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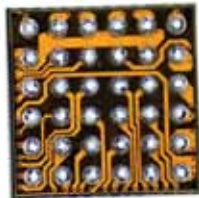


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Oscilloscopes play a key testing role in electronic labs. While Rohde & Schwarz has more than 85 years of experience with high-quality instruments equipping test labs, it wasn't until 2010 that the company expanded their test and measurement product range with their first digital oscilloscope, the R&S RTO1000. With subsequent additional introductions of oscilloscope instruments, probing, and applications, the company now offers the newest portfolio ranging from 70 MHz to 16 GHz bandwidth.

With the R&S MXO 4 series Rohde & Schwarz now adds a completely new oscilloscope series to its portfolio, bringing all the performance attributes from its upper class to the mid-range and delivering a number of firsts.

The R&S MXO 4 series come in four channel models, offering bandwidth of 200 MHz up to 1.5 GHz. It is the first of a new generation of instruments that are designed to excel in both performance and value, delivering an engineering breakthrough for accelerated insight.

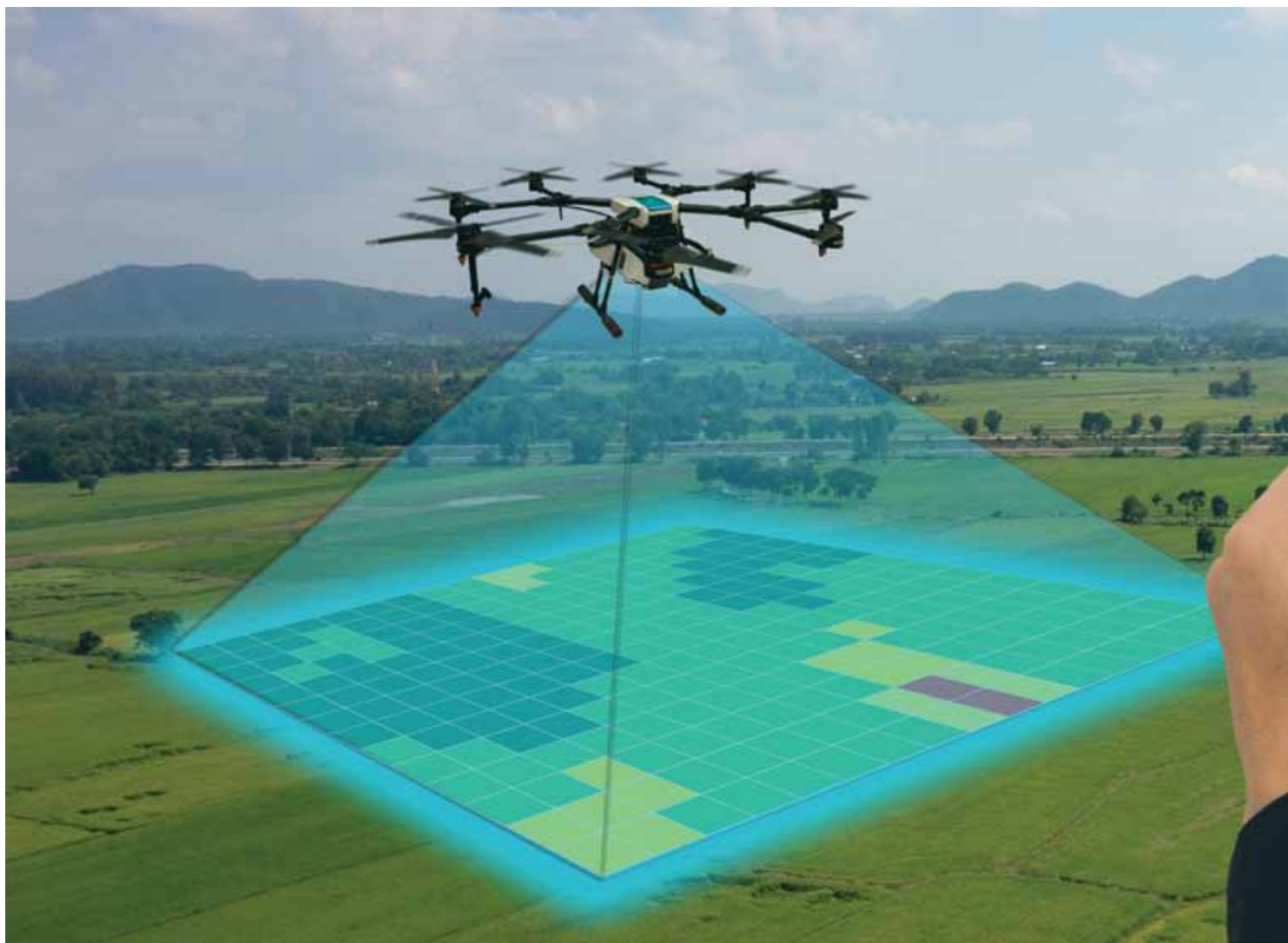
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# MINIATURISATION:

## PERFORMANCE VERSUS POWER IN EMBEDDED SYSTEMS

*Martin Kellerman\**

Learn more about how field programmable gate arrays (FPGAs) will empower the next-generation technology revolution with power-efficient performance in many new applications for every industry.

Miniaturisation is a key feature in most embedded systems today. Everyone wants more computing power in their pockets. Most FPGA-based embedded systems are also following the same trend. Consumers want smaller industrial and professional cameras, medical handhelds, smaller programmable logic controllers (PLCs) and driver assistance modules in cars. Miniaturisation also poses additional challenges — the biggest one can be condensed into a single term, 'power-efficient performance'. Typically, if a system's performance goes up, its power consumption does too, which, in turn, increases heat dissipation. And in smaller modules heat dissipation is a headache that designers cope with every day. Cooling a module so that it can operate under a thermally constrained environment often becomes the bottleneck to performance.

This article highlights how field programmable gate arrays (FPGAs) are enabling the next-generation technology revolution

by offering power-efficient performance in many new high-volume applications in every industry. Small form-factor cameras can be used for many different things, like running AI algorithms to guide farmers via drone images, providing video analytics in retail chains, counting passengers in transportation and reading licence plates in toll booths. In the medical field, portable ultrasound machines are democratising care delivery in the field. Endoscopes and surgical-assist smart glasses are providing much higher-resolution images to doctors than ever before. Thermal imaging-based surveillance systems designed to protect borders against intruders are also becoming smarter. Generally deployed in remote locations, these systems must operate autonomously while staying hidden.

Even amateur content creators are driving a need for FPGA-based streaming video converters, as they need the option to convert 4K video streams between any format like HDMI, SDI, USB or PCIe.



A block diagram for such a system can resemble Figure 1.

Additional interfaces such as visual light, motion or infrared sensors used to support

Let's have a look at various example use-cases where PolarFire FPGAs or PolarFire SoCs, with their hardened RISC-V processor system, are playing a vital role.

Professional drones have strict requirements for flight safety:

- To be successful in a large drone market, drone manufacturers need to differentiate themselves by providing additional features such as high-resolution imaging and artificial

The application range is very wide and includes monitoring crop health and growth status in farming, object detection and

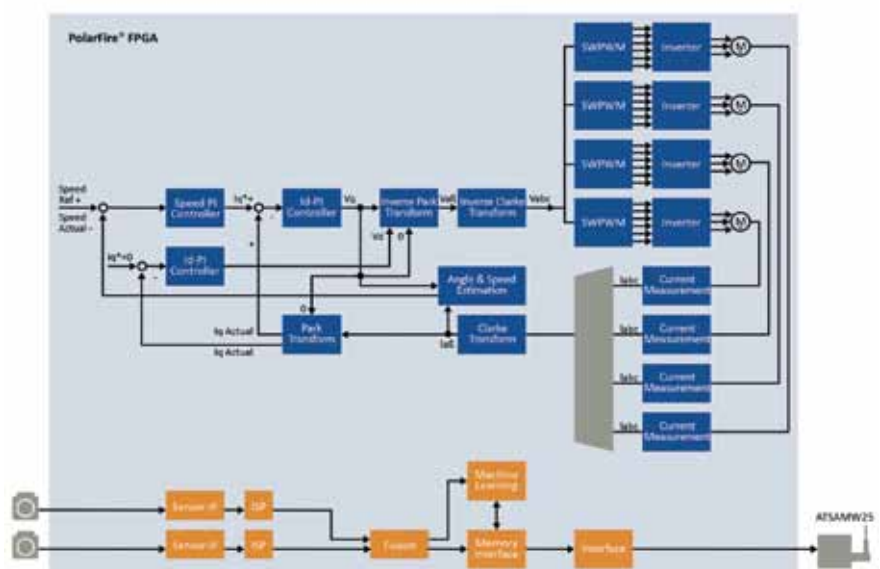


Figure 1.

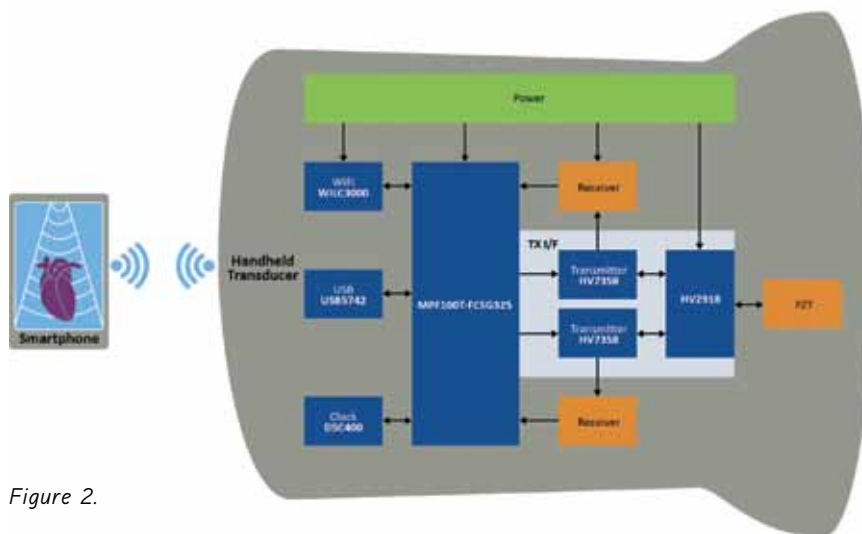


Figure 2.

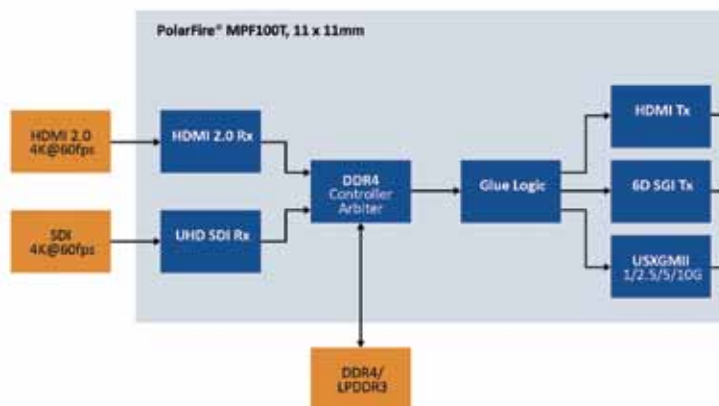


Figure 3.

enhanced features such as machine vision need careful consideration, and historically have required specialised expertise. Microchip's VectorBlox SDK and matrix processor IP helps novice FPGA developers to deploy complex neural network algorithms in the FPGA fabric. This allows classifications or detections at a very low-power footprint. The neural networks running on this accelerator-IP are designed using standard frameworks like TensorFlow or Caffe.

All results are buffered in local onboard memory and afterwards transferred to an on-board wireless module. This communicates with the operator where the collected data is received for storage and further use. The best-in-class security features of PolarFire devices protect both the transferred data and the drone itself from unauthorised access.

With complex drone architecture needing multiple application domains, motor control, flight control and imaging, using an FPGA provides the benefit of the individual 'tasks' running in parallel.

Professional drone systems typically need to operate on a tight power budget of 5 W or less. Using a PolarFire FPGA to manage multiple applications, power consumption of less than 1.5 W for the FPGA, including the operation of the neural network, is expected.

## Portable ultrasound

Due to the drive to miniaturise, coupled with power-efficient edge compute resources and enhanced thermal considerations, low-power medical imaging innovation is growing by leaps and bounds. Leading the way are point-of-care diagnostics such as portable ultrasound equipment, consisting of a handheld transducer, reading and sending sonographic data to a standard smartphone. Transmissions can happen with a simple cable or wirelessly. These systems are revolutionising and democratising diagnostic capabilities for emergency medical personal at incident sites, in less developed regions, and helping medical professionals make diagnostic decisions outside traditional hospital

environments. The block diagram in Figure 2 shows an example implementation.

Leveraging a PolarFire FPGA in a handheld medical device delivers the lowest total system power, which leads to efficient thermals and keeps the transducer head cool, allowing direct skin contact. These efficiencies extend operation time in a compact package footprint of only 11 x 11 mm<sup>2</sup>, supporting very small probe enclosures.

## Video converters

Another area where flexibility paired with low power consumption and a small physical footprint is essential is the realm of video converters. High-performance professional cameras typically provide a single data interface, limiting post-processing equipment selections that support that specific interface. Having a video converter provide a bridge to several interface standards allows flexibility in selecting post-processing equipment. Performance is not compromised as multi-protocols are supported with numerous multi-gigabit transceivers, and optimised line rates of up to 12.7 Gbps, supporting HDMI, CoaXPress, SDI and Ethernet protocols. The converters' form factors are compact as heatsinks and fans are no longer required. Video converters built on PolarFire technology are estimated to require less than 2 W of power consumption. Figure 3 provides a video converter design example.

## Industrial automation

Two different use cases are used as examples, industrial cameras and programmable logic controllers (PLCs).

Industrial cameras typically require high frame rates, high resolution and a small form factor, which make the thermal design a challenge. Thanks to the optimised package layout, and efficient thermal characteristics, this challenge can be easily tackled. The low static power consumption allows the device to remain cool, enhancing thermal management design considerations. Resolution is not compromised, image data of up to 4K with 60 fps can be easily handled with MIPI CSI-2 receiver-interfaces natively supporting up to 1.5 Gbps/line.

Even though it is physically larger as a complete system, PLCs are similarly space- and power-constrained as cameras.

These rack-based systems are modular, allowing end users to customise their system and offering standard chassis widths. Processing performance is still a must to support industrial Ethernet, human-machine interfaces, motor/driver control and real-time operating systems (RTOS).

# STM32Cube.AI

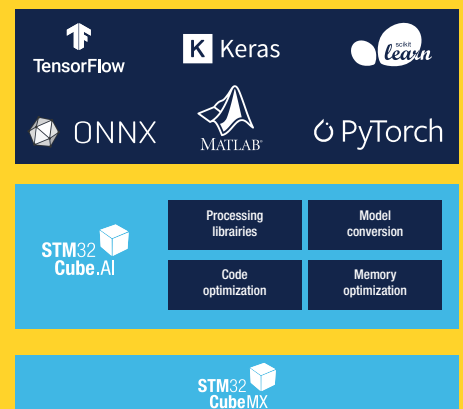


## Software tool to port and optimize your own artificial neural networks on STM32 MCUs



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- Brings developers many example applications, such as computer vision, sensing, and condition monitoring

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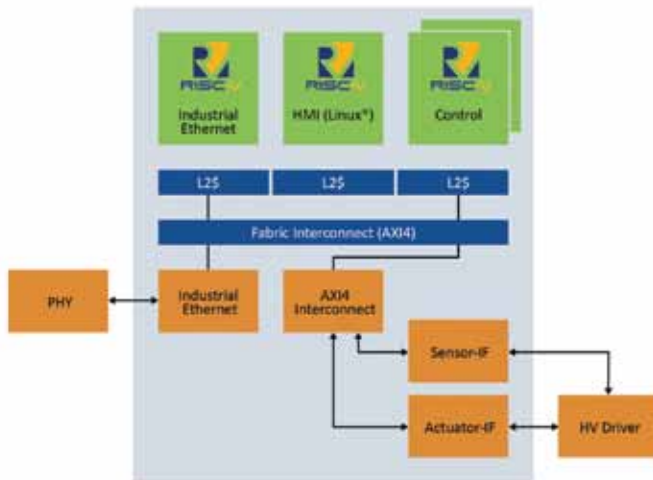


Figure 4.

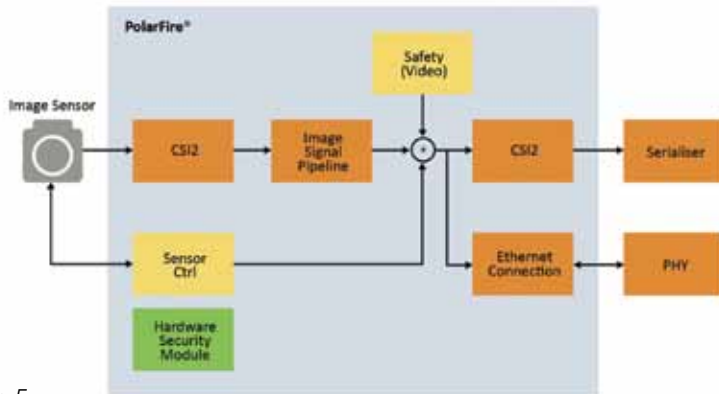


Figure 5.

Figure 4 shows a generic block diagram of such a system, mapped to PolarFire SoC, the first FPGA-SoC built on a quad-core RISC-V processor. The PolarFire SoC supports asymmetric multiprocessing (AMP) natively, together with a fixed, fine-granular allocation of cache-ways to individual processors. This native AMP support allows for multi-tasking. As an example, a single processor core can be allocated for an industrial Ethernet protocol stack, while a second core can be running a Linux operating system. The corresponding cache is fixed, and Linux is being separated from other hardware resources. Additionally, the other two available cores can be used to handle the required algorithms for motor control or an inverter.

Again, low power consumption plays an important role keeping the temperature of the electronic components inside the blade modules low, even in challenging thermal environments of 60°C ambient temperature and more.

Industrial automation spans a wide range of applications and requirements. Common

amongst industrial products is a need to offer support and availability of devices for 20 years or more. Microchip is fully dedicated to this longevity requirement and offers support with a robust 'assurance of supply' program.

## Automotive

Many different applications in today's automotive market require the flexibility of FPGAs, ranging from sensors like LIDAR, imaging radar or cameras to more hidden functionality like highly accurate and closely synchronised driving of electric motors via high-voltage drivers. A strongly emerging application is the use of cameras for collision warning. These cameras allow the detection of dangerous situations with feedback to the driver or also with direct control into the vehicle like automatically activating the brakes. These systems have strong requirements for functional safety, security and low-latency processing, combined with the capability to operate reliably in high-temperature environments caused by engine heat and sunlight.

Figure 5 shows a system setup using the PolarFire MPF050T; safety elements are drawn in yellow, security in green.

The integrated secure non-volatile memory (sNVM) allows the storage of fleet keys to authenticate within the camera module in the vehicle network. The received image frames are processed in streaming mode using the parallel nature of the FPGA and additionally provisioned with additional safety information like frame count and CRC for end-to-end protection of the communication. The streaming processing of the image data avoids the danger of using 'frozen images' from memory and allows processing with fixed execution time, directly translating into more time for the system to react. Depending on the exact OEM requirement, the FPGA also provides the required flexibility to support interfacing to various established proprietary serialisers.

Common to all applications, yet not detailed above, are the business drivers for bringing a successful product to market. Looking at how to reduce risk while reaching the client ahead of your competition, and optimising system cost while delivering profits to the bottom line, requires careful consideration of your system architecture and supply partner. The comprehensive Microchip portfolio offers a total system solution partnership. Benefit from key components and reference design solutions to reduce development risk and component counts. Designers can also save time and money as solutions are validated for cross functionality and offer warranties in many cases.

For further information, visit <https://www.microchip.com/en-us/products/fpgas-and-plds/fpgas/polarfire-fpgas>.

Additionally, if you are looking for in-depth information on why low power consumption is important in systems that are cable-powered, read this article: <https://www.microchip.com/en-us/about/blog/learning-center/low-power-system-saving-even-in-plug-in-devices>.

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\*Martin Kellerman is Marketing Manager in Microchip's FPGA business unit

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## SELF-POWERED WEARABLE MONITORS HEALTH

A self-powered, wristwatch-style health monitor, developed by researchers at the University of California, Irvine, can keep track of a wearer's pulse and wirelessly communicate with a nearby smartphone or tablet — without needing an external power source or battery. In a paper published in the journal *Nano Energy*, researchers from UCI's Henry Samueli School of Engineering described their innovation, built via 3D printing of nanomaterials on flexible substrates for real-time and wireless monitoring of vital signs. The current prototype serves as a self-powered radial artery pulse monitor, but can also gauge other aspects of health, such as heart rate, body temperature or blood pressure, by changing the sensor circuitry.

Senior co-author and UCI assistant professor Rahim Esfandiyar-Pour said the self-powered and wireless device allows users to monitor a person's vital signs urgently and accurately, in situations where there is a need to keep track of health information on demand. "This device allows you to do that without relying on a battery that can lose its charge and has the thermal runaway issue [overheating of lithium-ion batteries that can lead to combustion]," Esfandiyar-Pour said.

The device delivers health information in two ways. In one mode, the energy created by tapping the wristband's nano energy generators powers up the sensor circuitry, and the wearer's pulse rate soon appears as a flashing signal on an LED display. The second mode works when a smartphone or similar device is held near the wearable. Embedded near-field communication technology facilitates the wireless exchange of power and data between the wristband and the mobile device, and biophysical information is plotted and displayed on the smartphone's screen.

The on-demand and self-powered characteristics of the invention are made possible by triboelectric nanogenerators (TENGs) that produce voltage through mechanical thumping or pressure. The TENGs are fabricated using titanium-based MXenes, a relatively new class of ultrathin 2D material with unique electrical and mechanical properties. A few atoms thick, MXene layers are bendable, stretchable and can be printed onto the surface of flexible, bandage-like material or a wearable arm- or wristband.

"This innovation enables continuous, battery-free, wireless and on-demand health monitoring," Esfandiyar-Pour said.

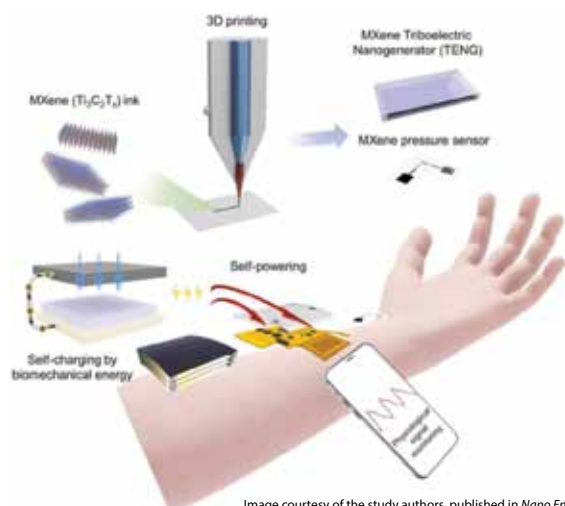


Image courtesy of the study authors, published in *Nano Energy*.



## AUSTRALIAN QUANTUM INDUSTRY LEADERS FORM ALLIANCE

Local and global leaders in Australia's quantum industry have launched a new group called the Australian Quantum Alliance (AQA), to be the voice of the quantum industry in Australia. Launched on 31 August 2022 under the auspices of the Tech Council of Australia (TCA), the AQA aims to promote, strengthen and connect Australia's quantum ecosystem.

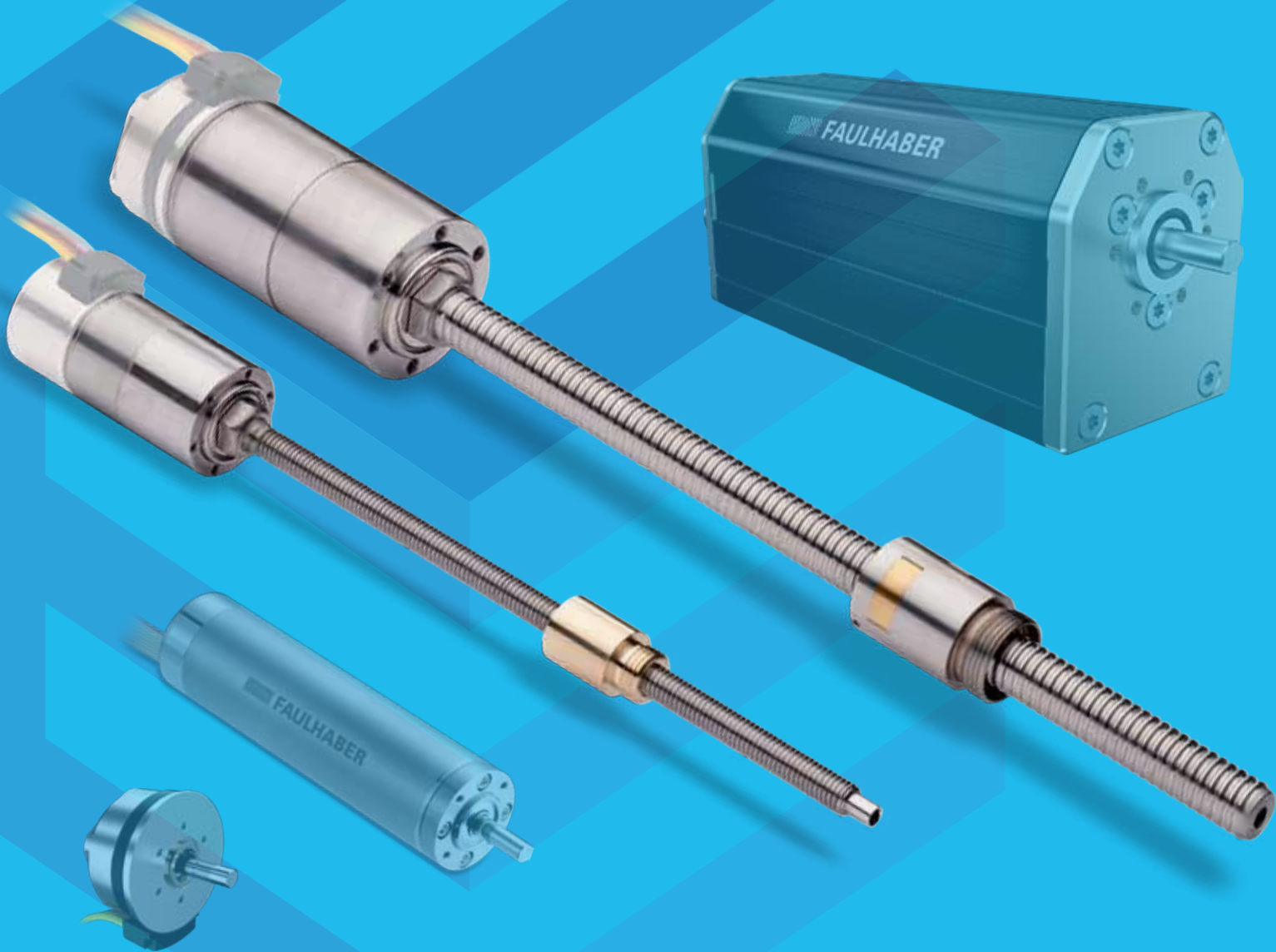
The AQA's formation recognises the global potential and growing impact of the quantum sector in Australia and recognises the need to have a single industry group to work with governments on a range of policy issues impacting the sector, including the Australian Government's Quantum Strategy, the regulation of critical technologies, the design of the proposed Critical Technologies Fund, and skills and migration.

The AQA was formed by leaders across the quantum industry and includes nine local and global companies. Founding members include leading local companies Quintessence Labs, Q-CTRL, Quantum Brilliance, Silicon Quantum Computing, Nomad Atomics and Diraq, and global companies Google, Microsoft and Rigetti. Research released by the Tech Council highlights that the quantum industry is among Australia's most high-potential emerging sectors, with more than 3% of global quantum start-ups originating in Australia, compared to 1.7% of startups on average. The Australian quantum industry attracts 3.6% of all global VC investment in the quantum industry, in excess of Australia's global GDP share of 1.6%. Australia is also attracting investment in quantum research and development from the significant global companies.

Vikram Sharma, Founder and CEO of the AQA, welcomed the establishment of the Australian Quantum Alliance, the culmination of the year's collaboration between quantum industry stakeholders and the government. "With the prowess of the TCA, we hope to collectively drive the development of a vibrant quantum industry, provide guidance to the government on the development of the industry, help corporate decision-makers understand and adopt quantum technology, and build strong domestic and international partnerships for the greatest national benefit to Australia," Sharma said.

Kate Pounder, CEO of TCA, said the AQA will help ensure that Australia maintains its head start in the global quantum race. "Australia is leading the world in quantum research. Now we need to lead in commercialising that research by creating, scaling and attracting world-leading quantum companies in Australia."

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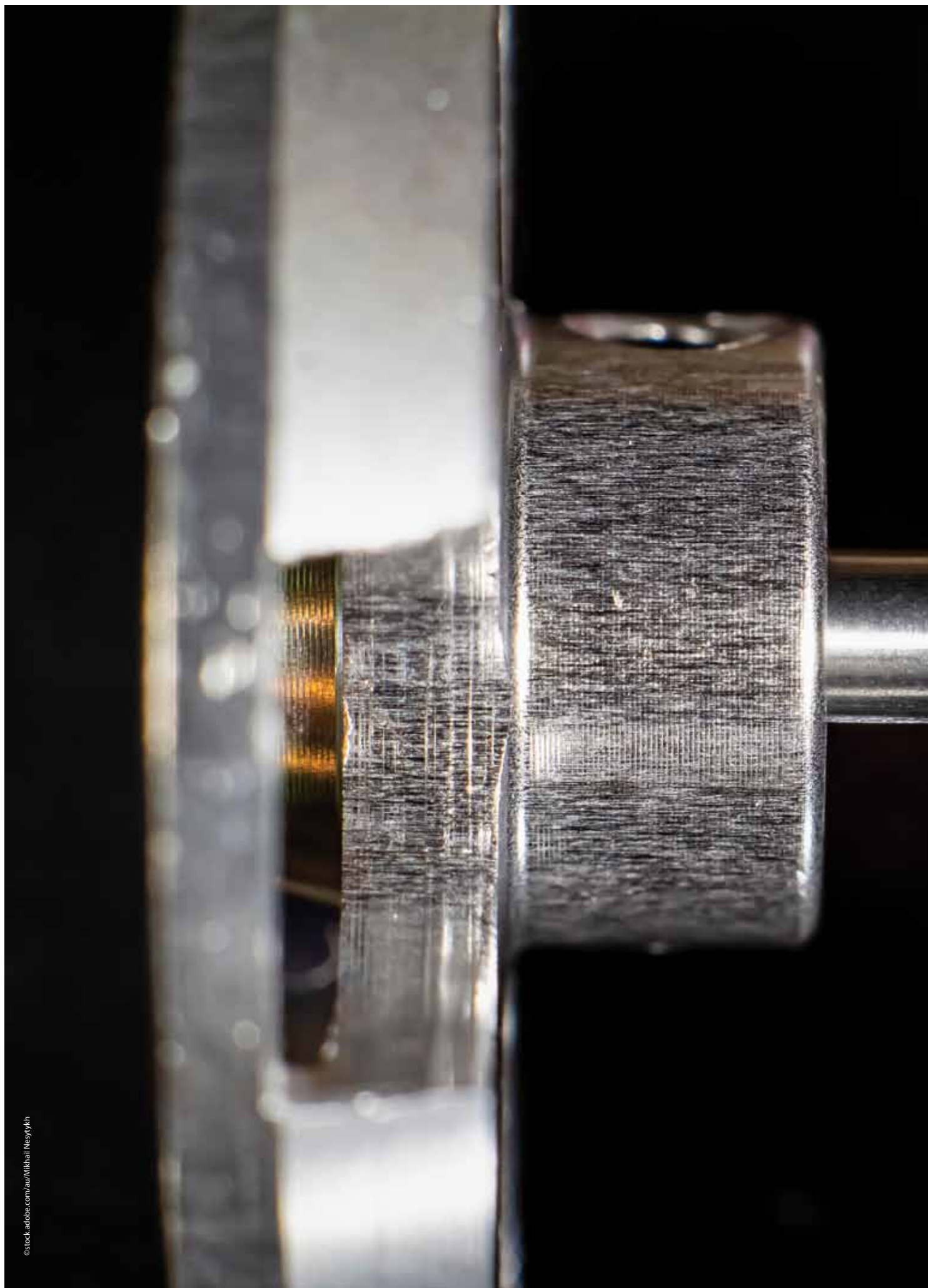
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# BRUSHLESS MOTORS — DESIGN, OPERATION AND ADVANTAGES

Find out why you should choose a brushless motor.



## Brushless motors — design and operation

In order to understand the phenomenon of brushless motors, which are rapidly entering the power tool market, it is necessary to understand the principle of operation of the formerly applied commutator motors and learn about the main differences between these two types of motors.

The basic task of an **electric motor** is to convert electrical energy into mechanical energy, ie, to set the shaft of the driven device in motion. In a conventional motor, the commutator of a rotating rotor receives an electric charge from graphite brushes, which conduct electricity through direct contact with the rotating part. The resulting magnetic field generated by the commutator causes rotational movement by means of special magnets.

The design and therefore the operating principle of a brushless motor is slightly different from that of a commutator motor. The commutator and brushes in this device are replaced by coils that are wound on a stationary core, the so-called stator (in a brush motor the coils are placed on a moving rotor). It is these coils that, when current flows through them, create the magnetic field that puts the rotor into motion. A very common and basic solution is to use three windings. However, due to the torque ripples occurring, manufacturers also offer motors equipped with sets from one to even eight pairs of poles.

Due to the lack of direct contact between the rotating part and the fixed coils, there is no need to use graphite brushes. The use of permanent magnets in the brushless motor design allows for higher torque and improved efficiency. This is all thanks to the high energy density of these magnets.

## Why it is worth choosing brushless motors

The design of a **brushless motor** offers a number of advantages. The most important differences in favour of brushless motors include:

- **Quieter operation and fewer failures.** During operation, the brushes rub against the rotating parts, causing noise. Brushes are the most common wear-and-tear component in commutator motors, which significantly reduces their service life.
- **Improved work safety.** During operation, brushless motors do not cause sparks which are dangerous for the user. This advantage allows the motor to be used in explosive and flammable environments.
- **Higher efficiency of the device.** Elimination of mechanical resistance enables higher rotor speeds and improved torque.
- **Improved battery life.** A brushless motor draws less current than its traditional counterpart. This fact is extremely



BRUSHLESS MOTORS ARE IDEAL FOR COMPUTER EQUIPMENT THAT REQUIRES SAFE, UNINTERRUPTED OPERATION FOR LONG PERIODS.

important for rechargeable devices, which can run much longer on a single charge.

- **Better control precision.** BLDC motors enable high precision torque control, which helps reduce inertia and power consumption.
- **Significantly reduced or zero maintenance.** If used properly, the motor should operate without failure or the need for external intervention in the structure. This is because the absence of brushes means that there are no longer any critical parts inside the machine that wear out during normal operation. The benefit of this fact is that the motor can be installed in a place that is difficult to access.

### Applications where a brushless motor is unbeatable

Brushless motors are ideal for computer equipment that requires safe, uninterrupted operation for long periods. Examples include hard disk drives and computer fans, which are designed to continuously reduce component temperatures during computer use.

As mentioned above, thanks to their reduced power consumption and extremely compact dimensions, brushless motors are indispensable in professional cordless devices such as drill-drivers, drills and angle grinders. Battery-powered operation is more economical and longer. A very popular industry today that relies heavily on brushless motors is the manufacture of electric and hybrid vehicles.

The use of brushless technology in the construction of washing machines and air conditioners is equally important. Spark-free operation is essential due to the high electrocution risk. In addition, washing machine manufacturers offer a longer warranty on products equipped with brushless motors due to the more stable operation of the drum, which allows for fewer breakdowns. Another benefit of purchasing such a washing machine is the reduction of running costs.

### Types of brushless motors — BLDC and PMSM

The most commonly used brushless motors are **BLDC** motors (brushless DC motors), ie, a solution employing a trapezoidal EMF (electromotive force) waveform, and **PMSMs** (permanent magnet synchronous motors) with a sinusoidal EMF waveform. A distinction is also made between DC and AC drives.

### Brushless motor control

The use of windings on the stator makes it possible to control the motor by varying the currents applied to the windings and to manipulate the torque value on the fly. As already mentioned above, a distinction is made between BLDC and PMSM motors. The motor type marking indicates how the device is controlled. Trapezoidal control allows for regulation when no control of the speed or the torque of the motor is required. Such motors are equipped with Hall sensors, which determine the position of the rotor. This solution is less complicated, but also less accurate. The main disadvantage of this design is the problematic adjustment at low speeds.

In PMSM motors, ie, those with a sinusoidal EMF waveform, thanks to the application of special encoders, undesirable commutation effects occurring in BLDC motors are eliminated, thanks to which easy control is possible even at low rotational speeds. In addition, such a solution minimises the risk of torque ripple.

The third and most advanced type of brushless motor control is vector control. This solution consists in using a special transformation block upstream the PI (proportional-integral) controller. This results in improved control accuracy compared to the previously mentioned types, while eliminating ripples and offering better control at low speeds.

### Summary

The **use of a brushless motor** is undoubtedly a solution that is worth the attention of both the manufacturer and the consumer. The former gets rid of the risk of frequent breakdowns. Products gain in quality, while the number of necessary assembly components is reduced. The buyer, on the other hand, receives a product that will serve them for years and will not require any special interference in its operation. Despite a certain price difference, the peace of mind and security are bought for a lifetime. It is therefore worth considering the offer of devices equipped with brushless motors.

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





































































































































































































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Altitude

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Operating  
Temperature

#### 5 Yrs

Warranty

Series	Output Power	Input Voltage	Output Voltage															Efficiency	Leakage Current	Package
			Single	Dual	Triple	3.3V	5V	7.5V	9V	12V	15V	18V	24V	28V	36V	48V	53V			
	(W)	(VAC)																(%)	(μA)	*For PCB/ chassis mounting
MSC15	15	85-264																89	75	*Encapsulated 2.82"x1.14"x0.82"
MSD30	30	85-264																91.5	100	*Encapsulated 3.95"x1.50"x1.00"
MSD40	40	85-264																93	75	*Encapsulated 4.30"x2.20"x1.20"
MSD65	65	85-264																93.5	75	*Encapsulated 4.30"x2.20"x1.20"
MAC15	15	85-264																89	75	Open Frame 2.61"x1.00"x0.62"
MAD30	30	85-264																91.5	100	Open Frame 3.34"x1.36"x0.77"
MAD40-Single	40	85-264																93	75	Open Frame/ Enclosed 3.00"x2.00"x0.94"
MAD65-Single	65	85-264																93.5	75	Open Frame/ Enclosed 3.00"x2.00"x0.94"
MAD40-Multi	40	85-264				5/ 3.3, 12/ 5, 12/ 3.3, 15/ 5, 24/ 5, 28/ 5, 5/ 3.3/ -5, 5/ 3.3/ 12, 5/ 3.3/ -12, 12/ 5/ -5, 12/ 5/ -12, 12/ 3.3/ 5, 12/ 3.3/ -12, 15/ 5/ -15, 24/ 5/ 12, 24/ 5/ -12											90	75	Open Frame/ Enclosed 3.50"x2.00"x0.98"	
MAD65-Multi	65	85-264				5/ 3.3, 12/ 5, 12/ 3.3, 15/ 5, 24/ 5, 28/ 5, 5/ 3.3/ -5, 5/ 3.3/ 12, 5/ 3.3/ -12, 12/ 5/ -5, 12/ 5/ -12, 12/ 3.3/ 5, 12/ 3.3/ -12, 15/ 5/ -15, 24/ 5/ 12, 24/ 5/ -12											90.5	75	Open Frame/ Enclosed 3.50"x2.00"x0.98"	
MAD100	100	85-264																92	75	Open Frame/ Enclosed 3.00"x2.00"x1.16"
MAF150	150	85-264																92	100	Open Frame/ Enclosed 4.00"x2.00"x1.16"
MAD180	180	85-264																94	100	Open Frame/ Enclosed 3.00"x2.00"x1.24"
MAF300	300	85-264																93	100	Open Frame/ Enclosed 4.00"x2.09"x1.26"
MAH450	450	85-264																94	100	Open Frame/ Enclosed 5.00"x3.00"x1.58"

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## AUTOSAR-READY DIGITAL SIGNAL CONTROLLERS

Microchip is expanding its broad portfolio of dsPIC33C digital signal controllers (DSCs) to cover the large memory segment with the ISO 26262-compliant dsPIC33CK1024MP7xx family. This family of DSCs with

1 MB Flash enables applications running automotive software like AUTOSAR, OS,

MCAL drivers, ISO 26262 functional safety diagnostics and security libraries. The family also includes a high-performance central processing unit (CPU) with deterministic response and specialised peripherals for general automotive, advanced sensing and control, digital power and motor control applications.

The benefit of adopting AUTOSAR-ready devices like this one is that users can improve their risk and complexity management while decreasing development time through reusability. Those who have previously designed bare metal or non-AUTOSAR automotive applications and are now adopting AUTOSAR can scale up by staying within the dsPIC33C DSC ecosystem and continuing to take advantage of Microchip's value-added solutions, customer support and product advantages with the AUTOSAR-ready dsPIC33C DSCs. The AUTOSAR ecosystem for the DSCs includes MICROSAR Classic from Vector, KSAR OS from KPIT Technologies and ASPICE- and ASIL B-compliant MCAL drivers from Microchip.

Microchip has expanded its functional safety packages that include FMEDA reports, safety manuals and diagnostic libraries to cover the ISO 26262-compliant dsPIC33CK1024MP7xx DSCs. The AUTOSAR-ready DSCs, used together with Microchip's TA100 CryptoAutomotive security integrated circuits (ICs), enable the implementation of robust security in automotive designs.

**Microchip Technology Australia**  
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## AIoT DEVELOPER KIT

ICP Australia has introduced iEi's TANK-XM811 AIoT Developer Kit, which is equipped with the 12th generation Intel Core processor and the Intel R680E chipset. This processor uses Intel 7 process technology and offers up to 16 cores and 24 threads with Intel Hybrid Technology to facilitate a multi-threaded performance.

The AIoT Developer Kit delivers low latency, high network and data transmission speed with the support of PCI Express 4.0 for double throughput and provides Intel Wi-Fi 6E. It has a rich I/O design, including dual independent 4K display ports (HDMI and DP++), six COM ports, eight USB 3.2 Gen 2 ports, two 2.5GbE LAN ports and also two PCIe x8 slots. It also allows for extra I/O expansion cards, such as PoE LAN, M.2 A-Key or B-Key to support various applications at edge AI.

The AIoT Developer Kit is integrated with Intel Iris Xe graphics, to provide GPU computing performance and speed for users. Powered by Intel Distribution of Open VINO Toolkit and Intel Movidius Vision Processing Unit (VPU) accelerator cards to improve AI performance, users can enjoy next-gen applications in automating business, inference computing and data analysis. The AIoT Developer Kit also offers Modular Expansion.

**ICP Electronics Australia Pty Ltd**  
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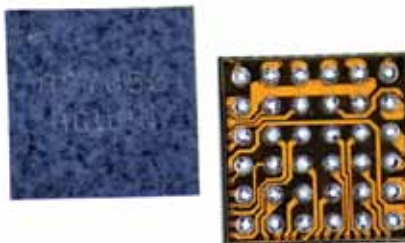
## MEDICAL AND HEALTH SENSOR

The AS7050 is a medical and health sensor from ams OSRAM. It provides design engineers with next-generation biosignal conversion for a variety of applications, including smart devices, heart rate, electrocardiogram (ECG) and photoplethysmography (PPG) monitoring, optical sensor platforms, wearables and more.

The product is a biosignal sensor analog front end that offers up to eight LED driver outputs, samples up to six photodiode inputs and includes support for external electrodes, enabling high flexibility for multiple LED and photodiode arrangements in different applications. The analog front end provides two analog-to-digital converter (ADC) channels for simultaneous PPG and ECG measurements and an automatic photodiode offset control.

The sensor operates from a supply voltage range of 1.7 to 1.98 V and features a 1 MHz fast-mode plus, 400 MHz fast mode and 100 MHz standard mode through an I<sup>2</sup>C bus for maximum efficiency.

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



## UNIVERSAL 19" RACK SHELVES

Universal cantilever shelves from METCASE enable electronics equipment without built-in 19" fittings to be added to racks or cabinets quickly and easily.

The 2U shelves are DIN 41494 and IEC 60297-3 compliant. They are suitable for a wide range of applications, including networking and communications equipment, industrial computers, sound and studio systems, laboratory instruments and industrial control.

Slots in the bottom of the C4 mild steel shelves aid in-rack ventilation. The shelves are finished in tough powder polyester paint in either anthracite or light grey. There are two standard sizes — 2U x 280 mm and 2U x 400 mm. Custom sizes are available on request.

The shelves form part of METCASE's range of accessories, acting as an alternative to the company's open-topped COMBIMET T aluminium 19" rack cases. Unlike the shelves, COMBIMET T has a front panel and a rear lip. It is available in 2U and 3U heights (2U x 365 mm and 3U x 365 mm). The standard colours are light grey and black.

METCASE's accessory range now includes the 19" cantilever shelves, 19" mounting kits, a PCB mounting kit, PCB/panel fixing screws, PCB guides, mounting plates, front panels, chassis plates (METTEC 19"), wall-mounting kits (UNIDESK), an assembly tool (UNICASE) and a wide range of case feet (including tilt-leg versions).



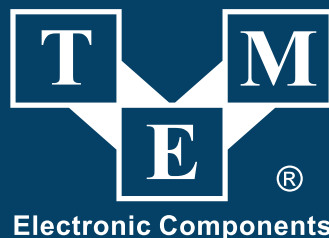
All METCASE enclosures can be supplied fully customised. Services include bespoke sizes, custom front panels, CNC machining, fixings and inserts, painting/finishing and photo-quality digital printing of graphics, legends and logos.

**ROLEC OKW Australia New Zealand P/L**  
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# Panasonic

## INDUSTRY

## Standalone Bluetooth modules for IoT applications



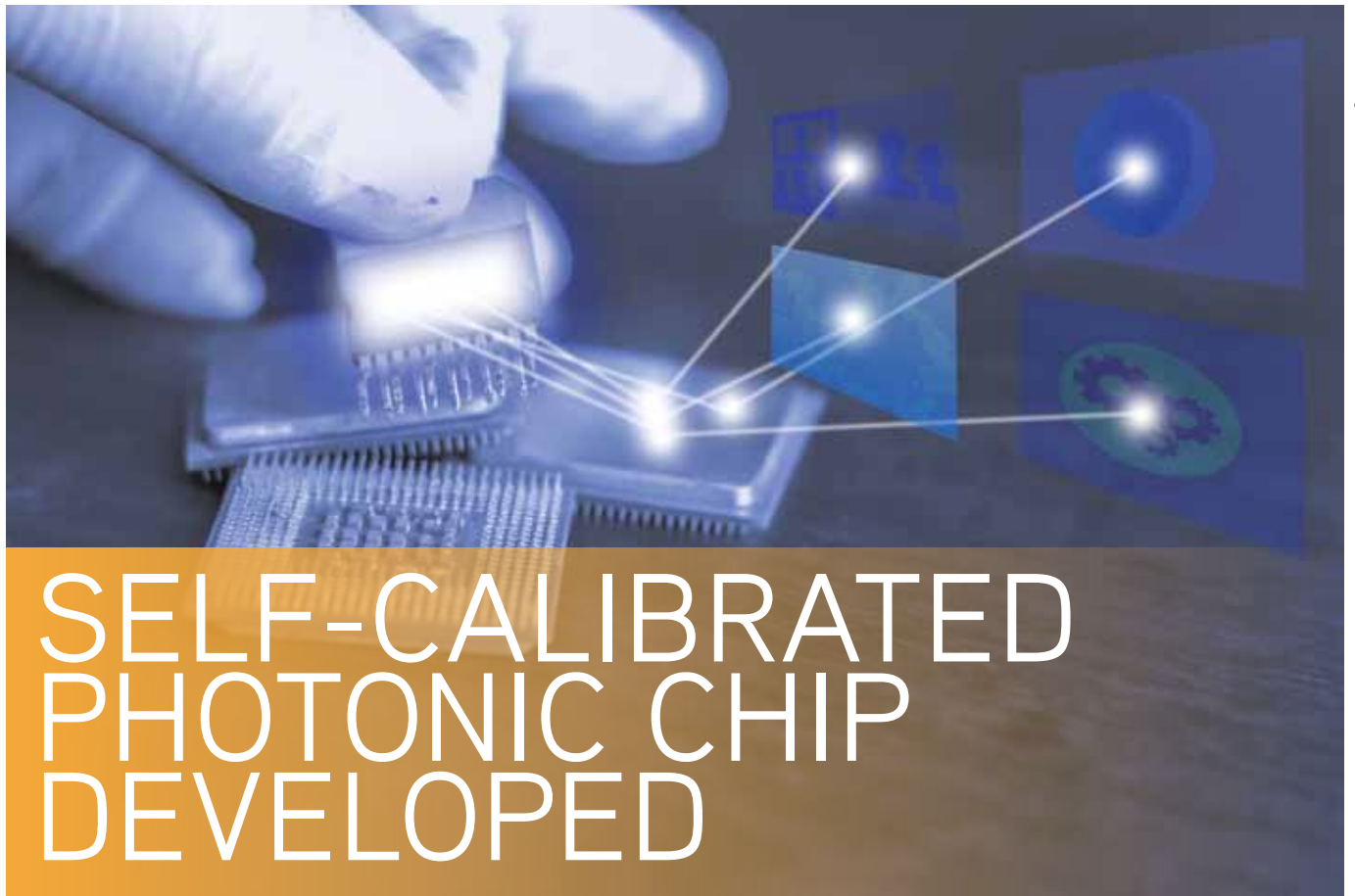
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Australian researchers have found a way to create an advanced photonic integrated circuit that builds bridges between so-called data superhighways, which is set to revolutionise the connectivity of current optical chips and replace bulky 3D optics with a wafer-thin slice of silicon. Their breakthrough, which was three years in the making, has been described in the journal *Nature Photonics*.

**W**hether it's turning on a TV or keeping a satellite on course, photonics (the science of light) is transforming the way we live. Photonic chips can transform the processing capability of bulky, bench-sized utilities onto fingernail-sized chips.

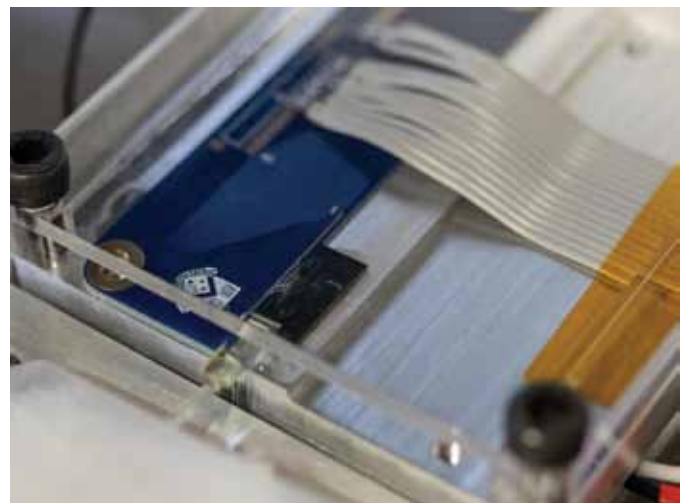
"As we integrate more and more pieces of bench-sized equipment onto fingernail-sized chips, it becomes more and more difficult to get them all working together to achieve the speed and function they did when they were bigger," said study co-author Dr Andy Boes, from The University of Adelaide. "We overcame this challenge by creating a chip that was clever enough to calibrate itself so all the components could act at the speed they needed to in unison."

The project's lead investigator, Monash University's Professor Arthur Lowery, said the work complements Dr Bill Corcoran's 2020 invention of a new optical microcomb chip that can squeeze three times the traffic of the entire nbn through a single optical fibre, regarded as the world's fastest internet speed from a single fingernail-sized chip. The optical microcomb chip built multiple lanes of the superhighway; now the self-calibrating chip has created the on and off ramps and bridges that connect them all and allow greater movement of data.

Internet-reliant technologies like self-driving cars, remote-controlled mining equipment and medical equipment will require even faster and increased bandwidth in the future. Bandwidth increase is not just about improving the optical fibres the internet travels through — it's about providing compact switches of many

colours, going many directions, so data can be sent down many channels at once.

"Self-calibration is significant because it makes tunable photonic integrated circuits useful in the real world," Lowery said. "Applications include optical communications systems that switch signals to destinations based on their colour, very fast computations of similarity (correlators), scientific instrumentation for chemical or biological analysis, and even astronomy."



“Electronics saw similar improvements in the stability of radio filters using digital techniques that led to many mobiles being able to share the same chunk of spectrum: our optical chips have similar architectures, but can operate on signals with terahertz bandwidths.”

Photonic circuits are able to manipulate and route optical channels of information, but they can also provide some computational ability; for example, searching for patterns. Pattern searching is fundamental to many applications: medical diagnosis, autonomous vehicles, internet security, threat identification and search algorithms.

Rapid and reliable reprogramming of the chips enables new search tasks to be programmed speedily and accurately. However, this manufacturing needs to be precise to the degree of a tiny wavelength of light (nanometres), which is currently difficult and extremely expensive. Self-calibration overcomes this problem.

A key challenge of the research was integrating all the optical functions onto a device that could be ‘plugged in’ to existing infrastructure. The solution, said Lowery, was to “calibrate the chips after manufacturing, to tune them up in effect by using an on-chip reference, rather than by using external equipment”.

“We use the beauty of causality — effect following cause — which dictates that the optical delays of the paths through the chip can be uniquely deduced from the intensity versus wavelength, which is far easier to measure than precise time delays,” Lowery said. “We have added a strong reference path to our chip and

calibrated it. This gives us all the settings required to ‘dial up’ a desired switching function or spectral response.”

The method is a critical step to make photonic chips practically useful. Rather than searching for a setting, akin to tuning in an old radio, the researchers could tune the chip in one step, enabling the quick and reliable switch of data streams from one destination to another.

“Our photonic technology is now sufficiently advanced so that truly complex systems can be integrated on a single chip,” said study co-author Professor Arnan Mitchell, from RMIT’s Integrated Photonics and Applications Centre (InPAC). “The idea that a device can have an on-chip reference system that allows all its components to work as one is a technological breakthrough that will allow us to address bottleneck internet issues by rapidly reconfiguring the optical networks that carry our internet to get data where it’s needed the most.”

The development has the ability to speed up the global advancement of artificial intelligence and offers real-world applications such as safer driverless cars capable of instantly interpreting their surroundings; smaller switches for reconfiguring optical networks; enabling AI to more rapidly diagnose medical conditions; and making natural language processing even faster for apps such as Google Homes, Alexa and Siri. Reliable tuning of photonic chips also opens up applications such as optical correlators, which can almost instantaneously find patterns of data in data streams, such as images — something the group has also been working on.



## Certified SIL 2/3 Self-Test Library for Industrial Safety

### Simplify Your System Development and Certification

Industrial safety is critical in the field of industrial controls, robots, sensors, gas detectors and smoke detectors, making the IEC 61508 Industrial Safety Standard a pre-requisite for these applications.



Our broad portfolio of 32-bit SAM and PIC32 Microcontrollers (MCUs) and dsPIC33C Digital Signal Controllers (DSCs) offers TÜV Rheinland-certified diagnostic libraries (self-test libraries) for designs targeting up to SIL 3, IEC 61508 FMEDA and/or safety manuals, which are available in a complete package.

Utilize the comprehensive set of documentation and certified software libraries to simplify and accelerate your system development while saving certification cost and time.

#### Advantages of Microchip's IEC 61508 Diagnostic Libraries:

- TÜV Rheinland certified diagnostic libraries can be used to implement an SIL 2 safety level in single-channel applications and an SIL 3 safety level in dual-channel applications
- Detects random hardware failures in the core, Flash memory, SRAM and other peripherals
- The SIL 2/3 diagnostic libraries are part of an overall safety package that includes a software safety manual as well as a safety checklist offering for the IEC 61508 industrial safety designs
- Complete source code for PIC® and AVR® MCUs and dsPIC33C DSCs, and binaries for PIC32C and SAM 32-bit MCUs

#### Contact Information

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# Hydrogen fuel-cell technology lights up Marvel Stadium

In a demonstration of the power and potential applications of hydrogen technology, Toyota used a stationary fuel cell to power Melbourne's iconic Marvel Stadium sign and coaches' box for the Round 19 AFL clash between the Western Bulldogs and Melbourne Demons on 23 July. The demonstration used the same type of Toyota-designed fuel cell as seen in the Mirai FCEV (fuel cell electric vehicle).

Toyota Australia Manager of Energy Solutions Matt Macleod said the demonstration aimed to showcase the broader applications of hydrogen-powered fuel-cell technology beyond the transport sector, as a clean and efficient source of energy generation across a range of industries.

"Toyota sees hydrogen fuel cells as a key source of clean, renewable electrical energy going forward, as evidenced by vehicles like the Mirai FCEV," Macleod said.

"Partnering with the AFL to help power the Round 19 game at Marvel Stadium shows the incredible scope this technology has, all while producing no CO<sub>2</sub> emissions."

The EODev GEH2 fuel cell unit is capable of producing roughly 80 kW of power, but only 10–15% of this capacity was required to power the Marvel Stadium facilities, providing 105 kWh of electricity over the course of seven hours. Running in the lead-up to and during the game, the EODev unit used 6 kg of hydrogen, saving an estimated 100 kg of CO<sub>2</sub> emissions compared to running the lighting off the electricity grid, demonstrating immediate environmental benefits.

To further raise awareness of its fuel-cell technology, Toyota had a cross-section of the Mirai and its FCEV powertrain on display at the Marvel Stadium concourse, allowing passers-by to view the technology up close.

The Mirai powertrain is composed of a 330-cell fuel cell stack, three compressed hydrogen tanks, a lithium-ion battery and integrated electric motor, combining to produce 134 kW/300 Nm. The three carbon-fibre reinforced plastic (CFRP) tanks are capable of storing up to 5.6 kg of hydrogen, which allows for a driving range of approximately 650 km with only water vapour as emissions.

Toyota's stated commitment to hydrogen-powered technology is part of its strategy for achieving a more sustainable future under the Toyota Environmental Challenge 2050, which aims to achieve zero CO<sub>2</sub> emissions from the corporation's vehicles and plants globally by 2050.



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## RUGGED TABLET

Winmate's M140TG is a 14" Intel Core i5-1135G7 Windows rugged tablet. It features a large screen with optical bonding technology and an anti-glare coating, making the display readable even under sunlight. It supports rain and glove touch capability, offering visibility and productivity in hostile environments and situations.

The industrial mobile PC can operate in temperatures ranging from -20 to 60°C (when charging) or -10 to 50°C (on battery). It offers flexibility of use for a wide range of industrial sectors.

In a world where industrial mobile PCs need to work 24/7/365, power-up continuity is essential. The product has an internal battery that provides a hot swap capability to support the never-power-down PC, which is useful when the device is pooled between workers or required across multiple work shifts.

The 14" tablet comes with an optional kickstand/hard handle and mounting choices making it easy to carry. The device can withstand impact, shock, vibration, liquid spills and dust. The industrial mobile PC has been independently tested and meets the IP65 rating and MIL-STD-810H standard.

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## MOTHERBOARD

The AIMB-288E motherboard features a slender design to deliver computing power and graphics performance to visual computing in edge intelligence. It supports three independent displays (two Display Ports and one eDP with up to 4K resolution) to support visualisation during diverse inspection tasks. In addition, the motherboard benefits from Advantech's thermal technology and IEC-60068-2 compliance — attributes that provide stability during long-term operation. This combination of features and capabilities makes the motherboard suitable for AI development and deployment in applications requiring a compact, slim form factor design.

The motherboard utilises 12th Gen Intel Core Desktop Processor and NVIDIA Quadro T1000 GPU (MXM module type) with 896 CUDA Cores and 4 GB GDDR6 to deliver 2.5 Tflops single-precision performance. Furthermore, by using 3Dmark Time SPY, the motherboard delivers a 5.2-fold increase in 3D graphics performance as comparable native GPU graphics solutions. This module is capable of handling graphics processing demands in high-end medical imaging where it improves quality of care.

The motherboard's GPU produces better image processing results while enabling the CPU to focus on data processing. This solution makes the power provided by the CPU, the i3-12100E (quad cores with 4.3 GHz turbo capability), more than sufficient for most applications. Moreover, this single thread rating and DDR5 4800 memory produce a 1.36-fold increase in performance when compared to 10th Gen Intel Core i7 processors. Consequentially, the motherboard is able to consolidate workloads by using the ISA between CPU and GPU.



To boost up AI and machine learning deployment, the motherboard supports Windows and/or Linux Ubuntu OS to empower diverse AI development. Equipped with M.2 B Key expansion for 4G wireless connectivity and through utilisation of WISE-DeviceOn, this solution supports remote management capabilities — including device health status monitoring, real-time control, troubleshooting and over-the-air (OTA) software/firmware upgrades. This combination of hardware and software makes the motherboard a suitable choice for AI, machine learning and edge intelligence applications.

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## EMI TEST RECEIVER BANDWIDTH EXTENSIONS

To help EMC engineers meet the increasing demand for higher measurement speeds, Rohde & Schwarz is introducing a wideband solution that is able to measure up to 970 MHz in real time, while keeping a high dynamic range and measurement accuracy.

In order to speed up measurement time and to provide a more careful analysis of interfering signals, the R&S ESW EMI test receiver will offer the possibility to increase its FFT (fast

Fourier transform) bandwidth to 350 MHz with the R&S ESW-B350 option, and to 970 MHz with the R&S ESW-B1000 option. This makes the unit not only an instrument of high performance in RF, functionality, versatility and hardware quality, but also in high-speed testing, especially for pretests and general EMI analysis.

With the R&S ESW-B1000 offering 970 MHz of FFT bandwidth, the product can process the CISPR Bands C and D in one shot — even with quasi peak and CISPR average detectors working in parallel — offering a gain in measurement speed. The 970 MHz wide spectrum is measured in real time, so users benefit from a truly gapless spectrogram. Infrequent emissions can be observed over a long time and are detected with high probability. Emissions from equipment under test going through a duty cycle are recorded over a broad spectrum of 970 MHz without missing the shortest pulse.

EMC engineers working in commercial, military, aerospace and automotive applications should benefit from the fast speed and signal insights provided by the FFT bandwidth extensions. Both the R&S ESW-B1000 and R&S ESW-B350 options are hardware extensions to the R&S ESW EMI test receiver and can be retrofitted to every R&S ESW (S/N  $\geq 103000$ ).

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# AUTOMATING SEMICONDUCTOR RESEARCH

## WITH MACHINE LEARNING

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The development of new thin semiconductor materials requires a quantitative analysis of a large amount of reflection high-energy electron diffraction (RHEED) data, which is time-consuming and requires expertise. To tackle this issue, scientists have identified machine learning techniques that could help automate RHEED data analysis, accelerating semiconductor research in the process.

The semiconductor industry has been growing steadily ever since its first steps in the mid-20th century, and today there is a growing need for faster, more integrated and more energy-efficient semiconductor devices. However, modern semiconductor processes have already reached the nanometre scale, and the design of novel high-performance materials now involves the structural analysis of semiconductor nanofilms.

RHEED is a widely used analytical method that can be used to determine the structures that form on the surface of thin films at the atomic level and can even capture structural changes in real time as the thin film is being synthesised. Unfortunately, RHEED is sometimes hindered by the fact that its output patterns are complex and difficult to interpret. In virtually all cases, a highly skilled experimenter is needed to make sense of the huge amounts of data that RHEED can produce in the form of diffraction patterns.

Now, Japanese researchers have explored the possibility of using machine learning to automatically analyse RHEED data. This work was led by Dr Naoka Nagamura, a visiting associate professor at the Tokyo University of Science (TUS) and senior researcher at Japan's National Institute for Materials Science (NIMS), with results published in the journal *Science and Technology of Advanced Materials: Methods*.

The researchers focused on the surface superstructures that form on the first atomic layers of clean single-crystal silicon — one of the most versatile semiconductor materials — depending on the amount of indium atoms adsorbed and slight differences in temperature. Surface superstructures are atomic arrangements unique to crystal surfaces where atoms stabilise in different periodic patterns than those inside the bulk of the crystal, depending on differences in the surrounding environment. Because they often exhibit unique physical properties, surface superstructures are the focus of much interest in materials science.

First, the team used different hierarchical clustering methods, which are aimed at dividing samples into different clusters based on various measures of similarity. This approach serves to detect how many different surface superstructures are present. After trying different techniques, the researchers found that Ward's method could best track the actual phase transitions in surface superstructures.

The scientists then sought to determine the optimal process conditions for synthesising each of the identified surface superstructures. They focused on the indium deposition time for which each superstructure was most extensively formed. Principal component analysis and other typical methods for dimensionality reduction did not perform well. Fortunately, non-negative matrix factorisation, a different clustering and dimensionality reduction technique, could automatically obtain the optimal deposition times for each superstructure.

"Our efforts will help automate the work that typically requires time-consuming manual analysis by specialists," Nagamura said. "We believe our study has the potential to change the way materials research is done and allow scientists to spend more time on creative pursuits."

Overall, the findings reported in this study should lead to new and effective ways of using machine learning techniques for materials science — a central topic in the field of materials informatics. In turn, this would have implications in our everyday lives as existing devices and technologies are upgraded with better materials.

"Our approach can be used to analyse the superstructures grown not only on thin-film silicon single-crystal surfaces, but also metal crystal surfaces, sapphire, silicon carbide, gallium nitride and various other important substrates," Nagamura said. "Thus, we expect our work to accelerate the research and development of next-generation semiconductors and high-speed communication devices."

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## INDUSTRIAL MICRO-ATX MOTHERBOARD

Powered by the AMD desktop processor Ryzen Embedded 5000 with up to eight high-performance Zen 3 cores, the AIMB-522 industrial Micro-ATX motherboard comes with a full suite of technologies designed to elevate applications, including high computing performance efficiency, high expandability with PCIe Gen4, and up to 4x Gigabit Ethernet ports and 8x USB 3.2.

The product features AMD's latest desktop processor with Zen 3 performance, achieving high levels of processing and power efficiency. The Zen 3 core's instructions per clock offer 19% more performance from every MHz of frequency relative to the previous generation. The Zen 3 architecture transitions to a new design that brings eight cores and 32 MB of L3 cache into a single group of resources.



For easy deployment for diverse computer vision applications, the integration of multiple high-speed digital cameras is essential to capture images seamlessly. AIMB-522 is heavily equipped with 4x Gigabit Ethernet ports and 8x USB 3.2 10 Gbps interfaces, offering complete connectivity for the latest high-data-throughput cameras with transfer bandwidths up to 350 MBps and 60 fps.

Deep learning-assisted imaging processing will be a key requirement in automated manufacturing applications in coming years. AIMB-522 supports PCI-Express x16 Gen4 technology for graphics-demanding applications. Furthermore, dual PCI-Express x4 slots offer the expandability to integrate the robotic (arm) controller cards in the industrial market. The onboard M.2 M-Key socket supports high-speed SSD for real-time OS operations.

The just-fit adaptability of the motherboard for industrial peripherals helps users to upgrade a factory automation controller to an AI-enabled imaging processing solution.

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## THERMAL INSULATION TAPES

Digi-Key Electronics now offers a range of RockeTape, powered by Blueshift. RockeTape is a structured air thermal insulation tape designed for hot and cold spots. The RockeTape range of products leverages Blueshift's patented AeroZero structured air polymeric aerogel technology to deliver a combination of low thermal conductivity and diffusivity. This line of thin and lightweight thermal insulation tape is designed to provide performance in a range of demanding applications.

Its structured air aerogel composition provides thermal insulation and protection. With its thin flexible film and standardised narrow-width roll format, the insulation tape is easy to apply onto sensitive devices and surfaces to provide protection from temperature fluctuations and overheating.

Initial products in the launch include the AZS AeroZero polyimide aerogel + Silicone Adhesive, the GRS AeroZero polyimide aerogel + Graphite + Silicone Adhesive and the PIS AeroZero polyimide aerogel + Polyimide + Silicone Adhesive.

The range of thermal insulation tapes is suitable for market sectors that need an insulative as well as a high-temperature tape.

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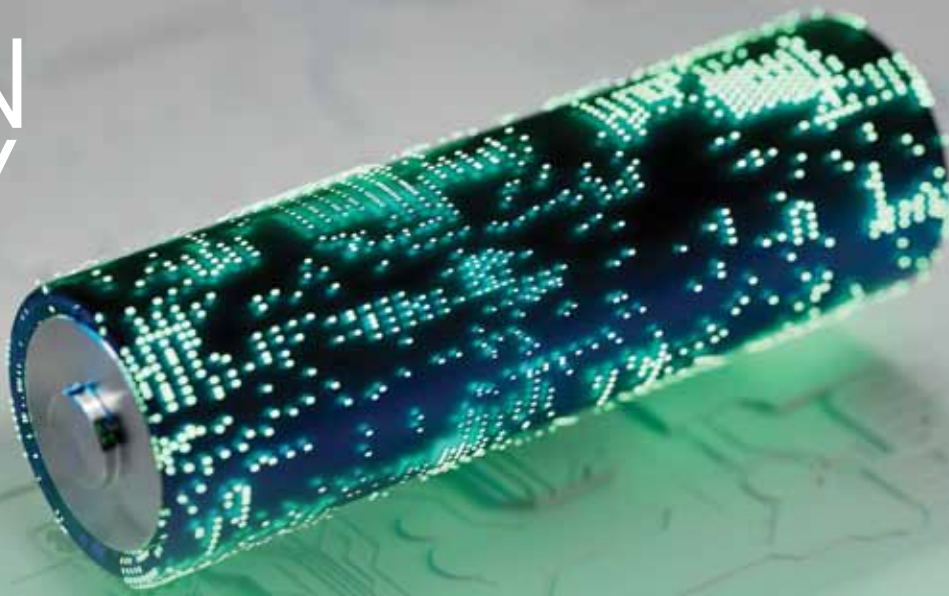
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# AMPING UP LI-ION BATTERY

PERFORMANCE WITH BLACK GLASS



A group of researchers from the Japan Advanced Institute of Science and Technology (JAIST), led by Professor Noriyoshi Matsumi, have developed an electrode material inspired by the properties of silicon grafted with black glasses.

**S**ilicon-based negative electrode materials have excellent energy capacity, making them suitable for use in lithium-ion batteries. However, their practical application faces challenges including the lack of mechanical strength and rapid capacity fading. The researchers from JAIST aim to alleviate this problem through the use of anodes prepared from this silicon microparticle-based material, which were highly resilient with excellent capacity retention.

Silicon is reportedly the most abundant element on earth, making up 27.7% of the earth's crust. Apart from its ability to create sandy beaches and clear glasses, silicon also holds the potential to make highly efficient metal-ion batteries. In a world where alternative energy storage devices like lithium-ion batteries are gaining momentum, there is a need to harness the specific energy capacity of silicon as an electrode material. The commercial application of silicon-based electrode materials is often hindered due to two reasons: the lack of mechanical stability arising from uncontrolled volume expansion upon lithiation (the process of combining with a lithium-ion) and the rapid energy fading caused by the formation of unstable solid-electrode interface (SEI) formation.

Over the years, scientists have developed various advanced silicon-based negative electrodes or anode materials to overcome the aforementioned problems. Among the most prominent are silicon nanomaterials. However, silicon nanomaterials come with certain demerits, such as a large demand and supply gap, difficult and expensive synthesis process, and a threat of fast battery dry-up. Now, the researchers from JAIST, led by Professor Noriyoshi Matsumi, have proposed a solution to these issues plaguing silicon microparticles (SiMP).

In the study published in the *Journal of Materials Chemistry A*, the researchers reported a holistic approach to synthesising novel highly resilient SiMPs consisting of black glasses (silicon oxycarbide) grafted silicon as anode material for lithium-ion batteries. The research team included Ravi Nandan, a research fellow, Noriyuki Takamori, a doctoral course student, Koichi Higashimine,

a technical Specialist, and Dr Rajashekar Badam, a former Senior Lecturer at JAIST.

"Silicon nanoparticles might provide increased effective surface area but that comes with its own drawbacks like increased consumption of electrolyte as well as poor initial coulombic efficiency after a few cycles of charging and discharging. SiMPs are the most appropriate, low-cost and easily available alternatives, especially when combined with materials that have exceptional structural properties, such as silicon oxycarbide black glasses. Our material is not only high performing but also conducive to scale opportunities," Matsumi said.

The researchers designed a core-shell type material where the core was made up of SiMP coated in a layer of carbon. The silicon oxycarbide black glasses were then grafted on as the shell layer. The prepared materials were then used in an anodic half-cell configuration to test their ability to reversibly store lithium under different potential windows. This screening showed that the material has great lithium diffusion ability, reduced internal resistance and overall volumetric expansion. The superior electrochemical properties of this new material were established by the 99.4% retention of energy capacity after 775 cycles of charging and discharging. In addition to the superlative energy storage abilities, the material also exhibited great mechanical stability throughout the testing process.

The results indicated the superiority of the new SiMP-based active anode materials. These materials have now opened up pathways for the application of silicon in next-generation secondary lithium-ion batteries. The upscaling ability of this synthesis process can help bridge the gap between laboratory research and industrial applications in the field of energy storage. This is particularly important for producing low-cost electric vehicles, which can appreciably reduce carbon emissions.

"Our methodology offers an effective avenue for the development of high-performance anode materials for energy-efficient lithium-ion batteries, which is an essential building block towards creating a sustainable and low-carbon tomorrow," said Matsumi, when asked about the significant application of the study.

# ENGINEERS PRESENT CHIP

## THAT BOOSTS AI COMPUTING EFFICIENCY

AI-powered edge computing has become pervasive; devices like drones, smart wearables and industrial IoT sensors are equipped with AI-enabled chips so that computing can occur at the 'edge' of the internet, where the data originates. This allows real-time processing and guarantees data privacy.

However, AI functionalities on these tiny edge devices are limited by the energy provided by a battery. Therefore, improving energy efficiency is crucial. In today's AI chips, data processing and data storage happen at separate places — a compute unit and a memory unit. The frequent data movement between these units consumes most of the energy during AI processing, so reducing the data movement is key to addressing the energy issue.

Engineers from Stanford University have created a possible solution: a novel resistive random-access memory (RRAM) chip that does the AI processing within the memory itself, thereby eliminating the separation between the compute and memory units. Their 'compute-in-memory' (CIM) chip, called NeuRRAM, is about the size of a fingertip and does more work with limited battery power than what current chips do. H. S. Philip Wong, the Willard R. and Inez Kerr Bell Professor in the School of Engineering, said that having those calculations done on the chip instead of sending information to and from the cloud could enable faster, more secure, cheaper and more scalable AI in the future, and give more people access to AI power.

Weier Wan, a graduate at Stanford who is leading this project, said the data movement issue is similar to spending eight hours in commute for a two-hour workday. "With our chip, we are showing a technology to tackle this challenge," Wan said.

NeuRRAM was presented in a recent article in the journal *Nature*. This chip demonstrates a broad range of AI applications on hardware, rather than through simulation alone. To overcome the data movement bottleneck, researchers implemented compute-in-memory, a novel chip architecture that performs AI computing directly within memory rather than in separate computing units. The memory technology that NeuRRAM used is resistive random-access memory (RRAM), a type of non-volatile memory that retains data even once power is off, which has emerged in commercial products. RRAM can store large AI models in a small area footprint, and consume very little power, making them perfect for small-size and low-power edge devices.

Even though the concept of CIM chips is well established and the idea of implementing AI computing into RRAM isn't new, this is reportedly one of the first instances to integrate a lot of memory right onto the neural network chip and present all benchmark results through hardware measurements, according to the co-senior author of the *Nature* paper. The architecture of NeuRRAM allows the chip to perform analog in-memory computation at low power and in a compact-area footprint. It was designed in collaboration with the lab of Gert Cauwenberghs at the University of California, San Diego, who pioneered low-power neuromorphic hardware design. The architecture also enables reconfigurability in dataflow directions, supports various AI workload mapping strategies and can

work with different kinds of AI algorithms — all without sacrificing AI computation accuracy.

To show the accuracy of NeuRRAM's AI abilities, researchers tested its function on different tasks and found that it is 99% accurate in letter recognition from the MNIST dataset, 85.7% accurate on image classification from the CIFAR-10 dataset, 84.7% accurate on Google speech command recognition and showed a 70% reduction in image-reconstructed error on a Bayesian image recovery task.

"Efficiency, versatility and accuracy are all important aspects for broader adoption of the technology. But to realise them all at once is not simple. Co-optimising the full stack from hardware to software is the key," Wan said.

"Such full-stack co-design is made possible with an international team of researchers with diverse expertise," Wong said.

The NeuRRAM is currently a physical proof of concept but needs more development before it is ready to be translated into actual edge devices. But this combined efficiency, accuracy and ability to do different tasks showcases the chip's potential.

"Maybe today it is used to do simple AI tasks such as keyword spotting or human detection, but tomorrow it could enable a whole different user experience. Imagine real-time video analytics combined with speech recognition all within a tiny device. To realise this, we need to continue improving the design and scaling RRAM to more advanced technology nodes," Wan said.

Priyanka Raina, assistant professor of electrical engineering and a co-author of the paper, said the work opens up several avenues of future research on RRAM device engineering and programming models and neural network design for compute-in-memory, to make this technology scalable and usable by software developers.

If successful, RRAM compute-in-memory chips like NeuRRAM could be embedded in crop fields to do real-time AI calculations for adjusting irrigation systems to current soil conditions. If mass produced, these chips would be cheap enough, adaptable enough and low power enough that they could be used to advance technologies, like in medical devices that allow home health monitoring. They could also be used to solve global societal challenges as well.

"By having these kinds of smart electronics that can be placed almost anywhere, you can monitor the changing world and be part of the solution. These chips could be used to solve all kinds of problems from climate change to food security," Wong said.



## INDUSTRIAL-GRADE POWER SUPPLIES

Helios has added a 300 W output power supply series, the TAF300 from P-Duke Technology, to its industrial-grade AC/DC power supplies range. The high conversion efficiency up to 93% and the power consumption as low as 300 mW allows for a power module designed in a compact industry standard 4"x2" package. Additionally, its output can deliver up to 360 W peak power for 5 s to support a variety of automation systems and motor/valve devices in the industrial field.

TAF300 comes in 4"x2" open frame versions or optional enclosed versions or DIN-rail. With a universal input range of 85 to 264 VAC (120–370 VDC) input range. This series provides 12, 15, 18, 24, 28, 36, 48, and 53 VDC single output voltages. The output voltage can be adjusted up to  $\pm 10\%$  with the integrated potentiometer.

A 12 VDC auxiliary output is available for a temperature-controlled variable speed fan. The optional remote control and power good signal offer a convenient approach to controlling and monitoring the unit. Protection functions include over-voltage protection (latch mode), over-current protection (hiccup mode and auto-recovery), short-circuit protection (continuous and auto-recovery) and over-temperature protection (sensed by an internal thermistor; hiccup mode and auto-recovery).

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## MACHINE-LEARNING DESIGN SOFTWARE

STMicroelectronics has expanded its NanoEdge AI Studio machine-learning design software with support for smart sensors that contain the company's embedded Intelligent Sensor Processing Unit (ISPU). The latest release extends the tool's capability to enable on-device learning of AI models for anomaly detection inside intelligent sensors.

Designers can now use the software to distribute inference workloads across multiple devices including microcontrollers (MCUs) and sensors with ISPU in their systems, reducing application power consumption. Always-on sensors that contain the ISPU can perform event detection at low power, only waking the MCU when the sensor detects anomalies.

The tool provides a complete end-to-end automated workflow that should ease development of high-performing AI algorithms such as anomaly detection, classification and regression. Increasing convenience and efficiency, on-device learning also permits development without requiring an exhaustive dataset to manage pre-deployment training. In addition, support for incremental learning adds flexibility to complete partially trained models.

The libraries generated by the software can run on any STM32 MCU, from entry-level devices containing the Arm Cortex-M0 core to the high-performance MCUs containing the Cortex-M7 core. Support for ISPU-enhanced sensors includes the ISM3301SN 6-axis inertial measurement unit (IMU).

The latest version of the tool delivers support for embedded AI development that combines dedicated hardware, software, tools, sample code, support and training for developers.

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## INDUSTRIAL DC/DC CONVERTERS

TDK-Lambda has released the CCG series of industrial converters in a square case with a 1" x 1" footprint. The devices are designed for demanding applications such as industry, transportation and automation.

Due to the use of case shielding (also on the pins side), the products have high resistance to interference. The converters are available with single and double output, designed to control symmetrical voltage.

They come in two power variants, 15 and 30 W, with the input voltage spanning from 9 to 36 VDC and from 18 up to 76 VDC. Additional features include high efficiency (up to 91%), a wide range of input voltages and operating temperatures ranging from -40 to 110°C (selected models).

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## PANEL MOUNT CONNECTORS

binder has expanded its M12 range to include panel mount connectors with L-coding and dip solder contacts. The standardised products are soldered onto printed circuit boards and designed to support the trend towards decentralisation and serve to supply devices with 63 V and 16 A. The 823 series products are suitable for hand soldering, wave soldering and reflow soldering in printed circuit boards (PCBs) in automation applications that are typically subject to installation restrictions. There, they serve as electrochemical interfaces in the power supply of industrial devices up to 63 V (DC) and 16 A.

With the trend towards decentralised automation, miniaturisation is also advancing, with field devices such as sensors, actuators and controllers shrinking while their functionality increases and their power requirements grow. L-coded M12 connectors are a space-saving alternative to the 7/8" connection technology established in power supply.

The 823 series includes two-piece male and female panel mount connectors, each consisting of a mounting body and a socket housing, which are not permanently connected to each other. Compared to the use of single-piece components, assembly and disassembly of the PCB are simplified. The IP68-protected (when mated) connectors are suitable for both front and rear panel mounting.

The 823 series featured a buried and captive O-ring with metallic blocking and an O-ring between the socket housing and contact body that prevents sealing compound from leaking out when the user's housing is being sealed. A seal to the cable part is provided on the socket housing and the latter is guided, even in the case of thin-walled mounting flanges.

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## REMOTE ETHERNET I/O MODULES

Acromag's BusWorks NT Series remote I/O modules are now enhanced with EtherNet/IP support. EtherNet/IP is traditional Ethernet combined with an industrial application layer protocol targeted to industrial automation. Applications for the high-performance Ethernet I/O modules are remote monitoring and control, condition monitoring and predictive maintenance, building HVAC energy consumption, and more.

The models have dual RJ45 ports and a webserver with Modbus TCP/IP and EtherNet/IP communication to monitor or control the internal I/O channels. An integrated DIN rail bus allows connections of up to three NTX expansion I/O modules. Each I/O module adds up to 16 input or output signals allowing a mix of voltage, current, temperature, TTL and relay control signals networked on one IP address.

Ethernet I/O modules distribute 9–32 V DC power along the DIN rail bus to expansion modules. The space-saving design requires only 25 mm of DIN rail per module. Hazardous location approvals, high noise immunity and -40 to 70°C operation make the I/O suitable for use in harsh environments.

The NT2000 Series offers a broad variety of I/O signal processing options. Nine I/O configurations are available as either NTE Ethernet I/O or NTX expansion I/O models. Analog I/O models feature eight differential or 16 single-ended inputs for monitoring current or voltage signals. Discrete I/O models provide 16 tandem input/output channels with active high/low input and sinking/sourcing output. A six-channel mechanical relay output model is also available. For temperature monitoring, a thermocouple input model supports many sensor types and also millivolt ranges.

The Ethernet I/O modules are user-configurable for EtherNet/IP or Modbus/TCP, offering a convenient solution for engineers with multi-protocol control systems. The modules typically function as a network slave, but also offer Acromag's i2o peer-to-peer communication technology to transfer data between modules directly without a host or master in between. Multicast capability is included.

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# ENERGY-EFFICIENT SWITCHES WOULD ENABLE NEXT-GEN DATA CENTRES

With demand for data growing exponentially, there is increasing pressure for data centres to become more energy efficient. A team led by University of Washington (UW) scientists has now reported the design of a silicon-based non-volatile switch that would greatly reduce the energy needs of data centres, with their results published in the journal *Nature Nanotechnology*.

One way to reduce energy consumption in data centres is to use light to communicate information, with electrically controlled optical switches controlling the flow of light — and therefore information — between servers. These optical switches need to be multifunctional and energy efficient to support the continued expansion of data centres.

Silicon photonic switches are widely used in part because they can be made using well-established semiconductor fabrication techniques. Traditionally, these switches have been tuned through thermal effect — a process where heat is applied, often by passing a current through a metal or semiconductor, to change the optical properties of a material in the switch, thus changing the path of the light. However, not only is this process not energy efficient, but the changes it induces are not permanent. As soon as the current is removed, the material reverts to its previous state and the connection — and flow of information — is broken.

To address this, researchers from UW, Stanford University, Charles Stark Draper Laboratory, the University of Maryland and the Massachusetts Institute of Technology (MIT) created a 'set and forget' switch capable of maintaining the connection without any additional energy. They used a phase-change material that is non-volatile, meaning the material is transformed by briefly heating it, and it remains in that state until it receives another heat pulse, at which point it reverts back to its original state. This eliminates the need to constantly input energy to maintain the desired state.

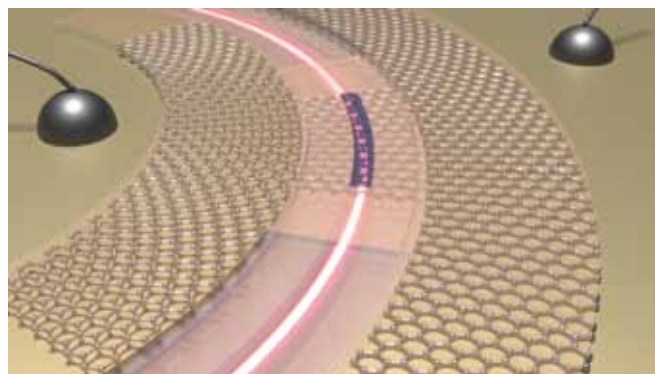


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Previously, researchers have used doped silicon to heat the phase-change material. Silicon alone doesn't conduct electricity, but when selectively doped with different elements like phosphorus or boron, silicon is able to both conduct electricity and propagate light without any excess absorption. When a current is pumped through the doped silicon, it can act like a heater to switch the state of the phase-change material on top of it. The catch is that this is also not a very energy-efficient process — the amount of energy needed to switch the phase-change material is similar to the amount of energy used by traditional thermo-optic switches. This is because the entire 220 nm-thick doped silicon layer has to be heated to transform only 10 nm of phase-change material. A lot of energy is wasted heating such a large volume of silicon to switch a much smaller volume of phase-change material.

"We realised we had to figure out how to reduce the volume that needed to be heated in order to boost the efficiency of the switches," said lead and co-corresponding author Zhuoran (Roger) Fang, a PhD student at UW.

One approach would be to make a thinner silicon film, but silicon doesn't propagate light well if it is thinner than 200 nm. So instead, they used an un-doped 220 nm silicon layer to propagate light and introduced a layer of graphene between the silicon and phase-change material to conduct electricity. Like metal, graphene is an excellent conductor of electricity, but unlike metal, it is atomically thin — it consists of just a single layer of carbon atoms arranged



*An artistic rendering of a silicon-based switch that manipulates light through the use of phase-change material (dark blue segment) and graphene heater (honeycomb lattice). Image courtesy of Zhuoran (Roger) Fang.*

in a two-dimensional honeycomb lattice. This design eliminates wasted energy by directing all heat generated by the graphene to go towards changing the phase-change material. In fact, the switching energy density of this set-up is only 8.7 attojoules (aJ)/nm<sup>3</sup>, a 70-fold reduction compared to doped silicon heaters, the current state of the art. This is also within one order of magnitude of the fundamental limit of switching energy density (1.2 aJ/nm<sup>3</sup>).

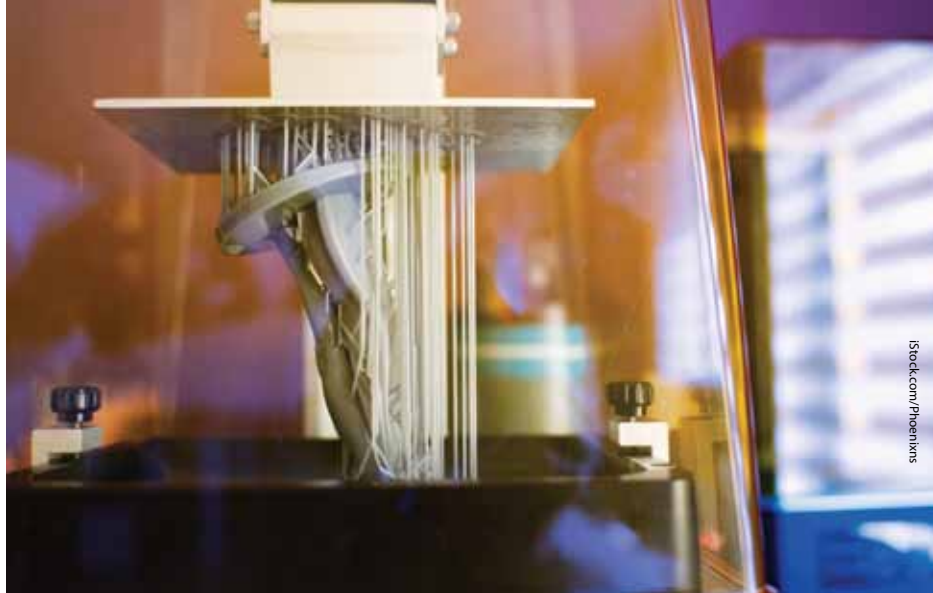
Even though using graphene to conduct electricity induces some optical losses, meaning some light is absorbed, graphene is so thin that not only are the losses minimal, but the phase-change material can still interact with the light propagating in the silicon layer. The team established that a graphene-based heater can reliably switch the state of the phase-change material more than 1000 cycles. This is a notable improvement over the doped silicon heaters, which have only been shown to have an endurance of around 500 cycles.

"Even 1000 is not enough," said corresponding author Arka Majumdar, an associate professor at UW. "Practically speaking, we need about a billion cycles endurance, which we are currently working on."

Now that they have demonstrated that light can be controlled using a phase-change material and graphene heater, the team plans to show that these switches can be used for optical routing of information through a network of devices, a key step towards establishing their use in data centres. They are also interested in applying this technology to silicon nitride for routing single photons for quantum computing.

"The ability to be able to tune the optical properties of a material with just an atomically thin heater is a game changer," Majumdar said. "The exceptional performance of our system in terms of energy efficiency and reliability is really unheard of and could help advance both information technology and quantum computing."

"Compared with what is currently being used in data centres to control photonic circuits, this technology would greatly reduce the energy needs of data centres, making them more sustainable and environmentally friendly."



# 3D PRINTING SOFTWARE

OPTIMISES PROPERTIES OF PLASTIC COMPONENTS

3D printers are a flexible way to produce components; now, researchers at Technische Universität Kaiserslautern (TUK) are using this technology to optimise the printing result for plastics.

**T**he researchers have developed software that can adjust parameters such as temperature and printing speed during printing. Temperature differences between the individual layers, which can occur during production, can negatively affect the properties of the plastic. The researchers are striving to overcome these problems with their software.

In 3D printing, a component is printed layer by layer along a specified path. This technique allows companies to produce their goods without much effort. However, various parameters such as temperature, printing speed, printing direction, layer height and geometry of the component can influence the printing result.

Researchers at the Institute for Composite Materials, led by Professor Dr-Ing Alois K. Schlarb at TUK, are working on 3D printing technologies to optimise the properties of the printed products. Miaozi Huang, a research assistant at the Institute, said that once a layer is printed, it cools down — when the next layer is applied on top of it, it has a higher temperature than the one underneath, and the layer underneath heats up again. “This contact temperature or local temperature between the printed part and the part to be printed influences the quality of the seam or the weld,” Huang said. This can affect the properties of the product — in the finished component, this is a weak spot, especially if the local temperature was not high enough when the seams were created.

To solve this issue, engineers from Kaiserslautern have developed a software which during printing ensures that various constants such as the temperature of the print nozzle or the printing speed can be flexibly changed, depending on the shape of the component and the plastic used.

“The aim of our technology is to optimally exploit the material properties. Similar processes do not yet exist,” said Alexander Schlicher, who is involved in implementing the concepts at the Institute. With the software, researchers can flexibly change the parameters for each individual movement of the printing process.

Researchers have tested the new procedure in the laboratory; two samples, one printed with conventional software, the other with the new technique, differ in their structure, as observed under the microscope. “There is also a difference in the properties, especially in the tensile strength across the direction of printing. This method allows the weak points in the printed products to be eliminated,” Huang said. For example, with this method it is possible to keep the contact temperatures between two strands in the optimal range for the respective moulded part geometry.

Such optimisations are important, for example, for increasing the service life of a component. The method used by the team from Kaiserslautern is designed to allow weak points in the plastic to be avoided.

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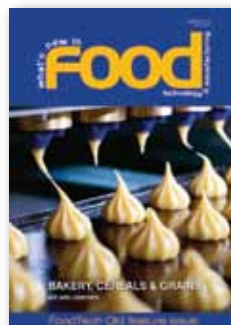
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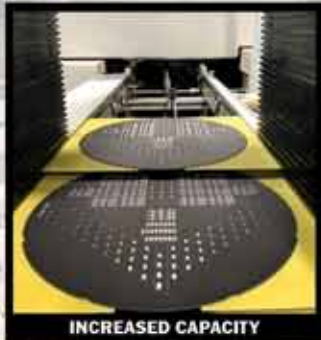
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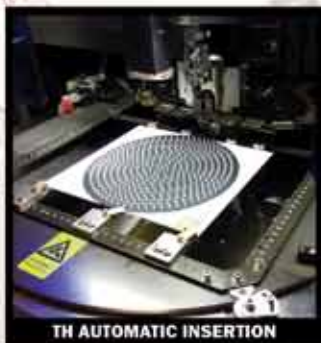
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