers at KAUST show.

**M**etal-ion batteries, such as lithium-ion batteries, are the go-to energy storage solution. They dominate the market for portable consumer electronics and electric vehicles because of their high energy density and versatility. However, metal ions used in the electrolytes come from limited and declining resources, which threatens long-term availability. Their toxicity and flammability can be unsafe and harmful to the environment.

There have been several attempts to generate ammonium-ion-based batteries to solve sustainability and environmental issues because these cations are lightweight and easy to synthesise and recycle. However, ammonium cations are prone to reduction into hydrogen and ammonia at low operation potential, preventing the batteries from achieving their full potential. They also dissolve readily in electrolytes, making them difficult to incorporate into electrode materials.

Husam Alshareef, postdoc Zhiming Zhao and coworkers developed a high-efficiency metal-free battery by combining an ammonium-cation-containing electrolyte with carbon-based electrodes. The graphite cathode and the organic semiconductor anode are cheap, environmentally friendly and renewable, Zhao said.

With the ammonium cations, the researchers chose hexafluorophosphate ions as negative charge carriers and exploited the ability

of graphite to reversibly accommodate these anions within its layers to create a “dual-ion” battery. In the battery, cations and anions simultaneously insert into their corresponding electrode during charge cycles and are released into the electrolyte during discharge cycles.

This differentiates our work from other studies, Zhao said.

“We designed an electrolyte that is both antioxidative and antireductive by screening a series of solvents resistant to high voltage and also taking into account its reduction stability,” Zhao said.

The antioxidative solvent mainly solvated anions participating in the cathode reaction, while its antireductive counterpart formed a solvation sphere around cations involved in the anode reaction. “This configuration is crucial for battery stability,” Zhao explained.

The battery outperformed existing ammonium-ion-based analogues with a record operation voltage of 2.75 volts. “It is now possible to develop high-energy, nonmetallic ion batteries that can compete with metal-ion batteries,” Zhao said.

The team is currently working to enhance the performance to get closer to large-scale applications. “We are exploring anode materials with a higher capacity, which is crucial for improving the energy density,” Zhao said.

Alshareef’s group is developing cheap alternatives to lithium-ion batteries, particularly for grid-scale storage. “To eventually completely decarbonise the grid, the battery costs must significantly come down,” said Alshareef. Replacing lithium with nonmetallic charge carriers, such as ammonium ions, can help lower these costs.

The research findings were published in the international edition of the journal *Angewandte Chemie*.

*This article was supplied by King Abdullah University of Science and Technology (KAUST).*



Defense



Railway



Industrial



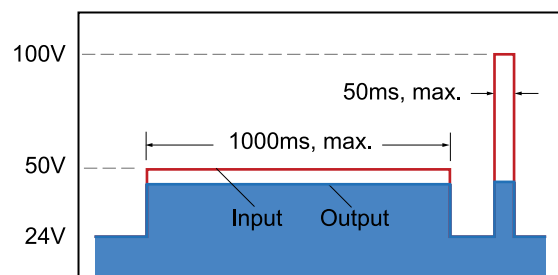
**P-DUKE**  
**POWER**



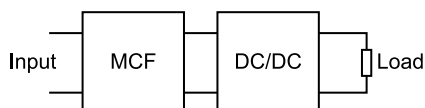
DC/DC Front-end Filters

# MCF Series

**MCF** series is a fully integrated front-end module which offers active input over-voltage protection which clamps over-voltages for maximum 50ms up to 100V to a safe level of 40V and absorbs +/-250V spikes with the internal protection circuits. By connecting the MCF module with a few additional MLCCs, its internal EMI filter meets MIL-STD 461G limits. Besides, it also features other active protection functions for an advanced protection of the DC/DC converter module such as remote on/off control, overload protection, output short-circuit protection, reverse polarity protection, inrush current limitation, etc.



Active Surge Voltage Protection



Model	Max. Output Power	Input Range
MCF-028005-001	45W	9 - 36 Vdc
MCF-028015-001	250W	

Meet Standard	V <sub>nom</sub>	Operating Input Range	Brownout	Transient	Spike
MIL-STD 1275D	28Vdc	23-33 Vdc		40V / 500ms 100V / 50ms	±250V / 70μs
EN 50155	24Vdc	16.6-30 Vdc	14.4V / 100ms	33.6V / 1000ms	
RIA12	24Vdc	16.6-30 Vdc	14.4V / 100ms	36V / 1000ms 84V / 20ms	
NF F 01-510	24Vdc	18-34 Vdc	12V / 100ms	40V / 100ms	

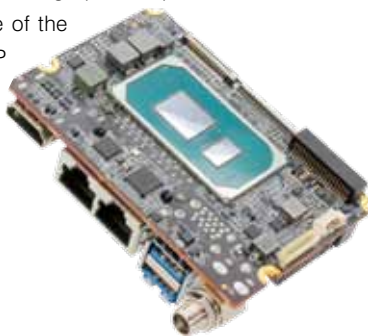


## EMBEDDED SINGLE BOARD COMPUTER

AAEON's business card-sized de next-TGU8 is powered by an 11th Generation Intel Core Processor, equipped with processing power of up to 4 cores, with 8 threads. Its minute form factor, full I/O and 16 GB of onboard LPDDR4x memory make the embedded single board computer suitable for edge AI and drone applications. Designed to facilitate ultra-high-speed connectivity via dual RJ45 Ethernet ports, 6 USB ports and a dual display interface via HDMI and eDP ports, the device is suited to edge AI applications in robotics.

Support for AI acceleration, Wi-Fi and 4G expansion modules offer the versatility to suit diverse application requirements. Additional expansion accessories include an FPC slot for PCIe [x4] Gen 3 with Riser kit, which provides users with additional storage or more advanced graphics options with which to take advantage of the board's dual HDMI/eDP interface.

**AAEON  
Technology Inc.**  
[www.aaeon.com](http://www.aaeon.com)



## REMOTE TEMPERATURE AND HUMIDITY DATA LOGGER

ICP Australia has introduced ICP DAS's DL-100S-E Series, which are data logger devices that can be used to record temperature, humidity and dewpoint information, including the date and time stamps for each record.

Real-time data can be accessed from the data logger from anywhere and at any time using the free Windows software, the iOS App or the Android App, as long as it is connected to the same local network as the data logger. The data logger supports industrial protocols

such as Modbus TCP, as well as the emerging machine-to-machine (M2M)/IoT (Internet of Things) connectivity protocol — MQTT. The data logger can be connected using a range of communication interfaces including Ethernet and PoE, meaning that the device can be integrated into existing HMI or SCADA systems, for easy maintenance in a distributed control system.

The IP66 version of the data logger is designed for industrial applications in harsh environments that provide IP66-grade protection approval. The rugged RJ-45 is designed to provide tight, robust connections for reliable operation and applications that are subject to high vibration and shock.

The data logger features a measurement range of -20 to +60°C and 0 to 100% RH, with an LCD display that shows temperature, relative humidity, date and time. The data logger is able to store up to 600,000 records with date and time stamps.

**ICP Electronics Australia Pty Ltd**  
[www.icp-australia.com.au](http://www.icp-australia.com.au)

## 5G NR MODULE SERIES

Quectel Wireless Solutions has launched automotive grade 5G NR modules: the AG59x series. The modules deliver a range of enhancements including multi-gigabit cellular connectivity, C-V2X PC5 direct communications, improved location services, a high-performance multicore application processor as well as strengthened security, making it suitable for supporting next-generation automotive applications.

Based on the AEC-Q100 qualified Qualcomm chipsets, the range of modules includes the AG59xH series, which integrates the Qualcomm SA525M and the AG59xE series featuring the Qualcomm SA522M inside. Similar to Quectel's other automotive products, the new series of modules comply with the international IATF 16949:2016 automotive quality management system to address the demanding requirements of automotive devices. Featuring high robustness, the series is designed to perform under high temperature environments.

The series is designed for a range of automotive applications including telematics boxes, telematics control units, C-V2X systems, onboard units and roadside units. Meeting the 3GPP Release 16 specification and supporting both 5G NR standalone (SA) and non-standalone (NSA) modes, the modules are backward-compatible with existing LTE, WCDMA and GSM networks, allowing them to be connected in areas without current 5G NR deployment. Additionally, its Dual SIM Dual Standby (DSDS) technology can help tackle poor signal coverage when needed.

The modules support 4 x 4 downlink multiple input multiple output (MIMO) technology which improves wireless communication performance and enhances data speeds. The modules deliver maximum downlink rates of 4.3 Gbps and uplink rates of 1 Gbps for 5G NR, while providing up to 2.4 Gbps peak downlink rate and 550 Mbps uplink rate. Their faster data speeds help to ensure that user emergency data and diagnostic data can be transferred in real time for increased reliability.

Supporting optional C-V2X PC5 direct communications, the modules are designed to enhance the performance of vehicle-to-vehicle (V2V) and vehicle-to-roadside infrastructure (V2I) communications for improved traffic efficiency and safety. The module integrates an application processor with up to 20 KDMIPS computing power available to run C-V2X stack and applications. It also has an integrated ECDSA engine to fulfil C-V2X verification capability.

**Quectel**  
[www.quectel.com](http://www.quectel.com)



## WIRELESS MICROCONTROLLER FAMILY

Microchip's PIC32CX-BZ2 MCU family includes System-on-Chip (SoC) devices as well as global regulatory-certified, RF-ready modules. In addition to Bluetooth Low Energy functionality, the family includes Zigbee stacks and Over the Air (OTA) update capabilities. Hardware features include a 12-bit Analog-to-Digital Converter (ADC), multiple timer/counters for control (TCC) channels, an on-board encryption engine, and a broad set of interfaces to touch, CAN, sensor, display and other peripherals. The family's 1 MB of Flash memory supports large application codes, multiprotocol wireless stacks, and OTA updates. AEC-Q100 Grade 1 (125 °C) qualified packages further simplify wireless connectivity integration where highly robust solutions are required.

The family is designed to simplify development through its MPLAB Harmony 32-bit embedded software development framework. MPLAB Code Configurator integration enables developers to begin prototyping with the PIC32CX-BZ2 family using drag-and-drop auto code generation. Numerous application code examples are hosted on GitHub and linked through MPLAB Code Configurator and MPLAB Discover. RF design with PIC32CX-BZ2 SoCs is simplified with the ecosystem's chip-down reference design packages and wireless design check services. Customers with little to no RF expertise can benefit from Microchip's WBZ451 modules that are pre-certified to multiple regulations around the world and feature an optimised on-board RF design.

**Microchip Technology Hong Kong Limited**  
[www.microchip.com](http://www.microchip.com)

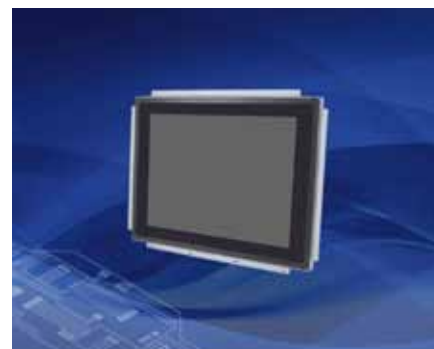
## OPEN FRAME PANEL PC

Backplane Systems Technology has launched Aplex's OPC-5158P, which is a 15" open frame panel PC that is powered by an x86 base Intel Celeron N2930 Processor. The panel PC has a low power consumption design, as well as a wide-ranging 9~36 VDC power input.

The open frame panel PC has a slim and fanless design with a flat front bezel style, making it easy to deploy. Furthermore, the panel PC has an option for high brightness and offers an optical bonding solution to make it convenient to use in varying light conditions. The front bezel is IP65 certified, allowing it to withstand dust, splashes and low-pressure jets.

The panel PC supports a range of I/O, making it suitable for a variety of applications. For example, 2x USB 3.0 and 2x GbE LAN. The panel PC also supports a 1x Intel Mini PCIe expansion slot to extend its functionality. The panel PC is designed to survive tough environmental conditions as it has an operating temperature ranging from 0~40°C. The adjustable front panel is IP65 rated and comes in 2, 3 and 6 mm sizes. The panel PC features a 5-wire resistive touch window and a projected capacitive touch screen with an output of 7H. The panel PC also features a system power LED light.

**Backplane Systems Technology Pty Ltd**  
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# HOW THE INDUSTRIAL IoT IS POWERING INDUSTRY 4.0

*Lorenzo Amicucci, Business Development Manager, Nordic Semiconductor*

The Industrial Revolution began in Britain sometime around 1760, and ushered in a period where coal-fired steam engines powered increased mechanisation and productivity, and transformed a largely agrarian society into a manufacturing one.

Things dramatically accelerated again in the 1870s as machine tools, the Bessemer steel-making process, the telegraph, electrification, the internal combustion engine and widespread availability of oil and gas supercharged industry. Then, in the late 1960s, the third era of industrial disruption began, thanks to the emergence of digital computers. This allowed for computer-aided design (CAD), consistent manufacture of complex components, greater automation and higher productivity.

## Industry 4.0 in full swing

Now we find ourselves in the midst of 'Industry 4.0'. This is characterised by the large-scale automation of traditional manufacturing and industrial practices, using smart technology, widespread machine-to-machine communication (M2M) and the transformative power of machine learning (ML). The key difference between Industry 3.0 and 4.0 is that while digital information is key to both, in the former case it is used by humans to make better decisions, while Industry 4.0 uses the same information (and more besides) to optimise things largely without human intervention.

The 'Industrial' Internet of Things (IIoT) is at the heart of this new phase of manufacturing and production. It is the platform through which automation, M2M and ML are supported. The IIoT uses feedback loops

whereby sensors monitor processes, and their data is then used to control and refine machine operation.

## The importance of precision

Optimisation is important because manufacturing relies on precision and repeatability. A car component, for example, must be manufactured to tolerances tight enough such that the product can be bolted to any of thousands of examples of a particular model and work perfectly every time for many years. The smaller and more delicate the manufactured items are — think of the mechanism of a fine watch, the windings of a tiny electric motor or the soldering in a smartphone — the greater the precision required during manufacturing.

Getting products right first time reduces potential field failures and expensive warranty claims. It also saves large amounts of resources and money, especially if components are made from exotic materials or by machine tools that are expensive to purchase and run. It is also more environmentally friendly to make things correctly first time as it saves the energy and carbon emissions it takes to produce new items to replace the defects.

## The use of ML in manufacturing

The key to ensuring precision time and time again is process control. Sensors and cameras can monitor machines and measure finished parts to pick up any minor deviations in the product, and correct the process before things

drift out of tolerance. Beyond the manufacturing process itself, many other factors can compromise a process so other sensors keep track of things like vibration, temperature, humidity and air quality.

But a continuous and large-scale manufacturing process will generate a lot of sensor data. And much of that data will show little change. Transmitting and analysing huge volumes of data is time-consuming, costly and uses a lot of energy. Instead, sensors are now starting to incorporate onboard edge processing and ML to 'learn' how to spot significant trends in an otherwise unchanging stream of data. When trends are detected, the information is sent to the cloud for analysis and action.

ML can also help to pre-empt issues that might arise due to external factors — for







instance, an increase in humidity caused by workers arriving for the day, air flow from open windows and doors, and changes in temperature throughout the day and night. Using this information, processes can be tuned ahead of any potential problems.

### Linking the front office and the factory floor

The IIoT is not only changing the way products are made but also how they're designed. Industry 3.0 made full use of computers, but those doing the design work and those doing the manufacturing didn't talk to each other. Engineers would take CAD outputs from the design office and use the information to manually program the machine tools. Apart from being labour-intensive and prone to error, it also missed the chance to refine the design to

make it easier, cheaper and quicker to make.

Industry 4.0 links the front office to the factory floor. Using M2M communications, design computers can talk to machine tools to directly program them to make parts. And machine tools can speak to design computers to let them know where the bottlenecks are in the manufacturing process such that products can be redesigned for simpler manufacture without compromising function. And a centralised computer can take all the design and manufacturing data to work out the best way to make future products that are long-lasting, able to be repaired and, at the end of their lives, easily recyclable.

### The IIoT will usher in Industry 5.0

Investing in the IIoT is expensive. However, wireless technology does cut the cost of

installing wiring and makes it easy to re-configure networks as the factory changes and expands. And the long-term savings brought by better design and manufacture are significant as productivity increases and product failures decline.

Industry 4.0 is here and the vision for Industry 5.0 is clear. That vision is sustainability. According to the EU, the next leap will take industry "beyond efficiency and productivity as the sole goals, and reinforces the role and the contribution of industry to society while, crucially, respecting the production limits of the planet". That is a laudable objective but a huge challenge. But it's one that the IIoT will help us solve.

Nordic Semiconductor  
[www.nordicsemi.com](http://www.nordicsemi.com)



## BENCHTOP AND RACKMOUNT SYSTEMS

Helios Power Solutions offers a range of DC Programmable Laboratory/Variable Power Supplies that are primarily designed for R&D purposes but have been used in a range of applications, such as aircraft superconducting electric propulsion technology, solar panel I-V testing, battery manufacturing, cooper test equipment, cathodic protection pipelines, battery charger maintenance and variable PSU works as a backup.

Variable power supplies are DC power systems that can be operated in constant voltage (CV) mode or in constant current (CC) mode automatically depending on load conditions within the range of voltage values and current values that have been set ahead of time.

The Programmable DC Power Supply Series provides high power density (from 200 W to 36 kW) with a complete set of interfaces in benchtop or rackmount profiles and offers output voltages from 0 to 2250 V at output currents up to 1200 A using worldwide AC inputs (with built-in power factor correction).

The company's technical sales engineers in Australia and New Zealand are always available to provide assistance on how to choose the most suitable DC variable power system.

**Helios Power Solutions**  
[www.heliosps.com.au](http://www.heliosps.com.au)

## 3-AXIS ACCELEROMETER

STMicroelectronics is enabling more acoustically comfortable cars with its new sensor for road-noise cancellation (RNC) through active noise-control (ANC) techniques. ST has leveraged its competencies in micro electro-mechanical system (MEMS) ICs to give the AIS25BA 3-axis accelerometer the characteristics to enhance RNC system accuracy. The sensor is designed to provide minimal electrical noise, which helps vehicle engineers achieve a calm in-car environment. It also has the fast response/low latency needed by the RNC system to calculate corrective waveforms in real time as well as wide bandwidth to capture disturbances across the full spectrum of sound frequency relevant for the application. Its wide temperature range and mechanical robustness allow placement in harsh places inside today's vehicles: near the engine or electric drive as well as close to wheels and suspension.

The accelerometer is engineered to prioritise RNC system accuracy. At 30  $\mu\text{g}/\sqrt{\text{Hz}}$  in X and Y axes and 50  $\mu\text{g}/\sqrt{\text{Hz}}$  in the Z axis, it has low noise density. The accelerometer's noise performance enables the frequency response to extend to 2 and hence covers the spectrum relevant for in-car noise cancellation. Similarly, the total sensor latency of 266  $\mu\text{s}$  is engineered for leaving the system plenty of time to generate noise-cancellation signals in real time.

The sensor also has a time-division multiplex (TDM) digital interface that enables the system to synchronise the outputs from multiple accelerometers installed to measure vibrations throughout the vehicle. This audio-friendly interface also facilitates easy connection to other types of data bases adopted in the automotive industry. The full-scale measurement range is selectable up to  $\pm 7.7\text{ g}$ , giving plenty of margin with respect to the intense vibrations typical of the application. The supply-voltage range is 1.71 to 1.99 V. The AIS25BA is compliant with AEC-Q100 and is available now in a 14-lead 2.5 x 2.5 x 0.86 mm LGA package.

**STMicroelectronics Pty Ltd**  
[www.st.com](http://www.st.com)



## SNAP FERRITES

Würth Elektronik has launched another line of retrofittable interference suppression solutions with AEC-Q200 qualification, as required for the automotive industry. The WE-CAR-TEC series snap ferrites feature a NiZn core material. The snap ferrites are designed to suppress electromagnetic interference in the frequency range from 1 MHz to 1 GHz.

The internal security locking system prevents unauthorised removal from the cable. The WE-STAR-KEY key technology makes the ferrite reusable and therefore suitable for test and measuring purposes in the EMC lab. Each packaging unit comes with a WE-STAR-KEY to open the snap ferrites. The snap ferrites are available in four different sizes for cable diameters from 3.5 to 8.5 mm. The plastic housing is UL94-V0 classified; the operating temperature ranges from -50 to +105°C.

The snap ferrites are available from stock and free samples are available.

**Würth Electronics Australia Pty**  
[www.we-online.com](http://www.we-online.com)







## COMPUTER VISION SYSTEM

Axiomtek has introduced the RSC201, a fanless edge AI computer vision system with Xilinx AI accelerator that supports the simultaneous execution of multiple algorithms through the built-in, multi-node function, delivering enhanced AI computing performance with low latency. The device's compact size and wide operating temperature are designed to fit in various environments, while its 5G wireless connection empowers rapid data transmission between edge devices and data centres that improve the decision-making process in machine learning. The device is suitable for traffic management, automated warehouse logistics, smart fence, and AGV/AMR.

The device is powered by the Xilinx Kria K26 SoM, an advanced AI accelerator that is designed to provide fast vision AI computing with native ROS 2 support for higher productivity in robotics and industrial automation. The device also has onboard 4 GB DDR4 system memory and eMMC 16 GB. When it comes to expansion interfaces, the device supports one M.2 Key B 3052 slot and one SIM socket for 5G communication and has an M.2 Key B 2242 slot for SSD storage. Turning to the system I/O, it has one 10/100/1000 Mbps Ethernet LAN port, one DisplayPort 1.4, two USB 3.0 ports, one COM port, one CANbus for real-time communication among microcontrollers, one PMOD for peripheral modules connecting, and 12–24 VDC wide power input.

As a rugged design, the fanless device can withstand an operating temperature range of –30 to +75°C to facilitate operation in harsh environments. The device also adopts an IP40-rated extruded aluminium and heavy-duty steel housing against dust and dirt. The device has a compact size with a weight of 1.5 kg; it also supports the Linux operating system.

The device applies the Xilinx industrial chipset which enables precise edge AI computing.

**Tekdis**

[www.tekdis.com.au](http://www.tekdis.com.au)

## FANLESS EMBEDDED BOX PC

The BOXER-6645-ADS contains processing capabilities of up to 16 cores and 24 threads with 12th Generation Intel Core i3/i5/i7/i9 Processor platforms, in addition to hosting I/O features. With up to eight 10 Gbps USB 3.2 Gen 2 for high-speed peripherals, four LAN ports for camera and sensor connectivity, and four independent display outputs, the fanless embedded box PC is built for applications such as traffic management control rooms.

Hosting a dual-channel DDR5 4800 MHz SODIMM slot, the fanless embedded box PC supports 64 GB of system memory, which offers a 50% increase in bandwidth, significantly boosting data rate transfer speed. Combined with the power of 12th Generation Intel Core processors, this enables real-time edge-server communication for IoT Gateway use.

Alongside its processing power, the fanless processing box PC comes with a range of integrated peripheral technologies, ranging from Intel DL Boost to Intel Iris Xe Graphics to enable AI inferencing performance for smart city and Industry 4.0 solutions.



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## COMPACT EXPANDABLE EMBEDDED PC

Backplane Systems Technology has launched the iBase AMS310, an embedded computer featuring high performance yet low power consumption and an operating temperature range from -10 to 60°C. The fanless PC is suitable for customers looking for a robust computing platform for machine automation, and industrial and harsh environment applications.

Built with a passive finned heat sink that provides an efficient transfer of heat away from components, the box PC houses the IBase MB310 customised board with Intel Q470E PCH to support 10th Gen Intel Core i7/i5/i3 desktop processors (35 W TDP). It allows the connection of up to six antennas, offering industrial-grade connectivity using M.2 2030 E-Key and 3052 B-Key for WLAN/4G/5G connections. The embedded PC features a front removable drive bay for HDD/SSD and is designed to support DIN-rail mount and wall mount.

The embedded PC's platform measures 275 x 150 x 70 mm and accommodates up to 64 GB DDR4 system memory. The rear panel provides connectors for HDMI, DP, line-out, 6x USB, 2x COM, 2x RJ45 for 2.5G LAN and 24V DC-in power. System storage is supported by an externally accessible 2.5" drive bay and an M.2 M-keyed socket for fast NVMe SSDs. Other features include TPM 2.0 security, over/under/reverse voltage protection and multiple OS support.

**Backplane Systems Technology Pty Ltd**  
[www.backplane.com.au](http://www.backplane.com.au)



## ANTENNAS FOR WI-FI6 AND WI-FI6E

Antenova has announced three antennas for Wi-Fi6 and Wi-Fi6E — a surface mounted antenna, a flexible antenna and an external antenna. All three antennas use the 2.4, 5 and 6 GHz bands and support IEEE standards 802.11a/b/g/j/n/ac/ax.

The SMD antenna, named Billi (part number SR43W078), measures 15 x 6 x 1 mm and requires only 1 mm of clearance on the PCB. This makes it a low-profile solution for slim devices with a small space for the antenna. In tests the antenna showed high efficiency across all three bands. It is suitable for pick-and-place manufacturing processes.

The FPC antenna, named Lotti (part number SRF3W077), is a flexible antenna measuring 30.0 x 8 x 0.15 mm. It has a self-adhesive mounting for easy integration into small designs. The antenna does not require a ground plane on the PCB and also showed high efficiency in tests.

The third antenna is Nitida (part number SRE3W084), an antenna for external mounting. It is supplied with an SMA connector and offering a waterproof variant. It is simple to add to a design because it does not require a matching network.

The antennas will be suitable for high-performing wireless devices that combine mobility with high throughput, eg, routers and USB dongles for Wi-Fi6 and Wi-Fi6E, games consoles, set-top boxes, surveillance cameras, networked IoT devices and MIMO systems. The Lotti and Nitida antennas connect directly to a PCB, which makes for an easier integration and a shorter design cycle. The emerging Wi-Fi7 standard will also utilise the 6 GHz band, so manufacturers choosing one of the antennas now will be positioned to deliver ultrafast Wi-Fi7 speeds in future.

**Antenova Limited**  
[www.antenova.com](http://www.antenova.com)

## C-V2X MODULE

Quectel Wireless Solutions has launched its AG18 automotive module, a next-generation cellular vehicle-to-everything (C-V2X) module. Featuring PC5 direct communications, the module enables vehicles to effectively communicate with one another and with their surroundings, which should improve safety and traffic efficiency. In addition to C-V2X communication capabilities, the module was designed to feature flexible positioning service options including L1+L5 dual frequency GNSS, Qualcomm Dead Reckoning (QDR3) and high-precision PPE (RTK) technologies, so that global automotive OEMs and Tier 1 suppliers can leverage location technology appropriate to their application requirements.

Based on the AEC-Q100 qualified Qualcomm SA415M chipset, the product complies with the international IATF 16949:2016 automotive quality management system. It is designed for use in harsh environments and provides good ESD/EMI protection.

The device is pin-to-pin compatible with Quectel's previous-generation C-V2X module AG15, allowing existing OEM customer devices to migrate seamlessly and upgrade through a simple drop-in replacement. Additionally, it includes multiple interfaces including PCIe, USB 3.0/2.0, SPI, I2C, UART, GPIO, ADC and 1pps, enabling users to develop a wide range of applications including telematics control units (TCU), telematics boxes (T-BOX), virtual boxes (V-BOX) and roadside units (RSU).

**Quectel**  
[www.quectel.com](http://www.quectel.com)



# STRETCHABLE PACKAGING DEVELOPED

TO PROTECT BATTERIES FROM GAS, MOISTURE



Wearable batteries have garnered attention for their potential as sensors that could monitor various biomarkers and as medical devices.

In order for these wearable devices to be functional, they need to have stretchable and deformable batteries. Because wearable devices are exposed to the atmosphere, it is important to extend battery life while protecting the batteries from atmospheric moisture and gases. Researchers from Yokohama National University in Japan have developed a stretchable packaging film for these batteries with a high gas and moisture barrier functionality. Their results were published in *ACS Applied Materials & Interfaces*.

Corresponding author Hiroki Ota of the Department of Mechanical Engineering at Yokohama National University said that although soft and stretchable batteries have been studied in the world, they cannot be used in air due to the high gas and moisture permeability of the packaging materials of stretchable batteries. "Currently, the use of solid and large batteries for stretchable de-

vices is a problem in stretchable electronics; that is, while sensors and interfaces are soft, batteries still use hard batteries," Ota said.

To create this flexible film with a high gas barrier, the researchers coated a thin layer of liquid metal onto a gold-deposited thermoplastic polyurethane film using the layer-by-layer method. This method allowed for the desired deformability, unlike aluminium-laminated films, which were used previously to address the issue of gas and moisture permeability but failed to allow for the needed flexibility. According to researchers, the resulting film demonstrates oxygen gas impermeability under mechanical strain, and low moisture permeability. The stretchable lithium-ion battery that they assembled in the study was also able to operate reliably in air due to the stretchable gas barrier film that they developed.

"It is exciting that in addition to the development of a stretchable battery, which could be used in the next generation of smart devices, including future wearable devices, films with high gas and moisture barrier properties can be achieved by using a novel material called liquid metal," Ota said.

This research could enable the use of batteries that have high energy density, high working voltage and long-term stability and that are also highly deformable — as



Image credit: Yokohama National University

opposed to bulky and inflexible — in wearable devices. As a result, the findings bring wearable devices closer to becoming more practical, thereby opening up opportunities in medicine and health. "This research contributes to the social implementation of stretchable devices," Ota said.

Next, the researchers aim to enhance the moisture protection ability of the film by modifying the materials. Another future direction involves improving the stability of the performance of the batteries, even under deformation, by developing materials better suited for their parts. Making the film cost-effective will also contribute to eventual scalability. "Further cost reductions of the developed film will lead to the implementation of stretchable batteries. In addition, the film could be useful as a barrier film for organic electronics and so on," Ota said.



## RACKMOUNT NETWORK APPLIANCE

ICP Australia has introduced the iEi PUZZLE-5030, which is a 1U rackmount network appliance with Intel Xeon E Processor and the Intel C256 Chipset. The rackmount network appliance is designed to offer functionality in a small footprint measuring up to 430 x 426 x 44.2 mm.

In terms of I/O the rackmount network appliance supports 1 x HDMI, 8 x LAN, 4 x USB 3.0 and 1 x Console port. Likewise for expansion, the appliance facilitates 1 x PCIe x8, 1 x PCIe x4, 1 x PCIe mini-Card Slot and 1 x M.2, thereby enabling expanded capabilities and advanced functionality. Furthermore, the system has up to 128G memory and supports 3x cooling fans with a smart fan and 1x system fan, which enable the appliance to perform set tasks in a timely manner. Also, the rackmount network appliance provides sufficient storage solutions with 2 x 2.5" SSD/HDD and 1 x SATA.

The appliance can also function under tough environmental conditions as it has a wide operating temperature range from 0~40°C.

Key features of the rackmount network appliance include 4 x DDR4 3200MHz non-ECC UDIMM, up to 128G, and 8 x 2.5 Gbps RJ-45 LAN Ports and 2 pairs LAN Bypass. The appliance also comes with two 2.5" SATA HDD/SSD bay, 1 x M.2 M key 2260/2280, 1 x PCIe Mini with SIM Card Slot, along with 300 W redundant/non-redundant PSUs.

**ICP Electronics Australia Pty Ltd**

[www.icp-australia.com.au](http://www.icp-australia.com.au)

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## SMALL-SIZED MICROCONTROLLERS

Nuvoton Technology has launched the NuMicro M030G/M031G series microcontrollers to offer a complete platform solution for optical transceiver applications. The features of the microcontrollers make them suitable for optical transceiver applications.

The series is equipped with a small-sized package with QFN24 3 x 3 mm and QFN 4 x 4 mm, built-in temperature with accuracy  $\pm 2^\circ\text{C}$  under  $-40$  to  $105^\circ\text{C}$ , high-speed I2C interface that can reach 1 MHz in Slave Mode, built-in hardware Manchester Codec for optical communication to do Manchester Code transformation, and built-in hardware DAC that supports Auto Data Generation Function to generate the smooth sine waveform in Manchester Code by cooperating with Manchester Codec.

The microcontrollers are equipped with four sets of DAC and up to 16 channels of ADC, making it more flexible for applications by integrating the analog peripherals in this small-sized IC. In addition to optical transceiver applications, the microcontroller series is also adopted in the applications of sensors, small screens, small home appliances, power modules, pico projectors, and wearable devices.

**Arrow Electronics Australia Pty Ltd**

[www.arrowaustralia.com](http://www.arrowaustralia.com)

## HOLLOW CONE LIQUID NOZZLES

The EXAIR 3/8 NPT HollowStream liquid atomising spray nozzles provide a hollow cone spray pattern for pressurised liquids. They are applied to solve cooling, cleaning, foam breaking, rinsing and dust suppression applications for industry. The tangential flow design is vaneless, with wide open internal features to resist clogging so they work well with liquids containing particulate. The liquid nozzles are designed to produce a uniform distribution of liquid in a ring pattern with medium to large droplets. Their right-angle design is compact and can fit in small areas. Liquid operating pressure is up to 17.2 BAR (250 PSI).

With the hollow cone liquid nozzles, the liquid is supplied into the body of the nozzle, creating a swirling action within a vortex chamber. This vortex produces the hollow-cone spray pattern when the precision nozzle breaks the liquid surface tension as it exits the orifice into a controlled spray angle.

Available from Compressed Air Australia, the stainless steel construction of the liquid atomising nozzles adds to their durability and corrosion resistance. These nozzles are CE compliant and available in a variety of flow rates. They complement EXAIR's line of other 1/8, 1/4, 3/8 and 1/2" atomising spray nozzles, which are also available in a variety of liquid patterns and flow rates.

**Compressed Air Australia Pty Ltd**

[www.caasafety.com.au](http://www.caasafety.com.au)





## FIXED ISOLATED MICROMODULE

Würth Elektronik has launched the MagI<sup>2</sup>C-FIMM Fixed Isolated MicroModule. It combines the features of an isolated power module with those of a MicroModule in an LGA-7 package and measures 9 x 7 x 3.1 mm. The isolation capacitance between the primary and secondary windings is just 8 PF. The 1 W output power is maintained up to an ambient temperature of 100°C without derating. It also features an efficiency up to 91%.

The fixed isolated MicroModule features a fully integrated DC/DC converter with switching power stage, controller, and inductor as well as input/output capacitors. It requires no external circuitry — all components, including CIN and COUT, are integrated, allowing quick and easy circuit design without transformer expertise.

The MicroModule features a small size and is designed to provide high efficiency, as well as an extended operating ambient temperature range up to 125°C. The module offers continuous short-circuit protection and overvoltage protection up to 3000 V.

The module is suitable for applications in data acquisition, test and measurement technology, for supplying interfaces and microcontrollers, and other requirements in industrial electronics. It provides functional isolation for overvoltage protection and minimises ground loops and ground shifts as well as noise in the signal path or sensor systems. Per the manufacturer's measurements, the low radiated EMI with tested filter combination is below the EN55032 Class B/CISPR-32 limits. The module is certified according to the current UL standard UL62368-1.

Developers can now order free samples and an evaluation board is available. The module is available from stock without a minimum order quantity.

**Würth Electronics Australia Pty**

[www.we-online.com](http://www.we-online.com)



## MULTI-SPECTRAL SENSOR

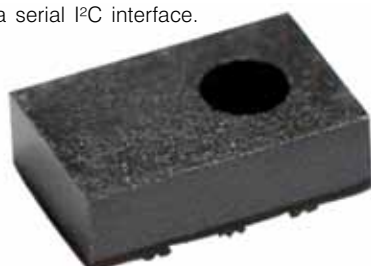
Mouser Electronics, Inc. now stocks the AS7343L 13-channel multi-spectral sensor from ams OSRAM. The sensor combines multi-channel colour analysis with XYZ sensor technology to match the human eye's perception of colour and light intensity. When integrated into colorimeters, portable spectrometers, and consumer devices, the multi-spectral sensor provides flexibility and functionality to users in applications for colour matching, lighting control and spectral analysis. The device is designed for reflective, transmissive and emissive measurements including lateral flow test applications, fluid or reagent analysis, colour matching, and spectral identification in the visible range.

The sensor is suitable for colour analysis in applications that require frequent, accurate measurements. The sensor can be used in smoke alarms and heat alarms, for the detection of spectral smoke signatures. Spectral analysis by the sensor can enable a smoke sensor to distinguish between different types of smoke, from burning wood to plastic or water vapour.

The sensor is housed in a flat 3.1 x 2.0 x 1.0 mm package, suitable for space-constrained applications. The device integrates a programmable digital GPIO and LED driver facilitating light source and trigger/sync control. Device control and spectral data access are implemented through a serial I<sup>2</sup>C interface.

**Mouser Electronics**

[au.mouser.com](http://au.mouser.com)



## RACKMOUNT SERVER

Avalue Technology Inc. has introduced the 19-inch high-performance 2U rackmount server HPS-621U2A. Designed for limited space and expandable to accommodate increase in workload, the server supports



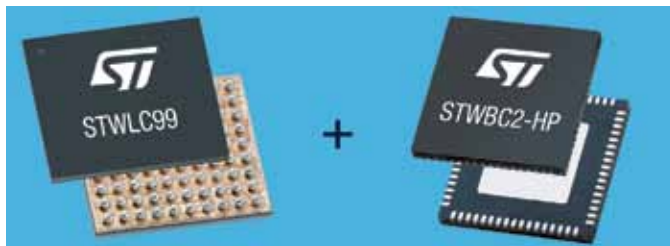
1st-Gen and 2nd-Gen Intel Xeon scalable processors, Intel C621 chipset, seven low-profile PCIe/PCI slots, and six DDR4 RDIMM and LRDIMM slots. Designed for flexible storage, the server provides four 5.25-inch storage bays which are convertible to 2.5-inch or 3.5-inch drive bays depending on requirement.

It also supports M.2 M-key PCIe 3.0 x4 NVMe SSD, and is equipped with a variety of I/O interfaces (1 x RS232, 1 x VGA, 4 x RJ-45 network connectors), 500 W 80 plus gold PSU with at least 87% efficiency rating, and four fans which save energy consumption through IPMI (Intelligent Platform Management Interface) 2.0.

The server provides customised choices, such as the L6 barebone system or L10 fully completed system, according to customers' requirements. Designed to be expandable and deployable, the high-performance server accelerates simulation, architectural model construction, machine learning and analysis, and precision prediction, making it suitable for various vertical industrial applications, including automation, smart city and medical diagnosis.

**Avalue**

[www.avalu.com.tw](http://www.avalu.com.tw)



## WIRELESS POWER RECEIVER

STMicroelectronics has launched a wireless power receiver with a power rating of 100 watts. The STWLC99 device provides a fast wireless charging time and can also recharge high-end smartphones in less than 30 minutes.

In addition to enhancing user convenience, high-power wireless charging lets designers create industrial products that are free of power sockets and cords, which can deliver various advantages. Eliminating the charging socket can save space and allow sealing against water or dust ingress in challenging environments. Complications due to twisting or tangling of the cord can be avoided. Independently mobile devices such as robots and drones can recharge without a mechanism or human intervention to connect the cable.

Housed in a 4.859 x 4.859 mm wafer-level chip-scale package (WLCSP), the wireless power receiver is in production now. With an energy-efficient architecture comprising a synchronous rectifier with MOSFETs of low RDS (on) and a low-dropout regulator, the wireless power receiver directs the received energy to the charging battery with minimal loss and low thermal dissipation.

Compliant with Qi 1.2.4 and 1.3, it supports the Qi Extended Power Profile (EPP) and leverages ST's optimised STSuperCharge (STSC) protocol for fast charging. The battery charging power reaches up to 100 W when combined with ST's STWBC2-HP transmitter solution.

The wireless power receiver contains non-volatile memory for storing configuration parameters and provides an I2C interface for exchanging configuration data and charging control. A comprehensive set of safety features is built in, including foreign object detection with accurate current sensing, Q-factor detection in transmit mode, and overcurrent, overvoltage and thermal protection. The wireless power receiver is also capable of operating as a power transmitter up to 25 W for charging other devices.

**STMicroelectronics Pty Ltd**

[www.st.com](http://www.st.com)

## CYBERSECURITY GATEWAY

Axiomtek has launched the iNA200, a DIN-rail cybersecurity gateway for operational technology (OT) network security. The cybersecurity gateway is powered by the Intel Atom x6212RE or x6414RE processor (Elkhart Lake) and has one DDR4-3200 SO-DIMM for up to 32 GB of system memory. For rugged environments, this fanless IIoT edge gateway comes with an operating temperature range of -40 to 70°C and supports a power input of 9 to 36 VDC with dual power input. The cybersecurity gateway also has two 2.5 G LAN ports, sufficient storage, and high expandability for various industrial application needs.

The cybersecurity gateway is designed to safeguard OT assets and avoid network threats for critical infrastructure. It also features an M.2 Key B slot to enable 5G connectivity for next-generation industrial use cases. With Trusted Platform Module 2.0 (TPM 2.0) support, this cybersecurity gateway increases security offering hardware-level protection against malware and sophisticated cyber attacks.

The edge gateway enables continued operations and public safety to meet the changing demands of diverse industrial IoT applications. It has one 2.5" SATA 3.0 SSD and eMMC onboard (optional) for storage. It also supports one full-size PCIe Mini Card slot (USB + SATA interface) and one M.2 Key B 3042/3052 slot (PCIe + USB interface) for wireless modules.

For the network interfaces, the cybersecurity gateway provides two GbE LAN ports with LAN Bypass, two 2.5 G LAN ports with LAN Bypass and TSN function, and two 1 G SFP (Intel I210-IS) ports. More I/O options include one HDMI, two USB 3.0 ports, one COM port (RS-232/422/485) with DB9 type, one COM port (RS-485) with 3-pin terminal block, one tact switch, four antenna holes, one power input connector, and one console port (RJ-45). In addition, the DIN-rail cybersecurity gateway runs well with Windows 10 and Linux operating systems.

The cybersecurity gateway is suitable for OT field site cybersecurity and secured edge.

**Tekdis**

[www.tekdis.com.au](http://www.tekdis.com.au)



## INDUSTRIAL MONITOR

ICP Australia has introduced the iEi DM-F22A IP65 Industrial Monitor. The industrial monitor provides comprehensive video input from conventional analog VGA to broad bandwidth digital HDMI and Display Port to fulfil different needs. Power requirement varies from application to application. The industrial monitor series provides 9-36 VDC input to simplify system integration through an adapter or DC source.

The industrial monitor is designed for outdoor applications as it is IP65 certified, and the build constitutes an aluminium front bezel, to facilitate panel mount installation. Hence, it can endure tough environments and protect the device against dust, splashes and low-pressure jets. The industrial monitor also has a range of I/O, to suit a variety of applications. For example, 1 x VGA, 1 x HDMI, 1 x DisplayPort1.1, 1 x USB 2.0, etc.

The monitor is designed to survive tough environmental conditions as it has a wide temperature support whereby the industrial monitor can function in -10 to 50°C. The industrial monitor also features projected capacitive multi-touch and resistive single touch options.

**ICP Electronics Australia Pty Ltd**

[www.icp-australia.com.au](http://www.icp-australia.com.au)

# TURNING WASTE PAPER INTO LI-ION BATTERY PARTS

Scientists from Nanyang Technological University, Singapore (NTU Singapore) have developed a technique to convert waste paper from single-use packaging and bags, and cardboard boxes, into a crucial component of lithium-ion batteries.



Through a process called carbonisation that converts paper into pure carbon, the researchers turned the paper's fibres into electrodes, which can be made into rechargeable batteries that power mobile phones, medical equipment and electric vehicles. To carbonise the paper, the team exposed the paper to high temperatures, which reduces it to pure carbon, water vapour and oils that can be used for biofuel. As carbonisation takes place in the absence of oxygen, this emits negligible amounts of carbon dioxide, and the process is a greener alternative to disposing of kraft paper through incineration, producing large amounts of greenhouse gases.

The carbon anodes produced by the research team demonstrated superior durability, flexibility and electrochemical properties. Laboratory tests showed that the anodes could be charged and discharged up to 1200 times. The batteries that used the NTU-made anodes could also withstand more physical stress than their counterparts, absorbing crushing energy up to five times better. The NTU-developed method uses fewer energy-intensive processes and fewer heavy metals compared to current industrial methods of manufacturing battery anodes. The research findings were published in the scientific journal *Additive Manufacturing*.

Using waste paper as the raw material to produce battery anodes would ease the reliance on conventional sources for carbon, such as carbonaceous fillers and carbon-yielding binders, which are mined and processed with harsh chemicals and machinery. The current innovation, which presents an opportunity to upcycle waste products and reduce the dependence on fossil fuels, reflects NTU's commitment to mitigating humanity's impact on the environment. Assistant Professor Lai Changquan, who led the project, said that while paper is used in many facets of our daily lives, little is done to manage it when it is disposed of, besides incineration, which generates high levels of carbon emissions due to its composition. "Our method to give kraft paper another lease of life, funnelling it into the growing need for devices such as electric vehicles and smartphones, would not only help cut down on carbon emissions but would also ease the reliance on mining and heavy industrial methods," Changquan said.

To produce the carbon diodes, the researchers joined and laser cut several thin sheets of kraft paper to form different lattice geometries, some resembling a spiky piñata.

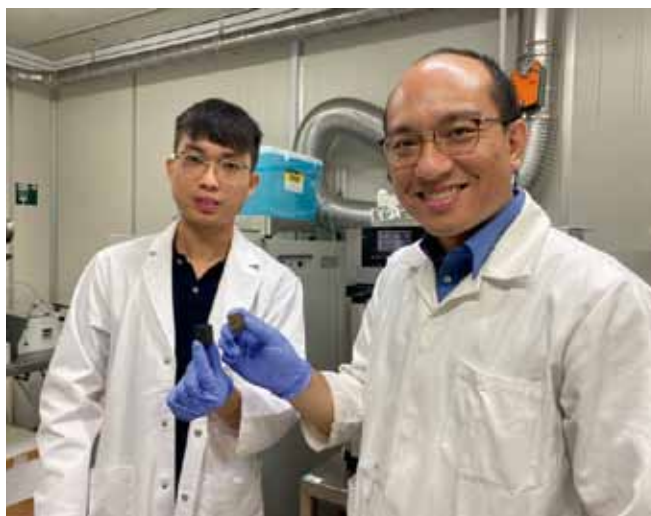


Image credit: Nanyang Technological University, Singapore

The paper was then heated to 1200°C in a furnace without the presence of oxygen, to convert it into carbon, forming the anodes. The researchers attribute the anode's durability, flexibility and electrochemical properties to the arrangement of the paper fibres. The combination of strength and mechanical toughness shown by the NTU-made anodes could allow batteries of phones, laptops and automobiles to better withstand shocks from falls and crashes.



USING WASTE PAPER AS THE RAW MATERIAL TO PRODUCE BATTERY ANODES WOULD EASE THE RELIANCE ON CONVENTIONAL SOURCES FOR CARBON ... WHICH ARE MINED AND PROCESSED WITH HARSH CHEMICALS AND MACHINERY.

Currently Li-ion battery technology relies on internal carbon electrodes that gradually crack and crumble after physical shocks from being dropped, which is one of the main reasons why battery life gets shorter with time. The researchers said that their anodes, which are harder than current electrodes used in batteries, will help address this problem and extend the life of batteries in a range of uses, from electronics to electric vehicles. Co-author of the study Lim Guo Yao said the anodes displayed a combination of strengths, such as durability, shock absorption and electrical conductivity, which are not found in current materials. "These properties demonstrate that our kraft paper-based anodes are a sustainable and scalable alternative to current carbon materials and would find economic value in demanding, high-end, multifunctional applications, such as the nascent field of structural batteries," Yao said.

According to Lai, the NTU method converts a common and ubiquitous material

— paper — into another that is durable and in high demand. "We hope that our anodes will serve the world's quickly growing need for a sustainable and greener material for batteries, whose manufacturing and improper waste management have shown to have a negative impact on our environment," Lai said.

Professor Juan Hinestroza from Cornell University, US, who was not involved in the research, said that the creative approach

pioneered by the researchers at NTU Singapore could have great potential for impact at a global scale, because kraft paper is produced in large quantities and disposed likewise, all over the world. "Any discovery that will allow the use of waste as a raw material for high-value products like electrodes and foams is indeed a great contribution. I think that this work may open a new avenue and motivate other researchers to find pathways for the transformation of other cellulose-based substrates, such as textiles and packaging materials, which are being discarded in large quantities all over the globe," Hinestroza said.

The NTU researchers will conduct further research to improve the energy storage capacity of their material and minimise the heat energy required to convert the paper into carbon. The research team has filed for a patent with NTUitive and is also working towards commercialising the invention.

## MULTI-FUNCTION PMIC

The Nordic Semiconductor nPM1300 multi-function Power Management IC (PMIC) is designed to simplify system design by integrating the features required for Bluetooth Low Energy embedded designs, while supporting longer run times and efficient battery charging.



The PMIC adds support for both charging of larger batteries and four regulated power rails. The multi-function PMIC will be optimised for efficiency and compact size (3.1 x 2.4 mm WL-CSP or 5 x 5 mm QFN) and is digitally configurable through an I2C-compatible Two Wire Interface (TWI). The digital interface provides access to several system management functions that are usually implemented as discrete functions in Bluetooth Low Energy (LE) embedded designs — such as hard reset, battery fuel gauge, system-level watchdog, power loss warning and recovery from failed boot.

The multi-function PMIC is designed to provide efficient power regulation for Nordic's nRF52 and nRF53 Series advanced wireless multiprotocol systems-on-chips (SoCs). The PMIC's four regulated power rails and battery charger make it suitable for compact and advanced IoT products.

The PMIC operates from an external power supply of 4.0 to 5.5 V and can operate from a battery voltage down to 2.4 V. Two power rails are regulated by separate DC/DC buck converters that are configurable between 1.0 and 3.3 V and up to 200 mA maximum current. The other two power rails operate as load switches — switching currents of up to 100 mA from external sources — but can also perform as low drop out (LDO) voltage converters when powered directly by the PMIC. When operating as LDOs, these power rail outputs are configurable between 1.0 and 3.3 V with a maximum output current of 50 mA. The unregulated input voltage is also available as an output from the nPM1300.

The PMIC charges single-cell Li-ion, Li-Pol and LiFePO4 batteries with a linear charging module that supports up to 800 mA charge current. The termination voltage is programmable from 3.5 to 4.45 V. The battery charger features automatic thermal regulation with programmable maximum chip temperature during charging to enable simple thermal management that can be adapted to any system requirement.

The nPM1300 also features USB port detection with automatic current limits of 100 or 500 mA through standard USB or up to 1500 mA through USB-C PD (power delivery); dynamic power path management which automatically switches to battery power if a mains power connection is removed; voltage, current and temperature monitoring for accurate fuel gauging; and ultra-low current hibernate mode with a programmable wake-up timer in addition to the other system management features already mentioned. The PMIC also features three LED drivers and five GPIOs that can be repurposed to direct control lines to time-critical control functions as an alternative to serial commands.

The nPM1300 will be available to order from Nordic's distributors mid-2023.

**Nordic Semiconductor**  
[www.nordicsemi.com/](http://www.nordicsemi.com/)

## COMPACT ANTENNA BOARD

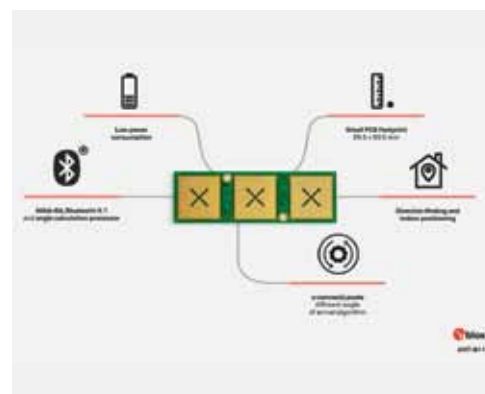
The u-blox ANT-B11 compact antenna board is designed to deliver high-precision direction finding and 2D indoor positioning. It can be integrated into commercial tracking solutions.

The product contributes to solving the ongoing indoor location challenge, where technologies such as GNSS find difficulties in performing effectively. It is equipped with the u-blox NINA-B411 Bluetooth 5.1 module and runs the u-connectLocate software, which executes the u-blox angle calculation algorithm. In conjunction with an application board, the product functions as an indoor angle-of-arrival (AoA) anchor point. The angle calculated by the antenna board does not require any additional processing; thus, it is ready for use at the application level.

Depending on its orientation, the board outputs the final azimuth or elevation angle in fractions of a second. With this information, it is possible to track assets and plot their positions in applications aiming at 2D visualisation.

Due to its 29.5 x 93.5 mm compact size, the board easily fits existing enclosures or casings. It can be used to follow assets in indoor areas, grant building access and avoid collisions, making it useful for industrial, retail and medical environments. In addition, it can be used in indoor spaces for positioning purposes wherein showing the location of an asset in 2D may suffice.

**u-blox Singapore Pte Ltd**  
[www.u-blox.com](http://www.u-blox.com)



HIGH ENERGY X-RAYS

# PAVE THE WAY FOR BETTER EV BATTERIES

A team of scientists led by chemists at the U.S. Department of Energy's Brookhaven National Laboratory and Pacific Northwest National Laboratory (PNNL) has unravelled the complex chemical mechanisms of a battery component that is crucial for boosting energy density: the interphase. The research was published in *Nature Nanotechnology*.





Many electronics, including smartphones and electric vehicles, currently rely on conventional lithium-ion batteries. While Li-ion batteries have become common due to their high efficiency and long lifespan, these batteries face challenges in more demanding applications, such as powering electric vehicles over long distances. To help build a better battery for electric vehicles, researchers have formed a consortium called Battery500. Led by PNNL, the consortium aims to make battery cells with an energy density of 500 watt-hours per kilogram — more than double the energy density of current batteries. To do so, the researchers are focusing on lithium-metal batteries. While lithium-ion batteries rely on graphite anodes, these batteries use lithium-metal anodes.

Lithium-metal anodes provide a higher energy density than graphite anodes, but there are trade-offs; it is challenging to find a way to stabilise the anode as the battery charges and discharges. Scientists at Brookhaven Lab and PNNL led a study on lithium-metal batteries' solid-electrolyte interphase. The interphase is a chemical layer formed between the anode and the electrolyte as the battery charges and discharges. Scientists have learned that the interphase is the key to stabilising lithium-metal batteries, but it is a sensitive sample with convoluted chemistry, making it difficult to study and, therefore, difficult to fully understand.

Brookhaven chemist Enyuan Hu, who led the study, said the interphase influences the cyclability of the whole battery. "It's a very important, but elusive system. Many techniques can damage this small, sensitive sample, which also has both crystalline and amorphous phases," Hu said.

The scientific community has conducted many studies using a variety of experimental techniques, including cryo-electron microscopy, to better understand the interphase. "A comprehensive understanding of the interphase provides the foundation for building an effective interphase. The Battery500 Consortium strongly encourages collaborations. We have been collaborating with Brookhaven Lab closely on many scientific projects, especially understanding the interphase," said Xia Cao, a PNNL scientist who co-led the study.

To analyse the complex and elusive chemistry of the interphase, the researchers turned to a tool called the National Synchrotron Light Source II (NSLS-II). The NSLS-II is a DOE Office of Science User at Brookhaven Lab that generates ultra-bright X-rays for studying the atomic-scale makeup of materials. Hu and colleagues have been leveraging the advanced capabilities of the X-ray powder diffraction (XPD) beamline at NSLS-II to make new discoveries in battery chemistry for many years; the team then turned to XPD to gather precise findings on the interphase.

According to Hu, the researchers had previously discovered that high-energy synchrotron X-rays do not damage the interphase sample — this is important because one of the greatest challenges in characterising the interphase is that the samples are sensitive to other types of radiation, including low-energy X-rays. "We took advantage of two techniques that use high-energy X-rays, X-ray diffraction and pair distribution function analysis to capture the chemistries of both the crystalline and the amorphous phases in the lithium-metal anode interphase," Hu said.

After cycling a lithium-metal battery 50 times and harvesting enough interphase sample, researchers disassembled the cell, scraped off a trace amount of interphase powder from the surface of the lithium metal and directed XPD's high-energy X-rays at the sample to reveal its chemistry.

"XPD is one of the few beamlines in the world that is capable of carrying out

this research. The beamline provided three advantages for this work: a small absorption cross-section, which damages the sample less; combined techniques, X-ray diffraction to get the phase information and pair distribution function for real space information; and a high-intensity beam for delivering quality data from a trace sample," said Sanjit Ghose, co-author of the study.

This combination of advanced X-ray techniques provided a detailed chemical map of the interphase components — their origins, functionalities, interactions and evolutions. Sha Tan, first author of the paper, said the researchers focused on three different components of the interphase; first was lithium hydride and its formation mechanism. The researchers had previously found that lithium hydride existed in the interphase, and this time they identified that lithium hydroxide, which can be found natively in the lithium-metal anode, is the likely contributor to lithium hydride. Controlling the composition of this compound will help scientists design an improved interphase with a high performance.

"Second, we studied lithium fluoride, which is very important for electrochemical performance, and found that it can be formed at a large scale in low concentration electrolytes," Tan said. Previously, scientists believed that lithium fluoride could only be formed in electrolytes using high-concentration electrolytes, which rely on expensive salts. Thus, the work provides evidence that low-concentration electrolytes, which are more cost-effective, can potentially perform well in these battery systems.

"Third, we looked at lithium hydroxide to understand how it is consumed during battery cycling. These are all very new findings and important for understanding the interphase," Tan said. These findings helped highlight previously overlooked components of the interphase and will enable more accurate and controllable interphase design for lithium-metal batteries.

The team will continue to contribute additional studies to the Battery500 consortium. The consortium is currently in its second phase, which will continue through 2026.



## BOARD-TO-BOARD CONNECTOR

Interplex has released its Multi-Row Board-to-Board (BTB) connector featuring an innovative snap-in biscuit design. This interconnect concept allows multiple connector units to be stacked together. This means interconnections can be appropriately sized while avoiding the need for them to be custom built. This unique approach will enable different pin count require-

ments to be attended to via the same basic interconnect platform, without any extra expense or engineering effort.

The BTB connectors feature 0.4 mm miniPLX press-fit pins, so the need for soldering is eliminated. These pins are made from a copper alloy and exhibit low levels of contact resistance ( $<1\text{ m}\Omega$ ). Each pin has a 3 A current carrying capability. The optional coating of these pins with the company's patented IndiCoat plating technology mitigates tin whisker build-up, in order to prevent the risk of short circuits and extend operational lifespan.

The BTB connectors are available in board stacking heights from 7 to 30 mm. They can have between one and six rows, with up to 30 contact terminals being incorporated into each row. Conforming with automotive performance requirements, these rugged products can withstand high humidity levels (8 h cycling up to 10% RH), shocks (35g for 5 to 10 ms across 10 axes) and vibrations (8 h per axis). A working temperature range of  $-40$  to  $+150^\circ\text{C}$  is also supported.

There are a number of applications that the robust Multi-Row BTB connectors can be targeted at, including electric vehicles (EVs), particularly for electric power steering and electronic control unit functions. There are also opportunities for these connectors to be used in industrial automation systems (as robots), transportation hardware (trains) and medical instrumentation (such as imaging scanners).

**Interplex Precision Technology (Singapore) Pte Ltd**  
[www.interplex.com](http://www.interplex.com)

## ANTENNAS FOR WI-FI AND BLUETOOTH APPLICATIONS

Laird Connectivity has released the FlexPIFA 2 dBi and FlexPIFA 3 dBi antennas with MHF1/U.FL cables. The flexible planar inverted-F antennas (PIFA) are designed for Wi-Fi or Bluetooth applications mounting on non-conductive or irregular surfaces, regardless of humidity or hot/cold cycles ( $-40$  to  $+85^\circ\text{C}$ ).

The antennas are designed to improve performance across a broad array of environments, enclosures or even body-worn applications. The 2 dBi FlexPIFA antenna is an ultrasmall ( $40.1 \times 11 \times 2.5\text{ mm}$ ), single-band (2.4 GHz) device offering 2 dBi peak gain, linear polarisation and  $50\Omega$  impedance, suitable for Wi-Fi 802.11b/g/n and Bluetooth applications.

The 3 dBi FlexPIFA antenna features dual-band (2.4/5.5 GHz) performance in a  $38.5 \times 12.7 \times 2.5\text{ mm}$  form factor, with 3 dBi peak gain and  $50\Omega$  impedance. The antenna is also suitable for Wi-Fi 802.11b/g/n and Bluetooth applications, as well as legacy Wi-Fi 802.11a applications.

The FlexPIFA family of antennas delivers robust performance and easy installation, making them useful for challenging Internet of Things (IoT) and harsh environment design applications.

**Mouser Electronics**  
[au.mouser.com](http://au.mouser.com)



## AUTOMOTIVE MULTI-BAND GNSS MODULE

The u-blox ZED-F9K-01A is a high-precision GNSS module with embedded advanced hardware, software and the latest-generation IMU (inertial measurement unit) to provide a self-contained positioning solution. The module supports both L1/L2/E5B and L1/L5 bands for maximum flexibility, satellite availability and security. It combines multi-band and multi-constellation global navigation satellite system (GNSS) technology with dead reckoning high-precision RTK (real-time kinematic), which enables decimetre-level accuracy.

The product natively supports the u-blox PointPerfect GNSS augmentation service. It delivers multiple GNSS and IMU outputs in parallel to support all possible architectures, including a 50 Hz sensor-fused solution with low latency. It enables real-time applications, while the optimised multi-band and multi-constellation

capability maximises the number of visible satellites even in urban conditions.

The device includes a dependable protection level output and security features including anti-spoofing and anti-jamming. Operation up to  $105^\circ\text{C}$  makes it possible to integrate the product anywhere in the car without design constraints.

The product primarily targets ADAS applications, paving the way to full car autonomy. Being a fully integrated solution that includes the latest u-blox R&D technology for automotive, it should help OEMs reduce their development efforts and time to market.

**u-blox Singapore Pte Ltd**  
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# HELPING LITHIUM-SULFUR BATTERIES

## REACH THEIR FULL POTENTIAL

While lithium-ion batteries have come a long way since they were first introduced, they face some challenges, such as short lifetimes, overheating and supply chain issues for certain raw materials.

Scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory are researching solutions to these issues by testing new materials in battery construction. One such material is sulfur; sulfur is abundant and cost-effective and can hold more energy than traditional ion-based batteries. Researchers have now advanced sulfur-based battery research by creating a layer within the battery that adds energy storage capacity while nearly eliminating a traditional problem with sulfur batteries that caused corrosion.

Wenqian Xu, a beamline scientist at APS, said the research demonstrates that a redox-active interlayer could have a huge impact on Li-S battery development. A promising battery design pairs a sulfur-containing positive electrode (cathode) with a lithium metal negative electrode (anode). In between those components is the electrolyte, or the substance that allows ions to pass between the two ends of the battery. Early lithium-sulfur (Li-S) batteries did not perform

well because sulfur species (polysulfides) dissolved into the electrolyte, causing its corrosion. This polysulfide shuttling effect negatively impacts battery life and reduces the number of times the battery can be recharged.

To prevent polysulfide shuttling, researchers tried placing a redox-inactive interlayer between the cathode and anode. 'Redox-inactive' means the material does not undergo reactions like those in an electrode. But this protective interlayer is heavy and dense, reducing energy storage capacity per unit weight for the battery. It also does not adequately reduce shuttling — this has proved a barrier to the commercialisation of Li-S batteries.

To address this, researchers developed and tested a porous sulfur-containing interlayer. Tests showed initial capacity about three times higher in Li-S cells with this active, as opposed to inactive, interlayer. The cells with the interlayer also maintained high capacity over 700 charge-discharge cycles.

"Previous experiments with cells having the redox-inactive layer only suppressed the shuttling, but in doing so, they sacrificed the energy for a given cell weight because the layer added extra weight. By contrast, our redox-active layer adds to energy storage capacity and suppresses the shuttle effect," said Guiliang Xu, an Argonne chemist and co-author of the paper.

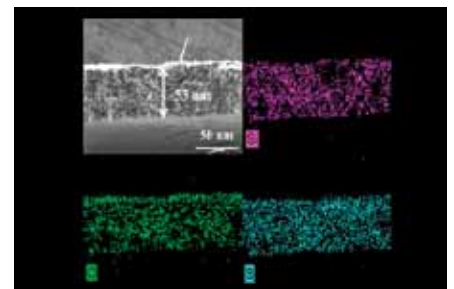


Image shows microstructure and elemental mapping (silicon, oxygen and sulfur) of porous sulfur-containing interlayer after 500 charge-discharge cycles in lithium-sulfur cell. Image credit: Guiliang Xu/Argonne National Laboratory

To further study the redox-active layer, the team conducted experiments at the 17-BM beamline of Argonne's Advanced Photon Source (APS); the data gathered from exposing cells with this layer to X-ray beams allowed the team to ascertain the interlayer's benefits. The data confirmed that a redox-active interlayer can reduce shuttling, reduce detrimental reactions within the battery and increase the battery's capacity to hold more charge and last for more cycles.

The team plans to evaluate the growth potential of the redox-active interlayer technology, with the aim of making it thinner and lighter. A paper based on the research was published in *Nature Communications*.



## Powering secure, contactless convenience in Google Pixel 7

STMicroelectronics, a global semiconductor leader serving customers across the spectrum of electronics applications, has revealed that its ST54K IC is handling control and security for contactless NFC communication in the newly launched Google Pixel 7 smartphone. The ST54K single-chip NFC controller and secure element, combined with Thales's secure OS, provides reliable and high-performing contactless functionality in Android handsets and is available to all OEMs without restriction.

Chosen by Google's designers, ST's device combines NFC control and a certified Secure Element in a single chip that saves space and simplifies handset design. Containing proprietary technologies that enhance NFC contactless sensitivity, the ST54K was selected to ensure the most reliable connectivity, deliver excellent contactless user experiences, and ensure the highest contactless transaction security.

STMicroelectronics has revealed that its ST54K IC is handling control and security for contactless NFC communication in the Google Pixel 7 smartphone. Chosen by Google's designers, the device combines NFC control and a certified Secure Element in a single chip that saves space and enhances handset design. Containing proprietary technologies that enhance NFC contactless sensitivity, the ST54K was selected to provide reliable connectivity, ease of use, and high contactless transaction security.

For Google's Pixel 7, ST combined the ST54K with the mobile secure operating system (OS) by Thales. The OS meets high security industry standards and supports convergence of the embedded SAM (eSIM) with other secure NFC applications into the same ST54K secure element. Marie-France Li-Saï Florentin, Vice President of Microcontrollers and Digital ICs Group at STMicroelectronics, said Google selected the ST54K for its performance, low power and robust security that meets CC EAL5+ assurance. "As a result, it ensures the best possible user experience and protection for contactless transactions," Li-Saï Florentin said.

Emmanuel Unguran, SVP Mobile Connectivity Solutions at Thales, said the combination of the ST54K and Thales's secure OS and personalisation capabilities provides a certified and evolutive solution for smartphones to support diverse digital services, such as embedded SIM for instant connectivity and digital wallet services, transit ticketing and digital car keys. "It is also the first in the Android ecosystem to support the eSIM Multiple Enabled Profiles," Unguran said.

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