

INNOVATIVE TECH VOL 3

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Researchers develop simple, low-cost method to detect GPS trackers hidden in vehicles

by [NYU Tandon School of Engineering](#) edited by [Lisa Lock](#), reviewed by [Andrew Zinin](#)

tinySA spectrum analyzer installed in a vehicle, detecting presence of a hidden GPS tracker. Credit: Mo Satt

A team of researchers at NYU Tandon School of Engineering has developed a novel method to detect hidden GPS tracking devices in vehicles, offering new hope to victims of technology-enabled domestic abuse.

Overseen by NYU Tandon assistant professor Danny Y. Huang, the research addresses a growing problem: abusers secretly placing GPS trackers in their partners' or ex-partners' vehicles to monitor their movements. Traditionally, detecting these devices has been difficult and expensive, leaving many victims vulnerable to continued surveillance.

"The [tech industry](#) has created many tools that can be repurposed for cyberstalking, but has invested far less in technologies that protect privacy," said Huang. "We believe this innovation has the potential to significantly empower victims of domestic abuse by providing them with a readily accessible way to regain their privacy and safety."

Huang holds appointments in both the Electrical & Computer Engineering and Computer Science & Engineering departments. He is also a member of NYU Center for Cybersecurity, NYU Tandon's Center for Urban Science + Progress, and Center for Advanced Technology in Telecommunications.

"GPS tracking in domestic abuse situations is unfortunately common," said Moshe (Mo) Satt, a Ph.D. candidate working under Huang who is the lead author on the [research paper](#) that he will present at [USENIX VehicleSec '25](#), a major cybersecurity conference, held in Seattle in August 2025.

Satt is the Chief Information Security Officer (CISO) at the NYC Department of Sanitation and teaches several cybersecurity courses at the graduate and undergraduate levels as an NYU Tandon adjunct faculty member. "We wanted to develop a tool to combat it that is inexpensive and potentially very [user-friendly](#)."

The team's innovative approach relies on tinySA, a \$150 palm-sized spectrum analyzer typically used by amateur radio enthusiasts for testing antennas and debugging wireless equipment.

Using this commercially available device, the researchers developed a specialized algorithm that distinguishes weak tracker signals amid cellular transmission noise by monitoring LTE IoT uplink frequency bands.

This approach—the first to reliably detect concealed 4G LTE IoT cellular GPS vehicle trackers using affordable equipment—isolates signals sent from concealed devices to nearby cell towers, solving [technical challenges](#) in determining which frequencies to scan, interpreting results, and filtering false positives.

For victims, the setup can potentially be used as a mobile detection system while driving. If the user observes regular signal peaks on the tinySA during or after a drive, they can likely identify the presence of a cellular GPS tracker without requiring technical expertise. The setup could detect hidden GPS tracker signals within a range of up to three feet, according to the study.

The research addresses a significant public safety concern affecting approximately 13.5 million stalking victims annually in the United States, 80% experiencing technological stalking. In some cases, this surveillance has led to violent attacks.

The researchers are developing several pathways to real-world implementation, including smartphone integration, automated "black box" detection systems that could notify the user if a tracker is detected, partnerships with abuse support organizations, and a mobile detection service model similar to roadside assistance.

More information: You Can Drive But You Cannot Hide: Detection of Hidden Cellular GPS Vehicle Trackers. www.researchgate.net/publication/354111111-GPS_Vehicle_Trackers
Provided by [NYU Tandon School of Engineering](#)

JUNE 10, 2025

Baby talk is real: Adults speak differently to babies in at least 10 different languages

by International Research Center for Neurointelligence (WPI-IRCN), The University of Tokyo

edited by [Gaby Clark](#), reviewed by [Robert Egan](#)

There are many factors that contribute to infant language development, not least of which is baby talk—the modified speech mothers and other adults often use when speaking to infants.

Baby talk is more formally referred to as infant-directed speech (IDS) and often differs from adult-directed speech (ADS) in both pitch and vocabulary. One component of IDS that remains controversial, however, is the exaggeration or hyperarticulation of vowel sounds. Some experts contend that vowel exaggeration produces clearer speech sounds that are easier for infants to process, but studies conflict on whether or not vowel hyperarticulation is actually present in IDS.

A group of scientists from the International Research Center for Neurointelligence (WPI-IRCN) at The University of Tokyo, the University of Amsterdam, PSL University and Aarhus University analyzed the existing research on vowel hyperarticulation in IDS to determine whether or not this specific type of speech exaggeration occurs in IDS.

The team [published](#) their research on 2 June 2025 in the journal *Psychological Bulletin*.

Before the meta-analysis, one group of studies suggested that adults particularly exaggerate the vowels "a," "i" and "u" when speaking to infants, making vowels easier to perceive and potentially facilitating word learning. In contrast, other studies had not detected the consistent exaggeration of vowels in IDS, suggesting that [baby talk](#) may instead be a by-product of smiling or some other positive effect.

"[W]e decided to conduct [a] meta-analysis on all studies done on this topic to understand if vowel exaggeration is a feature of speech directed to babies, and if so, which factors lead to it and to the observed differences in existing research," said Irena Lovčević, postdoctoral researcher at the International Research Center for Neurointelligence (WPI-IRCN) at The University of Tokyo and first author of the research paper.

The x-axis represents the average value of each vowel on the first formant (F1, relates to how high or low the tongue is during the vowel production), the y-axis the same on the second formant (F2, relates to how forward or backward the tongue is in the mouth during vowel production). The larger vowel space triangle in IDS represents the exaggeration of vowels. Credit: Irena Lovčević, International Research Center for Neurointelligence (WPI-IRCN), The University of Tokyo

The researchers performed meta-analyses on 20 IDS vowel hyperarticulation studies that used similar methodology and 35 studies that used any research method. Meta-analysis techniques combine the results of more than one similar research study to improve the statistical power of the results.

"Our [meta-analysis](#) confirms that mothers exaggerate vowels in speech directed to babies in at least 10 languages. However, our results also point to the diversity of methods used in the existing research. Hence, we want the readers, especially speech acquisition researchers, to carefully consider and document the methodological decisions in their

research and avoid the generalization from one language to another or one method to another," said Lovčević.

Overall, the team observed that IDS vowel hyperarticulation studies have lower sample sizes than would be expected for well-powered statistical analysis and recommended that study size be increased. The researchers also noted that differences in hyperarticulation across languages were difficult to detect due to smaller sample sizes for less represented languages and that more cross-linguistic and cross-cultural research is needed to be able to generalize language acquisition research findings.

Additionally, the size of vowel hyperarticulation could also be influenced by the measurement scale (e.g., Hertz, Mel) used by the research team, illustrating how intimately methodology can influence experimental results and the ability to compare those results across studies.

After establishing the presence of [vowel](#) hyperarticulation in IDS, the research team has their sights set on learning more about other aspects of infant [language development](#).

"The next step is further examination of different factors influencing language development in babies, with special focus on modifiable factors from babies' immediate environment, such as the amount of speech that babies are exposed to and the qualities of vocal caregiver-baby interactions. How babies learn to speak without so much effort is still a big puzzle, so my goal is to contribute to solving ... this puzzle," said Lovčević.

More information: Irena Lovčević et al, Acoustic exaggeration of vowels in infant-directed speech: A multimethod meta-analytic review., *Psychological Bulletin* (2025). DOI: [10.1037/bul0000479](https://doi.org/10.1037/bul0000479)

Journal information: [Psychological Bulletin](#)

Provided by International Research Center for Neurointelligence (WPI-IRCN), The University of Tokyo

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New security flaw allows eavesdropping via laptop and smart speaker microphones

by [University of Florida](#) edited by [Gaby Clark](#), reviewed by [Andrew Zinin](#)

The ghostly woman's voice pipes through the speakers, covered in radio static but her message intact from beyond—"The birch canoe slid on the smooth planks."

A secret message from the other side? A spectral insight?

No, something much spookier: Voice recordings captured, secretly, from the [radio frequencies](#) emitted by ubiquitous, cheap microphones in laptops and [smart speakers](#). These unintentional signals pass, ghost-like, through walls, only to be captured by simple radio components and translated back to static-filled—but easily intelligible—speech.

For the first time, researchers at the University of Florida and the University of Electro-Communications in Japan [have revealed a security and privacy risk](#) inherent in the design of these microphones, which emit radio signals as a kind of interference when processing audio data.

The attack could open up people to industry espionage or even government spying, all without any tampering of their devices. But the [security researchers](#) have also identified multiple ways to address the [design flaw](#) and shared their work with manufacturers for potential fixes going forward.

A demonstration of the microphone attack through a 15 cm wall. Credit: Sara Rampazzi "With an FM radio receiver and a copper antenna, you can eavesdrop on these microphones. That's how easy this can be," said Sara Rampazzi, Ph.D., a professor of computer and [information science](#) and engineering at UF and co-author of the new study. "It costs maybe a hundred dollars, or even less."

They used standardized recordings of random sentences to test the attack, giving the eerie impression of a ghostly woman talking about canoes or imploring you to "Glue the sheet to the dark blue background." Each nonsense sentence instantly recognizable despite, in some cases, passing through concrete walls 10 inches thick.

The vulnerability is based on the design of digital MEMS microphones, which are widespread in devices like laptops and smart speakers. When processing [audio data](#), they release weak radio signals that contain information about everything the microphone is picking up. Like other radio signals, these transmissions can pass through walls to be captured by simple antennas.

Even when someone is not intentionally using their microphone, it can be picking up and transmitting these signals. Common browser apps like Spotify, YouTube, Amazon Music and Google Drive enable the microphone sufficiently to leak out radio signals of anything said in the room.

The researchers tested a range of laptops, the Google Home smart speaker, and headsets used for video conferencing. Eavesdropping worked best on the laptops, in part because their microphones were attached to long wires that served as antennas amplifying the signal.

Rampazzi's lab also used machine learning-driven programs from companies like OpenAI and Microsoft to clean up the noisy [radio signals](#) and transcribe them to text, which demonstrated how easy it would be to then search eavesdropped conversations for keywords.

However, a series of fairly simple changes could greatly decrease the effectiveness of the attack. Changing where microphones are placed in laptops could avoid long cables, which amplify the radio leakage. Slight tweaks to the standard audio processing protocols would reduce the intelligibility of the signals.

The researchers have shared these ideas with laptop and smart speaker manufacturers, but it's not clear if the companies will make the upgrades in future devices.

More information: Sound of Interference: Electromagnetic Eavesdropping Attack on Digital Microphones Using Pulse Density Modulation, [www.usenix.org/conference/usenix ...](http://www.usenix.org/conference/usenix15/presentation/onishi)
/presentation/onishi
Provided by [University of Florida](#)

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From 2D to 3D: A high-resolution photothermal tomographic technique for subsurface inspection

by International Journal of Extreme Manufacturing

edited by [Lisa Lock](#), reviewed by [Robert Egan](#)

By employing either flash pulse excitation or linear laser scanning, thermophotonic energy penetrates the material's interior and evolves with time. The acquired relaxation signals are then processed through truncated correlation using frequency-incremented units. This approach enables depth-encoded signals to produce tomograms with high axial resolution, leveraging the quantitative relationship between heat diffusion length and frequency. Credit: *International Journal of Extreme Manufacturing* (2025). DOI: 10.1088/2631-7990/ada837

Infrared thermography (IRT) is an effective inspection technique in manufacturing due to its contactless and noninvasive imaging mode. However, existing IRT techniques can only produce 2D results of subsurface structures. The limitations of finite 2D imaging modes significantly impede the inspection and evaluation of material aging and failure.

The work, [published](#) in the *International Journal of Extreme Manufacturing*, offers a novel photothermal coherence [tomography](#) technique—frequency-multiplexed photothermal correlation tomography (FM-PCT)—to bring IRT from limited 2D imaging to 3D tomography.

The research collaboration involving Laval University, Harbin Institute of Technology, University of Toronto, University of L' Aquila, and University of Rome introduced the high-resolution photothermal tomographic technique that can detect subsurface 3D structures of materials with precision comparable to X-ray micro-computed tomography.

"Traditional diffusion-wave techniques are limited by the physics of parabolic diffusion and can only produce depth-integrated planar images," said Andreas Mandelis, corresponding author on the paper and Professor at the University of Toronto. "We need to design a novel imaging modality that can preserve the energy within the instantaneous frequency bandwidth with minimal or no loss, despite the diffusive nature of the signal."

Infrared thermography is based on the photothermal effect in materials, i.e., an abnormal thermal distribution when a [heat wave](#) encounters a discontinuous interface. Multiple algorithms have been developed to quantitatively estimate defect depths or sizes by assuming regular defect shapes and constant depths, making them less effective for real-world applications.

In 1990, Vavilov and Maldague proposed the concept of dynamic thermal tomography (DTT), but its development has been limited by a low signal-to-noise ratio. Later in 2014, Kaipilavil and Mandelis introduced truncated-correlation photothermal coherence tomography (TC-PCT), which requires extremely high computational and data storage resources.

In FM-PCT, a single pulse or line-scan laser is applied to the specimen. According to Fourier transform theory, single pulse excitation can be treated as a combination of multifrequency signals. This provides a new perspective on the truncated-correlation process.

The FM-PCT modality decomposes the pulse excitation into multiple sinusoidal signals and performs matched filtering with captured thermal signals. As is well known, modulation frequency is directly related to the penetration depth. Therefore, by controlling the frequency of matched filtering, FM-PCT can create [tomographic images](#) at various subsurface depths.

"FM-PCT bridges the gap in microscale tomography caused by the limitations of general X-ray CT and ultrasound imaging, especially for thin specimens," said co-author Hai Zhang, Full Professor at Harbin Institute of Technology and Adjunct Professor at Laval University. "This technique will significantly improve the inspection capability and help detect early-stage defects in industrial manufacturing and lesions in biomedical fields."

The researchers are continuing to refine the approach with the aim of applying it to real-world industrial inspection and material evaluation. They also plan to extend this noninvasive method to biomedical imaging and to develop advanced super-resolution imaging algorithms that can enhance spatial and axial resolution for observing both in vivo and ex vivo tissues.

More information: Pengfei Zhu et al, Frequency multiplexed photothermal correlation tomography for non-destructive evaluation of manufactured materials, *International Journal of Extreme Manufacturing* (2025). DOI: [10.1088/2631-7990/ada837](https://doi.org/10.1088/2631-7990/ada837)
Provided by International Journal of Extreme Manufacturing

JUNE 11, 2025

How was the wheel invented? Computer simulations reveal the unlikely birth of a world-changing technology

by Kai James, [The Conversation](#) edited by [Lisa Lock](#), reviewed by [Andrew Zinin](#)

Imagine you're a copper miner in southeastern Europe in the year 3900 B.C.E. Day after day you haul copper ore through the mine's sweltering tunnels.

You've resigned yourself to the grueling monotony of mining life. Then one afternoon, you witness a fellow worker doing something remarkable.

With an odd-looking contraption, he casually transports the equivalent of three times his body weight on a single trip. As he returns to the mine to fetch another load, it suddenly dawns on you that your chosen profession is about to get far less taxing and much more lucrative.

What you don't realize: You're witnessing something that will change the course of history—not just for your tiny mining community, but for all of humanity.

Despite the [wheel's](#) immeasurable impact, no one is certain as to who invented it, or when and where it was first conceived. The hypothetical scenario described above is [based on a 2015 theory](#) that miners in the Carpathian Mountains—now Hungary—first invented the wheel nearly 6,000 years ago as a means to transport copper ore.

The theory is supported by the discovery of [more than 150 miniaturized wagons](#) by archaeologists working in the region. These pint-sized, four-wheeled models were made from clay, and their outer surfaces were engraved with a wickerwork pattern reminiscent of the basketry used by mining communities at the time. Carbon dating later revealed that these wagons are the earliest known depictions of wheeled transport to date.

This theory also raises a question of particular interest to me, [an aerospace engineer](#) who studies the [science of engineering design](#). How did an obscure, scientifically naive mining society discover the wheel, when highly advanced civilizations, [such as the ancient Egyptians](#), did not?

A controversial idea

It has long been assumed that [wheels evolved from simple wooden rollers](#). But until recently no one could explain how or why this transformation took place. What's more, beginning in the 1960s, some researchers started to [express strong doubts](#) about the roller-to-wheel theory.

After all, for rollers to be useful, they require flat, firm terrain and a path free of inclines and sharp curves. Furthermore, once the cart passes them, used rollers need to be continually brought around to the front of the line to keep the cargo moving. For all these reasons, the ancient world [used rollers sparingly](#). According to the skeptics, rollers were too rare and too impractical to have been the starting point for the evolution of the wheel.

But a mine—with its enclosed, human-made passageways—would have provided favorable conditions for rollers. This factor, among others, compelled my team to revisit the roller hypothesis.

A turning point

The transition from rollers to wheels requires two key innovations. The first is a modification of the cart that carries the cargo. The cart's base must be outfitted with semicircular sockets, which hold the rollers in place. This way, as the operator pulls the cart, the rollers are pulled along with it.

This innovation may have been motivated by the confined nature of the mine environment, where having to periodically carry used rollers back around to the front of the cart would have been especially onerous.

The discovery of socketed rollers represented a turning point in the evolution of the wheel and paved the way for the second and most important innovation. This next step involved a change to the rollers themselves. To understand how and why this change occurred, we turned to physics and computer-aided engineering.

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Simulating the wheel's evolution

To begin [our investigation](#), we created a computer program designed to simulate the evolution from a roller to a wheel. Our hypothesis was that this transformation was driven by a phenomenon called "[mechanical advantage](#)." This same principle allows pliers to amplify a user's grip strength by providing added leverage. Similarly, if we could modify the shape of the roller to generate a mechanical advantage, this would amplify the user's pushing force, making it easier to advance the cart.

Our algorithm worked by modeling hundreds of potential roller shapes and evaluating how each one performed, both in terms of mechanical advantage and structural strength. The latter was used to determine whether a given roller would break under the weight of the cargo. As predicted, the algorithm ultimately converged upon the familiar wheel-and-axle shape, which it determined to be optimal.

During the execution of the algorithm, each new design performed slightly better than its predecessor. We believe a similar evolutionary process played out with the miners 6,000 years ago.

It is unclear what initially prompted the miners to explore alternative roller shapes. One possibility is that friction at the roller-socket interface caused the surrounding wood to wear away, leading to a slight narrowing of the roller at the point of contact. Another theory is that the miners began thinning out the rollers so that their carts could pass over small obstructions on the ground.

Either way, thanks to mechanical advantage, this narrowing of the axle region made the carts easier to push. As time passed, better-performing designs were repeatedly favored over the others, and new rollers were crafted to mimic these top performers.

Consequently, the rollers became more and more narrow, until all that remained was a slender bar capped on both ends by large disks. This rudimentary structure marks the birth of what we now refer to as "the wheel."

According to our theory, there was no precise moment at which the wheel was invented. Rather, just like the evolution of species, the wheel emerged gradually from an accumulation of small improvements.

This is just one of the many chapters in the wheel's long and ongoing evolution. More than 5,000 years after the contributions of the Carpathian miners, a Parisian bicycle mechanic [invented radial ball bearings](#), which once again revolutionized wheeled transportation.

Ironically, [ball bearings](#) are conceptually identical to rollers, the wheel's evolutionary precursor. Ball bearings [form a ring around the axle](#), creating a rolling interface between the axle and the wheel hub, thereby circumventing friction. With this innovation, the evolution of the wheel came full circle.

This example also shows how the wheel's evolution, much like its iconic shape, traces a circuitous path—one with no clear beginning, no end, and countless quiet revolutions along the way.

Provided by [The Conversation](#)



Engineers design ultra-light armor stronger than steel

Engineers and material scientists have made a groundbreaking advancement with the development of ultra-light armor that is stronger than steel. This innovative material promises to revolutionize industries, from military applications to consumer electronics, by providing enhanced protection without the added weight.



The Inspiration Behind the Innovation

©Image by Freepik

The quest for creating materials that are both lightweight and incredibly strong often draws inspiration from nature. Biomimicry, a design approach that seeks to emulate natural structures, has been pivotal in the development of this new ultra-light armor. By studying the intricate designs of natural materials like spider silk and the exoskeletons of beetles, scientists have uncovered patterns and structures that offer exceptional strength while maintaining minimal weight. These biological materials have evolved over millions of years to optimize for both durability and efficiency, providing a blueprint for modern engineering challenges.

Historically, the pursuit of materials that combine lightness with strength has faced numerous hurdles. Previous attempts often resulted in compromises, where enhancing one property would detrimentally affect another. The development of composite materials, such as carbon fiber reinforced polymers, marked significant progress, but limitations in scalability and cost hindered widespread adoption. The new ultra-light armor addresses these challenges by utilizing advanced materials science and cutting-edge

fabrication techniques to achieve a balance previously considered unattainable.



The Science of Ultra-Light Armor

©Image by Freepik

At the heart of this ultra-light armor's strength lies its unique molecular composition and structure. The material is engineered at the nanoscale, where precise control over atomic arrangements allows for extraordinary mechanical properties. By aligning molecules in a highly ordered fashion, scientists have created a structure that mimics the load-bearing efficiency found in nature. This meticulous arrangement not only provides strength but also enables the material to remain incredibly lightweight.

Fabrication of this revolutionary armor involves state-of-the-art techniques that allow for both precision and scalability. Advanced manufacturing processes, such as 3D printing and molecular self-assembly, enable the creation of complex structures that would be impossible to achieve through traditional manufacturing methods. These techniques also facilitate the mass production of the material, making it viable for large-scale applications. The

combination of innovative design and efficient fabrication processes ensures that the ultra-light armor can be produced at a cost and scale competitive with traditional materials.



Applications and Implications

©Image by Freepik

The potential applications of this ultra-light armor are vast and varied, with significant implications for both military and civilian sectors. In the realm of [military and defense](#), the material offers a game-changing advantage. Personal protective gear, such as helmets and body armor, can be made lighter without sacrificing protection, increasing mobility and comfort for soldiers. Additionally, vehicle armor can be significantly reduced in weight, enhancing fuel efficiency and agility without compromising safety.

Beyond military applications, the ultra-light armor holds promise for consumer electronics. Devices like smartphones and laptops can benefit from increased durability and reduced weight, enhancing user experience and extending product lifespan. For instance, the [Samsung Galaxy Z Fold7](#) could incorporate this material to create a device that is both more robust and lighter than its

predecessors. The potential to revolutionize product design and performance in the electronics industry is significant, offering consumers products that are both more sustainable and user-friendly.



Comparative Analysis with Traditional Materials

©Image by Freepik

When comparing the new ultra-light armor with traditional materials like steel, the advantages become clear. The material's [strength-to-weight ratio](#) far surpasses that of steel, offering equivalent or superior performance at a fraction of the weight. This characteristic not only enhances the material's versatility but also opens up new possibilities for design and application across various industries. Furthermore, the reduced weight can lead to cost savings in transportation and logistics, as lighter products require less energy to move.

In terms of durability and longevity, the ultra-light armor demonstrates remarkable resistance to environmental stressors. Unlike steel, which can corrode over time when exposed to moisture and oxygen, this new material maintains its integrity under harsh conditions. This resilience ensures a longer lifespan and reduced maintenance costs, making it an attractive alternative for

industries reliant on durable materials. The ability to withstand a wide range of conditions without degrading underscores the material's potential as a game-changer in fields where reliability is paramount.



Future Prospects and Challenges

©Image by Freepik

While the promise of ultra-light armor is undeniable, scaling production to meet global demand presents both economic and logistical challenges. The transition from laboratory-scale manufacturing to mass production requires significant investment in infrastructure and technology. Companies must navigate these hurdles to bring the material to market at a competitive price point. Addressing these challenges is crucial to ensuring the material's widespread adoption and realizing its full potential.

Beyond the technical and economic aspects, ethical and environmental considerations must also be taken into account. The implications of integrating this material into everyday products extend to societal and environmental dimensions. For example, the reduced weight of consumer electronics could lead to decreased carbon emissions during transportation

and use. However, the production processes must be carefully managed to minimize environmental impact. Considering these factors is essential for achieving a sustainable balance between innovation and responsibility.

In conclusion, the development of ultra-light armor stronger than steel represents a significant leap forward in materials science. By harnessing the power of biomimicry and advanced manufacturing techniques, engineers have created a material with the potential to transform industries and enhance our everyday lives. As we look to the future, the successful implementation and adoption of this technology will depend on overcoming production challenges and addressing ethical concerns, paving the way for a new era of innovation and sustainability.

Affordable 17 beam Cold Laser Therapy

Low-level laser therapy (LLLT) is the use of a low-powered laser that emits specific wavelengths of light in the visible red and/or far infrared range for therapeutic purposes. This involves the application of low power light to areas of the body in order to stimulate healing. It is also known as cold laser, soft laser or low intensity laser.

The reason why the technique is termed LOW-level is that the optimum levels of energy density delivered are low when compared to other forms of laser therapy as practiced for ablation, cutting, and thermally coagulating tissue. more

Controlled research into the effects of low level laser is currently being conducted in various European centres and in Japan.

Knee injuries and conditions treated by low-level laser include tendonitis, bursitis, meniscus tears, runners knee/chondromalacia patella, knee joint effusion, iliotibial band syndrome, osgood schlatters disease, osteoarthritis and rheumatoid arthritis, and much more

Indications:

Knee, Feet, Ankle, Shoulder, Back, Elbow, Hand, Joint & Muscle Arthritis
Tennis Elbow
Tailbone Inflammation
Athletics System Injuries
Soft Tissue Injuries
Sports Injuries & Sprain
Wound & Ulcer Acupuncture
Diminish Inflammation

How does laser work for inflammatory therapy?

-laser therapy improves Ca^{++} uptake in the mitochondria.(mitochondria in the red cells)

-ATP production and synthesis are significantly enhanced, contributing to cellular repair, reproduction and functional ability.

- Laser-mediated vasodilation enhances the transport of nutrients and oxygen to the damaged cells and facilitates repair and removal of cellular debris.

Low-level laser therapy (LLLT) is the use of a low-powered laser that emits specific wavelengths of light in the visible red and/or far infrared range for therapeutic purposes. This involves the application of low power light to areas of the body in order to stimulate healing. It is also known as cold laser, soft laser or low intensity laser.

-Enhanced lymphocyte response.

-Increased angiogenesis.Laser-induced increases in NO and the growth factors.

-Decreased C-reactive protein and neopterin levels. Laser therapy has been shown to lower the serum levels of these inflammation markers, particularly in rheumatoid arthritis patients. Decreased marker levels are indicative that the combined effects of all LLLT-induced anti-inflammatory actions are effectively reducing the inflammatory process.

lasers are not magical; it is the light that they produce that yields the biological effect

Low-level laser therapy may sometimes provide an effective alternative to surgery or medications—without accompanying side effects. It can help regenerate tissue, reduce inflammation, decrease

pain, and increase immunity, and research has shown its efficacy in treating many conditions.

How does laser therapy Heal wounds?

- Enhanced leukocyte infiltration. .
- Increased macrophage activity. LLLT accelerates macrophage activity in phagocytosis, growth factor secretion and stimulation of collagen synthesis.
- Increased neovascularization. Endothelial cell regeneration is accelerated.
- Increased fibroblast proliferation. LLLT stimulation increases collagen production.

"Low-level lasers emit light in the red and infrared range. Red and infrared light penetrate deeply into human tissue, where the light energy is absorbed and turned into biochemical energy. By increasing cellular energy in the treated area, low-level laser therapy is believed to speed healing and reduce inflammation and pain. There are no reported side effects."

- Early epithelialization. Laser-stimulated acceleration of epithelial cell regeneration speeds up wound healing, minimizes scarring, and reduces infection opportunities.
- Enhanced cell proliferation and differentiation. Laser-induced increases in NO, ATP and other compounds that stimulate higher activity in cell proliferation and differentiation into mature cells.
- Greater healed wound tensile strength. By increasing the amount of collagen production/synthesis and by increasing the intra and inter-molecular hydrogen bonding in the collagen molecules, laser therapy contributes to improved tensile strength.

In 2007, low-level light therapy (LLLT) was approved by the FDA as a treatment for hair loss

How to Use?

1st week: Start with the secondary power on pulse mode

2nd week: Adjust to maximum power on pulse mode

3rd week: You can start using it on maximum power on constant mode

Duration: Please use 2-3 times a day for about 10-20 minutes. You can set 15x time settings, 15-60 minutes

Distance from Skin: Keep a little distance of 1-2 inches away from the skin

History of laser therapy for pain?

Infrared light penetrates to the inner layers of the skin at about 2 to 7 centimeters deep. Hence, it reaches the muscles, nerves and even the bones. Many studies have shown that a frequency of infrared light, with wavelengths from 700 to 1,000 nanometers, is best used for healing inflammatory conditions.

The use of electricity for healing purposes began in 2,750 BC when people used electric eels to give electric shocks. Electricity and magnetism were used in people with just little success. However, in 1975, transcutaneous electrical stimulation (TENS) was developed to treat chronic pain. It was not until recently that infrared therapy was developed to improve wound healing, reduce the pain caused by arthritis, boost endorphin levels, and bioactivate neuromodulators.

1. Inside is lithium battery 1800mAh, it can be rechargeable .

2. 808nm and 650nm combine together
3. Working mode : Pulse and continuously can be selection
4. Treatment time can be adjusted
5. Power intensity can be adjusted also .
6. 17 laser beam in one device
7. Type C and USB charge port.
8. 5200mAh lithium battery powered .
9. Easy to use.

Affordable Cold Laser Therapy

Package Includes:

- 1x low-level cold laser device
- 1x Power adapter
- 1x Zipper carry case
- 1x Manual
- 1x Warranty card
- 1x safety glasses with case

Recomended Retail \$US250.00

JUNE 12, 2025

Training robots without robots: Smart glasses capture first-person task demos

by [Ingrid Fadelli](#), Phys.org edited by [Lisa Lock](#), reviewed by [Robert Egan](#)

Human demonstrations are done with only black ovens (top). The policy transfers zero-shot to the robot with the same oven (middle) and also generalizes to a new oven instance (bottom). The points are color-coded to represent the correspondence. Credit: Liu et al. Over the past few decades, robots have gradually started making their way into various real-world settings, including some malls, airports and hospitals, as well as a few offices and households.

For robots to be deployed on a larger scale, serving as reliable everyday assistants, they should be able to complete a wide range of common manual tasks and chores, such as cleaning, washing the dishes, cooking and doing the laundry.

Training machine learning algorithms that allow robots to successfully complete these tasks can be challenging, as it often requires extensive annotated data and/or demonstration videos showing humans the tasks. Devising more effective methods to collect data to train robotics algorithms could thus be highly advantageous, as it could help to further broaden the capabilities of robots.

Researchers at New York University and UC Berkeley recently introduced EgoZero, a new system to collect ego-centric demonstrations of humans completing specific manual tasks. This system, introduced in a [paper](#) posted to the *arXiv* preprint server, relies on the use of Project Aria glasses, the [smart glasses](#) for augmented reality (AR) developed by Meta.

"We believe that general-purpose robotics is bottlenecked by a lack of internet-scale data, and that the best way to address this problem would be to collect and learn from first-person human data," Lerrel Pinto, senior author of the paper, told Tech Xplore.

"The primary objectives of this project were to develop a way to collect accurate action-labeled data for robot training, optimize for the ergonomics of the data collection wearables needed, and transfer human behaviors into robot policies with zero robot data."

EgoZero, the new system developed by Pinto and his colleagues, relies on Project Aria smart glasses to easily collect video demonstrations of humans completing tasks while performing robot-executable actions, captured from the point of view of the person wearing the glasses.

These demonstrations can in turn be used to train robotics algorithms on new manipulation policies, which could in turn allow robots to successfully complete various manual tasks.

"Unlike prior works that require multiple calibrated cameras, wrist wearables, or motion capture gloves, EgoZero is unique in that it is able to extract these 3D representations with only smart glasses (Project Aria smart glasses)," explained Ademi Adeniji, student and co-lead author of the paper.

"As a result, robots can learn a new task from as little as 20 minutes of human demonstrations, with no teleoperation."

Architecture diagram. EgoZero trains policies in a unified state-action space defined as egocentric 3D points. Unlike previous methods, EgoZero localizes object points via triangulation over the camera trajectory, and computes action points via Aria MPS hand pose and a hand estimation model. These points supervise a closed-loop Transformer policy, which is rolled out on unprojected points from an iPhone during inference. Credit: Liu et al.

To evaluate their proposed system, the researchers used it to collect video demonstrations of simple actions that are commonly completed in a household environment (e.g., opening an oven door) and then used these demonstrations to train a machine learning algorithm.

The machine learning algorithm was then deployed on Franka Panda, a [robotic arm](#) with a gripper attached at its end. Notably, they found that the robotic arm successfully completed most of the tasks they tested it on, even if the [algorithm](#) planning its movements underwent minimal training.

"EgoZero's biggest contribution is that it can transfer human behaviors into robot policies with zero robot data, with just a pair of smart glasses," said Pinto.

"It extends past work (Point Policy) by showing that 3D representations enable efficient robot learning from humans, but completely in-the-wild. We hope this serves as a foundation for future exploration of representations and algorithms to enable human-to-robot learning at scale."

The code for the data collection system introduced by Pinto and his colleagues was [published on GitHub](#) and can be easily accessed by other research teams.

In the future, it could be used to rapidly collect datasets to train robotics algorithms, which could contribute to the further development of robots, ultimately facilitating their deployment in a greater number of households and offices worldwide.

"We now hope to explore the tradeoffs between 2D and 3D representations at a larger scale," added Vincent Liu, student and co-lead author of the paper.

"EgoZero and past work (Point Policy, P3PO) have only explored single-task 3D policies, so it would be interesting to extend this framework of learning from 3D points in the form of a fine-tuned LLM/VLM, similar to how modern VLA models are trained."

Written for you by our author [Ingrid Fadelli](#), edited by [Lisa Lock](#), and fact-checked and reviewed by [Robert Egan](#)—this article is the result of careful human work. We rely on readers like you to keep independent science journalism alive. If this reporting matters to

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More information: Vincent Liu et al, EgoZero: Robot Learning from Smart Glasses, *arXiv* (2025). DOI: [10.48550/arxiv.2505.20290](https://doi.org/10.48550/arxiv.2505.20290)

Journal information: [arXiv](#)

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JUNE 12, 2025

Kirigami-inspired design enables uniform 200% stretch in multi-pixel display arrays

by [Pohang University of Science and Technology](#) edited by [Gaby Clark](#), reviewed by [Robert Egan](#)

A research team at POSTECH (Pohang University of Science and Technology) has successfully developed the world's first technology that enables uniform and even stretching across multiple pixels in a stretchable display. This breakthrough overcomes a critical challenge in the field and has been selected as a Back Cover [article](#) in the journal *Advanced Functional Materials*. The team was led by Professor Su Seok Choi from the Department of Electrical Engineering and Ph.D. candidate Jun Hyuk Shin.

Display technology is currently undergoing a global transformation, with intense competition surrounding shape-deformable devices. Innovations such as foldable, bendable, and slidable displays have already emerged, and now attention is rapidly shifting—especially in South Korea—toward stretchable displays, which go beyond simple curvature and can physically expand.

Stretchable displays are expected to evolve into next-generation devices that integrate with sensors to form electronic skin-like systems, capable of mimicking the flexibility and softness of human skin. For this direction, ideally fully and intrinsically stretchable technology with uniform control is highly desired.

The limitations of existing stretchable display technologies

Most existing stretchable technologies rely on an extrinsic approach, using rigid electronic components connected by wavy or serpentine interconnects. While this allows some degree of mechanical deformation, it comes with significant trade-offs—limited stretching range, reduced [pixel density](#), and degradation in display uniformity and image quality under strain.

Comparison of strain distribution of 7 by 7 arrayed CLCEs in pristine and cut pattern & rigid plates design by FEM. Credit: *Advanced Functional Materials* (2024). DOI: 10.1002/adfm.202422772

In contrast, the intrinsic approach, which uses materials like silicone or rubber that are inherently stretchable, is considered the ideal path forward. However, such systems have struggled with non-uniform strain distribution, particularly in multi-pixel arrays. As each pixel experiences a different degree of deformation depending on its location, this leads to inconsistencies in color, brightness, and signal transmission.

This issue is fundamentally rooted in geometry and physics: when a stretchable material is pulled, areas farther from the point of tension receive less strain—similar to how the center of a rubber band or melted cheese stretches more than its edges. So far, achieving uniform stretching across all pixels in an intrinsically stretchable system has remained a critical and unsolved problem.

To overcome this challenge, the POSTECH team drew inspiration from kirigami, the traditional Japanese art of paper cutting. By introducing finely patterned incisions on the surface of the stretchable substrate, they were able to evenly distribute mechanical stress during stretching.

As a result, they successfully achieved uniform stretching up to 200% (twice the original length) in all areas of a 7×7 pixel array. Additionally, the researchers implemented a "strain stopper"—a [rigid structure](#) embedded in specific areas of the material—to suppress undesired deformation in certain directions. This marks the first successful demonstration of fully controlled, uniform, multi-directional stretching across a multi-pixel stretchable display system.

The team further integrated a chiral liquid crystal elastomer (CLCE)—an intrinsically stretchable and also mechanochromic material that changes color in response to [mechanical stress](#). By combining CLCEs with their kirigami-structured platform, they developed a stretchable display capable of revealing hidden patterns only when stretched, a feature with strong potential in encryption and anti-counterfeiting applications.

The CLCEs also exhibit circular polarization selectivity, enabling high-level optical security. When paired with a polarization filter, the display shows different colors or patterns depending on the [viewing angle](#), allowing for dynamic, angle-dependent, secure information display. This technology could enable encrypted displays that are invisible to the [naked eye](#) but detectable using special optical equipment.

Optimization of unit CLCE-shape design and initial substrate for optimal strain-induced, color-band shift. A) Color shift effect of shape variation of CLCEs ($\epsilon = 3$). Color variation of effect on structure of C) initial substrate length ($\epsilon = 0.5$), and D) initial substrate width ($\epsilon = 1$). Credit: *Advanced Functional Materials* (2024). DOI: 10.1002/adfm.202422772

Toward real-world applications

This research not only solves a long-standing mechanical issue in stretchable displays but also opens doors to new applications in wearable electronics, flexible displays, and data security. By demonstrating a working system that combines uniform mechanical

performance and advanced optical functionality, the team provides a foundation for future commercial stretchable devices.

Professor Choi commented, "By addressing the challenge of non-uniform deformation, this work greatly enhances the practical potential of intrinsically stretchable materials such as silicone, rubber, and artificial skin. It will also contribute significantly to the development of stretchable optical components and secure display technologies."

More information: Jun Hyuk Shin et al, Optimized and Uniform Strain Control in Intrinsic Stretchable Mechanochromic Materials with Color- and Polarization-Separating Encryption Using Kirigami Cuts and Rigid Strain-Stoppers, *Advanced Functional Materials* (2024). DOI: [10.1002/adfm.202422772](https://doi.org/10.1002/adfm.202422772)

Journal information: [Advanced Functional Materials](#)
Provided by [Pohang University of Science and Technology](#)

JUNE 12, 2025

NASA's Roman to peer into cosmic 'lenses' to better define dark matter

by Claire Blome, Christine Pulliam, [Space Telescope Science Institute](#)

edited by [Gaby Clark](#), reviewed by [Andrew Zinin](#)

This image shows a simulated observation from NASA's Nancy Grace Roman Space Telescope with an overlay of its Wide Field Instrument's field of view. More than 20 gravitational lenses, with examples shown at left and right, are expected to pop out in every one of Roman's vast observations. A journal paper led by Bryce Wedig, a graduate student at Washington University in St. Louis, Missouri, estimates that of those Roman detects, about 500 from the telescope's High-Latitude Wide-Area Survey will be suitable for dark matter studies. By examining such a large population of gravitational lenses, the researchers hope to learn a lot more about the mysterious nature of dark matter. Credit: Science: NASA, Bryce Wedig (Washington University in St. Louis), Tansu Daylan (Washington University in St. Louis). Image: Joseph DePasquale (STScI)

Dark matter affects how stars move within galaxies, how galaxies build up over time, and how everything in the universe is held together—but no existing tool has directly detected it. While dark matter does not reflect, absorb, or emit light, it can still be indirectly observed by telescopes.

To better characterize dark matter, astronomers look for its influence on the light they can observe. Dark matter possesses mass, therefore it can distort light traveling through the cosmos in a process known as gravitational lensing.

The Nancy Grace Roman Space Telescope, set to survey the sky following its launch, will turn up hundreds of gravitational lenses where a [massive galaxy](#) in the foreground magnifies and distorts light from the [background galaxy](#) into arcs and swoops. Researchers will use Roman's data to measure tiny deviations in the repeated imagery of the background galaxies, which will help them measure the effects of dark matter on incredibly small scales and better pinpoint what it is.

A funky effect Einstein predicted, known as gravitational lensing—when a foreground galaxy magnifies more distant galaxies behind it—will soon become common when NASA's Nancy Grace Roman Space Telescope begins science operations in 2027 and produces vast surveys of the cosmos.

A particular subset of gravitational lenses, known as strong lenses, is the focus of a [new paper](#) published in the *Astrophysical Journal* led by Bryce Wedig, a graduate student at Washington University in St. Louis.

The research team has calculated that over 160,000 gravitational lenses, including hundreds suitable for this study, are expected to pop up in Roman's vast images. Each Roman image will be 200 times larger than infrared snapshots from NASA's Hubble Space Telescope, and its upcoming "wealth" of lenses will vastly outpace the hundreds studied by Hubble to date.

Roman will conduct three core surveys, providing expansive views of the universe. This science team's work is based on a previous version of Roman's now fully defined High-Latitude Wide-Area Survey. The researchers are working on a follow-up paper that will align with the final survey's specifications to fully support the research community.

"The current sample size of these objects from other telescopes is fairly small because we're relying on two galaxies to be lined up nearly perfectly along our line of sight," Wedig said. "Other telescopes are either limited to a smaller field of view or less precise observations, making gravitational lenses harder to detect."

Gravitational lenses are made up of at least two cosmic objects. In some cases, a single foreground galaxy has enough mass to act like a lens, magnifying a galaxy that is almost perfectly behind it. Light from the background galaxy curves around the foreground galaxy along more than one path, appearing in observations as warped arcs and crescents. Of the 160,000 lensed galaxies Roman may identify, the team expects to narrow that down to about 500 that are suitable for studying the structure of dark matter at scales smaller than those galaxies.

"Roman will not only significantly increase our sample size—its sharp, high-resolution images will also allow us to discover gravitational lenses that appear smaller on the sky," said Tansu Daylan, the principal investigator of the science team conducting this research program. Daylan is an assistant professor and a faculty fellow at the McDonnell Center for the Space Sciences at Washington University in St. Louis.

"Ultimately, both the alignment and the brightness of the background galaxies need to meet a certain threshold so we can characterize the dark matter within the foreground galaxies."

This video shows how a background galaxy's light is lensed or magnified by a massive foreground galaxy, seen at center, before reaching NASA's Roman Space Telescope. Light from the background galaxy is distorted, curving around the foreground galaxy and appearing more than once as warped arcs and crescents. Researchers studying these objects, known as gravitational lenses, can better characterize the mass of the foreground galaxy, which offers clues about the particle nature of dark matter. Credit: NASA, STScI, Joseph Olmsted (STScI)

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What is dark matter?

Not all mass in galaxies is made up of objects we can see, like star clusters. A significant fraction of a galaxy's mass is made up of dark matter, so called because it doesn't emit, reflect, or absorb light. Dark matter does, however, possess mass, and like anything else with mass, it can cause gravitational lensing.

When the gravity of a foreground galaxy bends the path of a background galaxy's light, its light is routed onto multiple paths. "This effect produces multiple images of the background galaxy that are magnified and distorted differently," Daylan said. These "duplicates" are a huge advantage for researchers—they allow multiple measurements of the lensing galaxy's mass distribution, ensuring that the resulting measurement is far more precise.

Roman's 300-megapixel camera, known as its Wide Field Instrument, will allow researchers to accurately determine the bending of the background galaxies' light by as little as 50 milliarcseconds, which is like measuring the diameter of a human hair from the distance of more than two and a half American football fields or soccer pitches.

The amount of [gravitational lensing](#) that the background light experiences depends on the intervening mass. Less massive clumps of dark matter cause smaller distortions. As a result, if researchers are able to measure tinier amounts of bending, they can detect and characterize smaller, less massive dark matter structures—the types of structures that gradually merged over time to build up the galaxies we see today.

With Roman, the team will accumulate overwhelming statistics about the size and structures of early galaxies. "Finding [gravitational lenses](#) and being able to detect clumps of dark matter in them is a game of tiny odds. With Roman, we can cast a wide net and expect to get lucky often," Wedig said. "We won't see dark matter in the images—it's invisible—but we can measure its effects."

"Ultimately, the question we're trying to address is: What particle or particles constitute dark matter?" Daylan added. "While some properties of dark matter are known, we essentially have no idea what makes up dark matter. Roman will help us to distinguish how dark matter is distributed on small scales and, hence, its particle nature."

Preparations continue

Before Roman launches, the team will also search for more candidates in observations from ESA's (the European Space Agency's) Euclid mission and the upcoming ground-based Vera C. Rubin Observatory in Chile, which will begin its full-scale operations in a few weeks. Once Roman's infrared images are in hand, the researchers will combine them with complementary visible light images from Euclid, Rubin, and Hubble to maximize what's known about these galaxies.

"We will push the limits of what we can observe, and use every gravitational lens we detect with Roman to pin down the particle nature of [dark matter](#)," Daylan said.

More information: Bryce Wedig et al, The Roman View of Strong Gravitational Lenses, *The Astrophysical Journal* (2025). DOI: [10.3847/1538-4357/adc24f](https://doi.org/10.3847/1538-4357/adc24f)

Journal information: [Astrophysical Journal](#)

Provided by [Space Telescope Science Institute](#)

JUNE 12, 2025

Brain-like chips are boosting computers and battling cybercrime

by Tom Cassauwers, [Horizon: The EU Research & Innovation Magazine](#)

edited by [Sadie Harley](#), reviewed by [Robert Egan](#)

Credit: CC0 Public Domain

The human brain is more powerful and energy-efficient than any computer. Scientists are imitating the way it works to produce better computer chips and help deal with the growing amounts of data generated every day.

To prevent smart household devices from being hacked, researchers are developing ultra-fast, energy-efficient brain-like chips that can detect threats in real time, right on our devices.

From smart fridges and TVs to internet-connected toothbrushes, more and more household gadgets are now part of the Internet of Things. That makes it easier to analyze usage data or install remote updates. But it is also a security risk.

These smart devices are frequently targeted by hackers to create so-called botnets—networks of compromised devices that can be used to launch large-scale cyber-attacks.

Computing on the edge

To address this, we can, for example, collect all the data that passes through a device and send it to a data center where AI algorithms are used to spot suspicious activity in millions of connected devices. But that takes time and requires transferring enormous amounts of data.

This is why scientists want to be able to do these calculations locally—on the fridge or the toothbrush itself.

But this concept of edge computing, where calculations happen locally, on the edge of the network, also has its challenges. A number of complex calculations must be quickly done on small chips that do not use much electricity.

"If you're generating these quantities of data, then processing it on the fly is very demanding," said Dr. Matěj Hejda, a research scientist specializing in advanced computing and photonics. Hejda is part of an initiative called NEUROPULS, which is tackling this problem head-on.

Hejda and other researchers on the NEUROPULS team are developing a small [chip](#), or processor, which can make very fast AI calculations while consuming hardly any energy.

"If a cyber-attack occurs, you can't afford delays. We rely on AI to make rapid decisions based on very large amounts of data. That's what our chip is designed to do," he said.

Brain power

Their innovation is inspired by the [human brain](#), which can perform complex tasks with far less energy than today's conventional computers. By basing their work on the key features of neural processing, the team hopes to deliver smart, low-power computing for a range of real-world applications.

"The circuits mimic the behavior of the brain," said Dr. Fabio Pavanello, a lead French National Center for Scientific Research researcher at the Center for Radiofrequencies, Optic and Micro-nanoelectronics in the Alps. Pavanello is responsible for coordinating the NEUROPULS research.

This new blend of neuroscience and high tech is called neuromorphic computing, and it is quickly gaining relevance.

"There are a lot of ways to do this. We chose photonics, which means that we use [light beams](#) instead of electrical signals to make the computations," said Pavanello.

Merging memory and processing

Some of the research is being done at the Hewlett Packard Enterprise labs in Belgium, where Hejda works. The researchers there are working to resolve one of the bottlenecks in modern AI computing: memory.

"We have a way to bypass that barrier," said Pavanello. On conventional computers, the memory is separated from the [central processing unit](#) where the calculations happen. The processor calculates things, while the data used in that calculation is stored in the memory unit.

That data needs to be constantly shifted from the memory to the processor and back, generally through some electrical circuit. That creates a bottleneck for AI because the connection between the processor and the memory cannot handle such massive data flows.

This bottleneck leads to slower calculations and higher energy use. But the researchers may have found a workaround.

"We aim to place the memory and the calculations in the same place," said Hejda. "This is also how it's done in our brain, by the way. In nature, memories and thinking appear to be co-located."

Light waves

Another innovation the NEUROPULS chip proposes is ultra-[low-power](#) photonic computing. Instead of doing calculations with [electrical signals](#), it uses special chips where light passes through microscopic pathways called waveguides.

Using light provides several advantages, such as minimal signal loss, ultra-low latencies or delays between sending and receiving data, and large data rates.

"It's also easier to do many parallel calculations with it by using different colors of light," Pavanello said.

"Using these systems, you can have more sensors and gather more data. That means we can make better informed decisions with lower costs in energy."

Another advantage of using photonic technology is the potential for building more secure shields for such chips to better protect their operation and the data they handle. "This is a key requirement for their safe use in systems and networks," Pavanello added.

Boost for self-driving cars

The NEUROPULS research team plans to test the new chip in practical applications such as detecting intrusions on computer networks. But they also want to use it in other real-world situations.

For example, it could be used to speed up the reaction times of self-driving cars. When a vehicle needs to brake or swerve suddenly in traffic, it cannot wait for a remote data center to process information and respond—everything must happen instantly and reliably.

The photonic architectures used in NEURO-PULS will provide high bandwidth and low latency, allowing the cars' software to make real-time decisions and improving road safety.

The chips can also be used in traffic cameras and sensors, helping to optimize urban mobility, or in wearable health devices that monitor vital signs and send out real-time alerts if something is wrong.

Fast progress ahead

Partners in the project include the French Alternative Energies and Atomic Energy Commission, the Barcelona Supercomputing Center, and leading universities from Italy, Belgium, Portugal, Germany and Greece.

The researchers aim to finalize and test their new chip design by 2027. Still, it might take some time before the brain chips find their way into our devices, as they need to be made ready for larger-scale applications.

"It will take some years before this actually goes into widespread use, although our approach is highly scalable, thanks to the use of the same technology used for microchips," said Pavanello.

That said, neuromorphic and photonic chips are already becoming the latest tech fashion. Large AI chip companies such as Nvidia are investing in integrated photonic technology. For Hejda, this is a sign that the technology is on the cusp of wider acceptance.

"It is becoming apparent that the biggest players in the market think photonics is a technology they need to look at," he said. "That's a good sign and could accelerate the path to real-world applications."

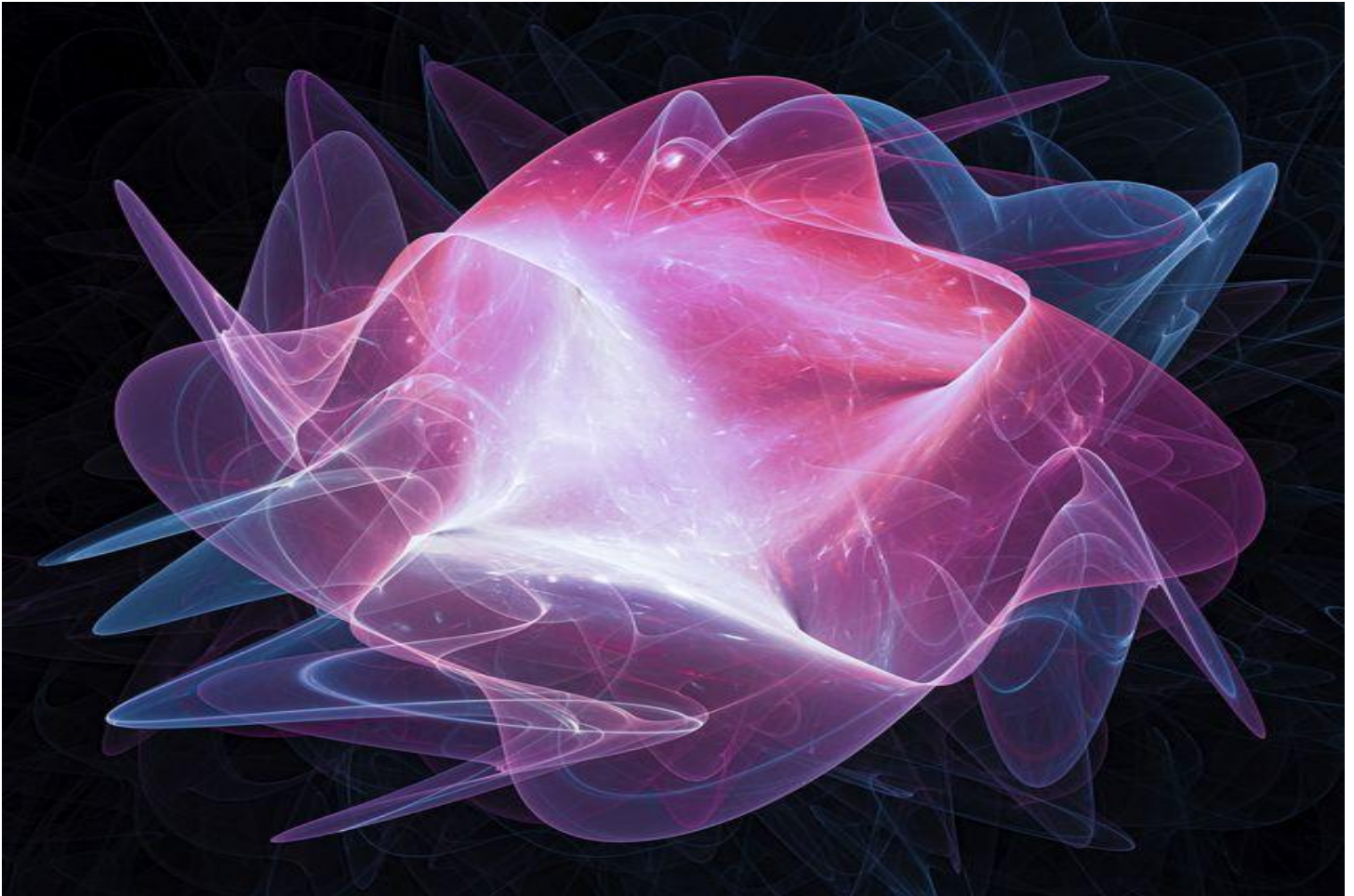
More information:

- [NEURO-PULS](#)
- [NEURO-PULS project website](#)
- [A Europe fit for the digital age](#)

Provided by [Horizon: The EU Research & Innovation Magazine](#)

Scientists Produced a Particle of Light That Simultaneously Accessed 37 Different Dimensions

It's got us beat by 34. PUBLISHED: JUN 18, 2025



Here's what you'll learn when you read this story:

- The Greenberger–Horne–Zeilinger (GHZ) paradox describes how quantum theory cannot be described by local realistic descriptions.
- A new study takes this GHZ paradox to new heights to see just how non-classical the quantum world can get.
- In the process, their experiment included photons in 37 dimensions, taking science even further down this strange quantum rabbit hole with the hopes of finding applications in these high-dimensional systems.

Classical and quantum mechanics don't really get along as the science of the subatomic can get, well, weird. Take, for instance, [quantum entanglement](#), which says that the state of one particle can be determined by examining the state of its entangled pair regardless of distance. This strange fact flies in the face of classical physics, and even led [Albert Einstein](#) to famously describe this quantum quirk as “spooky action at a distance.”

This is what is known as “quantum nonlocality,” where objects are influenced across distances (seeming beyond the speed of light) whereas classical physics follows local theory, the idea that objects are influenced by their immediate surroundings. This is a pretty sharp divide as explained by the famous no-go theorem known as the Greenberger–Horne–Zeilinger (GHZ) paradox, which essentially details how quantum theory cannot be described by local realistic description.

Named for the physicists who described the paradox in 1989, GHZ-type paradoxes show that when particles can only be influenced by proximity they produce mathematical impossibilities. As [New Scientist reports](#), the paradox can even be expressed through a calculation where 1 equals -1. This paradox is useful in showing how quantum properties can not be described using classical means, but a new paper published in the journal [Science Advances](#), decided to see just how strange these paradoxes could get.

Essentially, an international team of scientists wanted to see how *un*-classical particles of light could get—and the results were maybe stranger than the authors originally anticipated. This extremely technical experiment produced [photons](#), or particles of light, that existed in 37 dimensions. Just as you and I exist in three dimension—plus an additional temporal dimension—these photons required 37 similar reference points.

“This experiment shows that quantum physics is more nonclassical than many of us thought,” Technical University of Denmark’s Zhenghao Liu, a co-author of the study, told *New Scientist*. “It could be [that] 100 years after its discovery, we are still only seeing the tip of the iceberg.”

Pulling this off is not an easy thing to do as Liu and his team needed to feed a version of the GHZ paradox into coherent light—even in color and [wavelength](#)—so that they could easily manipulate the photons. This essentially resulted in the most “nonclassical effects in the quantum world” that’s ever been created, Liu told *New Scientist*.

“We believe that this work has opened several avenues for future research,” the authors write. “We hope our findings can be used to build even stronger quantum advantages in high-dimensional systems.”

In other words, if we’ve only discovered the tip of the iceberg, just imagine what quantum breakthroughs are lurking just below the surface.

Quantum Vacuum Breakthrough: Oxford Physicists Make Light Emerge From “Nothing”

BY UNIVERSITY OF OXFORD JUNE 20, 2025

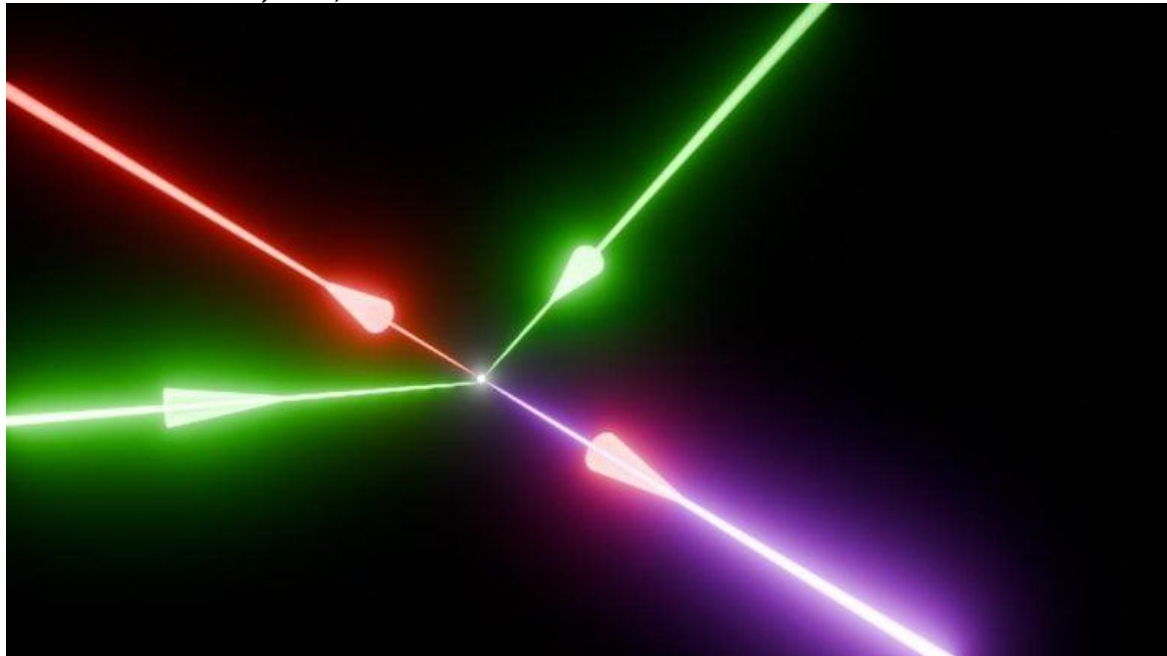


Illustration of photon-photon scattering in the laboratory. Two green petawatt lasers beams collide at the focus with a third red beam to polarize the quantum vacuum. This allows a fourth blue laser beam to be generated, with a unique direction and color, which conserves momentum and energy. Credit: Zixin (Lily) Zhang

- Oxford scientists have simulated light interacting with “empty” space—a strange quantum effect that sounds like science fiction but is rooted in real physics.
- Incredibly, the simulation shows light being created from darkness, confirming predictions from quantum theory about the vacuum being filled with invisible, flickering particles.

- This breakthrough brings us one step closer to proving these wild effects in real-world labs, using ultra-powerful laser systems now coming online around the world.
- The research was published in *Communications Physics*, marking a major step in turning once-theoretical physics into testable reality.

Quantum Vacuum Unveiled With Laser Power

Powerful lasers are letting scientists peer into the “empty” vacuum of space, and it turns out that emptiness isn’t empty at all.

Researchers at the University of Oxford and Portugal’s Instituto Superior Técnico have run the first real-time, 3D computer simulations showing how ultra-intense laser beams can stir up the so-called quantum vacuum, a realm seething with fleeting electron-positron pairs.

Their model captures a mind-bending effect called *vacuum four-wave mixing*. Picture three tightly focused laser pulses converging: their combined electromagnetic fields jolt those virtual particles, making photons ricochet off one another like billiard balls. The payoff is a fourth laser beam—light literally emerging from darkness—that could expose brand-new physics at extreme energies.

Towards Experimental Confirmation of Quantum Predictions

“This is not just an academic curiosity—it is a major step toward experimental confirmation of quantum effects that until now have been mostly theoretical,” said study co-author Professor Peter Norreys, Department of Physics, University of Oxford.

The work arrives just in time as a new generation of ultra-powerful lasers starts to come online. Facilities such as the UK’s Vulcan 20-20, the European ‘Extreme Light Infrastructure (ELI)’ project, and China’s Station for Extreme Light (SEL) and SHINE facilities are set to deliver power levels high enough to potentially confirm photon-photon scattering in the lab for the first time. Photon-photon scattering has already been selected as one of three flagship experiments at the University of Rochester’s OPAL dual-beam 25 PW laser facility in the United States.

Next-Gen OSIRIS Simulation Powers Discovery

The simulations were carried out using an advanced version of OSIRIS, a simulation software package that models interactions between laser beams and matter or plasma. Lead author Zixin (Lily) Zhang, a doctoral student at Oxford’s Department of Physics, said: “Our computer program gives us a time-resolved, 3D window into quantum vacuum interactions that were previously out of reach. By applying our model to a three-beam scattering experiment, we were able to capture the full range of quantum signatures, along with detailed insights into the interaction region and key time scales. Having thoroughly

benchmarked the simulation, we can now turn our attention to more complex and exploratory scenarios—including exotic laser beam structures and flying-focus pulses.”

Crucially, these models provide details that experimentalists depend on to design precise, real-world tests including realistic laser shapes and pulse timings. The simulations also reveal new insights, including how these interactions evolve in real time and how subtle asymmetries in beam geometry can shift the outcome.

Hunting Dark Matter With Virtual Light

According to the team, the tool will not only assist in planning future high-energy laser experiments but could also help search for signs of hypothetical particles such as axions and millicharged particles—potential candidates for dark matter.

Study co-author Professor Luis Silva (at the Instituto Superior Tecnico, University of Lisbon, and Visiting Professor in Physics at the University of Oxford) added: “A wide range of planned experiments at the most advanced laser facilities will be greatly assisted by our new computational method implemented in OSIRIS. The combination of ultra-intense lasers, state-of-the-art detection, cutting-edge analytical and numerical modeling are the foundations for a new era in laser-matter interactions, which will open new horizons for fundamental physics.”

Reference: “Computational modelling of the semi-classical quantum vacuum in 3D” by Zixin Zhang, Ramy Aboushelbaya, Iustin Ouatu, Elliott Denis, Abigail James, Robin J. L. Timmis, Marko W. Von Der Leyen, Peter A. Norreys, Rui Torres, Thomas Grismayer and Luis O. Silva, 5 June 2025, *Communications Physics*.

DOI: [10.1038/s42005-025-02128-8](https://doi.org/10.1038/s42005-025-02128-8)

New Catalyst Destroys “Forever Chemicals” in Seconds

BY GOETHE UNIVERSITY FRANKFURT JUNE 20, 2025

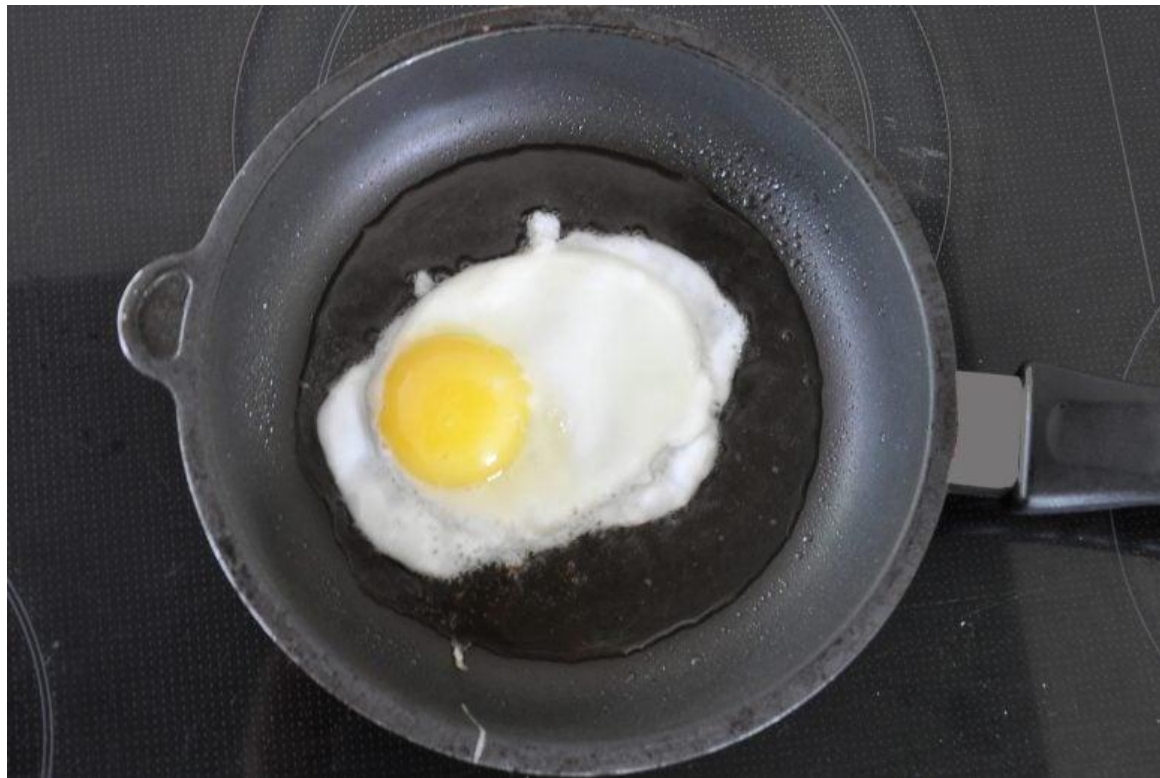


PFAS, known for their extraordinary resistance and widespread utility, have become an environmental and health concern due to their extreme persistence and bioaccumulation. A new boron-based catalyst may offer a groundbreaking solution by rapidly breaking the ultra-stable C–F bonds that make PFAS so durable. Credit: Stock
New catalyst developed at Goethe University Frankfurt can break strong carbon-fluorine bonds, with potential applications in pharmaceutical production.

PFAS are remarkable molecules in many respects. Even a thin coating can repel water, oil, and dirt. They are also highly resistant to heat and UV light, making them ideal for products like breathable outdoor clothing, stain-resistant carpets, disposable tableware, irons, and non-stick cookware.

In industrial settings, PFAS are used as lubricants, surfactants, wetting agents, in chrome plating, and in fire-fighting foams. Their applications are widespread, and PFAS are found in countless everyday items.

However, these advantages come with serious drawbacks. Because PFAS are so stable, they remain in the environment long after their use. Although they can be nearly completely destroyed in waste incineration plants, they may still build up during recycling processes—such as in textiles or sewage sludge—and eventually make their way into the environment.



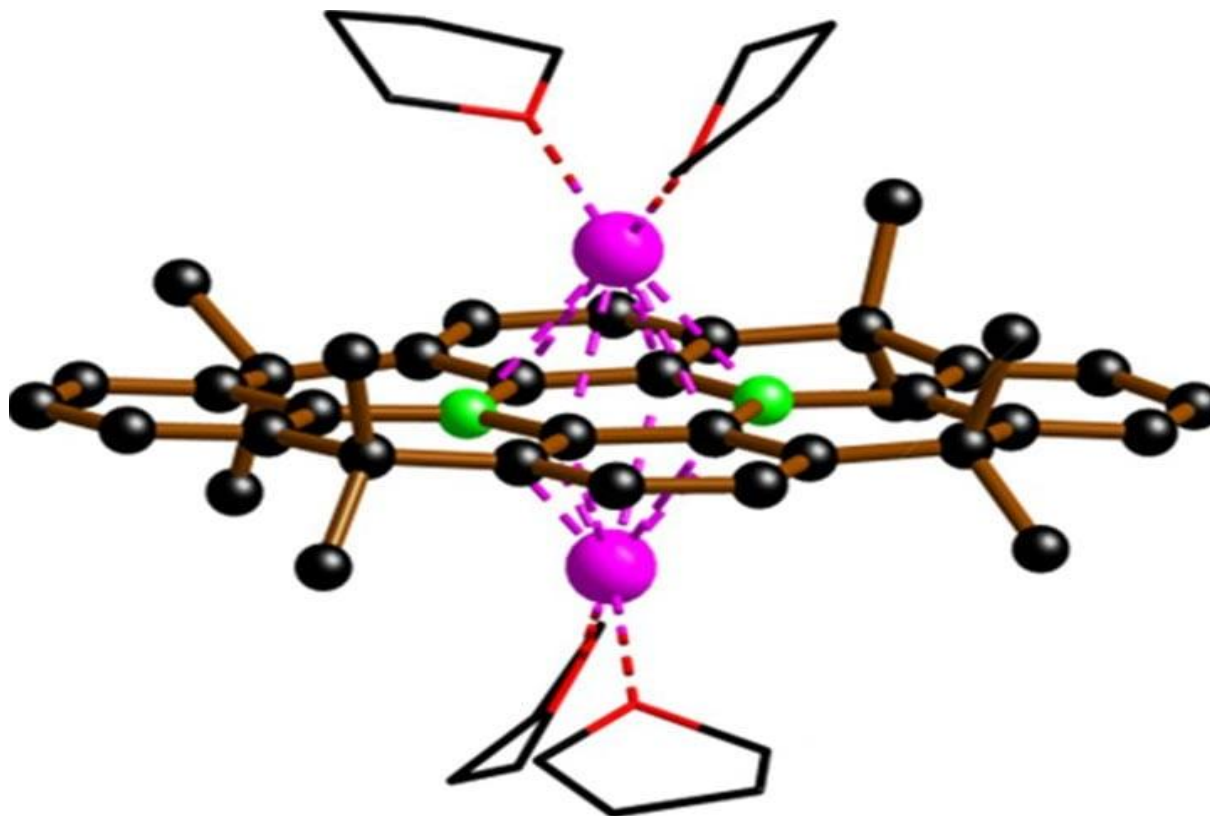
Coatings containing PFAS ensure that the egg does not stick in the pan. PFAS hardly degrade in the environment and are therefore considered “eternal chemicals”. Credit: Markus Bernards for Goethe University Frankfurt

PFAS have been detected in water, soil, plants, and even inside the human body. This is especially concerning because some of the roughly 4,700 known PFAS compounds are suspected to be carcinogenic or linked to other health risks.

How the catalyst works at the molecular level

The key to both the effectiveness and environmental persistence of PFAS lies in their extremely stable molecular structure, particularly the carbon–fluorine (C–F) bonds. A team of chemists led by Professor Matthias Wagner at Goethe University’s Institute of Inorganic and Analytical Chemistry has now developed a catalyst that can break these C–F bonds within seconds at room temperature.

At the core of the catalyst are two boron atoms embedded in a carbon framework, which makes the structure resistant to air and moisture—a rare and highly useful feature for boron-based compounds.



Two boron atoms (green spheres) are embedded in a framework of carbon atoms (black). The electrons required for C-F cleaving currently still come from lithium (pink), in future from electric current. Credit: Group of Matthias Wagner, Goethe University Frankfurt

Christoph Buch, a doctoral researcher in Wagner's group and first author of the study, explains: "To break C-F bonds, we need electrons, which our catalyst transfers with exceptional efficiency. So far, we've been using alkali metals like lithium as the electron source, but we're already working on switching to electrical current instead. That would make the process both much simpler and more efficient."

Future applications in pharmaceuticals

Beyond PFAS degradation, Wagner sees broader applications for the catalyst: "Many pharmacologically important substances contain fluorine atoms to increase their physiological stability and enhance their effect. Fluorine atoms can also improve drug uptake. With this catalyst, we now have a tool that allows us to precisely control the degree of fluorination in such compounds."

Reference: "Planarity Is Not Plain: Closed- vs Open-Shell Reactivity of a Structurally Constrained, Doubly Reduced Arylborane toward Fluorobenzenes" by Christoph D. Buch, Alexander Virovets, Eugenia Peresyphkina, Burkhard Endeward, Hans-Wolfram Lerner, Felipe Fantuzzi, Shigehiro Yamaguchi and Matthias Wagner, 29 May 2025, *Journal of the American Chemical Society*.

DOI: [10.1021/jacs.5c05588](https://doi.org/10.1021/jacs.5c05588)

SMARTWATCHES COULD BE THE NEXT SPY THREAT: NEW RESEARCH UNCOVERS HOW THEY COULD BYPASS AIR-GAPPED SYSTEMS

TIM MCMILLAN • JUNE 17, 2025

Researchers at Ben-Gurion University of the Negev in Israel have demonstrated how seemingly harmless smartwatches can be used as a covert data exfiltration tool.

Using [ultrasonic](#) signals, the team has demonstrated how the popular [wearable technology](#) can be used to siphon sensitive information from even the most secure air-gapped systems.

In a preprint paper published on [arXiv](#), Dr. Mordechai Guri, head of the Offensive Cyber Research Lab at Ben-Gurion University, unveiled a technique dubbed “SmartAttack.” This technique exposes a chilling vulnerability that could turn ordinary [smartwatches](#) into tools of corporate espionage or state-sponsored surveillance, potentially disrupting the security of high-profile institutions.

“Through experimental validation, we assess the feasibility of this attack under varying environmental conditions, distances, orientations, and noise levels,” Dr. Guri writes. “Our findings highlight the security risks posed by [smartwatches](#) in high-security environments.”

Air-gapped systems—computers or networks physically isolated from unsecured connections—have long been considered the gold standard for protecting critical data.

These systems are typically deployed in environments where security is paramount, such as [military installations](#), nuclear facilities, and financial institutions. However, as research shows, physical separation alone is no longer guaranteed against intrusion.

In his recent study, Dr. Guri explored how smartwatches, worn innocuously on the wrist, can act as silent receivers of **ultrasonic data** transmissions. Using the built-in **microphones** in these devices, attackers can capture inaudible signals (between 18 and 22 kHz) emitted by a compromised computer's speakers. These signals can encode sensitive information such as passwords, encryption keys, and confidential files, which the smartwatch then decodes and transmits to an attacker—bypassing conventional security measures entirely.

Unlike smartphones, which may be subject to security screening or physical checks in high-security zones, Dr. Guri points out that smartwatches “are designed for continuous wear, allowing them to be discreetly carried into various environments, including secured or air-gapped systems.” Their constant presence on the wrist, proximity to computers, and seamless integration into daily life make them ideal tools for this type of covert communication.

Dr. Guri tested the feasibility of SmartAttack under various conditions, including different distances, orientations, and environmental noise levels. The experiments revealed that data could be reliably exfiltrated at distances exceeding 20 feet, with bit rates up to 50 bits per second. However, they noted that lower bit rates, such as 5 bits per second, offered greater stability and accuracy over longer distances.

One key factor influencing the attack's success is the position of the smartwatch relative to the transmitting computer. The study found that signal reception was strongest when the smartwatch had a direct line of sight to the computer's speaker, particularly at angles where the body did not obstruct the signal.

For example, reception quality significantly improved when the smartwatch faced the computer directly or was oriented at certain angles (such as 90° or 225° relative to the speaker). In contrast, positions where the body or clothing blocked the signal led to greater attenuation and degradation.

The study also examined the effectiveness of different types of speakers used as transmitters. With built-in amplifiers, active

speakers were the most reliable for sending ultrasonic signals over long distances, maintaining high signal-to-noise ratios (SNR) even up to 30 feet.

While more limited in power, laptop speakers still proved effective at short to medium ranges. On the other hand, passive speakers exhibited significant signal degradation beyond 20 feet, making them less suitable for long-range covert communication.

While ultrasonic hacking might sound like science fiction, the underlying technology is based on [well-established](#) principles. Ultrasonic covert channels have been studied for years, with earlier work focusing on smartphones as both transmitters and receivers. However, SmartAttack demonstrates a shift toward exploiting wearables that users are less likely to suspect or scrutinize.

Hackers could exploit supply chain attacks to transform unsuspecting smartwatch users into unwitting spies by compromising devices before reaching consumers.

In such attacks, malicious actors infiltrate smartwatch vendors' manufacturing, distribution, or software update processes, embedding malware deep within the device's firmware or pre-installed apps.

Once the smartwatch is used, the malware remains dormant until it detects specific triggers—such as proximity to a secure computer or an air-gapped system.

At that point, the infected smartwatch could silently activate its microphone to capture covert ultrasonic transmissions or other sensitive data, relaying it to the attacker via Wi-Fi, Bluetooth, or cellular connections. The user, unaware that their wearable has been weaponized, unknowingly carries an espionage tool into highly secure environments.

Traditional defenses, such as firewalls, intrusion detection systems, and endpoint security tools, provide no protection against acoustic-based data leaks. As Dr. Guri's research reveals, even the most

stringent cybersecurity measures can be compromised by the presence of a single smartwatch.”

Dr. Guri suggests several mitigation strategies to address the threat. These include restricting or banning audio-capable wearables in sensitive areas, deploying ultrasonic monitoring systems to detect unauthorized transmissions, or introducing ultrasonic jamming to disrupt potential covert channels.

However, each of these solutions comes with trade-offs. For instance, ultrasonic jamming could interfere with legitimate devices and applications that rely on ultrasonic signals.

The only foolproof defense is “audio-gapping,” which involves physically disabling or removing microphones and speakers in highly secure environments. This is the only truly effective way to eliminate the risk of covert acoustic-based spying.

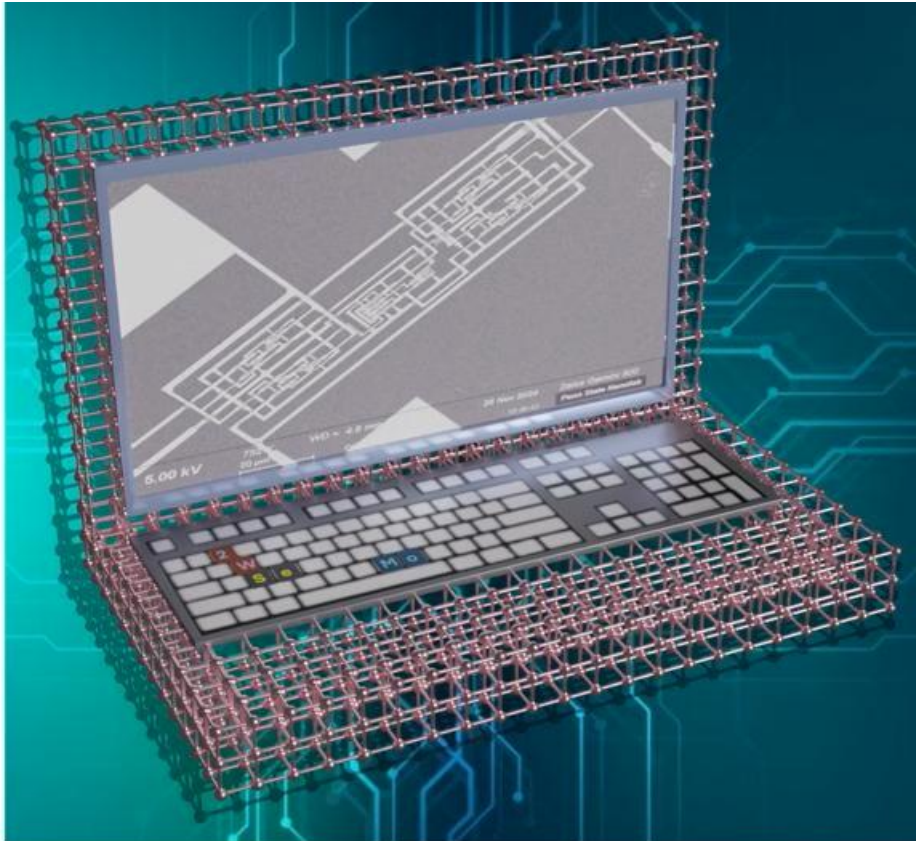
As technology continues to evolve and wearable smart devices become increasingly integrated into our daily routines, this study’s findings serve as a sobering reminder of the hidden risks associated with convenience. The implications of this research are far-reaching, potentially reshaping the way we approach cybersecurity in high-security environments.

Ultimately, the smartwatch on your wrist may do more than track your steps or notify you of emails—it could also turn you into an unexpected cyber spy.

World's first non-silicon 2D computer developed

Researchers at Penn State unveil groundbreaking 2D CMOS computer, utilising atom-thick materials for enhanced efficiency.

From Penn State 12/06/25 (first released 11/06/25)



This conceptual illustration of a computer based on 2D molecules displays an actual scanning electron microscope image of the computer fabricated by a team by researchers at Penn State. The keyboard features highlighted keys labeled with the abbreviations for molybdenum disulfide and tungsten diselenide, representing the two 2D materials used to develop the transistors in the computer. Credit: Krishnendu Mukhopadhyay/Penn State

Silicon is king in the semiconductor technology that underpins smartphones, computers, electric vehicles and more, but its crown may be slipping according to a team led by researchers at Penn State.

In a world first, they used two-dimensional (2D) materials, which are only an atom thick and retain their properties at that scale, unlike silicon, to develop a computer capable of simple operations.

The development, published today (June 11) in *Nature*, represents a major leap toward the realization of thinner, faster and more energy-efficient electronics, the researchers said.

They created a complementary metal-oxide semiconductor (CMOS) computer — technology at the heart of nearly every modern electronic device — without relying on silicon.

Instead, they used two different 2D materials to develop both types of transistors needed to control the electric current flow in CMOS computers: molybdenum disulfide for n-type transistors and tungsten diselenide for p-type transistors.

“Silicon has driven remarkable advances in electronics for decades by enabling continuous miniaturization of field-effect transistors (FETs),” said [Saptarshi Das](#), the Ackley Professor of Engineering and professor of engineering science and mechanics at Penn State, who led the research.

FETs control current flow using an electric field, which is produced when a voltage is applied.

“However, as silicon devices shrink, their performance begins to degrade.

Two-dimensional materials, by contrast, maintain their exceptional electronic properties at atomic thickness, offering a promising path forward.”

Das explained that CMOS technology requires both n-type and p-type semiconductors working together to achieve high performance at low power consumption — a key challenge that has stymied efforts to move beyond silicon.

Although previous studies demonstrated small circuits based on 2D materials, scaling to complex, functional computers had remained elusive, Das said.

“That’s the key advancement of our work,” Das said.

“We have demonstrated, for the first time, a CMOS computer built entirely from 2D materials, combining large area grown molybdenum disulfide and tungsten diselenide transistors.”

The team used metal-organic chemical vapor deposition (MOCVD) — a fabrication process that involves vaporizing ingredients, forcing a chemical reaction and depositing the products onto a substrate — to grow large sheets of molybdenum disulfide and tungsten diselenide and fabricate over 1,000 of each type of transistor.

By carefully tuning the device fabrication and post-processing steps, they were able to adjust the threshold voltages of both n- and p-type transistors, enabling the construction of fully functional CMOS logic circuits.

“Our 2D CMOS computer operates at low-supply voltages with minimal power consumption and can perform simple logic operations at frequencies up to 25 kilohertz,” said first author Subir Ghosh, a doctoral student pursuing a degree in engineering science and mechanics under Das’s mentorship.

Ghosh noted that the operating frequency is low compared to conventional silicon CMOS circuits, but their computer — known as a one instruction set computer — can still perform simple logic operations.

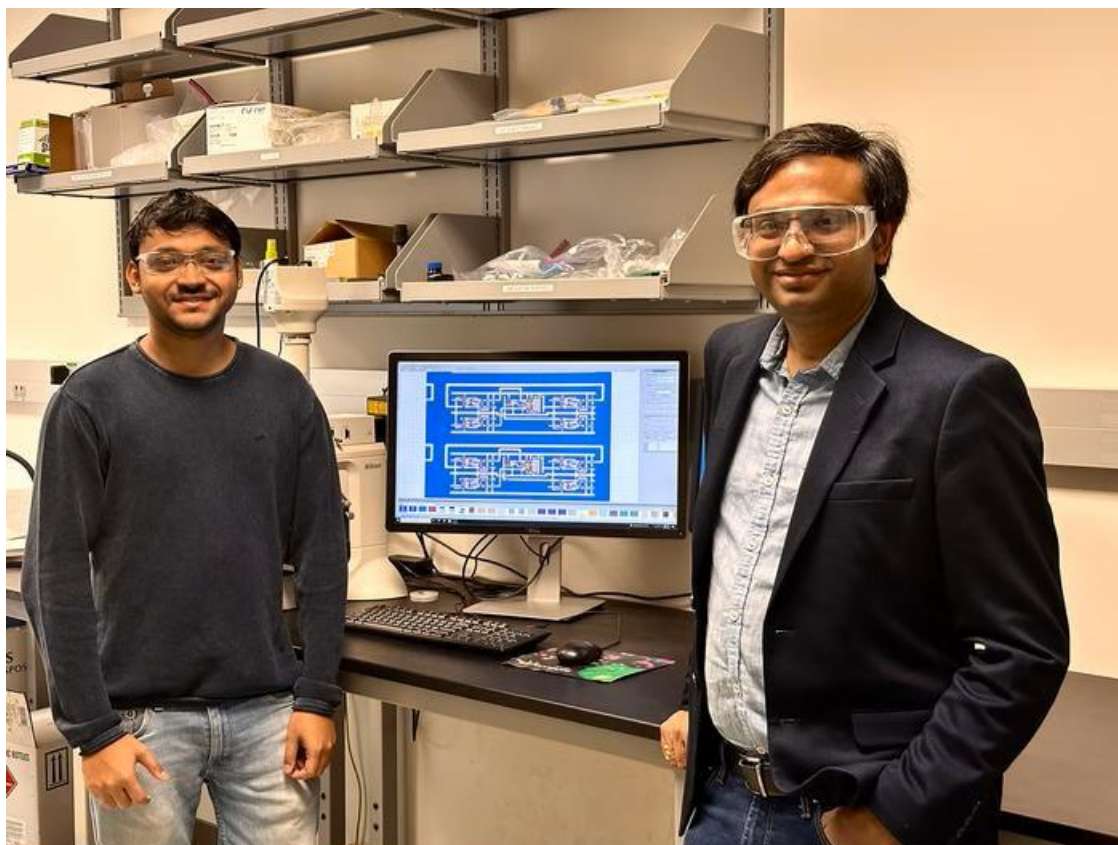
“We also developed a computational model, calibrated using experimental data and incorporating variations between devices, to project the performance of our 2D CMOS computer and benchmark it against state-of-the-art silicon technology,” Ghosh said.

“Although there remains scope for further optimization, this work marks a significant milestone in harnessing 2D materials to advance the field of electronics.”

Das agreed, explaining that more work is needed to further develop the 2D CMOS computer approach for broad use, but also emphasizing that the field is moving quickly when compared to the development of silicon technology.

“Silicon technology has been under development for about 80 years, but research into 2D materials is relatively recent, only really arising around 2010,” Das said.

“We expect that the development of 2D material computers is going to be a gradual process, too, but this is a leap forward compared to the trajectory of silicon.”



Subir Ghosh, left, and Saptarshi Das, right, led a team in developing a silicon-free, complementary metal-oxide-semiconductor computer capable of simple operations. Displayed between them is an microscope image of the fabricated computer. Credit: Penn State

Ghosh and Das credited the [2D Crystal Consortium Materials Innovation Platform](#) (2DCC-MIP) at Penn State with providing the facilities and tools needed to demonstrate their approach.

Das is also affiliated with the [Materials Research Institute](#), the 2DCC-MIP and the Departments of Electrical Engineering and of Materials Science and Engineering, all at Penn State.

Other contributors from the Penn State Department of Engineering Science and Mechanics include graduate students Yikai Zheng, Najam U. Sakib, Harikrishnan Ravichandran, Yongwen Sun, Andrew L. Pannone, Muhtasim Ul Karim Sadaf and Samriddha Ray; and Yang Yang, assistant professor.

Yang is also affiliated with the Materials Research Institute and the Ken and Mary Alice Lindquist Department of Nuclear Engineering at Penn State.

Joan Redwing, director of the 2DCC-MIP and distinguished professor of materials science and engineering and of electrical engineering, and Chen Chen, assistant research professor, also co-authored the paper.

Other contributors include Musaib Rafiq and Subham Sahay, Indian Institute of Technology; and Mrinmoy Goswami, Jadavpur University.

The U.S. National Science Foundation, the Army Research Office and the Office of Naval Research supported this work in part.

New 3D chips could make electronics faster and more energy-efficient

The low-cost, scalable technology can seamlessly integrate high-speed gallium nitride transistors onto a standard silicon chip.

Adam Zewe | MIT News Publication Date: June 18, 2025

The advanced semiconductor material gallium nitride will likely be key for the next generation of high-speed communication systems and the power electronics needed for state-of-the-art data centers.

Unfortunately, the high cost of gallium nitride (GaN) and the specialization required to incorporate this semiconductor material into conventional electronics have limited its use in commercial applications.

Now, researchers from MIT and elsewhere have developed a new fabrication process that integrates high-performance GaN transistors onto standard silicon CMOS chips in a way that is low-cost and scalable, and compatible with existing semiconductor foundries.

Their method involves building many tiny transistors on the surface of a GaN chip, cutting out each individual transistor, and then bonding just the necessary number of transistors onto a silicon chip using a low-temperature process that preserves the functionality of both materials.

The cost remains minimal since only a tiny amount of GaN material is added to the chip, but the resulting device can receive a significant performance boost from compact, high-speed transistors. In addition, by separating the GaN circuit into discrete transistors that can be spread over the silicon chip, the new technology is able to reduce the temperature of the overall system.

The researchers used this process to fabricate a power amplifier, an essential component in mobile phones, that achieves higher signal strength and efficiencies than devices with silicon transistors. In a smartphone, this could improve call quality, boost wireless bandwidth, enhance connectivity, and extend battery life.

Because their method fits into standard procedures, it could improve electronics that exist today as well as future technologies. Down the road, the new integration scheme could even enable quantum applications, as GaN performs better than silicon at the cryogenic temperatures essential for many types of quantum computing.

“If we can bring the cost down, improve the scalability, and, at the same time, enhance the performance of the electronic device, it is a no-brainer that we should adopt this technology. We’ve combined the best of what exists in silicon with the best possible gallium nitride electronics. These hybrid chips can revolutionize many commercial markets,” says Pradyot Yadav, an MIT graduate student and lead author of a [paper](#) on this method.

He is joined on the paper by fellow MIT graduate students Jinchen Wang and Patrick Darmawi-Iskandar; MIT postdoc John Niroula; senior authors Ulrich L. Rohde, a visiting scientist at the Microsystems Technology Laboratories (MTL), and Ruonan Han, an associate professor in the Department of Electrical Engineering and Computer Science (EECS) and member of MTL;

and Tomás Palacios, the Clarence J. LeBel Professor of EECS, and director of MTL; as well as collaborators at Georgia Tech and the Air Force Research Laboratory. The research was recently presented at the IEEE Radio Frequency Integrated Circuits Symposium.

Swapping transistors

Gallium nitride is the second most widely used semiconductor in the world, just after silicon, and its unique properties make it ideal for applications such as lighting, radar systems and power electronics.

The material has been around for decades and, to get access to its maximum performance, it is important for chips made of GaN to be connected to digital chips made of silicon, also called CMOS chips. To enable this, some integration methods bond GaN transistors onto a CMOS chip by soldering the connections, but this limits how small the GaN transistors can be. The tinier the transistors, the higher the frequency at which they can work.

Other methods integrate an entire gallium nitride wafer on top of a silicon wafer, but using so much material is extremely costly, especially since the GaN is only needed in a few tiny transistors. The rest of the material in the GaN wafer is wasted.

“We wanted to combine the functionality of GaN with the power of digital chips made of silicon, but without having to compromise on either cost of bandwidth. We achieved that by adding super-tiny discrete gallium nitride transistors right on top of the silicon chip,” Yadav explains.

The new chips are the result of a multistep process.

First, a tightly packed collection of miniscule transistors is fabricated across the entire surface of a GaN wafer. Using very fine laser technology, they cut each one down to just the size of the transistor, which is 240 by 410 microns, forming what they call a dielet. (A micron is one millionth of a meter.)

Each transistor is fabricated with tiny copper pillars on top, which they use to bond directly to the copper pillars on the surface of a standard silicon CMOS chip. Copper to copper bonding can be done at temperatures below 400 degrees Celsius, which is low enough to avoid damaging either material.

Current GaN integration techniques require bonds that utilize gold, an expensive material that needs much higher temperatures and stronger bonding forces than copper. Since gold can contaminate the tools used in most semiconductor foundries, it typically requires specialized facilities.

“We wanted a process that was low-cost, low-temperature, and low-force, and copper wins on all of those related to gold. At the same time, it has better conductivity,” Yadav says.

A new tool

To enable the integration process, they created a specialized new tool that can carefully integrate the extremely tiny GaN transistor with the silicon chips. The tool uses a vacuum to hold the dielet as it moves on top of a silicon chip, zeroing in on the copper bonding interface with nanometer precision.

They used advanced microscopy to monitor the interface, and then when the dielet is in the right position, they apply heat and pressure to bond the GaN transistor to the chip.

“For each step in the process, I had to find a new collaborator who knew how to do the technique that I needed, learn from them, and then integrate that into my platform. It was two years of constant learning,” Yadav says.

Once the researchers had perfected the fabrication process, they demonstrated it by developing power amplifiers, which are radio frequency circuits that boost wireless signals.

Their devices achieved higher bandwidth and better gain than devices made with traditional silicon transistors. Each compact chip has an area of less than half a square millimeter.

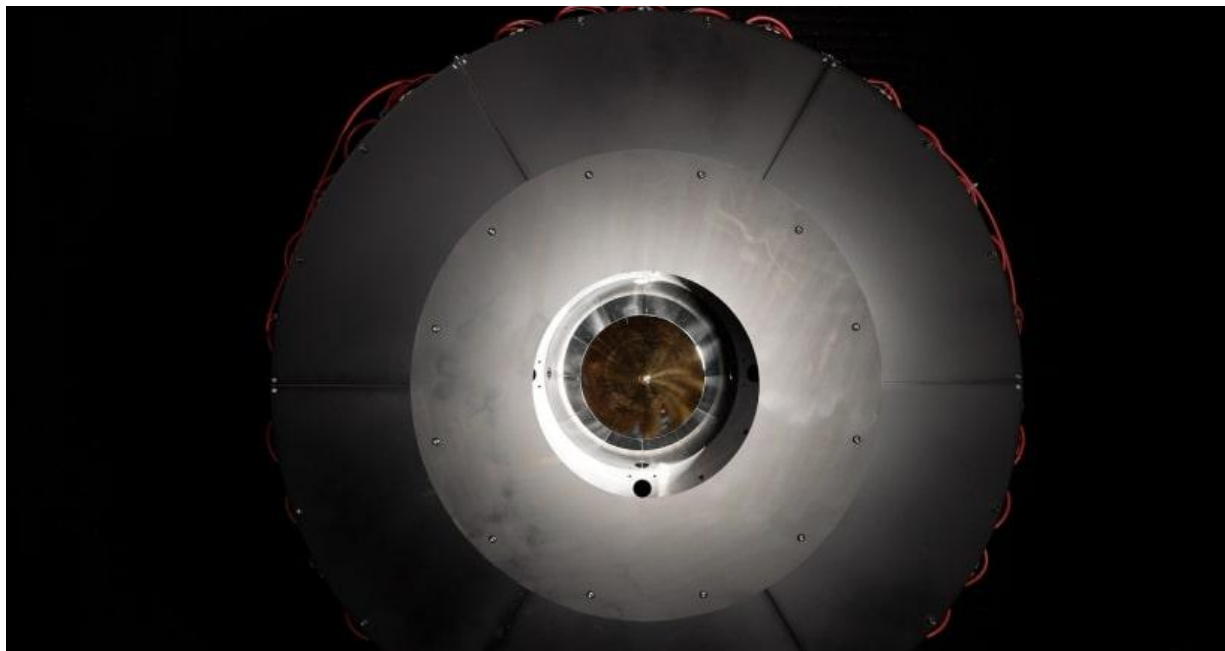
In addition, because the silicon chip they used in their demonstration is based on Intel 16 22nm FinFET state-of-the-art metallization and passive options, they were able to incorporate components often used in silicon circuits, such as neutralization capacitors. This significantly improved the gain of the amplifier, bringing it one step closer to enabling the next generation of wireless technologies.

“To address the slowdown of Moore’s Law in transistor scaling, heterogeneous integration has emerged as a promising solution for continued system scaling, reduced form factor, improved power efficiency, and cost optimization. Particularly in wireless technology, the tight integration of compound semiconductors with silicon-based wafers is critical to realizing unified systems of front-end integrated circuits, baseband processors, accelerators, and memory for next-generation antennas-to-AI platforms. This work makes a significant advancement by demonstrating 3D integration of multiple GaN chips with silicon CMOS and pushes the boundaries of current technological capabilities,” says Atom Watanabe, a research scientist at IBM who was not involved with this paper.

This work is supported, in part, by the U.S. Department of Defense through the National Defense Science and Engineering Graduate (NDSEG) Fellowship Program and CHIMES, one of the seven centers in JUMP 2.0, a Semiconductor Research Corporation Program by the Department of Defense and the Defense Advanced Research Projects Agency (DARPA). Fabrication was carried out using facilities at MIT.Nano, the Air Force Research Laboratory, and Georgia Tech.

DARPA smashes wireless power record, beaming energy more than 5 miles away — and uses it to make popcorn

The feat has significant applications for military purposes and space-based solar power.



The optical power beaming receiver designed for DARPA's power-beaming experiment. (Image credit: DARPA)

The U.S. military has set a new record for wireless power transmission, beaming a laser carrying more than 800 watts of power across a distance of 5.3 miles (8.6 kilometers).

The test, performed by the U.S. military's Defense Advanced Research Projects Agency (DARPA) as part of its Persistent Optical Wireless Energy Relay (POWER) program, is a key step toward unlocking the near-instant beaming of power.

It also smashes previous records set by the POWER program, which previously beamed 230 watts across 1 mile (1.7 km) for 25 seconds, and a smaller, undisclosed amount of power as far as 2.3 miles (3.7 km).

"It is beyond a doubt that we absolutely obliterated all previously reported optical power beaming demonstrations for power and distance," [Paul Jaffe](#), the POWER program manager, [said in a statement](#).

The concept of wireless power transmission (WPT) has been a popular goal since the days of Nikola Tesla, who in 1901 began constructing the Wardenclyffe Tower on Long Island, New York — a 187-foot (57 meters) structure intended to be the first node in a "World Wireless System" that would beam power around the globe. Yet technical challenges meant that funding for the project, initially provided by the financier J.P. Morgan, dried up, leaving Tesla's vision unrealized.

Nonetheless, interest in the concept has recently increased, both for military applications and space-based solar power, a nascent technology that would [collect and transmit energy from sunlight in space](#), where it is 10 times more intense than at Earth's surface.

Energy is essential for military operations, and getting that energy to the battlefields and disaster areas where it's needed is slow, risky, and resource intensive, often using up a lot of fuel, DARPA representatives wrote in the statement.

"These tests, referred to as PRAD (POWER Receiver Array Demo), mark an important step toward the POWER program's long-term goal of being able to instantly beam power from a location where it can be easily generated to wherever it's needed," the agency added.

In the latest experiment, conducted at the U.S. Army's White Sands Missile Range in New Mexico, the power was beamed over the 5.3-mile distance in a 30-second pulse.

The [laser](#) beam arrived at the receiver before passing through a small aperture, bouncing off a parabolic mirror onto solar cells within.

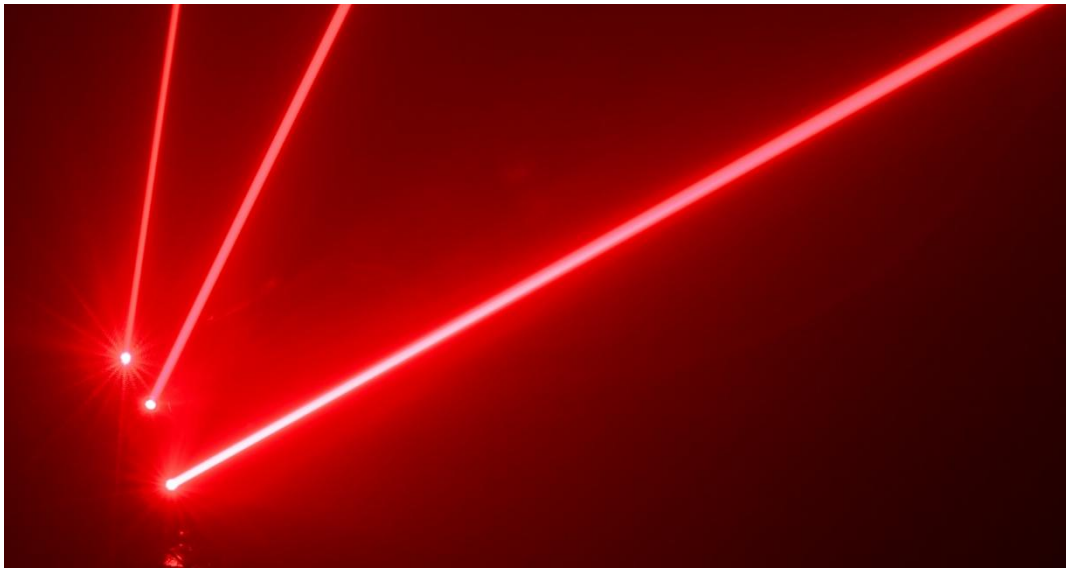
The pulse was transmitted with an approximate 20% efficiency, and some of the power it transmitted was used to make popcorn. The researchers have bigger ambitions for the system's use in the field, however, suggesting that it could be used to power unmanned aerial vehicles (UAVs).

They will now move on to testing power beaming both across multiple connected relays and vertically, where the atmosphere is thinner and transmission more efficient.

DARPA's military-grade 'quantum laser' will use entangled photons to outshine conventional laser beams

News By [Owen Hughes](#) published June 12, 2024

Prototype quantum photonic-dimer laser uses entanglement to bind photons and deliver a powerful beam of concentrated light that can shine through adverse weather like thick fog.



(Image credit: Chris Rogers/Getty Images)

Researchers are developing a new, military-grade "quantum laser" that can cut through fog and operate across long distances.

The U.S. Defense Advanced Research Projects Agency (DARPA) has awarded a \$1 million grant to scientists building a prototype "quantum photonic-dimer laser" that uses quantum entanglement to "glue" light particles together and generate a highly concentrated laser beam.

Lasers play a crucial role in military operations and are used in everything from satellite communications and [targeting technology](#) to mapping and tracking systems like [lidar](#) (light detection and ranging).

[Conventional lasers](#) work by stimulating electrons in atoms to oscillate in unison. When these electrons move from a high-energy state to a low-energy state, they release a form of light called "coherent light" — light with uniform wavelength and phase. As this light is bounced between mirrors inside the laser device, it is refined into a concentrated laser beam.

But by using entangled photons, the quantum photonic-dimer laser can maintain precision and strength over greater distances and in adverse conditions, the scientists said in [a statement](#). Quantum lasers could therefore provide better performance for military applications like surveillance and secure communications in harsh environments.

"Photons encode information when they travel, but the travel through the atmosphere is very damaging to them," project lead [Jung-Tsung Shen](#), associate professor of electrical & systems engineering at Washington University in St. Louis. "When two photons are bound together, they still suffer the effects of the atmosphere, but they can protect each other so that some phase information can still be preserved."

The two-color photonic dimer laser works by bonding pairs of photons — fundamental particles that represent the smallest building blocks of electromagnetic radiation — through a process called [quantum entanglement](#).

Quantum entanglement is [a strange and complex phenomenon](#) in the field of [quantum mechanics](#) that occurs when two or more [particles become interconnected](#) in such a way that one particle instantly influences the state of the other — regardless of the distance between them.

When two photons are linked together through quantum entanglement, they create what are known as photonic dimers, the researchers said. These pairs of photons are easier to manipulate because they act as a single entity, with any change applied to one photon directly affecting the other.

This binding of light particles increases the energy and stability of the laser, making it better at performing over long distances and in adverse conditions like extreme temperatures and fog.

[Previous work](#) by Shen and his team, published in December 2020, explored how quantum photonic-dimer laser technology could be used to improve deep brain imaging. In that study, they used photonic dimers to map intricate neural structures.

The technology can also play a role in [quantum computing](#) and telecommunications, the researchers said, possibly leading to faster and more secure ways of transmitting data.

"We are trying to exploit the property of entanglement to do something innovative. The entanglement can do many things that we can only dream of — this is just the tip of the iceberg," Shen said.

Scientists uncover the secret to building Star Wars-style laser weapons — but don't worry, we won't have a Death Star anytime soon

News By [Keumars Afifi-Sabet](#) published December 2, 2023

Today's infrared lasers are only powerful enough to disable aerial targets, but scientists now have the keys to building high-powered laser weaponry that can 'melt' distant targets.

We now have the blueprints for "Star Wars"-style laser weapons. (Image credit: Collection Christophel © Walt Disney pictures / Lucasfilm / Ram Bergman productions / Alamy Stock Photo)

High-powered infrared laser weapons could be on the horizon after scientists figured out how to make lasers nine times more powerful.

Militaries have already deployed laser-powered weapons, as popularized by films like "Star Wars," but they're much weaker than those seen on screen and can only disable small airborne targets.

The light in these current weapons, which is invisible to the naked eye, comes from single-mode optical fiber — which transmits a single wavelength of light, or mode, through the fiber core — and generates a focused beam. But it's difficult to increase the power because the light is confined to a tiny area.

Multimode optical fiber — which transmits multiple light modes — is much wider and can boost the power of infrared light emitted between three to nine times — but this technology generates beams that are messy and unfocused, due to scattering. That means their power dissipates rapidly over long distances.

In a new paper published Nov. 19 in the journal [Nature Communications](#), scientists found a solution that limits how much light scatters from multimode fibers. In theory, it means militaries could design lasers that are both high-powered enough to cause significant damage and focused enough to form a smooth, narrow beam. The new research was funded by the U.S. Air Force.

"A bad quality laser beam will diverge very rapidly as it propagates and therefore cannot deliver a concentrated amount of energy to the target. We have a way to control the property of light in such fibre so that it emerges as a focused point that can be turned into a narrow high-quality beam," lead authors [Stephen Warren-Smith](#) and [Linh Nguyen](#), researchers at the University of South Australia's Future Industries Institute, told Live Science in a jointly written email.

The defense sector has been developing military-grade lasers for years and is vying to deploy them in the real world. Lockheed Martin, for instance, announced plans this year for a [500 kilowatt-class laser](#) for use in directed-energy weapons systems to defend against threats.

The team behind the new study hasn't developed a prototype for such a weapon. But any lasers created using their blueprints may be powerful enough to confuse enemy navigation systems or deal significant thermal damage to vehicles or machines.

Current technology can zap small targets in the air at close range. But the new technology could be used on a much broader range of targets.

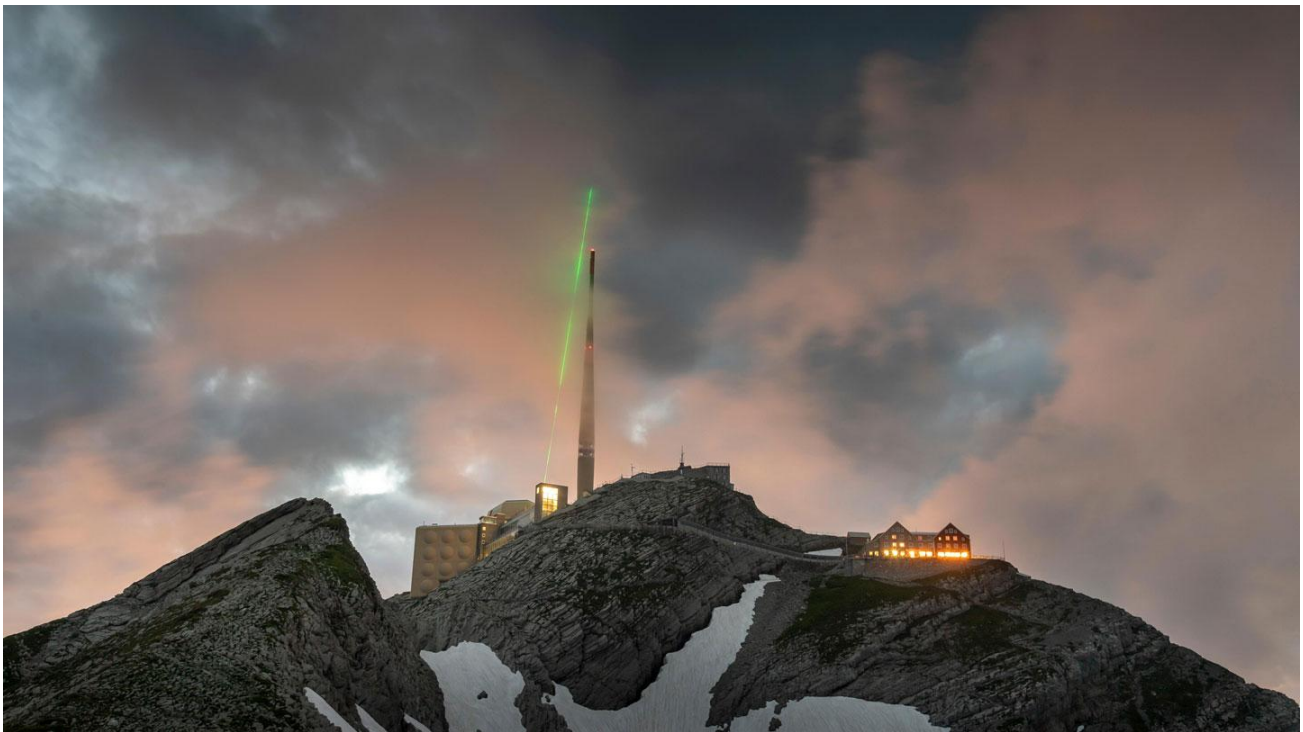
"The laser beam is focused on a distant target for perhaps a few seconds, which causes the target to melt or burn. This is most effective for small targets such as drones and mortars, but potentially larger targets if specific critical systems are damaged, such as onboard sensors or electronics," the researchers wrote in their email.

This doesn't mean the technology could be used to produce a Death Star any time soon, however. Rather, it's more likely the technology would be used to disable autonomous drones. It's very costly to expend ammunition to take drones down, but laser weapons offer an almost unlimited "magazine," with electricity as the only input energy source, the researchers said.

Beyond use in weaponry, the researchers think such powerful lasers could be used in remote sensing. High-powered lasers could, for example, determine wind speeds at a much further distance than conventional methods. High-powered lasers are also pivotal to research into gravitational wave detection, the researchers said, and they hope their discovery plays a role in future research endeavors.

Powerful laser blast used to control lightning for the first time

News By [Ben Turner](#) published January 18, 2023



This is the first ever real-world demonstration of the effect

The infrared laser beam fishes for lightning in the sky above Switzerland's Säntis mountain. (Image credit: TRUMPF/Martin Stollberg)

For the first time ever, scientists have used lasers to redirect lightning toward a safe target.

The experiment, which took place atop Säntis mountain on the northern edge of the Swiss Alps, is the first real-world demonstration that intense bursts of light can be used to fish for lightning from storms, and redirect it to a safe location.

Scientists have previously used lasers to [bend the path of electricity in the lab](#), but achieving this outside is challenging. After hauling their laser to Säntis' summit at an altitude of 8,200 feet (2,500 meters), the researchers fixed it to a 407-foot-tall (124 m) transmission tower there and pointed it at the sky. Then, by firing the infrared laser at passing storm clouds in short blasts of roughly 1,000 times per second, they corralled a path for lightning to hit the tower four times in six hours. The researchers published their findings [Jan 16. in the journal Nature Photonics](#).

"Although this research field has been very active for more than 20 years, this is the first field-result that experimentally demonstrates lightning guided by lasers," the researchers wrote in the study. "This work paves the way for new atmospheric applications of ultrashort lasers and represents an important step forward in the development of a laser based lightning protection for airports, launchpads or large infrastructures."

Lightning emerges when atmospheric static electricity, generated by the friction of ice clumps and rain in stormclouds, separates electrons from [atoms](#). The negatively charged electrons then pool at the stormcloud's base and attract positive charges from the ground. As electrons steadily accumulate, they begin to overcome the resistance of the air to their flow, ionizing the atmosphere below them as they approach the ground in multiple forking (and invisible) "leader" paths. When the first leader path makes contact with the ground, electrons hop to the earth from the point of contact, discharging from the bottom up in a flash of lightning (called the return stroke) that travels to the top of the cloud. Lightning rods shield buildings by providing leader paths with a quick and safe route to discharge electrons into the ground, but the area they protect is limited by the rod's height. To get around this limitation, the scientists beamed their powerful laser bursts at the air near the rod, tearing electrons from air molecules and sweeping those molecules away to create an electron trail between a nearby stormcloud and the rod for the lightning to travel along.

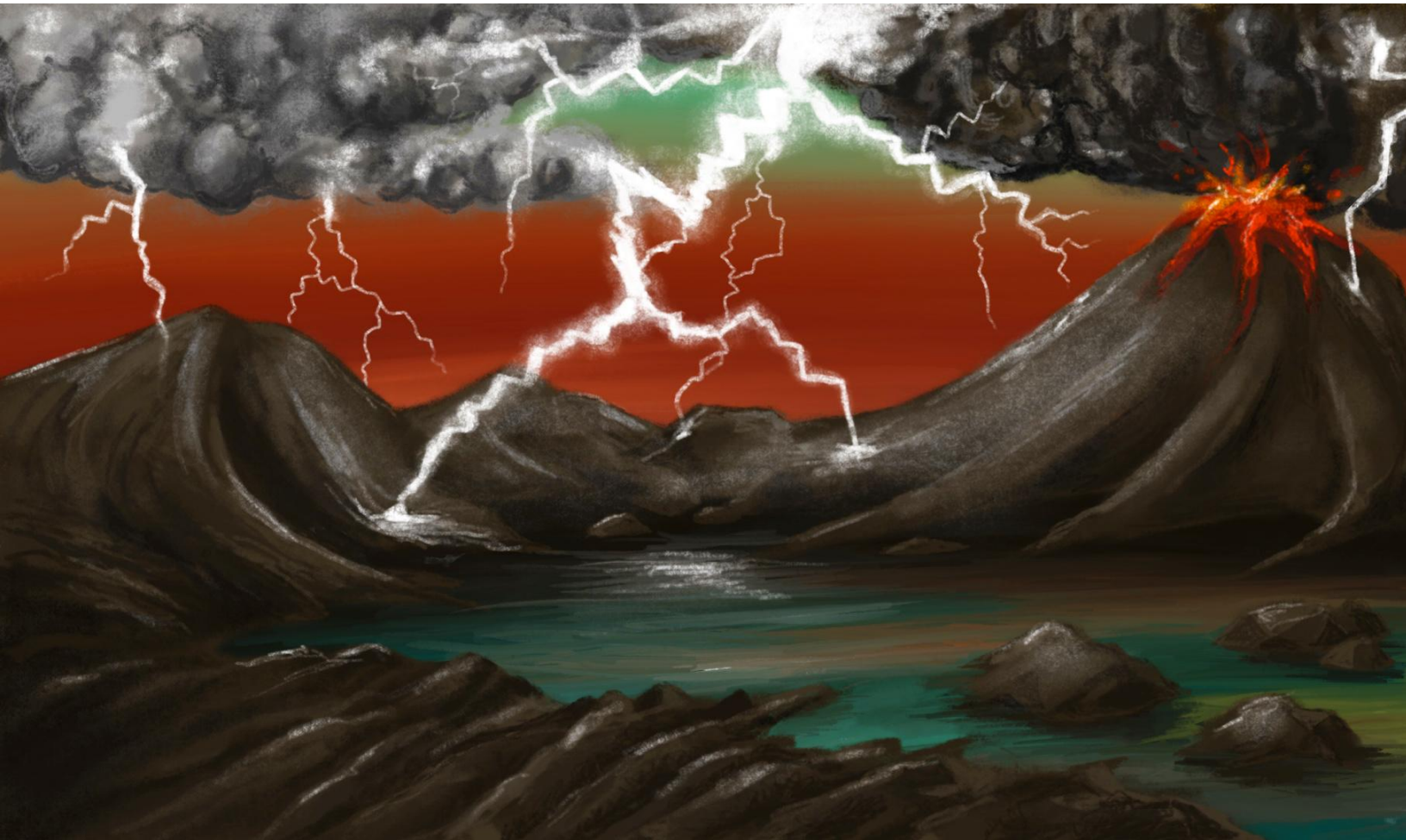
Sure enough, four strikes hit the rod during the six hours of the laser's operation, easily surpassing the usual frequency of strikes on the rod of roughly 100 times per year. Even more direct evidence of the experiment's success came from one of the strikes that was captured by cameras in slow motion as it zig-zagged onto the path cleared by the rod.

The scientists now want to replicate the effect in other locations with different atmospheric conditions, rods, lasers and pulses to see if this approach could be deployed more widely, and if lightning might strike twice.

Billions of lightning bolts may have jump-started life on Earth, study suggests

News By [Brandon Specktor](#) published 16 March 2021

How did Earth get the phosphorus it needed to make the first DNA and



RNA molecules? The answer may be crackling through the sky.

An artist's rendition of the early Earth environment. Lightning generated by storms and volcanic plumes frequently strikes volcanic rocks. The lightning strikes create fulgurites which contain phosphorus in a form that can be dissolved in water and concentrate in waters like volcanic ponds. Here, the phosphorus is able to form biomolecules which help lead to the emergence of life. (Image credit: Lucy Entwisle)

Life on Earth may have begun with a flash of [lightning](#).

No, an errant thunderbolt didn't literally animate the world's first microbes (sorry, Dr. Frankenstein). But according to a new study published Tuesday (March 16) in the journal [Nature Communications](#), trillions of lightning strikes over a billion of years

of Earth's early history may have helped unlock crucial phosphorus compounds that paved the way for life on [Earth](#).

"In our study, we show for the first time that lightning strikes were likely a significant source of reactive phosphorus on Earth around the time that life formed [3.5 billion to 4.5 billion years ago]," lead study author Benjamin Hess, a graduate student at Yale University's Department of Earth and Planetary Sciences, told Live Science. "Lightning strikes may have therefore played a role in providing [phosphorus](#) for the emergence of life on Earth."

Bombarded with life?

How does a bolt from the blue lead to terrestrial life? It's all about the phosphorus — or rather, the organic materials that phosphorus atoms can make when combined with other bio-essential elements.

Take phosphates, for example — ions composed of three [oxygen](#) atoms and one phosphorus atom, which are crucial to all known forms of life. Phosphates form the backbones of [DNA](#), [RNA](#) and ATP (the chief source of energy for cells), and are major components of bones, teeth and cell membranes.

But about 4 billion years ago, while there was likely plenty of water and carbon dioxide in the atmosphere to work with, which are also essential for life's fundamental molecules, most of the planet's natural phosphorus was bound up in insoluble rock, and impossible to combine into organic phosphates. How, then, did Earth acquire these critical compounds?

One theory holds that early Earth got its phosphorous from [meteors](#) carrying a mineral called schreibersite, which is made partly of phosphorous and is soluble in water; if loads of schreibersite meteorites crashed into Earth over millions or billions of years, then enough phosphorus could be released into a concentrated area to create the right conditions for biological life, according to the new study. However, about 3.5 billion to 4.5 billion years ago, when life on Earth emerged, the rate of meteor strikes on Earth dropped "exponentially" as most of our [solar system](#)'s planets and moons had largely taken shape, Hess said. This fact complicates the interstellar phosphorus theory.

However, there is another way to make schreibersite, right here on Earth, Hess said. All it takes is some land, a cloud and a few trillion jolts of lightning.

Billions of bolts

Lightning strikes can heat up surfaces to nearly 5,000 degrees Fahrenheit (2,760 degrees Celsius), forging new minerals that weren't there before. In the new study,

Hess and his colleagues examined a lightning-blasted clump of rock, called fulgurite, which was previously excavated from a site in Illinois. The team found that little balls of schreibersite had formed within the rock, along with a host of other glassy minerals.

With tentative proof in hand that lightning strikes can create phosphorus-rich schreibersite, the team next had to calculate whether enough lightning could have struck early Earth to release a significant amount of the element into the environment. Using models of Earth's early [atmosphere](#), the researchers estimated how many lightning strikes may have fallen over the planet each year.

Today, about 560 million lightning bolts flash over the planet a year; 4 billion years ago, when Earth's atmosphere was significantly richer in the greenhouse gas CO₂ (and therefore hotter and more prone to storms), it's likely that anywhere from 1 billion to 5 billion bolts flashed each year, the team calculated. Of those bolts, the team estimated that between 100 million and 1 billion bolts struck land each year (the rest discharged above the oceans).

And, over a billion years, up to a quintillion (a 1 followed by 18 zeros) lightning strikes may have hit our young planet, each one releasing a bit of usable phosphorus, Hess said. The team calculated that, between 4.5 billion and 3.5 billion years ago, lightning strikes alone could have given Earth anywhere from 250 to 25,000 pounds of phosphorus (110 to 11,000 kilograms) per year.

That's a huge range, with a lot of uncertainty about the conditions of early Earth built into it. But Hess said that even the lowest quantity of phosphorus could have made a difference for the emergence of life.

"For life to form, there just needs to be one location that has the right ingredients," Hess told Live Science. "If [250 lbs.] of phosphorus a year were concentrated in a single tropical island arc, then yes, it may well have been enough. But it's more likely that will happen if there are many such locations."

Whether lightning did strike enough exposed land on early Earth to make an impact on life is a question that can never be fully answered. However, the new study shows that, mathematically, it was at least possible.

It may be that a combination of asteroid impacts and lightning strikes ultimately gave Earth the phosphorus it needed to weave the first bio-essential molecules, such as DNA and RNA, the researchers concluded. But further studies of early terrestrial life should take care not to strike lightning from the record.

Sasers: Sound-based Lasers Invented

News By [Live Science Staff](#) last updated October 14, 2022

You've heard of lasers. They're focused beams of light used in everything from supermarket scanners to DVD players and futuristic weapons.

Now scientists have created what they call a "saser," the sound-based equivalent.

A saser produces an intense beam of uniform sound waves on a nano scale, scientists say. The new device could have significant and useful applications in the worlds of computing, imaging and even anti-terrorist security screening.

"While our work on sasers is driven mostly by pure scientific curiosity, we feel that the technology has the potential to transform the area of acoustics, much as the laser has transformed optics in the 50 years since its invention," said professor Anthony Kent from the University of Nottingham School of Physics and Astronomy.

The breakthrough, announced today, is detailed in this month's issue of the journal *Physical Review B*. Sasers had, until now, only been a theoretical concept.

"Laser" stands for Light Amplification by the Stimulated Emission of Radiation. Albert Einstein laid the theoretical groundwork in 1917 for the invention of lasers, but the first working laser device wasn't created until 1960.

A laser uses packets of electromagnetic vibrations called photons, the units of all light in the [electromagnetic spectrum](#), including visible, infrared and X-rays. you agree to the [Terms & Conditions](#) and [Privacy Policy](#) and are aged 16 or over.

A saser uses sound waves composed of sonic vibrations called phonons.

In a laser, the photon beam is produced by stimulating electrons with an external power source so they release energy when they collide with other photons in a highly reflective optical cavity, the researchers explain. This produces a coherent and controllable shining beam of laser light in which all the photons have the same frequency and rate of oscillation.

The saser mimics this technology, but using sound, to produce a sonic beam of phonons. The beam travels, not through an optical cavity like a laser, but through a tiny man-made structure called a superlattice. This is made out of around 50 super-thin sheets of two alternating semiconductor materials, gallium arsenide and aluminium arsenide, with each layer just a few atoms thick.

When stimulated by a power source (a light beam), the phonons multiply, bouncing back and forth between the layers of the lattice, until they escape out of the structure in the form of an ultra-high frequency phonon beam.

A key factor in this new science is that the saser is the first device to emit sound waves in the terahertz frequency range, the researchers said. The beam of coherent acoustic waves it produces has nanometer wavelengths (billionths of a meter).

Terahertz radiation is also used to [reveal what's under your clothes](#) in airport scans. In the future, a saser might spot defects in nanometer-scale objects like micro-electric circuits. Or sasers might be used for medical imaging and security screening in novel ways.

Physicists capture 'second sound' for the first time — after nearly 100 years of searching

News By [Ben Turner](#) published May 30, 2025

First theorized in 1938, heat's wave-like flow through superfluids, known as "second sound", has proven difficult to directly observe. Now, a new technique has finally done it, and could be used to study neutron stars and high-temperature superconductors.

An artist's illustration of particles moving inside a box. (Image credit: Getty Images)

Scientists have captured direct images of heat behaving like sound — an elusive phenomenon called 'second sound' — for the very first time.

Imaged within an exotic superfluid state of cold lithium-6 atoms by a new heat-mapping technique, the phenomenon shows heat moving as a wave, bouncing like sound around its container.

Understanding the way that second sound moves could help scientists predict how heat flows inside ultradense neutron stars and high-temperature [superconductors](#) — one of the "holy grails" of physics whose development would enable near-lossless energy transmission. The researchers published their findings in the journal [Science](#).

"It's as if you had a tank of water and made one half nearly boiling," study co-author [Richard Fletcher](#), an assistant professor of physics at Massachusetts Institute of Technology (MIT), [said in a statement](#). "If you then watched, the water itself might look totally calm, but suddenly the other side is hot, and then the other side is hot, and the heat goes back and forth, while the water looks totally still." Typically heat spreads from a localized source, slowly dissipating across an entire material as it raises the temperature across it.

But exotic materials called superfluids needn't play by these rules. Created when clouds of fermions (which include [protons, neutrons and electrons](#)) are cooled to temperatures

approaching absolute zero, atoms inside superfluids pair up and travel frictionlessly throughout the material.

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As a result, heat flows differently through the material: instead of spreading through the movements of particles within the fluid, as it typically flows, heat sloshes back and forth within superfluids like a sound wave. This second sound was first predicted by the physicist László Tisza in 1938, but heat-mapping techniques have, until now, proven unable to observe it directly.

"Second sound is the hallmark of superfluidity, but in ultracold gases so far you could only see it in this faint reflection of the density ripples that go along with it," study senior-author [Martin Zwierlein](#), a professor of physics at MIT, said in the statement. "The character of the heat wave could not be proven before."

To capture second sound, the researchers had to solve a daunting problem in tracking the flow of heat inside ultracold gases. These gases are so cold that they do not give off infrared radiation, upon which typical heat-mapping, or thermography, techniques rely.

Instead, the physicists developed a method to track the fermion pairs through their resonant frequencies. Lithium-6 atoms resonate at different radio frequencies as their temperatures change, with warmer atoms vibrating at higher frequencies.

By applying resonant radio frequencies corresponding to warmer atoms, the scientists made these atoms ring in response, enabling them to track the particles' flow frame by frame.

"For the first time, we can take pictures of this substance as we cool it through the critical temperature of superfluidity, and directly see how it transitions from being a normal fluid, where heat equilibrates boringly, to a superfluid where heat sloshes back and forth," Zwierlein said.

The physicists say that their groundbreaking technique will enable them to better study the behaviors of some of the universe's most extreme objects, such as neutron stars, and measure the conductivity of high-temperature superconductors to make even better designs.

"There are strong connections between our puff of gas, which is a million times thinner than air, and the behavior of electrons in high-temperature superconductors, and even neutrons in ultradense neutron stars," Zwierlein said. "Now we can probe pristinely the temperature response of our system, which teaches us about things that are very difficult to understand or even reach."

Physicists force atoms into state of quantum 'hyper-entanglement' using tweezers made of laser light

News By [Alan Bradley](#) published May 30, 2025

By controlling individual atoms, researchers have demonstrated a way to turn previously unwanted atomic motion into an advantage.

Using optical tweezers composed of laser light, researchers have developed a novel way to manipulate individual atoms and create a state of hyper-entanglement.

This breakthrough could lead to new forms of [quantum computing](#) and advances in quantum simulations designed to answer fundamental questions about physics. Caltech scientists have been using optical tweezers to control individual atoms for several decades, leading to a number of advances, including [quantum error correction](#) and a method for creating the [world's most accurate clocks](#).

One persistent issue in the process, however, has been the natural motion of atoms, which can introduce noise (and errors) into a quantum system. But in the breakthrough study, published in the journal [Science](#), that weakness has been transformed.

"We show that atomic motion, which is typically treated as a source of unwanted noise in quantum systems, can be turned into a strength," said [Adam Shaw](#) in a [statement](#) on Caltech's website, a postdoctoral researcher and first author on the study.

Instead of a disruptive influence, Shaw and colleagues have harnessed that movement to create hyper-entangled sets of atoms. Hyper-entanglement is distinct from traditional [quantum entanglement](#), which describes two or more particles that are in-sync and share a property across vast distances. Hyper-entangled atoms, by contrast, can share multiple properties at the same time.

In the experiment, the Caltech team was able to link both the states of motion and electronic states (a measure of an atom's internal energy level) in a pair of atoms at the same time.

This achievement is an important step in terms of both volume and efficiency, according to [Manuel Endres](#), a professor of physics at Caltech and co-lead author of the study. "This allows us to encode more quantum information per atom," he said in the statement. "You get more entanglement with fewer resources."

To achieve that state of hyper-entanglement, the team first had to cool an alkaline earth atom with no charge using a novel method that Endres said involved "detection and subsequent active correction of thermal motional excitations." By deploying this method, the team was able to almost completely freeze the atom's motion.

The next step was to cause atoms to oscillate like a pendulum on a tiny scale in two different directions simultaneously, creating a state of [superposition](#) — when a particle exhibits opposite properties at the same time. These oscillating atoms were then entangled

with partners that matched their motion, and finally hyper-entangled to also mirror their electronic states.

According to Endres, the point of the experiment was to find the limit of control they could exercise over the atoms. "We are essentially building a toolbox," he said. "We knew how to control the electrons within an atom, and we now learned how to control the external motion of the atom as a whole — it's like an atom toy that you have fully mastered."

One of the most exciting facets of this discovery is the implication that even more states or properties could be entangled, which Endres said could lead to a number of potential applications.

"Motional states could become a powerful resource for quantum technology, from computing to simulation to precision measurements."



JUNE 18, 2025

Perovskite-based image sensors promise higher sensitivity and resolution than silicon

by [ETH Zurich](#) edited by [Sadie Harley](#), reviewed by [Robert Egan](#)

Thin-film technology: One of the two perovskite-based sensor prototypes that the researchers have used to demonstrate that the technology can be successfully miniaturized. Credit: Empa / ETH Zurich

Image sensors are built into every smartphone and every digital camera. They distinguish colors in a similar way to the human eye. In our retinas, individual cone cells recognize red, green and blue (RGB). In image sensors, individual pixels absorb the corresponding wavelengths and convert them into electrical signals.

The vast majority of image sensors are made of silicon. This [semiconductor material](#) normally absorbs light over the entire visible spectrum. In order to manufacture it into RGB image sensors, the incoming light must be filtered. Pixels for red contain filters that block (and waste) green and blue, and so on. Each [pixel](#) in a silicon image sensor thus only receives around a third of the available light.

Maksym Kovalenko and his team associated with both ETH Zurich and Empa have proposed a novel solution, which allows them to utilize every photon of light for color recognition. For nearly a decade, they have been researching perovskite-based image sensors.

In a study [published](#) in *Nature*, they show how the new technology works.

Stacked pixels

The basis for their innovative image sensor is lead halide perovskite. This crystalline material is also a semiconductor. In contrast to silicon, however, it is particularly easy to process—and its physical properties vary with its exact chemical composition. This is precisely what the researchers are taking advantage of in the manufacture of perovskite image sensors.

If the perovskite contains slightly more iodine ions, it absorbs red light. For green, the researchers add more bromine, for blue more chlorine—without any need for filters. The perovskite pixel layers remain transparent for the other wavelengths, allowing them to pass through.

This means that the pixels for red, green and blue can be stacked on top of each other in the image sensor, unlike with silicon image sensors, where the pixels are arranged side-by-side.

Perovskite image sensors can, in theory, capture three times as much light as conventional image sensors of the same surface area while also providing three times higher spatial resolution. Credit: Sergii Yakunin / ETH Zurich and Empa

Working image sensors

Thanks to this arrangement, perovskite-based image sensors can, in theory, capture three times as much light as conventional image sensors of the same surface area while also providing three times higher spatial resolution. Researchers from Kovalenko's team were

able to demonstrate this a few years ago, initially with individual oversized pixels made of millimeter-large single crystals.

Now, for the first time, they have built two fully functional thin-film perovskite image sensors. "We are developing the technology further from a rough proof of principle to a dimension where it could actually be used," says Kovalenko.

A normal course of development for electronic components. "The first transistor consisted of a large piece of germanium with a couple of connections. Today, 60 years later, transistors measure just a few nanometers."

Perovskite image sensors are still in the early stages of development. With the two prototypes, however, the researchers were able to show that the technology can be miniaturized. Manufactured using thin-film processes common in industry, the sensors have reached their target size in the vertical dimension at least.

"Of course, there is always potential for optimization," notes co-author Sergii Yakunin from Kovalenko's team.

In numerous experiments, the researchers put the two prototypes, which differ in their readout technology, through their paces. Their results prove the advantages of perovskite: the sensors are more sensitive to light, more precise in color reproduction and can offer a significantly higher resolution than conventional silicon technology.

The fact that each pixel captures all the light also eliminates some of the artifacts of digital photography, such as demosaicing and the moiré effect.

Machine vision for medicine and the environment

However, consumer digital cameras are not the only area of application for perovskite image sensors. Due to the material's properties, they are also particularly suitable for use in machine vision. The focus on red, green and blue is dictated by the human eye.

These image sensors work in RGB format because our eyes see in RGB mode. However, when solving specific tasks, it is advisable to specify other optimal wavelength ranges that the computer image sensor should read. Often there are more than three—so-called hyperspectral imaging.

Perovskite sensors have a decisive advantage in hyperspectral imaging. Researchers can precisely control the wavelength range they absorb by each layer.

"With perovskite, we can define a larger number of color channels that are clearly separated from each other," says Yakunin. Silicon, with its broad absorption spectrum, requires numerous filters and complex computer algorithms.

"This is very impractical even with a relatively small number of colors," Kovalenko says. Hyperspectral image sensors based on perovskite could be used in medical analysis or in automated monitoring of agriculture and the environment, for example.

In the next step, the researchers want to further reduce the size and increase the number of pixels in their perovskite image sensors. Their two prototypes have pixel sizes between 0.5 and 1 millimeters. Pixels in commercial [image sensors](#) fall in the micrometer range (1 micrometer is 0.001 millimeters).

"It should be possible to make even smaller pixels from perovskite than from silicon," says Yakunin. The electronic connections and processing techniques need to be adapted for the new technology.

"Today's readout electronics are optimized for silicon. But [perovskite](#) is a different semiconductor, with different material properties," says Kovalenko. However, the researchers are convinced that these challenges can be overcome.

More information: Maksym Kovalenko, Vertically stacked monolithic perovskite colour photodetectors, *Nature* (2025). DOI: [10.1038/s41586-025-09062-3](https://doi.org/10.1038/s41586-025-09062-3). www.nature.com/articles/s41586-025-09062-3

Journal information: [Nature](#)

JUNE 18, 2025

Tiny gallium nitride transistors boost chip speed and efficiency in new 3D design

by Adam Zewe, [Massachusetts Institute of Technology](#) edited by [Lisa Lock](#), reviewed by [Robert Egan](#)

Researchers have developed a new fabrication process that integrates high-performance gallium nitride transistors onto standard silicon CMOS chips in a way that is low-cost and scalable. Credit: Massachusetts Institute of Technology

The advanced semiconductor material gallium nitride will likely be key for the next generation of high-speed communication systems and the power electronics needed for state-of-the-art data centers.

Unfortunately, the high cost of gallium nitride (GaN) and the specialization required to incorporate this [semiconductor material](#) into conventional electronics have limited its use in commercial applications.

Now, researchers from MIT and elsewhere have developed a new fabrication process that integrates high-performance GaN transistors onto standard silicon CMOS chips in a way that is low-cost and scalable, and compatible with existing semiconductor foundries.

Their method involves building many tiny transistors on the surface of a GaN chip, cutting out each individual transistor, and then bonding just the necessary number of transistors onto a [silicon chip](#) using a low-temperature process that preserves the functionality of both materials.

The cost remains minimal since only a tiny amount of GaN material is added to the chip, but the resulting device can receive a significant performance boost from compact, high-speed transistors. In addition, by separating the GaN circuit into discrete transistors that can be spread over the silicon chip, the new technology is able to reduce the temperature of the overall system.

The researchers used this process to fabricate a [power amplifier](#), an essential component in mobile phones, that achieves higher signal strength and efficiencies than devices with silicon transistors. In a smartphone, this could improve call quality, boost wireless bandwidth, enhance connectivity, and extend battery life.

Because their method fits into standard procedures, it could improve electronics that exist today as well as future technologies. Down the road, the new integration scheme could even enable quantum applications, as GaN performs better than silicon at the cryogenic temperatures essential for many types of quantum computing.

"If we can bring the cost down, improve the scalability, and, at the same time, enhance the performance of the electronic device, it is a no-brainer that we should adopt this technology. We've combined the best of what exists in silicon with the best possible gallium nitride electronics.

"These hybrid chips can revolutionize many commercial markets," says Pradyot Yadav, an MIT graduate student and lead author of a [paper](#) on this method. The paper was presented at the RTu2C session of the Radio Frequency Integrated Circuits Symposium ([RFIC 2025](#)) held 15–17 June 2025 in San Francisco, CA.

Swapping transistors

Gallium nitride is the second most widely used semiconductor in the world, just after silicon, and its unique properties make it ideal for applications such as lighting, radar systems and [power electronics](#).

The material has been around for decades and, to get access to its maximum performance, it is important for chips made of GaN to be connected to digital chips made of silicon, also called CMOS chips. To enable this, some integration methods bond GaN transistors onto a CMOS chip by soldering the connections, but this limits how small the GaN transistors can be. The tinier the transistors, the higher the frequency at which they can work.

Other methods integrate an entire gallium nitride wafer on top of a silicon wafer, but using so much material is extremely costly, especially since the GaN is only needed in a few tiny transistors. The rest of the material in the GaN wafer is wasted.

"We wanted to combine the functionality of GaN with the power of digital chips made of silicon, but without having to compromise on either cost or bandwidth. We achieved that by adding super-tiny discrete gallium nitride transistors right on top of the silicon chip," Yadav explains.

The new chips are the result of a multistep process.

First, a tightly packed collection of minuscule transistors is fabricated across the entire surface of a GaN wafer. Using very fine laser technology, they cut each one down to just the size of the transistor, which is 240 by 410 microns, forming what they call a dielet. (A micron is one millionth of a meter.)

Each transistor is fabricated with tiny copper pillars on top, which they use to bond directly to the copper pillars on the surface of a standard silicon CMOS chip. Copper to copper bonding can be done at temperatures below 400 degrees Celsius, which is low enough to avoid damaging either material.

Current GaN integration techniques require bonds that utilize gold, an expensive material that needs much higher temperatures and stronger bonding forces than copper. Since gold can contaminate the tools used in most semiconductor foundries, it typically requires specialized facilities.

"We wanted a process that was low-cost, low-temperature, and low-force, and copper wins on all of those related to gold. At the same time, it has better conductivity," Yadav says.

A new tool

To enable the integration process, they created a specialized new tool that can carefully integrate the extremely tiny GaN transistor with the silicon chips. The tool uses a vacuum to hold the dielet as it moves on top of a silicon chip, zeroing in on the copper bonding interface with nanometer precision.

They used advanced microscopy to monitor the interface, and then when the dielet is in the right position, they apply heat and pressure to bond the GaN transistor to the chip.

"For each step in the process, I had to find a new collaborator who knew how to do the technique that I needed, learn from them, and then integrate that into my platform. It was two years of constant learning," Yadav says.

Once the researchers had perfected the fabrication process, they demonstrated it by developing power amplifiers, which are radio frequency circuits that boost wireless signals.

Their devices achieved higher bandwidth and better gain than devices made with traditional silicon transistors. Each compact chip has an area of less than half a square millimeter.

In addition, because the silicon chip they used in their demonstration is based on Intel 16 22nm FinFET state-of-the-art metallization and passive options, they were able to incorporate components often used in silicon circuits, such as neutralization capacitors. This significantly improved the gain of the amplifier, bringing it one step closer to enabling the next generation of wireless technologies.

"To address the slowdown of Moore's Law in transistor scaling, heterogeneous integration has emerged as a promising solution for continued system scaling, reduced form factor, improved power efficiency, and cost optimization.

"Particularly in wireless technology, the tight integration of compound semiconductors with silicon-based wafers is critical to realizing unified systems of front-end integrated circuits, baseband processors, accelerators, and memory for next-generation antennas-to-AI platforms.

"This work makes a significant advancement by demonstrating 3D integration of multiple GaN chips with silicon CMOS and pushes the boundaries of current technological capabilities," says Atom Watanabe, a research scientist at IBM who was not involved with this paper.

More information: 3D-Millimeter Wave Integrated Circuit (3D-mmWIC) : A Gold-Free 3D-Integration Platform for Scaled RF GaN-on-Si Dielets with Intel 16 Si CMOS. IEEE Radio-Frequency Integrated Circuit Symposium (RFIC), San Francisco, CA, Jun. 2025. Provided by [Massachusetts Institute of Technology](#)

JUNE 18, 2025

Sustainable, manganese-based phosphors show promise for white-light LEDs

by Arne Claussen, [Heinrich-Heine University Duesseldorf](#) edited by [Lisa Lock](#), reviewed by [Robert Egan](#)

Crystal structure of an alkali lithofoxidosilicate, the site occupation of Mn^{2+} and the resulting emission colors. Credit: *Angewandte Chemie International Edition* (2025). DOI: 10.1002/anie.202504078

Virtually all light-emitting diodes used today require phosphors based on so-called rare-earth elements, which are expensive and challenging to obtain. In a collaborative research project between Heinrich Heine University Düsseldorf (HHU) and the University of

Innsbruck, chemists have now demonstrated that the element manganese is in principle also suitable for such applications.

In their study [published](#) in the journal *Angewandte Chemie International Edition*, they show that this approach enables white light to be generated from a single manganese-based phosphor.

Light-emitting diodes (LEDs) are energy-efficient and flexible, making them a key technology for sustainable lighting. Current white-light LEDs typically comprise a blue semiconductor LED, the light of which is then converted by two layers of photoactive materials into [green light](#) and red light. Combining these light colors creates the desired white light.

The phosphors used in current LEDs almost all contain rare-earth elements such as europium or cerium. However, obtaining these elements is costly and they are only extracted on a large scale in a few regions around the world, primarily in China. This presents significant strategic disadvantages.

A research team headed by Assistant Professor Dr. Markus Suta (Inorganic Photoactive Materials working group at HHU) and Professor Dr. Hubert Huppertz (Department of General, Inorganic and Theoretical Chemistry at the University of Innsbruck) has now sought alternatives, which are more widely available and easier to handle.

They identified the transition metal manganese (Mn)—more precisely the twofold positively charged manganese ion (Mn^{2+})—as promising. By contrast with rare earths, manganese is much more abundant in Earth's crust, can easily be mined and extracted from ores, and also offers straightforward handling.

So why has manganese not already been used for LEDs in the past? Professor Suta explains: "One fundamental disadvantage is the highly inefficient absorption of Mn^{2+} , meaning that the luminescence decays relatively slowly. High power densities are therefore needed to achieve sufficient brightness."

By contrast, the ion Mn^{4+} is already in use—it emits narrow-band red light in fluorides and is mostly used for display screens. However, the production of the corresponding phosphors involves hydrofluoric acid, which is problematic.

In *Angewandte Chemie International Edition*, the researchers now report on their examination of the luminescence—the radiation properties—of a special compound: the Mn^{2+} ion in so-called alkali lithosilicates. The working group headed by Professor Huppertz had already identified this class of compounds as potentially promising candidates for cyan-emitting narrow-band emitters for display screens several years ago, albeit still with europium as the emitter at that time.

Professor Suta states, "In contrast to europium ions, manganese ions are much smaller and more flexible when it comes to the selection of specific coordination geometries. Mn^{2+} ions emit narrow-band green light in proximity to four [oxygen atoms](#), but emit red light when surrounded by six to eight oxygen atoms.

"With the right structural details, the brightness of the luminescence retains a high level of thermal stability, which is important as LEDs with such inorganic phosphors reach operating temperatures of around 150°C."

Professor Huppertz states, "Together with the blue light of the semiconductor LED, efficient white light can thus be generated using a single phosphor obtained from available raw materials." Two different europium-based phosphors are currently mixed to achieve this.

"This offers the potential to create a [white light](#)-emitting LED with wide color tunability," adds Suta.

The researchers stress that further investigations are needed to determine the power densities required for excitation. Professor Huppertz concludes, "We need to see whether the brightness and power consumption of an LED with a manganese-activated [phosphor](#) based on our concept can actually compete with current LEDs."

More information: Lukas Maximilian Träger et al, Mn²⁺-Activated Alkali Lithooxidosilicate Phosphors as Sustainable Alternative White-Light Emitters, *Angewandte Chemie International Edition* (2025). DOI: [10.1002/anie.202504078](https://doi.org/10.1002/anie.202504078)

Journal information: [Angewandte Chemie International Edition](#)
Provided by [Heinrich-Heine University Duesseldorf](#)

JUNE 19, 2025

New report on importance of measurement of engineering

by [National Physical Laboratory](#) edited by [Lisa Lock](#), reviewed by [Andrew Zinin](#)

Credit: National Physical Laboratory

A new [report](#) launched today by the Institution of Mechanical Engineers (IMechE) and the National Physical Laboratory (NPL) emphasizes the critical role of measurement in engineering. As engineers drive innovation and commercialize new technologies, their expertise in measurement technologies is essential for ensuring precision and reliability across various industries.

The report outlines that better measurement leads to better outcomes, ensuring safety, efficiency, and sustainability. Selecting appropriate measurement tools and establishing robust protocols for their maintenance and [performance management](#) are crucial steps in mitigating the risks associated with inaccurate data.

Investment in training and education is vital to maintaining these standards. Engineers must possess a diverse skill set that includes not only technical knowledge but also an understanding of metrology's broader implications. Comprehensive training programs are

necessary to help professionals navigate the challenges posed by emerging technologies, ensuring the accuracy and reliability of measurements in ever-evolving engineering contexts.

IMechE and NPL are championing the importance of accurate measurement as a cornerstone of engineering excellence and innovation. The two organizations previously published a Good Practice Guide titled "Beginner's Guide to Measurement in Mechanical Engineering" in 2013, which remains relevant and widely used today. By promoting awareness of best practices in metrology and the need for robust training, IMechE and NPL aim to equip engineers with the necessary tools and knowledge to address the challenges posed by emerging technologies.

Investing in better measurement strengthens entire industries. By refining measurement techniques, engineers contribute to higher productivity, enhanced sustainability, and the seamless integration of emerging technologies.

NPL head of engineering, Dr. Rob Smith, said, "Measurement underpins much of our way of life and informs on decisions that can have impact on many aspects of our society. By successfully combining scientific and engineering approaches and capabilities, organizations like NPL can maximize the potential benefits from all aspects of accurate measurement. A trained and skilled workforce underpins any such strategy which makes the work of professional associations like the IMechE vital to our success."

IMechE President Clive Hickman OBE said, "Accurate measurement is critical to good engineering: If you can't measure it you can't make it! The U.K. is a leader in this area and should continue to invest in training the next generation of engineers and technicians in the sector. To deliver on our industrial strategy will require the expertise and leadership of our national laboratories, who underpin the science and engineering base of the U.K."

More information: The Power of Precision: How Better Measurement Drives Engineering Excellence. [www.imeche.org/policy-and-pres ... gineering-excellence](http://www.imeche.org/policy-and-pres...gineering-excellence)
Provided by [National Physical Laboratory](#)

JUNE 20, 2025

Three-mode smart window cut indoor temperature by 27°C and eliminate urban glare

by [The Korea Advanced Institute of Science and Technology \(KAIST\)](#) edited by [Sadie Harley](#), reviewed by [Robert Egan](#)

Operation mechanism of the RECM smart window. The RECM system can switch among three states—transparent, colored, and colored & deposition—via electrical stimulation. At -

1.6 V, DHV•+ and Prussian Blue (PB) are formed, blocking visible light to provide privacy protection and heat blocking. At -2.0 V, silver (Ag) is deposited on the electrode surface, reflecting light and heat, while DHV•+ and Prussian Blue absorb reflected light, effectively suppressing external glare. Through this mechanism, it functions as an active smart window that simultaneously controls light, heat, and glare. Credit: *ACS Energy Letters* (2025). DOI: 10.1021/acsenergylett.5c00637

In the building sector, which accounts for approximately 40% of global energy consumption, heat ingress through windows has been identified as a primary cause of wasted heating and cooling energy.

A KAIST research team has successfully developed a 'pedestrian-friendly smart window' technology capable of not only reducing heating and cooling energy in urban buildings but also resolving the persistent issue of 'light pollution' in urban living.

Professor Hong Chul Moon's research team at KAIST's Department of Chemical and Biomolecular Engineering have developed a 'smart window technology' that allows users to control the light and heat entering through windows according to their intent, and effectively neutralize glare from external sources.

The findings of this research are published in *ACS Energy Letters*.

Recently, active smart window technology, which enables free adjustment of light and heat based on user operation, has garnered significant attention. Unlike conventional windows that passively react to changes in temperature or light, this is a next-generation window system that can be controlled in real-time via electrical signals.

The next-generation smart window technology developed by the research team, RECM (Reversible Electrodeposition and Electrochromic Mirror), is a smart window system based on a single-structured electrochromic device that can actively control the transmittance of visible light and near-infrared (heat).

In particular, by effectively suppressing the glare phenomenon caused by external reflected light—a problem previously identified in traditional metal deposition smart windows—through the combined application of electrochromic materials, a 'pedestrian-friendly smart window' suitable for building facades has been realized.

Analysis of glare suppression effect of conventional reflective smart windows and RECM. This figure presents the results comparing the glare phenomenon occurring during silver (Ag) deposition between conventional reflective smart windows and RECM Mode III. Conventional reflective devices resulted in strong reflected light on the desk surface due to their high reflectivity. In contrast, RECM Mode III, where the colored material absorbed reflected light, showed a 33% reduction in reflected light intensity, and no reflected light was observed from outside. Credit: *ACS Energy Letters* (2025). DOI: 10.1021/acsenergylett.5c00637

The RECM system developed in this study operates in three modes depending on voltage control.

Mode I (transparent mode) is advantageous for allowing sunlight to enter the indoor space during winter, as it transmits both light and heat like ordinary glass.

In Mode II (colored mode), Prussian Blue (PB) and DHV+• [chemical species](#) are formed through a redox (oxidation-reduction) reaction, causing the window to turn a deep blue color. In this state, light is absorbed, and only a portion of the heat is transmitted, allowing for privacy while enabling appropriate indoor temperature control.

Mode III (colored and deposition mode) involves the reduction and deposition of silver (Ag^+) ions on the electrode surface, reflecting both light and heat. Concurrently, the colored material absorbs the reflected light, effectively blocking glare for external pedestrians.

The research team validated the practical indoor temperature reduction effect of the RECM technology through experiments utilizing a miniature model house.

When a conventional glass window was installed, the indoor temperature rose to 58.7°C within 45 minutes. Conversely, when RECM was operated in Mode III, the temperature reached 31.5°C , demonstrating a temperature reduction effect of approximately 27.2°C .

Furthermore, since each state transition is achievable solely by electrical signals, it is regarded as an active smart technology capable of instantaneous response according to season, time, and intended use.

Professor Hong Chul Moon of KAIST, the corresponding author of this study, stated, "This research goes beyond existing smart window technologies limited to visible light control, presenting a truly smart window platform that comprehensively considers not only active indoor thermal control but also the visual safety of pedestrians. Various applications are anticipated, from urban buildings to vehicles and trains."

More information: Hoy Jung Jo et al, Glare-Free, Energy-Efficient Smart Windows: A Pedestrian-Friendly System with Dynamically Tunable Light and Heat Regulation, *ACS Energy Letters* (2025). DOI: [10.1021/acsenergylett.5c00637](https://doi.org/10.1021/acsenergylett.5c00637)

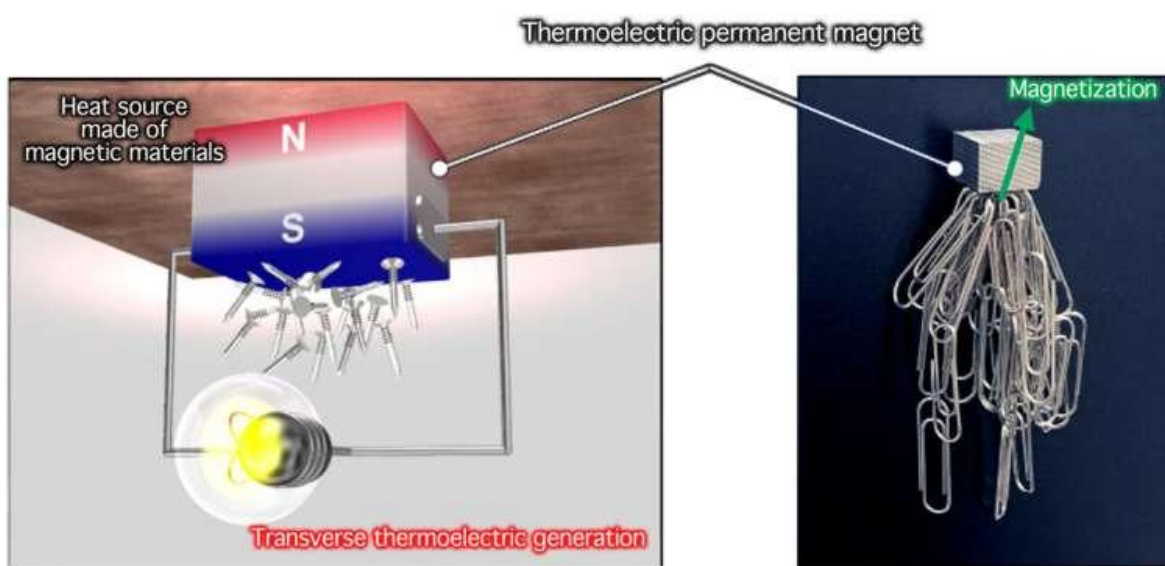
Journal information: [ACS Energy Letters](#)

Provided by [The Korea Advanced Institute of Science and Technology \(KAIST\)](#)

JUNE 23, 2025

'Thermoelectric permanent magnet' achieves record power density for energy harvesting

by [National Institute for Materials Science](#) edited by [Gaby Clark](#), reviewed by [Robert Egan](#)



Schematic of power generation by the thermoelectric permanent magnet, and a photograph of the artificially tilted multilayer consisting of a SmCo_5 -type magnet and $\text{Bi}_{0.2}\text{Sb}_{1.8}\text{Te}_3$. The thermoelectric permanent magnet can be easily installed onto a heat source made of magnetic materials with its magnetic force, and is capable of generating power by transverse thermoelectric conversion. The artificially tilted multilayer structure developed in this research has sufficient magnetic force to attach it onto a magnetic wall surface (background of the photograph) or to hang paper clips from it. Credit: Fuyuki Ando, National Institute for Materials Science; Ken-ichi Uchida, National Institute for Materials Science. In joint research with The University of Tokyo (UTokyo) and Nagoya University, the National Institute for Materials Science (NIMS) developed a new material "thermoelectric permanent magnet" exhibiting extremely high transverse thermoelectric conversion performance, and achieved transverse thermoelectric generation with a power density of 56.7 mW/cm^2 around room temperature in a thermoelectric-permanent-magnet-based module.

When converted into a value per applied temperature gradient, this is not only the world's highest power density among transverse thermoelectric modules, but a performance even comparable to commercial longitudinal thermoelectric modules. This achievement is

expected to lead to thermal energy harvesting and management technologies that can be utilized everywhere magnets are used. This research result was [published](#) in *Energy & Environmental Science* on March 18, 2025.

Conventional thermoelectric modules adopt a longitudinal thermoelectric effect, called the Seebeck effect, in which a charge current is generated in the same direction as an applied heat current. In general, the figure of merit zT for the Seebeck effect can be high, but the Seebeck-effect-based devices face the problem of having a complex module structure in order to separate the circuits for heat and charge currents.

On the other hand, a transverse thermoelectric effect, in which a charge current is generated in the orthogonal direction to an applied heat current, has drawn attention in recent years, as the module structure can be simplified significantly. However, there has been the problem that zT of known transverse thermoelectric materials is extremely low compared to that of longitudinal thermoelectric materials.

Magnetic and analytical transverse thermoelectric properties of MCM. Credit: *Energy & Environmental Science* (2025). DOI: 10.1039/D4EE04845H

The research group developed a "thermoelectric permanent magnet" with an artificially tilted multilayer structure consisting of an alternately stacked samarium-cobalt (SmCo_5)-type magnet and bismuth-antimony-tellurium ($\text{Bi}_{0.2}\text{Sb}_{1.8}\text{Te}_3$) compound that are sinter-bonded and cut in a tilted angle.

The group optimized the design of this tilted multilayer structure and minimized the electrical and thermal resistivities at the bonded interface, succeeding in obtaining two-orders of magnitude higher zT ($= 0.2$ at room temperature) than that previously reported by the anomalous Nernst effect in [magnetic materials](#).

Moreover, in power generation experiments, a thermoelectric module comprising the thermoelectric permanent magnet developed by the group achieved a [power density](#) of 56.7 mW/cm^2 at a temperature difference of 152°C . When converted into a value per applied [temperature gradient](#), this is not only the world's highest value among transverse thermoelectric modules, but a performance even comparable to commercial longitudinal modules.

Going forward, the research group aims to develop thermoelectric permanent magnet materials and thermoelectric generation / electronic cooling devices of even higher performance based on this research result. Having demonstrated thermoelectric generation performance comparable to commercial thermoelectric modules in a magnet, which is a material indispensable to human lives, this research is expected to lead to energy saving and energy harvesting technologies based on unprecedented concepts.

More information: Fuyuki Ando et al, Multifunctional composite magnet realizing record-high transverse thermoelectric generation, *Energy & Environmental Science* (2025). DOI: [10.1039/D4EE04845H](#)

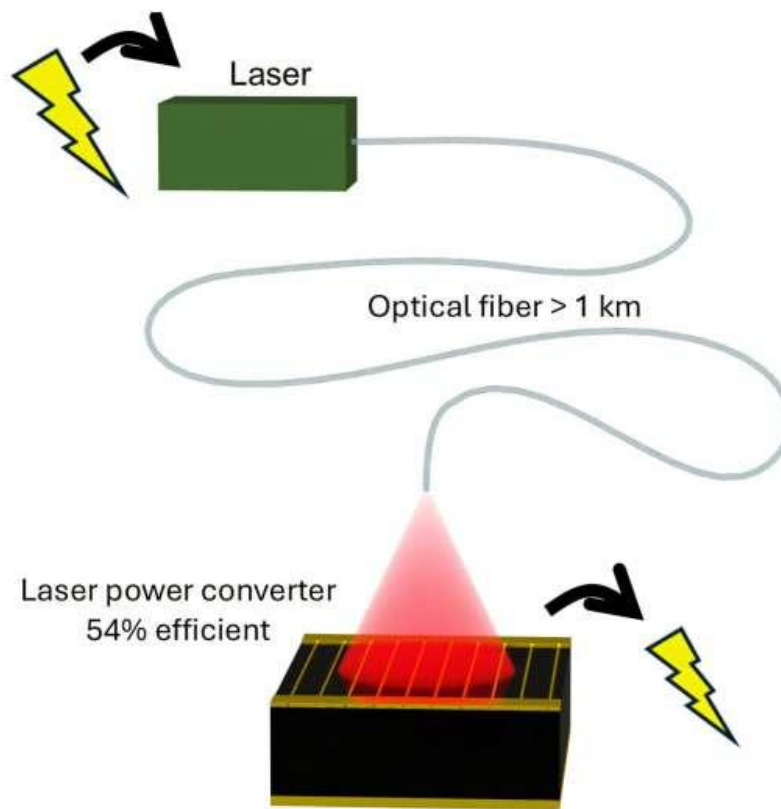
Journal information: [Energy & Environmental Science](#)

Provided by [National Institute for Materials Science](#)

JUNE 23, 2025

New laser power converters can transmit power to further, remote destinations

by [University of Ottawa](#) edited by [Lisa Lock](#), reviewed by [Robert Egan](#)



Credit: *Cell Reports Physical Science* (2025). DOI: 10.1016/j.xcrp.2025.102610

From smart grids to the internet of things, the modern world is increasingly reliant on connectivity between electronic devices. Thanks to University of Ottawa researchers, these devices can now be simultaneously connected and powered with a simple optical fiber over long distances, even in the harshest environments.

This significant step forward in the development of photonic power converters—devices that turn [laser light](#) into [electrical power](#)—could integrate laser-driven, remote power solutions into existing fiber optic infrastructure. This, in turn, could pave the way for improved connectivity and more reliable communication in remote locations and extreme situations.

"In traditional power over fiber systems, most of the laser light is lost," explains Professor Karin Hinzer of the University of Ottawa's SUNLAB, which collaborated with Germany's Fraunhofer Institute for Solar Energy Systems on the study. "With these new devices, the fiber can be much longer."

To address this, SUNLAB researchers developed a [simulation model](#) for multi-junction photonic power converters operating at [infrared wavelengths](#) used for telecommunications, which have low attenuation losses per kilometer in fiber. "The fabricated device shows a dramatic improvement in power and [data transmission](#) over distances longer than a kilometer, where traditional systems are not viable," adds Gavin Forcade, first author of the paper [published](#) in *Cell Reports Physical Science*.

Integrating power and fiber sensors

The term "multi-junction" means the devices are constructed by stacking many semiconductor junctions that absorb light, which results in more of the total laser light being converted to electric power, enabling higher efficiencies and voltages to be reached. Using this model, the teams were able to design and fabricate a photonic power converter producing over 2 volts at its maximum power point with an efficiency of more than 53%.

Adopting photonic power converters at telecom wavelengths could lead to more reliable telecommunication networks, reduce costs by enhancing systems performance and create faster more robust networks that could benefit many technologies, such as:

- Smart grid monitoring technologies
- Lightning-proof wind turbine blade monitoring sensors
- Spark-free fuel gauges in airplanes
- Distributed sensors for the Internet of Things (IoT)
- Remote video camera links
- Underwater sensors
- Laser power in free space, which enables future applications like simultaneously powering and communicating with drones, satellites and lunar vehicles.

"This could improve power to high voltage and monitoring sensors for [smart grids](#) without the risk of lightning faults, it could reduce sparking risks in hazardous environments and could potentially transmit power and data simultaneously to remote devices on existing fiber optic infrastructure," added Hinzer, the University Research Chair in Photonic Devices for Energy.

More information: Gavin P. Forcade et al, Multi-junction laser power converters exceeding 50% efficiency in the short wavelength infrared, *Cell Reports Physical Science* (2025). DOI: [10.1016/j.xcrp.2025.102610](https://doi.org/10.1016/j.xcrp.2025.102610)

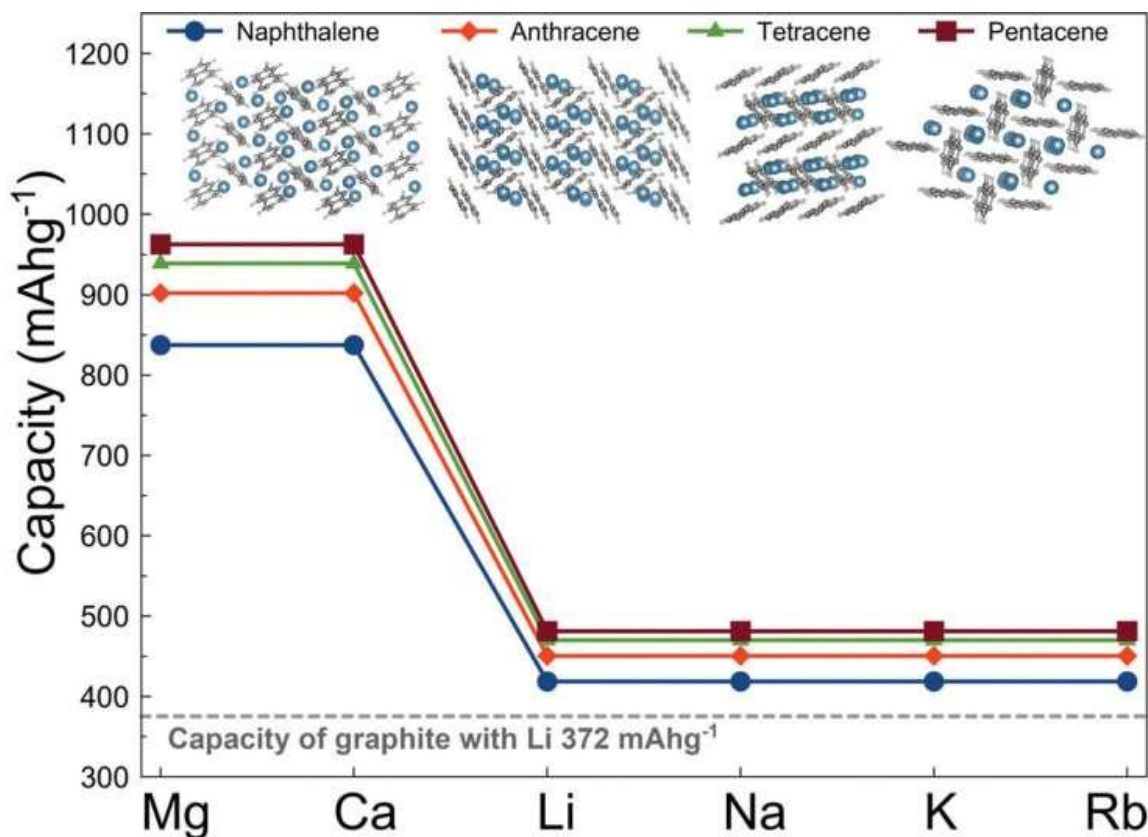
Journal information: [Cell Reports Physical Science](#)

Provided by [University of Ottawa](#)

JUNE 23, 2025

High-capacity battery anode material offers graphite alternative

by Oleg Sherbakov, [Skolkovo Institute of Science and Technology](#) edited by [Sadie Harley](#), reviewed by [Robert Egan](#)



Graphical abstract of the study. Credit: *Journal of Energy Storage* (2025). DOI: 10.1016/j.est.2025.116831

Skoltech researchers have investigated the use of polycyclic aromatic hydrocarbons as anode materials in metal-ion batteries. The high capacity, low operating voltage, and high electronic conductivity of carbon-based compounds make them a promising anode material.

The results of the study, [published](#) in the *Journal of Energy Storage*, open up prospects for creating cheaper and even more capacious anode materials.

Metal-ion batteries use graphite as their main anode material today. There are several drawbacks to it, such as its small capacity, which restricts the operating time of phones, computers, and other equipment, and its high cost. To produce it, the raw material must be burned at a temperature of about 3,000 degrees Celsius.

"Over the past few years, scientists have been actively looking toward creating anodes from organic materials such as [polyaromatic hydrocarbons](#)," said Senior Research Scientist Ilya Chepkasov from the Skoltech Energy Transition Center, the lead author of the study.

"They are cheaper and even more capacious than graphite. In our new work, we took four polyaromatic hydrocarbons—naphthalene, anthracene, tetracene, and pentacene—and intercalated various atoms—lithium, sodium, calcium, magnesium, rubidium, and potassium. All these metals are used in metal-ion batteries."

Polyaromatic hydrocarbons result from low-temperature combustion or thermal decomposition of organic materials. The main focus of the work is on the intercalation of atoms of alkali and alkaline earth metals (lithium, sodium, potassium, rubidium, magnesium, calcium) into the crystal structures of polyaromatic compounds. The calculations were done based on density functional theory.

The team examined different approaches to rectify Van der Waals interactions that affect the accuracy of calculations on the energy of metal intercalation into polyaromatic hydrocarbon crystals.

"We concluded that the capacity of all the studied crystals of polyaromatic hydrocarbons with metals significantly exceeds the standard values for a graphite electrode. For example, the capacity of lithium, sodium, potassium, and rubidium is 1.2–1.3 times higher than that of graphite. And with the intercalation of magnesium and calcium, this value reaches even higher values—about 2.3–2.6 times higher," said study co-author Professor Alexander Kvashnin from the Skoltech Energy Transition Center.

Polyaromatic hydrocarbons can enhance energy consumption in batteries, decrease the need for scarce elements (such as lithium), lessen the volumetric deformation of electrodes, and guarantee a quick charge-discharge reaction.

Tetracene and pentacene are particularly promising as [anode materials](#). They open the way to creating more efficient and cost-effective solutions for storing [electrical energy](#).

More information: Ilya V. Chepkasov et al, Polyaromatic hydrocarbons as prospective anode materials for metal ion battery, *Journal of Energy Storage* (2025). DOI: [10.1016/j.est.2025.116831](https://doi.org/10.1016/j.est.2025.116831)

Provided by [Skolkovo Institute of Science and Technology](#)

JUNE 30, 2025

Shape memory polymers with nanotips help solve micro-LED chip transfer problem

by [Pohang University of Science and Technology](#)

edited by [Gaby Clark](#), reviewed by [Robert Egan](#)

(Top) Macroscale applications (Bottom) Microscale applications(5 μ m-level micro-objects).
Credit: POSTECH

A research team at Pohang University of Science and Technology (POSTECH), has developed a novel dry adhesive technology that allows everything from microscale electronic components to common household materials to be easily attached and detached.

The study was recently [published](#) in the journal *Nature Communications*, and the team was led by Professor Seok Kim in collaboration with Professor Kihun Kim (POSTECH), Professor Namjoong Kim (Gachon University), Professor Haneol Lee (Chonbuk National University), and Dr. Chang-Hee Son (University of Connecticut, U.S.).

Micro-LEDs, a next-generation display technology, offer significant advantages such as higher brightness, longer lifespan, and the ability to enable flexible and transparent displays. However, transferring micro-LED chips—thinner than a strand of hair—onto target substrates with high precision and minimal residue has been a persistent challenge. Conventional methods relying on liquid adhesives or specialized films often result in overly complex processes, poor alignment accuracy, and residual contamination.

In addition, researchers have struggled with the so-called adhesion paradox—the theoretical prediction that surfaces should strongly adhere at the [atomic level](#), contrasted by the real-world difficulty of achieving strong adhesion due to [surface roughness](#) that limits actual contact area.

The POSTECH team ingeniously leveraged this paradox. Their solution lies in the use of shape memory polymers (SMPs) featuring densely packed nanotips. At room temperature, the surface remains rough, exhibiting low adhesion. When heated and pressed, the surface smooths out—much like ironing wrinkles—and achieves significantly stronger adhesion. Upon reheating, the surface returns to its original rough state, drastically reducing adhesion and enabling easy release.

This technology provides over 15 atmospheres of adhesion strength during bonding and near-zero force detachment through a self-release function. The difference in adhesion strength between the "on" and "off" states exceeds a factor of 1,000, outperforming

conventional approaches by orders of magnitude. The team demonstrated precise pick-and-place of micro-LED chips using a robotic system, and confirmed stable [adhesion](#) even with materials such as paper and fabric.

Manipulation of a curved shape object using the nanotipped SMP surface. Credit: POSTECH

"This innovation allows for the precise manipulation of delicate components without the need for sticky adhesives," said Professor Seok Kim of POSTECH. "It holds significant potential for applications in display and semiconductor manufacturing, and could bring about transformative changes when integrated with smart manufacturing systems across various industries."

More information: Junhyung Kim et al, Shape memory polymer surfaces with controllable roughness for multiscale switchable dry adhesion, *Nature Communications* (2025). DOI: [10.1038/s41467-025-60220-7](https://doi.org/10.1038/s41467-025-60220-7)

Journal information: [Nature Communications](#)

Provided by [Pohang University of Science and Technology](#)

JULY 4, 2025

Intelligent wound dressing controls inflammation

by Deborah Kyburz, [ETH Zurich](#) edited by [Sadie Harley](#), reviewed by [Andrew Zinin](#)

The intelligent wound dressing consists of a granular hydrogel. The small gel particles can be designed to specifically capture inflammatory signals or release healing molecules. Credit: Apoorv Singh / ETH Zurich

Chronic wounds are a major medical challenge, burdening health care systems with billions of dollars in costs every year. Pioneer Fellow BÖrte Emiroglu is developing a new product: a selective, sponge-like hydrogel that reduces inflammatory signals and actively promotes healing.

The work is [published](#) in the journal *Advanced Healthcare Materials*.

Emiroglu's academic career has taken her from Turkey to Zurich, after a master's degree, and straight into the interdisciplinary world of biomedical engineering at ETH Zurich. "Back then, I didn't even know what a hydrogel was," she recalls, thinking back to the early days of her doctoral research at the Macromolecular Engineering Laboratory under the supervision of Professor Mark Tibbitt.

But the unknown was precisely what fascinated her, and it was this that became the launchpad for a new technology. Emiroglu's goal was to develop an intelligent wound dressing that could actively influence the [healing process](#) in [chronic wounds](#). Her solution is based on granular hydrogels that capture pro-inflammatory signals from the tissue while simultaneously supporting regenerative processes.

Chronic wounds—such as those associated with diabetes or circulatory disorders—are a widespread medical problem. Many sufferers have open skin lesions that barely heal for months or even years. This is often due to an exaggerated immune response: instead of progressing to regeneration, the body remains trapped in a continuous loop of overactive inflammatory activity.

This is where start-up Immunosponge found its unique value, founded by Emiroglu and Apoorv Singh, a fellow researcher in Tibbitt's laboratory. Their wound dressing targets the molecular signals that perpetuate the loop.

"We want to guide a wound out of the inflammatory state and give it the right instructions for healing," says Emiroglu. "We want to aid the tissue to signal that now is the time for regeneration."

How exactly does the wound dressing work? "Imagine a sponge," says Emiroglu, "a material with a high absorption capacity." Technically speaking, the sponge consists of tiny gel particles—known as microgels—that are invisible to the naked eye. When combined in large numbers, they create a soft, sponge-like structure.

"In the laboratory, the material looks like jelly," explains Emiroglu.

This structure can be equipped with so-called ligands—surface molecules that target and bind specific signaling molecules. This enables the sponge to distinguish between useful and harmful signals.

"We don't want to just absorb anything and everything, like a kitchen sponge does; we need to selectively remove the pro-inflammatory molecules that wreak havoc in the local tissue, while at the same time initiating processes that promote healing," says Emiroglu.

The concept is heavily inspired by nature. "Mass transport is efficient at [short distances](#) in nature, especially in [unicellular organisms](#)," explains the researcher.

"But as soon as more complex organisms arise, there is a need for structures that organize the exchange of matter more efficiently—this is how cells within a tissue function and communicate with each other." It is precisely these principles that inspired Emiroglu and served as a model for the intelligent wound dressing.

The technology relies on lots of small building blocks to create an adaptable, functional structure.

"We are able to expand this library of building blocks which in the future will allow us to customize our technology for various patient groups and underlying diseases," says Emiroglu.

That means they can equip the gel beads with various other surface ligands so that different inflammatory messengers can be captured depending on the type of tissue defect.

Immunomodulatory granular hydrogels for the healing of chronic wounds. A) Granular hydrogels consist of microgel building blocks that are jammed into a macroscopic scaffold. B) Injectable granular hydrogels can be applied to a wound as a dressing, where diffusion and capture of inflammatory cytokines combined with the release of pro-angiogenic factors could improve wound healing outcomes. Credit: *Advanced Healthcare Materials* (2024). DOI: 10.1002/adhm.202400800

While the researchers are currently focusing on chronic skin wounds, the technology could also help with internal tissue damage, such as in the healing of bones, cartilage or tendons. "These tissues can have limited [blood supply](#) and thus often require efficient mass exchange during regeneration," explains Emiroglu.

In contrast to current methods, such as mechanical suction devices or non-specific wound dressings, which dry out a wound completely, Emiroglu's wound dressing targets a root cause and is intended to be used at an early stage.

The young researcher did not set out to enter the world of business. It was only towards the end of her dissertation that she and co-founder Singh began to think about taking the project one step further. Emiroglu officially began her Pioneer Fellowship at ETH Zurich at the start of April 2025.

Unofficially, she has been working on the translation of the technology for over a year. A job that involves much more than conducting research in the lab: "We're learning how the market works, what clinicians need and how we can turn our research into an effective product," explains Emiroglu.

This is also changing her perspective. "We come from a pure research background, where we rarely come into contact with users," she says. "Now, we're talking to doctors, nurses, market leaders and other professionals and getting to know their point of view."

Emiroglu states, "We are deliberately taking our time with the development. It's not about getting something onto the market as quickly as possible; it's about creating something with long-term value."

And in five or 10 years? "Maybe by then we'll have a market-ready solution with our start-up Immunosponge," she says. "Maybe we'll still be working on development. The important thing is to stay open, keep learning and not give up."

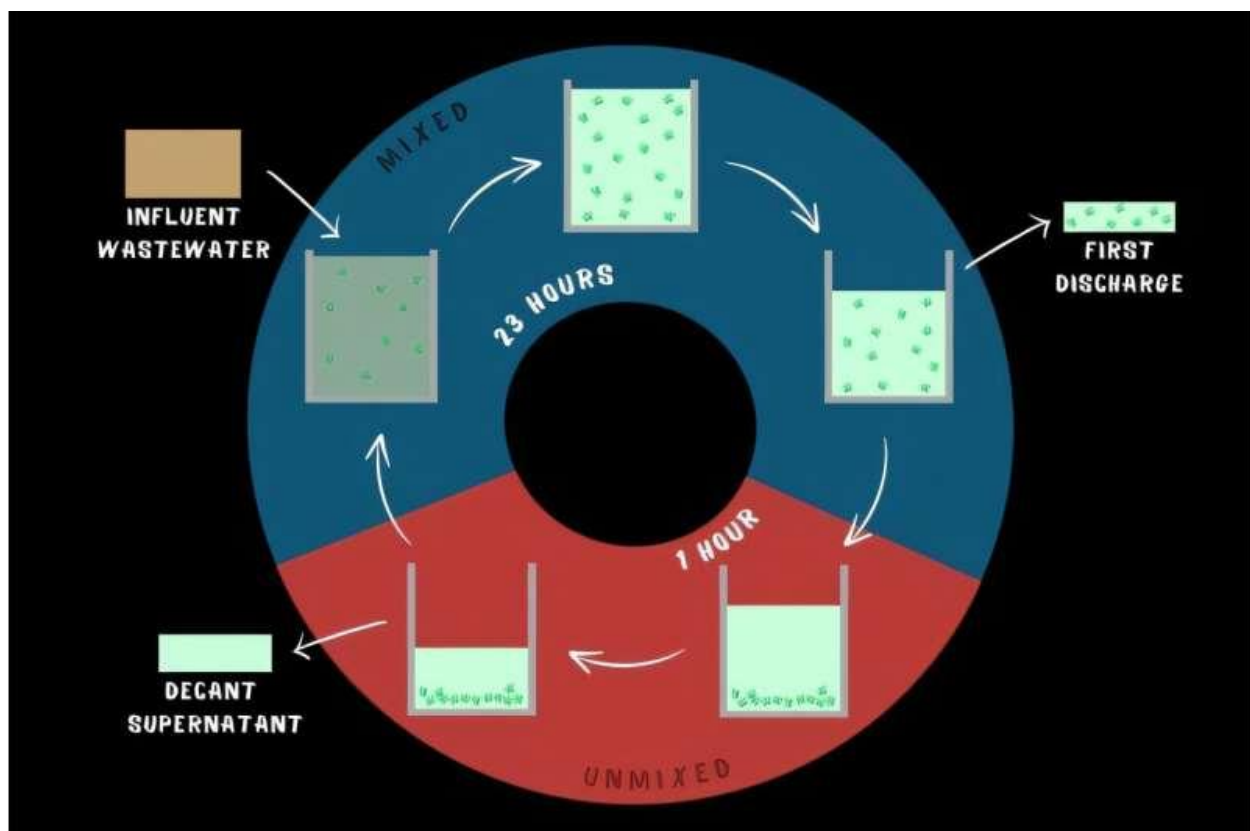
More information: Dilara Börte Emiroglu et al, Granular Biomaterials as Bioactive Sponges for the Sequestration and Release of Signaling Molecules, *Advanced Healthcare Materials* (2024). DOI: [10.1002/adhm.202400800](https://doi.org/10.1002/adhm.202400800)

Journal information: [Advanced Healthcare Materials](#)
Provided by [ETH Zurich](#)

JULY 4, 2025

Algae-based systems improve wastewater recycling for rural and regional communities

by [Flinders University](#) edited by [Sadie Harley](#), reviewed by [Andrew Zinin](#)



Graphical abstract. Credit: *Journal of Applied Phycology* (2025). DOI: [10.1007/s10811-025-03545-6](https://doi.org/10.1007/s10811-025-03545-6)

Rising rural populations, drought and climate change are making water scarcity a problem in country townships—with more efficient handling of sewage system wastewater part of the solution.

Pioneered by Flinders University environmental health experts, [local councils](#) in South Australia are operating sustainable energy-efficient sewage treatment operations with low-cost high-rate algal pond (HRAP) systems.

Now [new research](#) led by Flinders University is investigating improved effluent treatment and biosolids removal with "sequencing batch reactors"—or low-cost "SBR-HRAP" technology field trials—installed at SA Water's Angaston wastewater treatment plant in the Barossa Valley. The work is published in the *Journal of Applied Phycology*.

The good news is that the newer systems under development can work better and faster without major capital expense—due to the latest research of new approaches to bio-processing inside them, says Professor Howard Fallowfield, from the College of Science and Engineering at Flinders University.

The SBR techniques under development involve a new kind of algae and improved removal of waste from the water, for better quality non-potable water for use in parks, gardens, sporting fields and other purposes.

"Supported by SA Water and the ARC Biofilm Research and Innovation Center at Flinders, we are trialing selective enrichment of algal-bacterial combinations to produce higher-quality treated effluent," says Professor Fallowfield.

"Using wastewater from the Angaston community, our six pilot-scale HRAP tanks will compare the performance of these improved processes against the original HRAP operations."

Large high-rate algal pond systems, which have been treating wastewater at local council-owned facilities near [Kingston-on-Murray \(since 2013\)](#) and [Peterborough \(since 2018\)](#) in South Australia, use low-energy paddlewheels to move township and business organic waste along shallow channels where harmless green microalgae and bacteria remove pathogens and contaminants.

Ph.D. candidate Felipe Sabatté, who has used a native freshwater filamentous algal population to produce higher-quality clarified treated effluent, says the latest developments will be scaled up in the Angaston field trials.

"While high-rate algal ponds are an accepted method of wastewater treatment, particularly for regional and rural communities, they utilize microalgae which are difficult to remove from the treated wastewater, leading to unacceptably high suspended solids in the discharge," says Mr. Sabatté.

"These larger filamentous algae offer the prospect of easier separation from the treated wastewater, significantly improving treated effluent quality."

The outcome of this research provides a new operational strategy for wastewater HRAPs, particularly for the benefit of regional and [rural communities](#) challenged with water restrictions and to help meet [UN SDG6 \(clean water and sanitation\)](#) targets in the long run, he says.

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This research was conducted by the Australian Research Council Industrial Transformation Training Center for Biofilm Research and Innovation.

Also at the Angaston trial site, Flinders ARC Biofilm Research and Innovation Center Ph.D. researcher Sam Butterworth is investigating how to use this new technology to develop dense, algae-bacterial granules, which can be more readily removed from wastewater and to potentially reduce phosphorus levels.

"Algae-bacterial granule formation is a positive way for biofilms to form dense, fast-settling biomass and improve treated wastewater quality," says Mr. Butterworth.

"Using microalgae in high-rate algal ponds is increasingly seen as a better alternative to other wastewater treatment systems, such as activated sludge," he says.

Traditional wastewater treatment methods can use more energy and water and can be less sustainable due to higher greenhouse gas emissions.

[An independent validation](#) of the HRAP projects approved the treated [wastewater](#) to be used for non-food crop irrigation. For example, the Kingston-on-Murray ponds supply reuse water to irrigate a woodlot, and the ponds in Peterborough provide reuse water for a golf course and a sports field.

More information: F. Sabatte et al, High-rate algal ponds operated as sequencing batch reactors: Towards wastewater treatment with filamentous algae, *Journal of Applied Phycology* (2025). [DOI: 10.1007/s10811-025-03545-6](#)
Provided by [Flinders University](#)

JULY 3, 2025

The state of lithium

by Addison DeHaven, [South Dakota State University](#) edited by [Lisa Lock](#), reviewed by [Robert Egan](#)

Credit: Tyler Lastovich from Pexels

Shabbir Ahmed, assistant professor in South Dakota State University's Department of Mechanical Engineering, is conducting unique research to better understand a technological invention that has defined the 21st century: lithium-ion batteries.

In the late 1800s, miners extracted lithium from igneous rock deposits near Keystone, South Dakota. The Etta Mine was the first in the United States where lithium was unearthed, and doctors utilized the mineral to treat gout and mental illnesses, like mania and depression.

Today, lithium is almost exclusively used to make lithium-ion batteries—widely considered one of the most impactful technological inventions of the last 100 years. From iPhones to laptops to electric vehicles, the lithium-ion battery is the most powerful rechargeable battery commercially available and has effectively transformed how we communicate as a society. In the future, lithium-ion batteries are expected to be utilized even more for sustainable transportation and energy.

But there are still considerable challenges related to lithium-ion batteries, and Ahmed is working toward a solution.

Is the gauge accurate?

A fuel gauge is found in most cars and is used to indicate the amount of a fuel in a tank. Fuel gauges provide a clear picture of how long a car has before it must be refilled. Electronic devices—like cell phones, laptops and tablets—have a similar mechanism.

Often found in the upper right-hand corner of the screen, the "state of charge" displays the power remaining in the device. Like the fuel gauge in the car, it represents how much energy is left in the battery system and is inferred by microprocessors in the devices using a combination of current and voltage.

The state of charge is displayed as a percentage of the battery's storage. For example, your [cell phone](#) shows it has 75% remaining. The question is: How accurate is that percentage?

According to Ahmed, the state of charge is not nearly as accurate as we may think.

"It's not exactly accurate for several reasons," Ahmed said. "It's just an approximation."

Another consideration is the battery's "state of health." Lithium-ion batteries undergo an [aging process](#) with use. For example, cell phone owners might notice that the charge on their phone doesn't last nearly as long after a few years of use. This aging concept can be measured as the battery's "state of health," or how much of the original battery's capacity remains. In general, electronic devices do not provide users with the state of health of their device's lithium-ion battery.

"My research is looking to more accurately predict the state of charge and the state of health through different types of measurements," Ahmed said.

For cell phones, laptops and chargers, knowing the precise state of charge or the state of health is not exactly essential information for using the device. It may be inconvenient, but it does not completely inhibit usage. But if lithium-ion batteries are going to take a more central role in transportation—say, for all-electric helicopters—knowing the exact state of charge and state of health is essential.

"For cell phones, this might not be that important," Ahmed said. "But for EV-powered transportation, like cars or helicopters, it is much more important."

Wave measurements

Lithium-ion batteries function as lithium ions shuffle between the positive and negative sides of the battery via the separator. When a device is "on" (discharging) and providing an electric current, the anode—negative side of the battery—releases lithium ions to the cathode—the positive side—generating a flow of electrons. When the device is plugged in and charging, the opposite happens. Lithium ions are released by the cathode and received by the anode.

The amount of charge remaining in a device is essentially the concentration of ions on either side. For example, a fully charged device would see all the lithium ions concentrated on the anode side of battery.

In a lab condition, Ahmed would be able to disassemble the battery, separate the elements and see exactly how many lithium ions were on either side of the battery—giving him a precise measurement of the battery's lithium concentration and state of charge. But that's not feasible for real-world applications.

"When a lithium-ion battery is in use, you cannot disassemble it—you cannot measure it," Ahmed explained.

To get an exact measurement, Ahmed places a small sensor on the outside of the battery to send an ultrasonic guided wave signal through the lithium-ion battery. The wave signal—which Ahmed views as data on his computer—allows him to more accurately judge the lithium concentration. If the wave signal is higher than the lithium concentration, the battery is charged. If lower, the battery is discharging. The rate at which the wave changes in relation to the lithium concentration provides an accurate measurement of the battery's charge.

"By analyzing the wave signal's change, I can actually infer more accurately my state of charge and my state of health," Ahmed said.

This information can then be used to develop [efficient algorithms](#) to accurately predict the state of health and state of charge in lithium-ion batteries. Companies, especially those producing [electric vehicles](#), would be interested in the accuracy of these algorithms, Ahmed noted.

Ahmed, who earned his doctorate from Rensselaer Polytechnic Institute in New York, began this work as a postdoctoral scholar at Stanford University. At Rensselaer, he focused his research on modeling ultrasonic guided waves and developing robust algorithm through those models. He then applied that expertise to lithium-ion batteries at Stanford.

"There was limited research on this specific area of lithium-ion batteries," Ahmed explained.

In the future, Ahmed will continue his work on [lithium-ion batteries](#) but is eager to expand his research into the growing field of robotics, where he sees a range of possibilities.

Provided by [South Dakota State University](#)

JULY 3, 2025

AI helps discover optimal new material for removing radioactive iodine contamination

by [The Korea Advanced Institute of Science and Technology \(KAIST\)](#)

edited by [Lisa Lock](#), reviewed by [Robert Egan](#)

Credit: *Journal of Hazardous Materials* (2025). DOI: 10.1016/j.jhazmat.2025.138735
Managing radioactive waste is one of the core challenges in the use of nuclear energy. In particular, radioactive iodine poses serious environmental and health risks due to its long half-life (15.7 million years in the case of I-129), high mobility, and toxicity to living organisms.

A Korean research team has successfully used artificial intelligence to discover a new material that can remove iodine for nuclear environmental remediation. The team plans to push forward with commercialization through various industry–academia collaborations, from iodine-adsorbing powders to contaminated water treatment filters.

Professor Ho Jin Ryu's research team from the Department of Nuclear and Quantum Engineering, in collaboration with Dr. Juhwan Noh of the Digital Chemistry Research Center at the Korea Research Institute of Chemical Technology, developed a technique using AI to discover new materials that effectively remove [radioactive iodine](#) contaminants. Their research is [published](#) in the *Journal of Hazardous Materials*.

Recent studies show that radioactive iodine primarily exists in aqueous environments in the form of iodate (IO_3^-). However, existing silver-based adsorbents have weak chemical

adsorption strength for iodate, making them inefficient. Therefore, it is imperative to develop new adsorbent materials that can effectively remove iodate.

Professor Ho Jin Ryu's team used a machine learning-based experimental strategy to identify optimal iodate adsorbents among compounds called Layered Double Hydroxides (LDHs), which contain various metal elements.

The multi-metal LDH developed in this study— $\text{Cu}_3(\text{CrFeAl})$, based on copper, chromium, iron, and aluminum—showed exceptional adsorption performance, removing more than 90% of iodate. This achievement was made possible by efficiently exploring a vast compositional space using AI-driven active learning, which would be difficult to search through conventional trial-and-error experiments.

The research team focused on the fact that LDHs, like high-entropy materials, can incorporate a wide range of metal compositions and possess structures favorable for anion adsorption. However, due to the overwhelming number of possible metal combinations in multi-metal LDHs, identifying the optimal composition through traditional experimental methods has been nearly impossible.

To overcome this, the team employed AI ([machine learning](#)). Starting with [experimental data](#) from 24 binary and 96 ternary LDH compositions, they expanded their search to include quaternary and quinary candidates. As a result, they were able to discover the optimal material for iodate removal by testing only 16% of the total candidate materials.

Professor Ho Jin Ryu said, "This study shows the potential of using [artificial intelligence](#) to efficiently identify radioactive decontamination materials from a vast pool of new material candidates, which is expected to accelerate research for developing new materials for nuclear environmental cleanup."

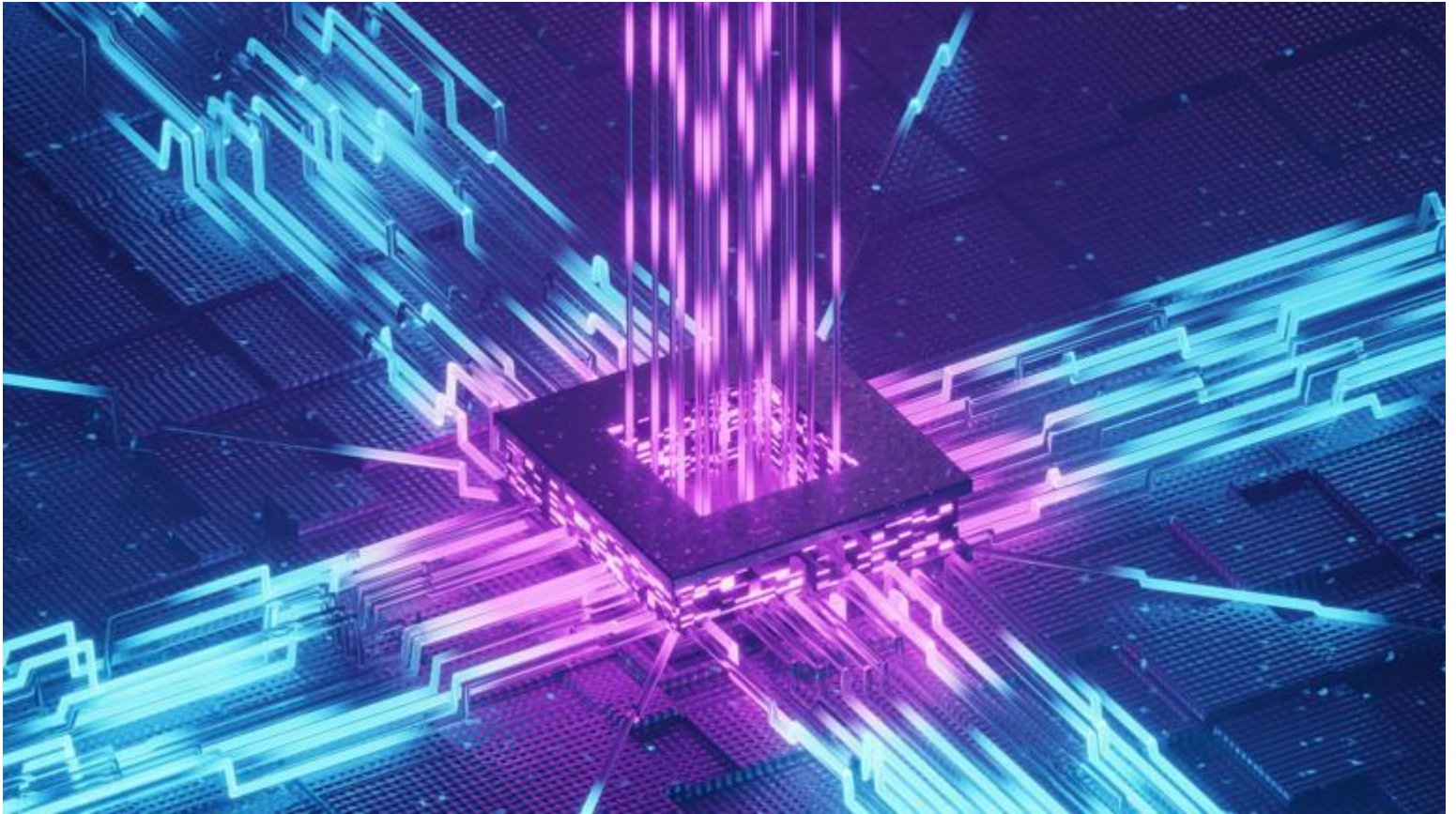
The research team has filed a domestic patent application for the developed powder technology and is currently proceeding with an international patent application. They plan to enhance the material's performance under various conditions and pursue commercialization through industry-academia cooperation in the development of filters for treating contaminated water.

More information: Sujeong Lee et al, Discovery of multi-metal-layered double hydroxides for decontamination of iodate by machine learning-assisted experiments, *Journal of Hazardous Materials* (2025). DOI: [10.1016/j.jhazmat.2025.138735](https://doi.org/10.1016/j.jhazmat.2025.138735)

Journal information: [Journal of Hazardous Materials](#)

Provided by [The Korea Advanced Institute of Science and Technology \(KAIST\)](#)

Quantum 'translator': A tiny silicon chip links microwaves and light like never before



Quantum 'translator': A tiny silicon chip links microwaves and light like never before

Imagine if future quantum computers could talk to each other across cities, countries, even continents without losing their spooky quantum connection. A team of researchers from the University of British Columbia (UBC) has created a device that could help us realize this future.

This device, which is just a tiny chip made of silicon, works like a universal translator, converting signals between two incompatible energies: microwaves and light. This chip can convert up to 95% of a quantum signal in both directions, and with almost zero noise.

“It’s like finding a translator that gets nearly every word right, keeps the message intact and adds no background chatter,” lead researchers Mohammad Khalifa, and a graduate research assistant at UBC’s Blusson Quantum Matter Institute, [said](#).

Khalifa and his team suggest that this [innovation](#) could one day unlock the [dream of a quantum internet](#), making information transfer more secure, faster, and much more powerful than anything we have today.

Quantum communication is a tricky game

Quantum computers store and process information using microwave signals, but microwaves can’t travel well through long-distance cables and get absorbed and lost. This is why the internet [uses light signals](#) (optical photons) that travel through fibre-optic cables.

For a quantum internet to work, we need a way to convert microwave signals into optical ones and back, without disturbing the fragile quantum information they carry. This is harder than it sounds. Even tiny disturbances during this conversion can destroy the quantum link between entangled particles, ruining the data.

Many experimental devices have tried to solve this problem, but most add too much noise, don’t work both ways, or only work in complex lab settings. The UBC team has proposed a device that solves this problem using a [clever trick inside silicon](#). Their design involves a silicon chip, similar to those used in everyday electronics, but with tiny magnetic defects intentionally added to it.

These defects contain electrons trapped at specific points. When a microwave signal (used in quantum computing) and an optical signal (used in communication) are carefully tuned to match the energy levels of these trapped electrons, the electrons can flip states without absorbing energy.

This lets them act as messengers, smoothly converting one type of signal into the other, and they do this very efficiently as well. For instance, the chip can convert up to 95% of the signal with virtually no added noise, a huge improvement over earlier attempts.

“Most importantly, this device preserves the quantum connections between distant particles and works in both directions. Without that, you’d just have expensive individual computers. With it, you get a true quantum network,” Khalifa added.

It’s also extremely power-efficient, running on just millionths of a watt. To keep everything stable and quantum-friendly, the design uses superconducting materials that conduct electricity with no resistance.

The future of the quantum internet

Though this approach is still theoretical, the proposed chip design represents a major step forward in building long-distance quantum networks. If realized, it could allow quantum computers in different parts of the world to stay entangled in a way that classical systems can’t match.

That could lead to [unhackable internet communication](#), indoor GPS systems, and ultra-powerful computing tools capable of designing new drugs or simulating complex natural systems.

However, this isn’t happening overnight. The team’s work lays the foundation, but now comes the challenge of physically building and testing the chip.

“We’re not getting a quantum internet tomorrow, but this clears a major roadblock. Currently, reliably sending quantum information between cities remains challenging. Our approach could change that,” Joseph Salfi, one of the study authors and an assistant professor at UBC, said.

Obviously, it would take some time before the design is realized. However, the best part is—the proposed device can be built using existing chip-manufacturing technologies. That means it can eventually be mass-produced and integrated into today’s [fiber-optic networks](#) without reinventing the entire system.

The [study](#) is published in the journal *npj quantum information*.

Scientists create 'universal translator' for quantum tech

Silicon breakthrough could lay the foundation for a global quantum internet

Date:

June 20, 2025

Source:

University of British Columbia

Summary:

Scientists at UBC have devised a chip-based device that acts as a "universal translator" for quantum computers, converting delicate microwave signals to optical ones and back with minimal loss and noise. This innovation preserves crucial quantum entanglement and works both ways, making it a potential backbone for a future quantum internet. By exploiting engineered flaws in silicon and using superconducting components, the device achieves near-perfect signal translation with extremely low power use and it all fits on a chip. If realized, this could transform secure communication, navigation, and even drug discovery.

UBC researchers have proposed a chip that could link quantum computers across long distances by translating signals between microwave and optical formats without losing quantum integrity. Credit: Shutterstock

UBC researchers are proposing a solution to a key hurdle in quantum networking: a device that can "translate" microwave to optical signals and vice versa.

The technology could serve as a universal translator for quantum computers -- enabling them to talk to each other over long distances and converting up to 95 per cent of a signal with virtually no noise. And it all fits on a silicon chip, the same material found in everyday computers.

"It's like finding a translator that gets nearly every word right, keeps the message intact and adds no background chatter," says study author Mohammad Khalifa, who conducted the research during his PhD at UBC's faculty of applied science and the UBC Blusson Quantum Matter Institute.

"Most importantly, this device preserves the quantum connections between distant particles and works in both directions. Without that, you'd just have expensive individual computers. With it, you get a true quantum network."

How it works

Quantum computers process information using microwave signals. But to send that information across cities or continents, it needs to be converted into optical signals that travel through fibre optic cables. These signals are so fragile, even tiny disturbances during translation can destroy them.

That's a problem for entanglement, the phenomenon quantum computers rely on, where two particles remain connected regardless of distance. Einstein called it "spooky action at a distance." Losing that connection means losing the quantum advantage. The UBC device, described in *npj Quantum Information*, could enable long-distance quantum communication while preserving these entangled links.

The silicon solution

The team's model is a microwave-optical photon converter that can be fabricated on a silicon wafer. The breakthrough lies in tiny engineered flaws, magnetic defects intentionally embedded in silicon to control its properties. When microwave and optical signals are precisely tuned, electrons in these defects convert one signal to the other without absorbing energy, avoiding the instability that plagues other transformation methods.

The device also runs efficiently at extremely low power -- just millionths of a watt. The authors outlined a practical design that uses superconducting components, materials that conduct electricity perfectly, alongside this specially engineered silicon.

What's next

While the work is still theoretical, it marks an important step in quantum networking.

"We're not getting a quantum internet tomorrow -- but this clears a major roadblock," says the study's senior author Dr. Joseph Salfi, an assistant professor in the department of electrical and computer engineering and principal investigator at UBC Blusson QMI.

"Currently, reliably sending quantum information between cities remains challenging. Our approach could change that: silicon-based converters could be built using existing chip fabrication technology and easily integrated into today's communication infrastructure."

Eventually, quantum networks could enable virtually unbreakable online security, GPS that works indoors, and the power to tackle problems beyond today's reach such as designing new medicines or predicting weather with dramatically improved accuracy.

In-Wheel EV Hub Motors Could Be A Game-Changer. Why Aren't They Here Yet?

In-Wheel EV Hub Motors Could Be A Game-Changer. Why Aren't They Here Yet?



In-wheel hub EV motor© InsideEVs

They seem like a natural choice for electric vehicles, yet hardly any modern EVs have them. That may be changing soon.

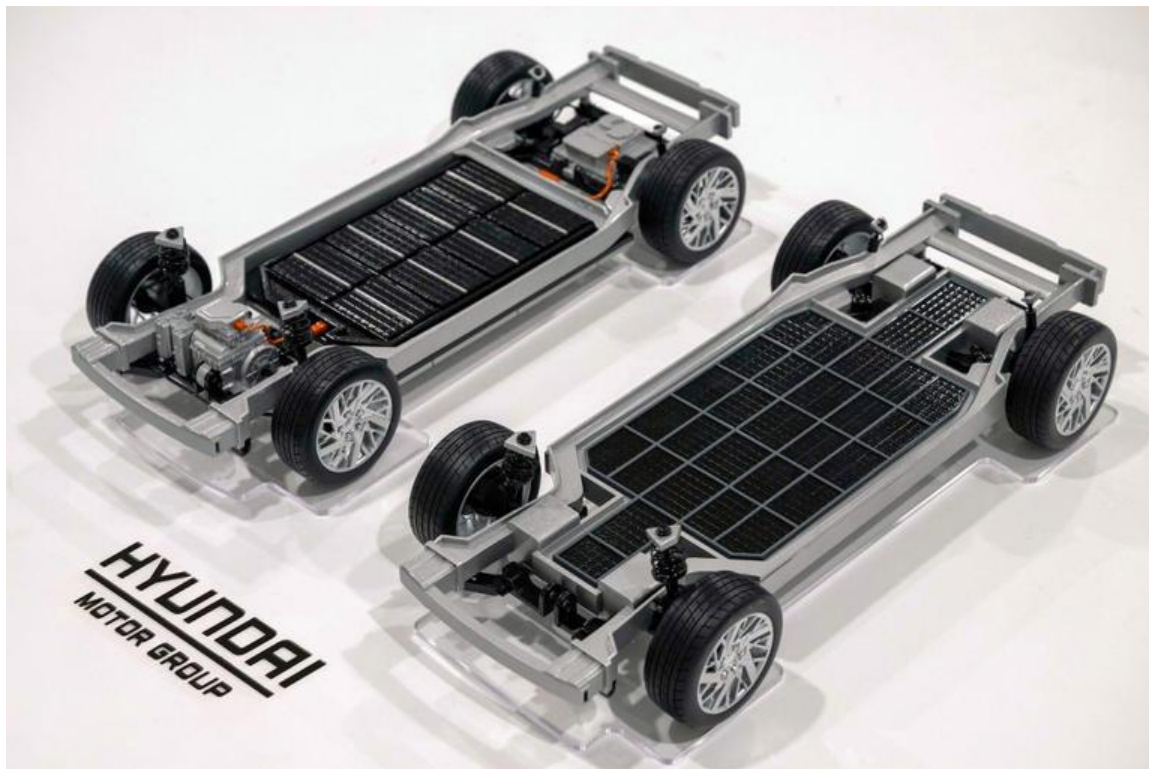
Ferdinand Porsche, it seems, was always ahead of the curve. He conceived one of the earliest electric cars back in 1900, which later added a gas engine to

compensate for its primitive lead batteries. Today, we'd call that a range-extended EV, and those may be the next big thing in electrification.

But that car had another bit of technology that's coming around again: [in-wheel hub motors](#), which eventually gave rise to the first all-wheel-drive vehicle. In-wheel motors differ from the ubiquitous inboard motors because they are essentially part of the wheel, eliminating the need for drive shafts or differentials.

They allow for more direct power transmission to the road and have several advantages that you'd think would have made them more popular by now.

Hyundai is one of the few other OEMs working on hub motors. Its project, [called Uni Wheel](#), envisions a broad range of drive units for uses in EVs and other products, touting the same benefits of improved packaging and freeing up more interior room. The manufacturer says it plans to use in-wheel motors in all types of vehicles, from small cars to performance EVs, in the future.



[large-57950-hyundaimotorandkiaunveilparadigm-shiftinguniwheel drivesystemtotransformmobilitydesign](#)

A view of a Hyundai EV platform without in-hub motors (left) and with them (right.) Notice the difference in space savings that could be used for new designs and packaging choices.

Photo by: Hyundai

Hub motors would also make sense in an urban delivery vehicle, where they could allow for even more cargo room within a set track width and wheelbase. Since you can get rid of a conventional axle, there's no reason why you couldn't use the space between the wheels for extra storage capacity, allowing the van to carry even more boxes.

Automotive driveline supplier Neapco teamed up with in-wheel motor specialist Elaphe and designed a hub motor called SuperBear specifically for this purpose, touting the above advantages. Its drive units even feature a built-in two-speed gearbox, and they are designed to fit on a regular commercial-grade rim for both front- and rear-wheel drive applications.

Having heavy motors that power the front wheels can't be good for steering, though. Having hub motors on the front axle may require additional reengineering of the front suspension and steering system to make it controllable and reduce what could potentially be very severe torque steer.

They are designed to power a vehicle on their own or together with a combustion engine as part of a hybrid system. Electrifying older vehicles is also a viable use for these motors, although the idea isn't new and other companies have also tried developing similar solutions but ultimately failed to deliver them to market as promised.

We also can't forget [the Lordstown Endurance](#), which had four Elaphe-sourced in-wheel motors, and it almost made it into production. Maybe it was too ahead of its time with its unique motors and extended-range electric powertrain that featured a small battery. Range extenders are seen as a possible next big thing in the electrified vehicle space, but none of them will have motors inside their wheels.

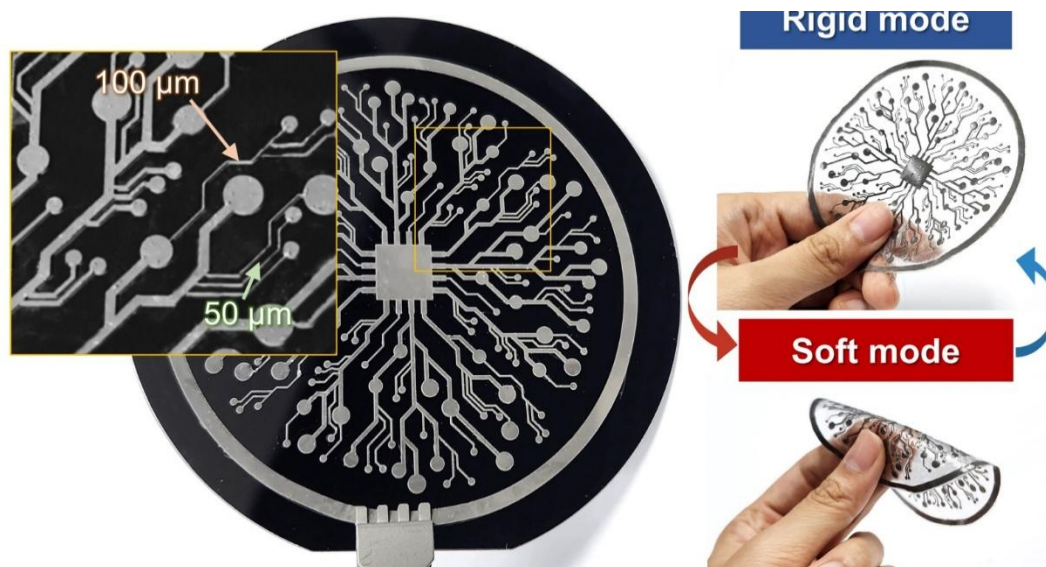
Like Neapco, UK-based Protean Electric is also working on in-wheel motors for both passenger and commercial vehicles, as well as more heavy-duty applications. Its most recent Gen 5 Proteandrive motors make 138 hp, so up to 552 hp in a quad-motor configuration. It fits inside an 18-inch wheel, and they say it's compatible with vehicles weighing up to 11,400 pounds (5.2 tonnes).

Many companies say their vehicle is built on a "skateboard platform," but, in reality, it's just a structural battery pack and two subframes bolted to it—it's not a true skateboard. Having four in-wheel motors would allow for a true skateboard-like platform, freeing up the space between the wheels to be used in other ways (like for additional battery modules to extend the range).

Hub motors have found widespread success in two-wheeled vehicles of all shapes and sizes. But in four-wheeled vehicles, they were only sporadically used over the decades, typically just for testing purposes (or in Moon rovers), but they never became a staple of electrified automotive engineering. That could all change once a company brings them to market, taking advantage of all their benefits and seeing success with such a project.

Scientists invent weird, shape-shifting 'electronic ink' that could give rise to a new generation of flexible gadgets published June 28, 2025

Scientists harnessed the unique properties of gallium to create the ink, which can be produced using conventional printing methods.



(Image credit: Authors: Simok Lee et al.)

Scientists have developed a new kind of "electronic ink" that can be used to print electronic circuits capable of switching between rigid and soft states when heated.

The technology could pave the way for next-generation electronic devices that change shape or stiffness depending on how and where they're used, from medical implants that soften inside the body to flexible robotics.

The ink combines gallium, a metal that's solid at room temperature but melts just below body temperature — 98.6 degrees Fahrenheit (37 degrees Celsius) — with a [polymer](#)-based solvent that breaks down when gently heated. The result is a stable, printable substance that becomes conductive after heating and can change its stiffness in response to temperature.

The findings were published May 30 in the journal [Science Advances](#).

"This opens up new possibilities for future personal electronics, medical devices and robotics," study co-author [Jae-Woong Jeong](#), professor of electrical engineering at the Korea Advanced Institute of Science and Technology (KAIST), said in a [statement](#).

Most electronics today fall into one of two camps: rigid devices like smartphones and [laptops](#), which offer performance and durability at the cost of flexibility; or soft systems like wearables, which are more comfortable to wear but can be harder to fabricate precisely or integrate with more complex components.

From hardware to soft-wear

So-called variable-stiffness electronics aim to bridge this gap, enabling devices to shift between hard and soft states as needed.

[Gallium](#) has long attracted interest in this area because of how differently it behaves in solid and liquid forms. But using it for printed electronics has proven difficult due to its high surface tension and tendency to oxidize when exposed to air, forming a kind of crust that prevents it from bonding or spreading properly.

To address this, the researchers developed a process for dispersing microscopic gallium particles into a polymer matrix — essentially a flexible, ink-like base — using a solvent called dimethyl sulfoxide (DMSO).

When the printed circuit is gently heated, the solvent breaks down and creates a slightly acidic environment. This strips away the oxide layer from the gallium particles, enabling them to melt and merge to form conductive pathways.

The resulting ink can be used to print features as small as 50 micrometers (0.002 inches or 0.005 centimeters) — [thinner than a human hair](#) — and can alternate between plastic-like hardness and rubbery softness as needed. The researchers said that the material became more than 1,400 times softer when warmed during tests.

The team built two working devices to demonstrate how the bendy technology might be used. One was a wearable health device that behaves like a rigid portable electronic at room temperature, then softens on contact with skin to improve comfort. The other was a flexible brain implant that remained rigid during surgery so it could be precisely inserted, and then softened once inside the brain to help reduce irritation and inflammation.

The ink can be used with common manufacturing techniques such as screen printing and dip coating, meaning it could be used in larger-scale or [3D-printed](#) electronics in the future, the researchers said.

"The core achievement of this research lies in overcoming the longstanding challenges of liquid metal printing through our innovative technology," Jeong said in the statement. "By controlling the ink's acidity, we were able to electrically and mechanically connect printed gallium particles, enabling the room-temperature fabrication of high-resolution, large-area circuits with tunable stiffness."

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JULY 7, 2025

[The GIST](#)

Stretchable electronics: Conductive polymer optimized for wearable biosensors

by Christian Schneider, [Max Planck Society](#) edited by [Sadie Harley](#), reviewed by [Robert Egan](#)

Properties of strained PEDOT:PSS thin films. Credit: *Advanced Science* (2025). DOI: 10.1002/advs.202502853

When aiming for stretchable, health-monitoring, skin-like sensor sheets, materials with demanding properties are required: they need to be flexible, biocompatible, and electrically conductive at the same time.

A research team at the Max Planck Institute for Polymer Research is tackling this complex task. In a recent study, the scientists present an innovative approach: using a transfer-printing process, the conductive polymer PEDOT:PSS is modified via plasticizers that diffuse from the substrate into the polymer film. This significantly improves both the electrical conductivity and the stretchability of the material.

The research results have been [published](#) in the journal *Advanced Science*.

A deformable patch that measures the [heart rate](#) or detects biomarkers in the sweat and feels as soft and flexible as one's own skin—such visions demand new material developments.

To realize ideas like these, as well as wearable and skin-like electronics in general, materials that possess both [high electrical conductivity](#) and mechanical stretchability are required.

A team of scientists at the Max Planck Institute for Polymer Research led by Dr. Ulrike Kraft is currently working on this challenge. However, stretchability and electrical conductivity are often contradictory, which complicates the development of suitable materials, explains Ulrike Kraft, head of the Organic Bioelectronics Research Group.

In their current study, the researchers demonstrate how these conflicting objectives can be overcome through the targeted transfer of plasticizers from the substrate into the PEDOT:PSS polymer film.

Their approach takes advantage of a transfer-printing process that enables the rapid, reliable, and straightforward transfer of conductive polymer films onto stretchable, biodegradable substrates. As a conducting polymer, the particularly promising material PEDOT:PSS is used, which combines transparency, flexibility, and biocompatibility.

"The plasticizers contained in the substrates diffuse into the conductive polymer, thereby improving both the electrical performance and the [mechanical properties](#)," explains Carla Volkert, doctoral student and first author of the study.

The approach furthermore enables fundamental insights into the behavior of stretchable electronic materials. Combining various analytical methods—including electrical characterization, microscopic imaging, [atomic force microscopy](#), and Raman spectroscopy—the researchers were able to gain new insights into the morphological and electronic changes of PEDOT:PSS under strain.

Particularly noteworthy is the observed chain alignment of the [polymer](#) chains, which results in increased electrical conductivity under mechanical stress.

"Our method simultaneously improves the stretchability and electrical conductivity of PEDOT:PSS—an important step towards on-skin biosensors," explains Ulrike Kraft, head of the Organic Bioelectronics Research Group.

This work hence not only represents an important contribution to the fundamental understanding of soft, stretchable conductive materials, but also opens up new perspectives for the development of innovative technologies—from flexible electrodes for electrocardiograms (ECGs) to stretchable biosensors on the skin that can detect and monitor analytes such as stress hormones in sweat.

The next aim will be the application of this new approach for the fabrication and characterization of stretchable biosensors.

More information: Carla Volkert et al, Enhanced Electrical Performance and Stretchability by Plasticizer-Facilitated PEDOT:PSS Self-Alignment, *Advanced Science* (2025). DOI: [10.1002/advs.202502853](https://doi.org/10.1002/advs.202502853)

Journal information: [Advanced Science](#)
Provided by [Max Planck Society](#)

JULY 9, 2025

High-temperature shape memory alloys could boost fighter jet efficiency and performance

by Leon Contreras, [Texas A&M University](#) edited by [Gaby Clark](#), reviewed by [Andrew Zinin](#)

Credit: Pixabay/CC0 Public Domain

In aerospace applications, high-temperature shape memory alloys (HTSMAs)—materials capable of remembering and returning to their original shapes after heating—are often constrained by high costs since they rely on expensive elements to function at elevated temperatures.

Fighter jets like the F/A-18 need to fold their wings to fit on crowded aircraft carriers. The system that folds the wings relies on heavy mechanical parts. But with new lighter, smarter alloys, those movements could be done with less weight and more efficiency. That means more jets can be ready to fly, faster and with less energy wasted.

The researchers have published their findings in the journal [Acta Materialia](#). The research showcases how artificial intelligence (AI) and high-throughput experimentation can be combined to accelerate materials discovery and reduce development costs.

This pioneering study sets the stage for a new era in functional alloy design—faster, cheaper, and smarter. That means everything that can use this process could soon be made with materials that are not only more efficient but also more affordable for those seeking to save on costs.

The team is being led by Department Head and Chevron Professor Dr. Ibrahim Karaman and Chevron Professor II Dr. Raymundo Arroyave, who have developed a data-driven approach to material discovery.

"This work shows that we can design better high-temperature alloys not through expensive trial-and-error but through smart, targeted exploration driven by data and physics," said Karman.

"This project is exciting as it shows the power of the advanced alloy development frameworks we have been developing in the past years." Arroyave added.

Background

Designing new metals usually takes a lot of time and money. Scientists must test thousands of metal mixtures to find the right one—and even tiny changes, like adding just 0.1% more of one element, can totally change how the material behaves. With so many options, finding the correct combination for the alloy would be like guessing the right lottery numbers.

Graphical abstract. Credit: *Acta Materialia* (2024). DOI: 10.1016/j.actamat.2024.120651 To speed things up, researchers at Texas A&M University are using powerful computers and [artificial intelligence](#). These tools help them predict how different metal mixtures would interact, so they don't have to test every single option in their labs. Instead, they utilize AI to help them concentrate their efforts on the more promising ones.

"With advanced computational tools, we're not just speeding up alloy discovery—we're reshaping how discovery happens," said Sina Hossein Zadeh, a Ph.D. student in the Department of Materials Science and Engineering.

Research innovation

The standout feature of this project is its integration of machine learning and [experimental work](#) through a framework known as Batch Bayesian Optimization (BBO). BBO allows scientists to iteratively refine their alloy predictions based on past experimental results, minimizing waste and maximizing discovery efficiency.

"This framework not only speeds up discovery," Karaman says, "but also opens the door to tailoring alloys for specific functions, such as reducing [energy loss](#) or improving actuation performance in many applications."

The goal is to make materials that move or change shape in response to something like heat or electricity—kind of like muscles for machines. These special materials are called actuators, and they're often used in aerospace, robotics, and even medical devices.

Challenges and the future

Currently, the model explores alloying with copper and hafnium to enhance shape memory behavior and raise transformation temperatures. However, further research is needed to incorporate more elements and predict additional performance metrics, such as transformation strain—how much the alloy can actually move or change shape during operation.

According to Broucek, "The next frontier is to design alloys that not only transform at the right temperatures but also deliver meaningful strain in service. That's what will make them viable for aerospace and energy applications."

More information: J. Broucek et al, Design of high-temperature NiTiCuHf shape memory alloys with minimum thermal hysteresis using Bayesian optimization, *Acta Materialia* (2024). DOI: [10.1016/j.actamat.2024.120651](https://doi.org/10.1016/j.actamat.2024.120651)

Journal information: [Acta Materialia](#)

Provided by [Texas A&M University](#)

JULY 10, 2025

Health experts' 8 recommendations for the UN Plastics Treaty

by [University of Sydney](#) edited by [Sadie Harley](#), reviewed by [Andrew Zinin](#)

Credit: Unsplash/CC0 Public Domain

A leading expert in the health impacts of plastic pollution and microplastics is calling on the UN to end the use of toxic chemicals in all plastics, cap and reduce plastic production and argues against a treaty focused on waste management and recycling, as part of an international Plastics Treaty.

The World Health Organization (WHO) [estimates that approximately one quarter of all global deaths](#) are attributable to environmental harm including chemicals, pollution and waste.

Much of this pollution is linked to plastic production, use and disposal, and disproportionately affects low- and middle-income countries. Alarming, plastic production is [predicted to grow 300% by 2060](#).

Dr. Nicholas Chartres, Senior Research Fellow at the University of Sydney School of Pharmacy, has joined with other leading [health experts](#), authoring an [editorial](#) for the WHO which outlines eight considerations the United Nations Environment Program should consider when its members meet in August to discuss an international, legally-binding treaty to end [plastic pollution](#). The editorial appears in the *Bulletin of the World Health Organization*.

"Plastics are a [health hazard](#) around the globe, affecting numerous bodily systems and increasing rates of chronic diseases, cancers, and infertility," says Dr. Chartres.

"The United Nations Environment Assembly resolved in March 2022 to negotiate a plastics treaty that would obligate member states to end plastic production because of its danger to human health," Dr. Chartres said.

"Yet, despite the importance of health in driving efforts to manage plastics pollution, the current proposed treaty text has major gaps that put human health at risk from hazardous chemicals and plastics."

Dr. Chartres and his co-authors argue the treaty needs to:

1. Protect health and the environment as core treaty objectives;
2. Mandate consideration of health risks and impacts in all relevant treaty obligations and decisions;
3. Focus on capping and reducing plastic production and incentivize alternatives;
4. End production and use of [toxic chemicals](#) in all plastics and ensure safe, toxin-free alternatives while preventing substitution of similar [hazardous chemicals](#);
5. Remove toxic releases and emissions at all stages of the lifecycle of plastics, including banning recycling of plastics that contain toxic chemicals;
6. Require reporting, transparency and accountability on plastic production and wastes, imports and exports (including their associated chemicals);
7. Use all financing mechanisms to implement the treaty, including extended producer responsibility and the 'polluter pays' principle;
8. Reject blanket exemptions, including plastics in health care—a major generator of plastic waste—while ensuring essential medicines and health products remain accessible and affordable to those who need them.

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Microplastics and forever chemicals

"Plastics are made of more than 16,000 chemicals, mostly derived from oil and gas. [Over 4,200 are known to be hazardous](#), while the toxicity of the majority of the remaining is unknown," said Dr. Chartres.

This includes per- and poly-fluoroalkyl substances (known as "forever chemicals"), phthalates and bisphenols (the "[everywhere and everyone chemicals](#)"), and other endocrine-disrupting chemicals, which can interfere with our bodies' natural hormone systems and lead to harmful health effects.

Exposure to these and many other chemicals used in plastics has been identified to increase rates of chronic disease, including cancer, neurodevelopmental harm and infertility.

The authors also note the [growing evidence that microplastics increase the risk of respiratory, reproductive and gastrointestinal harm](#), and have been linked to some forms of cancer based on their world-first review led by Dr. Chartres.

Meanwhile, the [health care industry](#) has become increasingly reliant on single-use plastics, especially following the COVID-19 pandemic.

"Much of this plastic has gone to waste with little evidence of benefit from the shift. A [plastics treaty](#) should incentivize the health sector to promote environmental sustainability and innovations for safer materials."

More information: Nicholas Chartres, et al. Negotiating the plastics treaty to protect health and the environment, *Bulletin of the World Health Organization* (2025). DOI: [10.2471/BLT.25.294144](#)

Journal information: [Bulletin of the World Health Organization](#)
Provided by [University of Sydney](#)

JULY 11, 2025

Turning step-growth into chain-growth with click polymerization

by [Institute of Science Tokyo](#) edited by [Stephanie Baum](#), reviewed by [Andrew Zinin](#)

By designing azide- and alkyne-type initiators that coordinate with copper catalysts, researchers achieved chain-growth polymerization of AB-type monomers containing azide- and alkyne groups exclusively at polymer ends. Credit: Institute of Science Tokyo

A controlled/"living" click polymerization method developed by researchers at the Institute of Science Tokyo and Nagoya University enables precise chain-growth of AB-type monomers—traditionally limited to step-growth processes—by leveraging copper-catalyzed azide–alkyne cycloaddition. The approach achieves well-defined polymers with narrow dispersity and enables the bidirectional synthesis of ABA-type block copolymers, offering a powerful new strategy for constructing functional macromolecular architectures from a wide range of monomers.

Traditional polyaddition reactions involving AB-type monomers, which contain both azide and alkyne groups, typically proceed via a step-growth mechanism, forming polymers with triazole rings as the main chain. In such reactions, the [reactive molecules](#) (monomers, dimers, or oligomers) can combine randomly with each other, making it challenging to regulate chain length or achieve polymers with desirable structures, a vital requirement for designing polymers with complex and functional architectures.

To address this limitation, a research team led by Professor Kotaro Satoh from the Institute of Science Tokyo (Science Tokyo) and Nagoya University, Japan, developed a "controlled/'living' click polymerization" system. This method uses click chemistry to drive AB-type monomers to polymerize in a chain-growth fashion, where monomers add selectively to the reactive ends of growing chains—similar to living polymerization—enabling [precise control](#) over polymer length and structure.

The findings are [published](#) in the *Journal of the American Chemical Society*.

"We present a novel bidirectional precision polymerization system, enabling controlled chain growth in either direction—an advancement not seen in conventional polymerization methods. This strategy opens new possibilities for creating functionalized polymers," says Satoh.

The strategy is inspired by the copper(I)-catalyzed azide-alkyne cycloaddition, well-known as the click reaction, in which azide and alkyne groups react with the aid of a copper catalyst to form a stable triazole ring. Bifunctional azide compounds, which contain two azide groups, have been reported to selectively produce molecules with two triazole rings. In this reaction, the first triazole that forms behaves like a ligand, binding to the copper catalyst and creating a reactive site for the formation of the second triazole ring.

To mimic this process, the researchers designed a new polymerization system with initiators, azide- or alkyne-based initiators containing triazole rings and terminal functional groups. These initiators coordinate with the copper catalyst, localizing it near the polymer chain end, and directing monomer addition in a selective and controlled manner.

Using these initiators, the team polymerized an ester-type AB monomer containing azide and alkyne groups under click-reaction-like conditions in dimethylformamide solvent at 20 °C with a copper iodide catalyst. The resulting polymers had long chains with number-average molecular weights (M_n) of up to 11,900 and narrow molecular weight distributions

($M_w/M_n \approx 1.1$) like conventional living polymerizations, with very few cyclic oligomers as side products. In contrast, without initiators, the reaction produced only short polymers ($M_n \approx 2,000$) with a broad size distribution.

The direction of polymer chain growth depended on the type of initiator used. Azide-type initiators began the chain growth from the alkyne end of the monomer, yielding triazole rings with terminal azide groups. Conversely, alkyne-type initiators produced chains ending in alkyne groups.

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The reactive end groups on the polymer allowed the researchers to build [block copolymers](#) with distinct segments by simply adding new monomers to both ends of a precursor polymer chain. Starting with a polyester segment (poly(M-1)) bearing two terminal azides, they introduced an amide-type monomer (M-2), whose alkyne groups reacted with azide termini of the M-1 polymer to form an ABA-type triblock copolymer, with polyamide segments on either side of the original polyester block.

By leveraging triazole–copper coordination, this approach provides a new toolset for creating functional, well-defined polymers from a wide range of AB-type monomers.

"The presence of azide and alkyne groups appears sufficient to drive polymerization, regardless of the internal structure of the [monomer](#). This flexibility opens up new avenues for the design of complex polymer architectures, which we are now investigating," says Satoh.

Overall, the insights gained from this study could be used for developing advanced functional materials, nanostructure designs, and biomedical materials. Let us hope that these findings will revolutionize the area of polymer synthesis.

More information: Controlled/"Living" Click Polymerization with Possible Bidirectional Chain-Growth Propagation During Polyaddition, *Journal of the American Chemical Society* (2025). DOI: [10.1021/jacs.5c01247](https://doi.org/10.1021/jacs.5c01247)

Journal information: *Journal of the American Chemical Society*
Provided by [Institute of Science Tokyo](#)

JULY 11, 2025

Driving assistance systems could backfire: Some warning alerts can lead to more hazardous driving

by Kiah Collier, [University of Texas at Austin](#) edited by [Andrew Zinin](#)

Credit: Unsplash/CC0 Public Domain

In recent years, every new car driver has been getting used to bells and beeps. As automakers try to make cars safer, they've introduced increasingly sophisticated driving assistance systems, to warn a driver when they're drifting out of their lane or someone's in their blind spot.

But do these features actually improve safety? Proponents point to studies showing that [blind spot](#) and [lane departure](#) warnings lead to decreases in collisions. Skeptics contend the systems can make drivers less attentive, relying too much on warning signals.

New research from Ashish Agarwal, associate professor of information, risk, and [operations management](#) at Texas McCombs, finds evidence for both viewpoints. By considering how human beings react to different kinds of warning signals, he suggests, [automakers](#) could better reduce risky driving behaviors.

"Our objective here is to give feedback to the car companies," Agarwal says. "When they're designing these features, they have to be aware that in some cases, they may make behaviors worse."

Credit: University of Texas at Austin

Agarwal worked with Cenying Yang of the City University of Hong Kong and Prabhudev Konana of the University of Maryland to analyze data from a large automaker for cars sold in 2018 and 2019. The data, collected from onboard sensors, included trips, speeds, and acceleration rates for 195,743 vehicles. Some had Advanced Driving Assistance Systems (ADAS), and some did not.

The team's main question was: Do these systems affect the general driving behavior of users over time, and, if so, how?

Affecting driving in opposite ways

They gauged two kinds of hazardous driving behavior: rates of hard braking and rates of speeding. They also zeroed in on two sets of ADAS features that demand driver responses: blind spot detection and lane departure/forward collision warnings.

"We compared cars with blind spot detection with the ones that don't have that to see how it influences speeding and hard braking behavior," Agarwal says.

Controlling for variables such as vehicle features and driver demographics, the team found the two kinds of warning signals had opposite effects on driving behavior.

- Blind spot detection reduced the daily number of hard braking events 6.76% and speeding events 9.34%, compared with cars without ADAS.
- By contrast, lane departure/forward collision warnings led to 5.65% more hard braking and 5.34% more speeding.

Time magnified both effects, the researchers found, as drivers grew accustomed to the systems.

- Drivers sped 0.40% less often for each extra month they used blind spot detection.
- They sped 0.32% more for every added month with lane departure warnings.

Two kinds of thinking

Why do different features prompt different behaviors? In line with a psychological concept called [dual process theory](#), Agarwal believes they trigger two different modes of thinking.

Urgent warnings, such as lane departure and forward collision, require a driver to correct course immediately. That causes System 1 or reactive thinking, which is automatic and largely unconscious. Says Agarwal, "It triggers risk compensation behavior, which impedes your learning and makes your behavior worse."

By comparison, [blind spot](#) detection does not demand an instant reaction. It allows time for deliberate, System 2 thinking, reasoning one's way to a response.

Automakers should consider these findings as they design the next generation of ADAS features, Agarwal says. For example, a car could repeat a [warning](#) signal after a lane departure as well as during. That might encourage System 2 thinking, helping a driver reconsider their risky behavior.

"For learning to take place, you need to be in the System 2 mode," he says. "That means that you learn, and your [behavior](#) improves over time."

"[General Behavioral Impact of Smart System Warnings: A Case of Advanced Driving Assistance Systems](#)" is published in *Production and Operations Management*.

More information: Cenying Yang et al, General Behavioral Impact of Smart System Warnings: A Case of Advanced Driving Assistance Systems, *Production and Operations Management* (2025). DOI: [10.1177/10591478251336742](https://doi.org/10.1177/10591478251336742)
Provided by [University of Texas at Austin](#)

JULY 11, 2025

Muscle-like gel polymer gets stronger with a new recipe

by [Hokkaido University](#) edited by [Sadie Harley](#), reviewed by [Andrew Zinin](#)

Computational screening process for mechanophore candidates that can engender rapid self-strengthening in hydrogel materials. Credit: *Chemical Science* (2025). DOI: 10.1039/D5SC00151J

A new recipe, or design guidelines, for a self-strengthening muscle-like hydrogel has been developed through strategic integration of computational, information, and experimental research. The resulting gel exhibits rapid reinforcement under mechanical stress with improved stability.

Hydrogels are a permeable soft material consisting of polymer networks and water that are relevant for biological material applications.

Professor Gong's group at WPI-ICReDD has previously developed muscle-like double-network hydrogel technologies that undergo self-strengthening activated by mechanical stress.

Upon [mechanical stress](#), the brittle polymer network breaks and generates radicals that form new, stronger polymer networks by reacting with monomers pre-dispersed in the material.

Recently, the group discovered that incorporating mechanophores containing weak bonds in the brittle network highly improves the efficiency of bond breaking and thereby leads to rapid self-strengthening. However, such weak bonds are also sensitive to heat and light-triggered reactions, which are concerning for material stability.

For this, a team of researchers from WPI-ICReDD developed a [computational design](#) that rapidly evaluates mechanophores that contain stronger bonds but create force-sensitive polymers.

Professor Maeda's research group has been developing the Artificial Force Induced Reaction (AFIR) method that automatically explores reaction pathways. Associate Professor Jiang has developed an extended-AFIR (EX-AFIR) method that analyzes reactions induced by mechanical force and predicts the force required to break [polymer chains](#).

By combining the EX-AFIR method with machine learning, developed by Assistant Professor Staub and Professor Varnek, they rapidly screened mechanophore candidates and identified key molecular parameters. The research has been published in [Chemical Science](#).

First, molecular candidates were prescreened for desirable limited rotational capability ($<90^\circ$). They predicted that limited rotation within a polymer chain would effectively introduce "nodes" where the chain can break under weak force despite having strong bonds.

EX-AFIR was then used to derive the activation force (F_{act}), the force necessary to initiate radical generation of these candidates with a node. Lastly, EX-AFIR was combined with [machine learning](#) to calculate the decay pathways of the radicals and identify mechanophores that could generate long-lived radicals.

Gels were synthesized from selected mechanophores and investigated to confirm the practicality of this computational selection method.

These gels featured rapid reinforcement and the mechanophores remained unchanged after heating at 80°C or UV light exposure for 10 hours, as expected, highlighting the significance of the node-like structure. Additionally, gels synthesized from mechanophores that were filtered out based on computational simulations were also investigated.

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As predicted, these gels failed to demonstrate self-strengthening qualities, further validating the practicality of this computational design approach. These results highlight the exciting opportunities for integrating computational calculations to rapidly advance technologies that would otherwise be time-intensive.

The radical generation of hydrogels suggested (DN-Cam) and filtered out (DN-Cy and DN-Pin) by computational simulations. As the computational simulations suggested, only the DN-Cam gel produced a noticeable color change, suggesting stable radical generation.

Credit: WPI-ICReDD

The video compares the radical generation of [hydrogels](#) suggested (DN-Cam) and filtered out (DN-Cy and DN-Pin) by computational simulations. Pre-dispersed in the gels are ferrous ions (Fe^{2+}) and xylene orange.

Radicals generated from the broken polymer networks will oxidize the ferrous ions into ferric ions ($\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$) which then complex with xylene orange to produce a distinct orange color.

As the computational simulations suggested, only the DN-Cam gel produced a noticeable color change, suggesting the other gels generate unstable radicals that rapidly decay.

More information: Julong Jiang et al, "Node" facilitated thermostable mechanophores for rapid self-strengthening in double network materials, *Chemical Science* (2025). DOI: [10.1039/D5SC00151J](https://doi.org/10.1039/D5SC00151J)

Journal information: [Chemical Science](#)

Provided by [Hokkaido University](#)

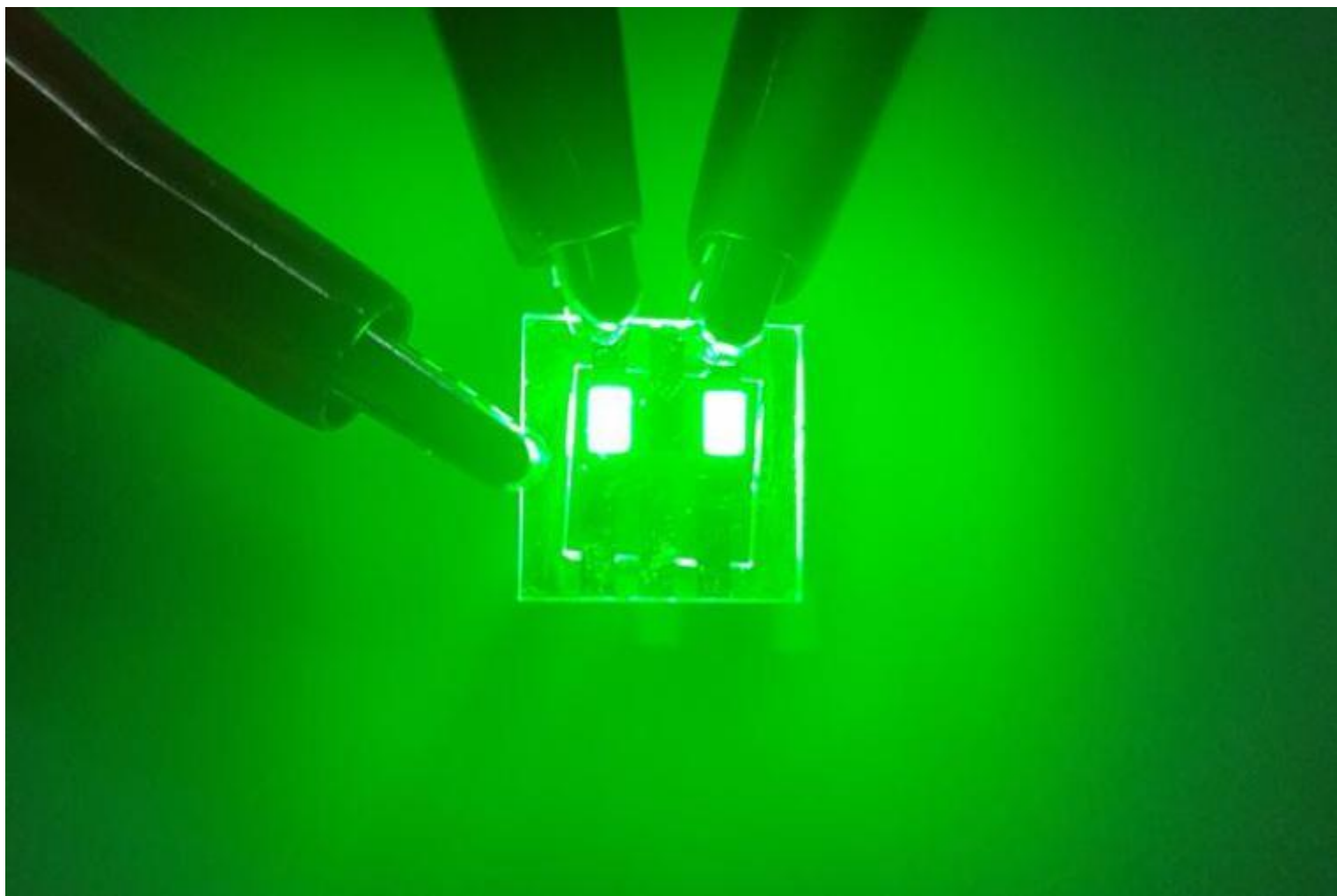


Image credit: HKUST.

FORGET OLEDs, QLEDs AND PHOLEDs. NEW ULTRA-BRIGHT QRLEDs ARE FINALLY HERE

CHRISTOPHER PLAIN • JULY 16, 2025

Researchers from the Hong Kong University of Science and Technology (HKUST) School of Engineering say they have invented the world's brightest and most energy-efficient [quantum rod](#) LEDs (QRLEDs).

Designed to maximize energy efficiency while delivering highly bright, deep green emissions “at the top of the color triangle,” these potentially breakthrough QRLEDs could replace organic LEDs (OLEDs)

and quantum dot LEDs (QLEDs), and even in-development phosphorescent light emitting diodes ([PHOLEDS](#)), as the state-of-the-art LED architecture for [smartphones](#), Televisions, and [AR/VR devices](#) by offering unprecedented color purity and a maximized color gamut.

In a statement announcing the breakthrough design, team leader Professor Abhishek K. Srivastava said their QRLED “paves the way for high-resolution, [energy-efficient displays](#) with unprecedented brightness and longevity.”

Digital displays used in smartphones and other electronic devices generate images using Light Emitting Diodes (LEDs). As resolution and display capacity have evolved, engineers have countered with more advanced LED designs, including OLEDs and QLEDs. Along with increased energy efficiency, these new LED designs also offer improved color purity and narrower emission bandwidths compared to traditional designs.

More recently, scientists have explored further improving the performance of these designs with QRLEDs. According to the research team behind the newest version, QRLEDs, which use a narrower quantum rod design than quantum dot designs, offer higher light coupling efficiency than the best OLEDs and QLEDs. This increased efficiency makes them brighter and clearer than their predecessors.

However, the research team says most incarnations “face challenges.” For example, QRLEDs’ green emission underperforms compared to quantum dot LEDs “due to inefficient charge injection, electron leakage at interfaces, and structural barriers.” These include thick insulating shells and long organic ligands, which are molecules attached to the outer surface of a nanorod that “hinder charge transport and stability.”

Curious if current QRLED designs could be improved to reduce or eliminate these shortcomings without sacrificing the benefits, Prof. Srivastava’s team designed an all-new QRLED structure. According to the team’s statement, this entirely new class of green-emitting quantum rods features a “customized core-gradient alloy structure

with minimized outer shell thickness.” The researchers say the design improvements help their QRLEDs achieve “highly bright deep green emission” between 515 and 525 nanometers, which is “at the peak” of the so-called color triangle. The result is a maximized display color gamut that outperforms all previous LED designs.

To enable dense, void-free film packing, the team engineered the quantum rods at the heart of the new LEDs to have a shorter, uniform, and smooth morphology. To boost efficiency and stability, the QRLEDs also feature shorter ligands and a bilayer hole transport layer, collectively enhancing charge balance and suppressing electron leakage.

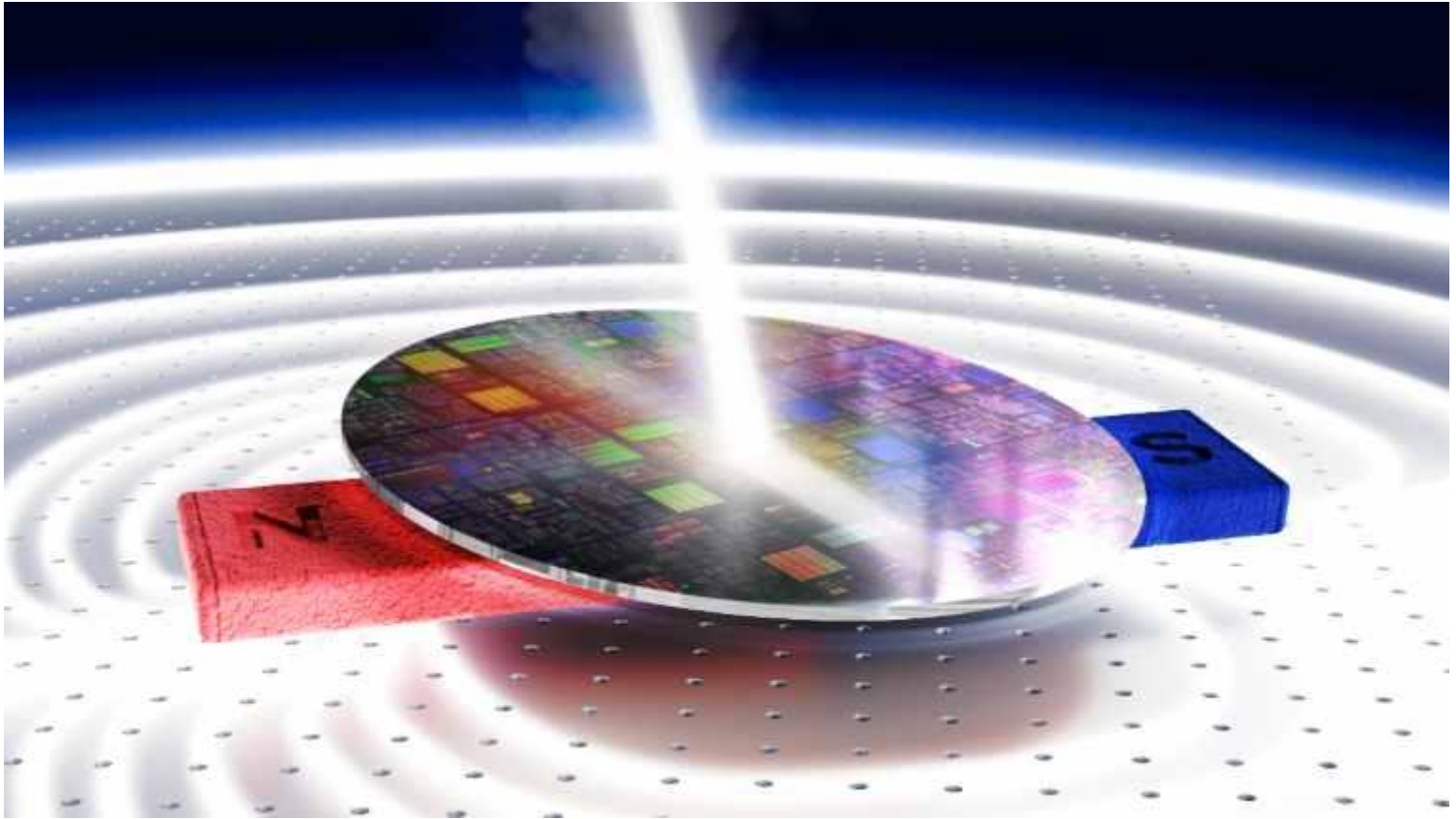
After designing their new QRLEDs, the team tested their performance and efficiency. According to their study, the new designs turned electricity into light with 24% external quantum efficiency compared to 22% for older models.

When tested for brightness per energy, the team said their new model produced 89 candela per ampere. This level of brightness per unit of energy is higher than all existing QRLEDs. The new designs also shone three times brighter than older green LEDs. According to the study, the new model achieved a tested luminescence “exceeding 500,000 cd m².”

Finally, the research team stated that their new QRLED design demonstrated operational stability of 22,000 hours. They said this level of durability positions their design for commercial display applications.

“We have successfully developed remarkably efficient and bright green-emitting QRLEDs by precisely designing the quantum rod composition, morphology, shape, and ligand structure, alongside the rational engineering of the device’s hole transport layer,” Prof. Srivastava said.

“Our work demonstrates that meticulous control over nanorod composition and interface engineering can lead to disruptive advances in optoelectronic performance.”



Optical Hall Measurements of the Silicon Wafer. Credit: Paz Roth

SCIENTISTS ACHIEVE THE “IMPOSSIBLE” BY DETECTING INVISIBLE FORCES IN ORDINARY METAL

CHRISTOPHER PLAIN · JULY 17, 2025

An international team of scientists working to observe the effect of [magnetic fields](#) on light has successfully detected [invisible forces](#) within ordinary, non-magnetic metals, such as aluminum, copper, and gold—a feat they say was previously considered impossible.

The breakthrough detection could help to improve the understanding of how magnetic fields interact with metals used in everyday electronic devices, resulting in improvements for technologies ranging from [smartphones](#) to [quantum computers](#).

“TRYING TO HEAR A WHISPER IN A NOISY ROOM”

Although scientists can readily demonstrate how magnetic fields can bend an electric current, known as [the Hall effect](#), showing how these currents affect light waves has not been as easy.

Efforts to demonstrate the effect on visual light wavelengths, involving what is called the optical Hall effect, have proven difficult due to the subtlety of the effect. This effect is even weaker in non-magnetic metals, leading scientists to suggest that detecting it in gold, copper, and aluminum may be impossible.

“It was like trying to hear a whisper in a noisy room for decades,” said Professor Amir Capua from the Institute of Electrical Engineering and Applied Physics at Hebrew University, who led the study along with Ph.D. candidate Nadav Am Shalom. “Everyone knew the whisper was there, but we didn’t have a microphone sensitive enough to hear it.”

According to Prof. Capula, even though scientists had long known that these invisible forces were present, figuring out how to detect the minuscule effects on light in the visible spectrum, where laser sources are abundant, remained a challenge. The professor said that detection is especially true for metals we think of as magnetically ‘quiet’, since they don’t stick to the refrigerator like magnets do. However, Capula also said that under the right conditions, these types of metals will respond to magnetic fields “just in extremely subtle ways.”

“Interestingly, even Edwin Hall, the greatest scientist of all, who discovered the Hall effect, attempted to measure his effect using a beam of light with no success,” the Professor recalled. “He summarizes in the closing sentence of his notable paper from 1881: ‘I think that, if the action of silver had been one tenth as strong as that of iron, the effect would have been detected. No such effect was observed.’ (E. Hall, 1881).”

UPGRADED MOKE MAKES HISTORIC OPTICAL HALL EFFECT DETECTION

To attempt to detect the invisible forces underlying the optical Hall effect for the first time, the researchers collaborated with Prof. Binghai Yan from the Weizmann Institute of Science, Prof. Igor Rozhansky from the University of Manchester, and Prof. Yan from Pennsylvania State University. According to the team's published study, the first step required the researchers to upgrade a currently used method called the magneto-optical Kerr effect (MOKE). Designed with a visible spectrum laser, the MOKE measures how magnetism alters light's reflection.

"Think of it like using a high-powered flashlight to catch the faintest glint off a surface in the dark," they explain.

To enhance the MOKE device's sensitivity in detecting invisible forces acting on non-metallic materials, the team combined a 440-nanometer blue laser with large-amplitude modulation of the external magnetic field. The team then used the device to test samples of copper, gold, aluminum, tantalum, and platinum. According to the team's announcement, the improved MOKE detected magnetic "echoes" in all of the samples, "a feat previously considered near-impossible."

"By tuning in to the right frequency—and knowing where to look—we've found a way to measure what was once thought invisible," Capula said.

After further analysis of their tests, the team discovered that what had initially appeared as random 'noise' in the signal actually had a familiar quantum pattern linking how electrons move to their spin, known as spin-orbit coupling. Shalom said discovering the known pattern was like "discovering that static on a radio isn't just interference—it's someone whispering valuable information."

“We’re now using light to ‘listen’ to these hidden messages from electrons,” Shalom said.

POTENTIAL APPLICATIONS INCLUDE QUANTUM COMPUTERS AND SPINTRONIC DEVICES

Although the Hall effect is used in semiconductor manufacturing, current methods of detection typically involve physical wire connections and a process that the team described as “time-consuming and tricky,” especially when testing nanometer-sized components. Because their process merely requires the tester to shine a laser on the device to detect the effects of invisible forces, the team believes their breakthrough process offers a “non-invasive, highly sensitive tool for exploring magnetism in metals without the need for massive magnets or cryogenic conditions.”

The new process could help engineers build faster computer processors, more energy-efficient electronic systems, and extremely sensitive sensors with unprecedented accuracy, capable of detecting these invisible forces with unprecedented means and accuracy. The discovery could also have implications for magnetic memory designs, spintronic devices, and potentially quantum-based systems, such as quantum processors.

“This research turns a nearly 150-year-old scientific problem into a new opportunity,” said Prof. Capua.

“WE ARE ACTUALLY VERY CLOSE TO THIS SCIENCE FICTION”: META-OPTICAL TECH MAY SOON ENABLE ‘PROJECTION-GLASSES,’ NOVEL CAMERAS, AND MORE

RYAN WHALEN • JULY 30, 2025

Australia’s ARC Centre of Excellence for Transformative Meta-Optical Systems (TMOS) is working to overcome the limitations of present-day [optical](#) technologies with meta-[optical](#) systems that manipulate [light](#).

Existing optics enable the communications and [imaging](#) technologies by employing the unique properties of various materials and shapes to manipulate [light](#) in different ways. While researchers have uncovered many ways to reflect, refract, and transmit [light](#), the previously unsurpassed boundary imposed by present technological barriers is one that the TMOS team, under the leadership of Professor Dragomir Neshev, is now set to cross.

META-OPTICAL SYSTEMS

TMOS’s meta-optical systems consist of millions of nanostructures, as varied as their larger cousins, and which similarly allow for generating, manipulating, and detecting light in a range of ways. What makes the system unique is that these new nanostructures enable new interactions with light that are not possible with larger-scale optical systems.

While novel light manipulations are interesting, miniaturization is the practical result at the forefront of TMOS’s work. Among their initial applications for meta-optics technologies are attempts to reduce the size of mobile phone camera lenses, which is a major obstacle to producing thinner smartphones. They also envision their work reducing the cost and difficulty of producing other similar items, such as miniature sensors used in early disease detection.



Dragomir Neshev, seen with a meta-optical system (Image Credit: ARC)

RETHINKING QUANTUM COMMUNICATIONS AND MORE

While quantum technologies, ranging from computing to communication, offer numerous hopeful potentialities, they have yet to come to fruition due to the real-world limitations of any device operating through quantum means.

Currently, the practical applications remain elusive, with many experiments relegated to laboratory curiosities and demonstrations of technology. With quantum communications, such systems require a sterile, clean environment and cryogenic cooling to operate, which is infeasible for large-scale use despite the technology's high degree of information security.

Nonetheless, TMOS researchers claim that meta-optics will enable a reduction in complexity, leading to room-temperature quantum communication systems. Additionally, the team is working to bring

their work to wearables, a category that has struggled for more than a decade since the introduction of Google Glass.

“Everybody has seen science fiction movies with glasses that project things. I feel like we are actually very close to this science fiction,” [said Professor Neshev](#).

SUPPORT FOR TMOS

TMOS relies on the contributions of 142 researchers spread between five Australian universities, with additional support from 18 international institutions. Over 100 private companies are also engaged, including some looking to bring augmented reality glasses to market using TMOS’s advances. Neshev believes that remaining grounded in industry partnerships is important as it ensures that their work is relevant to real-world concerns.

“What we’ve seen in the last couple of years is big companies have invested billions of dollars into these technologies,” Neshev said.

One of those partnerships TMOS has been specifically focused on delivering solutions for is a driver fatigue monitor currently being developed by one of TMOS’s collaborators.

“[The company] came to us and said they need to squeeze all these tiny elements that can detect if the driver is fatigued or not... and they need to do this with very little space, which they realised quickly is not possible in any conventional way,” Neshev explained.

Fundamentally, Neshev and his team’s mission continues, although as the old adage goes, part of the enjoyment of it all has been the journey, rather than merely the race to attain working applications for their technology.

“I’m humbled but also very proud to lead this Centre of Excellence,” Neshev said in a statement. “I think everybody in the entire Centre works really well as a body with a joint mission and joint vision to

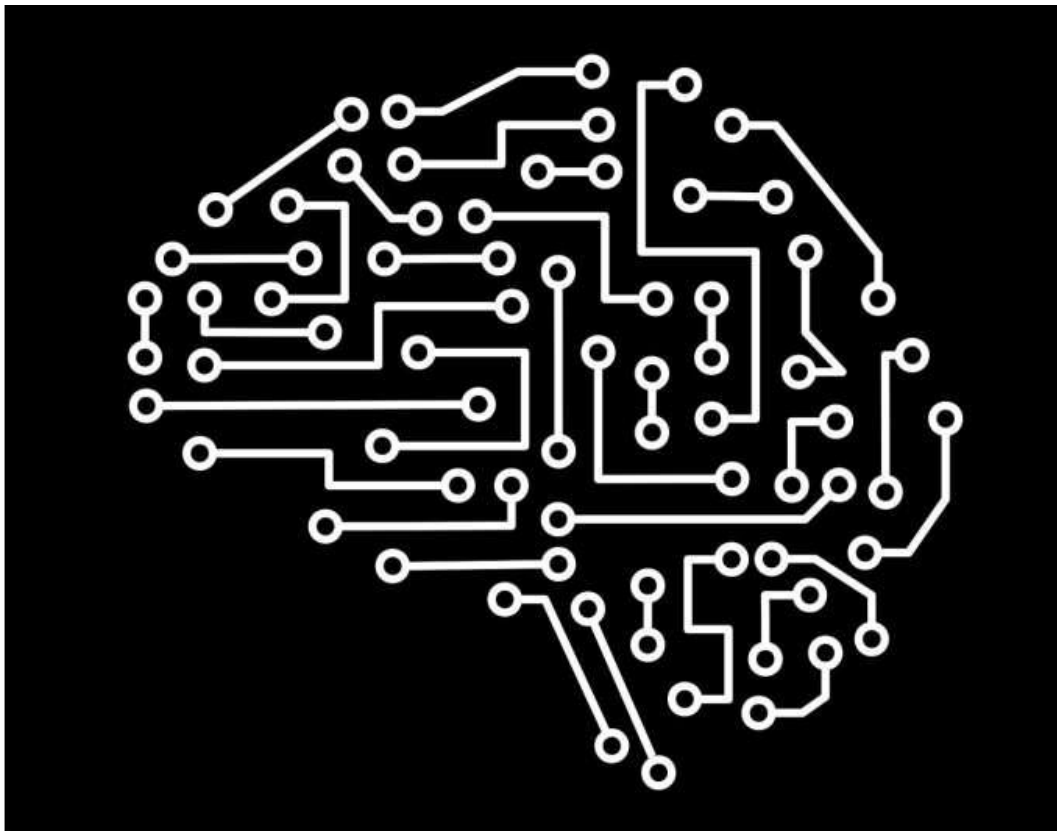
deliver what we have put in our plans, and it's just a pleasure to lead such a Centre."

"I take this as my biggest achievement," Neshev said.

AUGUST 14, 2025

Low-power 'microwave brain' on a chip computes on both ultrafast data and wireless signals

by [Cornell University](#) edited by [Sadie Harley](#), reviewed by [Robert Egan](#)



Cornell University researchers have developed a low-power microchip they call a "microwave brain," the first processor to compute on both ultrafast data signals and wireless communication signals by harnessing the physics of microwaves.

Detailed in the journal *Nature Electronics*, the processor is the first true [microwave neural network](#) and is fully integrated on a silicon microchip. It performs real-time frequency

domain computation for tasks like radio signal decoding, radar target tracking and digital data processing, all while consuming less than 200 milliwatts of power.

"Because it's able to distort in a programmable way across a wide band of frequencies instantaneously, it can be repurposed for several computing tasks," said lead author Bal Govind, a doctoral student who conducted the research with Maxwell Anderson, also a doctoral student. "It bypasses a large number of signal processing steps that digital computers normally have to do."

That capability is enabled by the chip's design as a neural network, a computer system modeled on the brain, using interconnected modes produced in tunable waveguides.

This allows it to recognize patterns and learn from data. But unlike traditional neural networks that rely on digital operations and step-by-step instructions timed by a clock, this network uses analog, nonlinear behavior in the microwave regime, allowing it to handle data streams in the tens of gigahertz—much faster than most digital chips.

"Bal threw away a lot of conventional circuit design to achieve this," said Alyssa Apsel, professor of engineering, who was co-senior author with Peter McMahon, associate professor of applied and engineering physics.

"Instead of trying to mimic the structure of digital neural networks exactly, he created something that looks more like a controlled mush of frequency behaviors that can ultimately give you high-performance computation."

The chip can perform both low-level logic functions and complex tasks like identifying bit sequences or counting binary values in high-speed data. It achieved at or above 88% accuracy on multiple classification tasks involving wireless signal types, comparable to digital neural networks but with a fraction of the power and size.

"In traditional digital systems, as tasks get more complex, you need more circuitry, more power and more [error correction](#) to maintain accuracy," Govind said. "But with our probabilistic approach, we're able to maintain high accuracy on both simple and complex computations, without that added overhead."

The chip's extreme sensitivity to inputs makes it well-suited for hardware security applications like sensing anomalies in [wireless communications](#) across multiple bands of microwave frequencies, according to the researchers.

"We also think that if we reduce the [power consumption](#) more, we can deploy it to applications like edge computing," Apsel said. "You could deploy it on a smartwatch or a cellphone and build native models on your smart device instead of having to depend on a cloud server for everything."

Though the chip is still experimental, the researchers are optimistic about its scalability. They are experimenting with ways to improve its accuracy and integrate it into existing microwave and digital processing platforms.

The work emerged from an exploratory effort within a larger project supported by the Defense Advanced Research Projects Agency and the Cornell NanoScale Science and Technology Facility.

More information: An integrated microwave neural network for broadband computation and communication, *Nature Electronics* (2025). DOI: [10.1038/s41928-025-01422-1](https://doi.org/10.1038/s41928-025-01422-1)

Journal information: [Nature Electronics](#)
Provided by [Cornell University](#)

AUGUST 13, 2025

AI glasses could be a improvement for those with hearing loss

by [University of Stirling](#) edited by [Gaby Clark](#), reviewed by [Andrew Zinin](#)



Artificial intelligence-powered glasses developed by a University of Stirling researcher could dramatically improve how people with hearing loss experience sound.

It aims to help by filtering out [background noise](#) in real time, even in loud environments, through the use of AI-powered smart glasses.

The device uses a small camera built into glasses to track the speaker's lip movements, while a smartphone app uses 5G to send both audio and [visual data](#) to a powerful cloud server.

There, [artificial intelligence](#) isolates the speaker's voice from surrounding noise and sends the cleaned-up sound back to the listener's [hearing](#) aid or headphones almost instantly.

This approach, known as audio-visual speech enhancement, takes advantage of the close link between lip movements and speech.

While some noise-canceling technologies already exist, they struggle with overlapping voices or complex background sounds - something this system aims to overcome.

The project, which [builds on a 2015 Stirling-led study](#), has been led by Heriot-Watt University and involves Dr. Ahsan Adeel from the University of Stirling's Faculty of Natural Sciences - working alongside researchers from the University of Edinburgh and Edinburgh Napier University.

Dr. Ahsan Adeel, Associate Professor in Artificial Intelligence at the University of Stirling's Computing Science and Mathematics Division, who first coined the idea of [5G-IoT-enabled, multi-modal hearing aids](#) in 2018, said, "It is highly gratifying to see that the next-generation hearing aid vision is now taking practical shape.

"We are grateful to our 5G Internet of Things colleagues at Heriot-Watt, Napier, and the University of Edinburgh for believing in this vision and helping make it a reality."

Breakthrough

Dr. Adeel continued, "Looking ahead, to further overcome persistent challenges of delay, privacy, and cost, we are moving beyond current AI – built on the oversimplified, 20th-century conception of neurons – towards harnessing the extraordinary capabilities of pyramidal cells in the mammalian neocortex, the part of the brain in mammals that handles reasoning and decision making, regarded as a hallmark of conscious processing.

"This breakthrough approach shifts from abstract, human-level cognitive audio-visual models to true cellular-level multisensory processing, enabling the world's first personalized, standalone, data center, cloud-independent, biologically plausible hearing aids – a feat beyond current AI and neuromorphic systems.

"These devices will match human-level performance while consuming less power than a dim light bulb, delivering minimal latency, and ensuring complete privacy.

"This work is deepening our understanding of the neurobiological foundations of multisensory audio-visual speech processing and accelerating the creation of next-generation, biologically inspired models and hearing aids. Ultimately enhancing hearing aid uptake and enabling better participation in challenging social settings."

A new approach

More than 1.2 million adults in the UK have hearing loss severe enough to make ordinary conversation difficult, according to the Royal National Institute for Deaf People.

Hearing aids can help, but most are limited by size and processing power and often struggle in noisy places like cafés, transport hubs or workplaces.

By shifting the heavy processing work to cloud servers, the researchers can apply powerful deep-learning algorithms without overloading the small, wearable device.

The group is working on multiple fronts, from cloud AI to edge device AI, to achieve optimal results for sustainability.

From lab to life

Still in the prototype stage, the team has already tested the technology with people who use hearing aids. Early results are promising and the team are speaking to hearing aid manufacturers about future partnerships and hoping to reduce costs to make the devices more widely available.

The team has already hosted workshops for hearing aid users and continue to collect noise samples, from washing machines to traffic, to improve the system.

They believe the cloud-based model could one day be public, allowing anyone with a compatible device to connect and benefit.

Professor Mathini Sellathurai of Heriot Watt University, who leads the project, said, "We're not trying to reinvent hearing aids. We're trying to give them superpowers. You simply point the camera or look at the person you want to hear.

"Even if two people are talking at once, the AI uses visual cues to extract the voice of the person you're looking at. There's a slight delay, since the sound travels to Sweden and back, but with 5G, it's fast enough to feel instant.

"One of the most exciting parts is how general the technology could be. Yes, it's aimed to support people who use hearing aids and who have severe visual impairments, but it could help anyone working in noisy places, from oil rigs to hospital wards.

"There are only a few big companies that make hearing aids, and they have limited support in noisy environments. We want to break that barrier and help more people, especially children and older adults, access affordable, AI-driven hearing support."

Provided by [University of Stirling](#)

AUGUST 8, 2025

Do neurotechnologies threaten our mental privacy?

by Anne-Muriel Brouet, [Ecole Polytechnique Federale de Lausanne](#)

edited by [Sadie Harley](#), reviewed by [Robert Egan](#)

Consumer devices may soon be able to directly access and interfere with the human brain—but this raises unprecedented ethical and legal questions. How can we leverage the benefits of this technology for therapeutic purposes while preventing its misuse?

Just about every technological revolution raises a crucial question: how can society unlock the potential of the new technology while limiting the risk of it being used for malevolent purposes? Today, that question is being applied to neurotechnology, with advances in neural interfaces, bioelectronics, brain-computer interfaces and more.

This progress could improve the lives of millions of patients by restoring their motor function, mental and cognitive capabilities or ability to communicate. But it also opens the door to businesses or even criminals making use of our most personal data, including our thoughts, moods and memories, and could widen the gap between those who can afford such technology—to treat an illness or improve their performance, for example—and those who can't.

In other words, combined breakthroughs in neuroscience and engineering are ushering in a new era that can transform our understanding of the human brain and augment our capacities in unimaginable ways. Yet they're also raising very thorny ethical and legal questions, in a world where established principles are increasingly being cast aside.

Compared with conventional biological data, neural data come with an entirely new set of risks and opportunities. They reveal our mental, cognitive and [emotional states](#), getting right to the essence of who we are as individuals—our thinking capability and experiences, our memory, our planning process and our intentions, perceptions and emotions.

These states influence our behavior and shape our decisions. If devices are able to interpret our neural data, they could eventually be able to alter our cognitive and emotional processes, which could in turn influence our neural data. For instance, they could apply stimuli such as electrical impulses or magnetic fields, which—coupled with the brain's natural neuroplasticity—could give rise to new mechanisms of brain activity or change existing ones.

"It's imperative that we speed the development of neurotechnology," says Marcello Ienca from the Technical University of Munich, a philosopher and neuroethics expert who headed EPFL's Hybrid Minds Project from 2021 to 2024.

"Around a third of the world's population will experience a neurological disorder and around half will suffer from a [mental health condition](#) at some point in their lives. Advancements in neurotechnology can help us understand the human brain and treat these people. But once we go beyond R&D and medical applications, it's a slippery slope.

"We live in a world where our brain is our most important asset—it underpins the data-driven business models of social media operators and online retailers. These companies want to know all about our psychological preferences so that they can influence our purchasing decisions, exploit our vulnerabilities and keep us captive.

"Neural data can make their data-driven applications more accurate and effective. What's more, companies can use [brain-computer interfaces](#) to combine the behavioral data they already have with more complete datasets collected directly from the brain. It's as if they could go straight to the source. Consumers today aren't aware of all the information contained in their brain signals."

Portable mini-EEG machines

A number of businesses, generally working in conjunction with neuroscientists, have developed implants for treating disorders such as depression, Parkinson's disease and paraplegia. For now, brain implants can be used only for therapeutic purposes. But some companies have their sights set higher.

Neuralink, owned by Elon Musk, is already venturing in this direction. "It's the only company that has clearly stated it wants to implant brain chips in millions of people for nonmedical purposes—that is, solely to improve their performance," says Ienca. However, he's skeptical.

"I'd be surprised if the company manages to implant 100 brain chips over the next five years. But the idea that Neuralink could convince a significant number of people to share their neural data is still worrying. My biggest concern is that if the company slips up—if a patient dies or there's a major data leak, for example—that will undermine trust in neurotechnology and the scientific community as a whole."

For now, noninvasive technology in the form of portable mini-EEG machines is being integrated into headphones, fitness bands and sleep trackers in order to monitor our brain activity.

"These devices don't require surgery or come with any physical risks, so companies can use them for nonmedical purposes to support their business goals, whether to control devices remotely, provide neurogaming or entertainment services or offer something else entirely," says Ienca.

"These devices aren't as effective as brain implants but they allow companies to collect data from a larger pool of consumers—and today, more data means better-trained AI programs and more robust predictive algorithms."

Collecting data and consumer preferences

It's no coincidence that Musk has branched out into neurotechnology and that his AI business acquired Twitter, now X. Nor that Apple has patented brain activity sensing technology that can be integrated into future generations of its AirPods.

"These neurotechnological advancements are what data-driven business models have been waiting for—they let companies collect data on consumer preferences, intentions and wishes straight from the neurobiological source," says lenca.

"And there's a real chance that our mental privacy is at stake, with the risk that the technology will be used to manipulate and exploit consumers."

"We're about to witness a boom in neurotechnology," according to lenca. "This decade could be to neurotechnology what the 1980s were to personal computers. Neurotechnology will become personal, and we'll use it not because it's useful but because someone has convinced us it's useful.

"The [gaming industry](#) could be the Trojan horse for this kind of shift by developing neurogames where players can control avatars with their thoughts, for example." And we won't even go into military applications.

Designing regulations that don't handicap innovation

"In 2017, we worked with colleagues at ETH Zurich to introduce the concept of neurorights, which is based on the idea that protecting our thoughts and mental processes is a fundamental human right that obviously didn't occur to the individuals who drafted the Universal Declaration of Human Rights back in 1948. So we suggested updating the Declaration by either adding new rights or interpreting the existing ones so they also apply to neural data," says Marcello lenca.

The first legally binding international document to address the issue of data protection was the Council of Europe's Convention 108 on data protection, adopted in 1981. The Council of Europe has 46 member states, including Switzerland, but 55 countries have signed the convention.

lenca recently served on a Council of Europe ad hoc committee that wrote guidelines for neural data protection and proposed an amendment to Convention 108, which will be discussed in a plenary council meeting in June 2025.

He also sat on a UNESCO working group that drafted recommendations on the ethics of neurotechnology, which are currently being reviewed by UNESCO member states. In addition, EPFL's College of Humanities, in collaboration with the Swiss Commission for UNESCO, hosted the Western European regional consultation on the first draft text of the UNESCO Recommendation on the Ethics of Neurotechnology last July.

When it comes to neural data protection, a number of local governments are rolling out initiatives in this area. In April 2024, Colorado became the first US state to adopt an act protecting neural data in the same way as other types of personal data, such as DNA, fingerprints, facial images and biometric data. California followed suit with a similar law in September.

"It's true that as things currently stand, rules and regulations don't seem to be a priority and can easily be ignored—but that doesn't mean we should give up our efforts to establish a legal framework," says Ienca. "That's why we need to combine this top-down regulatory approach with a bottom-up one based on making consumers aware of the value of their data, the actual risks involved and how they can mitigate those risks."

He also points to another important issue: regulators must take steps to prevent monopolies from being formed, like the ones we're seeing today in AI and the IT industry.

"Having a monopoly on the [human brain](#) is the riskiest thing that could happen to our species," says Ienca. "Preventing that from happening will be very difficult, but one thing we could do is adopt a strong European strategy. European countries still abide by the rule of law, and it's important that we introduce democratic strategies to guide neurotechnology development."

"Also, Europe—and especially EPFL—is ideally positioned in the field of neurotechnology. We need to strike the right balance between a complete lack of regulation—which is what people like Musk are advocating—and overly burdensome regulations that stifle innovation."

"European universities could serve as a catalyst by promoting responsible innovation that upholds our fundamental rights and aims to limit the societal impacts of neurotechnology, thereby asserting their global leadership in this field."

"Much like skin can stretch, heal, and return to its original shape, the material deformed, healed, and 'remembered' its original shape, becoming more durable than when it was originally made," the professor said in a [press release](#).

Naraghi believes the breakthrough is more than a new class of materials and represents a blueprint for how science and strategic partnerships can create plastics that evolve and adapt. "It's through trial and error, collaborations, and partnerships that we turn exciting curiosity into impactful applications," he concluded."

US scientists develop self-healing plastic stronger than steel

Scientists in the US have designed a carbon-fiber plastic composite that not only heals itself the way skin does, but also recovers its original shape under heat and outperforms steel in strength.

The new recyclable material, an advanced carbon-fiber plastic composite called Aromatic Thermosetting Copolyester (ATSP), was developed by researchers at Texas A&M University and the University of Tulsa.

Funded by the US Department of Defense and led by Mohammad Naraghi, PhD, director of the nanostructured materials lab and professor of aerospace engineering at Texas A&M, the research paves the way for transformative applications in the defense, aerospace, and automotive industries.

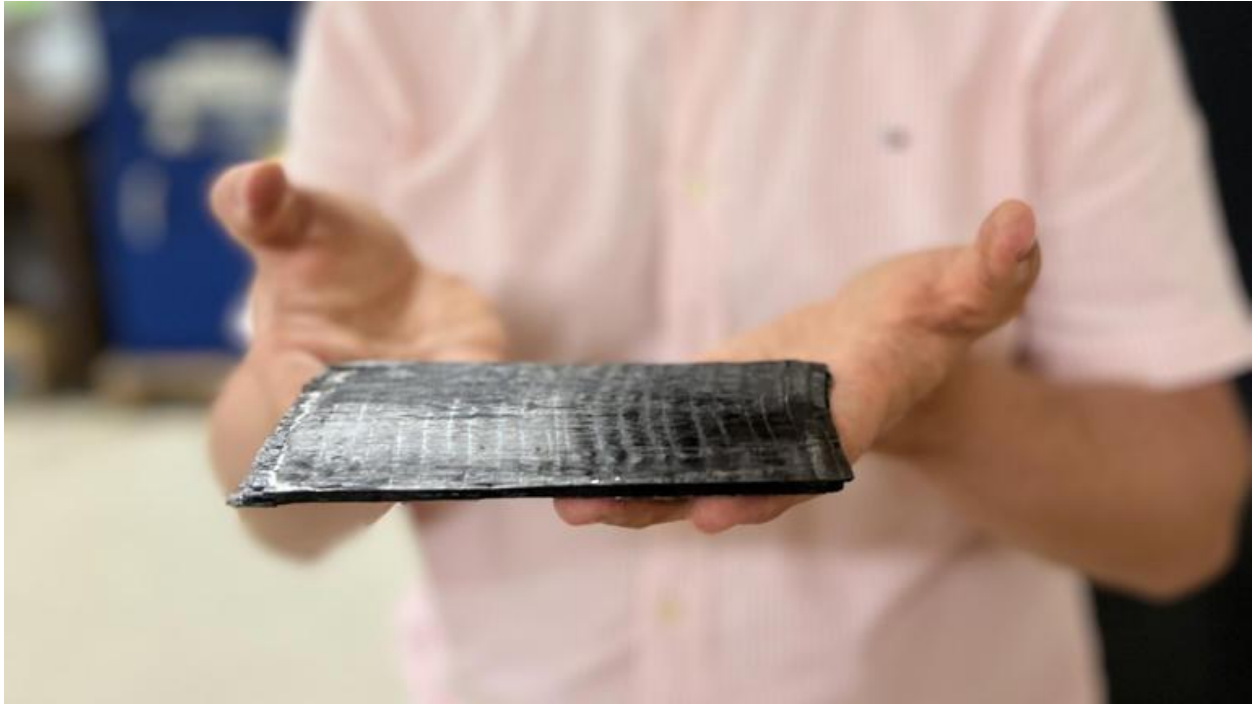
"What's really exciting is that this material isn't just ultra-durable – it's also adaptive," Naraghi said. "From on-demand healing in damaged aircraft to enhancing passenger safety in vehicles, these properties make it incredibly valuable for future materials and design innovations."

A self-repairing solution

ATSP's unique [bond-exchange chemistry](#) enables components to repair cracks and deformations by simply applying heat, thus restoring them to near-original strength, or even improving it.

As per Naraghi, extreme stress and [high temperatures](#) can lead to dangerous material damage in aerospace applications. When this damage affects a critical part of an airplane, crews can use on-demand self-healing to restore its function.

The technology also holds promise for improving safety design in cars. It can reportedly restore a car's shape after a collision and, more importantly, greatly improve safety by protecting passengers.



Mohammad Naraghi, PhD, showcasing ATSP, the carbon-fiber smart plastic. Image credit: Dr. Mohammad Naraghi/Texas A&M University College of Engineering

The material is recyclable and a more sustainable alternative to [traditional plastics](#). Its chemistry remains stable over multiple reshaping cycles, making it a strong candidate for reducing waste without compromising reliability.

"ATSPs are an emerging class of vitrimers that combine the best features of traditional plastics," Naraghi elaborated, adding that they fuse thermoplastic flexibility with thermoset stability. "So, when combined with strong carbon fibers, you get a material that is several times stronger than steel, yet lighter than aluminum."

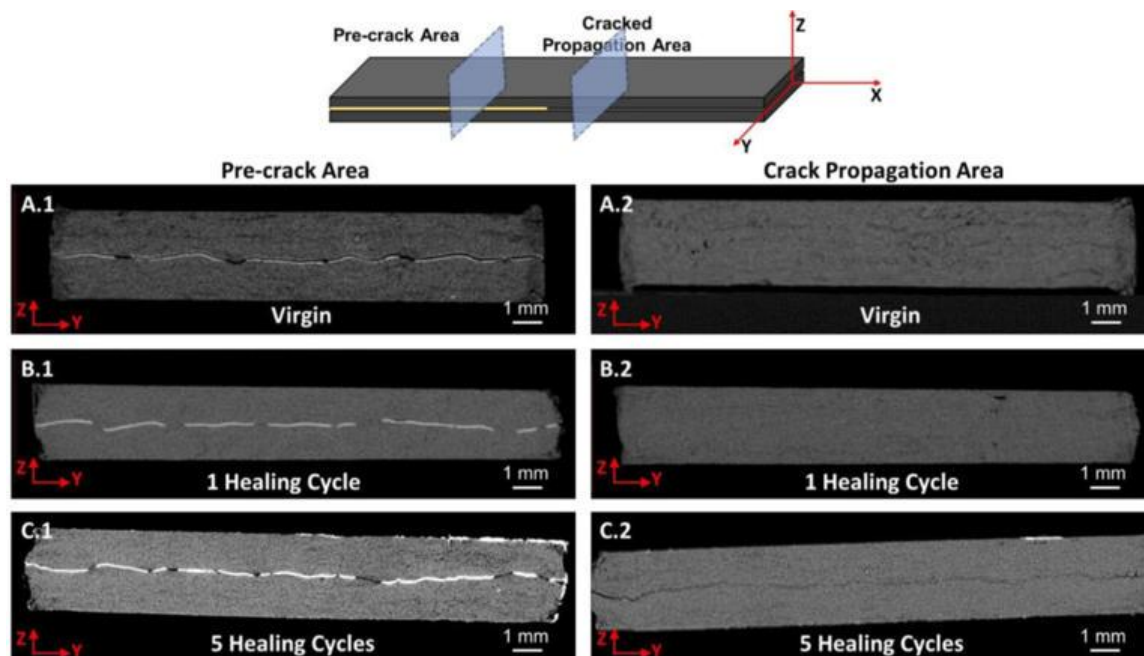
When reinforced with discontinuous fibers, vitrimers, a [class of plastic](#), can be reshaped repeatedly, crushed, and molded into new forms many times without their chemical structure degrading.

Testing the waters

To investigate ATSP's self-healing and shape-shifting capabilities, the researchers tested cyclical creep by repeatedly stretching and releasing the material while measuring how it stored and released strain energy.

Using cyclical loading, they identified two critical temperatures, the first one being the glass transition temperature, where polymer chains move freely. The second one was the vitrification temperature, where bonds become active enough to enable healing, reshaping, and recovery.

During one trial, they heated the composite to around 320 degrees Fahrenheit (160 degrees Celsius) to trigger shape recovery. The results showed that ATSP samples endured hundreds of stress and heating cycles without failure and became more durable during healing.



X-ray images of ATSP across five different damage-healing cycles. Image credit: Dr. Mohammad Naraghi/Texas A&M University

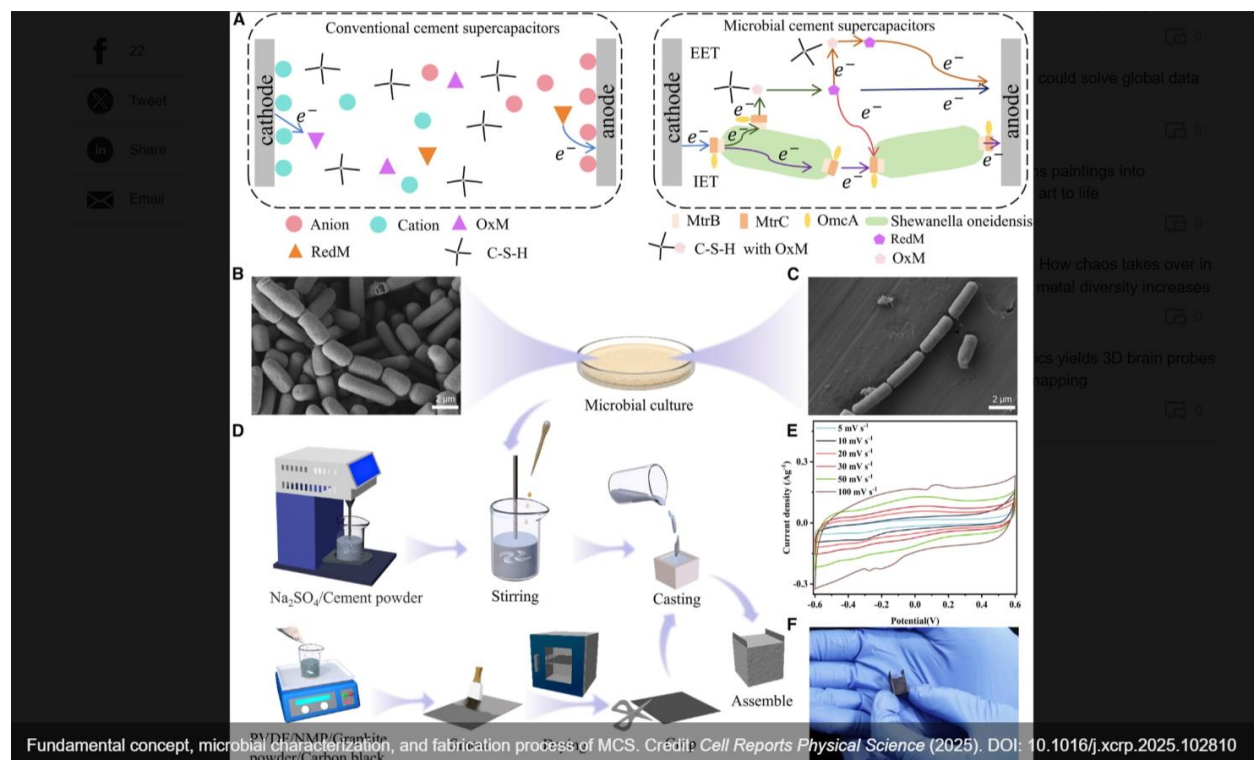
In another experiment, they exposed damaged samples to 536 degrees Fahrenheit (280 degrees Celsius) after stress testing. After two full damage-healing cycles, the material returned to nearly full strength. By the fifth cycle, healing efficiency declined to about 80 percent due to mechanical fatigue from manufacturing defects. Chemical stability, however, remained intact.

SEPTEMBER 10, 2025

Living cement: Scientists turn bacteria-infused cement into energy-storing supercapacitors

by Aarhus University

edited by Gaby Clark, reviewed by Robert Egan



Imagine a house that doesn't just shelter you but also stores electricity. It may sound like science fiction, but it's now closer to reality than ever before. A research team at Aarhus University has demonstrated how the world's most widely used building material can be transformed into a living energy device. By embedding energy-producing bacteria in cement, they have created a biohybrid supercapacitor with surprisingly high performance and a remarkable ability to regenerate itself over time.

"We've combined structure with function," says lead researcher Qi Luo. "The result is a new kind of material that can both bear loads and store energy—and which is capable of regaining its performance when supplied with nutrients."

Where biology meets building materials

Concrete has long been seen as inert and lifeless. But this new study, just [published](#) by the team in the journal *Cell Reports Physical Science*, takes a radically different approach: They add *Shewanella oneidensis*, a bacterium known for its ability to transfer electrons to external surfaces via so-called extracellular electron transfer.

Once embedded in the cement matrix, these bacteria create a network of charge carriers capable of both storing and releasing electrical energy. Even at this early stage, the material already shows performance well beyond what traditional cement-based energy storage systems have achieved, suggesting promising potential for future development.

But what's perhaps most striking is that the material continues to function even after the microbes have died—and that it can be brought back to life.

A recoverable power network

Because microbial activity gradually fades due to nutrient depletion or environmental stress, the researchers designed an integrated microfluidic network within the cement that can deliver a nutrient solution containing proteins, vitamins, salts and growth factors to keep the bacteria alive or "reawaken" the system.

With this method, up to 80% of the original energy capacity can be recovered.

In practical terms, this opens the door to recoverable energy materials that maintain their function over time, without the need to replace batteries or perform costly repairs.

The researchers also stress-tested the material under challenging conditions. Even at freezing temperatures and at elevated heat, the cement retained its ability to store and discharge electricity. And when six cement blocks were connected in series, they produced enough energy to power an LED light.

"This isn't just a lab experiment," says Qi Luo. "We envision this technology being integrated into real buildings, in walls, foundations, or bridges, where it can support renewable energy sources like solar panels by providing local energy storage. Imagine a regular room built with bacteria-infused cement: even at a modest energy density of 5 Wh/kg, the walls alone could store about 10 kWh—enough to keep a standard enterprise server running for a whole day."

Infrastructure that stores its own power

As the world shifts to renewable energy sources, there is a growing need for scalable, affordable, and sustainable energy storage. Conventional batteries rely on rare and expensive materials like lithium and cobalt—and they degrade over time.

The new cement-based material, on the other hand, is made from abundant and inexpensive components and can be produced at scale. The bacteria used are naturally occurring and environmentally friendly.

Though still at the proof-of-concept stage, the findings open up an entirely new chapter in building technology: house façades that double as batteries. Bridges that power their own sensors. Infrastructure that lives—and delivers energy.

More information: Living microbial cement supercapacitors with reactivatable energy storage, *Cell Reports Physical Science* (2025). DOI:

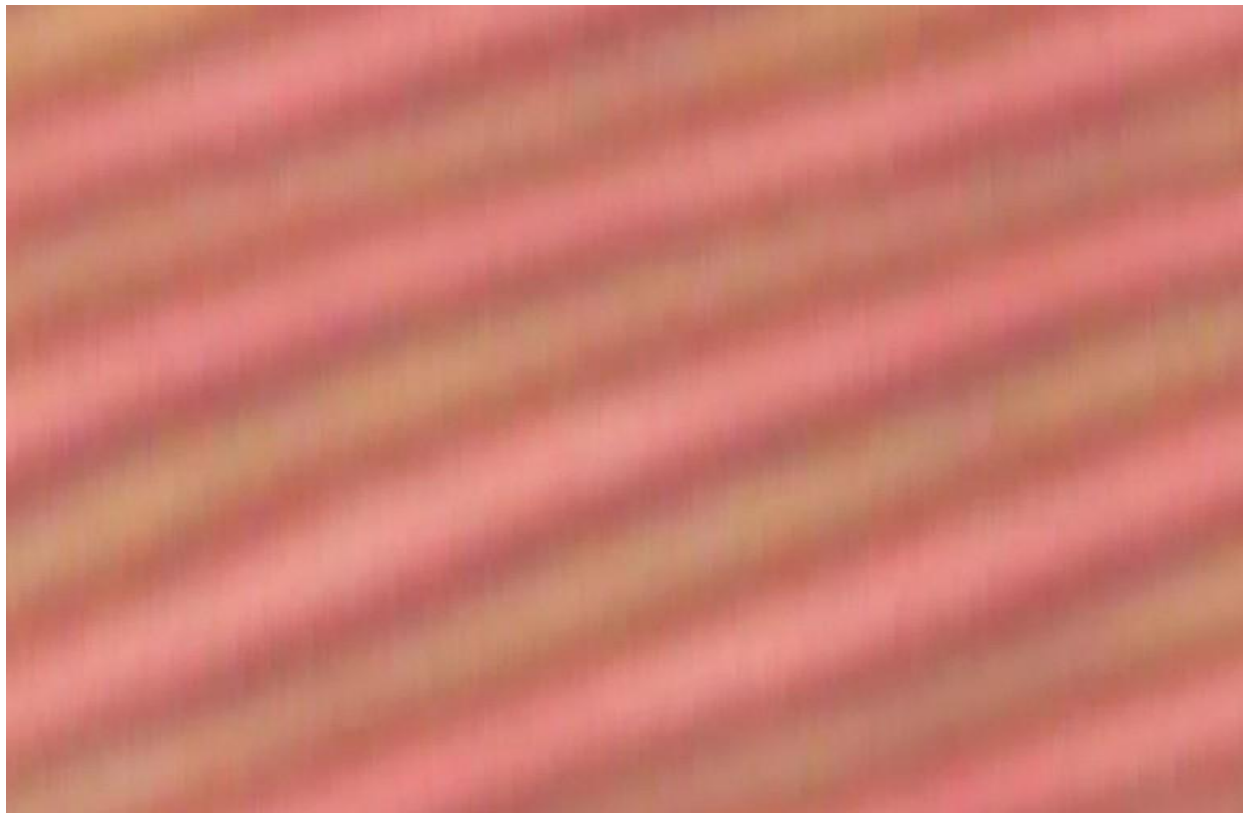
10.1016/j.xcrp.2025.102810. www.cell.com/cell-reports-phys ... 2666-3864(25)00409-6

Journal information: *Cell Reports Physical Science*

Provided by [Aarhus University](#)

Weird ‘time crystals’ are made visible at last

Time crystals, a state of matter once thought physically impossible, could soon be on a banknote. By [Elizabeth Gibney](#) 15 September 2025



A time crystal as seen under a microscope. Credit: Zhao & Smalyukh, 2025, *Nature Materials*

A time crystal is a form of matter that shows continuous, repeating patterns over time, much like how atoms in a normal crystal repeat in space. Examples once existed in only [complex, quantum matter](#), but now physicists have found a way to make a time crystal that can be seen, under certain conditions, with the naked eye.

The feat, accomplished by physicists at the University of Colorado Boulder, and published in *Nature Materials* on 4 September¹, involved liquid crystals — bar-shaped molecules with properties between those of a liquid and those of a solid. Simply by shining a light on the liquid crystals, the team created ripples of twisting molecules through them. The ripples kept moving for hours, undulating with a distinct beat, even when the researchers changed the conditions. The rhythm was also out of sync with any incoming force — fulfilling the two defining criteria for a time crystal.

Although some of this behaviour of liquid crystals was already known, no one had previously considered whether it could be harnessed to make a time crystal, says Young-Ki Kim, a materials scientist at the Pohang University of Science and Technology in South Korea.

The macroscopic scale of the time crystal — at millimetres to centimetres across — creates opportunities “to provide deeper understanding” of the phenomena, he says. The distinctive patterns in the crystals could also allow them to be used in anti-counterfeit devices, say the authors.

Impossible machines

Nobel-prizewinning physicist Frank Wilczek [first proposed the idea of a time crystal](#) in 2012. Wilczek’s version was almost like a perpetual-motion machine; something that cycled endlessly while in its natural resting state. A team later published a paper that mathematically proved this concept was impossible², but researchers soon found that other kinds of time crystal were possible. Ordered time crystals [could exist, for example, in bizarre systems that were perpetually in flux](#), rather than at rest.

Time crystals have since been made in a variety of ways, using interacting [nanoscale defects in diamonds, trapped ions](#) and simulated on Google’s Sycamore quantum computer. But most examples have been at the microscopic scale.

The latest system involves shining a light, even that from a normal light bulb, on a liquid-crystal film trapped between two glass plates. When the light hits photosensitive dye molecules on the glass plates, they switch their orientation, which triggers molecules in the liquid crystal to begin twisting.

Intermolecular forces between rod-like liquid crystal molecules mean that they usually all point in the same direction. If some begin twisting, this sets off a domino effect: the molecules reorient themselves in a complex interaction that moves across the sample like a Mexican wave.

From this soup of molecules arise stable twisted formations that behave like particles. These particles interact with each other to create observable ripples. “We were surprised and excited to

see that such time-crystalline order can be readily observed in soft matter systems,” says Ivan Smalyukh, a physicist at the University of Colorado Boulder, who led the work.

To observe the molecular dance in detail, the authors looked at the time-crystal system using a kind of microscope that transmits only polarized light. The amount of light that passes through depends on a molecule’s alignment, revealing the time crystal’s ripples as a series of dark and bright stripes.

The time crystal maintained its distinctive rhythm for hours, even when the researchers varied its temperature and the light intensity. Because the set-up can be tweaked to create patterns that are centimetres across, the effect can be seen by the naked eye, albeit with less contrast and resolution than with the microscope, says Smalyukh.

Because the pattern changes across both space and time, the system is technically a space-time crystal, say the authors. It unquestionably fits the definition of a time crystal, adds Smalyukh, but it does pose the question of whether other periodic effects also fit the bill.

The authors say that these time crystals are not just a curiosity. The thin layers of crystal could be embedded in bank notes as a way to verify their authenticity. Light passing through stacks of different crystals, each with a different characteristic pattern, would create not just a ripple in one direction, but a changing 2D barcode that would be extremely difficult to counterfeit and could also be used to store information, they say.

“We don’t want to put a limit on the applications right now,” added Smalyukh, in a statement. “I think there are opportunities to push this technology in all sorts of directions.”

doi: <https://doi.org/10.1038/d41586-025-02939-3>

UK: World's first quantum computer built using standard silicon chips launched

The new quantum computer was deployed at the UK National Quantum Computing Centre (NQCC). Sep 16, 2025 [Georgina Jedikovska](#)



The first full-stack quantum computer delivered by Quantum Motion.

AUK startup has made a revolutionary advancement after delivering the world's first full-stack quantum computer, built using the same silicon chip technology found in smartphones and laptops.

London-based Quantum Motion, a quantum computing startup that develops scalable quantum computing tech using silicon, launched the industry's first full-stack quantum computer made with silicon. It was deployed at the UK National Quantum Computing Centre (NQCC).

Skip in 4s

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This is reportedly the first quantum computer to be built using the standard complementary metal-oxide-semiconductor (CMOS) chip fabrication process which is the same transistor technology used in conventional computers.

A key part of this approach is building cryoelectronics that connect qubits with control circuits that work at very low temperatures, making it possible to scale up quantum processors greatly.

"This is quantum computing's silicon moment," James Palles-Dimmock, Quantum Motion's CEO, stated. "Today's announcement demonstrates you can build a robust, functional quantum computer using the world's most scalable technology, which can be mass-produced."

Built for mass production

The system combines the company's Quantum Processing Unit (QPU) with a user interface and control stack that supports industry-standard frameworks such as Qiskit and Cirq, making it a full-stack [quantum computing solution](#).

What's more, it also features a data center-friendly footprint that occupies just three 19-inch server racks that house the dilution refrigerator and integrated [control electronics](#).

"The NQCC is accelerating UK quantum capabilities by evaluating several diverse hardware platforms by leading companies worldwide," Michael Cuthbert, PhD, NQCC's director, explained.

The auxiliary equipment operates separately from the main system, which enables easy integration into standard data center environments. This modular setup supports upgrades to significantly larger QPUs without changing the system's [physical footprint](#).

Cuthbert stated that installing the system greatly advances the NQCC's quantum computing testbeds initiative. "The NQCC team is really excited to start testing and validation of the system and better understand how real-world applications will map onto its silicon architecture," he said.

Tested in real conditions

In contrast to other quantum computing approaches, the startup used high-volume industrial 300 millimeter chipmaking processes from commercial foundries to produce qubits.

The architecture, control stack, and manufacturing approach are all built to scale to host millions of qubits and pave the way for fault-tolerant, utility-scale, and commercially viable quantum computing.

“With the delivery of this system, [Quantum Motion](#) is on track to bring commercially useful quantum computers to market this decade,” Hugo Saleh, Quantum Motion’s CEO and president, revealed.

The system’s underlying QPU is built on a tile-based architecture, integrating all compute, readout, and control components into a dense, repeatable array. This design enables future expansion to millions of qubits per chip, with no changes to the system’s physical footprint.

According to Quantum Motion, the system represents a breakthrough in AI machine-learning tuning, enabling more efficient operation and automated algorithms for control and calibration.

“It’s a customer, user, and developer first approach – using standard CMOS, the basis for all modern technology, from mobile phones to AI GPUs, to deliver the revolutionary next inflection point in computing,” Saleh concluded in a [press release](#).

Quantum Motion Delivers the Industry's First Full-Stack Silicon CMOS Quantum Computer

Marking a major milestone for silicon-based quantum technology, the system has been installed at the UK's National Quantum Computing Centre

15 September 2025, London, UK – Quantum Motion has delivered the industry's first full-stack quantum computer to be built using a standard silicon CMOS chip fabrication process – the same transistor technology used in conventional computers. Deployed at the UK National Quantum Computing Centre (NQCC), this is the first full-stack quantum computer to use mass manufacturable 300mm silicon CMOS wafer technology and the first silicon spin-qubit computer installed under the NQCC's Quantum Computing Testbed Programme.

The system integrates the company's Quantum Processing Unit (QPU) with a user interface and control stack compatible with industry standard software frameworks, such as Qiskit and Cirq, making it a full-stack solution. The system has a data-centre-friendly footprint of just three 19" server racks, housing the dilution refrigerator and integrated control electronics. Auxiliary equipment is designed to sit separately, enabling it to fit in standard data-centre environments and supporting upgrades to much larger QPUs without any change to the system footprint.

"This is quantum computing's silicon moment," said **James Palles-Dimmock, CEO, Quantum Motion**. "Today's announcement demonstrates you can build a robust, functional quantum computer using the world's most scalable technology, with the ability to be mass-produced."

Dr Michael Cuthbert, Director of NQCC, added: “The NQCC is accelerating UK quantum capabilities by evaluating a number of diverse hardware platforms by leading companies worldwide. The successful installation of Quantum Motion’s system marks an important step forward in the NQCC’s quantum computing testbeds initiative. The NQCC team are really excited to start test and validation of the system and better understand how real-world applications will map onto its silicon architecture.”

UK Science Minister Lord Vallance said: “Our National Quantum Computing Centre offers a unique space for innovators to trial new quantum technologies. This new form of quantum computer from Quantum Motion will take this groundbreaking technology another step closer to commercial viability – which could help support healthcare with faster drug discovery or clean energy by optimising energy grids.”

Unlike other quantum computing approaches, Quantum Motion’s architecture leverages high-volume industrial chipmaking to produce qubits, using industry standard 300 mm processes from commercial chip foundries.

Quantum Motion’s architecture, control stack and manufacturing approach is designed to scale to host millions of qubits, enabling fault tolerant, utility-scale and commercially viable quantum computing.

Quantum Motion’s QPU is based on a scalable tile architecture which integrates all the needed compute, readout, and control elements into a dense array that can be repeatedly printed onto a chip, enabling future expansion to millions of qubits per QPU. This design enables systems to be easily upgraded by installing future generation QPUs. The system also represents a breakthrough in AI machine-learning tuning, enabling more efficient operation and automated algorithms for control and calibration.

“With the delivery of this system, Quantum Motion is on track to bringing commercially useful quantum computers to market this decade,” said **Hugo Saleh, President and CCO, Quantum Motion**. “It’s a customer, user, and developer first approach – using standard CMOS, the basis for all modern technology, from mobile phones to AI GPUs, to deliver the revolutionary next inflection point in computing.”

“When I look at the new system we’ve delivered to the UK’s National Quantum Computing Centre, built by the amazing interdisciplinary team of scientists and engineers we’ve assembled at Quantum Motion, the message is

clear: silicon quantum computing has just landed,” said **John Morton, CTO and cofounder, Quantum Motion**.

Alongside the UK government funded NQCC testbed initiative, Quantum Motion was recently awarded the SiQEC silicon quantum error correction project to demonstrate fault-tolerant silicon-based quantum computing and is an active performer in DARPA’s QBI.

About Quantum Motion

Quantum Motion develops and deploys full-stack quantum computers manufactured using industry standard 300mm CMOS wafer technology with the goal of delivering commercially viable, utility scale, fault tolerant systems. A key part of this approach is the development of cryoelectronics, integrating qubits with classical control circuits capable of operating at deep cryogenic temperatures, which enables extreme scaling of quantum processors. Fault tolerant quantum computing will enable the most powerful quantum algorithms, targeting solutions to currently intractable problems in fields as diverse as chemistry, materials science, medicine and artificial intelligence. The company employs over 100 people, across the UK, US, Australia and Spain and comprises specialists in quantum theory, hardware and system engineering and software. www.quantummotion.tech

About the NQCC

The National Quantum Computing Centre (NQCC) is the UK’s national lab for quantum computing, dedicated to accelerating the development of quantum computing by addressing the challenges of scaling up the technology. The centre is working with businesses, government, and the research community to deliver quantum computing capabilities for the UK and support the growth of the emerging industry. It is a part of the National Quantum Technologies Programme (NQTP).

Scientists control atomically thin semiconductors using ultrashort pulses of terahertz light

German physicists use light, not wires, to switch ultrathin materials in under a trillionth of a second. Jul 27, 2025 [Christopher McFadden](#)



Artist's impression of an atomically thin semiconductors.

[Bielefeld University](#)

German scientists have discovered a method to control atomically thin semiconductors using ultrashort pulses of terahertz light, rather than traditional electric signals.

This could open doors for electronic components (like transistors or sensors) that work thousands of times faster, controlled by light, not wires or slow electronics. To make this possible, the researchers use terahertz light (a type of electromagnetic radiation between infrared and microwave in the spectrum).

Skip in 5s

The video player is currently playing an ad. You can skip the ad in 5 sec with a mouse or keyboard

This kind of light is super fast and can “tickle” materials in ways regular electronics can’t, the researchers explain. Another important component is nanoantennas, which are tiny 3D–2D structures designed to capture terahertz light and convert it directly into vertical electric fields within the semiconductor.

The electric fields they generate are extremely strong (millions of volts per centimeter) and, likewise, are super fast. However, the core of the discovery lies in atomically thin semiconductors.

Atomically thin semiconductors

Materials like molybdenum disulfide (MoS_2) are only a few atoms thick. These are already being studied for use in ultrathin electronics, displays, and solar cells.

Normally, to change the behavior of a [semiconductor](#) (such as switching a transistor), you apply a voltage through traditional circuitry. But the process is slow, limited to microwave speeds, and dependent on bulky electrical components.

To this end, the new method utilizes light for switching. This is clearly ultrafast, on the order of femtoseconds to picoseconds (one trillionth of a second).

It is also non-contact, so there is no need for physical connections, such as wires. This means they can be more energy-efficient and potentially miniaturized further.

To test their idea, the team attempted to prove the concept in the lab. They found that when they hit the MoS₂ with pulses of terahertz light, the material's electronic and optical properties changed.

This, the team explains, was a sign they were controlling it in real-time. Specifically, they observed a “Stark shift,” or a change in the energy levels of the material's excitons (electron-hole pairs).

This, [they explain](#), proved that their strong light-induced electric field was working. The Stark effect is a well-known phenomenon in which electric fields shift the energy levels of electrons in atoms or materials. Seeing this means that the terahertz field was strong and direct.

Exciting possibilities in the future

It also means the change happened without wires or conventional circuits, and the response was coherent (well-controlled and repeatable). This discovery, the team explains, could lead to some interesting possibilities.

It could, for example, be used to develop next-generation computers that use light-controlled transistors. The discovery could also lead to faster data transmission systems and ultrafast cameras or sensors.

It could also be used for quantum computing components that can be manipulated optically or to develop devices that are smaller, faster, and possibly more energy-efficient.

“Traditionally, such vertical electric fields, used, for example, to switch transistors and other electronic devices, are applied using electronic gating, but this method is fundamentally limited to relatively slow response times,” explains the project leader, physics professor [Dr Dmitry Turchinovich](#) from Bielefeld University.

Scientists build 'DNA cassette tape' to store massive data for 1000s of years

The technology harnesses the high density of DNA to store immense quantities of data in a tiny, durable format. bSep 15, 2025 [Mrigakshi Dixit](#)



Representational image: Researchers have designed “DNA cassette tape” to address the global data storage crisis.

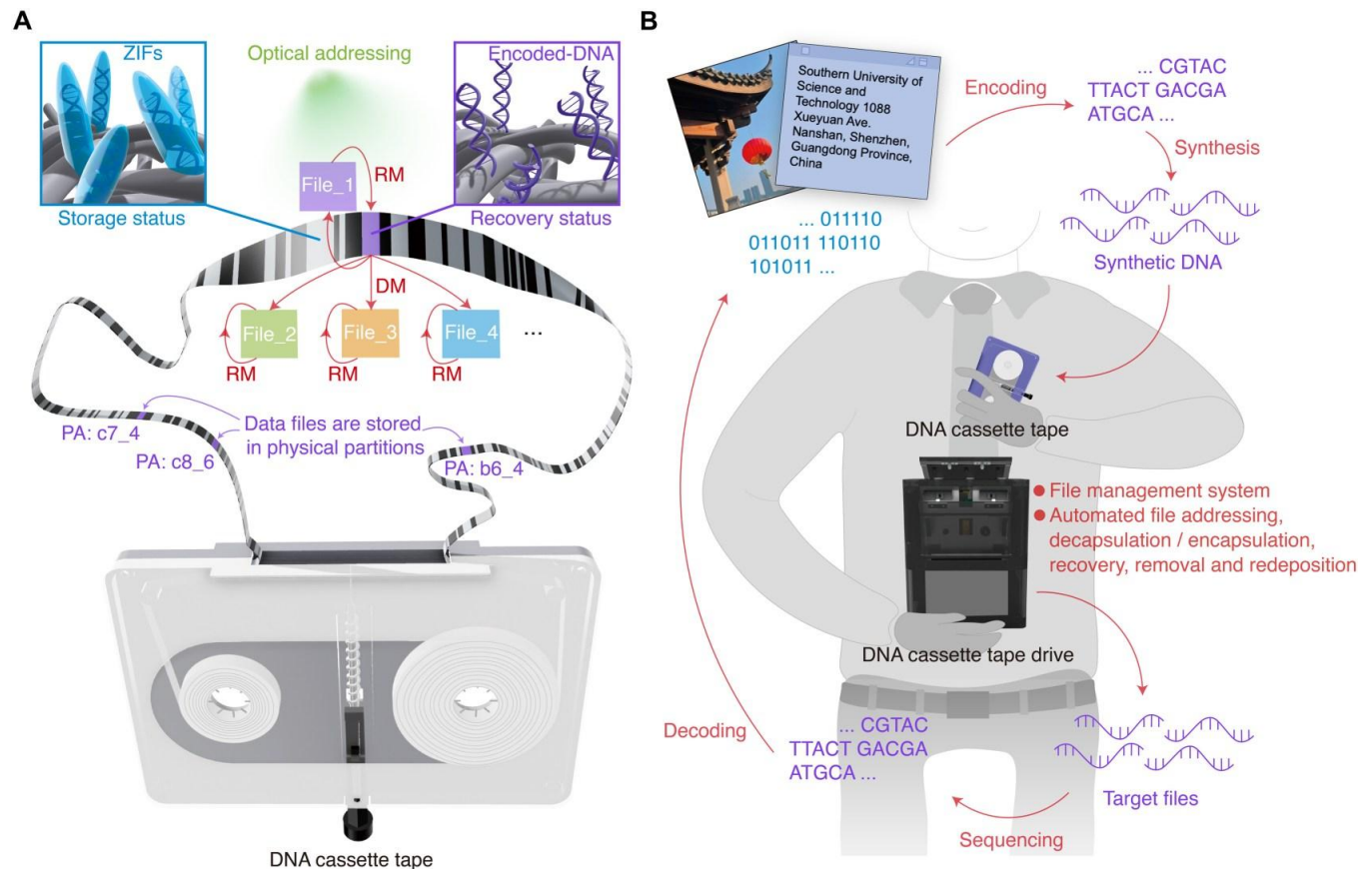
[Getty Images](#)

As the creation of digital data outpaces its ability to store it, scientists are turning to a solution found in nature itself: DNA.

Scientists have developed an experimental “DNA cassette tape” to address the global data storage crisis.

This new technology harnesses the high density of DNA (deoxyribonucleic acid) to store immense quantities of data in a tiny, durable format.

“DNA cassette tape provides a strategy for fast, compact, large-scale DNA-based cold or warm data storage,” researchers from the Southern University of Science and Technology in China wrote in the study paper dated September 10.



Schematic of DNA cassette tape and DNA cassette tape drive. Science Advances

Storing data in DNA

The world is drowning in data. Every click, every photo, every video creates an endless tsunami of information. And the current storage solutions could be soon hitting their limits.

Hard drives are bulky, consume massive amounts of energy, and degrade over time.

That's why experts have been exploring [DNA as a data storage](#) solution to store vast amounts of information in a tiny format that can last for thousands of years.

This approach offers a potential alternative to standard servers and hard drives.

For instance, a single human cell's DNA is said to hold a theoretical data storage capacity of [3.2 gigabytes](#), equivalent to 6,000 books, 1,000 songs, or two movies.

Various previous studies have already explored DNA as a potential storage medium. However, the challenge has been how to make it a practical, accessible system.

The new study presents a solution that borrows a nostalgic idea from the 80s and 90s: a DNA cassette tape that stores data just like old audio tapes stored music.

A physical tape was developed from a polyester-nylon blend. After this, barcode patterns were printed onto its surface, creating millions of tiny, addressable sections – like individual folders on your computer.

This innovative design could allow you to find the exact data you need quickly.

Digital data is translated into a DNA sequence (using the bases A, C, G, and T as code) and then stored on the tape. DNA code works much like a computer's binary code.

Furthermore, a protective crystalline layer is then applied to the tape to prevent the [DNA](#) from degrading. It ensures the DNA storage can last for hundreds or even thousands of years without electricity.

System's functionality

The team successfully demonstrated the system's ability to quickly store and retrieve a digital image, proving its functionality for fast, large-scale data storage.

In the study paper, they verified “its functionality by randomly depositing incomplete images into the data partition, demonstrating a completely automated closed-loop operation involving addressing, recovery, removal, subsequent file deposition, and file recovery again, all accomplished within 50 min.”

[PopSci](#) reported that a single 328-foot DNA cassette tape may hold over 3 billion songs, a capacity far exceeding that of a traditional cassette tape.

Moreover, the prototype device is expected to have “36 petabytes” of data, which is the same as the storage of “36,000 hard drives.”

If successful, DNA cassette technology could provide a scalable solution for [data centers](#) by offering a more efficient and sustainable way to store vast amounts of data without much energy.

The findings were published in the journal [Science Advances](#).

An Aging Expert Thinks Humans Can Live for 20,000 Years. He's Not Crazy. Tim Newcomb

Aging Expert Thinks Humans Can Live for 20k Years

- A molecular biogerontology professor believes we've only started to move toward holding off aging, and that humans will eventually have the potential to live for 1,000 to 20,000 years.
- Technology not yet created would be key to extreme longevity, as we would need to be able to eliminate aging at the cellular level.
- DNA repair and reprogramming cells are the only ways to grant impressively different aging outcomes.

If humans living for 1,000 years seems like a complete stretch, aging expert João Pedro de Magalhães will do you one better: how about humans living for *20,000* years?

The professor of molecular biogerontology at the Institute of Inflammation and Ageing at the University of Birmingham in England talked with *Scientific American* about the tools needed to really impact [human aging](#). And he isn't focused on gaining a few years here or there—he wants to add thousands of years to a human lifespan.

All it takes, he believes, is new technology—yet to be created—that can eliminate aging at the cellular level, repair [DNA](#), and reprogram cells for a drastically different aging process. “My hypothesis is that we have a very complicated set of computerlike programs in our DNA that turn us into an adult human being,” he [told](#) *Scientific American*. “But maybe some of these same programs, as they continue into later life, become detrimental.”

Changing those programs may provide an answer.

Magalhães says that the key isn't so much finding the next [drug](#)—although, certainly, medicine has improved lifespans significantly and helped eliminate

some leading causes of death. He believes that the medical intervention necessary for these extremely long lives will require finding a way to eliminate aging at the cellular level by reprogramming cells and genes critical to the aging process.

His [research](#) has so far focused on animals seemingly outperforming similar species. These include such animals as the bowhead whale—with its 200-year [lifespan](#)—and the naked mole rat—which can live 30 years, while similar rodents live just a few.

“Various long-lived animals, such as humans, whales, and [elephants](#) all have to cope with the same issues, such as cancer, but they use different molecular tricks to achieve their longevity,” Magalhães [said](#). “With bowhead whales, they seem to have much better DNA repair.” He cites the P53 gene and its cancer suppression capabilities as important to this long lifespan, and says that there may be other genes we need to target.

While adding in new drugs—rapamycin has shown to lengthen the life of [animals](#) as much as 15 percent—has an impact, achieving the wild life spans of 1,000 to 20,000 years would require cells that don’t age. To figure out how to stop the cellular aging process in its tracks, humans need to be a bit more like a naked mole rat.

“In terms of cancer resistance and probably overall aging as well, it’s their ability to respond to and repair DNA damage,” he [said](#), adding he believes aging is more a software problem than a hardware problem.

Magalhães believes, at least in theory, that humans can have radical interventions that rewrite genetic software and redesign human [biology](#) “to delay or even reverse aging. In practice, it is difficult, but in theory, I think there’s a huge potential.”

By huge, he means pretty much as huge as you can imagine. “I actually did some calculations years ago and found that if we could cure human aging, average human life span would be more than 1,000 years,” he [tells](#) *Scientific American*. “Maximum life span, barring accidents and violent death, could be as long as 20,000 years.”

All it takes, Magalhães admits, is redesigning our biology to eliminate cancer and evade the detrimental actions of our [genetic code](#). He thinks we'll get there one day. We'll just have to wait and see if he's right.

How Old Can Humans Get?

An expert on aging thinks humans could live to be 1,000 years old—with a few tweaks to our genetic “software”

BY [BILL GIFFORD](#) EDITED BY [MARK FISCHETTI](#)

How long can human beings live? Although [life expectancy](#) has increased significantly over the past century, thanks largely to improved sanitation and medicine, research into hunter-gatherer populations suggests that individuals who escaped disease and violent deaths could live to about their seventh or eighth decade. This means our typical human life span may be static: around 70 years, with an extra decade or so for advanced medical care and cautious behavior. Some geneticists believe a hard limit of around 115 years is essentially programmed into our genome by evolution.

Other scientists in the fast-moving field of aging research, or geroscience, think we can live much longer. A handful of compounds have been shown to lengthen the life spans of laboratory animals slightly, yet some scientists are more ambitious—a lot more ambitious.

João Pedro de Magalhães, a professor of molecular biogerontology at the Institute of Inflammation and Ageing at the University of Birmingham in England, thinks humans could live for 1,000 years. He has scrutinized the genomes of [very long-lived animals](#) such as the [bowhead whale](#) (which can reach 200 years) and the [naked mole rat](#). His surprising conclusion: if we eliminated aging at the cellular level, humans could live for a millennium—and potentially as long as 20,000 years.

How can that be? If aging is programmed, scientists could theoretically reprogram our cells by tweaking genes that are central to aging. This would require technology that we don't presently have, but Magalhães thinks it can be created. His great-grandfather died of pneumonia—a leading cause of mortality in the 1920s. When Magalhães contracted the same disease as a child, he was cured with a simple dose of [penicillin](#). He thinks scientists can

similarly develop therapies for aging, an endeavor to which he has now devoted his career. “I want to cheat death,” he says bluntly.

How has cheating death worked out so far?

I don't think we're going to have a drug that “cures” aging the way penicillin cures infections anytime soon. But a compound called rapamycin is quite promising. It extends life span by 10 to 15 percent in animals, and it is approved for human use, such as for organ transplant recipients. It does have side effects. I am optimistic that we will develop drugs akin to statins [taken daily to lessen risk of heart disease] that we take every day for longevity purposes. If you could slow down human aging 10 or even 5 percent, that would still be pretty amazing.