

INNOVATIVE TECH





THE SCIENCE OF BECOMING AN ELITE SPECIAL FORCES SOLDIER: NEW STUDY REVEALS WHAT IT TAKES TO MAKE THE CUT

TIM MCMILLAN • FEBRUARY 28, 2025

Elite military forces are often romanticized as the epitome of resilience, strength, and determination. But what exactly determines whether a soldier has what it takes to become a member of the U.S. Army [Special Forces](#)?

An upcoming study by the U.S. Army Research Institute, set to be published in the March edition of [Physiology & Behavior](#), examines the physiological, psychological, and nutritional factors that influence success in [Special Forces training](#). The findings provide a scientific framework for understanding what sets graduates apart from those who don't make the cut.

“Soldiers in the U.S. Army Special Operations Forces conduct time-sensitive, clandestine, high-risk operations in hostile, denied, or politically sensitive environments,” researchers wrote. “The demands of these activities require that these elite soldiers be resilient in response to both physical and cognitive stressors.”

The U.S. Army Special Forces, commonly known as the Green Berets, are tasked with conducting [high-risk operations](#) that require extraordinary physical endurance, mental fortitude, and adaptability.

Enlisting in the Army Special Forces pipeline requires meeting significantly higher standards than those for general military enlistment. For example, while the average Armed Services Vocational Aptitude Battery (ASVAB) score for standard recruits is around 50, aspiring Special Forces candidates must score at least 110 to even be considered for a slot.

Likewise, active-duty service members seeking to transfer into a Special Forces Military Occupational Specialty (MOS) must meet even stricter criteria. This includes surpassing higher physical fitness standards and holding a minimum rank of E-3 for enlisted personnel or first lieutenant for officers.

However, meeting these entry requirements merely earns someone a chance to undergo the initial assessment process, where they must demonstrate the mental and physical resilience required to join the ranks of the world’s most elite warfighters.

Green Beret hopefuls undergo the Special Forces Assessment and Selection (SFAS) process to identify the best candidates. This grueling 19-to-20-day challenge tests their physical, cognitive, and emotional limits. According to an [unclassified report](#) by U.S. Special Operations Command (SOCOM), roughly 75% of enlisted and 50% of officers fail to make it through SFAS.

However, the few who pass SFAS advance to the Special Forces Qualification Course (SFQC), commonly known as the Q Course. This final training phase, lasting one to two years, includes rigorous

survival training, advanced tactical skill development, and cultural competency instruction.

After completing SFQC, soldiers are finally considered “special forces qualified” and awarded the iconic green beret and coveted special forces uniform tab. Graduates are then generally assigned to a 12-man Operational Detachment in one of the five active duty or two National Guard special forces groups.

While the Department of Defense does not publicly disclose the exact number, [estimates](#) suggest that approximately 5,500 active-duty soldiers are Special Forces-qualified. That figure accounts for just over 1% of all active-duty Army personnel, highlighting the elite nature of special forces soldiers.

In a recent study, researchers at the [U.S. Army Research](#) Institute analyzed soldiers at various stages—before SFAS, after SFAS, and upon completing SFQC—to pinpoint the key traits and physiological responses that distinguish those who make it into the elite 1%.

One of the study’s most compelling findings is that specific physiological and [psychological responses](#) during SFAS directly correlate with a soldier’s likelihood of completing SFQC.

Researchers collected fasting blood samples, analyzed self-reported resilience, and measured physical performance to track changes over time. Several factors emerged as strong predictors of success.

Soldiers with higher cortisol and ferritin levels and lower A1C were more likely to graduate from SFQC.

Higher cortisol levels indicate a strong physiological adaptation to stress, suggesting that candidates who can sustain high energy and performance under duress are more likely to succeed. Elevated ferritin levels, which reflect better iron stores and oxygen transport efficiency, may improve endurance and resilience to physical exhaustion.

Finally, Lower A1C, a marker of better long-term glucose regulation, suggests that individuals with more stable energy metabolism are

better equipped to handle the rigorous demands of prolonged training.

These findings suggest that metabolic efficiency, iron availability, and robust stress response are crucial in determining a soldier's ability to persevere through one of the military's most grueling qualification courses.

Better obstacle course scores and faster road march times during SFAS were similarly linked to a higher probability of graduating from SFQC. The study underscores the importance of sustained endurance and strength in determining success.

Soldiers who lost more body mass, particularly fat mass, during SFAS, were also more likely to graduate from SFQC. The energy deficit experienced during training is intense, and those who adapt well to these conditions have a better chance of enduring the complete two-year training program.

Non-smokers had over four times the likelihood of graduating compared to those who smoked, indicating that lung function and overall cardiovascular health may play a critical role in enduring the demands of Special Forces training.

While many aspects of elite military training are expected to push human limits, the study also provides empirical evidence of the physiological toll it takes.

Resilience scores remained relatively stable after SFAS but declined by the end of SFQC. This suggests that while initial resilience may be enough to push candidates through selection, the prolonged stress of two years of training can take a toll on even the most determined soldiers.

Diet quality decreased after training, with soldiers consuming less fruit and dairy while increasing sodium intake. While this could be partially attributed to field training conditions, it highlights a potential area for improvement in sustaining long-term nutritional health for elite soldiers.

Testosterone and DHEA-S, crucial for muscle maintenance and recovery, declined after SFAS but rebounded following SFQC. This recovery suggests that extreme training depletes essential hormones. However, the body adapts and restores balance over time.

These findings provide invaluable insights into what makes a successful Special Forces soldier and offer potential applications for refining military training programs.

Military leadership can optimize training regimens, refine candidate selection criteria, and enhance recovery protocols to ensure long-term health and effectiveness by identifying physiological markers that predict success.

Furthermore, the study reinforces the importance of monitoring soldiers' stress responses and resilience over time. Developing targeted interventions to maintain mental toughness throughout training could improve retention rates and overall performance.

Becoming a U.S. Army Special Forces soldier is one of the most physically and mentally demanding experiences a person can endure. This new research provides a data-driven look at what separates those who succeed from those who fall short.

The findings suggest that it's not just about physical strength or mental determination—it's about how well a soldier's body and mind adapt to stress. By understanding these critical factors, military trainers and aspiring Special Forces candidates can better prepare for the challenges ahead, ensuring that only the most capable individuals make it through one of the most demanding selection processes in the world.

As the military continues to evolve, studies like this can provide a scientific foundation for making Special Forces training more effective, efficient, and sustainable—ensuring that America's elite warriors are always ready for whatever mission lies ahead.

General Dynamics' small surface vessel prototype could revolutionize naval warfare



General Dynamics' small surface vessel prototype could revolutionize naval warfare

American aerospace and defense company General Dynamics has partnered with UK-based Juliet Marine Systems to develop a small surface vessel dubbed 'Ghost'. The vessel features Small Waterplane Area Twin Hull (SWATH) design that reportedly has the potential to revolutionize naval warfare.

The prototype of the vessel—which is currently undergoing tests—is versatile, stable and equipped to be deployed on manned, unmanned and remote-controlled operations. According to General Dynamics, the vessel boasts of a large payload capacity and innovative sea-keeping abilities. Its SWATH design enables the vessel to carry payloads in challenging sea states, typically not possible on other small surface vessels.

Stable speeds and compact size

The 'Ghost' is designed for quick deployment and easy construction, allowing it to be used in varying environments. Small vessels like the 'Ghost' are stable at speeds of up to 40.3 mph, making them extremely fast on the water, *Slashgear* [reported](#).

Due to its compact size, the 'Ghost' can be deployed by amphibious and cargo ships, trucks or can even be dropped from airplanes, making it a highly versatile asset for the US Navy.

The seacraft can be operated remotely or with a crew of two. It can carry up to ten passengers in standard seating or 16 with maximum seating, which makes it ideal for amphibious landings, whether crewed or not.

The vessel can transport passengers to safety or serve as a vehicle for deploying [Navy SEAL](#) teams to shorelines, and operate at its top speed for up to 6.4 hours, with a total endurance range of 20.4 hours.

From missile launches to special ops

The 'Ghost' modular design supports various missions, such as carrying missiles, ISTAR (intelligence, surveillance, target acquisition and reconnaissance), anti-submarine [warfare](#), command and control, and special warfare load-out. The prototype is powered by two T53-L13B turboshaft engines, delivering a total of 2,380 shp.

These compact vessels displace between 22.4 and 30.2 tons of seawater and can carry over two tons of payload. They range from 25 to 40 feet in width, depending on the strut angle, and are 65 feet long overall.

The timeline for the 'Ghost' to move from the prototype stage to full-scale production remains uncertain, and it's possible the project could be reconsidered before reaching completion. However, taking into account the vessel's projected utility and capabilities, the Navy may show interest in procurement, *Slashgear* noted.

Last year, General Dynamics [won](#) a US Navy contract worth an estimated \$15.9 million to develop its planned Mining Expendable Delivery Unmanned Submarine Asset (MEDUSA) System. The system is intended for use by the Navy's submarine fleet.

Experts and analysts viewed the contract as part of a larger strategy to create a hybrid fleet of both crewed and uncrewed vessels, aimed at significantly enhancing the Navy's operational effectiveness and agility across various maritime environments. This is also where the 'Ghost' fits in.

3D-printed hydrogels show promise for radiation-proof spacesuits, spacecraft



3D-printed hydrogels show promise for radiation-proof spacesuits, spacecraft

Earth's atmosphere and magnetic field protect us from most cosmic radiation.

Beyond this, space is a harsh environment for humans. Astronauts and spacecraft face constant bombardment from high-energy radiation, posing significant risks to both human health and sensitive equipment.

This requires the development of effective radiation shielding solutions.

Researchers at Ghent University in Belgium are working on the development of advanced 3D-printed hydrogels for radiation shielding.

Hydrogels are materials that can absorb and retain vast amounts of water.

“Hydrogels are found in many things we use every day, from contact lenses to diapers and sanitary products. Our research group has experience with applications in the medical field – using hydrogels as a soft implantable material to repair damaged tissues and organs,” said Lenny Van Daele.

Water retention property

Water is excellent for radiation shielding due to its density and hydrogen content, which slows down radiation. However, using free-flowing water for shielding presents challenges.

Using water for radiation shielding in spacesuits is problematic because bulky containers restrict movement, uneven water distribution compromises protection, and leaks (especially near electronics) pose a danger.

Researchers are investigating superabsorbent polymers (SAPs) as a safer and more effective alternative to [water](#) for radiation shielding.

SAPs can absorb many times their weight in liquid, becoming hydrogels when swollen.

Hydrogels, because they retain water, are promising for radiation shielding in both habitats and spacesuits. The non-free-flowing water property ensures even protection and prevents leaks — even if the shield is punctured. This technique would give astronauts time to react if a suit is damaged.

“The material could also potentially be applied to uncrewed missions – in radiation shields for spacecraft, or as water reservoirs once we have optimized the method of retrieving water from the hydrogel,” said Malgorzata Holynska of European Space Agency’s Materials, Environments and Contamination Control Section.

3D-printed hydrogels

The developers highlight that the superabsorbent polymer they use is unusually versatile in how it can be processed. They prefer 3D printing, as it enables them to create hydrogels in virtually any desired shape.

3D printing technique allows for customized shapes and sizes, perfect for spacesuits or spacecraft shielding.

Interestingly, researchers have created a 3D model of a space shuttle and an astronaut on the Moon using [hydrogel](#)-based 3D printing. This demonstrates the potential of this technology to create various shapes for space applications.

“There is a constant search for lightweight radiation protection materials. In our Discovery activity, we successfully demonstrated that hydrogels are safe to use under space conditions. In this follow-up project, we are applying different techniques to shape the material into a 3D structure and scale up the production process, so that we can come a step closer to industrialization,” said Peter Dubruel, lead of the project in the [press release](#).

Beyond Earth’s protective shield, astronauts receive a year’s worth of radiation in just one day. Longer missions, like a Mars trip, require additional radiation shielding.

3D-printed hydrogels offer a lightweight, versatile, and highly effective way to safeguard both astronauts and equipment for safe exploration.

Scientists develop novel self-healing electronic skin for health monitoring

Researchers have achieved a breakthrough in wearable health technology by developing a novel self-healing electronic skin (E-Skin) that repairs itself in seconds after damage. This could potentially transform the landscape of personal health monitoring.

In a study [published](#) in *Science Advances*, scientists demonstrate an unprecedented advancement in E-Skin technology that recovers over 80% of its

functionality within 10 seconds of being damaged—a dramatic improvement over existing technologies that can take minutes or hours to heal.

The technology seamlessly combines ultra-rapid self-healing capabilities, reliable performance in extreme conditions, advanced artificial intelligence integration, and highly accurate health monitoring systems. This integration enables real-time fatigue detection and muscle strength assessment with remarkable precision.

"This self-healing technology represents a fundamental shift in wearable electronics," says Professor Yangzhi Zhu. "By achieving healing times of just seconds rather than minutes or hours, we've overcome one of the major barriers to practical, everyday use of electronic skin devices."

The technology shows particular promise in muscle strength monitoring and fatigue assessment, offering potential applications in athletics, rehabilitation, and general health monitoring. Its ability to function in various environmental conditions makes it particularly versatile for real-world use.

"What makes this breakthrough particularly exciting is its immediate practical implications," notes Professor Ali Khademhosseini.

"We've created a technology that not only survives daily wear and tear but continues to provide accurate health monitoring even in challenging conditions like underwater environments. This durability opens up entirely new possibilities for personal health monitoring."

This advancement addresses a critical challenge in wearable technology—the need for durability in daily use. Traditional electronic skin devices often fail when scratched or damaged, limiting their practical application. This new technology's self-healing capability ensures consistent, reliable health monitoring even under challenging conditions.

The research team envisions applications ranging from athletic performance monitoring to medical rehabilitation and everyday health tracking.

More information: Yongju Lee et al, Rapidly Self-Healing Electronic Skin for Machine Learning-Assisted Physiological and Movement Evaluation, *Science Advances* (2025). [DOI:10.1126/sciadv.ads1301](https://doi.org/10.1126/sciadv.ads1301). www.science.org/doi/10.1126/sciadv.ads1301 Provided by Terasaki Institute for Biomedical Innovation

Rapidly self-healing electronic skin for machine learning–assisted physiological and movement evaluation

YONGJU LEE [____](#), XINYU TIAN [____](#), JAEWON PARK [____](#), DONG HYUN NAM [____](#),
ZHUOHONG WU [____](#), HYOJEONG CHOI, JUHWAN KIM, DONG-WOOK PARK [____](#),
KEREN ZHOU [____](#), [...], AND YANGZHI ZHU

SCIENCE ADVANCES

12 Feb 2025

Vol 11, Issue 7

Abstract

Emerging electronic skins (E-Skins) offer continuous, real-time electrophysiological monitoring. However, daily mechanical scratches compromise their functionality, underscoring urgent need for self-healing E-Skins resistant to mechanical damage. Current materials have slow recovery times, impeding reliable signal measurement. The inability to heal within 1 minute is a major barrier to commercialization. A composition achieving 80% recovery within 1 minute has not yet been reported. Here, we present a rapidly self-healing E-Skin tailored for real-time monitoring of physical and physiological bioinformation. The E-Skin recovers more than 80% of its functionality within 10 seconds after physical damage, without the need of external stimuli. It consistently maintains reliable biometric assessment, even in extreme environments such as underwater or at various temperatures. Demonstrating its potential for efficient health assessment, the E-Skin achieves an accuracy exceeding 95%, excelling in wearable muscle strength analytics and on-site AI-driven fatigue identification. This study accelerates the advancement of E-Skin through rapid self-healing capabilities.

INTRODUCTION

Electronic skins (E-Skins) represent a transformative technology that integrates seamlessly with the paradigms of telehealth, personalized health care, and precision medicine ([1](#), [2](#)). E-Skins facilitate the active and continuous monitoring of physical, physiological, and chemical biosignatures related to fatigue while maintaining comfort and minimizing disruption to daily activities, thus significantly enhancing the capacity for self-monitoring and substantially

promoting the overall quality of health care delivery (3–5). Specifically, real-time wearable electrophysiological devices are widely used to monitor muscle conditions in a noninvasive manner (6, 7). This enables the assessment of muscle fatigue and the evaluation of postoperative muscle rehabilitation as well as the facilitation of proactive and personalized interventions tailored to individual physiological responses, thus ensuring both safety and performance.

The field has advanced over the past 20 years, yet persistent challenges remain unresolved. Critical issues, whether related to materials or devices, continue to hinder progress. Unexpected mechanical damage caused by repeated wear and tear and accidental cutting or scratching is the leading cause of device failure when undertaking labor-intensive and repetitive tasks, both indoors and outdoors. So far, achieving the requisite performance within 1 min after mechanical damage has proven difficult, posing a notable material challenge that remains unmet. Consequently, the 1-min performance threshold necessary for commercialization has not been attained. In addition, there is also the hurdle for E-skin technology to be effectively integrated into daily life.

Here, we report an E-Skin capable of rapidly self-repairing after unexpected internal or external mechanical damage, recovering critical functions with a high recovery rate of 80% within 10 s and remaining operable. The rapidly self-healing E-Skin is designed to offer noninvasive electrophysiological monitoring and machine learning–assisted fatigue evaluation during daily routines. Because of its high mechanical-electrical conversion efficiency, the E-Skin can also accurately track diverse human motions without requiring an external energy supply. To effectively simulate and evaluate the practical application potential of the E-Skin under realistic conditions, experimental parameters were selected to encompass a broad spectrum of environments. These parameters were deliberately chosen to mirror real-world usage scenarios, such as extreme temperatures and varying humidity levels, ensuring that the self-healing capabilities remain reliable across diverse operational conditions. Moreover, we develop an on-site AI-driven analytical tool capable of identifying and classifying muscle fatigue with more than 95% accuracy. In addition, the system features a personalized graphical user interface, enabling comprehensive real-time biometric interpretation.

RESULTS

Structural design, self-healing capability, and flexibility of the E-Skin

As illustrated conceptually in Fig 1A, the E-Skin provides wearable electrophysiological monitoring, including surface electromyography (sEMG), electrocardiography (ECG), and self-powered motion tracking. This E-Skin adheres seamlessly and conformably to the epidermis, enabling real-time results display on mobile devices (Fig 1B). The primary material used is fibrous thermoplastic polyurethane (TPU), chosen for its softness, excellent breathability (water/air permeability), and self-protective abilities against adverse loading events (8–10). Specifically, TPU is composed of both soft and hard segments, with the soft segments providing flexibility and the hard segments contributing mechanical strength. Its thermoplastic nature enables high chain mobility at elevated temperatures, facilitating bond reformation and supporting efficient self-healing. In addition, TPU's robust hydrogen bonds facilitate the rapid reconnection of damaged areas without requiring external stimuli, making it an ideal material for balancing durability and flexibility while promoting fast self-repair. Its excellent biocompatibility further ensures safety for extended skin contact (11–13). Polytetramethylene ether glycol (PTMEG) soft segments were further incorporated to enhance its softness, achieving a tissue-like consistency with a Young's modulus of approximately 0.1 MPa (14, 15).

The self-healing capability is essential to ensure that the E-Skin retains its functionality despite continuous mechanical stress from actions such as flipping, folding, and stretching, as well as potential user mishandling, such as accidental cuts or scratches during labor-intensive and repetitive tasks. To accomplish this, we used TPU as the backbone for the E-Skin and incorporated *bis*(4-hydroxyphenyl)disulfide into the matrix to promote the formation of intramolecular disulfide bonds (fig. S1) (16, 17). We incorporated isophorone diisocyanate (IPDI) into the TPU matrix. The asymmetric alicyclic structure of IPDI significantly enhances the flexibility and mobility of the polymer chains, which is essential for effective self-healing. IPDI facilitates the disulfide metathesis reaction within the TPU matrix, enabling the reversible breaking and reformation of disulfide bonds autonomously. The biocompatibility of the IPDI-based TPU is clarified in note S1 (18, 19). This reversible bonding mechanism is fundamental to the self-healing process, allowing it to occur without requiring heat or other external stimuli (Fig 1C and

note S2). These disulfide (R–S–S–R') bonds readily form through redox reactions between thiol (–SH) groups in cysteine amino acids, even under ambient conditions, due to their very low redox potentials (Fig 1D and fig. S2) (20, 21). A detailed summary of the material optimization process is provided in note S3 and figs. S3 and S4.

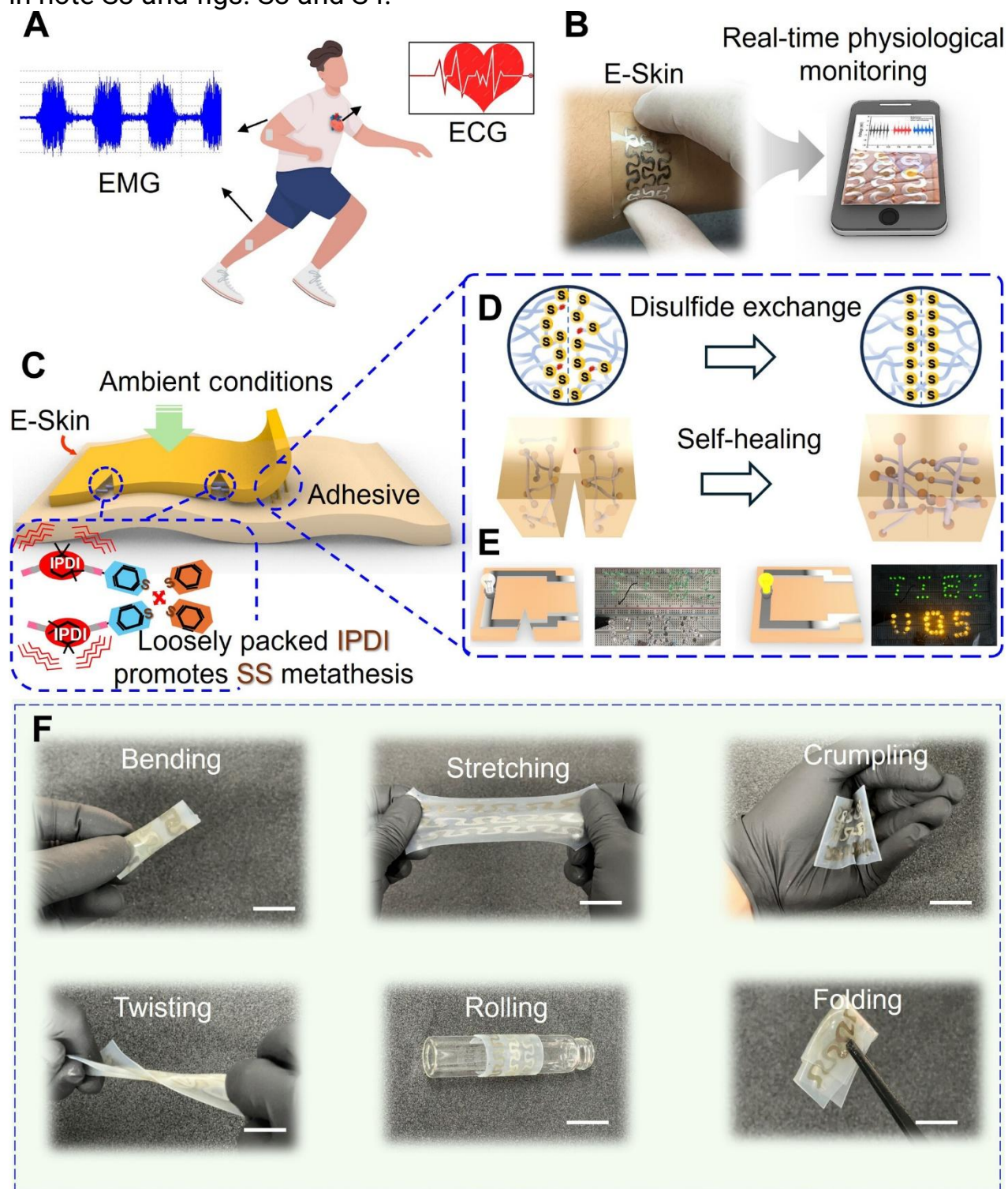


Fig. 1. Structural design, self-healing capability, and mechanical flexibility of the E-Skin.

(A) Schematic illustration of the E-Skin designed for continuous, noninvasive monitoring of electrophysiological (sEMG and ECG) and joint movements. (B) Digital image showing the E-Skin conformally applied to the epidermis. (C) Schematic representation of the self-healing mechanism of the E-Skin, highlighting the incorporation of IPDI into the TPU matrix, where it interacts with disulfide bonds (SS) to enhance chain mobility and promote self-healing, emphasizing the role of IPDI in maintaining the flexibility and integrity of the rapid self-healable E-Skin. (D) Schematic depicting the self-healing capability through disulfide exchange. (E) Schematics and images demonstrate the restoration of conductivity of the E-Skin after being completely cut, as evidenced by successful powering of LED arrays. (F) Photographic images illustrating the mechanical performance and durability of the E-Skin. Scale bars, 1 cm.

The silver nanowire (AgNW) conductive patterns were printed onto the substrate to ensure sufficient conductivity (22, 23). The justification for using AgNWs as the electrode material in this study is detailed in note S4 and table S1 [(24–27)] and fig. S5. As shown in Fig 1E and movies S1, the E-Skin demonstrated its ability to fully restore mechanical and electrical properties after complete severance, evidenced by a standalone light-emitting diode (LED) that resumed illumination within seconds. This rapid recovery of electrical conduction pathways after mechanical damage is attributed to the dynamic reconfiguration of nanostructured conductive networks. These networks comprise a one-dimensional (1D) AgNW network interfaced with a cross-linked, self-healing polymer matrix. The excellent durability and mechanical flexibility of the E-Skin allowed it to adapt to various dynamic deformation conditions (i.e., bending, stretching, crumpling, twisting, rolling, and folding) that can occur during device handling, cleaning, storage, and fitting without mechanical failure (Fig 1F). Also, the patch thickness could be further decreased via tuning the parameters (i.e., speed and duration) of the spin coating (fig. S6). To further evaluate the durability of the E-Skin under repeated mechanical deformation, a bending test was performed with a radius of 5 cm for up to 50,000 cycles (fig. S7). Only a 10% increase in resistance was observed, suggesting its structural and functional integrity when subjected to repeated mechanical stress.

Mechanical performance, stretchability, and self-healing properties of the E-Skin

To characterize the mechanical capabilities of the E-Skin, we plotted the stress-strain curve (Fig 2A) and calculated the Young's modulus (FIG 2B) after complete severance. As shown in Fig 2c, the healed E-Skin demonstrated great elasticity, sustaining up to 900% stretchability. The Young's modulus exhibited superior mechanical properties 1 hour post-self-healing compared to its original state. This enhancement is likely due to the increased formation of disulfide bonds, which bolster the structural integrity of the E-Skin patch. During the healing process, microstructured changes occur, such as the densification and alignment of polymer chains, leading to improved mechanical properties. These changes contribute to the observed increase in Young's modulus by enhancing the elasticity and strength of the E-Skin. Atomic force microscopy validated the successful healing process (Fig 2d). Moreover, the healed E-Skin preserved its structural integrity while supporting a load of 1 kg, which is 1500 times its own weight, without any signs of failure (Fig 2E). Post-healing functionality was verified by attaching the E-Skin to the body, where it effectively continued to detect force through the triboelectric effect (Fig 2E and movie S2). The self-healing ability can be defined as $\text{Self-healing ability} = \frac{\text{Young's modulus (healed ESkin)}}{\text{Young's modulus (pristine E-Skin)}}$

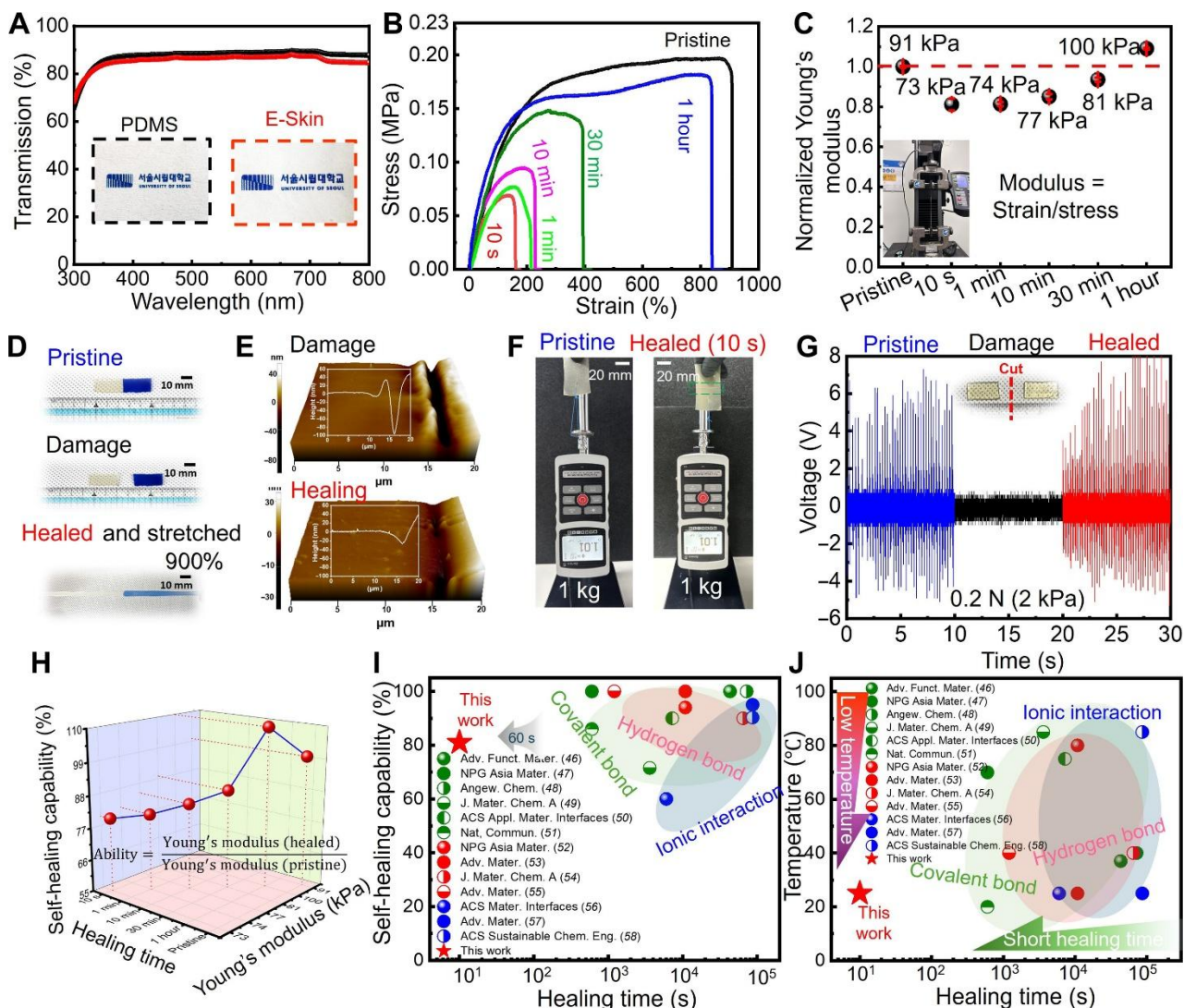


Fig. 2. Optical properties, stretchability, and self-healing characteristics of the E-Skin.

(A) Wavelength-dependent transmittance and a corresponding photograph comparing the E-Skin with commonly used PDMS. (B) Stress-strain profile of the E-Skin throughout the healing process following a complete cut. (C) Changes in Young's modulus observed during the healing process. (D) Photographs illustrating the self-healing process of two rectangular E-Skin devices under ambient conditions, without external stimulation, highlighting its ability to stretch up to 900% post-healing. (E) Atomic force microscopy (AFM) measurements capturing the healing progression. (F) Photographic images

showing the damaged E-Skin's capacity to support a 1 kg of weight within 10-s post-cut, without external stimulation. (G) E-skin sensing test under 0.2-N external stimulation. (H) A 3D graph showing the self-healing capability and Young's modulus of the E-Skin post-cut. (I and J) Comparative analysis of the E-Skin developed in this work with previously reported self-healing devices (46–58), evaluating healing time, self-healing ability, and temperature. The additional comparison of the E-Skin with existing devices is summarized in table S2.

Young's modulus was ascertained by examining the slope of the stress-strain curve, as shown in Fig 2A. (28) The self-healing capacity of the E-Skin was restored to approximately 80% within just 10 s (Fig 2H). Movie S3 demonstrates the dynamic self-healing process of the E-Skin under ambient conditions after being completely cut using polydimethylsiloxane (PDMS), a widely used E-Skin material, as a comparative benchmark.

As mentioned above, incorporating IPDI with an asymmetric alicyclic structure into the TPU matrix enhances chain mobility, thereby promoting disulfide metathesis for self-healing while preserving mechanical robustness (29, 30). The asymmetric structure of IPDI ensures sufficient chain mobility, facilitating self-healing even at low temperatures. These bonds can be activated at room temperature without the need for additional heat or external stimuli and are also responsive at intermediate temperatures (60°–90°C), enabling efficient self-healing across a wide range of temperatures, from low and high.

Figure S8 presents the temperature-dependent kinetics of the self-healing process of the E-Skin. Elevated temperatures significantly accelerate this process by enhancing interactions among the polymer chains within the E-Skin. Specifically, the complete healing time decreased to about 7 min at 40°C, a temperature comparable to the skin surface during outdoor operations. In addition, fig. S9 evaluates the long-term durability and repeatability of the E-Skin through repetitive damaging (cutting)–healing cycles at various temperatures (30 cycles at 25°C, 50 cycles at 40°C, and 100 cycles at 60°C).

The findings demonstrate minimal variation in the self-healing ability of the E-Skin even after extended use. Movie S4 showcases the E-Skin's practical application potential across various temperatures (–3°, 25°, 36°, and 50°C) and underwater, underscoring its waterproof properties due to the protective PDMS layer. This waterproof capability was further corroborated by pressure-sensing performance tests under different humidity conditions (40, 60, and

80%), as depicted in fig. S10. We assessed the self-healing performance under varying humidity levels of 40, 60, and 80%, representing a range of indoor and outdoor environmental conditions, ranging from relatively dry to highly humid settings (fig. S11). A comprehensive explanation of the criteria used to establish these aforementioned experimental conditions for evaluating self-healing performance is provided in note S5.

We further evaluated the changes in the physical and electrical properties of the E-Skin following repeated self-healing cycles. As shown in fig. S12, the E-Skin was subjected to up to 40 cycles of cutting and self-healing at 10-s intervals, with continuous monitoring of its electrical output during touch tests. The results indicate the reliability of the rapid self-healing capability of the E-Skin. In addition, we conducted up to 50 self-healing tests, measuring conductivity after each cycle (fig. S13). The results indicate negligible degradation, highlighting the E-Skin's superior durability, even after multiple cycles of cutting and self-healing. Fig 2 highlights the self-healing ability of the E-Skin over time, while illustrates the correlation between self-healing ability and temperature. A comprehensive comparison has also been summarized in table S2. Moreover, the presence of sweat does not influence the self-healing capabilities, as consistent electrical output is maintained from the self-healed E-Skin patch on sweating skin, comparable to that of the pristine E-Skin patch (fig. S14).

Whole-body monitoring of physiological signals and joint movements

Excessive work-related physiological demands can adversely affect safety and productivity by diminishing workers' well-being, attentiveness, motivation, and manual labor capacity (31). Thus, it is imperative to assess their physiological conditions using comfortable, nonintrusive monitoring tools designed for everyday use, which are essential for any ergonomics study. Owing to its exceptional pressure sensitivity and conformal capability, our E-Skin enables real-time, noninvasive, and self-powered monitoring of various physiological signals. The triboelectric effect offers a robust strategy for powering E-Skin applications (32–34). Detailed information of the self-healing mechanism can be found in note S6 and fig. S15. For accurate monitoring of subtle signals, it is essential for the E-Skin to establish conformal and intimate contact with the epidermis. This was achieved by securely attaching the E-Skin to the epidermis using biocompatible medical adhesive (Fig 3). In addition, the application of medical adhesive has a minimal impact on the self-healing performance (fig. S16). Facial expressions—including ocular blinking,

frowning, and smiling—are primary channels for conveying human emotions and external communication. The E-Skin can capture minute muscle movements from microexpressions through variations in voltage signals. Specifically, subtle voltage signals induced by blinking were detected when the E-Skin was mounted on an eyelid (Fig 3A). In addition, the E-Skin can differentiate between normal and rapid blinking based on variations in frequency and amplitude.

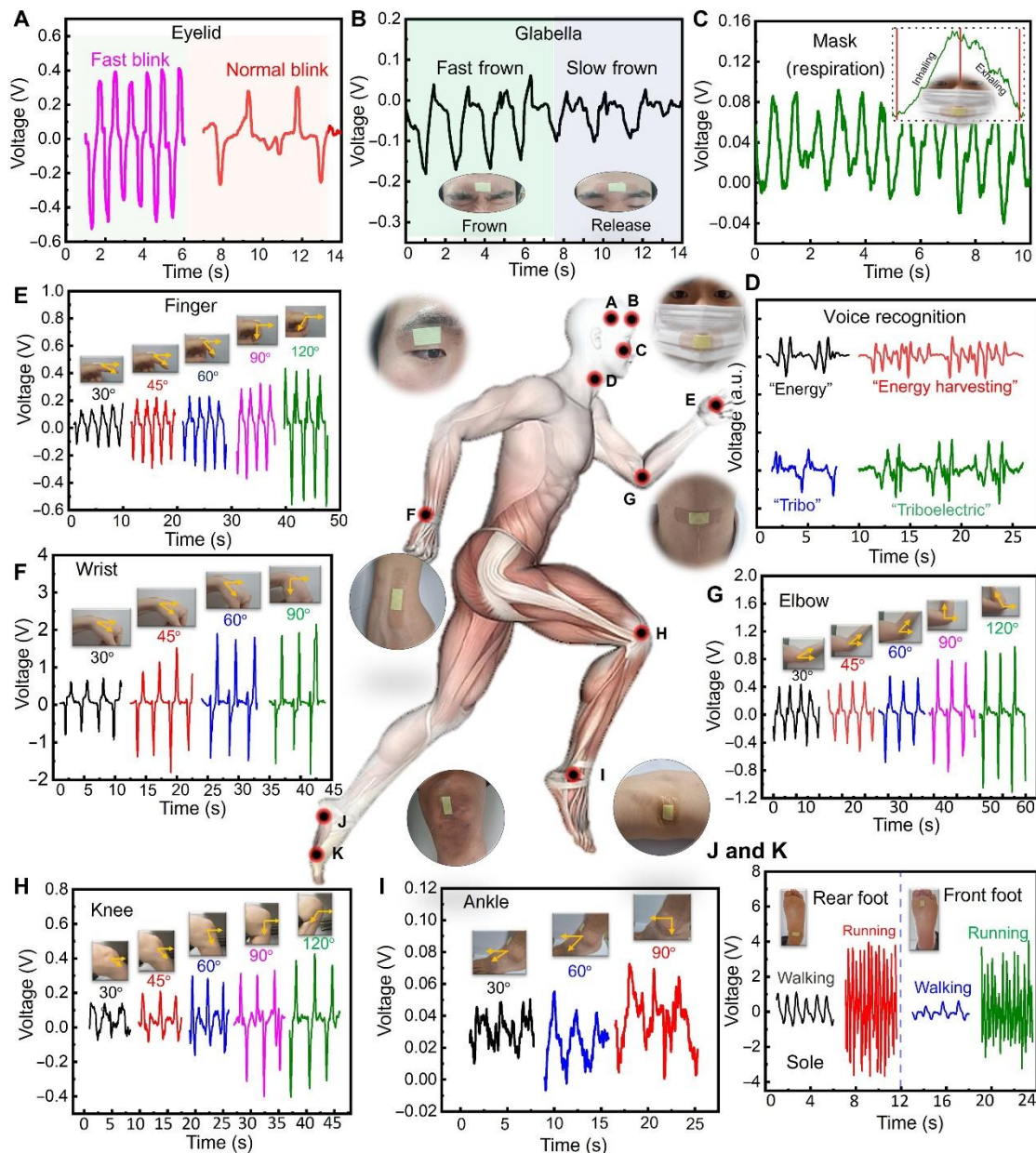


Fig. 3. Comprehensive whole-body monitoring of physiological signals and joint movements using E-Skin.

(A) Monitoring blinking behavior by attaching the E-Skin to the eyelid. (B) Voltage response to frowning, with the E-Skin applied on the forehead. (C) Continuous monitoring of oral breathing using the E-Skin under a dust mask; the inset shows the voltage signal during a single inhalation-exhalation cycle. (D) Sound and speech recognition via E-Skin mounted on a volunteer's throat to detect vocal cord vibrations. (E) Detection of finger-bending angles. (F) Detection of wrist-bending angles. (G) Detection of arm flexion. (H) Measurement of leg-swing angles. (I) Detection of leg flexion. (J and K) Monitoring of foot movements with the E-Skin attached to the corresponding limb.

To achieve accurate monitoring, it is essential for the E-Skin to maintain conformal and intimate contact with the epidermis. This was accomplished by securely attaching the E-Skin to the skin using biocompatible medical bandages (Fig 3). Facial expressions such as blinking, frowning, and smiling are fundamental for conveying human emotions and serve as primary external communication channels. The minute muscle movements associated with microexpressions can be effectively captured through variations in voltage signals. Specifically, subtle voltage changes induced by blinking were detected by affixing the E-Skin to an eyelid (Fig 3A). Furthermore, distinctions in the frequency and amplitude of regular versus rapid blinking were also discernible.

Attaching the E-Skin to the forehead allowed for monitoring consistent and reproducible voltage signals during alternating regular and frowning movements (Fig 3B). Respiration, detectable through the flow of breath or the expansion and contraction of the chest and abdomen during inhalation and exhalation, is a vital sign for assessing users' health. When positioned on the vent of a conventional mask, the E-Skin successfully identified voltage signal changes associated with repeated oral breathing (Fig 3C).

Upon conformal attachment to the throat, the E-Skin effectively recognized distinct words and phrases such as "energy," "energy harvesting", "tribo," and "triboelectric". This demonstrates the voice recognition capabilities (Fig 3D and fig. S17). Each word was recorded three times, consistently generating similar voltage signal responses, indicating high repeatability for voice recognition. This feature could be instrumental in rehabilitating the speech abilities of

users with damaged vocal cords by training them to control their throat muscle movements through remote human-machine interaction and control. In addition, the E-Skin demonstrates a robust response to subtle skin-level stimuli and can accurately track small joint movements, including the knuckle, elbow, knee, and ankle. For instance, when attached to the lateral knuckle of the index finger, the E-Skin recorded voltage responses during multiple bending-releasing cycles, with bending angles ranging from 30° to 120° (Fig 3E).

The E-Skin effectively detected motion angles across various joints, including the wrist (Fig 3F), elbow (Fig 3G), knee (Fig 3H), and ankle (Fig 3I). When applied to these joints and subjected to different degrees of bending and straightening, the E-Skin produced consistent and reproducible voltage signals corresponding to the joint angles, demonstrating its stability and reliability. Minor variations in the output frequencies of the voltage signals were observed, likely due to slight inconsistencies in movement patterns. The increased voltage output with larger bending angles is attributed to the expanded contact area between the E-Skin and the joints. The accurate recognition of joint motion angles facilitated by the E-Skin holds significant potential for real-time remote operation of robotic movements, thereby enhancing human-machine interaction capabilities.

The human movement state is a critical indicator of work intensity, which can be effectively monitored by placing the E-Skin on the ankle. Fig 3 (J and K) shows that attaching the E-Skin to either the back or front of the foot results in notable variations in the amplitude and frequency of the voltage signals, enabling the differentiation between walking and running. These examples illustrate that diverse physiological characteristics and movements can be translated into readable, quantifiable, real-time voltage signals via the E-Skin, thus offering a promising approach for comprehensive electrophysiological and motion monitoring. Therefore, the E-Skin shows great promise for applications in patient rehabilitation, worker performance monitoring, and as a human-machine interface for controlling robots to operate hazardous tasks. Movie S5 (2× speed) records physiological signals and joint movements.

Comprehensive assessment of wearable electrophysiology under various conditions

Wearable electrophysiological monitoring, particularly sEMG and ECG, is crucial for identifying potential safety risks and health issues in real-life

scenarios, such as heart attacks or muscular injuries (35, 36). For stable and reliable signal acquisition, the E-Skin was conformally attached to the epidermis (Fig 4A). The E-Skin was placed on the forearm, and sEMG signals were recorded during muscle clenching and relaxing using a local field potential amplifier equipped with integrated high-pass and low-pass filters (Fig 4B and movie S6). To improve signal quality and minimize noise, we used band-pass filters designed for the specific frequency ranges of the measurements: 10 to 500 Hz for EMG and 0.3 to 40 Hz for ECG. For enhanced signal-to-noise ratio (SNR), we used a three-electrode configuration instead of a two-electrode system, incorporating a third electrode connected to a drive-right-leg circuit to reduce power line noise. The collected data were then imported into MATLAB for further processing, where we applied a digital Butterworth filter and a notch filter with a sharper slope to effectively clean the data. A more detailed clarification of the numerical computation methods used for data processing and analysis is provided in note S7.

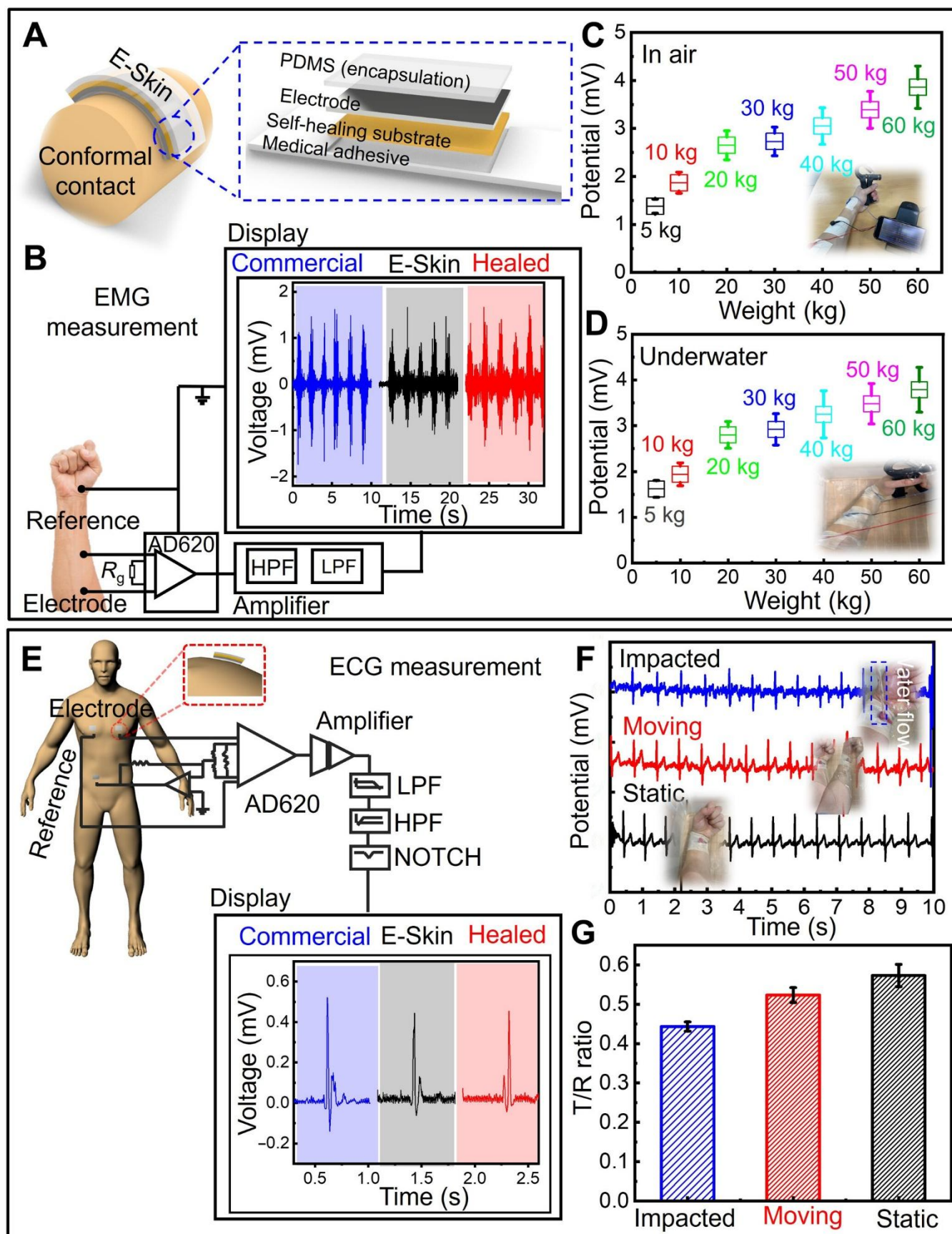


Fig. 4. Comprehensive evaluation of wearable electrophysiological measurements using the E-Skin under diverse conditions.

(A) Schematic illustrating the convenient and conformal attachment of the E-Skin to the epidermis, along with a magnified view of its 3D network structure. (B) Real-time comparison of sEMG measurements using a commercial sEMG Sensor, the E-Skin, and the healed E-Skin. (C) sEMG signals recorded by the E-Skin on the forearm under different grasping forces. (D) sEMG captured underwater with the E-Skin. (E) Real-time ECG measurements compared among a commercial ECG sensor, the E-Skin, and the healed E-Skin. (F) ECG signals recorded underwater, with corresponding photos illustrating different recording conditions: static, moving, and water-impacted. For the latter, water was directed through a 6.0-mm-diameter pipe at a flow rate of 2.0 liter/min. (G) Graphs detecting T/R peak ratio measurements corresponding to (F). LPF, low pass filter; HPF, high pass filter.

Furthermore, the developed E-Skin exhibited rapid stability in sEMG recording within 10 s post-healing under ambient conditions, achieving performance comparable to existing technologies (fig. S18). The sEMG signal processing workflow is detailed in fig. S19. When applied to the forearm and synchronized with a hand dynamometer, the E-Skin detected an increase in EMG signal intensity corresponding to increased grasping force (Fig 4C). The E-Skin maintained its functionality underwater, effectively tracking muscle activity as its conductive and adhesive properties remained intact during water immersion (Fig 4D, fig. S20, and movie S7).

Consistent with the sEMG measurements, ECG recordings were reliably achieved using the E-Skin device paired with a cost-effective AD620 instrumentation amplifier (Fig 4E). The self-healing capability of the E-Skin quickly restored its functionality, yielding signal quality comparable to that of an intact E-Skin measured in static air condition (fig. S21). To assess underwater ECG recording performance with the E-Skin, we tested three conditions: without arm motion (static), with arm motion (moving), and with water flow impacting the E-Skin (affected) (Fig 4F, figs. S22 and S23, and movie S8). Given that most underwater environments involve dynamic water flow, the affected condition offers a more accurate representation of real-life applications. The recorded data were analyzed for quality and stability to enable a comprehensive comparison. The ECG signals were characterized by

their key components: the P wave, the QRS complex, and the T wave (fig. S24) (37). The R wave appears during ventricular contraction, representing the heart's pumping function, while the T wave (around a third of the size of the R wave) indicates the relaxing and blood-filling phase of the ventricles (38). Labor-intensive tasks increase ventricular relaxation, enlarging the T wave. As shown in Fig 4G, the T/R ratios recorded during movement and water impact were similar to those recorded under static conditions due to the tight contact of the E-skin with the epidermis. We expanded our experimental scope to encompass a broad range of dynamic and complex conditions, aiming to better simulate real-world scenarios and further validate the device's reliability and adaptability. As shown in fig. S25, ECG measurements were conducted under diverse aquatic conditions, including variations in water temperature (10°, 25°, and 40°C), depth (0, 30, and 60 cm), and type (sea water and tap water), as well as during dynamic movements such as swiveling, swaying, and flapping. These results demonstrate the device's capability to maintain stable ECG measurements across varying underwater environments and during different dynamic motions.

To elucidate the potential variations in ECG signals across different age groups and health conditions, we conducted additional experiments to expand our dataset. Figure S26A presents EMG signals recorded from adolescents (ages 10 to 19), vicenarians (ages 20 to 29), and tricenarians (ages 30 to 39) following a high-intensity strength exercise (30 push-ups, along with grip strength measurements). The results indicate that younger individuals exhibit stronger EMG signals and faster muscle responses. Figure S26B demonstrates that younger participants tend to have higher heart rate variability and normal ECG waveforms. ECG signals recorded post a 100-m sprint show that participants across all age groups (adolescents, vicenarians, and tricenarians) experienced an increased heart rate following exercise. A detailed clarification of differences in ECG signals across different ages and health conditions is provided in note S8. Furthermore, we conducted on-skin tests to evaluate the long-term wearability of the E-Skin. For comparison, two patches (the E-skin and a commercial gel electrode) were applied to the forearms of an adult subject for 1 day. As shown in fig. S27, the E-skin caused no adverse skin reactions with daily use. In contrast, the commercial gel electrode resulted in noticeable skin erythema, likely due to its limited oxygen and moisture permeability.

Machine learning–empowered prediction and classification of muscle fatigue

The time-domain and frequency-domain features of sEMG signals are well-established indicators for assessing muscle strength and fatigue (39–43). Key biometric parameters—such as the average rectified value (ARV), root mean square (RMS), mean frequency (MEF), and median frequency (MDF)—have been extensively used to quantify muscle fatigue. Time-domain metrics, including ARV and RMS, offer insights into muscle fatigue and are instrumental in estimating endurance time. Moreover, alternations in the frequency-domain patterns of sEMG are associated with reductions in muscle force from an unfatigued state (44, 45). Our analysis of sEMG signals, as detailed in table S3, enabled us to quantify muscle fatigue and strength effectively.

We used a machine learning–powered system to predict and classify muscle fatigue by analyzing time- and frequency-domain features of sEMG signals obtained from the E-Skin. The system integrates wireless electronics with embedded algorithms, offering advanced neurorecording capabilities and comprehensive sEMG pattern recognition. The electronic circuit of the E-Skin system is composed of a bluetooth low energy (BLE) system-on-chip (SoC) system that is responsible for acquiring data from the analog front-ends (AFEs) dedicated to sEMG signals. The BLE SoC enables wireless data communication to a graphic user interface, which houses a compressed AI model, and a specialized deep-learning inference framework optimized for real-time wearable applications (figs. S28 and S29). These embedded components facilitate real-time sEMG signal pattern recognition and accurate prediction of muscle fatigue levels.

We used this machine learning model to analyze sEMG signals for the assessment of muscle fatigue, with data gathered via the E-Skin. Fig 5 provides an overview of the methodology, detailing a series of analyses and model training processes. Raw sEMG signals were initially captured as subjects performed a standardized dumbbell exercise regimen. The study involved 21 subjects, with their characteristics detailed in table S4. The protocol consisted of a cyclic sequence where subjects lifted and held a dumbbell for 5 s, followed by a 5-s rest period. Additional details regarding the protocol are available in note S9 and table S5. This sequence was repeated to generate a robust dataset representing varying levels of muscle fatigue (Fig 5 A).

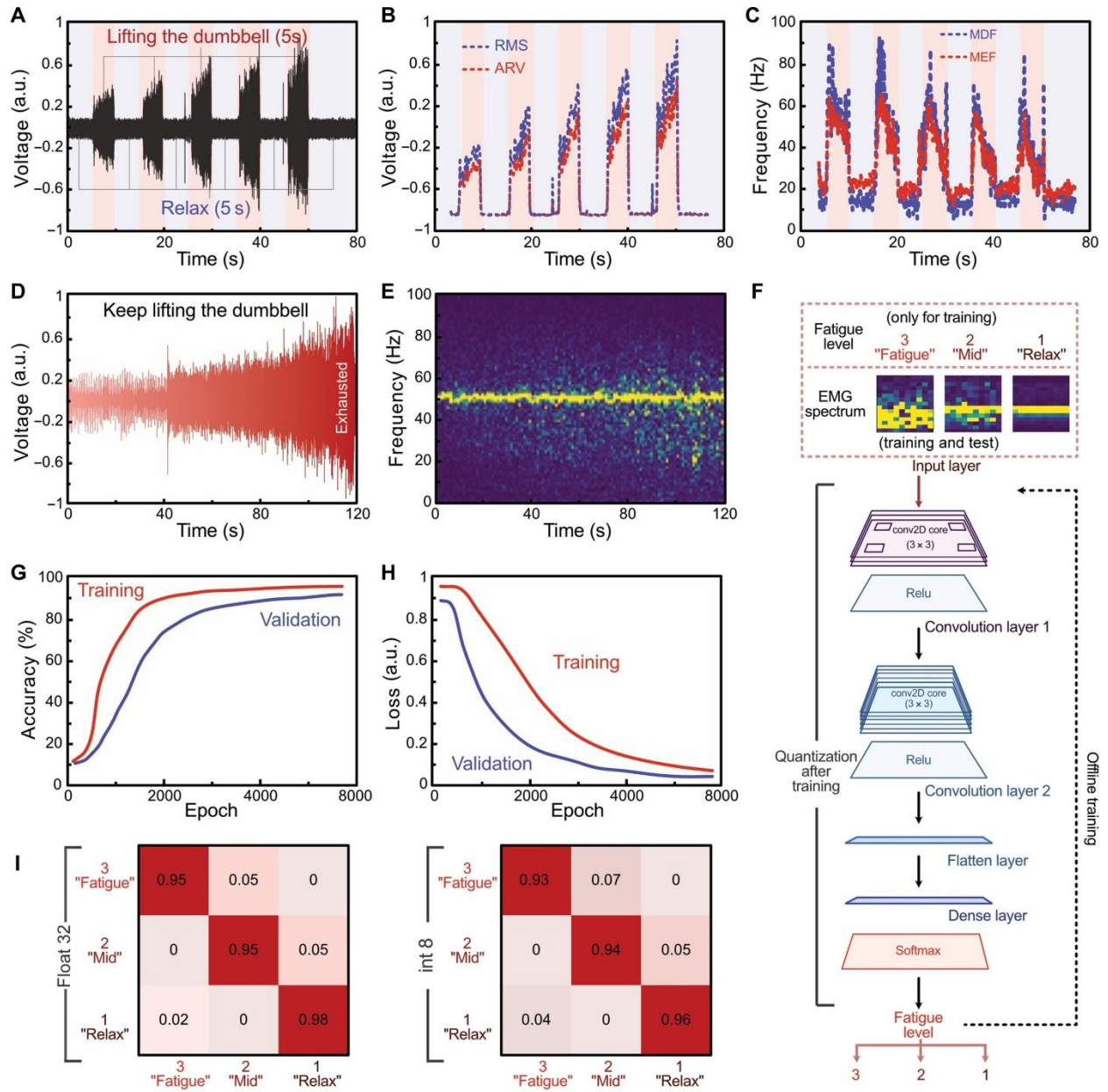


Fig. 5. Machine learning-based muscle fatigue prediction and classification.

(A) Raw sEMG signal data from the E-Skin during a sequence of lifting a dumbbell, holding the lifted position for 5 s, lowering it, and relaxing for another 5 s. (B and C) Analysis of the raw sEMG data in both the time domain (ARV and RMS) and the frequency domain (MDF and MEF). (D) Real-time sEMG signals at different levels of muscle fatigue, used as the training dataset for the machine learning model. (E) Time-frequency diagram of the sEMG signals generated

under continuous muscle exertion for 2 min. **(F)**. Structure of the machine learning model. **(G and H)** Changes in accuracy and loss changes during the training process. **(I)** True- and false-positive plots under various quantification conditions. a.u., arbitrary units.

We then extracted temporal- and frequency-domain features from the data presented in Fig 5A. The time-domain analysis focused on computing ARV and RMS to indicate signal magnitude and muscular activity. Concurrently, the frequency-domain analysis used MDF and MEF to characterize muscle fatigue over time (fig. S30). As muscle fatigue increased, initial increments in the RMS and ARV values were observed due to the recruitment of additional muscle fibers. However, as fatigue intensified, a reduction in muscle fiber capability led to decreased RMS values. Both MDF and MEF generally declined with increasing muscle fatigue, indicating a shift in the signal toward a lower frequency as fatigue progressed. As shown in Fig (B and C), ARV and RMS values increased, while MDF and MEF values decreased with an increase in fatigue induced by repeated lifting of a 5-kg dumbbell. To provide a more comprehensive analysis, the subjects continued the dumbbell lifting exercise for 2 min post-rest, during which sEMG signals were captured to monitor the onset and progression of muscle fatigue. This extensive dataset provided a suitable training dataset for the machine learning algorithm (Fig 5D).

To investigate the interplay between temporal evolution and spectral changes in muscle activity, we visualized the time-frequency distribution of the sEMG signal, providing insights into spectral patterns associated with sustained effort (Fig 5E). For this purpose, we developed a two-layer convolutional neural network (CNN) model to classify levels of muscle fatigue from the sEMG data (Fig 5F). The model's architecture includes an initial input layer, followed by a first 2D convolution layer with rectified linear unit (ReLU) activation to enhance computational efficiency, and a second 2D convolution layer to further extract fatigue-related features, both using 8×10 filters. The output from the second convolution layer is passed through an additional ReLU activation layer, flattened, and fed into a fully connected layer for feature mapping, ultimately producing the final fatigue score via SoftMax activation.

We divided the pre-collected EMG data into three sets to train the model: 60% for training, 20% for validation, and 20% for testing. The CNN model was trained while minimizing the cross-entropy loss function, with a dropout rate of 0.5 applied to mitigate overfitting. After 100,000 epochs, the CNN model

achieved an accuracy exceeding 90% (Fig (G and H)). Subsequently, the model parameter values were fixed, and quantization was applied, resulting in an 8-bit model with a reduced size of less than 20 kB, facilitating integration with the real-time graphic user interface (movie S9).

We assessed the classification performance of the CNN model using confusion matrices to quantitatively represent the model's predictions across three distinct classes: Fatigue, medium (Mid), and relax. As shown in Fig 5I, the matrix on the left depicts the performance using 32-bit floating-point precision, while the matrix on the right illustrates the performance after applying 8-bit integer quantization. In these confusion matrices, the diagonal elements indicate the proportion of correct predictions for each class, while the off-diagonal elements represent misclassifications.

The 32-bit model demonstrated high accuracy in classifying different states, achieving 96% for "Fatigue," 95% for "Mid," and 98% for "Relax." Similarly, the quantized 8-bit model showed strong performance, with classification accuracies of 93% for Fatigue, 94% for Mid, and 96% for Relax. These results indicate that the model preserves high predictive accuracy following quantization. While quantization typically reduces the memory footprint and computational complexity of the model at the cost of some accuracy, our CNN model maintains high-performance post-quantization. This underscores its potential for real-time fatigue monitoring in wearable devices.

DISCUSSION

We developed a rapid self-healing E-Skin patch for noninvasive real-time electrophysiological and joint-movement monitoring. The E-Skin was constructed from stretchable PTMEG-modified TPU and a soft silver nanowire network that enabled direct and intimate contact with the skin. This design ensured self-healing within 10 s, without the need of external stimuli, and under ambient conditions, effectively responding to mechanical damage resulting from the skin's dynamic movements, providing adaptability suitable for real daily life use. This was achieved by integrating bis(4-hydroxyphenyl) disulfide into the TPU matrix, which endowed the E-Skin with self-healing capabilities through the formation of intracellular disulfide bonds. IPDI, characterized by its an asymmetric alicyclic structure, was used to enhance chain mobility, thereby facilitating disulfide exchange. This modification further improved material's self-healing capabilities across a broad

temperature range, including both high temperature and low temperatures. This significantly mitigated mechanical damage from repeated wear, tear, and accidental cuts or scratches, thereby preserving the device's structural integrity and functionality over prolonged use.

Integrating E-Skin with wireless electronics and embedded algorithms enabled the long-term monitoring of biophysical signals and facilitated on-site AI-powered analysis. This system provided real-time identification and classification of muscle fatigue. Leveraging a CNN algorithm to learn from sEMG signal patterns associated with fatigue, the system offers a robust tool to monitor the muscular status of the users and potentially supply an early warning of injury risk due to muscle fatigue. The seamless incorporation of AI and embedded algorithms further enhanced its utility in health evaluation and rehabilitative therapies.

Despite the significant performance of the E-Skin device, future advancements focus on several key areas:

First, enhancing electrode materials and mechanical structure is essential; while AgNW has shown effectiveness, alternative materials such as MXene, CNTs, and conductive polymers hold additional potential. Future research will prioritize exploring these materials individually and in combination to optimize device performance, aiming for improved stability, reliability, and cost-effectiveness.

Second, extending the operational duration of the E-Skin is crucial to facilitate long-term electrophysiological monitoring in real-life scenarios, and to enable the device to function continuously for days or even weeks.

Third, achieving full miniaturization of the E-Skin will require the development of integrated electronics capable of supporting electro-impedance spectroscopy, signal processing, and wireless transmission. By creating a standalone E-Skin sensing interface equipped with AI-assisted on-site signal processing, the device can be transformed into a comprehensive, skin-interfaced monitoring system. Lastly, conducting large-scale validation studies across diverse populations is essential, given the variability of physiological signals. These studies will ensure the E-Skin functions reliably for a wide range of users, paving the way for a fully integrated, intelligent platform that provides valuable insights into individual health and

physiological status, contributing to injury prevention and management, particularly in labor-intensive occupations.

We envision this rapidly self-healing E-Skin patch offers substantial benefits to a diverse group of users—including construction workers, athletes, and military personnel—by enabling robust health monitoring in daily life and under extreme conditions. It aims to prevent and manage injuries related to labor-intensive activities, optimize training regimens, and support physical therapy by real-time tracking recovery progress. Ultimately, this E-Skin patch has the potential to enhance overall health and performance across various real-world scenarios.

MATERIALS AND METHODS

Materials

PTMEG with an average molecular weight of 1000 g mol⁻¹, IPDI (98%, mixture of isomers), and dibutyltin dilaurate were obtained from Sigma-Aldrich. Dimethylacetamide was sourced from Samchun Chemical, and bis(4-hydroxyphenyl) disulfide was acquired from Ambeed. All reagents were used as received without further purification.

Self-healing polymer fabrication

PTMEG (15 g) was dried at 100°C for 1 hour to remove residual moisture and then cooled to 70°C. Meanwhile, IPDI (10 g, 44.98 mmol) and dibutyltin dilaurate (0.2 g) were dissolved in 5 ml of *N,N*-dimethylacetamide (DMAc) under a nitrogen (N₂) atmosphere for 2 hours and then cooled to room temperature. Bis(hydroxyphenyl) disulfide (3.63 g, 14.50 mmol), dissolved in 10 ml of DMAc, was introduced into the reactor as a chain extender. The reactor temperature was raised to 40°C, allowing the reaction to continue until the NCO peak was no longer detectable. The concentration of the resultant polymer solution was adjusted to 30 weight % by adding 43 ml of DMAc. The solution was then degassed under vacuum for approximately 1 hour to eliminate bubbles. Subsequently, 20 ml of the synthesized polymer solution was poured onto a Teflon-coated dish, cured on a hotplate at 40°C for 1 day, and then allowed to cure at room temperature.

E-Skin fabrication

The E-Skin substrate was treated with ultraviolet (UV)–Ozone (UVC-30s, Jasung Engineering) to eliminate potential organic contaminants and introduce oxygen-containing functional groups, thereby enhancing its hydrophilic properties. Silver nanowire ink was prepared following our established methods (23, 28). The silver nanowire electrodes were precisely patterned onto the self-healing E-Skin substrate using screen-printing techniques facilitated by laser-cut shadow masks. The printed E-Skin was then annealed to improve its stability at room temperature.

On-body validation of the E-Skin

The epidermal evaluation was conducted on healthy adult individuals without heart conditions, diabetes, or chronic pain, adhering strictly to the protocol sanctioned by the Institutional Review Board at the University of California, Los Angeles (IRB#17-000170). Further, informed written consent was obtained from all participants.

ECG measurement

The E-Skin was applied to the forearm for ECG measurements. Two E-Skin patches were positioned on the volunteer's left and right forearms secured with a commercially available medical adhesive (3M, USA) to ensure proper adhesion. ECG signals were acquired using a commercial ECG board (SparkFun AD8232 ECG monitor) and recorded with a digital phosphor oscilloscope (Tektronix, DPO3014). The electronic circuit board was powered by a portable power source (Dr. Meter, PS-305DM) at approximately 3.3 V. The circuit board utilized an AD8232 chip to amplify and filter the raw ECG signals.

Electrical integration for sEMG recording

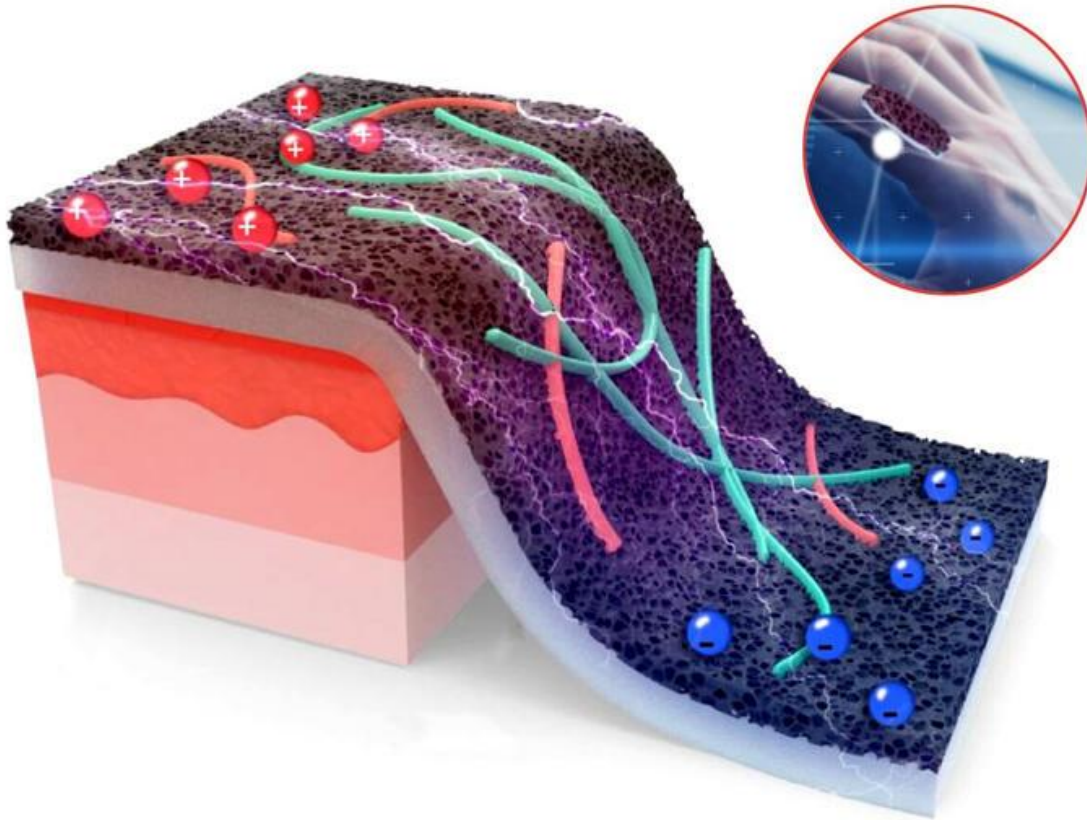
We incorporated a BLE SoC (NRF52840-CKAA, Nordic Semiconductor) encased in a compact wafer-level chip-scale package (WLCSP) measuring 3.5 mm by 3.6 mm, serving as both the central processing unit and Bluetooth communication module to facilitate deep-learning operations. A rechargeable lithium-polymer battery, connected to a low-dropout linear voltage regulator (ADP7112, Analog Devices), provided a stable voltage output. For wireless data transmission, the BLE SoC used a miniature ceramic antenna (2450AT18A100, Johanson Technology) measuring 3.2 mm by 1.6 mm and operating at 2.45 GHz. The amplification, filtering, and digitization of sEMG

signals were performed using ultralow-power biopotential AFEs (MAX30003, Maxim Integrated) in a WLCSP format measuring 2.74 mm by 2.9 mm. These AFEs exhibited exceptional performance, with an ultralow-power consumption of 180 μ W and a high common-mode rejection ratio exceeding 100 dB. Digital sEMG data were transmitted to the BLE SoC via the serial peripheral interface. To ensure a stable 1.8-V supply for the biopotential AFE, a secondary low-dropout voltage regulator (LP5907UVX, Texas Instruments) in a four-pin WLCSP measuring 0.645 mm by 0.645 mm was connected to the output of the primary voltage regulator. The integration of passive components in 0201 packages, known for their compact size, helped minimize the system's overall physical footprint.

Characterizations and measurements

The transmittance spectra of PDMS and E-Skin were recorded using a Shimadzu UV-visible spectrophotometer. The strain-stress response of the E-Skin during the healing process was analyzed with a JSH-H1000 Horizontal Acomatic Handy Test Stand and SOP-EG1 software. The applied force was quantified using a Mark-10 force monitor, and the corresponding output characteristics were captured with an MDO-3052 oscilloscope. This oscilloscope was also used to record output characteristics from various body locations. The healing process of the E-Skin following complete severance was assessed using AFM (NX10). For EMG and ECG measurements, a PZ5 neuro digitizer amplifier and RZ2 software were used.

Self-powered graphene smart sensor takes the pain out of wound monitoring



The flexible sensor, ideal for use in the human body, uses laser-induced graphene to simultaneously but separately measure temperature and strain, potentially enabling better wound healing monitoring by providing clearer insights into inflammation and recovery. Credit: Jennifer M. McCann

A major challenge in self-powered wearable sensors for health care monitoring is distinguishing different signals when they occur at the same time. Researchers from Penn State and China's Hebei University of Technology have addressed this issue by uncovering a new property of a sensor material, enabling the team to develop a new type of flexible sensor that can accurately measure both temperature and physical strain simultaneously but separately to more precisely pinpoint various signals.

"This unique sensor material we've developed has potentially important applications in health care monitoring," said Huanyu "Larry" Cheng, James L. Henderson, Jr. Memorial Associate Professor of Engineering Science and

Mechanics (ESM) at Penn State and co-corresponding author of the study, in *Nature Communications*.

"By accurately measuring both temperature changes and physical deformation or strain created by a healing wound and measure that by separating the two signals, it could revolutionize the tracking of wound healing. Doctors could get a much clearer picture of the healing process, identifying issues like inflammation early on."

The researchers aimed to accurately measure temperature and strain signals without cross talk by using laser-induced graphene, a two-dimensional (2D) material. Like all 2D materials including regular graphene, laser-induced graphene is one to a few atoms thick with unique properties, but with a twist. Laser-induced graphene (LIG) forms when a laser heats certain carbon-rich materials—like plastic or wood—in a way that converts their surface into a graphene structure. The laser essentially "writes" the graphene directly onto the material, making it a simple and scalable way to produce graphene patterns for electronics, sensors, and energy devices.

LIG has been used before in various applications. Previously, Cheng and his team used LIG for gas sensors, electrochemical detectors for sweat analysis, supercapacitors, and more. However, the researchers said they believe they discovered a new property of LIG for the first time that makes it ideal for a multi-purpose and accurate sensor.

"In this particular study, we kind of stumbled upon the fact that this material also has thermoelectric properties," Cheng said. "We believe this is the first time anyone has reported laser-induced graphene having thermoelectric capabilities. And that's really important for what we're trying to do here, which is to separately measure both temperature changes and physical strain or deformation."

Thermoelectric properties in a material refer to the ability to convert temperature differences into electrical voltage and vice versa, enabling such materials to be used for applications like energy harvesting and temperature sensing. According to Cheng, this newly identified thermoelectric property of LIG makes it easy to separate the two sensor measurements and is ideal for healthcare applications such as a sensor embedded in a bandage.

"When you have materials that are sensitive to both temperature and strain, it can be tricky to tell which signal is causing changes in the material," Cheng said. "But by using this thermoelectric effect in the laser-induced graphene, we can essentially decouple those two measurements. We can look at the electrical resistance to get information about the strain, while also measuring the thermal voltage to determine the temperature. This is why doctors could use it to track both temperature fluctuations and physical changes in the wound site and give a much clearer picture of how the healing is progressing."

He also noted that the sensor is highly sensitive, detecting temperature changes as small as 0.5 degrees Celsius. The material's design takes advantage of the way porous graphene and thermoelectric components work together, making it nearly four times better at converting heat into electricity. The sensor can also stretch up to 45%, as well as conform to different shapes and surfaces, without losing function.

"The porous structure of this material creates a lot of tiny spaces and channels that allow it to interact with its surroundings in a very sensitive way," Cheng said. "This makes it well-suited for interfacing with human soft tissues, in contrast to more rigid thermoelectric materials, such as ceramic-based ones."

Since the thermoelectric aspect of LIG also means it can generate electrical power when there is a temperature difference, LIG sensors are self-powered. According to Cheng, this could be particularly useful for continuous monitoring in clinical settings and for other applications, such as helping detect fires in remote locations.

In addition to refining the sensor, the team is developing a wireless system that will allow people to monitor the data from the sensor remotely. This will make it possible to track important information, such as temperature or strain, in real-time using smartphones or other devices.

"For example, a doctor could monitor a patient's condition from a distance, or emergency responders could receive alerts about dangerous temperature changes," Cheng said. "These advancements aim to make technology more accessible and effective, helping to improve health monitoring and safety in everyday situations."

Along with Cheng, other paper authors include Ankan Dutta, graduate student in engineering science and mechanics at Penn State; and Li Yang, Xue Chen, Hui Zhang, Zihan Wang, Mingyang Zin, Shuaijie Du and Guizhi Xu, all from Hebei University of Technology.

More information: Li Yang et al, Thermoelectric porous laser-induced graphene-based strain-temperature decoupling and self-powered sensing, *Nature Communications* (2025). DOI: [10.1038/s41467-024-55790-x](https://doi.org/10.1038/s41467-024-55790-x)

Provided by Pennsylvania State University

HOTTEST TOPICS IN TYPE ONE RESEARCH

The discussion on **beyond conventional physics** encompasses several advanced topics:

- **Extended Electrodynamics:** This area explores the limits of classical electrodynamics and its implications for new technologies.
 - **Lattice Confinement Fusion:** A method of achieving nuclear fusion that utilizes lattice structures to confine and enhance reactions.
 - **Zero-Point Energy:** The concept of harnessing energy from the quantum vacuum, which could revolutionize energy production.
 - **Advanced Propulsion:** Innovations in propulsion technologies that could lead to breakthroughs in space travel and energy efficiency.
- These topics are being explored by leading experts in aerospace and energy, suggesting potential revolutionary advances in technology.



New smartglasses use insect vision tech to restore full 3D visual experience



New smartglasses use insect vision tech to restore full 3D visual experience

SolidddVision smartglasses, inspired by the eyes of a fly and powered by virtual reality technology, are offering a miraculous chance for people suffering from macular degeneration to regain their sight.

Developed by Soliddd Corp, this innovative technology, showcased at CES 2025, represents the “first true vision correction” for one of the leading causes of blindness: macular degeneration. This condition blurs central vision due to damage to the macula.

As a unique and advanced form of augmented reality (AR) and virtual reality (VR) glasses, SolidddVision smartglasses utilize a sophisticated blend of technologies.

They project multiple separate images onto the areas of the retina that remain unaffected, using lenses that mimic a fly’s eye, according to Soliddd’s website.

The company has discovered a novel way to engage the visual cortex by beaming light in parallel rays from the periphery of the wearer’s field of vision to the far edges of the retina, effectively creating a complete visual picture. In the United

States alone, an estimated [19.8 million](#) people over the age of 40 have age-related macular degeneration.

These groundbreaking eyeglasses have already received rave reviews, bringing new hope to the millions experiencing vision loss.

A seriously cool pair of eyeglasses

Over a decade in the making, SolidddVision smartglasses leverage 3D technology and computer vision artificial intelligence (AI) to produce a groundbreaking effect: “providing sight in areas of the visual field where patients typically see nothing,” Neal Weinstock Soliddd CEO and founder explained.

The smart glasses are equipped with two sets of cameras—one set facing outward and the other facing the wearer. These cameras record what the wearer sees while tracking their gaze. The software processes this data.

SolidddVision smartglasses utilize the brain’s natural mechanisms to their advantage, sending 100 views to the displays behind the lenses. This mimics how the brain processes visual stimuli, assembling a cohesive picture. The technology projects a “single, stereo, full-field image” from a series of inputs, allowing an improved visual experience. Each display contains 49 lenses, but the product will feature three times that number.

The design draws inspiration from the eyes of a fly, with each lens projecting a version of the image captured by the forward-facing cameras onto healthy areas of the retina at various angles.

“This allows the brain to naturally construct stereopsis (the making of a 3D image in the brain) and a single full-field image with good acuity that feels like normal, in-focus sight,” according to Soliddd.

Even with impaired vision, the “redundant visual information” sent to undamaged areas of the retina allows the brain to process sightlines normally.

50% of clinical patients saw a real improvement

Researchers at New York's Lighthouse Guild conducted a clinical trial involving 30 patients with macular diseases. Remarkably, 50% of participants showed improvement in their reading abilities.

Feedback from trial participants has been overwhelmingly positive.

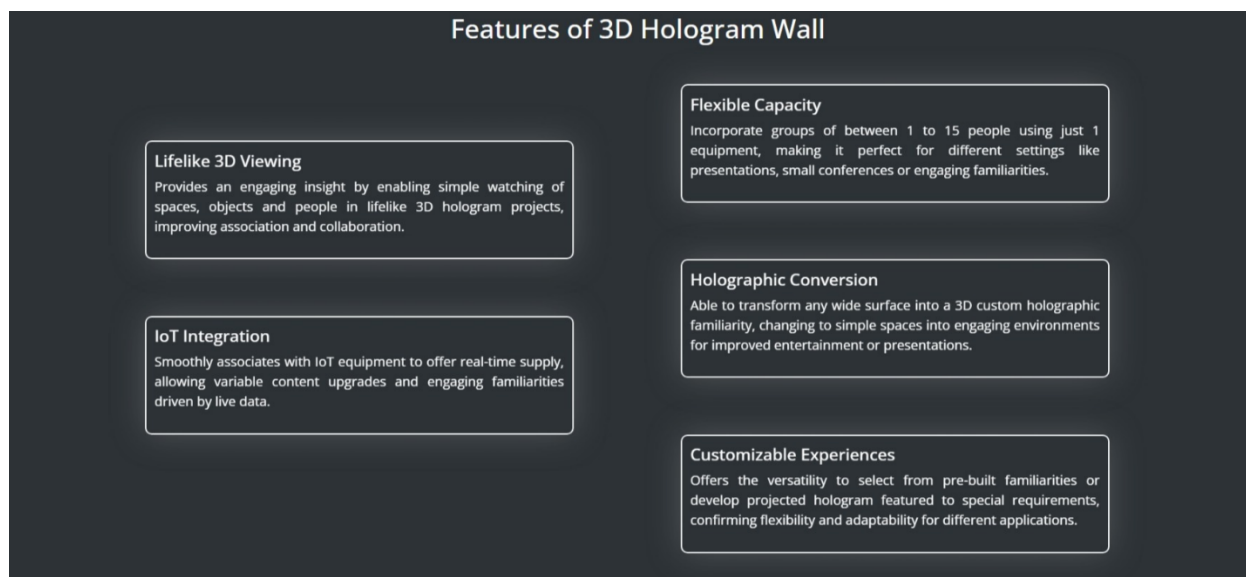
Chad Kline, a trial participant, shared, "After over two decades of experiencing distorted vision from a retinal detachment, trying the SolidddVision glasses enabled me to see without the double vision and distortion that have affected my daily life."

Judy Scheck, another participant, expressed, "I'm nearly blind, but when I looked through the Soliddd device, I could clearly see an image of Taylor Swift and, best of all, read some text. This is truly a life-changing invention for me and others like me."

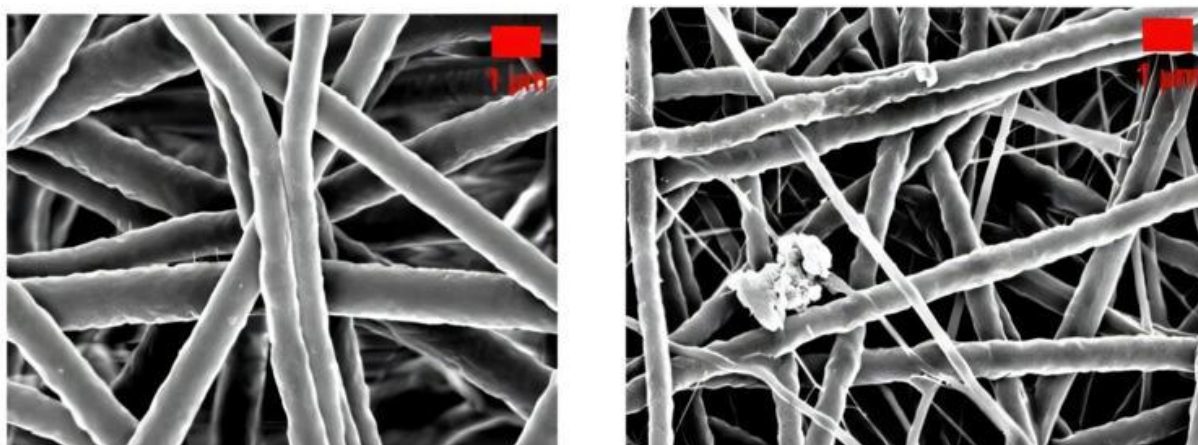
Megan Lisenby stated, "Since the age of 19, I've lived with a black, empty smudge in the center of my vision due to central cone dystrophy. When I tried the SolidddVision [technology](#), for the first time in almost 30 years, that smudge disappeared and was replaced by an actual image."

To enthusiastic reviews, Soliddd plans to launch their groundbreaking [smartglasses](#) in the marketplace in 2025 after conducting another series of rigorous patient tests.

"SolidddVision [smartglasses](#) are lightweight and easily integrated into daily life. Our mission is to help restore and improve sight for the millions of consumers worldwide suffering from vision loss caused by macular degeneration," concluded Neal Weinstock on the company's [website](#).



Scientists develop magnesium-enriched nanofiber patches for safer wound healing



The figure shows scanning electron microscope images comparing the structural morphology of pristine polyurethane (left) and magnesium chloride-enriched polyurethane nanofiber patches (right). Credit: Dr. Saravana Kumar Jaganathan from the University of Lincoln, UK Source Link: <https://doi.org/10.2147/IJN.S460921>

The skin serves as the body's primary defense against harmful microorganisms, toxins, and physical damage. However, severe injuries from burns, trauma, surgery, or conditions like diabetes can compromise its ability to heal naturally, necessitating advanced wound care solutions. While minor wounds can heal with conventional care, severe injuries demand innovative materials and techniques to ensure rapid and complication-free healing.

To address this, a team of researchers led by Dr. Saravana Kumar Jaganathan has introduced nanofiber wound patches that combine polyurethane (PU) with magnesium chloride (MgCl_2). These advanced patches, developed using electrospinning technology, exhibit enhanced strength, superior blood compatibility, and effective antimicrobial properties. Their findings, published in the [*International Journal of Nanomedicine*](#), on November 1, 2024, mark a significant advancement in wound care.

"The efficacy of wound management heavily relies on the selection of optimal wound dressings. Our research explores how combining polyurethane and magnesium chloride can address this challenge effectively," states Dr. Jaganathan.

PU has long been recognized as a versatile material in medical applications due to its flexibility, durability, and biocompatibility. However, Dr. Jaganathan and his team saw the potential for improvement. As he explains, "Wound management is a critical issue. Polymeric wound dressings have garnered wide attention for their ability to accelerate healing, and our study builds on this foundation."

The team utilized electrospinning—a technique that produces nanofibers mimicking the structure of natural tissue to create these innovative patches. This unique structure supports cell attachment and growth while maintaining controlled porosity, which is essential for optimal wound healing. The inclusion of MgCl_2 further amplified the patch's effectiveness, significantly enhancing its mechanical and biological properties.

One standout feature of these patches is their remarkable mechanical strength. Laboratory tests revealed that magnesium-infused patches were almost twice as strong as traditional PU patches, ensuring durability and reliability during clinical use. This makes them particularly suited for handling the demands of severe wound care.

Additionally, the patches demonstrated excellent blood compatibility. Coagulation tests, such as activated partial thromboplastin time and prothrombin time, indicated that MgCl_2 delayed clotting time, reducing the risk of adverse reactions and ensuring safer interactions with the body's healing processes.

Infection control is another critical aspect of effective wound care. The researchers tested the antimicrobial properties of their patches against two common wound-infecting bacteria, *Staphylococcus aureus* and *Escherichia coli*.

The results were impressive: the MgCl_2 -enhanced patches successfully inhibited bacterial growth, while traditional PU patches showed no such activity. This antimicrobial capability significantly reduces the risk of infections, a common and serious complication in wound management.

The team also evaluated the patch's impact on skin cells, particularly fibroblasts, which are vital for tissue regeneration. Cell viability tests demonstrated that magnesium-infused patches supported fibroblast growth more effectively than conventional PU patches. This non-toxic nature ensures that the patch promotes faster and more efficient healing without compromising safety.

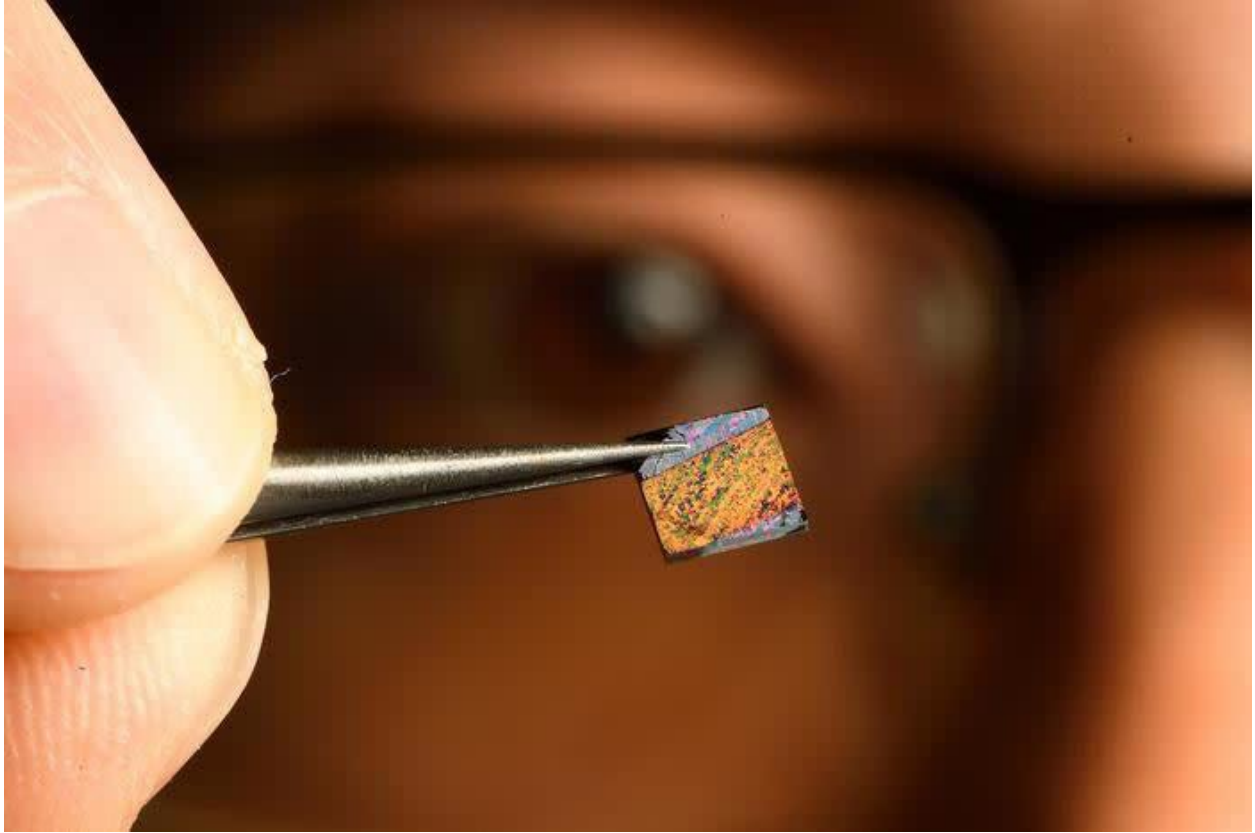
Despite these promising results, the researchers acknowledge that additional studies are needed to validate the patch's effectiveness in real-world clinical scenarios. In vivo testing will be essential to assess the performance under practical conditions.

This research paves the way for a new era in wound care, promising improved outcomes and enhanced quality of life for those in need of effective wound management solutions.

More information: Mohan Mani et al, Characterization and Performance Evaluation of Magnesium Chloride-Enriched Polyurethane Nanofiber Patches for Wound Dressings, *International Journal of Nanomedicine* (2024). DOI: [10.2147/IJN.S460921](https://doi.org/10.2147/IJN.S460921)

Provided by Shibaura Institute of Technology

Revolutionary nano-chip quickly detects earliest sign of heart attack



Discover how advanced SERS technology is revolutionizing diagnostics with rapid, accurate tools for heart attacks and beyond, redefining precision medicine. (CREDIT: Will Kirk/Johns Hopkins University)© The Brighter Side of News

Surface-enhanced Raman spectroscopy (SERS) is revolutionizing biomedical diagnostics and therapeutics, enabling breakthroughs in biopharmaceuticals, antimicrobial resistance detection, forensic science, and homeland security. With its unique ability to detect [molecular fingerprints](#) with single-molecule sensitivity,

SERS offers unparalleled potential. However, translating this method into reliable clinical tools faces significant hurdles—chiefly the reliance on electric fields for signal enhancement and unpredictable intensity fluctuations.

Traditionally, SERS enhancement depends on electromagnetic fields, particularly electric fields (E-fields). While effective, the magnetic field (H-field) component

remains underutilized due to the limited magnetic permeability of metals at optical frequencies.

This omission underscores a missed opportunity to fully exploit electromagnetic mechanisms in SERS. Addressing this gap requires innovative solutions, such as plasmonic substrates that activate both E- and H-fields.

Recent advances in photonic metamaterials present a promising path forward. Published in the journal, [Science Advances](#), these engineered structures exhibit unique optical properties, including the ability to generate significant magnetism at optical frequencies.

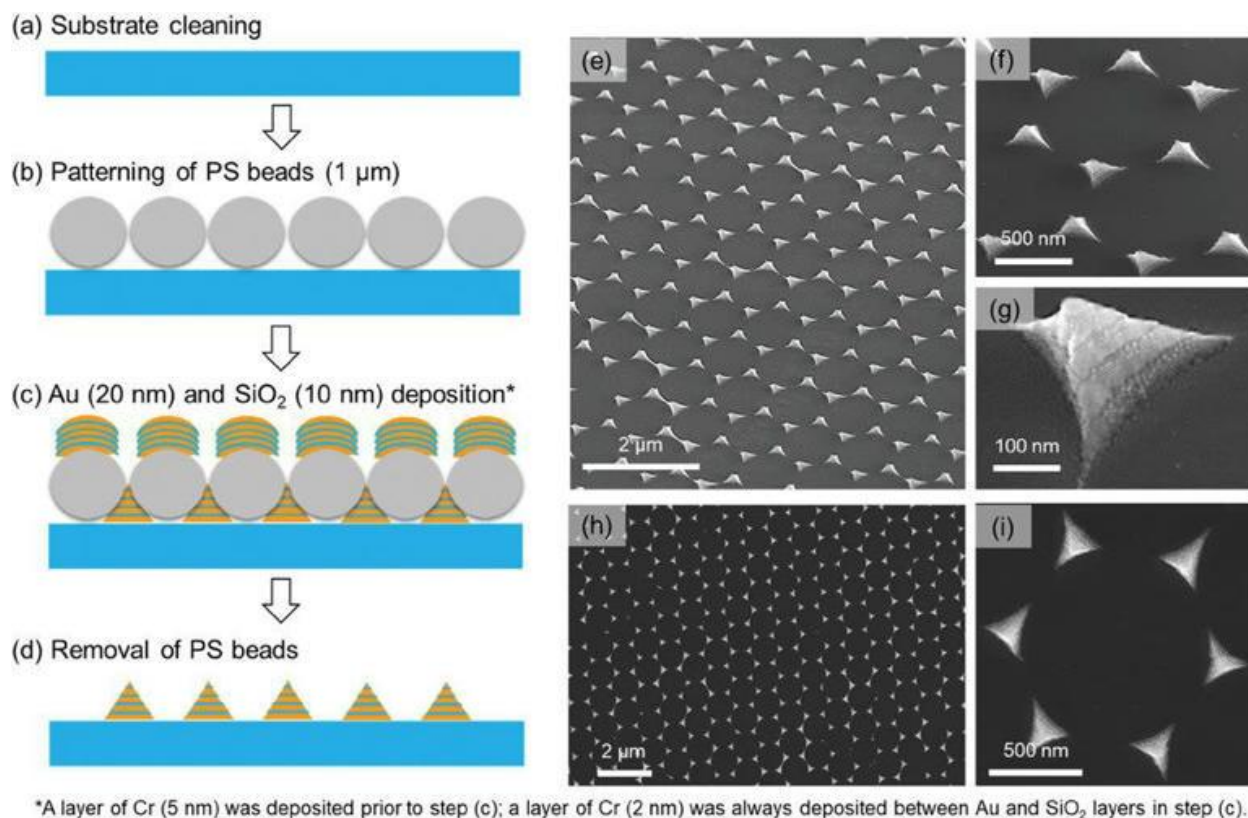
Research has demonstrated the viability of frequency-based SERS immunoassays using antibody-antigen interactions. These interactions induce structural changes in antibody-conjugated Raman molecules, resulting in characteristic frequency shifts.

Notably, this method simplifies assay design by requiring only one type of antibody, reducing time, cost, and complexity. Such frequency-based approaches have successfully detected proteins, [nucleic acids](#), and even circulating tumor DNA.

The adoption of frequency-based SERS has implications beyond simplifying assay procedures. It addresses one of the long-standing challenges in spectroscopic analysis: reproducibility.

By focusing on frequency shifts rather than intensity variations, researchers can achieve more consistent and reliable results, even in complex biological environments. This advancement is particularly important for applications in personalized medicine, where diagnostic precision can significantly impact treatment outcomes.

Building on these advances, researchers have combined plasmonic metasurfaces and frequency-shift monitoring to develop a groundbreaking diagnostic tool for cardiac biomarkers.



Fabrication and characterization of the gold–silica–gold alternately layered pyramidal plasmonic metasurfaces. (CREDIT: Advanced Science)© The Brighter Side of News

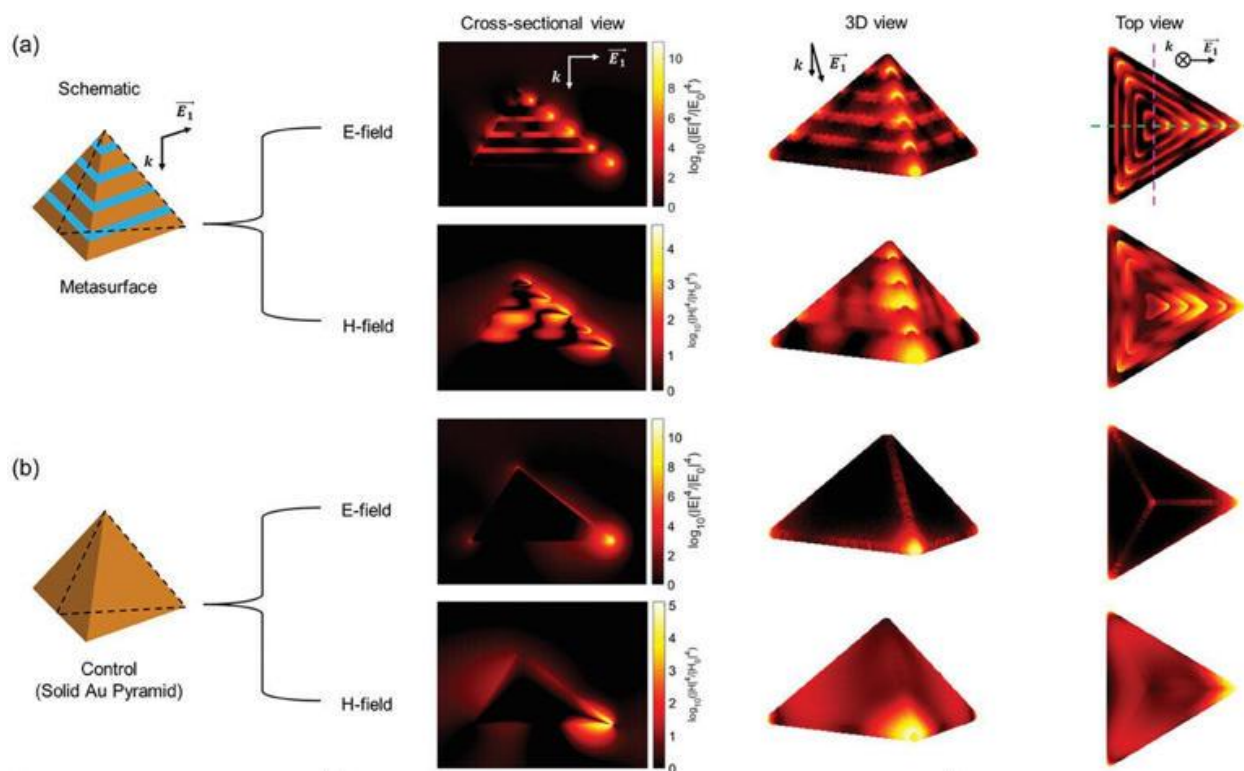
Acute myocardial infarction (AMI), commonly known as a [heart attack](#), requires rapid diagnosis to enable timely medical intervention. Key biomarkers for AMI include creatine kinase-myocardial band (CK-MB), myoglobin (Mb), and cardiac troponin-I (cTnI).

This new diagnostic platform employs alternately stacked gold-silica pyramidal metasurfaces. These structures, fabricated using nanosphere lithography, activate both E- and H-fields to enhance SERS signals. Complemented by 3D-printed compartmentalized biosensors, the platform allows simultaneous detection of multiple biomarkers with unprecedented speed and accuracy.

Finite-difference time-domain simulations confirmed the metasurfaces' ability to produce spatially consistent SERS enhancement. By addressing the "SERS memory effect"—a common challenge in reusing substrates—this method enables high-throughput, interference-free analysis of serum samples. The result is a stand-alone [blood test](#) capable of delivering results in five to seven minutes, outperforming traditional methods that can take hours.

The ability to detect multiple biomarkers simultaneously is a significant advancement. Current diagnostic methods often rely on separate tests for each biomarker, increasing the time and cost of diagnosis.

The integration of multiplexed detection into a single platform not only streamlines the diagnostic process but also reduces the likelihood of errors associated with handling multiple samples. This improvement is particularly valuable in emergency settings, where rapid and accurate diagnosis can be lifesaving.



FDTD calculations of the E- and H-fields for SERS enhancement on the plasmonic metasurface and Au nanostructure. (CREDIT: Advanced Sciences)© The Brighter Side of News

The heart of this innovation lies in its chip-based design, featuring a [nanostructured metasurface](#). This surface amplifies both electric and magnetic signals during Raman spectroscopy, making it sensitive enough to detect ultra-low concentrations of biomarkers. This capability is crucial for early-stage diagnosis when medical intervention can save lives.

Beyond its clinical applications, the technology holds promise for first responders and even at-home use. A handheld device based on this platform could enable rapid, accurate diagnostics outside hospital settings. "We're talking about speed,

accuracy, and the ability to perform measurements outside of a hospital,” explained bioengineer Ishan Barman. Such advancements could revolutionize emergency care and democratize access to critical diagnostic tools.

The potential for at-home diagnostic tools represents a major shift in healthcare delivery. By empowering individuals to monitor their health in real time, these devices could reduce the burden on [healthcare systems](#) and enable earlier detection of conditions that might otherwise go unnoticed. This approach aligns with the growing emphasis on preventative medicine and personalized healthcare.

While initially designed for heart attack diagnosis, this platform technology has broader implications. It could be adapted to detect cancer biomarkers, infectious diseases, and other health conditions. The flexibility of the metasurface design makes it a versatile tool for various biomedical applications.

“There is enormous commercial potential,” said Barman. “There’s nothing that limits this platform technology.” Future research will focus on refining the test and conducting larger clinical trials to validate its efficacy across diverse populations and conditions.

The development of this technology also opens the door to new research opportunities in other fields. For example, environmental scientists could use similar platforms to [detect pollutants](#) at trace levels, while forensic experts might employ them to analyze crime scene evidence with unprecedented precision. These interdisciplinary applications highlight the versatility and far-reaching impact of advances in SERS-based diagnostics.

This innovation exemplifies the transformative power of combining advanced materials science with biophotonics. By leveraging the strengths of both E- and H-fields and embracing frequency-based detection, SERS is poised to redefine diagnostics.

From improving heart attack outcomes to enabling early detection of diseases, this technology heralds a new era of precision medicine.

The integration of [advanced spectroscopy](#), innovative materials, and cutting-edge engineering underscores the potential for SERS to address some of the most pressing challenges in healthcare and beyond.

Scientists create ‘living’ gels that heal themselves like human tissue

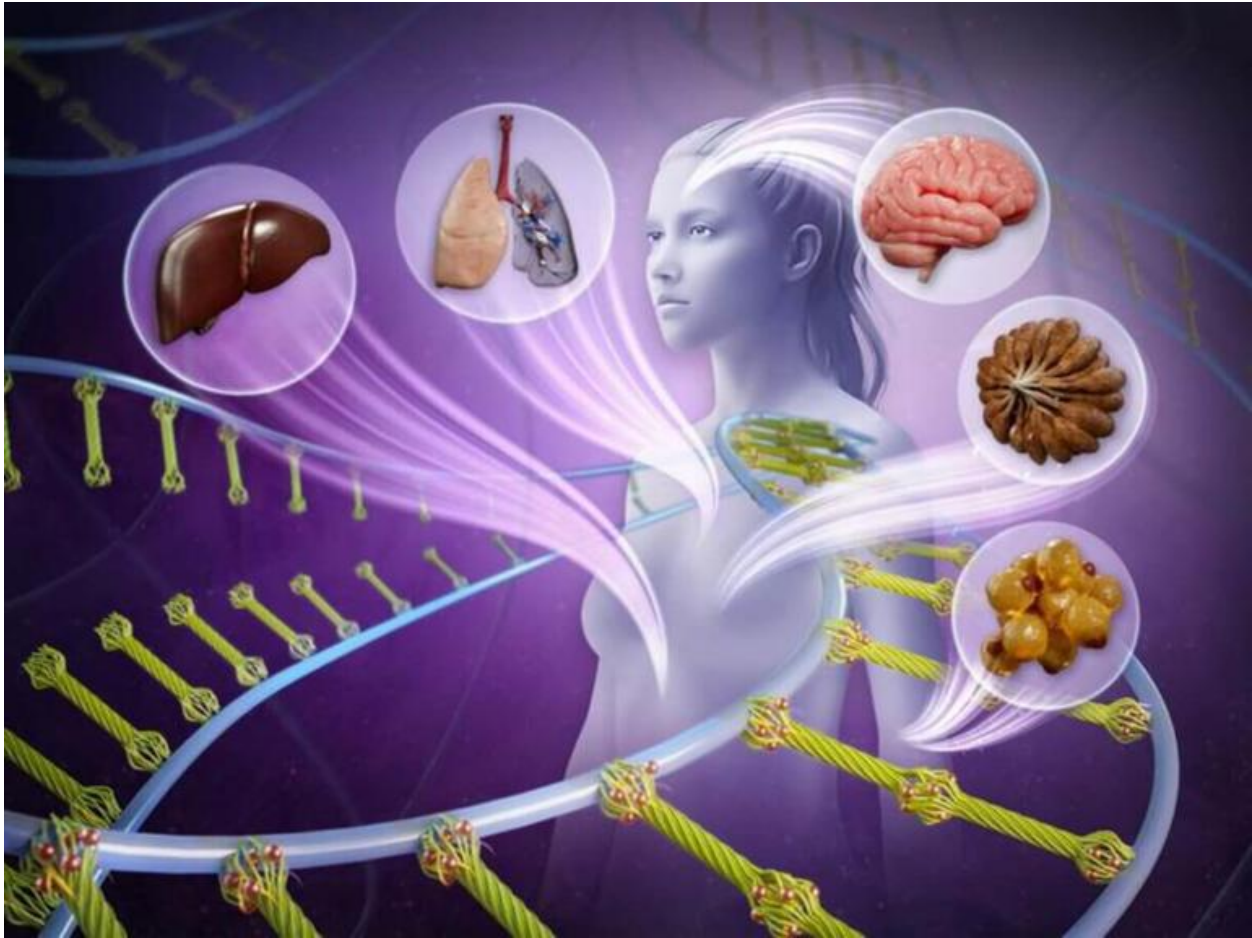
Major breakthrough advances efforts in regenerative medicine

UNIVERSITY PARK, Pa.— When you press your finger against your skin, the tissue underneath temporarily stiffens to resist the pressure. Cut yourself, and your tissue gradually heals. These seemingly simple responses have proven remarkably difficult to replicate in synthetic materials. Now, researchers at Penn State have made a breakthrough by developing special hydrogels that can actually mimic these complex tissue behaviors.

The human body’s tissues are supported by an intricate scaffolding called the extracellular matrix (ECM). This natural framework provides structural support for cells and helps tissues maintain their shape and function. When pressure or strain is applied to healthy tissue, the ECM responds by becoming temporarily stiffer, a property that helps protect our organs and tissues from damage. Additionally, tissues can repair minor damage through natural healing processes. In a new study published in [Materials Horizons](#), researchers have found a way to recreate these sophisticated biological properties in laboratory-made materials.

“We developed a cell-free — or acellular — material that dynamically mimics the behavior of ECMs, which are key building blocks of mammalian tissues that are crucial for tissue structure and [cell functions](#),” explains corresponding author Amir Sheikhi, associate professor of chemical engineering at Penn State, in a statement.

Creating synthetic materials that can replicate these sophisticated behaviors has proven extremely challenging. Previous attempts using [synthetic hydrogels](#), materials mostly made of water held together by polymer networks, fell short. These earlier versions couldn’t properly mimic the way natural tissues respond to mechanical forces while maintaining the ability to self-heal.



A new biomaterial developed by Penn State engineers mimics a key building block of human tissue, extracellular matrices, which act like scaffolding and enable cells to heal after damage. (Credit: Sheikhi Research Group/Penn State)

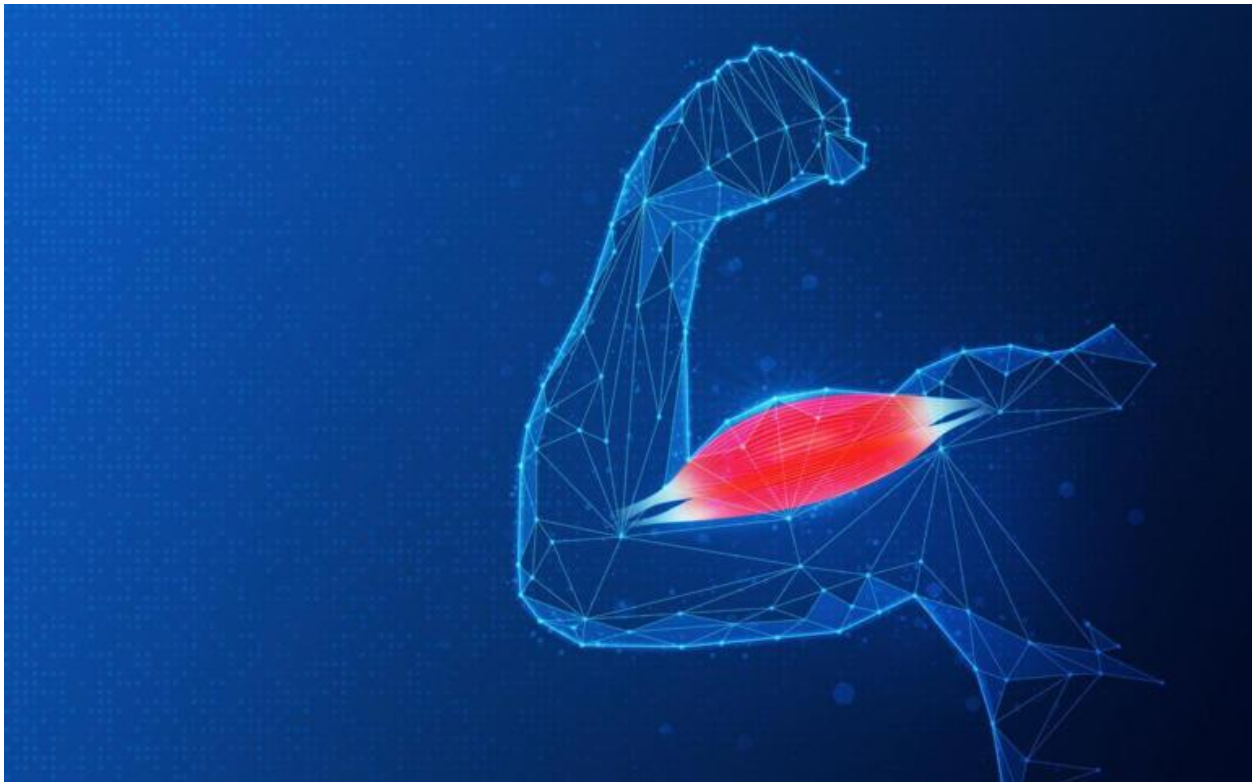
"Specifically, these materials need to replicate *nonlinear strain-stiffening*, which is when ECM networks stiffen under strain caused by physical forces exerted by cells or external stimuli," says Sheikhi.

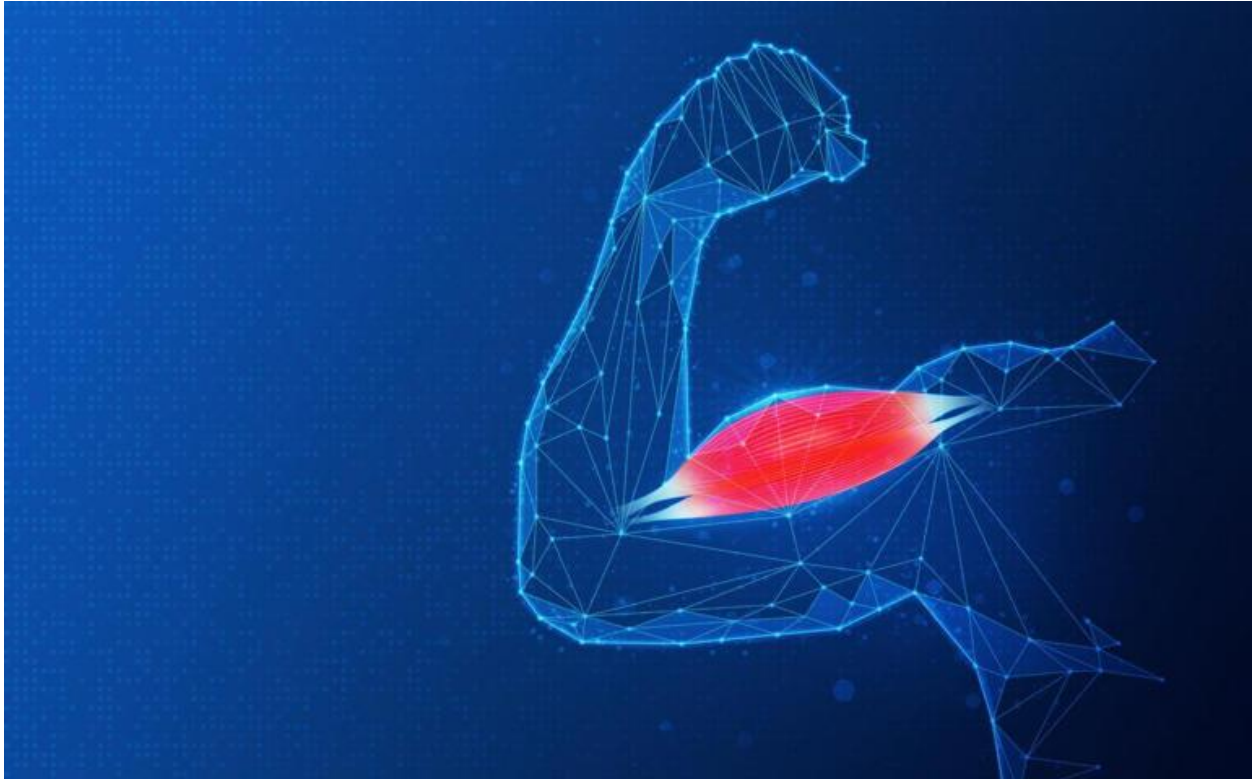
The Penn State team solved this problem by developing what they call "LivGels" using an innovative combination of natural materials. They started with *alginate*, a polymer derived from [seaweed](#), and modified it to create a flexible network. Then they engineered special nanoparticles from modified wood pulp cellulose. These tiny particles, called *nLinkers*, are rod-shaped with special molecular "hairs" at their ends that can form reversible chemical bonds.

The nLinker particles act like dynamic connection points throughout the gel network. When force is applied to the gel, these connections can temporarily break and reform in new configurations, allowing the material to become stiffer

in response to stress. When the material is damaged, these same reversible connections enable [self-healing](#).

Through careful testing, the researchers demonstrated that they could control the gel's properties by adjusting two key factors: the concentration of nLinker particles and the number of [calcium](#) ions added to create additional connection points. This tunability means they can create gels with different levels of stiffness and responsiveness to match various types of human tissue, from soft brain tissue to firmer [muscle tissue](#).





This self-healing material could be extremely important for regenerative medicine across various types of body tissues. (ArtemisDiana/Shutterstock)

Unlike previous synthetic alternatives that raised concerns about [biocompatibility](#), these hydrogels avoid synthetic polymers entirely. The researchers used specialized testing methods to show that the LivGels could quickly recover their structure after experiencing high strain, confirming their self-healing abilities.

In regenerative medicine, these new materials could serve as scaffolds for [tissue repair](#) and regeneration, providing cells with an environment that better mimics natural tissue. For drug development, these materials could create more realistic tissue models for testing new medications. They might also enable the development of improved surgical materials and wound dressings that actively promote healing.

Beyond medical applications, these materials could advance the field of soft [robotics](#), allowing for the creation of robots with parts that can change their stiffness as needed and self-repair when damaged. The technology might also find applications in [3D bioprinting](#), where these gels could be used to create customized tissue-like structures.

“Our next steps include optimizing LivGels for specific tissue types, exploring in vivo applications for [regenerative medicine](#), integrating LivGels with 3D bioprinting platforms and investigating potential in dynamic wearable or implantable devices,” says Sheikhi.

By successfully mimicking the dynamic properties of natural tissues, these [hydrogels](#) open new possibilities for everything from improved medical implants to more realistic disease models. While significant testing remains before clinical use, this advance demonstrates how understanding natural biological systems can drive innovation in materials science.

Paper Summary

Methodology

The researchers developed their hydrogels through a carefully designed process. First, they chemically modified alginate to create a network-forming polymer with special attachment points. Separately, they transformed wood pulp cellulose through a series of chemical reactions to create the nLinker particles, which feature two types of chemical groups that can form reversible bonds. By combining these components in various ratios, sometimes with added calcium ions, they created gels with different properties. They then used specialized equipment to measure how the gels responded to various types of mechanical stress and strain.

Results

Testing revealed that the hydrogels could increase their stiffness when subjected to mechanical forces, similar to natural tissues. They demonstrated rapid self-healing, recovering their properties within seconds after experiencing high strain. Importantly, the gels achieved stiffness values (30-591 Pa) comparable to natural soft tissues, and their properties could be tuned by adjusting their composition.

Limitations

While the results are promising, the research focused primarily on mechanical properties rather than biological interactions. Further studies would be needed to fully understand how these materials interact with living cells and tissues over time. The maximum stiffness achieved was also limited compared to some firmer tissue types.

Takeaways and Discussion

This research presents a new approach to creating dynamic hydrogels using naturally derived components. The materials successfully mimicked key mechanical properties of natural tissues, including strain-stiffening and self-healing. Their tunability and natural composition make them particularly promising for biomedical applications.

Funding and Disclosures

The research was supported by Penn State, including: the Dorothy Foehr Huck and J. Lloyd Huck Early Career Chair; the Convergence Center for Living Multifunctional Material Systems and the Cluster of Excellence Living, Adaptive and Energy-autonomous Materials Systems Living Multifunctional Materials Collaborative Research Seed Grant Program; the Materials Research Institute; and the College of Engineering Materials Matter at the Human Level seed grants. The authors declared no conflicts of interest.

Publication Information

This research was published in [Materials Horizons](#) (2025, Volume 12, pages 103-118) by authors Roya Koshani, Sina Kheirabadi, and Amir Sheikhi from The Pennsylvania State University's Departments of Chemical Engineering, Biomedical Engineering, Chemistry, and affiliated institutes. The paper is titled "Nano-enabled dynamically responsive living acellular hydrogels."

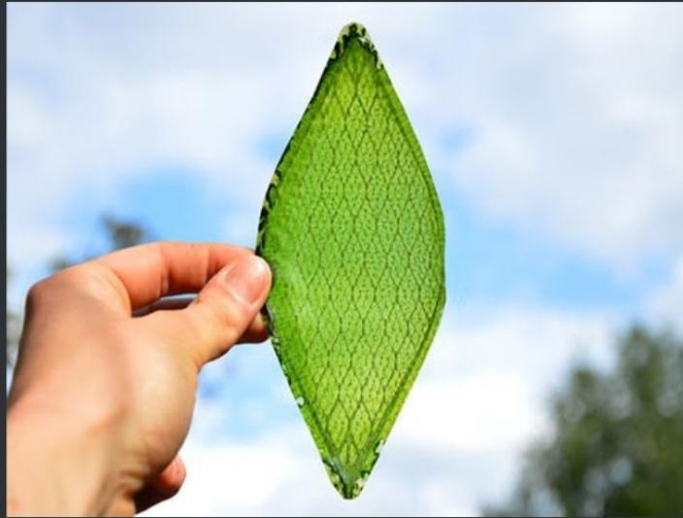
First man-made biological leaf to make oxygen for space travel



PTI

Last Updated : 01 August 2014, 00:46 IST

Follow Us :



An inventor in the UK has developed the world's first synthetic biological leaf that absorbs water and carbon dioxide to produce oxygen just like a plant, and it could enable long-distance space travel. Photo courtesy: Dezeen

An inventor in the UK has developed the world's first synthetic biological leaf that absorbs water and carbon dioxide to produce oxygen just like a plant, and it could enable long-distance space travel.

The leaf, created by Royal College of Art student Julian Melchiorri, consists of chloroplasts suspended in a matrix made out of silk protein. "The material is extracted directly from the fibres of silk," Melchiorri said.

"This material has an amazing property of stabilising molecules. I extracted chloroplasts from plant cells and placed them inside this silk protein. As an outcome I have the first photosynthetic material that is living and breathing as a leaf does," he said.

Like the leaves of a plant, Melchiorri's Silk Leaf needs light and a small amount of water to produce oxygen, 'Dezeen' reported.

"Silk Leaf is the first man-made biological leaf. It's very light, low energy-consuming, it's completely biological," Melchiorri said.

"Plants don't grow in zero gravity. NASA is researching different ways to produce oxygen for long-distance space journeys to let us live in space. This material could allow us to explore space much further than we can now," said Melchiorri.

The Silk Leaf project was developed as part of the Royal College of Art's Innovation Design Engineering course in collaboration with Tufts University silk lab. Melchiorri said the leaf could also be used for outdoor applications.

"So facades, ventilation systems. You can absorb air from outside, pass it through these biological filters and then bring oxygenated air inside," he said.

First baby conceived via breakthrough fertility tech born

December 17, 2024



The first baby born using the innovative Fertilo technique

An innovative fertility technology using stem cells to help an embryo mature outside the body has resulted in the world's first live human birth. Gameto, the company that developed the approach, says it's faster, safer and more accessible than conventional IVF.

Since the birth of the world's first 'test tube baby' in 1978, [in vitro fertilization](#) (IVF) has helped millions of people worldwide overcome fertility issues and become parents. But while the procedure is designed to deliver a bundle – or bundles – of joy into the world, it's not without some downsides. A new fertility technique developed by [Gameto](#), a female-led biotech company dedicated to advancing women's reproductive health, provides an alternative to traditional IVF and, the company says, it has fewer drawbacks. What's more, the first live human baby conceived by the technique - which is called Fertilo - was recently born.

“We are delighted to celebrate the world’s first live birth conceived using Fertilo,” said Dr Dina Radenkovic, Gameto’s CEO and co-founder. “By overcoming the major challenges of conventional IVF, such as long treatment cycles, significant side effects, and the emotional and physical strain, Fertilo provides a potentially faster, safer, and more accessible solution for families. This milestone marks a turning point in reproductive health and highlights the first application of iPSC [induced pluripotent stem cell] technology in IVF and the immense potential of our technology.”

In conventional IVF, mature eggs are collected from ovaries and fertilized by sperm in a laboratory. After spending around five days in a protected lab environment, the fertilized egg (embryo) is transferred into the uterus in hopes that pregnancy will occur. But that’s really the end part of the process. Prior to egg collection, the ovaries are stimulated to produce more eggs than usual through the administration of one or two hormone injections a day, sometimes up to 90 shots per treatment cycle. A full cycle of IVF takes about two-to-three weeks.

There are some downsides to IVF. As with most things in life, there are no guarantees; IVF does not guarantee a baby. There’s a risk of multiple pregnancies, which carries its own risks. Additionally, the required hormone injections can cause ovarian hyperstimulation syndrome, where the ovaries become swollen and painful. There’s the physical and emotional stress that couples go through that’s associated with regular check-ups, injections, and the constant question, ‘Am I pregnant?’ Then, of course, there’s the cost.

In the US, it’s estimated that the [average base cost](#) of one IVF cycle falls somewhere between US\$14,000 and \$20,000. In Australia, the publicly funded health insurance scheme (Medicare) covers part of the cost per calendar year, making the [out-of-pocket cost](#) for one cycle a little over US\$3,800 (AUD\$6,000). A subsequent cycle in the same calendar year carries an out-of-pocket cost of around AUD\$5,300.

The Fertilo procedure differs from traditional IVF because it takes ovarian support cells (OSCs) derived from human induced pluripotent stem cells (iPSCs) and co-cultures them with an immature egg to mimic the natural egg maturation process in the lab. A [2023 study](#) showed that this method significantly improved egg maturation and embryo formation. Gameto says the

Fertilo procedure avoids 80% of the hormone injections that traditional IVF requires and reduces the duration of a treatment cycle to three days.

“The ability to mature eggs outside the body within minimal hormonal intervention significantly reduces risks such as ovarian hyperstimulation syndrome and alleviates the side effects caused by high hormone doses,” said Dr Luis Guzmán, the lead at [Pranor Laboratories](#), Peru, who oversaw the Fertilo procedure that resulted in the first live birth. “Fertilo is a major advancement for women who cannot tolerate or do not want to undergo the burden of the traditional IVF protocol, bringing hope and new possibilities to a broader patient population.”

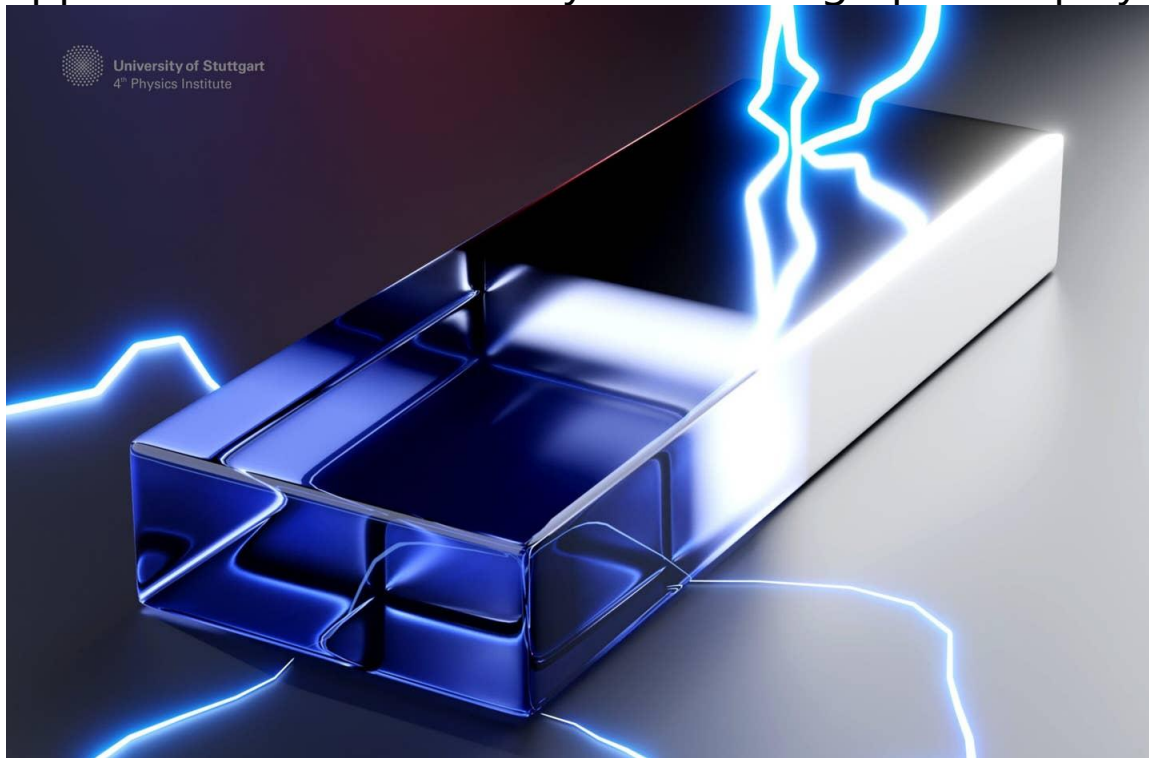
The mother of the world’s first 'Fertilo baby,' born in the Santa Isabel Clinic in Lima, Peru, couldn’t be happier.

“The Fertilo method was the preferred option compared to traditional approaches,” she said. “With fewer injections and a gentler, less invasive egg retrieval process, it gave me hope and reassurance during a deeply personal journey. Fertilo’s innovative approach made the physical experience easier and also lightened the emotional burden of many hormone injections. I am profoundly grateful to the Pranor Clinic and the Gameto team for their care and dedication in making my dream of having a family a reality.”

Only last week, Gameto announced that it had partnered with the Australia-based IVF clinic chain IVFAustralia (IVFA), making the Fertilo approach available to patients at select clinics throughout the country. That means that Gameto has regulatory clearance for Fertilo in Australia, Japan, Argentina, Paraguay, Mexico and Peru. The US may be next, with the company preparing for Phase 3 trials there.

Researchers make a breakthrough in 3D holographic displays

Researchers have now introduced a completely new approach to realize such dynamic holographic displays.



[University of Stuttgart]

a completely new approach to realize such dynamic holographic displays. (CREDIT: Julian Karst, University of Stuttgart)

Video conferencing played a key role during the COVID-19 pandemic and is set to dominate many meetings in the future. To realize the true feeling of a face-to-face dialog, three dimensional video is required and yet the holographic technology is still missing.

Researchers at the University of Stuttgart in Germany have now introduced a completely new approach to realize such dynamic holographic displays, based on electrically switchable plasmonic nanoantennas made from conductive metallic polymers. This key element provides the missing technology to enable holographic displays at video rate, which would enable virtual conferences with a "real-life" feeling. The paper detailing this work has been published in the journal Science on 29 October 2021.

Holograms creating impressive three-dimensional static images are well known. Dynamic holograms switchable at video rates using data from a high-speed internet connection are not possible until now.

Previously, the limiting factor was the display resolution. Holographic images require a resolution of 50 000 dpi (pixels per inch) which is 100x more than the best smartphone displays.

For such a resolution one has to reduce the pixel size to half a micrometer (one thousands of a millimeter). However, current liquid-crystal technology does not allow for such small pixels, being limited to a few micrometers pixel size.

Researchers at the University of Stuttgart have succeeded in breaking this fundamental barrier. In an interdisciplinary collaboration between Physics and Chemistry, they developed the idea to use electrically switchable plasmonic nanoantennas with dimensions of only a few hundred nanometers and made from conductive polymers. For several years, researchers had created metasurfaces that generate static 3-dimensional holograms. However, their components, or nanoantennas, consisted of metals such as gold or aluminum that could not be switched like common liquid crystal materials.

After searching for several years for the right material, Ph.D. student Julian Karst and nanophotonics expert Dr. Mario Hentschel from the group of Prof. Harald Giessen, together with polymer chemist Prof. Sabine Ludwigs and her team, identified electrically conducting polymers as possible candidates for switchable plasmonics.

Sabine Ludwigs contributed her expertise on electrochemical switching of such functional polymers, that were at the focus of the 2000 Chemistry Nobel Prize. Until now such materials had mostly been used for current transport in flexible displays and solar cells. In collaboration with cleanroom head Monika Ubl, Karst and Hentschel developed a process to nanostructure the metallic polymers using a combination of electron beam lithography and etching, thereby creating the plasmonic nanoantennas. The team showed that the optical appearance of the nanoantennas could be switched between that of a shiny metal and a transparent material by applying a voltage between minus and plus one volt. This switching effect works even at video rates of 30 Hertz. Despite being only a few tens of nanometers thick and less than 400 nanometers in size, the nanoantennas do the same job as the much larger and thicker liquid crystals used in current state-of-the-art technology. These new devices reach the required pixel densities of about 50.000 dpi.

Karst created a simple hologram metasurface from the nanoantennas that could deflect an infrared laser beam 10 degrees onto one side by applying a voltage.

Currently, he is working on making this deflection available for many angles for applications in LIDAR devices in autonomous vehicles, of keen interest to the automotive industry. Additionally, Karst created a hologram that behaves like an optical lens, which can be turned on and off by simply applying ± 1 Volt.

This technology is crucial for future smartphone cameras or optical sensors that could be zoomed from wide angle to telephoto by switching the applied voltage. Currently, up to four lenses are required for this functionality.

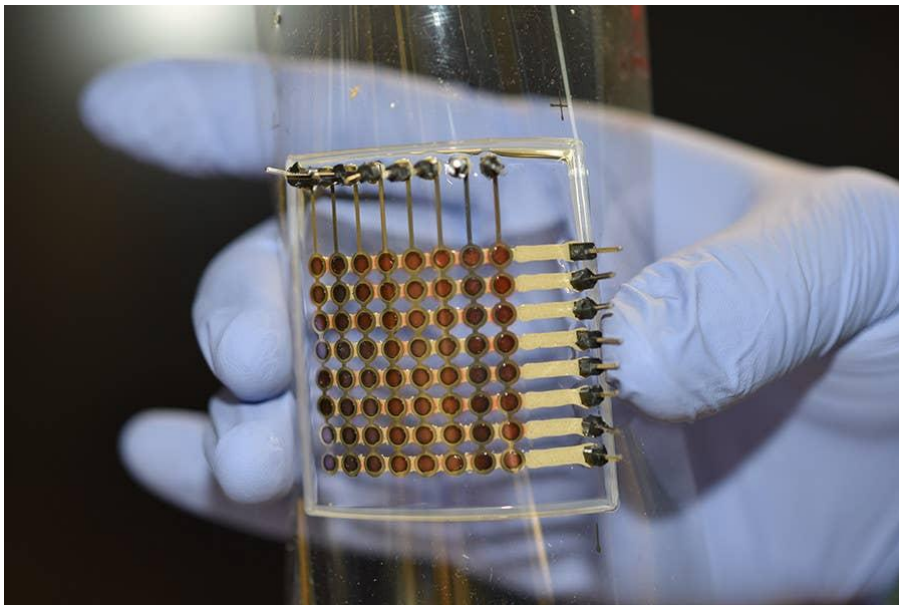
In the future, Prof. Harald Giessen and his team aim to address every single pixel individually, to dynamically change the holograms at will at video rates. Also, the optical properties of the polymer nanoantennas have to be shifted into the visible wavelength range, which requires collaborations with chemists and material scientists.

Together with engineers, integrated and dynamically switchable optical displays and the first moving holograms could be integrated into AR/VR goggles and eventually onto smartphone screens and even televisions.

Applying Moore's law to display technology, this advance by about a factor of 100 could happen commercially around the year 2035.

Researchers develop first fully 3D-printed, flexible OLED display

The fully 3D-printed flexible organic light-emitting diode (OLED) display prototype is about 1.5 inches on each side and has 64 pixels.



[University of Minnesota](#)

The fully 3D-printed flexible organic light-emitting diode (OLED) display prototype is about 1.5 inches on each side and has 64 pixels. Every pixel works and displays light. The 3D-printed display is also flexible, which could make it useful for a wide variety of applications, such as foldable smartphone displays. (CREDIT: McAlpine Group, University of Minnesota)

In a groundbreaking new study, researchers at the University of Minnesota Twin Cities used a customized printer to fully 3D print a flexible organic light-emitting diode (OLED) display. The discovery could result in low-cost OLED displays in the future that could be widely produced using 3D printers by anyone at home, instead of by technicians in expensive microfabrication facilities.

The research is published in *Science Advances*, a peer-reviewed scientific journal published by the American Association for the Advancement of Science (AAAS). The OLED display technology is based on the conversion of electricity into light using an organic material layer. OLEDs function as high quality digital displays, which can be

made flexible and used in both large-scale devices such as television screens and monitors as well as handheld electronics such as smartphones.

OLED displays have gained popularity because they are lightweight, power-efficient, thin and flexible, and offer a wide viewing angle and high contrast ratio.

"OLED displays are usually produced in big, expensive, ultra-clean fabrication facilities," said Michael McAlpine, a University of Minnesota Kuhrmeyer Family Chair Professor in the Department of Mechanical Engineering and the senior author of the study.

"We wanted to see if we could basically condense all of that down and print an OLED display on our table-top 3D printer, which was custom built and costs about the same as a Tesla Model S."

The group had previously tried 3D printing OLED displays, but they struggled with the uniformity of the light-emitting layers. Other groups partially printed displays but also relied on spin-coating or thermal evaporation to deposit certain components and create functional devices.

In this new study, the University of Minnesota research team combined two different modes of printing to print the six device layers that resulted in a fully 3D-printed, flexible organic light-emitting diode display. The electrodes, interconnects, insulation, and encapsulation were all extrusion printed, while the active layers were spray printed using the same 3D printer at room temperature. The display prototype was about 1.5 inches on each side and had 64 pixels. Every pixel worked and displayed light.

"I thought I would get something, but maybe not a fully working display," said Ruitao Su, the first author of the study and a 2020 University of Minnesota mechanical engineering Ph.D. graduate who is now a postdoctoral researcher at MIT. "But then it turns out all the pixels were working, and I can display the text I designed. My first reaction was 'It is real!' I was not able to sleep, the whole night."

Su said the 3D-printed display was also flexible and could be packaged in an encapsulating material, which could make it useful for a wide variety of applications.

"The device exhibited a relatively stable emission over the 2,000 bending cycles, suggesting that fully 3D printed OLEDs can potentially be used for important applications in soft electronics and wearable devices," Su said.

The researchers said the next steps are to 3D print OLED displays that are higher resolution with improved brightness.

"The nice part about our research is that the manufacturing is all built in, so we're not talking 20 years out with some 'pie in the sky' vision," McAlpine said. "This is something that we actually manufactured in the lab, and it is not hard to imagine that you could translate this to printing all kinds of displays ourselves at home or on the go within just a few years, on a small portable printer."

In addition to McAlpine and Su, the research team included University of Minnesota mechanical engineering researchers Xia Ouyang, a postdoctoral researcher; Sung Hyun Park, who is now a senior researcher at Korea Institute of Industrial Technology; and Song Ih Ahn, who is now an assistant professor of mechanical engineering at Pusan National University in Korea.

The research was funded primarily by the National Institute of Biomedical Imaging and Bioengineering of the National Institutes of Health (Award No. 1DP2EB020537) with additional support from The Boeing Company and the Minnesota Discovery, Research, and InnoVation Economy (MnDRIVE) Initiative through the State of Minnesota. Portions of this study were conducted in the Minnesota Nano Center, which is supported by the National Science Foundation through the National Nano Coordinated Infrastructure Network (NNCI).

To read the entire research paper entitled "3D printed flexible organic light-emitting diode displays," visit the [Science Advances website](#).

Stretchy, bendy, flexible PeLEDs may be the first step in an electronics revolution

Sure, you could attach two screens with a hinge and call a cell phone “foldable,” but what if you could roll it up and put it in your wallet

Sure, you could attach two screens with a hinge and call a cell phone “foldable,” but what if you could roll it up and put it in your wallet? Or stretch it around your wrist to wear it as a watch?

The next step in digital displays being developed at the McKelvey School of Engineering at Washington University in St. Louis could make that a reality.

First, there were light-emitting diodes, or LEDs. Then, organic LEDs, or OLEDs. Now, researchers in the lab of [Chuan Wang](#), assistant professor in the Preston M. Green Department of Electrical & Systems Engineering, have developed a new material that has the best of both technologies and a novel way to fabricate it — using an inkjet printer.

The research was published this month in the journal [Advanced Materials](#). Organic LEDs, made with organic small molecules or polymer materials, are cheap and flexible. “You can bend or stretch them — but they have relatively low performance and short lifetime,” Wang said. “Inorganic LEDs such as microLEDs are high performing, super bright and very reliable, but not flexible and very expensive.”

“What we have made is an organic-inorganic compound,” he said. “It has the best of both worlds.”

They used a particular type of crystalline material called an organometal halide perovskite — though with a novel twist. The traditional way to create a thin layer of perovskite, which is in liquid form, is to drip it onto a flat, spinning substrate, like a spin art toy, in a process known as spin coating. As the substrate spins, the liquid spreads out, eventually covering it in a thin layer.

From there, it can be recovered and made into perovskite LEDs, or PeLEDs.

Like spin art, however, a lot of material is wasted in that process — as the substrate spins at several thousand RPM, some of the dripping perovskite splatters and flies away, not sticking to the substrate.

“Because it comes in a liquid form,” Wang said, “we imagined we could use an inkjet printer” in place of spin coating.

Inkjet fabrication saves materials, as the perovskite can be deposited only where it’s needed, in a similar way to the precision with which letters and numbers are printed on a piece of paper; no splatter, less waste. The process is much faster as well, cutting fabrication time from more than five hours to less than 25 minutes.

Another benefit of using the inkjet printing method has the potential to reshape the future of electronics: perovskite can be printed onto a variety of unconventional substrates, including those that wouldn’t lend themselves to stability while spinning — materials such as rubber.

“Imagine having a device that starts out the size of a cell phone but can be stretched to the size of a tablet,” Wang said.

For a display to be flexible, however, printing stiff LEDs on rubber won’t do the trick. The LEDs themselves need to be flexible. Perovskite is not.

First author Junyi Zhao, a PhD candidate in Wang’s lab, was able to solve the problem by embedding the inorganic perovskite crystals into an organic, polymer matrix made of polymer binders. This made the perovskite and, by association, the PeLEDs, themselves, elastic and stretchable in nature.

The best of both worlds.

The process wasn’t exactly straightforward. It took long days — and a few nights — in the lab before getting it right. Wang and Zhao agreed that the biggest roadblock was making sure the different layers of material didn’t mix.

Because all parts of the PeLED were made from liquid — the perovskite layer as well as the two electrodes and a buffer layer — a major concern was keeping all of the layers from mixing.

LEDs are constructed in a sandwich-like configuration, with at least an emissive layer, an anode layer and a cathode layer. Additional layers such as electron and hole transporting layers may sometimes also be used. Zhao had to keep the perovskite layer

safe from mixing with any of the others, the way running a highlighter over freshly written ink might smear it.

He needed to find a suitable polymer, one that could be inserted between the perovskite and the other layers, protecting it from them while not interfering too much with the PeLED's performance.

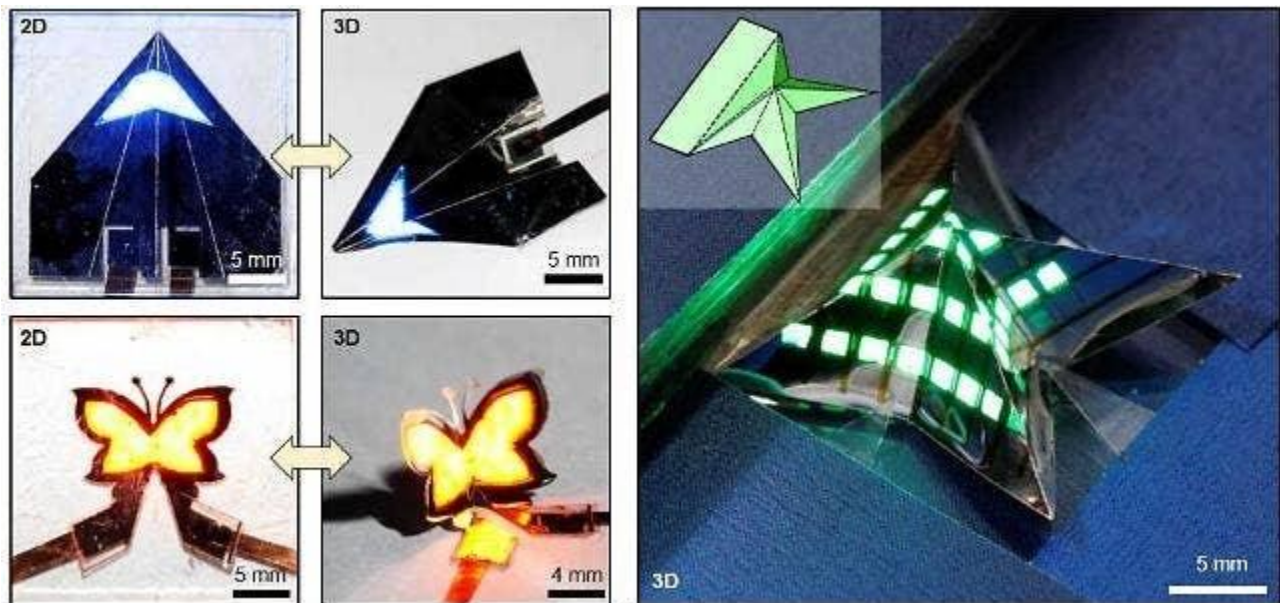
"We found the best material and best thickness to balance performance and protection of the device," Zhao said. After that, he went on to print the first stretchy PeLEDs. The university's Office of Technology Management has a pending patent on the technology and fabrication method.

These PeLEDs may be just the first step in an electronics revolution: Walls could provide lighting or even display the day's newspaper. They can be used to make wearable devices, even smart wearables, like a pulse oximeter to measure blood oxygen.

Most excitingly, being able to print stretchy, flexible PeLEDs cheaply and quickly may lead to new technologies yet to be dreamed up.

Revolutionary new quantum dot LED (QLED) is as flexible to fold as paper

The new 3 micrometer thick QLED paper can be folded into complex 3D structures such as butterflies, airplanes, and pyramids.



Quantum dot light-emitting diode (QLED), which employs quantum dots as a light-emitting material, has attracted significant attention as a promising alternative for next-generation display technologies, owing to its outstanding electroluminescence properties. Since it does not require any bulky components such as backlight units, QLED displays can potentially be manufactured into an ultrathin form factor.

A joint research team led by KIM Dae-Hyeong (Professor at Seoul National University) and HYEON Taeghwan (Distinguished professor at Seoul National University) from the Center for Nanoparticle Research within the Institute for Basic Science has previously unveiled a prototype QLED back in 2015. The device had a thickness of only 3 micrometers, which is only one-thirtieth of that of human hair. Due to such an extremely reduced thickness, the ultrathin QLED exhibited outstanding mechanical flexibility, which allowed it to be readily applicable in various wearable devices, such as electronic tattoos. Recently, the team further advanced this technology and developed a foldable variant of the ultrathin QLED, inspired by the ancient art of paper folding known as origami. The IBS researchers reported three-dimensional foldable QLEDs, which can be freely transformed into various user-customized 3D structures, such as butterflies, airplanes,

and pyramids. Considering the rising popularity of foldable smartphones, the advancement of foldable display technology is gaining greater importance. It is expected this technology can provide unprecedented opportunities for next-generation electronics with user-customized form factors with complex structures, as well as allowing for dynamic three-dimensional display of visual information.

The researchers endowed foldability to the conventional planar QLED via a new fabrication process that can partially etch the epoxy film deposited on the QLED surface without damaging the underlying QLED. Using a power-controllable carbon dioxide pulsed laser and the silver-aluminum alloy-based etch-stop layers, the etching depth can be precisely controlled. As the laser-etched part of the device is relatively thinner than the surrounding region, it is possible to etch out deformation lines along which the device can be folded like origami paper.

Based on the selective laser-etching technique, researchers were able to precisely control the radius of curvature down to less than 50 micrometers. Under such a small curvature radius, the fold line resembles a sharp edge with no visible curvature. By using mechanical simulation to carefully engineer the device, researchers were able to minimize the strain loaded on the light-emitting components. The entire QLED including the crease region (a fold line) was able to maintain a stable light-emitting performance even when after it was repeatedly folded 500 times. The technology was applied to fabricate 3D foldable QLEDs with various complex shapes such as butterflies, airplanes, and pyramids.

"We were able to build a 3D foldable QLED that can be freely folded just like a paper artwork", said KIM Dae-Hyeong, the vice-director of the Center for Nanoparticle Research. He also said, "By fabricating the passively driven, 3D foldable QLED arrays composed of 64 individual pixels, we have shown the possibility of developing displays with greater complexity in the future." HYEON Taeghwan, the director of the Center for Nanoparticle Research, states that "Through the technology reported in this research, paper-like QLEDs that can be folded into various complex structures have been successfully fabricated. Who knows when the day will come when electronic paper with a display unit can replace real paper?"

Bioengineers develop new class of human-powered bioelectronics

The technology converts human body motions into electricity that could be used to power wearable and implantable diagnostic sensors.



UCLA-designed self-powered, stretchable, waterproof magnetoelastic generator for bioelectronics. (Credit: Jun Chen/UCLA)

A team of bioengineers at the UCLA Samueli School of Engineering has invented a novel soft and flexible self-powered bioelectronic device. The technology converts human body motions—from bending an elbow to subtle movements such as a pulse on one's wrist—into electricity that could be used to power wearable and implantable diagnostic sensors.

The researchers discovered that the magnetoelastic effect, which is the change of how much a material is magnetized when tiny magnets are constantly pushed together and pulled apart by mechanical pressure, can exist in a soft and flexible system—not just one that is rigid. To prove their concept, the team used microscopic magnets dispersed in a paper-thin silicone matrix to generate a magnetic field that changes in strength as the matrix undulated. As the magnetic field's strength shifts, electricity is generated. Nature Materials published today a research study detailing the discovery, the theoretical model behind the breakthrough and the demonstration.

"Our finding opens up a new avenue for practical energy, sensing and therapeutic technologies that are human-body-centric and can be connected to the Internet of

Things," said study leader Jun Chen, an assistant professor of bioengineering at UCLA Samueli. "What makes this technology unique is that it allows people to stretch and move with comfort when the device is pressed against human skin, and because it relies on magnetism rather than electricity, humidity and our own sweat do not compromise its effectiveness."

Chen and his team built a small, flexible magnetoelastic generator (about the size of a U.S. quarter) made of a platinum-catalyzed silicone polymer matrix and neodymium-iron-boron nanomagnets. They then affixed it to a subject's elbow with a soft, stretchy silicone band. The magnetoelastic effect they observed was four times greater than similarly sized setups with rigid metal alloys. As a result, the device generated electrical currents of 4.27 milliamperes per square centimeter, which is 10,000 times better than the next best comparable technology.

In fact, the flexible magnetoelastic generator is so sensitive that it could convert human pulse waves into electrical signals and act as a self-powered, waterproof heart-rate monitor. The electricity generated can also be used to sustainably power other wearable devices, such as a sweat sensor or a thermometer.

There have been ongoing efforts to make wearable generators that harvest energy from human body movements to power sensors and other devices, but the lack of practicality has hindered such progress. For example, rigid metal alloys with magnetoelastic effect do not bend sufficiently to compress against the skin and generate meaningful levels of power for viable applications.

Other devices that rely on static electricity tend not to generate enough energy. Their performance can also suffer in humid conditions, or when there is sweat on the skin. Some have tried to encapsulate such devices in order to keep water out, but that cuts down their effectiveness. The UCLA team's novel wearable magnetoelastic generators, however, tested well even after being soaked in artificial perspiration for a week. A patent on the technology has been filed by the UCLA Technology Development Group.

New LED material emits light without generating heat

The brighter these LED technologies shine, the more inefficient they become, releasing more energy as heat instead of light.



Applying mechanical strain on this atomically thin, transparent monolayer semiconductor results in a material with near 100% light-emission efficiency. (Credit: Ali Javey/Berkeley Lab)

Smartphones, laptops, and lighting applications rely on light-emitting diodes (LEDs) to shine bright. But the brighter these LED technologies shine, the more inefficient they become, releasing more energy as heat instead of light.

Now, as reported in the journal *Science*, a team led by researchers at Lawrence Berkeley National Laboratory (Berkeley Lab) and UC Berkeley has demonstrated an approach for achieving near 100% light-emission efficiency at all brightness levels. Their approach focuses on stretching or compressing a thin semiconductor film in a way that favorably changes its electronic structure.

The team identified just how the semiconductor's electronic structure dictated interaction among the energetic particles within the material. Those particles sometimes collide and annihilate each other, losing energy as heat instead of emitting light in the process. Changing the material's electronic structure reduced the likelihood for

annihilation and led to a near-perfect conversion of energy to light, even at high brightness.

"It's always easier to emit heat than emit light, particularly at high brightness levels. In our work we have been able to reduce the loss process by one hundredfold," said Ali Javey, a faculty senior scientist at Berkeley Lab and professor of electrical engineering and computer sciences at UC Berkeley.

LED performance depends on excitons

The Berkeley team's discovery was made using a single, 3-atom-thick layer of a type of semiconductor material, called a transition metal dichalcogenide, that was subjected to mechanical strain. These thin materials have a unique crystal structure that gives rise to unique electronic and optical properties: When their atoms are excited either by passing an electric current or shining light, energetic particles called excitons are created.

Excitons can release their energy either by emitting light or heat. The efficiency with which excitons emit light as opposed to heat is an important metric that determines the ultimate performance of LEDs. But achieving high performance requires precisely the right conditions.

"When the exciton concentration is low, we had previously found how to achieve perfect light-emission efficiency," said Shiekh Zia Uddin, a UC Berkeley graduate student and co-lead author on the paper. He and his colleagues had shown that chemically or electrostatically charging single-layered materials could lead to high-efficiency conversion, but only for a low concentration of excitons.

For the high exciton concentration at which optical and electronic devices typically operate, though, too many excitons annihilate each other. The Berkeley team's new work suggests that the trick to achieve high performance for high concentrations lay in tweaking the material's band structure, an electronic property that controls how excitons interact with each other and could reduce the probability of exciton annihilation.

"When more excited particles are created, the balance tilts toward creating more heat instead of light. In our work, we first understood how this balance is controlled by the band structure," said Hyungjin Kim, a postdoctoral fellow and co-lead author on the work. That understanding led them to propose modifying the band structure in a controlled way using physical strain.

High-performance under strain

The researchers started by carefully placing a thin semiconductor (tungsten disulfide, or WS₂) film atop a flexible plastic substrate. By bending the plastic substrate, they applied

a small amount of strain to the film. At the same time, the researchers focused a laser beam with different intensities on the film, with a more intense beam leading to a higher concentration of excitons—a high "brightness" setting in an electronic device. Detailed optical microscope measurements allowed the researchers to observe the number of photons emitted by the material as a fraction of the photons it had absorbed from the laser. They found that the material emitted light at nearly perfect efficiency at all brightness levels through appropriate strain.

To further understand the material's behavior under strain, the team performed analytical modeling.

They found that the heat-losing collisions between excitons are enhanced due to "saddle points"—regions where an energy surface curves in a way that resembles a mountain pass between two peaks—found naturally in the single-layer semiconductor's band structure.

Applying the mechanical strain led the energy of that process to change slightly, drawing the excitons away from the saddle points. As a result, the particles' tendency to collide was reduced, and the reduction in efficiency at high concentrations of charged particles ceased to be a problem.

"These single-layer semiconductor materials are intriguing for optoelectronic applications as they uniquely provide high efficiency even at high brightness levels and despite the presence of large number of imperfections in their crystals," said Javey. Future work by the Berkeley Lab team will focus on using the material to fabricate actual LED devices for further testing of the technology's high efficiency under increasing brightness.

New LED innovation will enable refrigerators to identify food that is spoiling

Your smart device could soon be even smarter with a new infrared light emitting diode that is 'tuneable' to different wavelengths of light

Your smart device could soon be even smarter with a new infrared light emitting diode (LED) that is 'tuneable' to different wavelengths of light – it could enable your fridge to

tell you when your food is going off and your phone to tell you if that Gucci purse is real.

The technology has been developed by the [University of Melbourne](#), the [Lawrence Berkeley National Laboratory](#), the [University of California, Berkeley](#), and the Australian Research Council Centre of Excellence for Transformative Meta-Optical Systems (TMOS). They have come up with a device that could identify a suite of gases, potentially including lethal ones, improving the safety of firefighters, miners, the military, and your local plumber. The work appeared in the journal, [Nature](#).

Infrared (IR) spectrometers are common laboratory equipment that can identify different materials by analyzing their infrared signatures, which is invisible to the human eye. Just like an AM radio can be tuned to different frequencies of radio wave, IR spectrometers can be tuned to different wavelengths, giving a broad-spectrum analysis of a gas sample. However, these machines are bulky and expensive and not usually practical to take out of the laboratory and into the field.

"Our new technology bonds a thin layer of black phosphorus crystals to a flexible, plastic-like substrate, allowing it to be bent in ways that cause the black phosphorus to emit light of different wavelengths essentially creating a tuneable infrared LED that allows for the detection of multiple materials," University of Melbourne Professor Kenneth Crozier said. "This technology could fit inside smartphones and become part of everyday use."

For example, the bacteria found in meat release various gases as they multiply. The presence of these gases is a good indication that the meat is spoiling and is no longer fit for consumption.

"The device placed inside a fridge could send a notification that meat is going off. When pointed at a handbag, it could reveal whether the bag is made of real leather or a cheaper substitute," said Professor Crozier, who is also the Deputy Director of TMOS. Current materials that are used for IR photodetectors and light emitting devices can be difficult to manufacture, in large part due to the need for multiple layers of perfectly linked crystals. This new black phosphorus technology requires just one layer allowing the device to be flexible, giving it unique properties when bent.

"The shift in black phosphorus' emission wavelength with bending is really quite dramatic, enabling the LED to be tuned across the mid-infrared," said Professor Ali Javey, from the University of California at Berkeley, whose group led the work.

Importantly, the device could make the work of firefighters, miners and military safer, allowing them to identify potentially lethal gases from safe distances as the ultra-thin, ultra-light devices can be placed on small drones. Flying such a drone over a building fire could tell firefighters what dangers they face and equipment they'll need.

The low-cost technology could also make its way into devices for use by plumbers and building managers.

"Our IR photo detectors could be integrated into a camera so that we could look at our phone screen and 'see' gas leaks or emissions and be able to determine what kind of gas it is," Professor Crozier said.

Researchers are developing interactive holograms you can touch and feel

Star Trek: The Next Generation introduced millions of people to the idea of a complete environment that you could interact with and touch.



The TV show "Star Trek: The Next Generation" introduced millions of people to the idea of a holodeck: an immersive, realistic 3D holographic projection of a complete environment that you could interact with and even touch.

In the 21st century, holograms are already being used in a variety of ways such as medical systems, education, art, security and defense. Scientists are still developing ways to use lasers, modern digital processors, and motion-sensing technologies to create several different types of holograms which could change the way we interact.

My colleagues and I working in the University of Glasgow's bendable electronics and sensing technologies research group have now developed a system of holograms of people using "aeroaptics," creating feelings of touch with jets of air. Those jets of air deliver a sensation of touch on people's fingers, hands and wrists.

In time, this could be developed to allow you to meet a virtual avatar of a colleague on the other side of the world and really feel their handshake. It could even be the first steps towards building something like a holodeck.

To create this feeling of touch we use affordable, commercially available parts to pair computer-generated graphics with carefully directed and controlled jets of air.

In some ways, it's a step beyond the current generation of virtual reality, which usually requires a headset to deliver 3D graphics and smart gloves or handheld controllers to provide haptic feedback, a stimulation that feels like touch. Most of the wearable gadgets-based approaches are limited to controlling [the virtual object](#) that is being displayed.

Controlling a virtual object doesn't give the feeling that you would experience when two people touch. The addition of an artificial touch sensation can deliver the additional dimension without having to wear gloves to feel objects, and so feels much more natural.

Using glass and mirrors

Our research uses graphics that provide the illusion of a 3D virtual image. It's a modern variation on a 19th-century illusion technique known as Pepper's Ghost, which thrilled Victorian theatergoers with visions of the supernatural onstage.

The systems uses glass and mirrors to make a two-dimensional image appear to hover in space without the need for any additional equipment. And our haptic feedback is created with nothing but air.

The mirrors making up our system are arranged in a pyramid shape with one open side. Users put their hands through the open side and interact with computer-generated objects which appear to be floating in free space inside the pyramid. The objects are

graphics created and controlled by a software program called Unity Game Engine, which is often used to create 3D objects and worlds in videogames.

Located just below the pyramid is a sensor that tracks the movements of users' hands and fingers, and a single air nozzle, which directs jets of air towards them to create complex sensations of touch. The overall system is directed by electronic hardware programmed to control nozzle movements. We developed an algorithm which allowed the air nozzle to respond to the movements of users' hands with appropriate combinations of direction and force.

One of the ways we've demonstrated the capabilities of the "aerohaptic" system is with an interactive projection of a basketball, which can be convincingly touched, rolled and bounced. The touch feedback from air jets from the system is also modulated based on the virtual surface of the basketball, allowing users to feel the rounded shape of the ball as it rolls from their fingertips when they bounce it and the slap in their palm when it returns.

Users can even push the virtual ball with varying force and sense the resulting difference in how a hard bounce or a soft bounce feels in their palm. Even something as apparently simple as bouncing a basketball required us to work hard to model the physics of the action and how we could replicate that familiar sensation with jets of air.

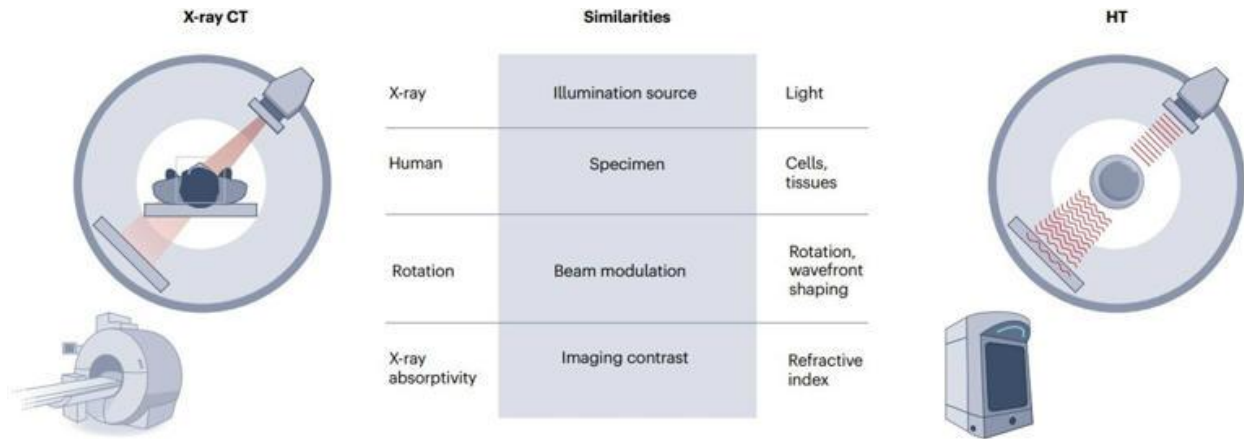
Smells of the future

While we don't expect to be delivering a full Star Trek holodeck experience in the near future, we're already boldly going in new directions to add additional functions to the system. Soon, we expect to be able to modify the temperature of the airflow to allow users to feel hot or cold surfaces. We're also exploring the possibility of adding scents to the airflow, deepening the illusion of virtual objects by allowing users to smell as well as touch them.

As the system expands and develops, we expect that it may find uses in a wide range of sectors. Delivering more absorbing video game experiences without having to wear cumbersome equipment is an obvious one, but it could also allow more convincing teleconferencing too. You could even take turns to add components to a virtual circuit board as you collaborate on a project.

It could also help clinicians to collaborate on [treatments for patients](#), and make patients feel more involved and informed in the process. Doctors could view, feel and discuss the features of tumor cells, and show patients plans for a medical procedure.

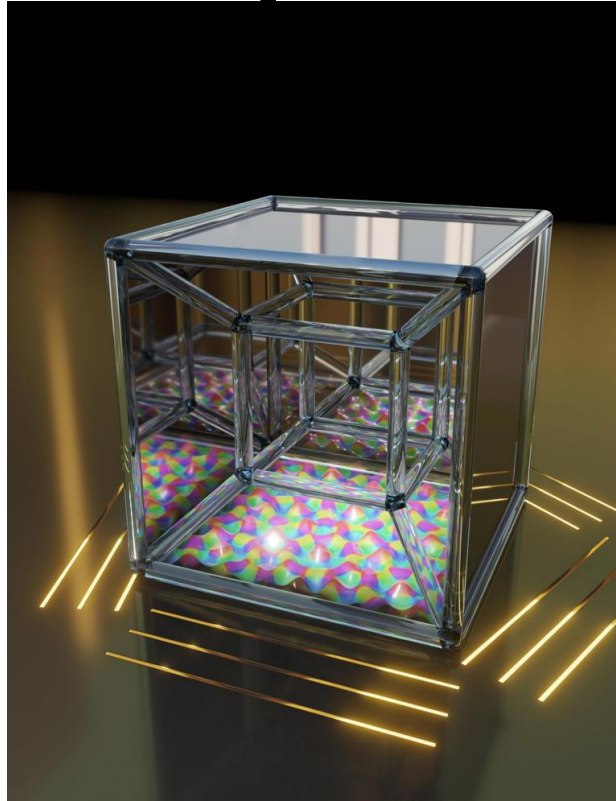
Paper introduces strategies for holotomography in advanced bio research



Schematic illustration of holotomography compared to X-ray CT. Similar to CT, they share the commonality of measuring the optical properties of an unlabeled specimen in three dimensions. Instead of X-rays, holotomography irradiates light in the visible range, and provides refractive index measurements of transparent specimens rather than absorptivity. While CT obtains three-dimensional information only through mechanical rotation of the irradiating light, holotomography can replace this by applying wavefront control technology in the visible range. Credit: KAIST Biomedical Optics Laboratory

Measuring and analyzing three-dimensional (3D) images of live cells and tissues is considered crucial in advanced fields of biology and medicine. Organoids, which are 3D structures that mimic organs, are particular examples that significantly benefit 3D live imaging. Organoids provide effective alternatives to animal testing in the drug development processes, and can rapidly determine personalized medicine. On the other hand, active research is ongoing to utilize organoids for organ replacement.

Greetings from the fourth dimension: Scientists glimpse 4D crystal structure using surface wave patterns



In the illustration: A tesseract (a four-dimensional cube) and the "shadow" it casts on a plane—the quasicrystal discovered by Shechtman. According to Prof. Bartal, "The fact that a quasicrystal is a 'shadow' of a periodic crystal in a higher dimension is not new in itself. What we discovered is that the projection includes not only the structure but also topological properties such as vortices."). Credit: Florian Sterl, Sterltech Optics

In April 1982, Prof. Dan Shechtman of the Technion–Israel Institute of Technology made the discovery that would later earn him the 2011 Nobel Prize in Chemistry: the quasiperiodic crystal. According to diffraction measurements made with an electron microscope, the new material appeared "disorganized" at smaller scales, yet with a distinct order and symmetry apparent at a larger scale.

This form of matter was considered impossible, and it took many years to convince the scientific community of the discovery's validity. The first physicists to theoretically explain this discovery were Prof. Dov Levine, then a doctoral student at the University of Pennsylvania and now a faculty member in the Technion Physics department, and his advisor, Prof. Paul Steinhardt.

The key insight that enabled their explanation was that quasicrystals were, in fact, periodic—but in a higher dimension than the one in which they exist physically. Using this realization, the physicists were able to describe and predict mechanical and thermodynamic properties of quasicrystals.

The concept of higher spatial dimension extends our familiar three-dimensional space—length, width, and height—by introducing additional directions which are perpendicular to all three. This is difficult to visualize, as we can only perceive the world around us as a three-dimensional space, and even more challenging to measure. An example of a four-dimensional object is the tesseract, also known as hypercube.

Just as a cube consists of six square facets, a tesseract comprises eight cubic cells. Although we cannot fully visualize a tesseract, we can represent it through its projections, much like looking at the shadow of a three-dimensional cube on a two-dimensional piece of paper.

In a new study [published](#) in *Science*, researchers from the Technion, together with the University of Stuttgart and University of Duisburg-Essen in Germany, shed new light on this phenomenon. In their study, led by Prof. Guy Bartal and Dr. Shai Tsesses from the Andrew and Erna Viterbi Faculty of Electrical and Computer Engineering, Prof. Harald Giessen from the University of Stuttgart, and Prof. Frank Meyer zu Heringdorf from the University of Duisburg-Essen, the research group demonstrated that not only do the higher dimensional crystals dictate the mechanical properties of quasiperiodic crystals, they also determine their topological properties.

Topology is a branch of mathematics that investigates the geometric properties that remain unchanged under continuous deformations. The topology of higher-dimensional spaces focuses on the properties of objects in more than three dimensions and can assist researchers, for example, in studying the structure of the universe and developing quantum computing algorithms.

The researchers examined quasiperiodic interference patterns of electromagnetic surface waves and discovered, to their surprise, that although the patterns appeared different, their topological properties in two dimensions could not be used to differentiate between them. They found the only way to distinguish between the patterns was by referring to an "original" higher-dimensional crystal.

This understanding agrees with the explanation given by Levine and Steinhardt, which was based on an earlier discovery by British mathematician, Sir Roger Penrose (2020 Nobel Prize laureate in Physics) and later conveyed by Nicolaas de Bruijn.

The researchers also discovered another intriguing phenomenon: Two different topological patterns of surface waves appeared identical when measured after a specific time interval. This interval was extremely short, measured in attoseconds—a billionth of a billionth of a second. The original theory by Levine and Steinhardt again explains this phenomenon as a "competition" between the topological and thermodynamic (energetic) properties of the crystals.

The findings were achieved using two methods: near-field scanning optical microscopy conducted in Prof. Guy Bartal's lab by Dr. Kobi Cohen and two-photon photoemission electron microscopy, measured in collaboration between the University of Stuttgart and the University of Duisburg-Essen in Germany. The discoveries reported in the manuscript pave the way for new methods to measure the thermodynamic properties of quasiperiodic crystals.

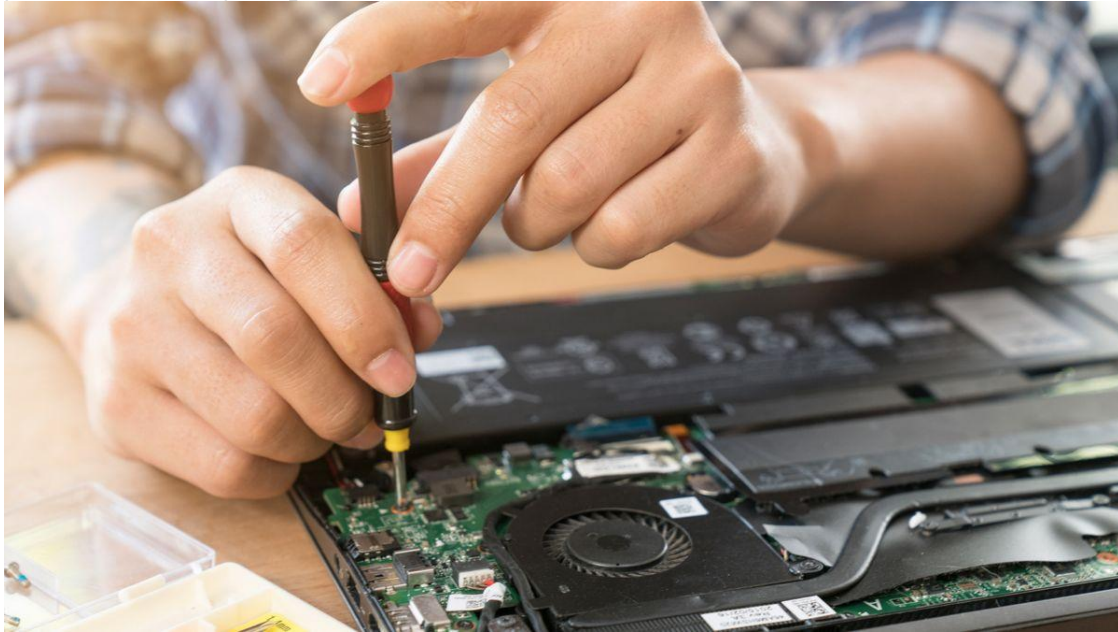
In the near future, the researchers plan to expand their findings to other physical systems and examine more deeply the interplay between thermodynamic and topological properties. Potentially, the unique higher-dimensional topological properties of quasicrystals could be used in the future to represent, encode, and transfer information.

More information: Shai Tsesses et al, Four-dimensional conserved topological charge vectors in plasmonic quasicrystals, *Science* (2025). DOI: [10.1126/science.adt2495](https://doi.org/10.1126/science.adt2495)

Provided by Technion - Israel Institute of Technology

'Next generation of laptops': Intel unveils blueprints for a fully repairable and modular computer

Intel's reference laptop design aims to cut e-waste and make computers you can easily repair.



(Image credit: Witthaya Prasongsin/Getty Images)

Reference designs for a new kind of modular computer could be the gateway toward laptops and mini-PCs that are easily repairable and reduce electronic waste (e-waste), Intel engineers hope.

The computing giant has shown off its ambitions to create a new PC architecture for laptops that revolves around a motherboard split into several modules — comprising a core mainboard and separate I/O modules for handling things like connectivity. This differs from the all-in-one design commonly found in most laptops. The engineers published their blueprints on Jan. 22 in a [blog post](#).

Splitting a traditional motherboard into multiple components creates a scalable design that enables the reuse of components in laptops of different sizes and layouts. This modular approach means you can swap out faulty motherboard components rather than needing to replace the entire mainboard. Adopting a standardized modular design also means laptop makers could cut manufacturing costs and reduce waste. "By developing a new approach to system design that allows for easy upgrades and component replacements, we aim to significantly extend the usable life of computing devices, thereby reducing electronic waste

and promoting a more sustainable consumption model," three Intel representatives jointly wrote in the [blog post](#).



Intel is reimagining modular laptops from the core up. (Image credit: Intel)

Modular moves

The crux of modular laptops is that if a component breaks or needs to be upgraded, it can be easily swapped out by the user or a skilled technician without needing to replace other parts of the machine or be sent back to the factory.

This has been the case with some parts of Panasonic's ToughBook laptops and the [Framework Laptop 13](#), a highly modular laptop with a design that enables multiple components to be swapped in and out, and hardware that's easily accessed — not glued down, as is the case with other laptop brands.

However, such modularity is far from standardized. Unfortunately, as good as the entries on our list of the [best laptops for coding and programming](#) and [best laptops for students](#) are, these machines lack many, if any, upgradable components. If they break, they often need specialist repair.

Intel's "Modular Architecture Blueprint" aims to change this by taking modularity further than Framework's laptops and delivering a reference design that addresses modularity from the manufacturing stage, to field repairs and user upgrades. Add in easily swappable memory, storage and Wi-Fi components — still not commonly replaceable in mainstream laptops — and Intel could usher in a laptop design that facilitates more customization for hardware makers yet doesn't stymie DIY repairs.

Intel is also looking to achieve the same with mini-PCs, only with hot-swappable M.2 modules that allow for key components like the graphics processing unit and processor to

be easily swapped in a "plug and play" approach. While full-size and compact desktop PCs have always been modular, with the ability to swap main components in and out, the compact nature of mini-PCs makes such modularity a harder proposition.

If Intel can ship these reference designs to computer makers, it could usher in more laptops and mini-PCs that can be upgraded and [repaired by users](#), while also reducing the amount of e-waste that is produced.

Modern [computers](#) are a triumph of technology. A single computer chip contains billions of nanometre-scaled transistors that operate extremely reliably and at a rate of millions of operations per second.

However, this high speed and reliability comes at the cost of significant energy consumption: data centres and household IT appliances like computers and smartphones account for around [3% of global electricity demand](#), and the use of [AI](#) is likely to drive [even more consumption](#).

But what if we could redesign the way computers work so that they could perform computation tasks as quickly as today while using far less energy? Here, nature may offer us some potential solutions. The IBM scientist Rolf Landauer addressed the question of whether we need to spend so much energy on computing tasks [in 1961](#). He came up with the Landauer limit, which states that a single computational task — for example setting a bit, the smallest unit of computer information, to have a value of zero or one — must expend about 10^{-21} joules (J) of energy.

This is a very small amount, notwithstanding the many billions of tasks that computers perform. If we could operate computers at such levels, the amount of electricity used in computation and managing waste heat with cooling systems would be of no concern.

However, there is a catch. To perform a bit operation near the Landauer limit, it needs to be carried out infinitely slowly. Computation in any finite time period is predicted to cost an additional amount that is proportional to the rate at which computations are performed. In other words, the faster the computation, the more energy is used.

More recently this has been [demonstrated by experiments](#) set up to simulate computational processes: the energy dissipation begins to increase measurably when you carry out more than about one operation per second. Processors that operate at a clock speed of a billion cycles per second, which is typical in today's semiconductors, use about 10^{-11} J per bit — about ten billion times more than the Landauer limit.

A solution may be to design computers in a fundamentally different way. The reason that traditional computers work at a very fast rate is that they operate serially, one operation at a time. If instead one could use a very large number of "computers" working in parallel, then each could work much slower.

For example, one could replace a "hare" processor that performs a billion operations in one second by a billion "tortoise" processors, each taking a full second to do their task, at a far lower energy cost per operation. A 2023 paper that I co-authored showed that a computer could then [operate near the Landauer limit](#), using orders of magnitude less energy than today's computers.

Tortoise power

Is it even possible to have billions of independent "computers" working in parallel? Parallel processing on a smaller scale is commonly used already today, for example when around 10,000 graphics processing units or GPUs run at the same time for training artificial intelligence models.

However, this is not done to reduce speed and increase energy efficiency, but rather out of necessity. The limits of heat management make it impossible to further increase the computation power of a single processor, so processors are used in parallel.

An alternative computing system that is much closer to what would be required to approach the Landauer limit is known as network-based biocomputation. It makes use of biological motor proteins, which are tiny machines that help perform mechanical tasks inside cells.

This system involves encoding a computational task into a nanofabricated maze of channels with carefully designed intersections, which are typically made of polymer patterns deposited on silicon wafers. All the possible paths through the maze are explored in parallel by a very large number of long thread-like molecules called biofilaments, which are powered by the motor proteins.

Each filament is just a few nanometres in diameter and about a micrometre long (1,000 nanometres). They each act as an individual "computer", encoding information by its spatial position in the maze.

This architecture is particularly suitable for solving so-called combinatorial problems. These are problems with many possible solutions, such as scheduling tasks, which are computationally very demanding for serial computers. [Experiments confirm](#) that such a biocomputer requires between 1,000 and 10,000 times less energy per computation than an electronic processor.

This is possible because biological motor proteins are themselves evolved to use no more energy than needed to perform their task at the required rate. This is typically a few hundred steps per second, a million times slower than transistors.

At present, [only small biological computers](#) have been built by researchers to [prove the concept](#). To be competitive with electronic computers in terms of speed and computation, and explore very large numbers of possible solutions in parallel, network-based biocomputation needs to be scaled up.

[A detailed analysis](#) shows that this should be possible with current semiconductor technology, and could profit from another great advantage of biomolecules over electrons, namely their ability to carry individual information, for example in the form of a DNA tag. There are nevertheless numerous obstacles to scaling these machines, including learning how to precisely control each of the biofilaments, reducing their error rates, and integrating them with current technology. If these kinds of challenges can be overcome in

the next few years, the resulting processors could solve certain types of challenging computational problems with a massively reduced energy cost.

Neuromorphic computing

Alternatively, it is an interesting exercise to compare the energy use in the [human brain](#). The brain is often hailed as being very energy efficient, [using just a few watts](#) — far less than AI models — for operations like breathing or thinking.

RELATED STORIES Yet it doesn't seem to be the basic physical elements of the brain that save energy. The firing of a synapse, which may be compared to a single computational step, actually uses about the same amount of energy as a transistor requires per bit.

However, the architecture of the brain is very highly interconnected and works fundamentally differently from both electronic processors and network-based biocomputers. So-called [neuromorphic computing](#) attempts to emulate this aspect of brain operations, but using novel types of computer hardware as opposed to biocomputing. It would be very interesting to compare neuromorphic architectures to the Landauer limit to see whether the same kinds of insights from biocomputing could be transferable to here in future. If so, it too could hold the key to a huge leap forward in computer energy-efficiency in the years ahead.

'Like a field plowed prior to planting': Researchers want to grow lasers, yes lasers, on material commonly found in sand

- **Researchers at Imec have found a way to grow lasers directly on silicon**
- **Imec's lasers use gallium arsenide, a material that doesn't naturally bond with silicon**
- **This breakthrough could lower costs and improve photonic chips for AI and telecom**

Silicon photonics uses light to transmit data instead of relying on electrical signals, but since silicon itself can't efficiently generate light, it requires lasers as a light source.

Placing lasers onto chips has traditionally been a challenge as Silicon - a material commonly found in sand - is not suitable for making lasers, and the best laser materials, such as gallium arsenide (GaAs), do not naturally work with it. Existing methods require bonding these materials onto silicon, a process that's both costly and wasteful.

Scientists at Belgium research center Imec, have come up with a solution to this problem which involves growing lasers directly on silicon. This discovery could lead to more affordable and scalable photonic devices, potentially transforming applications in data communication, machine learning, and AI.

Short wavelengths

Imec's approach, detailed in a paper published in [Nature](#), builds on nano-ridge engineering, which confines defects that would otherwise degrade laser performance.

They begin by covering a silicon wafer with a layer of silicon dioxide and etching in arrowhead-shaped trenches ("like a field plowed prior to planting" as [IEEE](#)

Spectrum describes it). Gallium arsenide is then deposited into these trenches, where it only makes contact with silicon at the bottom. This placement keeps any defects buried within the trench and prevents them from spreading into the laser material above.

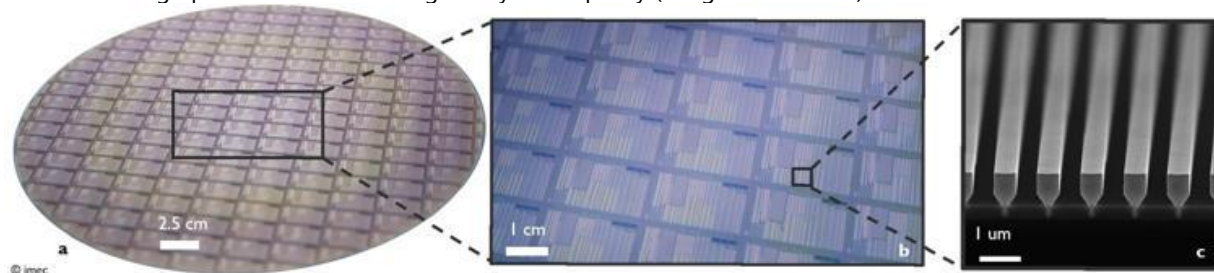
The lasers use indium gallium arsenide (InGaAs) multiple quantum wells as the optical gain region and are embedded in a doped p-i-n diode structure. They operate at room temperature with continuous-wave electrical injection, achieving threshold currents as low as 5 mA and output powers of up to 1.75 mW.

"Over the past years, Imec has pioneered nano-ridge engineering, a technique that builds on SAG [selective-area growth] and ART [aspect-ratio trapping] to grow low-defectivity III-V nano-ridges outside the trenches," said Bernardette Kunert, scientific director at Imec.

"Now, Imec exploited the III-V nano-ridge engineering concept to demonstrate the first full wafer-scale fabrication of electrically pumped GaAs-based lasers on standard 300 mm silicon wafers, entirely within a CMOS pilot manufacturing line."

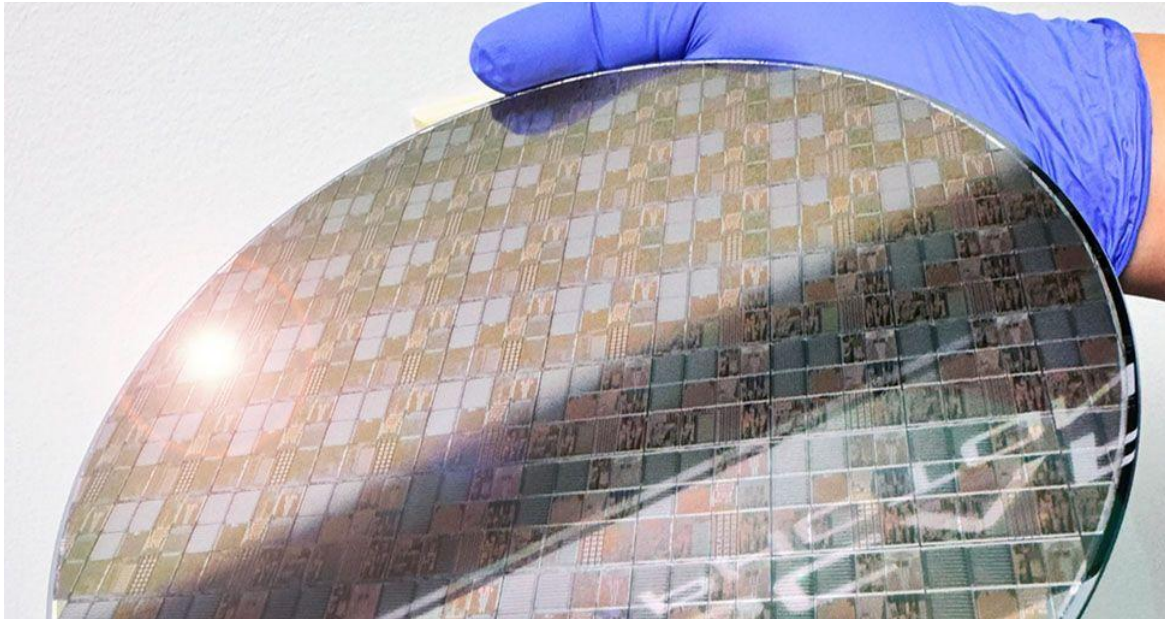
The nanoridge lasers emit light at 1,020 nanometers, which *IEEE Spectrum* points out, is a shorter wavelength than those typically used in telecommunications. Imec's researchers say they are actively working to extend the wavelength and improve the design to reduce defects near electrical contacts. If successful, this approach could provide a scalable and cost-effective solution for integrating lasers into silicon photonics, paving the way for the high-performance optical devices of the future.

A 300 mm silicon wafer containing thousands of GaAs devices with a close-up of multiple dies and a scanning electron micrograph of a GaAs nano-ridge array after epitaxy (Image credit: Imec)



published October 30, 2024

Xscape Photonics' ChromX platform has received investment from Nvidia and others



(Image credit: Xscape Photonics)

Bandwidth limitations have become a significant bottleneck in AI and high-performance computing (HPC), as GPUs are underutilized due to bandwidth constraints, with nearly half of their computational power going to waste.

[Nvidia](#) is not expected to release optical interconnects for its NVLink protocol until the "Rubin Ultra" GPU compute engine launches in 2027.

This delay has led hyperscalers and cloud builders to explore ways to leapfrog Nvidia's technology by adopting optical interconnects earlier.

[Xscape Photonics](#), an optical interconnect company spun out of research at Columbia University, is using photonics to realize scalable, high-bandwidth, energy-sustainable, and cost-effective solutions to enable the next generation of AI, ML, and simulation hardware. This could help the AI industry save billions of dollars in wasted GPU capacity while also offering a path to greener, more sustainable AI infrastructures.

[The Next Platform](#) recently took a closer look at Xscape Photonics and spoke with the team behind it, including CEO Vivek Raghunathan, a former MIT researcher and [Intel](#) engineer. Raghunathan highlighted the inefficiencies of current GPU systems, explaining that as scaling continues, the problem shifts "from GPU device-level performance to a system-level networking problem."

This is where Xscape's technology comes into play. By converting electrical signals into optical ones directly within the GPU, Xscape can dramatically increase bandwidth while simultaneously reducing power consumption.

The startup's solution, called the "ChromX" platform, uses a laser that can transmit multiple wavelengths of light simultaneously through a single optical fiber - up to 128 different wavelengths (or "colors"). This enables a 32-fold increase in bandwidth compared to lasers that use only four wavelengths.

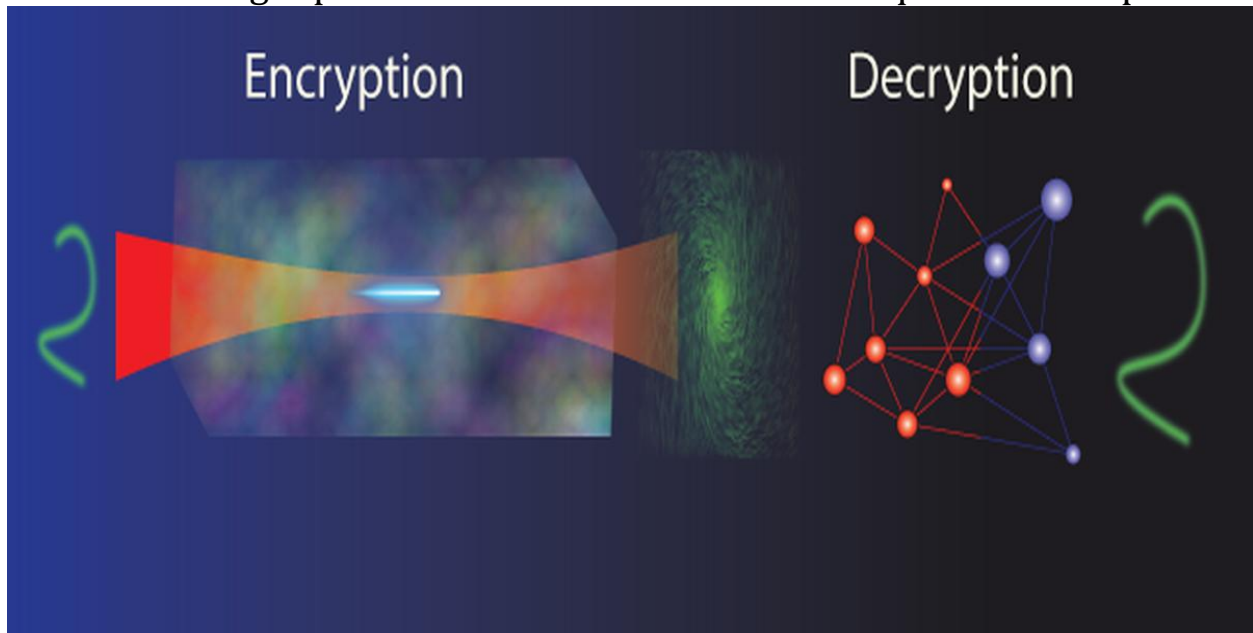
The ChromX platform also relies on simpler modulation schemes like NRZ (Non-Return-to-Zero), which reduce latency compared to higher-order schemes like PAM-4 used in other systems such as InfiniBand and Ethernet. The ChromX platform is programmable, allowing it to adjust the number of wavelengths to match the specific needs of an AI workload, whether for training or inference tasks.

Raghunathan told *The Next Platform's* Timothy Prickett Morgan, "The vision is to match in-package communication bandwidth to off-package communication escape bandwidth. And we think when we use our multicolor approach, we can match that so that giant datacenters - or multiple datacenters - behave as one big GPU."

The potential impact of this technology is enormous. AI workloads consume vast amounts of energy, and with data center demand projected to triple by 2035, power grids may struggle to keep up. Xscape Photonics' innovations could offer a vital solution, enabling AI systems to operate more efficiently and sustainably.

Is it quantum-resistant? Researchers create 'uncrackable' encryption system by pairing AI and holograms produced by laser

Uses chaotic light patterns and AI to outsmart even quantum computers



(Image credit: Optica/Stelios Tzortzakis)

- **High-power lasers and ethanol create scrambled holograms to encrypt data**
- **AI was trained to decrypt the data with 90-95% accuracy**
- **The optical encryption tech won't hit the market soon as some shortcomings inhibit its practicality**

A team of Greek scientists has developed an optical encryption system that could potentially render traditional hacking methods obsolete.

In a research paper published by [Optica](#), the researchers behind the system revealed it combines artificial intelligence (AI) and laser-generated holograms to provide high-level data protection that could be virtually impossible to crack.

Unlike traditional encryption methods, which rely on mathematical algorithms, this optical approach uses the physical properties of light, making it resistant to attacks from even the most advanced computers, including quantum machines.

How it works: scrambling light for security

"From rapidly evolving digital currencies to governance, healthcare, communications and social networks, the demand for robust protection systems to combat digital fraud continues to grow," said research team leader Stelios Tzortzakis, from the Institute of Electronic Structure and Laser, Foundation for Research and Technology Hellas and the University of Crete.

To this end, the team's optical [encryption](#) system relies on the chaotic pattern produced when a high-power laser interacts with a small container of ethanol due to scrambled light beams. This process, enhanced by thermal turbulence within the liquid, ensures that the original information is hidden beyond recognition, making it nearly impossible to decode using conventional methods.

For a way to retrieve the encrypted data, the researchers turned to AI. By training a neural network to recognize and decode the scrambled holograms, they achieved a 90-95% accuracy rate in retrieving the original images.

"We came up with the idea of training neural networks to recognize the incredibly fine details of the scrambled light patterns," Tzortzakis continued.

"By creating billions of complex connections, or synapses, within the neural networks, we were able to reconstruct the original light beam shapes. This meant we had a way to create the decryption key that was specific for each encryption system configuration."

"The method we developed is highly reliable even in harsh and unpredictable conditions, addressing real-world challenges like tough weather that often limit the performance of free-space optical systems."

Finally, he said that "[the team's] new system achieves an exceptional level of encryption by utilizing a neural network to generate the decryption key, which can only be created by the owner of the encryption system."

The team has tested the system by encoding and decoding thousands of images, including of animals, tools, everyday objects, and handwritten digits. However, the technology isn't quite ready for commercialization, as the current laser system used in the encryption process is bulky and expensive, thereby limiting its practicality and affordability.

Molecules That Can Never Exist Naturally On Earth

Feb. 6, 2025



Adastra/Getty Images

The mysteries of outer space are too great for anyone to truly wrap their head around. Our view of the universe is incredibly narrow, and almost everything we discover about it only raises more questions. Although we are naturally drawn to the dramatic sights of supernovae, planetary nebulae, and constellations in the night sky, the greatest mysteries of space are also on the chemical level. Indeed, far beyond our little blue orb, there are molecules that don't even exist on Earth.

The interstellar medium – the space between stars — is primarily made up of gases. Hydrogen is the most abundant, but helium comes in second place, and it plays a special role in the chemical world. Helium is a noble gas, part of a group of elements that do not naturally form bonds with other elements, meaning they only exist independently, not as part of any molecule. The longstanding scientific assumption has been that noble gases are completely inert, but it turns out that the laws of space are different from those of our planet. Here, we can only bind noble gases in laboratories, but in outer space, those

chemical reactions happen naturally, and these so-called "impossible elements" may provide vital answers to the mystery of the universe's formation.

How noble gases work

group

period

hydrogen
1
1.008
1.008

helium
2
4.0026
4.0026

lithium
3
6.94
6.94

beryllium
4
9.0122
9.0122

sodium
11
22.990
22.990

magnesium
12
24.305
24.305

aluminum
13
26.982
26.982

silicon
14
28.086
28.086

phosphorus
15
30.974
30.974

sulfur
16
32.06
32.06

chlorine
17
35.45
35.45

argon
18
39.948
39.948

potassium
19
39.098
39.098

calcium
20
40.078
40.078

scandium
21
44.956
44.956

titanium
22
47.867
47.867

vanadium
23
50.942
50.942

chromium
24
51.996
51.996

manganese
25
54.938
54.938

iron
26
55.845
55.845

cobalt
27
58.933
58.933

nickel
28
58.693
58.693

copper
29
63.546
63.546

zinc
30
65.38
65.38

gallium
31
69.723
69.723

germanium
32
72.630
72.630

arsenic
33
74.922
74.922

selenium
34
78.971
78.971

bromine
35
79.904
79.904

krypton
36
83.798
83.798

rubidium
37
85.468
85.468

strontium
38
87.62
87.62

yttrium
39
88.906
88.906

zirconium
40
91.224
91.224

niobium
41
92.906
92.906

molybdenum
42
95.94
95.94

technetium
43
[98]
[98]

ruthenium
44
101.07
101.07

rhodium
45
102.91
102.91

silver
46
107.87
107.87

cadmium
47
112.41
112.41

indium
48
114.82
114.82

tin
49
118.71
118.71

antimony
50
121.76
121.76

tellurium
51
127.60
127.60

iodine
52
126.905
126.905

xenon
54
131.29
131.29

cesium
55
132.91
132.91

barium
56
137.33
137.33

lanthanoids
57-71

hafnium
72
178.49
178.49

tantalum
73
180.95
180.95

tungsten
74
183.84
183.84

rhenium
75
186.21
186.21

osmium
76
190.23
190.23

iridium
77
192.22
192.22

platinum
78
195.08
195.08

gold
79
196.97
196.97

mercury
80
200.59
200.59

thallium
81
204.38
204.38

lead
82
207.2
207.2

bismuth
83
208.98
208.98

polonium
84
[209]
[209]

astatine
85
[210]
[210]

radon
86
[222]
[222]

francium
87
[223]
[223]

radium
88
[226]
[226]

actinoids
89-103

rutherfordium
104
[261]
[261]

niobium
105
[260]
[260]

seaborgium
106
[266]
[266]

bohrium
107
[264]
[264]

hassium
108
[277]
[277]

meitnerium
109
[268]
[268]

darmstadtium
110
[281]
[281]

roentgenium
111
[282]
[282]

coppernium
112
[285]
[285]

nihonium
113
[286]
[286]

flerovium
114
[289]
[289]

moscovium
115
[290]
[290]

livermorium
116
[293]
[293]

tennessine
117
[294]
[294]

oganesson
118
[294]
[294]

lanthanum
57
138.91
138.91

cerium
58
140.12
140.12

praseodymium
59
140.91
140.91

neodymium
60
144.24
144.24

promethium
61
[145]
[145]

samarium
62
150.36
150.36

europium
63
151.96
151.96

gadolinium
64
157.25
157.25

terbium
65
158.93
158.93

dysprosium
66
162.50
162.50

holmium
67
164.93
164.93

erbium
68
167.26
167.26

thulium
69
168.93
168.93

ytterbium
70
173.05
173.05

lutetium
71
174.97
174.97

actinium
89
[227]
[227]

thorium
90
232.04
232.04

protactinium
91
[231]
[231]

uranium
92
238.03
238.03

neptunium
93
[237]
[237]

plutonium
94
[244]
[244]

americium
95
[243]
[243]

curium
96
[247]
[247]

berkelium
97
[247]
[247]

californium
98
[251]
[251]

einsteinium
99
[252]
[252]

fermium
100
[257]
[257]

mendelevium
101
[258]
[258]

nobelium
102
[259]
[259]

lawrencium
103
[262]
[262]

Thom Leach / Science Photo Library/Getty Images

If you look at the parts of the periodic table, you'll notice that all of the elements are arranged in columns called groups. Group 18, the furthest column to the right of the table, is typically colored differently than the rest, signifying a family of elements unlike any other. These are the seven noble gases: helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), radon (Rn), and oganesson (Og). The first six exist naturally on Earth, but oganesson, which is highly radioactive, has only been synthesized in a lab. It wasn't even discovered until 2002, and it's currently the heaviest known element in the universe.

Molecules form when atoms bond with each other. They either form covalent bonds, in which the atoms join by sharing electrons with each other, or ionic bonds, in which neutrally charged atoms lose electrons, and bond with other atoms to restore balance. The noble gases are outliers because their atoms already have the maximum number of electrons, and therefore they don't exchange with other elements. At least, not on Earth they don't, but scientists are discovering that noble gases behave differently in space.

The impossible molecules scientists found in space



NASA images/Shutterstock

The launch of the Herschel Space Telescope in 2009 finally allowed scientists to identify a type of noble gas molecule in space. Herschel captured data by tracking infrared radiation, and when it turned its attention to the Crab Nebula, something strange happened. The data showed a molecule in the wavelength of 485 microns, but there are no molecules in that wavelength. At least, that's what astronomers thought, until further data revealed the molecule to be argonium (ArH^+), a combination of hydrogen and the noble gas argon.

The reason that argonium can exist in the Crab Nebula is that electrically-charged cosmic rays passing through space strip argon atoms of an electron, allowing it to bond with hydrogen. Researchers also discovered that argonium is created from a different isotope of argon than the one in Earth's atmosphere.

Astronomers long theorized the existence of another noble gas molecule, called helium hydride (HeH^+), a combination of helium and hydrogen. It was presumed to exist because hydrogen and helium are the two most abundant elements in the universe, and the key elements in the composition of stars. Since hydrogen and helium were the primary chemicals created by the Big Bang, scientists came to believe that helium hydride had to be the first molecule that ever formed in the universe ... and yet, it didn't exist anywhere on

Earth. The breakthrough finally came in 2019, when a study published in Nature demonstrated the presence of helium hydride in a planetary nebula 3,000 light years away.

"Molecule That Made The Universe" Has More Sources Than We Thought



The famous Tarantula Nebula, as seen by JWST. - Image Credit: NASA, ESA, CSA, STScI© IFL Science

Trihydrogen cations, or H_3^+ , are not common molecules in our everyday lives – you might not have heard of them before this article, but we are probably here because of them. This peculiar type of ion is likely a crucial ingredient in the formation of stars as well as a catalyst in chemical reactions in interstellar space. Now, new work has shown new pathways for the formation of trihydrogen.

Take H_2 , the most common molecule in the universe, slam ionized H into it, and bam: you have trihydrogen. This is the main way to make it – but not the only one. Sometimes, a double ionized organic molecule loses two electrons after being hit by [cosmic rays](#) or energetic light. This formation path has now been seen in compounds

known as methyl halogens and pseudohalogens. This tells researchers that there are more ways to create this special ion, one of the most common in the universe.

"Hydrogen is the most common element in the universe, so H meeting H is still the key," co-author of the study Professor Marcos Dantus, from Michigan State University, said in a statement sent to IFLScience. "However, there are so many organic molecules in these diffuse molecular clouds that it's possible a lot of H is still being formed by the processes we've studied."

Interstellar clouds are full of [interesting chemistry](#), some of which led to the formation of precursor molecules to the building blocks of life on Earth. These halogens and pseudohalogens can easily get doubly ionized by cosmic rays in these interstellar clouds. They are surrounded by molecular hydrogen, which actually roams around the molecule, ready to steal a hydrogen ion given the chance.

"We demonstrated that the hydrogen didn't simply fly away, but it stuck around, sometimes for quite a long time," Dantus added. "This was highly unusual."

"It's not the usual way of thinking about the behavior of doubly ionized molecules, but a much trickier process," co-author Professor Piotr Piecuch, also from MSU, explained.

This process might be only responsible for the production of a small percentage of trihydrogen in the universe, but if we want to understand how this molecule comes to exist, it cannot be discounted.

"H is a small molecule that might not be as important to us on Earth as water or proteins, but it's a molecule we truly want to understand in terms of its abundance in the universe, how it is produced, and how fast its chemical reactions are," Piecuch added. "With our findings, we can communicate with others who are looking for sources of H and the molecules that can form it."

Astrophysical detection of the helium hydride ion HeH^+

- [Rolf Güsten](#),
- [Helmut Wiesemeyer](#),
- [David Neufeld](#),
- [Karl M. Menten](#),
- [Urs U. Graf](#),
- [Karl Jacobs](#),
- [Bernd Klein](#),
- [Oliver Ricken](#),
- [Christophe Risacher](#) &
- [Jürgen Stutzki](#)

[Nature](#) **volume 568**, pages357–359 (2019)

Abstract

During the dawn of chemistry¹², when the temperature of the young Universe had fallen below some 4,000 kelvin, the ions of the light elements produced in Big Bang nucleosynthesis recombined in reverse order of their ionization potential. With their higher ionization potentials, the helium ions He^{2+} and He^+ were the first to combine with free electrons, forming the first neutral atoms; the recombination of hydrogen followed. In this metal-free and low-density environment, neutral helium atoms formed the Universe's first molecular bond in the helium hydride ion HeH^+ through radiative association with protons. As recombination progressed, the destruction of HeH^+ created a path to the formation of molecular hydrogen. Despite its unquestioned importance in the evolution of the early Universe, the HeH^+ ion has so far eluded unequivocal detection in interstellar space. In the laboratory the ion was discovered³ as long ago as 1925, but only in the late 1970s was the possibility that HeH^+ might exist in local astrophysical plasmas discussed⁴⁵⁶⁷. In particular, the conditions in planetary nebulae were shown to be suitable for producing potentially detectable column densities of HeH^+ . Here we report observations, based on advances in terahertz spectroscopy⁸⁹ and a high-altitude observatory¹⁰, of the rotational ground-state transition of HeH^+ at a

wavelength of 149.1 micrometres in the planetary nebula NGC 7027. This confirmation of the existence of HeH^+ in nearby interstellar space constrains our understanding of the chemical networks that control the formation of this molecular ion, in particular the rates of radiative association and dissociative recombination.

Physicists Propose How To Test If The Universe Is Finely Tuned For Life



It sure looks made for us, but then it would. - Image credit: Triff/Shutterstock.com© IFL Science

A new paper has set out ways that we can test the anthropic principle, or whether the universe has been "finely tuned" for life. Surprisingly, it may be possible to have answers to this age-old question in a pretty short timescale.

There is a problem (or not, for fans of being alive) within physics, in that the universe appears finely tuned for life – at least of the kind we find on Earth – to emerge and thrive.

If gravity was substantially weaker than it is (and it's [already pretty weak](#), just ask any magnet), stars and planets would not have formed. If it was just a little weaker, or electromagnetism slightly stronger, stars would be cooler and not explode to produce the heavier elements needed for life to exist. There are

countless other examples. Mess around with the values of physics even slightly, and life as we know it in this universe would not exist.

"The cliché that 'life is balanced on a knife-edge' is a staggering understatement," physicist Paul Davies famously [wrote of the problem](#). "No knife in the universe could have an edge that fine."

Naturally, scientists and philosophers have attempted to tackle this problem in different ways. You could argue that the universe is not really fine-tuned for life. Perhaps if the constants had been different, a different sort of life would have emerged (by [different processes](#)) to ask why the universe appears to be so finely tuned for its existence.

One idea is that asking the question "Why is the universe so finely tuned for us?" is a kind of survivor bias, or the observer selection effect, sometimes termed the anthropic principle.

"Suppose the evolution of life and intelligence requires a set of exceedingly unlikely coincidences: planets at just the right distance from an unusually stable star in the galactic life zone, with a stabilizing moon and a comet-deflecting Jovian, just the right chemical diversity, a fantastically unlikely chemical coincidence producing cells, a long list of low-probability evolutionary steps leading up to a generalist species forced by environmental conditions to become a super-generalist intelligent species," [writes](#) Anders Sandberg of the Institute for Futures Studies. "Yet every intelligent species in the universe would have these coincidences under their belt. Conversely, knowing we exist does not tell us whether intelligence is common."

In short, any observers would find themselves in a universe that seems just right for them. If the conditions were not right, they would not be alive. They are alive, so the conditions must have been right for life. Extensions of the idea propose that we are simply in a [multiverse](#) with many possible values for various constants, and are in the part of it in which life is possible.

This is a pretty difficult idea to test, but, according to a new paper, it is possible, and we could have answers surprisingly soon.

The authors focused on dark matter, the mysterious substance that makes up most of the universe's matter, according to the standard dark energy/cold dark

matter model of physics. The search for dark matter has, so far, yielded zero particles that fit the required bill.

One idea for dark matter was weakly interacting massive particles (WIMPs). This idea was favored because it was predicted by [supersymmetry](#), and was expected to be produced in an abundance that would explain observations at the beginning of the universe. As such, their existence would not require the anthropic principle in order to explain why it (and we) are here.

However, we have not found WIMPs at the predicted energies, and physicists are increasingly turning to axions and "fuzzy axions" as an alternative explanation. [Axions](#) were first proposed to explain charge parity violation (or CP violation) and are predicted to be extremely light.

If they do make up dark matter, they are predicted to have been produced at specific masses during "high-scale inflation" in the early universe. If axion dark matter is found, or signs of it through upcoming observations, we could see it as a test of the anthropic principle.

"The point is, that the presence of high-scale inflation and ultralight axions with masses $m > 10^{-19}$ eV would imply that dark matter 'must' be an axion: for typical initial conditions, we'd end up with way too much dark matter, and we'd desperately need the anthropic principle to constrain it," Nemanja Kaloper, a physicist from the Department of Physics and Astronomy at the University of California, Davis, explained in a [statement](#).

"To find that axion is not dark matter, we'd infer that the initial conditions were not just unlikely (which can be fixed anthropically) but extremely unlikely, which really does not even fall under the domain of anthropic reasoning."

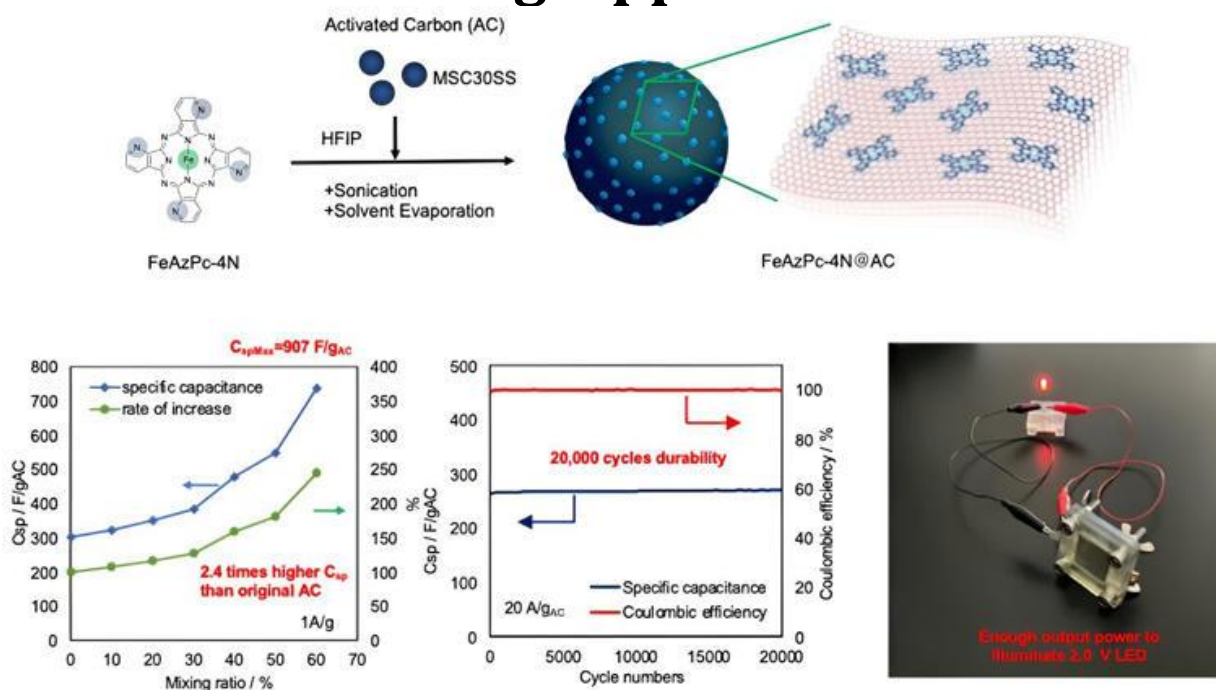
While finding dark matter seems like a long shot – we have been looking for a while, after all – the upcoming Lite Satellite for the Study of B-mode Polarization (LiteBIRD), set for launch by Japan in 2032, could provide evidence for or against the anthropic principle.

"It is possible that the LiteBIRD satellite discovers primordial gravity waves close to the current limits, which match high-scale inflation," Kaloper explained. "Most cosmologists would feel this confirms high-scale inflation."

"It is also possible that we discover signs of ultralight axions by surveying supermassive black holes in the universe. The axions affect the spin-to-mass ratio of black holes, and this could be observed," Kaloper continued. "Finally, it is possible that future direct dark matter searches discover that dark matter is predominantly not made up of ultralight axions. In which case, we'd think that the anthropic principle fails."

The study will be published in the Journal of Cosmology and Astroparticle Physics.

Achieving a supercapacitor through the 'molecular coating' approach



Schematic diagram of activated carbon with adsorbed iron azaphthalocyanine molecules (top), Capacitance and Capacitance Increase Ratio relative to activated carbon alone (bottom left), Capacitance and Capacitance Retention Rate after repeated charge-discharge cycles at 20 A/g_{AC} (bottom centre), and LED lighting experiment using a simple charge-discharge cell with two capacitor cells connected in series (bottom right). Credit: Hiroshi Yabu

Researchers at Tohoku University have successfully increased the capacity, lifetime durability, and cost-effectiveness of a capacitor in their pursuit of a more power-efficient future. The research is [published](#) in the journal *ACS Applied Materials & Interfaces*.

A capacitor is a device used as part of a circuit that can store and release energy, just like a battery. What makes a capacitor different from a battery is that it takes much less time to charge. For example, your cellphone battery will power your phone instantly, but charging that battery back up to 100% when it dies is far from instantaneous.

While this makes capacitors sound like the superior choice, they have some big drawbacks that need to be overcome. First, their capacity is much smaller than batteries, so they cannot store large amounts of energy at once. Second, they can be quite expensive.

In recent years, supercapacitors (capacitors with increased capacity and performance) have been developed using nanocarbon materials, such as carbon nanotubes (CNTs), which increase the surface area and overall capacity. However, due to the expensive nature of nanocarbon materials, large-scale production using this technique is not cost-effective.

In order to tackle these specific concerns to improve the overall performance of capacitors, a research group consisting of Professor Hiroshi Yabu (Tohoku University), AZUL Energy Co., Ltd. (a venture company from Tohoku University), and the AZUL Energy x Tohoku University Bio-Inspired GX Co-Creation Center was formed.

The team succeeded in increasing the capacity of capacitors by 2.4 times (to 907 F/gAC) compared to carbon alone by "sprinkling" iron azaphthalocyanine (FeAzPc-4N), a type of blue pigment, onto activated carbon.

This method allows the molecule to adsorb at the molecular level, utilizing its redox capabilities. Additionally, the study demonstrated that 20,000 charge-discharge cycles are possible even in high-load regions of 20 A/gAC, making it possible to power LEDs.

"This increased lifespan compared to batteries may help reduce waste, as the same capacitor can be reused many more times," comments Yabu. "The components of capacitors are also significantly less toxic than batteries."

The capacitor electrode developed in this research can increase capacity to the level of supercapacitors using CNTs while utilizing commonly available and inexpensive activated carbon, making it a potential option for next-generation

energy devices. The next step for the team is to make the supercapacitor even more super-powered.

More information: Kosuke Ishibashi et al, A Molecular Adsorption Concept for Increasing Energy Density of Hybrid Supercapacitors, *ACS Applied Materials & Interfaces* (2024). DOI: [10.1021/acsami.4c06084](https://doi.org/10.1021/acsami.4c06084)

Provided by Tohoku University

String theory is not dead yet

Scientists seeking the secrets of the universe would like to make a model that shows how all of nature's forces and particles fit together. It would be nice to do it with Legos. But perhaps a better bet would be connecting everything with strings.

Not literal strings, of course - but tiny loops or snippets of vibrating energy. And the "fit together" needs to be mathematical, not via properly shaped pieces of plastic. For decades now, many physicists have pursued the hope that equations involving an especially tiny "string" could provide the theory that solves nature's ultimate subatomic mysteries.

String theory, as it's called, has acquired a sort of fuzzy cultural acclaim, showing up in popular TV shows like *The Big Bang Theory* and *NCIS*. Among physicists, reaction to the theory has been mixed. After several promising bursts of discovery in the 1980s and '90s, strings fell somewhat out of favor for not delivering on their promises. Among those was providing the proper way to include gravity in the quantum theory of subatomic particles. Another was revealing the math that would show nature's multiple fundamental forces to be just different offspring of one unified force. Still promises unkept.

Yet during the time since string theory's retreat from the limelight, a considerable cadre of string devotees have labored to tie all the loose ends together. Success remains elusive, but real progress has been made. Questions plaguing physicists about not only the smallest bits of matter but also the properties of the entire universe may yet yield to string theorists' efforts.

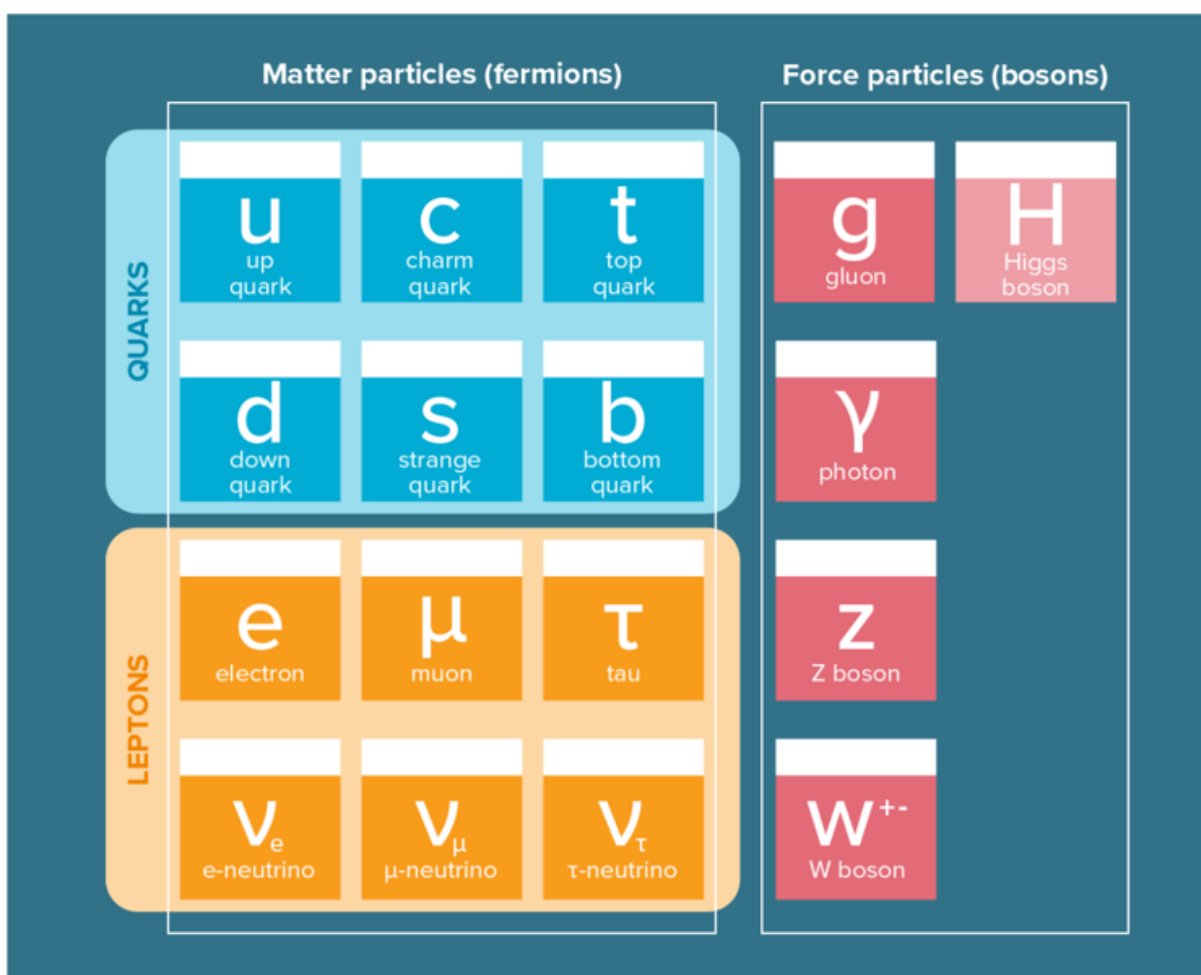
In Search Of The Theory Of Everything

"Many of the unsolved problems in particle physics and cosmology are deeply intertwined," write physicists [Fernando Marchesano](#), [Gary Shiu](#) and [Timo Weigand](#) in the 2024 [Annual Review of Nuclear and Particle Science](#). String theory may provide the path to solving those problems.

Reality's equations

One major approach in this quest is figuring out whether string theory can explain what is known as the Standard Model of particle physics. Developed in the last part of the 20th century, the Standard Model provides a sort of roster listing all of nature's basic particles. Some provide the building blocks of matter; others transmit forces between the matter particles, governing how they behave.

Standard Model of elementary particles



SOURCE: CERN

KNOWABLE MAGAZINE

The Standard Model of particle physics describes nature's known forces and subatomic particles. They include quarks, leptons and bosons. Protons and neutrons are composed of up and down quarks. Leptons include electrons and neutrinos. Photons transmit the electromagnetic force; gluons hold particles together in the atomic nucleus; and W and Z particles transmit the weak nuclear force, important for some forms of radioactivity. The Higgs boson is involved in conferring some particles with mass. Credit: CERN

It's pretty simple to draw a chart displaying those particles. You need 12 spots for matter particles - six quarks and six leptons. You need four spots for force particles (collectively known as bosons) plus a spot for the Higgs boson, a particle needed to explain why some particles have mass. But the mathematics underlying the chart is unfathomably complex, a combination of equations that make hieroglyphics seem self-explanatory.

Those equations work superbly for explaining the results of virtually all particle physics behavior. But the Standard Model cannot be the whole story of the universe. "Despite the incredible success of the Standard Model in describing the observed particle physics up to the currently accessible energy scales, there are compelling arguments for why it is incomplete," Marchesano and collaborators write.

For one thing, its equations do not encompass gravity, which has no spot on the Standard Model chart. And Standard Model math leaves many questions unanswered, such as why some of the particles have the precise masses that they do. Standard Model math also does not include the mysterious dark matter that lurks within and between galaxies, nor does it explain why empty space is infused with [a form of energy that causes the universe to expand](#) at an accelerating rate.

Some physicists investigating these problems believe that string theory can help, since a string version of the Standard Model will contain additional math that could account for its shortcomings. In other words, if string theory is correct, the Standard Model would be just one segment of string theory's full mathematical description of reality. The problem is that string theory describes many different versions of reality. That's because the strings exist in a realm with multiple dimensions of space beyond the ordinary three. Kind of like the Twilight Zone on steroids.

String theorists concede that daily life proceeds just fine in a three-dimensional world. Therefore, the extra dimensions of the string world must be too small to notice: They have to shrink, or "compactify," into submicroscopic size. It's like the way an ant living on a vast sheet of paper would perceive a two-dimensional surface without ever realizing the paper had a third, very small dimension.

Not only must string theory's extra dimensions shrink, but they also can shrink into innumerable different configurations, or geometries, of the vacuum of space.

One of those possible geometries might be the right shape of the shrunk dimensions to explain the properties of the Standard Model.

"Standard Model ... features, questions, and puzzles can be reformulated in terms of the geometry of extra dimensions," Marchesano and collaborators write.

Because string theory math can be expressed in several different forms, theorists have to explore multiple possible avenues to find the most fruitful formulation. So far, string approaches have been found that describe many features of the Standard Model. But different compactification geometries of the vacuum are needed to explain each feature. The challenge, Marchesano and colleagues point out, is to find one geometry for the vacuum that combines all those features at once, while also incorporating features that describe the known universe.

A successful compactification of the extra dimensions, for instance, would produce a vacuum in space that contained the right amount of "dark energy," the source of the universe's accelerating expansion. And candidates for the cosmic dark matter should appear in the string math as well. In fact, a whole additional set of force and matter particles emerges from string equations involving a mathematical property called supersymmetry. "Almost all string theory models that resemble the Standard Model display supersymmetry at the compactification scale," write Marchesano and his coauthors.

Versions of string theory containing supersymmetric particles go by the moniker "superstring theory." Such "superparticles" have long been suspected of comprising the universe's dark matter. But attempts to detect them in space or create them in particle accelerators have so far been unsuccessful.

As for gravity, particles conveying the gravitational force appear naturally in string theory math - one of the theory's big attractions to begin with. But the fact that many formulations of string theory include gravity does not tell you which formulation provides the correct description of the real world.

Tests are possible

If string theory is correct, [fundamental particles of nature](#) would not be the zero-dimensional pointlike objects of standard theory. Instead, different particles would result from different modes of vibration of a one-dimensional string, either

a loop or a snippet with ends attached to multidimensional spatial objects called branes. Such strings would roughly be smaller than an atom to the extent that an atom is smaller than the solar system. Very small, with no feasible way of detecting them directly. The amount of energy needed to probe scales so tiny is far beyond the reach of any practical technology.

But if string theory can account for the Standard Model, it would also contain other features of reality that would be accessible to experiments, such as types of particles not included on the Standard Model chart. "String constructions that realize the Standard Model always contain additional sectors ... at an energy scale that could be tested in the near future," Marchesano and colleagues write.

Ultimately, string theory remains a hopeful candidate for putting all the pieces of the cosmic puzzle together. If it works out, scientists could finally unravel the mysteries about how quantum physics' relation to gravity, and the properties of nature's particles and forces, are all deeply linked. "String theory," write Marchesano and colleagues, "has all the ingredients to help us understand this profound connection."

[10.1146/knownable-112124-2](https://doi.org/10.1146/knownable-112124-2)

Tom Siegfried is a science journalist in Avon, Ohio. His book [The Number of the Heavens](#), about the history of the multiverse, was published in 2019 by Harvard University Press.

This article originally appeared in [Knowable Magazine](#), an independent journalistic endeavor from Annual Reviews. Sign up for the [newsletter](#).

The post [String theory is not dead yet](#) appeared first on [Astronomy Magazine](#).

From spacesuits to car seats: New AI jacket tech adapts to your optimal body heat



From spacesuits to car seats: New AI jacket tech adapts to your optimal body heat

Researchers have developed a new artificial intelligence (AI)-driven smart textile that automatically adjusts heating and cooling for maximum user comfort. Dubbed 'smart jacket', the garment comes equipped with environmental sensors, heat-generating and color-changing yarns to prevent potentially harmful outcomes like hyperthermia or burns.

Electronic textiles are regularly employed as heating pads and electric blankets to keep wearers warm and help ease aches and pains. However, prolonged use can result in heat-related issues.

More sophisticated electronic textiles (e-textiles) can also incorporate sensors to monitor the wearer's heart rate, blood pressure, and movement; while others come equipped with Bluetooth to connect to mobile apps or temperature controls.

However, as the researchers point out, users can still risk injury from such products even with these functions. The elderly are especially vulnerable, as they suffer from decreased heat sensitivity. This is a potentially severe issue that can lead to the development of preventable illnesses or even the death of senior citizens.

Combining AI and thermochromic yarn

To this end, Jeanne Tan from Hong Kong Polytechnic University's School of Fashion and Textiles and her team believed they could boost [e-textile safety](#) by combining AI-driven systems with thermochromic yarn. This combination, they thought, would enable them to create a fabric that warms the user without overheating and provides immediate temperature readings for easy monitoring.

Electronic textiles are regularly employed as heating pads and electric blankets to keep wearers warm and help ease aches and pains. However, prolonged use can result in heat-related issues.

More sophisticated electronic textiles (e-textiles) can also incorporate sensors to monitor the wearer's heart rate, blood pressure, and movement; while others come equipped with Bluetooth to connect to mobile apps or temperature controls.

However, as the researchers point out, users can still risk injury from such products even with these functions. The elderly are especially vulnerable, as they suffer from decreased heat sensitivity. This is a potentially severe issue that can lead to the development of preventable illnesses or even the death of senior citizens.

Combining AI and thermochromic yarn

To this end, Jeanne Tan from Hong Kong Polytechnic University's School of Fashion and Textiles and her team believed they could boost [e-textile safety](#) by combining AI-driven systems with thermochromic yarn. This combination, they thought, would enable them to create a fabric that warms the user without overheating and provides immediate temperature readings for easy monitoring.

After research and development, the team created an intelligent heating jacket from their new e-textile, which contained heat-generating, silver-coated yarn and two types of thermochromic yarn.

The silver-coated yarn can warm the garment with less bulk and greater flexibility than traditional materials like carbon fiber. The AI control system was trained on 50 subjects of various ages, genders, and body types who identified their ideal heat settings in environments with varying temperatures, humidities, and wind speeds.

Tan's team also decided to integrate color-changing yarns as a safety feature for the jacket. One yarn transitioning from purple to pink indicates a heating temperature above 86 degrees Fahrenheit (30 degrees Celsius) to allow for easy temperature monitoring during the day.

AI determines optimal temperature

In dark environments, the other polymeric optical fiber yarn can give off a blue, yellow, or red glow to indicate temperatures of 86 degrees Fahrenheit (30 degrees Celsius), 104 degrees Fahrenheit (40 degrees Celsius), and 122 degrees Fahrenheit (50 degrees Celsius), respectively.

In a demonstration, the jacket's [thermochromic](#) and optical fiber yarns accurately indicated the heating temperature. The jacket's AI component predicted a comfortable temperature and provided consistent heating for the wearer, even when the environment changed.

"An AI model, trained on data from 50 wearability test subjects, determines optimal heating temperatures (40–50 °C) with 5.083 mean squared error (MSE), showing a high correlation between predicted and actual comfort levels," the researchers note in their study.

The research team believes its innovative e-textile technology could be used in various applications, from heated car seats and furniture to spacesuits.

The study has been published in the journal [ACS Applied Materials & Interfaces](#).

The laws of the universe as we know it could all change - because of one strange particle

Tachyons might sound like creatures ripped out of a George R. R. Martin novel, but the reality is that they refer to as-yet-non-existent [particles](#) not only capable of travelling faster than [the speed of light](#), but also of changing our understanding of the [universe](#).

The speed of light - [exactly 299,792,458 metres per second](#) – has already given us a lot of ideas about space and the universe, such as a lightyear which, in addition to being the surname of an animated children's character, also pertains to how many years it would take you to travel somewhere if you were going at the speed of light.

What's more, when looking up at the night's sky, the stars we see are shining from the past, as that light has taken a considerable amount of time to reach us.

And if we were to cut the travel part out of that equation and arrive at the source immediately, then that messes with the concepts of causality (basically, cause and effect) and relativity (how objects behave in space-time), raising questions around time travel and warp speed, too.

In 1994, a physicist called Dr Miguel Alcubierre, of the University of Wales in Cardiff, took [Albert Einstein's](#) theory of *general* relativity (different to *special* relativity, and concerning the concept of a space-time continuum of which gravity is a warp in this 'fabric') and [concluded](#) a 'warp drive' was possible, but required "negative energy".

More recently, [in May last year](#), University of Alabama researchers looked into whether such a 'warp drive' could actually be produced by something more familiar – namely particles underpinning the creation of planets and humans.

And they *could* use more ordinary matter to produce such a phenomenon, but only at *sub*-light speed, and lead researcher Dr Jared Fuchs [told BBC Science Focus](#) that "you need a lot of energy to make any small change in space".

The outlet writes: "To move a passenger compartment the size of a small room would require a 'warp bubble' the size of a small house. And to make that would require squeezing a few times the mass of Jupiter into a volume the size of a small asteroid."

Meanwhile Dr Fuchs said that although the possibility of that is a "maybe", he "wouldn't say" that it's practical, given it again raises challenges around the sheer amount of energy required.

But that brings us back to tachyons, which Polish professor Andrzej Dragan says "make perfect sense mathematically", and that while the familiar particles we've come across are *subluminal* (that is, slower than the speed of light), they could be hanging about with *superluminal* particles which are tachyons.

Though again, a question of energy comes up when it comes to slowing such particles down to the *subluminal* speeds we recognise.

Except there's another familiarity which was identified by Dragan, namely that they defied the strict cause and effect of causality (see above) which we see in subatomic particles.



To be specific, an atom can absorb a light photon and then emit it at a later stage, but we won't know in exactly *which* direction that will be – and Dragan is suggesting an interaction between a tachyon and ordinary matter could bring about an outcome which is just as unpredictable.

It doesn't follow strict cause and effect, because we only have the latter as something observable.

And so, to summarise, the bright beams of light you see blasted in the faces of space pilots in media such as *Star Trek* and *Star Wars* is being thought about, but significant challenges and questions remain.

Engineers forge 100 times lighter car fire shield that withstands 1832°F heat

Researchers have created a new feather-light insulation material, which is capable of withstanding temperatures exceeding 1000°C (1832°F).

The development comes from Aegis FibreTech, a newly formed spin-out company of the University of Birmingham.

This new insulation material aims to deliver increased efficiency and safety benefits to vehicles, including electric cars and those used in motorsport.

It is specifically engineered for high-temperature environments, such as those found around engines and exhaust systems in vehicles.

100 times lighter heat shield

The insulation material has two advantages: it transfers heat 10 times slower than current high-end automotive materials, and it's 100 times lighter than traditional ceramic fire blankets.

Ceramic fiber blankets, commonly used for heat-resistant insulation, are made from needled fibers and offer strong thermal and chemical resistance.

However, Aegis FibreTech's new material surpasses these existing options with its ultra-low density and precisely controlled fiber network. Its thinness, 12 times less than ceramic fiber blankets, enables effective insulation in confined spaces.

Moreover, it withstands high temperatures (1000°C) without damage.

"Aegis FibreTech's materials are so light you can't feel the weight of them. They provide an effective heat-shielding barrier to temperatures of up to 1000°C and could reduce the weight of a fire blanket to that of a couple of sheets of paper," said Sam Moxon, CEO of Aegis FibreTech, in the [press release](#).

There are several implications of this technology. For instance, it could be used to reduce exhaust system and engine temperatures, which enhances vehicle performance and longevity. It minimizes thermal stress on components and protects surrounding sensitive parts from heat damage.

Moreover, safety is enhanced by lowering the risk of fires and accidental burns.

The material is eco-friendly

The main technology behind this material development is an electrospinning process developed at the University of Birmingham.

Electrospinning utilizes an electrical field to pull polymer solutions into incredibly thin nanofibers.

Aegis FibreTech has opted for eco-friendly bioactive glass, a group of glass-ceramic biomaterials, as its base material.

This method offers the ability to manage fiber dimensions and structure carefully.

It could lead to the development of materials ranging from a highly flexible, "cotton-wool" like consistency to multi-layered flattened fabrics for increased density and strength.

Furthermore, this technique can produce robust woven sheets that maintain exceptional durability with a thin profile of just 0.5mm.

A notable feature of these electrospun fibers is their reusability, which is a major draw for eco-conscious sectors like EVs, construction, and aerospace.

"The electrospun fibers are made from bioactive glass, contributing to a more environmentally friendly product that can be reused. This sustainable approach aligns with modern industry demands for eco-friendly solutions," the company's [website](#) noted.

Innovation in vehicle heat and fire protection is rapidly advancing.

Last year, a Japanese technology company, Asahi Kasei, announced the development of a flame-retardant [nonwoven fabric](#) designed to enhance EV battery safety.

This material offers superior thermal runaway protection, withstanding flames up to 1,300°C while maintaining the opposite side below 400°C.

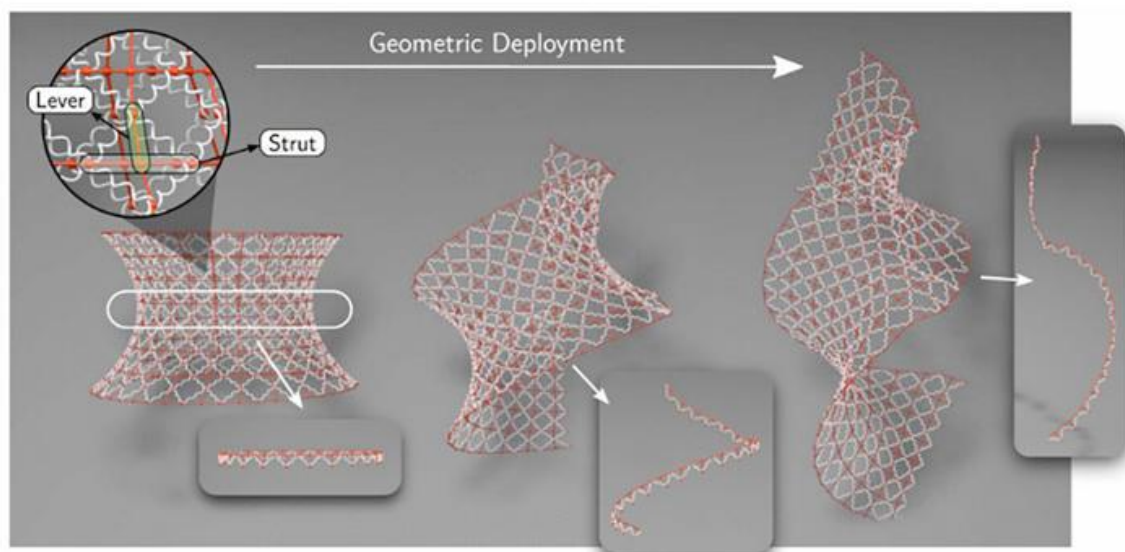
New flexible 'metamaterial' inspired by nature could help us build shapeshifting space habitats and telescopes

In living things, structures are built from simple, repeatable patterns. These often come in the form of a disorganized lattice. Large structures, like bones or coral, emerge from repeated rounds of growth of a fundamental pattern that builds off of itself in a haphazard way.

Despite this apparent disorganization, the [resulting structures can acquire a variety of shapes](#) and have surprising strengths, versatility and other useful properties. Most importantly, the resulting structure often has properties that the underlying lattice unit doesn't possess. For example, individual bone cells or coral polyp skeletons aren't very strong, but when they work together, they can support huge animals or gigantic underwater colonies.

Drawing inspiration from nature, engineers have sought to repeat this flexibility with human-designed materials. The goal is to make useful materials that can be built from the repeated growth of an underlying pattern, where the new structure acquires properties that the underlying pattern doesn't have alone. An advance beyond that is the study of metamaterials, which are structures that can change their shape or properties through the application of a simple external force, like an [electric field](#) or compression.

These kinds of materials are especially interesting for applications in space. We would love to launch a payload of simple materials and then have those materials assemble — and reassemble — themselves in space. This would avoid the challenges of testing and launch-proofing large, complex structures, like habitats and [telescopes](#), and give us the flexibility to change those structures if mission needs are updated.



Totimorphic assembly made from neutrally-stable unit cells. (Image credit: ESA Advanced Concepts Team)

One promising kind of metamaterial is known as a totimorphic lattice. The basic component of this lattice is a triangular structure. On one side is a fixed beam with a ball joint in the center. An arm attaches to that ball joint, and the other end of the arm is attached to the ends of the fixed beam with two springs. When many of these shapes are attached together, the resulting structure can morph into a wide variety of shapes and structures, all with very minimal input. This gives the totimorphic lattice incredible flexibility.

In [a recent paper](#), scientists with the [European Space Agency](#)'s Advanced Concepts Team took a major leap in advancing totimorphic lattices from a hypothetical idea to practical applications. One major question with these lattices was how to reconfigure a large structure into another shape without the lattice getting tangled and how to accomplish that transformation as efficiently as possible.

The researchers developed a computer simulation of totimorphic lattices and figured out how to optimize the transformation of one shape into another.

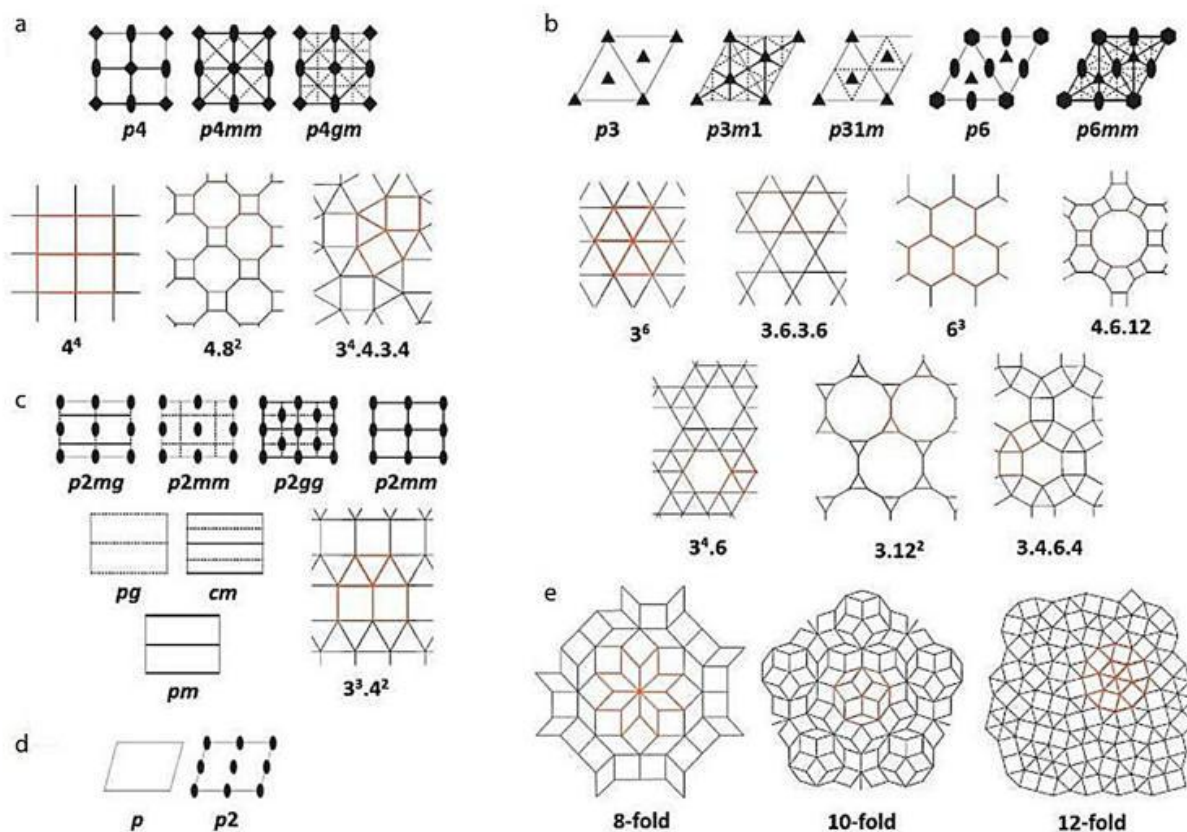
They showcased their new technique with two examples. In the first, they designed a simple habitat structure that could change its shape and stiffness. Future space explorers could deploy the same kind of material [to build a variety of habitat modules](#). These modules would hold their shape until they were reprogrammed to change their form and fulfill some other need.

In the second example, the researchers designed a flexible space telescope. With totimorphic lattices, the telescope could change its focal length by adapting the curvature of its lens. This would enable the launch of a single, [multipurpose telescope](#) that could adapt and readapt to provide the optimal observation strategies for various targets.

This work is still preliminary, however. Totimorphic lattices are still hypothetical; we don't actually have any of these materials that you could hold in your hands, let alone build into space telescopes. But this research is crucial for advancing humanity into space. The cost and difficulty of launching materials into space mean that we need flexible, adaptable structures that are cheap to launch and easy to deploy.

By drawing inspiration from nature and investigating the surprising properties of metamaterials, we may be getting closer to achieving our [futuristic space goals](#).

The art of molecular self-assembly: Crafting 2D nanostructures for advanced materials



Summary of two-dimension structures. Credit: Chinese Journal of Polymer Science (2023). DOI: 10.1007/s10118-023-3038-8© Provided by Phys.org

Creating periodic nanostructures is vital for progress in material science and nanotechnology. Traditional methods often struggle with complexity and scalability. Integrating bottom-up self-assembly of block molecules with top-down lithography offers a solution, enabling the formation of sophisticated nanostructures. These challenges necessitate innovative approaches to fabricate advanced nanostructures.

A new review addresses these issues by leveraging the unique properties of block molecules, which can self-assemble into complex two-dimensional (2D) patterns, promising significant advancements in nanofabrication and potential applications across various technological fields.

A team from the Beijing National Laboratory for Molecular Sciences, led by Wen-Bin Zhang and Yu Shao, published their [review](#) on unconventional 2D periodic nanopatterns in the *Chinese Journal of Polymer Science* on August 24, 2023.

Their work focuses on the self-assembly of block molecules to create intricate nanostructures, combining both bottom-up and top-down techniques to push the boundaries of nanofabrication.

The review investigates the self-assembly of block molecules, leading to the formation of diverse 2D periodic nanopatterns, such as tetragonal, hexagonal, rectangular, and oblique structures. The researchers detail the evolution from simple columnar phases to complex 2D tiling morphologies in materials like block copolymers, liquid crystals, and giant molecules.

By combining directed self-assembly with top-down lithography, sophisticated nanostructures with specific functions can be achieved.

The study highlights advanced nanofabrication techniques that enable the creation of intricate and functional nanostructures. Emphasizing the need for increased complexity in block molecules and refined lithography methods, the researchers provide a pathway to low-dimensional ordered morphologies.

This innovative approach has the potential to revolutionize nanotechnology by creating more complex and functional structures than traditional methods allow.

Dr. Wen-Bin Zhang from the Beijing National Laboratory for Molecular Sciences stated, "Our findings demonstrate the immense potential of block molecules in creating complex nanostructures. By integrating self-assembly with advanced nanofabrication techniques, we can pave the way for new applications in nanotechnology, overcoming the limitations of traditional methods."

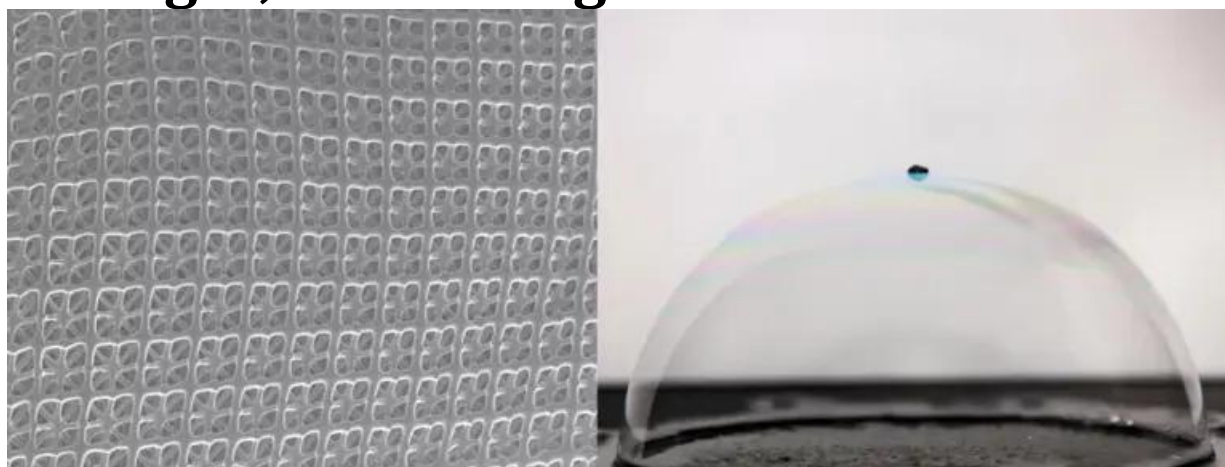
The development of unconventional 2D periodic nanopatterns has significant implications for nanotechnology. These sophisticated structures can be utilized in various applications, including electronics, photonics, and materials science.

The integration of bottom-up and top-down approaches offers a pathway to creating more intricate and functional nanostructures, potentially revolutionizing manufacturing processes and enabling the development of next-generation technologies.

More information: Bo Hou et al, Unconventional 2D Periodic Nanopatterns Based on Block Molecules, *Chinese Journal of Polymer Science* (2023). DOI: [10.1007/s10118-023-3038-8](https://doi.org/10.1007/s10118-023-3038-8)

Provided by TranSpread

AI-Designed Nanomaterials Promise Revolution in Aerospace with Steel Strength, Foam Weight



AI-Designed Nanomaterials Promise Revolution in Aerospace with Steel Strength, Foam Weight

University of Toronto engineers have [announced a breakthrough](#) in nano-architected materials that combine the strength of carbon steel with the lightness of Styrofoam, achieved through machine learning optimization that could revolutionize aerospace and automotive industries.

Why it matters: The development of these ultra-lightweight yet strong materials fundamentally changes the possibilities for vehicle design and fuel efficiency, with potential fuel savings of 80 liters per year for every kilogram of titanium replaced in aircraft.

Technical Achievement: The research team used an innovative machine learning approach to optimize material design at the nanoscale level, producing remarkable results:

- Five times stronger than titanium
- Matches carbon steel strength
- Weighs as little as Styrofoam

Industry Impact: The materials' unique properties make them particularly valuable for aerospace applications, where weight reduction directly impacts fuel consumption and environmental footprint. The team's approach to development was notably efficient:

- Required only 400 data points versus typical 20,000
- Doubled strength of existing designs
- Achieved 2.03 megapascals per cubic meter per kilogram

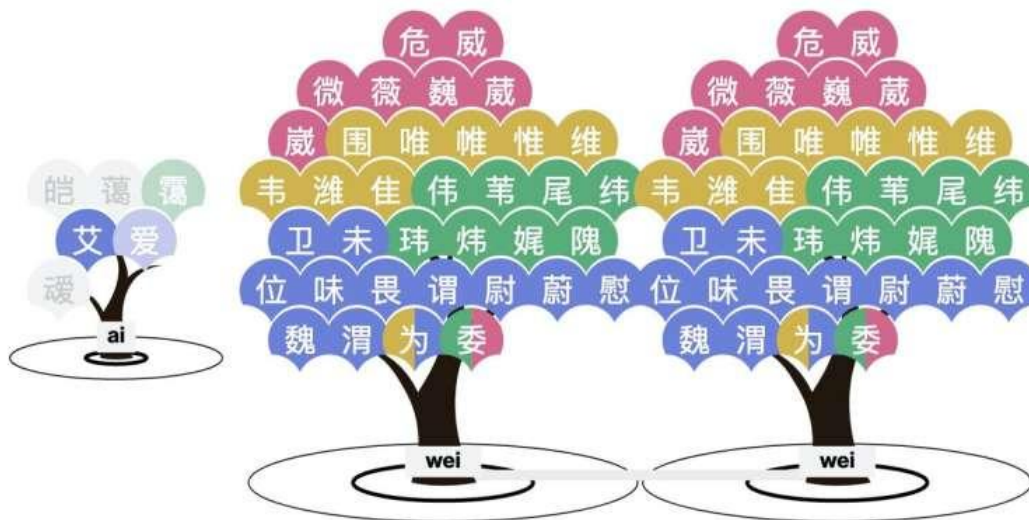
Peter Serles, Lead Author: "This is the first time machine learning has been applied to optimize nano-architected materials, and we were shocked by the improvements," [Serles explained](#).

Looking Forward: While the initial results are promising, researchers are now focusing on scaling up production for cost-effective manufacturing of larger components.

FEBRUARY 26, 2025

Lost in transliteration: Unlocking the complexity of Chinese names

by [Complexity Science Hub Vienna](#)



The Pinyin transliteration can create ambiguity, losing important cultural context and making it harder to infer details like gender. Take the name of Chinese artist and activist Ai Weiwei as an example. His given name is composed of two Chinese characters—two identical characters. When romanized, his name may seem straightforward, but it actually represents multiple Chinese characters with the same Pinyin spelling, "wei." This overlap makes it difficult to know which characters are intended, especially when context is missing. Credit: Complexity Science Hub

Have you ever felt lost when trying to pronounce or understand a Chinese name? Well, you're not alone. It's a challenge many of us face, and it stems from the way Chinese names are romanized using Pinyin, the standardized system for Mandarin pronunciation. The transliteration can create ambiguity, losing important cultural context and making it harder to infer details like gender. Even native Chinese speakers can find it tricky to recognize names when written in this way.

Take the name of Chinese artist and activist Ai Weiwei as an example.

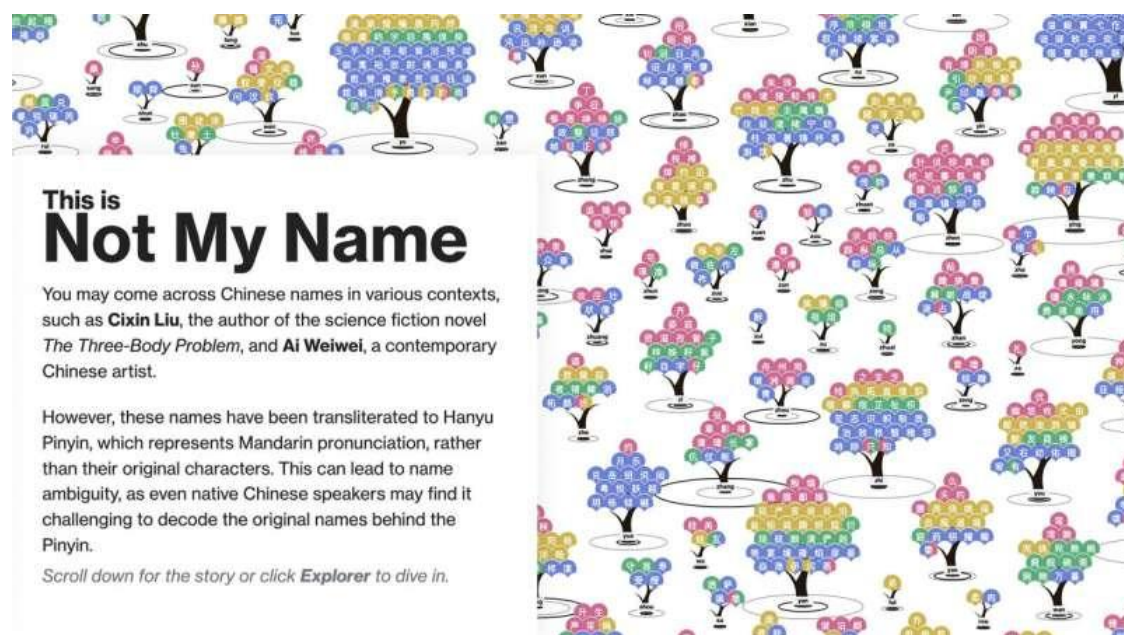
His given name is composed of two Chinese characters—two identical characters. When romanized, his name may seem straightforward, but it actually represents multiple Chinese characters with the same Pinyin spelling, "wei." This overlap makes it difficult to know which characters are intended, especially when context is missing. In some cases, people with different Chinese names will end up with the same Pinyin name, since thousands of distinct Chinese characters will be compressed into just 375 [syllables](#).

By the way, in Chinese characters, Ai Weiwei's name is 艾未未. If you are curious about how to pronounce it, or want to understand more about the intricacies of Chinese names,

check out the [insightful visualization](#) created by CSH researcher Liuhuaying Yang. The project Not My Name explores the complexity of Chinese names and the challenges of Pinyin transliteration.

Each leaf is unique

The visualization uses a leaf-and-tree metaphor: just as no two leaves are alike, every Chinese character is unique, explains Yang. "Yet, when transliterated, these unique characters are grouped into trees—clusters of characters sharing the same syllable—blurring their individuality," adds the CSH researcher. The project also illustrates the frequency of each syllable's use, showing how many people would be affected by the transliteration process.



The visualization Not My Name explores the complexity of Chinese names and the challenges of using Pinyin romanization, focusing on how it impacts the distinction between surnames and given names. Created by [Liuhuaying Yang](#), from the Complexity Science Hub, the visualization uses a leaf-and-tree metaphor: just as no two leaves are alike, every Chinese character is unique, explains Yang. Credit: Complexity Science Hub

The visualization highlights how transliteration affects recognition and understanding, particularly in official contexts where gender identification can become difficult. "When studying author relations or [gender inequality](#) in academia, foreign names like Chinese names are often excluded from research due to these challenges," notes Yang.

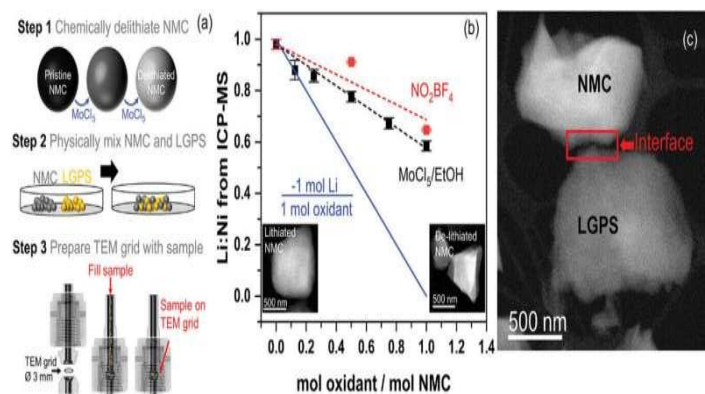
The CSH researcher hopes her [visualization](#) will provide a deeper understanding of Chinese language and culture, shedding light on these often-overlooked complexities. "This project strives to raise awareness of the barriers individuals face in cross-cultural communication when their names lose meaning and to promote a deeper global understanding."

Provided by [Complexity Science Hub Vienna](#)

FEBRUARY 27, 2025

Advanced imagery and ultra-thin coatings could enhance performance of solid-state batteries

by Eric Stann, [University of Missouri](#)



Credit: *Advanced Energy Materials* (2024). DOI: 10.1002/aenm.202403904

From electric vehicles to wireless earbuds, traditional lithium-ion batteries power our daily lives as they charge fast and store plenty of energy. However, they rely on a solution known as liquid electrolyte, which can catch on fire if damaged or overheated.

University of Missouri researchers may have a solution. Assistant Professor Matthias Young and team are figuring out how to use [solid electrolytes](#) instead of liquids or gels to make solid-state batteries, which are safer and more energy efficient. "Understanding Cathode–Electrolyte Interphase Formation in Solid State Li-Ion Batteries via 4D-STEM" was [published](#) in *Advanced Energy Materials*.

"When the solid electrolyte touches the cathode, it reacts and forms an interphase layer that's about 100 nanometers thick—1,000 times smaller than the width of a single human hair," said Young, who has joint appointments in Mizzou's College of Engineering and College of Arts and Science. "This layer blocks the lithium ions and electrons from moving easily, increasing resistance and hurting battery performance."

Understanding this issue with solid-state batteries—and how to overcome it—has vexed scientists for more than a decade.

Young's team tackled the problem by better understanding the root cause.

Using four-dimensional scanning [transmission electron microscopy](#) (4D STEM), the researchers examined the atomic structure of the battery without taking it apart—a breakthrough for the field. This novel process allowed them to gain a fundamental

understanding of the chemical reactions happening inside batteries, ultimately determining that the interphase layer was the culprit.

A potential solution

Young's lab specializes in thin-films formed by a vapor-phase deposition process known as oxidative molecular layer deposition (oMLD). Now, he plans to test whether his lab's thin-film materials can form [protective coatings](#) to prevent the solid electrolyte and cathode materials from reacting with each other.

"The coatings need to be thin enough to prevent reactions but not so thick that they block lithium-ion flow," he said. "We aim to maintain the high-performance characteristics of the solid electrolyte and [cathode](#) materials. Our goal is to use these materials together without sacrificing their performance for the sake of compatibility."

This carefully engineered approach at the nanoscale level will help ensure these materials work together seamlessly—making [solid-state batteries](#) one step closer to reality.

Study co-authors are Nikhila C. Paranamana, Andreas Werbrouck, Amit K. Datta and Xiaoqing He at Mizzou.

More information: Nikhila C. Paranamana et al, Understanding Cathode–Electrolyte Interphase Formation in Solid State Li-Ion Batteries via 4D-STEM, *Advanced Energy Materials* (2024). DOI: [10.1002/aenm.202403904](https://doi.org/10.1002/aenm.202403904)

Journal information: [Advanced Energy Materials](#)

Provided by [University of Missouri](#)

'Dark matter is more valuable than gold': Wobbly galaxies help shine a light on the universe's strangest stuff

Dark matter, widely known as the universe's most mysterious stuff, is rarer on Earth than gold — and that's despite the fact that dark matter outweighs "ordinary matter" by a staggering ratio of five to one.

The finding came courtesy of scientists who propose a novel way to map dark matter using the "wobble" of the [Milky Way](#). That wobble is due to the influence of the Milky Way's satellite galaxies, like the [Large Magellanic Cloud](#) (LMC), and rapidly rotating [neutron stars](#), or "[pulsars](#)." Fascinatingly, pulsars act like "cosmic lighthouses" in the cosmos, sweeping beams of light across vast distances.

The team's previous work has in fact used these extreme stars, when orbited by stellar companions in systems called "[binary pulsars](#)," as [dark matter](#) probes. The scientists' new research, however, further suggests solitary pulsars could be used in such an investigation, too.

"When we first began this work in 2021 and did the follow-up publication last year, our sample was composed of pairs of millisecond pulsars – binary millisecond pulsars," Sukanya Chakrabarti of the University of Alabama in Huntsville (UAH) [said in a statement](#). "However, most pulsars are not in pairs. Most of them are solitary. In this new work, we show how to effectively double the number of pulsars we can use to constrain dark matter in the galaxy by rigorously using solitary pulsars to measure galactic accelerations." By "[constraining dark matter](#)," Chakrabarti means limiting the possible properties and characteristics of dark matter.

As more neutron star data is collected, the gravitational acceleration measurement of binary pulsars and their single counterparts could shine a light on the gravitational field of the Milky Way and, thus, the shape and distribution of dark matter in our galaxy.

"Because it's a larger sample, we now have a breakthrough," Chakrabarti said. "We are able to measure the local dark matter density using direct acceleration measurements for the first time."

The team found that there is less than 2.2 pounds (1 kilogram) of dark matter in a volume equivalent to that of the entire Earth.

"If you compare that to millions of kilograms of gold produced every year — you can see that pound-for-pound, dark matter is more valuable than gold!" Chakrabarti said.

Dark matter glue and wobbly galaxies

Dark matter, which makes up about 85% of the total matter in the universe, has been sort of a problematic phenomenon for scientists because it doesn't interact with light — or, if it does, that interaction is too weak to be detected with current technology.

That tells researchers that dark matter can't be made of atoms like everyday matter is, because the particles that comprise atoms — [electrons](#), [protons](#), and [neutrons](#) — do interact with light.

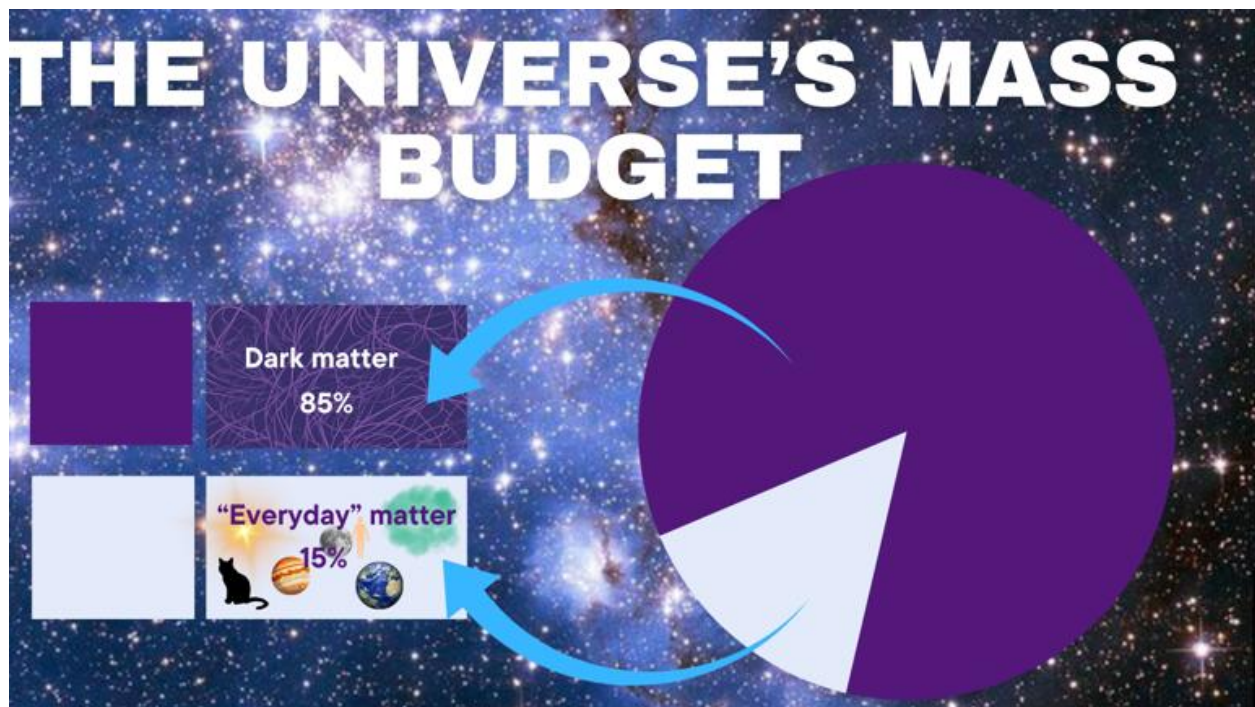


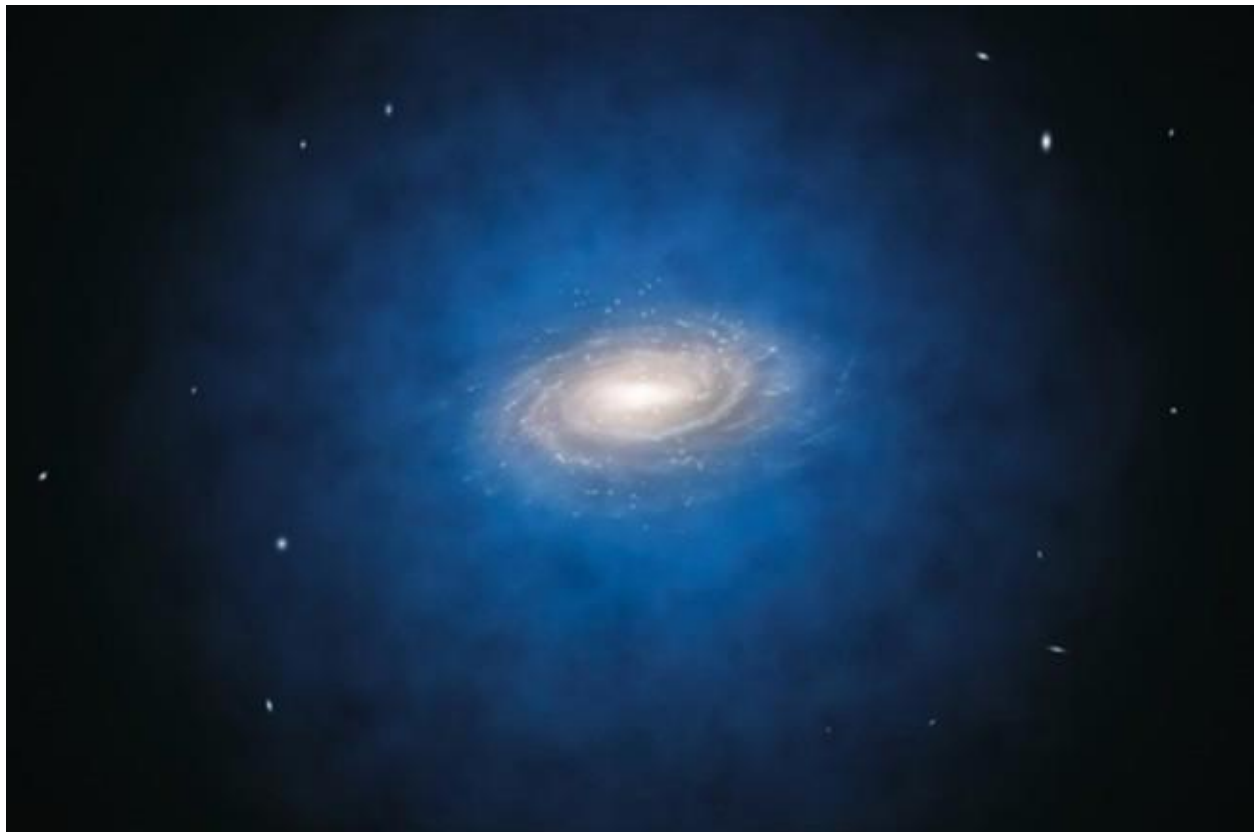
Image credit: Robert Lea (created with Canva))

The only way we can know whether dark matter exists at all is via its interaction with gravity and the influence this interaction has on light and everyday matter. In fact, this influence is crucial.

If galaxies weren't packed with invisible dark matter, the gravitational influence of their "everyday matter" — stars, planets, dust clouds, and so on — would not be sufficient to prevent them from flying apart as they spin.

Galactic dark matter content is thought to be heavily concentrated in the centers of galaxies, but it's believed the substance also extends out to form a spherical shell that extends far beyond the limits of a galaxy's visible matter.

That explains how dark matter can be less common in an average sphere around the size of Earth than gold is here on our planet — but still vastly outnumber atoms of all types. Space is vast, and dark matter is way more spread out across the universe than gold or other elements are.



An artist's impression of the dark matter halo (blue) that is believed to surround the Milky Way galaxy. (Image credit: ESO/L. Calçada)

Chakrabarti explained that in her earlier work, she used computer simulations to show that, as the Milky Way interacts with its [satellite galaxies](#), the stars in our galaxy feel a very different tug from gravity depending on whether the stars are located above or below what is known as the "galactic disk."

The LMC is one of the Milky Way's larger dwarf galactic satellites, for instance. As it orbits our own galaxy and passes near to the Milky Way, it can pull some of the mass in the Milky Way's galactic disk towards it, leading to a lopsided galaxy with more mass on one side. As a result, Chakrabarti said that gravity is felt more strongly on one side of the Milky Way.

"It's almost like the galaxy is wobbling — kind of like the way a toddler walks, not entirely balanced yet," she continued. "So this asymmetry or disproportionate effect in the pulsar accelerations that arises from the [pull of the LMC](#) is something that we were expecting to see.

"Here, with the larger sample of pulsar accelerations, we are actually able to measure this effect for the first time."

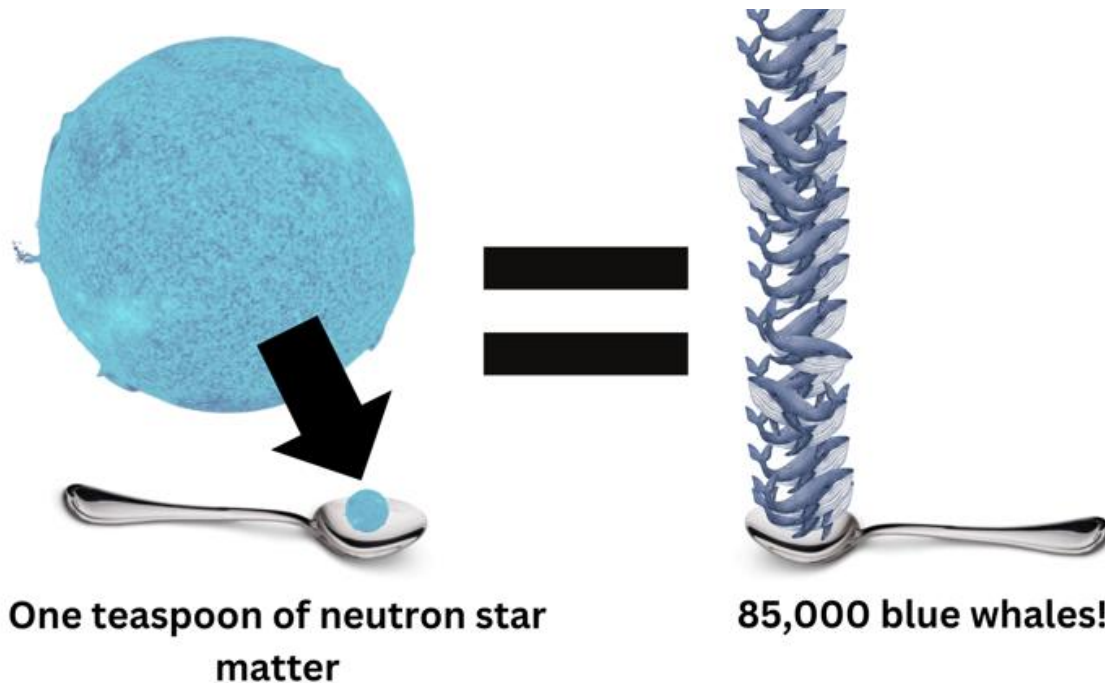
Cosmic lighthouses

Pulsars, like all neutron stars, are born when stars at least eight times as massive as [the sun](#) run out of their fuel supply needed for nuclear fusion and can no longer support themselves against the inward push of their own gravity.

As the cores of these stars crush down, the stars' outer layers, and most of their masses, are blown away in tremendous [core-collapse supernovas](#).

This leaves a stellar remnant with between one and two times the mass of the sun condensed into a width of around 12 miles (20 kilometers). This means neutron stars are composed of the densest matter in the known universe.

If a teaspoon of neutron matter were scooped up and brought to Earth, for context, it would weigh 10 million tons. That is equivalent to stacking 85,000 blue whales onto a teaspoon.



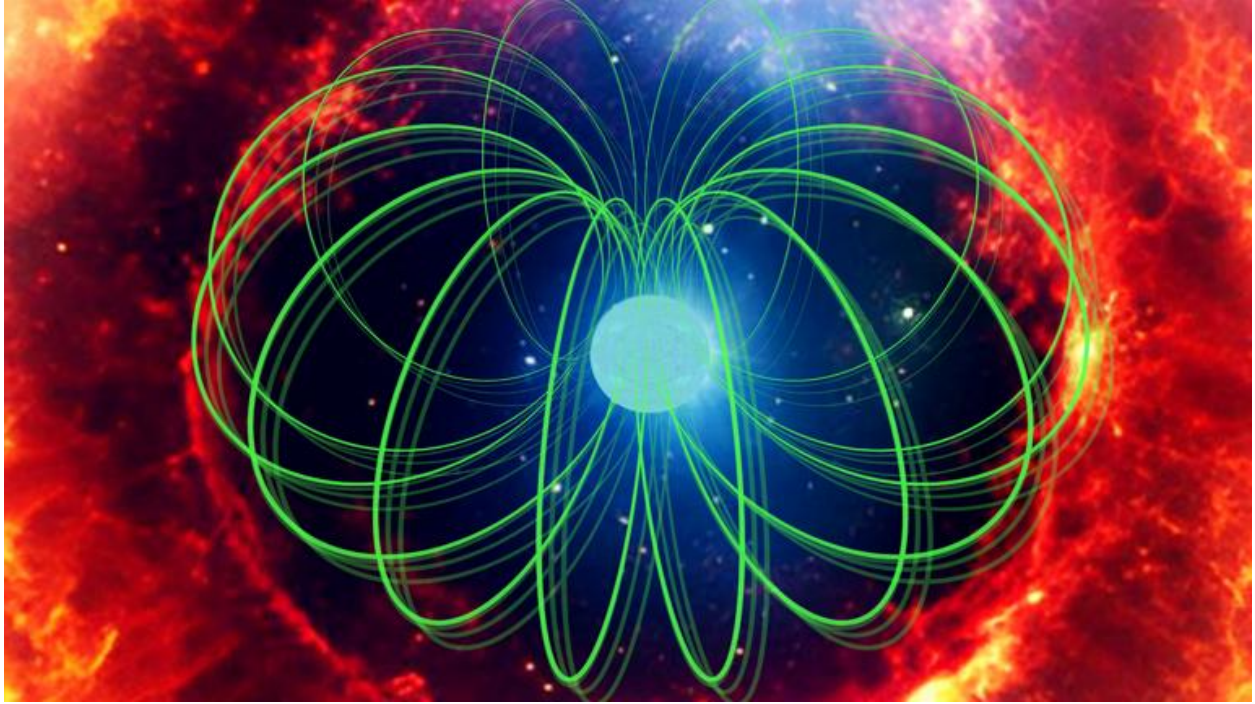
One teaspoon of neutron star matter equals about 85,000 blue whales. (Image credit: Robert Lea (created with Canva))

The rapid reduction in size of the massive stars' cores has another consequence: it speeds the neutron star up to rates of rotation that can reach **700 turns per second**. Think of this as being like the cosmic equivalent of an ice skater drawing in their arms to increase their rate of spin.

Luckily for scientists, this rapid spin and its precise frequency make pulsars excellent timing mechanisms.

Pulsars and other young neutron stars are also notable for possessing some of the **strongest magnetic fields** in the known universe.

"The incredibly strong magnetic field of the pulsars will twist and coil on itself as the pulsar spins, which leads to a kind of friction, like rubbing your hands together," team member and UAH postdoctoral associate Tom Donlon said in the statement. "Pulsars also emit particles at very high speeds, which beams away energy. These effects [known as magnetic braking] lead to the pulsar spinning more slowly as time goes on."



An illustration shows a magnetar surrounded by green magnetic field lines (Image credit: Robert Lea (created with Canva))

The magnetic field of a pulsar captures ejected particles and then flings them away as the neutron star rotates. These particles, dispersing as "[stellar wind](#)," also carry away angular momentum, slowing the spin of the pulsar, or causing it to spin down. The spin-down process is key in the team's research.

"Because of this spin down, we were initially forced to use only pulsars in binary systems to calculate accelerations because the orbits aren't affected by magnetic braking," Donlon said. "With our new technique, we are able to estimate the amount of magnetic braking with high accuracy, which allows us to also use individual pulsars to obtain accelerations."

Using this technique and the excess data it provides, researchers should be able to better determine how dark matter is distributed through our galaxy as more data is gathered.

"In essence, these new techniques now enable measurements of very small accelerations that arise from the pull of dark matter in the galaxy," Chakrabarti said. "In the astronomy community, we have been able to measure the large accelerations produced by [black holes](#) around visible stars and stars near the galactic center for some time now.

"We can now move beyond the measurement of large accelerations to measurements of tiny accelerations at the level of about 10 centimeters per second each decade, 10 centimeters per second is the speed of a crawling baby."

Scientists discovered 'secret life' of the universe before the Big Bang



Abstract big bang conceptual image.© iStockphoto by Getty Images

The universe might have had a "secret life" before the [Big Bang](#), a recent study has proposed.

Prior to the Big Bang, researchers say [black holes](#) were created as a result of the universe contracting and this could possibly explain the enigmatic nature of dark matter.

The new study, which was recently published in the Journal of Cosmology and Astroparticle Physics, challenges the traditional belief that the universe originated from the Big Bang which resulted in vast expansion.

Instead, after first contracting, the universe was in an extremely dense state and then began to "bounce" back in an expansion period, and it's this rebound that impacts what we understand about dark matter and black holes.

Density fluctuations may have brought about small black holes in the universe's contraction stage which survived the expansion phase and can so possibly make up the dark matter that adds up to around 80 per cent of the universe's total matter.

These findings could have major consequences on how we understand the universe, particularly where black holes and dark matter fit in all this.

It could provide a further understanding of the mystery of dark matter as its lack of light interaction has baffled scientists.

"Small primordial black holes can be produced during the very early stages of the universe, and if they are not too small, their decay due to Hawking radiation [a hypothetical phenomenon of black holes emitting particles due to quantum effects] will not be efficient enough to get rid of them, so they would still be around now," said Patrick Peter, director of research at the French National Centre for Scientific Research (CNRS), who was not involved in the study.

In an email, he told [Live Science](#). "Weighing more or less the mass of an asteroid, they could contribute to dark matter, or even solve this issue altogether."

Now, researchers hope to find further evidence to support this cosmology theory with gravitational wave detectors including the Laser Interferometer Space Antenna (LISA) and the Einstein Telescope, to find the waves produced when the primordial black holes were created.

The universe had a secret life before the Big Bang, new study hints

By [Andrey Feldman](#)

published August 31, 2024

The secrets of black holes and dark matter could lie before the Big Bang, a new study of "bouncing" cosmology hints.



An illustration showing various aspects of the early universe, including radiation generated by the Big Bang and ancient black holes (Image credit: ESA)

The [Big Bang](#) may not have been the beginning of the universe, according to a theory of cosmology that suggests the universe can “bounce” between phases of contraction and expansion. If that theory is true, then it could have profound implications about the nature of the cosmos, including two of its most mysterious components: black holes and dark matter.

With this in mind, a recent study suggests that dark matter could be composed of [black holes](#) formed during a transition from the universe's last contraction to the current expansion phase, which occurred before the Big Bang. If this hypothesis holds, the gravitational waves generated during the black hole formation process might be detectable by future gravitational wave observatories, providing a way to confirm this dark matter generation scenario.

Observations of stellar movements in galaxies and the cosmic microwave background — an afterglow of the Big Bang — indicate that about 80% of all matter in the universe is [dark matter](#), a substance that doesn't reflect, absorb or emit light. Despite its abundance, scientists have not yet identified what dark matter is made of. In the new study, researchers

explored a scenario where dark matter consists of primordial black holes formed from density fluctuations that occurred during the universe's last contraction phase, not long before the period of expansion that we observe now. They published their findings in June in the [Journal of Cosmology and Astroparticle Physics](#).

The bouncing cosmos

The traditional cosmological view of the universe suggests that it started from a singularity, followed by a short period of extremely rapid expansion, called inflation. However, the authors behind the new study analyzed a more exotic theory, known as non-singular matter bouncing cosmology, which posits that the universe first underwent a contraction phase. This phase ended with a rebound due to the increasing density of matter, leading to the Big Bang and the accelerated expansion we observe today.

Related: [The universe could stop expanding 'remarkably soon', study suggests](#)

In this bouncing cosmology, the universe contracted to a size about 50 orders of magnitude smaller than it is today. After the rebound, photons and other particles were born, marking the Big Bang. Near the rebound, the matter density was so high that small black holes formed from quantum fluctuations in the matter's density, making them viable candidates for dark matter.

Contact me with news and offers from other Future brandsReceive email from us on behalf of our trusted partners or sponsors

By submitting your information you agree to the [Terms & Conditions](#) and [Privacy Policy](#) and are aged 16 or over.

"Small [primordial black holes](#) can be produced during the very early stages of the universe, and if they are not too small, their decay due to Hawking radiation [a hypothetical phenomenon of black holes emitting particles due to quantum effects] will not be efficient enough to get rid of them, so they would still be around now," [Patrick Peter](#), director of research at the French National Centre for Scientific Research (CNRS), who was not involved in the study, told Live Science in an email. "Weighing more or less the mass of an [asteroid](#), they could contribute to dark matter, or even solve this issue altogether."

RELATED STORIES

The scientists' calculations show that this universe mode's properties, such as the curvature of space and the microwave background, match current observations, supporting their hypothesis.

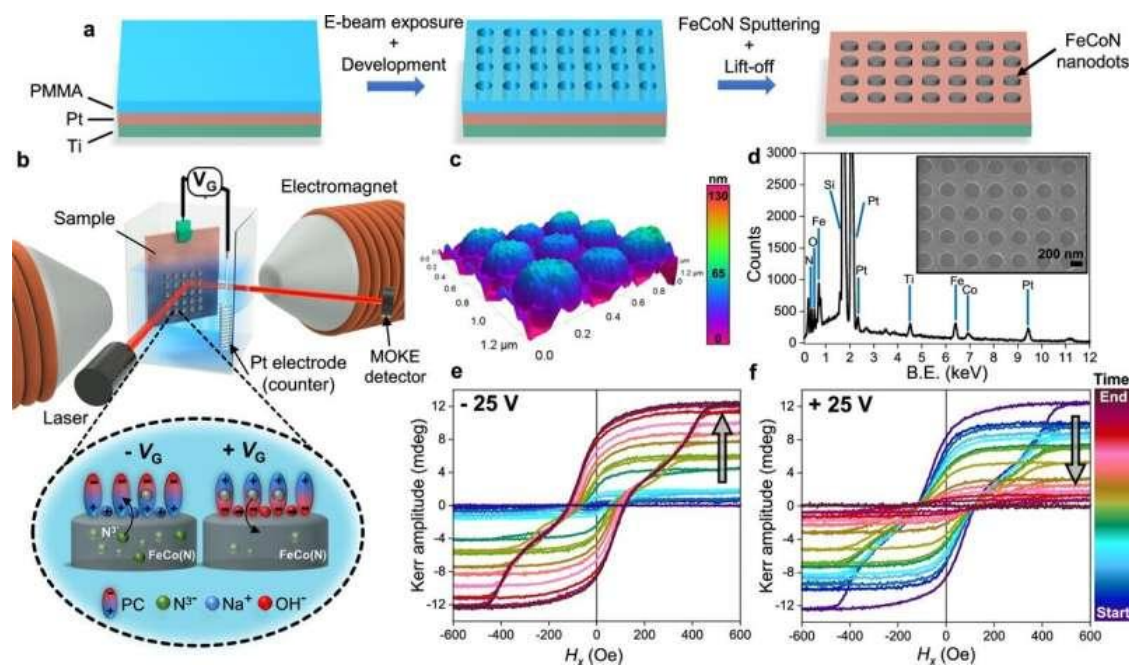
To further test their predictions, the researchers hope to make use of next-generation gravitational wave observatories. The scientists calculated the properties of the [gravitational waves](#) produced during black hole formation in their model and found that they could be detected by [upcoming gravitational observatories like the Laser Interferometer Space Antenna \(LISA\)](#) and the [Einstein Telescope](#). These detections could confirm whether primordial black holes are indeed dark matter; however, it could take more than a decade before either facility sees first light.

"This work is important in the sense that it provides a natural way of forming small yet still present black holes forming dark matter in a framework which is not the usual one based on inflation," Peter said. "Other works currently investigate the behavior of such tiny black holes around stars, potentially leading to a way of detecting them in the future."

MARCH 3, 2025

Vortion, a new magnetic state able to mimic neuronal synapses

by [Autonomous University of Barcelona](#)



Device and set-up schematics for voltage-induced ferromagnetism in FeCoN nanodots.

Credit: *Nature Communications* (2025). DOI: 10.1038/s41467-025-57321-8

Researchers from the Department of Physics have managed to experimentally develop a new magnetic state: a magneto-ionic vortex or "vortion." The research, [published](#) in *Nature Communications*, allows for an unprecedented level of control of magnetic properties at the nanoscale and at room temperature, and opens new horizons for the development of advanced magnetic devices.

The use of Big Data has multiplied the energy demand in information technologies. Generally, to store information, systems utilize electric currents to write data, which dissipates power by heating the devices. Controlling magnetic memories with voltage, instead of [electric currents](#), can minimize this energy expenditure.

One way to achieve this is by using magneto-ionic materials, which allow for the manipulation of their magnetic properties by adding or removing ions through changes in the polarity of the applied voltage. So far, most studies in this area have focused on continuous films, rather than on controlling properties at the nanometric scale in discrete "bits," essential for high-density data storage.

In addition, it is known that new magnetic phenomena can emerge at the sub-micrometer scale that do not exist at the macroscopic level, such as magnetic vortices—small swirl-like magnetic structures. These vortices have applications in the way magnetic data are currently recorded and read, as well as in biomedicine. Nevertheless, changing the vortex state in already prepared materials is often impossible or requires large amounts of energy.

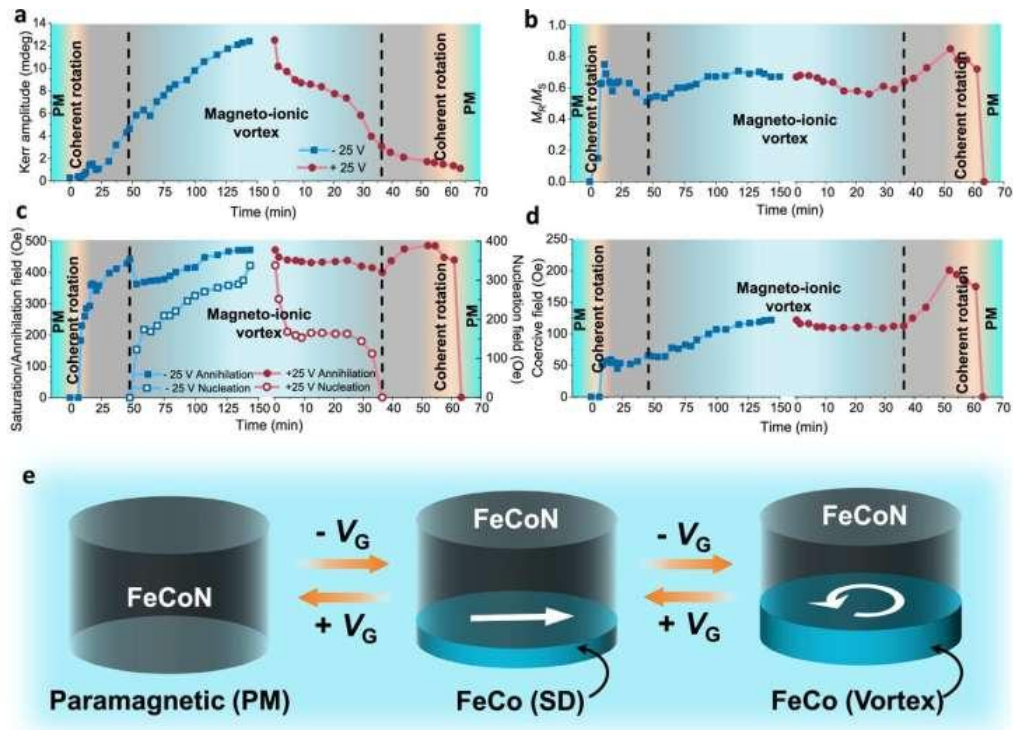
Researchers from the UAB Department of Physics, in collaboration with scientists from the ICMA-B-CSIC, the ALBA Synchrotron and research institutions in Italy and the United States, propose a new solution that combines magneto-ionics and [magnetic vortices](#). Researchers experimentally developed a new magnetic state that they have named magneto-ionic vortex, or "vortion."

This new object allows "on-demand" control of the magnetic properties of a nanodot (a dot of nanometric dimensions) with high precision. This is achieved by extracting nitrogen ions through the application of voltage, thus allowing for efficient control with very low energy consumption.

"This is a so far unexplored object at the nanoscale," explains ICREA researcher in the UAB Department of Physics Jordi Sort, director of the research. "There is a great demand for controlling magnetic states at the nanoscale but, surprisingly, most of the research in magneto-ionics has so far focused on the study of films of continuous materials.

"If we look at the effects of ion displacement in discrete structures of nanometer dimensions, the 'nanodots' we have analyzed, we see that very interesting dynamically evolving spin configurations appear, which are unique to these types of structures."

These spin configurations and the magnetic properties of the vortices vary as a function of the duration of the applied voltage. Thus, different magnetic states (e.g., vortices with different properties or states with uniform magnetic orientation) can be generated from nanodots of an initially non-magnetic material by the gradual extraction of ions through the application of voltage.



Magneto-ionic vortex (i.e., vortion) operation. Credit: *Nature Communications* (2025). DOI: 10.1038/s41467-025-57321-8

"With the 'vortions' we developed, we can have unprecedented control of magnetic properties such as magnetization, coercivity, remanence, anisotropy or the critical fields at which vortions are formed or annihilated.

"These are **fundamental properties** for storing information in magnetic memories, which we are now able to control and tune in an analog and reversible manner by a voltage-activated process with very low energy consumption," explains Irena Spasojević, postdoctoral researcher in the UAB Department of Physics and first author of the paper.

"The voltage actuation procedure, instead of using electric current, prevents heating in devices such as laptops, servers and data centers, and it drastically reduces energy loss."

Researchers have shown that by precisely controlling the thickness of the voltage-generated magnetic layer, the magnetic state of the material can be varied at will, in a controlled and reversible manner, between a non-magnetic state, a state with a uniform magnetic orientation (such as that found in a magnet), and the new magneto-ionic vortex state.

Ability to mimic the behavior of neuronal synapses

This unprecedented level of control of magnetic properties at the nanoscale and at room temperature opens new horizons for the development of advanced magnetic devices with functionalities that can be tailored once the material has been synthesized. This provides greater flexibility which is needed to meet specific technological demands.

"We envision, for example, the integration of reconfigurable magneto-ionic vortices in neural networks as dynamic synapses, capable of mimicking the behavior of biological synapses," says Sort. In the brain, the connections between neurons, the synapses, have different weights (intensities) that adapt dynamically according to the activity and learning process.

Similarly, "vortices" could provide tunable neuronal synaptic weights, reflected in reconfigurable magnetization or anisotropy values, for neuromorphic (brain-inspired) spintronic devices. In fact, "the activity of biological neurons and synapses is also controlled by electrical signals and ion migration, analogous to our magneto-ionic units," says Spasojević.

Researchers believe that, besides their impact in brain-inspired devices, analog computing or multi-state data storage systems, vortices may have other potential applications, including medical therapy techniques such as theragnostics, data security, magnetic spin computing devices (spin logics), and the generation of spin waves (magnonics).

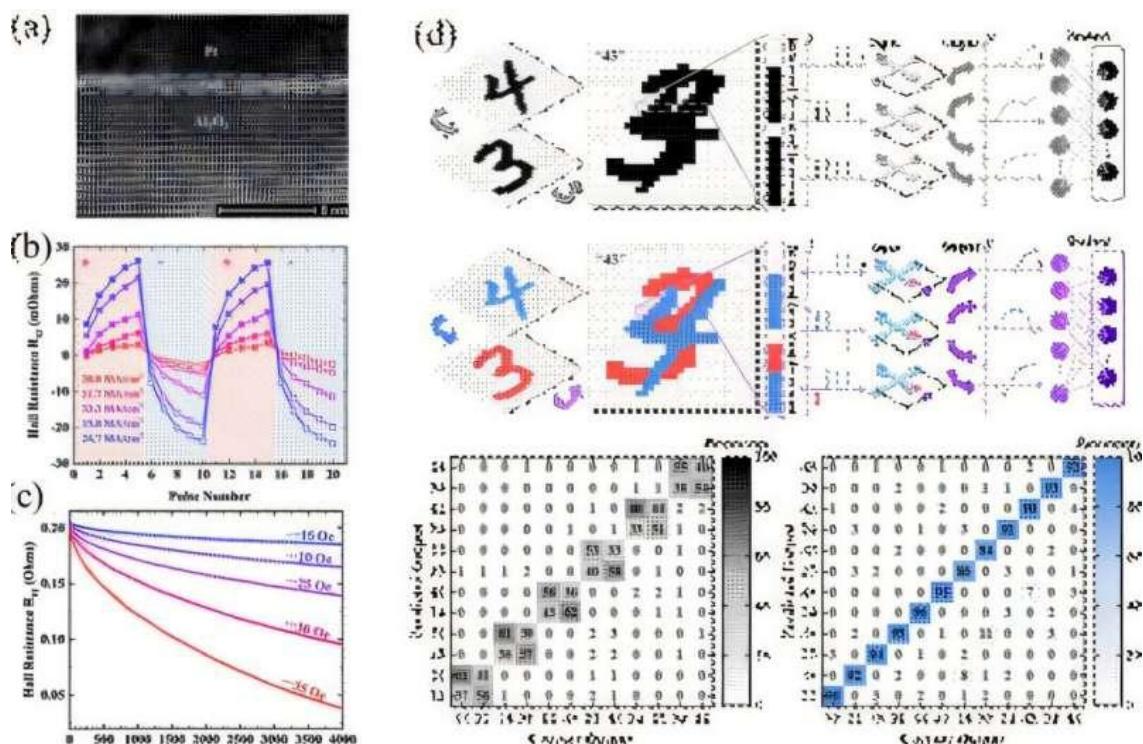
More information: Irena Spasojevic et al, Magneto-ionic vortices: voltage-reconfigurable swirling-spin analog-memory nanomagnets, *Nature Communications* (2025). DOI: [10.1038/s41467-025-57321-8](https://doi.org/10.1038/s41467-025-57321-8)

Journal information: [Nature Communications](#)
Provided by [Autonomous University of Barcelona](#)

MARCH 3, 2025

Antiferromagnetic neuromorphic memory: New spintronic device achieves brain-like memory and processing

by Liu Danxu, [University of Science and Technology of China](#)



AFM neuromorphic device and its application. Credit: *Nano Letters* (2024). DOI: 10.1021/acs.nanolett.4c02340

A research team led by Prof. Long Shibing from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences (CAS) has, for the first time, made spintronic neuromorphic devices based on CoO/Pt heterostructure. The study is [published](#) in *Nano Letters*.

Spintronics devices have attracted great attention due to their [low power consumption](#), high operation speed and radiation resistance. Antiferromagnetic (AFM) materials, with their atomic-scale alternating magnetic moment distribution, are ideal candidates for developing spintronic neuromorphic devices. However, constructing AFM neuromorphic devices is still a challenge.

First, researchers attained out-of-plane magnetic anisotropy based on CoO/Pt heterostructure with (111) orientation. By measuring the Hall resistance, researchers

confirmed the device's strong perpendicular anisotropy according to the first principle calculation.

The team achieved the device's nonlinear features of magnetization reversal, as well as its self-relaxation under thermal activation. Due to the rotatable regime of ultra-thin CoO, the CoO/Pt material of the device well reflects magnetization reversal.

The reversal of activated magnetic domains in the device determines its relaxation behavior, which is related to its short-term memory capability. In addition, researchers controlled the sweeping speed of the magnetic field to better identify the long-term memory in the system.

Based on these results, the neuromorphic device demonstrates nonlinear response and [short-term memory](#), realizing its all-electrical readout and writing.

The researchers also proved that this device can exhibit a high recognition accuracy in reservoir computing tasks, such as handwritten digit recognition and quantum state classification. The recognition accuracy is effectively improved by passing the pulse sequence through the nonlinear AFM device.

The team has proposed and verified its unique advantages in multi-dimensional information processing. On the basis of its bidirectional relaxation properties, the [device](#) enables ternary encoding and accurately recognizes information in the additional dimension.

The study lays the foundation for further leveraging AFM materials to develop neuromorphic computing systems with ultrahigh speed and ultracompact integration.

More information: Xueqiang Xiang et al, An Antiferromagnetic Neuromorphic Memory Based on Perpendicularly Magnetized CoO, *Nano Letters* (2024). DOI: [10.1021/acs.nanolett.4c02340](https://doi.org/10.1021/acs.nanolett.4c02340)

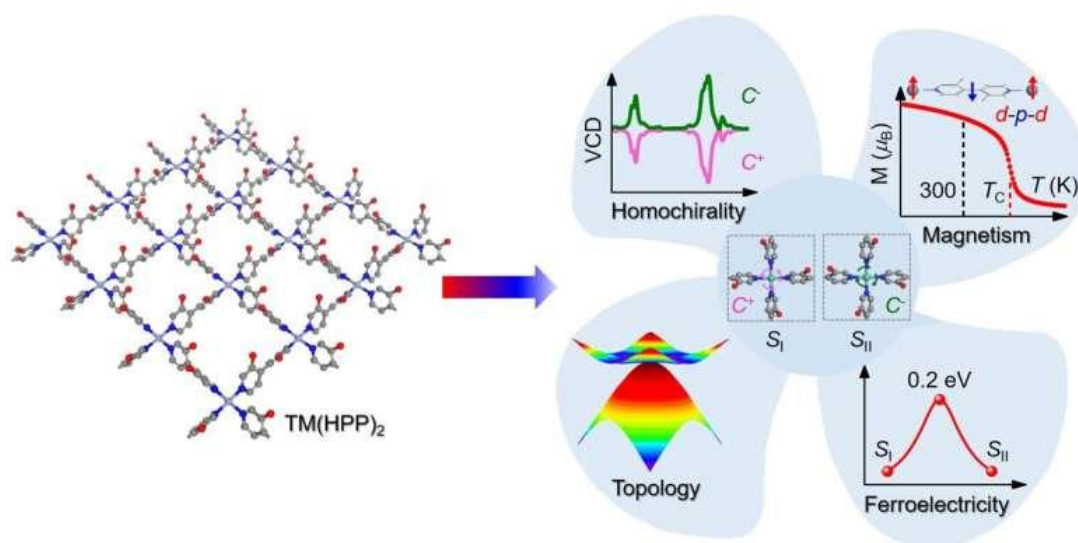
Journal information: [Nano Letters](#)

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

MARCH 3, 2025

Chiral organometallic nanosheets offer room-temperature multiferroicity and topological features

by Zhao Jing and Zhao Weiwei, [Chinese Academy of Sciences](#)



A class of homochiral multiferroic and magnetic topological organometallic nanosheets that can work at room temperature. Credit: Zhao Jing

Recently, a research team found a way to design a class of homochiral organometallic nanosheets that exhibit room-temperature multiferroic and topological nodes. Their study is [published](#) in *Nano Letters*.

Multiferroic and magnetic topological materials are pivotal for the development of next-generation electronic information devices, yet they often encounter practical limits due to low Curie temperatures. Chirality, essential in fields like chiral sensing and molecular recognition, offers potential for enhancing these materials' multifunctionality, though research remains scarce.

Notably, two-dimensional (2D) homochiral [multiferroic](#) and magnetic topological materials with room-temperature magnetic order are yet to be reported. Coupling chirality with multiferroic or topological properties is also an intriguing but challenging goal.

In this study, researchers predict a new class of homochiral organometallic nanosheets, where 4-(3-hydroxypyridin-4-yl)pyridin-3-ol (HPP) is used as an organic linker and transition

metals (TM = Cr, Mo, and W) serve as the nodes. These TM(HPP)₂ materials exhibit room-temperature multiferroic and topological properties. The homochirality arises from the chiral nature of the HPP organic linkers. Structural variations in chirality lead to a Weyl phonon topological phase transition.

The room-temperature magnetism is attributed to strong d-p direct spin coupling between the TM cations and HPP doublet anions, while the ferroelectricity results from the breaking of spatial inversion symmetry. The coupling between ferroelectricity and chirality enables the effective control of light absorption and phonon topology through an applied electric field. Notably, these materials are topologically nontrivial, characterized by a quadratic nodal point around the Fermi level.

This research achieves two significant advancements. First, it raises the Curie temperature of multiferroic and magnetic topological materials to room temperature, making these materials suitable for use in ambient conditions. Second, it integrates chirality into multiferroic and magnetic topological materials, enhancing their multifunctionality and introducing new physical phenomena. This work is expected to attract a broad readership across fields such as [chirality](#), magnetism, ferroelectricity, multiferroicity, topological materials, and multifunctional materials.

The team was led by Associate Professor Li Xiangyang and Professor Wang Xianlong from Institute of Solid State Physics, Hefei Institutes of Physical Science of the Chinese Academy of Sciences, and Professor LI Xingxing from University of Science and Technology of China.

More information: Jing Zhao et al, Designing Chiral Organometallic Nanosheets with Room-Temperature Multiferroicity and Topological Nodes, *Nano Letters* (2025). DOI: [10.1021/acs.nanolett.4c05408](https://doi.org/10.1021/acs.nanolett.4c05408)

Journal information: [Nano Letters](#)

Provided by [Chinese Academy of Sciences](#)

MARCH 3, 2025

Fiber optic networks enhanced with liquid crystal technology

by Desiree Haak, [Fraunhofer-Gesellschaft](#)



WESORAM project: The LCoS mirror splits the frequencies of the data signals and distributes them flexibly to various outputs. Credit: Fraunhofer-Gesellschaft
Applications such as self-driving vehicles, 6G mobile communications and quantum communications are pushing fiber optic networks to their limits. Fraunhofer researchers have joined forces with partners to devise clever ways to optimize data transmission. Optical switches with liquid crystal on silicon (LCoS) mirrors shrink data packets down to size so the network can carry more data, while signals are distributed across different fiber strands to create more flexibility.

Fiber [optic cables](#) transport signals at near light speed and can transmit even large volumes of data at blazing speeds. Even so, conventional fiber optic systems are no longer powerful enough to accommodate the technologies of the future. In two projects, WESORAM and Multi-Cap, the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena teamed up with partners to get fiber optic networks ready for the world of tomorrow.

Fiber optic networks already use technologies such as wavelength-division multiplexing. In this method, light is used as a carrier for a stream of data, with an optical switch splitting the light into multiple frequencies. A spectrometer grating divides the signal into different wavelengths and then transmits them to an LCoS mirror. This forwards the signals to the output fibers, which makes it possible for each fiber to transport multiple streams of data. However, this method can only be used over a limited frequency range.

Cross-wiring of signals

In the WESORAM project, short for Wellenlängenselektive Schalter für optisches Raummultiplex (Wavelength-Selective Switches for Optical Space-Division Multiplexing), Dr. Steffen Trautmann and his team at Fraunhofer IOF worked with project partners to refine this technology.

First the team added flexibility to the switching mechanism in the LCoS switch so it would be able to redirect the data stream to any fiber. Once the spectrometer grating has split the incoming light signal into frequencies, the LCoS mirror sends each frequency to a different fiber. This expands conventional wavelength-division multiplexing into a space-division multiplexing technique. To supplement the principle of "multiple frequencies on one fiber," this means the principle of "one frequency, multiple fibers" can also be applied.

"In our project, we succeeded in sending signals from eight input channels to 16 output channels at will. This kind of cross-wiring increases network capacity since there is much more flexibility to the transmission and forwarding of data streams. This is especially useful when data is being sent over longer distances such as between cities," says Trautmann, the project manager and an expert on optical systems.

Another advantage is that fewer [optical switches](#) are needed for the fiber optic network overall. This lowers the costs of both installation and ongoing operation.

Smaller data packets, higher throughput

As their next step, the researchers from Jena succeeded in increasing the resolution of the optical module with a newly developed grating. "Right now, spectral resolution of 100 GHz, or about 0.8 nm, is the state of the art. The mirror we developed can achieve up to 25 GHz, or approximately 0.2 nm," Trautmann explains.

The higher resolution means the light frequency for the data stream is narrower in band by a factor of four, so the data packets are proportionally smaller. And that in turn means the light conductors can transmit many more data packets simultaneously.

The project partners were Adtran, a company in Meiningen (Thuringia) that specializes in networks, and Berlin-based Holoeye, which focuses on optical systems and built the LCoS mirror. The experts from Fraunhofer IOF were responsible for the optical design. They also used ultra-precision technology to develop a [beam splitter](#) for the spectrometer grating and integrated all of the components into a single tiny part.

Multi-Cap amplifier serves multi-core fibers

WESORAM dovetails neatly with another project, Multi-Cap. In this project, researchers are working to increase the number of channels for parallel data transmission. Traditional fibers contain one data channel and one signal core, while multi-core fibers use multiple cores to

transmit data. Although these cables contain many more conductors, they are barely thicker at all.

The team at Fraunhofer IOF developed the signal amplifiers needed for multi-core fibers. They can serve up to 12 channels at the same time, achieving more than 20 dB of amplification per channel. This technology is significantly more energy-efficient, as only one amplifier module is needed for 12 channels.

Provided by [Fraunhofer-Gesellschaft](#)

MARCH 3, 2025

Growing evidence supports 40Hz gamma stimulation for brain health

by [Massachusetts Institute of Technology](#)



Li-Huei

Tsai speaks about the latest gamma rhythm sensory stimulation research in her lab at an MIT colloquium Feb. 27, 2025. Credit: MIT Picower Institute

A decade after scientists at The Picower Institute for Learning and Memory at MIT first began testing whether sensory stimulation of the brain's 40Hz "gamma" frequency rhythms could treat Alzheimer's disease in mice, a growing evidence base supporting the idea that it

can improve brain health—in humans as well as animals—has emerged from the work of labs all over the world.

A new review [article](#) in *PLOS Biology* describes the state of research so far and presents some of the fundamental and clinical questions at the forefront of the non-invasive [gamma](#) stimulation now.

"As we've made all our observations, many other people in the field have published results that are very consistent," said Li-Huei Tsai, Picower Professor at MIT, director of MIT's Aging Brain Initiative, and senior author of the new review with postdoc Jung Park. "People have used many different ways to induce gamma including [sensory stimulation](#), transcranial alternating current stimulation or [transcranial magnetic stimulation](#), but the key is delivering stimulation at 40 Hz. They all see beneficial effects."

A decade of discovery at MIT

Starting with a paper in *Nature* in [2016](#), a collaboration led by Tsai has produced a series of studies showing that 40Hz stimulation via [light](#), sound, [the two combined](#), or [tactile vibration](#) reduces hallmarks of Alzheimer's pathology such as amyloid and tau proteins, prevents neuron death, decreases synapse loss, and sustains memory and cognition in various Alzheimer's mouse models.

The collaboration's investigations of the underlying mechanisms that produce these benefits has so far identified specific cellular and molecular responses in many brain cell types including neurons, microglia, astrocytes, oligodendrocytes and the brain's blood vessels. [Last year](#), for instance, the lab reported in *Nature* that 40Hz audio and visual stimulation induced interneurons in mice to increase release of the peptide VIP, prompting increased clearance of amyloid from brain tissue via the brain's glymphatic "plumbing" system.

Meanwhile, at MIT and at the MIT spinoff company Cognito Therapeutics, phase II clinical studies have shown that people with Alzheimer's exposed to 40Hz light and sound experienced a significant slowing of brain atrophy and improvements on some cognitive measures compared to untreated controls. Cognito, which has also measured significant preservation of the brain's "white matter" in volunteers, has been conducting a pivotal, nationwide phase III clinical trial of sensory gamma stimulation for more than a year.

"Neuroscientists often lament that it is a great time to have AD if you are a mouse," Park and Tsai wrote in the review. "Our ultimate goal, therefore, is to translate GENUS discoveries into a safe, accessible, and non-invasive therapy for AD patients." The MIT team often refers to 40Hz stimulation as "GENUS" for Gamma Entrainment Using Sensory Stimulation.



Li-Huei Tsai speaks about the latest gamma rhythm sensory stimulation research in her lab at an MIT colloquium Feb. 27, 2025. Credit: MIT Picower Institute

A growing field

As Tsai's collaboration, which includes MIT colleagues Edward Boyden and Emery N. Brown, has published its results, many other labs have produced studies adding to the evidence that various methods of non-invasive gamma sensory stimulation can combat Alzheimer's pathology. Among many examples cited in the new review, in 2024 a research team in China independently [corroborated](#) that 40Hz sensory stimulation increases glymphatic fluid flows in mice.

In another example, a Harvard Medical School-based team in 2022 [showed](#) that 40Hz gamma stimulation using Transcranial Alternating Current Stimulation significantly reduced the burden of tau in three out of four human volunteers. And in [another study](#) involving more than 100 people, researchers in Scotland in 2023 used audio and visual gamma stimulation (at 37.5 Hz) to improve memory recall.

Open questions

Amid the growing number of publications describing preclinical studies with mice and [clinical trials](#) with people, open questions remain, Tsai and Park acknowledge. The MIT team and others are still exploring the cellular and [molecular mechanisms](#) that underlie GENUS's effects.

Tsai said her lab is looking at other neuropeptide and neuromodulatory systems to better understand the cascade of events linking sensory stimulation to the observed cellular responses. Meanwhile, the nature of how some cells, such as microglia, respond to gamma stimulation and how that affects pathology remains unclear, Tsai added.

Even with a national Phase III clinical trial underway, it is still important to investigate these fundamental mechanisms, Tsai said, because new insights into how non-invasive gamma stimulation affects the brain could improve and expand its therapeutic potential.

"The more we understand the mechanisms, the more we will have good ideas about how to further optimize the treatment," Tsai said. "And the more we understand its action and the circuits it affects, the more we will know beyond Alzheimer's disease what other neurological disorders will benefit from this."

Indeed the review points to studies at MIT and other institutions providing at least some evidence that GENUS might be able to help with Parkinson's disease, stroke, anxiety, epilepsy, and the cognitive side effects of chemotherapy and conditions that reduce [myelin](#) such as multiple sclerosis. Tsai's lab has been studying whether it can help with Down syndrome as well.

The open questions may help define the next decade of GENUS research.

More information: Jung M. Park et al, Innovations in noninvasive sensory stimulation treatments to combat Alzheimer's disease, *PLOS Biology* (2025). DOI: [10.1371/journal.pbio.3003046](https://doi.org/10.1371/journal.pbio.3003046)

Journal information: [PLOS Biology](#) , [Nature](#)
Provided by [Massachusetts Institute of Technology](#)

MARCH 3, 2025

Teaching kids how to become better citizens

by Jeff Grabmeier, [The Ohio State University](#)



CreditUnsplash/CC0 Public Domain

In our polarized society, a new study offers hope for the future: Even young children can learn to discuss and argue about meaningful problems in a respectful and productive way.

Researchers at The Ohio State University found success in a social studies curriculum for fourth graders based on teaching what they called "civic competencies."

Over the course of a school year, findings showed that the students participating in the curriculum significantly improved their argumentation skills and disciplinary thinking.

"This will give them the ability to collaborate, communicate effectively and consider multiple perspectives," said Tzu-Jung Lin, co-author of the study and professor of educational psychology at The Ohio State University.

"We aim to help cultivate a new generation of responsible community members and citizens who can work together to help solve complex issues," Lin said.

The study was [published](#) recently in the *Journal of Social Studies Research*.

The research involved 106 fourth-grade students and six social studies teachers from two public school districts in the Columbus area. They participated in a social studies curriculum called Digital Civic Learning (DCL), which was developed at Ohio State.

"Students as young as elementary school start to encounter important issues in the world around them that don't have a right or wrong answer," Lin said.

"What we are trying to do with the DCL curriculum is to teach children the process to be a better thinker about these issues and learn how to resolve conflicts around them."

One part of the curriculum involved what is called disciplinary thinking. This means teaching students how to read, write and think differently depending on the subject matter. In the DCL, students were taught four ways of thinking: geographic, economic, historical and civic.

"When students learn disciplinary thinking, they learn how professionals in each of these four disciplines approach a problem," said co-author Haeun Park, a doctoral student in educational psychology at Ohio State.

"And later in the curriculum, students learn how to use all of those types of thinking in an interdisciplinary way. For example, students may learn to think about a specific problem from an economics point of view, but also from the view of an historian."

This [interdisciplinary approach](#) can help students with their argumentation skills, which was the other focus of the curriculum. Students were taught how to develop an argument and counterargument about different positions using their disciplinary thinking skills.

In the classes, students honed their disciplinary thinking and argumentation skills through stories. The children were given a story about characters facing some sort of challenge, such as living in a food desert where healthy, affordable food options are limited.

"These stories are designed to be real-life problems that don't have a set answer," said study co-author Kevin Fulton, a doctoral student in educational psychology at Ohio State.

"The students can bring their own perspectives to the conversation, and they can agree on all the facts and disagree on what a good solution looks like."

In order to measure how much the students learned from the DCL curriculum, the researchers had the students write essays at the beginning of the school year and at the end on meaningful problems that were relevant to their lives.

For example, one writing prompt had to do with a school lunch system that used AI to scan faces to see if the student owed money for their meals.

Students had to grapple with the negative ethical and privacy issues of the system as well as the positive user-friendly advantages and come to a decision about whether the AI system should be implemented.

Trained coders rated how well the students did on using disciplinary thinking and argumentation skills in their essays at the beginning of the year, and then again at the end.

The goal was to see if the students improved after taking the DCL curriculum. Results showed they did.

For example, about 27% of students scored 3 out of 4 or above on claim-evidence integration (one of the argumentation skills) in their essays at the beginning of the course. But that increased to 43% at the end of the course.

Use of disciplinary thinking also showed an increase from 27% to 48% after the DCL curriculum was completed.

The researchers said they are hopeful that a [curriculum](#) like this could help long-term in healing some of the fractures in our society.

"We believe that if we can embrace these civic competencies, we can find common ground, even with our different beliefs and different backgrounds," Lin said.

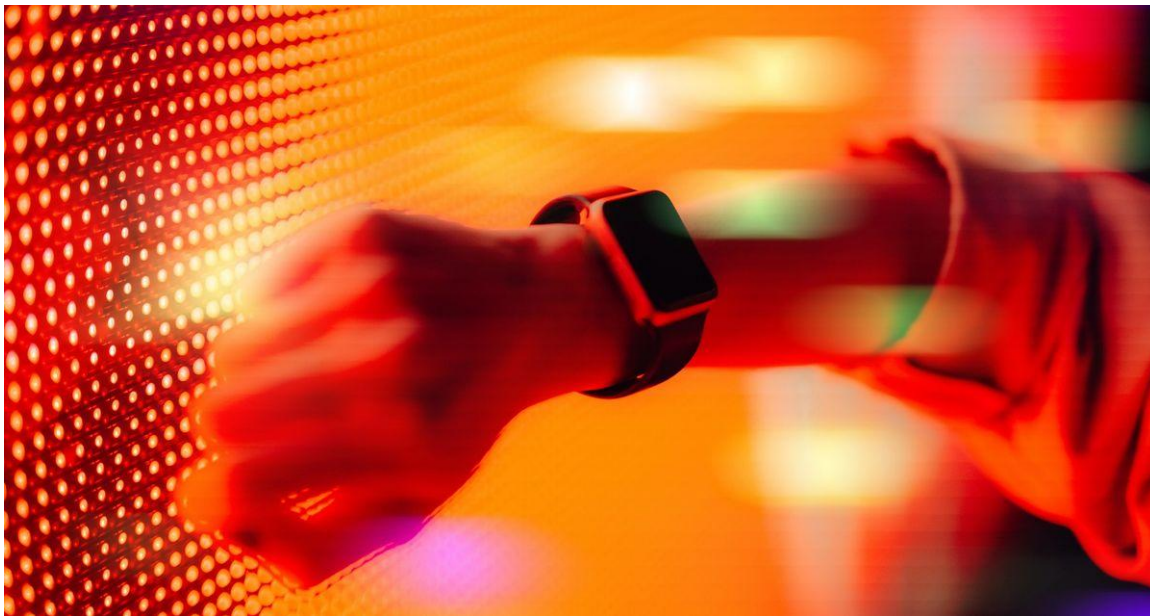
"We can still work together as a group to solve our problems."

More information: Haeun Park et al, Cultivating Civic Competencies Through Immersive Inquiry: A Digital-age Approach to Fourth Grader's Disciplinary Thinking and Argumentation, *The Journal of Social Studies Research* (2024). DOI: [10.1177/23522798241301436](https://doi.org/10.1177/23522798241301436)
Provided by [The Ohio State University](#)

Future wearable devices could draw power through your body using background 6G cellphone signals

published December 3, 2024

Excess energy from wireless 6G networks could be harvested by a copper coil and the human body.



(Image credit: Oscar Wong via Getty Images)

Your body could become a battery for wearable devices, thanks to a breakthrough in harvesting waste energy from 6G wireless communication.

Researchers from the University of Massachusetts Amherst found that waste radio frequency (RF) energy given off by [visible light communication](#) (VLC), if used to deliver 6G, can be harvested with small, inexpensive copper coils and transmitted to power other devices via the human body. 6G is a future wireless communication technology that is currently in development and is set to be deployed before the end of the decade.

As outlined in [a 2022 research paper](#), the crux of this mechanism lies with VLC — which transmits data through extremely fast flashes of [visible light](#) from sources such as LEDs. VLC is one method through which 6G signals might hypothetically be transmitted in the future. But LEDs also emit side-channel RF signals, as a form of leaked energy. The researchers found that this could be harvested by a coiled copper wire, whose energy recycling efficiency is boosted when touching human skin.

According to the study, skin contact boosted efficiency by up to 10 times compared to using the coil on its own. The human body also proved to be better at amplifying the coil's ability to collect leaked radio energy than wood, plastic, cardboard or steel.

Body batteries

From this, the researchers created "Bracelet+" — a simple copper wire coil that could be worn as a bracket on the upper forearm. The design can also be adapted to be worn as a necklace, anklet, belt or ring, although the scientists found the bracelet occupied a happy medium between power harvesting and wearability.

"The design is cheap — less than fifty cents," said the authors of the study in a [statement](#). "But Bracelet+ can reach up to micro-watts, enough to support many sensors such as on-body health monitoring sensors that require little power to work owing to their low sampling frequency and long sleep-mode duration."

With this in mind, such technology could solve the issue of limited battery life on wearable devices. Even highly rated smartwatches, like the Apple Watch, tend to need charging on a near-daily basis, which can mitigate how useful they are unless charging is part of one's daily routine. And now that smart rings are growing in popularity, there are even more devices that require regular power top-ups.

The energy harvesting technology that the Bracelet+ facilitates could, therefore, become a form of in-situ charger for next-generation wearable devices, providing of course that such devices come with a way of taking power from the bracelet. Of course, this relies on 6G networks that use VLC, which are currently far away from deployment, let alone widespread adoption and integration into consumer or industrial devices.

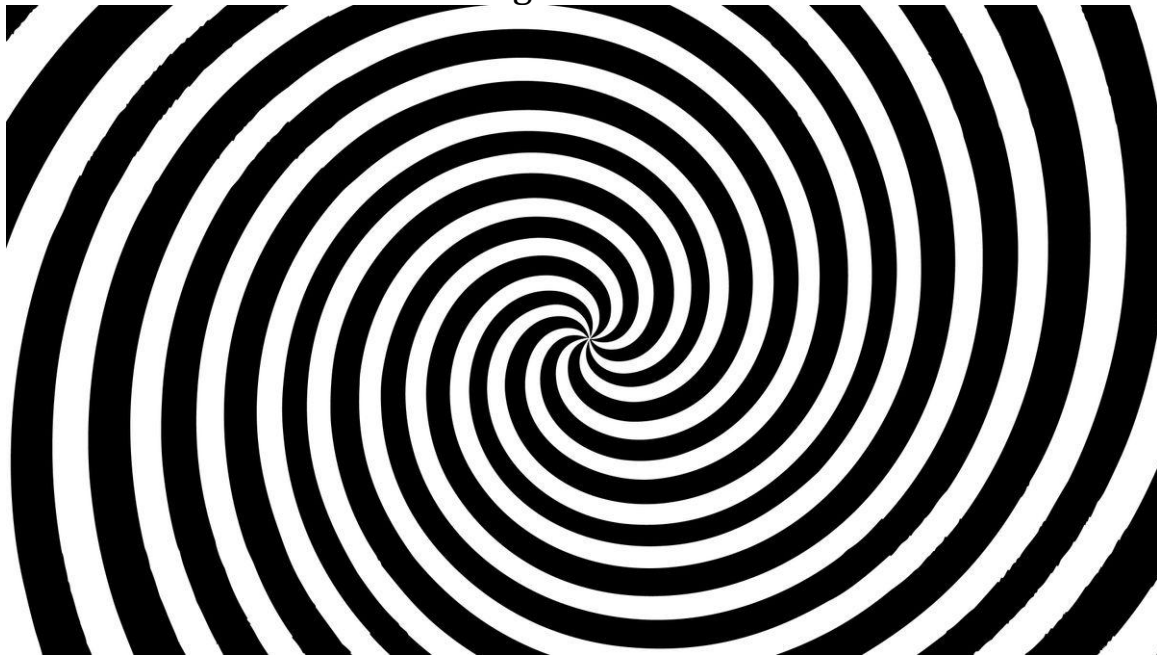
But this could be the advent of turning the human body into a form of battery to power technology, only in a more harmonious fashion than the future envisioned by "The Matrix."

"Ultimately," said lead author of the study [Jie Xiong](#), professor of information and computer sciences at UMass Amherst, in a statement, "we want to be able to harvest waste energy from all sorts of sources in order to power future technology."

This bizarre vortex doesn't just look cool — it can be a key cog in making scalable high-speed 6G networks a reality

published July 8, 2024

Flexible plates and nanotubes could pave the way for adaptable controllers for terahertz 6G signals.



Graphical representation of the component that can split a terahertz 6G beam into several channels. (Image credit: Getty Images/RobinOlimb)

The future of super-fast 6G communications could lie in the use of flexible plates with eye-catching spirals of carbon nanotubes tuned to broadcast terahertz (THz) signals.

In a new study published April 30 in the journal [Advanced Optical Materials](#), researchers explained how layers of spiral zone plates can act as optical components to manage a THz beam. This is [electromagnetic radiation](#) in the 1 trillion hertz spectrum that sits between the microwave and infrared frequency bands for use in 6G communications, microscopy and medicine.

The varifocal Fresnel zone plates – devices with transparent and opaque concentric rings used to focus light and other waveforms – were constructed of a thin film of carbon nanotubes arranged in a spiral pattern that can twist the waveform of a THz beam passing through it.

By combining two plates and rotating them relative to each other, the researchers changed the distribution of the intensity of the THz beam and split it into several areas of different radiation intensities. This could be used to create several channels for high-speed information transfer.

[Maria Burdanova](#), a senior researcher at the Moscow Institute of Physics and Technology's Laboratory of Nanooptics and Plasmonics, explained in a [statement](#) that the paper outlines a way to overcome the challenges of making instruments that can tap into the THz spectrum band — which will be essential for high-speed 6G in the future.

"One of the key features highlighting the prospects of carbon nanotubes is the possibility to create multifunctional devices with properties that can be fine-tuned by different effects through responses at the atomic, supramolecular, and micron levels," Burdanova said in the statement. "For the first time, our joint team has succeeded in introducing an additional effect: interaction of different nanotube patterns. This paves the way for future devices."

By creating plates with spiral patterns formed from thin carbon nanotubes on a flexible and stretchable substrate, the plates can then be stretched and orientated – tuning them for the specific manipulation of THz signals.

Tubular signals

6G is mostly in the early research stages at the moment, despite a predicted rollout slated for 2023 by [trade body GSMA](#). Until now, manipulating signals in the THz spectrum has been difficult to accomplish at range and scale.

As such, there's a need to create components that can modulate and generate terahertz vortex beams that carry data — or beams that can be used as a form of X-ray in medicine. That's why developing a varifocal Fresnel zone plate, based on focusing THz radiation via nanotubes, is significant.

Because the plates can be layered, stretched and rotated, they may pave the way for THz control components that can be tuned for different applications rather than needing different parts for communications and medical applications.

Furthermore, using nanotubes means engineers can create components that are compact and lightweight as well as tunable, which will be essential if 6G networks are to be developed at scale. With the constant demand for more data at faster speeds for both business and pleasure, 6G must be sufficiently scalable to usher in the next generation of high-speed communication.

Scientists create light-based semiconductor chip that will pave the way for 6G

published December 17, 2023

By combining photonic and electronic components, scientists have built a prototype communications chip that can effectively access high enough radio frequency bandwidths for uses including advanced radar as well as 6G and 7G.



6G support microchip on smartphone circuit board, next generation smart iot communication microprocessor, 3d rendering futuristic fast real time mobile network internet technology concept. (Image credit: Black_Kira via Getty Images)

A first-of-its-kind chip architecture that uses both electronic- and light-based components could pave the way for 6G technology.

The research, published Nov. 20 in [Nature Communications](#), offers a blueprint for communications chips needed for advanced radar, satellite systems, advanced wireless networks (Wi-Fi), and even future generations of 6G and 7G mobile technology. By integrating light-based, or photonic components, into a conventional electronic-based circuit board, researchers dramatically increased [radio frequency \(RF\) bandwidth](#), while demonstrating improved signal accuracy at high frequencies.

They built a working prototype of the networking semiconductor chip, measuring 0.2 by 0.2 inches (5 by 5 millimeters), by sourcing a silicon wafer and attaching the electronic and photonics components — in the form of "chipllets" — like Lego bricks.

Crucially, they also improved how the chips filtered information.

Wireless transceivers send out data, and microwave filters built into conventional chips block out signals in the wrong frequency range. Microwave photonic filters perform the same function for light-based signals. But it's been extremely challenging to combine photonic and electronic components, and effective microwave photonic filters, on one chip.

But by fine-tuning precisely into specific frequencies at higher bands, which tend to be crowded, more information can flow through the chip more accurately, according to the study. This is important for future wireless technologies which will come to rely on higher frequencies. These have shorter wavelengths, and can therefore carry more energy, which equates with a higher bandwidth for data.

"Microwave photonic filters play a crucial role in modern communication and radar applications, offering the flexibility to precisely filter different frequencies, reducing electromagnetic interference and enhancing signal quality," said research team leader [Ben Eggleton](#), pro-vice-chancellor (research) at the University of Sydney.

Devices that tap into 5G networks, like smartphones, transmit and receive data at varying radiofrequency ranges — ranging from low band (under one gigahertz) to high band (24 to 53 GHz) in the U.S, [Verizon](#) said.

Higher frequencies allow for faster speeds due to the greater energy capacity of the shorter wavelengths, but there's a higher chance of interference and obstruction. This is because shorter wavelengths struggle to pierce through larger surfaces and objects, also reducing signal range.

Meanwhile, 5G data speeds average 138 megabits per second in the U.S., according to [OpenSignal](#), and carriers run the networks on bands ranging from 2 to 4 GHz. 6G, which is expected to become mainstream by the 2030s will operate on a higher frequency — starting from 7 to 15 GHz, according to the [Global Systems for Mobile Communications Association \(GSMA\)](#).

The highest 6G bands, for industrial applications, however, will need to be above 100 GHz and possibly even reach 1,000 GHz, according to the [University of Liverpool](#), and speeds could reach a theoretical maximum of 1,000 gigabits per second.

This means there's a need to build communications chips with a significantly higher RF bandwidth, and the advanced filtering to eliminate the interference at these higher frequencies. This is where advancements in chip architecture come in — with photonics playing a key role in the networking semiconductor chips that will be used to power 6G devices.

Scientists achieve record-breaking 402 Tbps data transmission speeds — 1.6 million times faster than home broadband

published July 28, 2024

Scientists break data transmission rate world record for a second time this year — boosting fiber-optic speeds by 25% to a staggering 402 Tbps.



(Image credit: Yuichiro Chino/Getty Images)

Researchers have achieved record-breaking fiber-optic data transfer speeds of 402 terabits per second (Tbps) — roughly 1.6 million times faster than typical home broadband speeds.

The scientists at Aston University in the U.K. achieved these new speeds by tapping into all the wavelength bands used in commercially available fiber-optic cables. Only one or two bands are used in most fiber-optic broadband connections. They outlined their methods in a technical report published by Japan's [National Institute of Information and Communications Technology \(NICT\)](#).

The new record is 25% faster than the previous one set by the same team of scientists in March. In previous experiments, they [achieved speeds of 301 Tbps](#) by using four of the six wavelength bands in fiber-optic cables.

"This finding could help increase capacity on a single fiber so the world would have a higher performing system," [Ian Phillips](#), a teaching fellow in electronics and computer engineering at Aston University, said in a [statement](#). "The newly developed technology is expected to make a significant contribution to expand the communication capacity of the optical communication infrastructure as future data services rapidly increase demand." To

achieve the new record, the research team built the world's first optical transmission system that spanned all six wavelength bands used in fiber-optic communications, including O, E, S, C, L and U. These refer to different wavelength portions of infrared in the [electromagnetic spectrum](#), falling between 1,260 and 1,675 nanometers (nm). Visible light, for reference, falls between 400 nm and 700 nm on the spectrum.

Most current commercial fiber-optic connections transmit data using the C-band and L-band portions, which range between 1,530 nm and 1,625 nm, because they are the most stable segments — meaning the least amount of data is lost through transmission. But increased network congestion means these bands will one day be saturated — meaning new bands will need to be used, the researchers noted in the report.

In the past, the S-band, adjacent to the C-band and occupying the 1,460 nm to 1,530 nm segment, has also been used in combination with the others in a "wavelength division multiplexing" (WDM) system to reach much higher speeds.

In the previous study, the scientists stabilized connections that used the E-band portion. Normally, data lost when transmitting in this region shoots up to extremely high levels — five times the data loss versus the C-band and L-band regions. This is because fiber-optic cables are susceptible to exposure to hydroxyl (OH) molecules in the ground that can enter the tubes and disrupt connections.

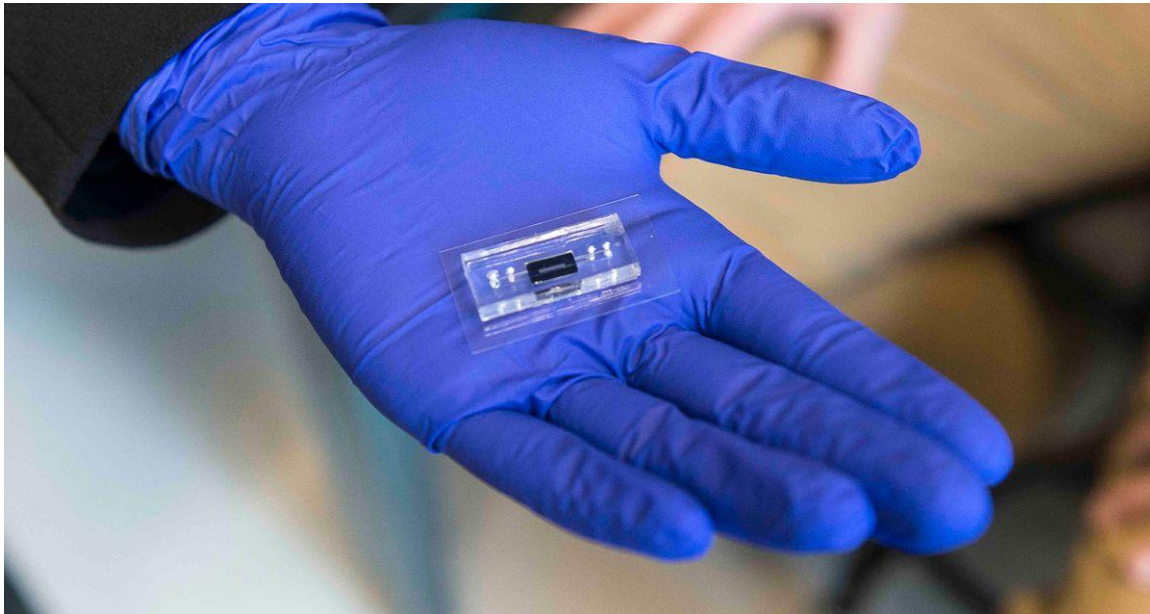
The new study went one step further and built new equipment that could also harness the O-band and U-band wavelengths. Specifically, the scientists built devices to amplify signals in the U-band portions. They also used off-the-shelf amplifiers to amplify O-band signals.

What's more, they achieved these speeds on standard commercially available fiber-optic cables — meaning there would be no need to install specialized cables to tap into these speeds.

New DNA-infused computer chip can perform calculations and make future AI models far more efficient

published March 8, 2024

The new processor stores data in modified DNA molecules and uses microfluidic channels to perform basic computations.



Microfluidic device built in RIT engineering laboratories. (Image credit: Photography/RIT)

Scientists have created a new biocomputing chip that makes calculations using a DNA substrate, including mathematical operations essential to artificial intelligence (AI) training and big data processing.

Researchers described the new biocomputing platform Oct. 19, 2023, in the journal [PLOS One](#). DNA is known as the blueprint for life and encodes genetic information, like data can be encoded onto electronic-based storage devices.

DNA-based devices have previously been used to encode data on a small scale, but this prototype chip uses DNA to process data too.0 seconds of 15 secondsVolume 0%

"DNA is excellent at storing information, in fact, it is much better than the electronic modes of memory because it is about 3-to-6 orders of magnitude more compact than most memory hardware that we have; it is also much more reliable and durable," study co-author [Amlan Ganguly](#), head of the Department of Computer Engineering at the Rochester Institute of Technology, [said in a statement](#).

DNA has long been proposed as a more effective way to store data than conventional methods, such as hard drives and solid state drives (SSDs), and companies such as [Microsoft](#) have also identified DNA as one candidate to store and manage [skyrocketing amounts of data](#). Researchers have previously built DNA-based storage devices, including encoding the DNA molecules of bacteria with a [video of a horse in 2017](#).

But data transfer speeds on DNA-based storage platforms are much slower than conventional storage devices, according to a 2018 paper published in the journal [3Biotech](#). DNA storage is also much more expensive to manufacture. In addition, not just storing but processing data on devices built from DNA has been relatively unexplored.

In the study, Ganguly and his team investigated how to manipulate DNA at the molecular level to mirror many of the functions that DNA shares with computing, such as sequencing (reading data) and synthesizing (writing data).

The encoded data on the DNA by nicking strands at various points to represent the 1s and 0s of binary, and represented different calculations by using a network of microfluidic channels. This transfers fluids around an integrated circuit to perform functions as chemical reactions

They found they could store and process data on the same chip and perform basic calculations that may one day help to train artificial intelligence (AI) models.

DNA-based data processing offers many benefits, according to the paper. Unlike in conventional computing, the storage and computing components are handled by the same component rather than separate ones, although this is not a benefit isolated to DNA storage.

This means that because DNA can store up to 1,000 times more data per unit volume than SSDs can, processing that data becomes more efficient. DNA processing can also offer "unprecedented parallelism" by conducting billions of operations simultaneously, the scientists wrote in their paper.

This new device is a proof-of-concept, but the scientists hope that by scaling the device it can one day be used to train AI systems.

"That is the bridge from storage to computation and using DNA as a vehicle to do the computation," Ganguly said in the statement, adding that a computer made from a DNA substrate could be far more environmentally sustainable than traditional electronics.

From Selfies to 3D Prints—The Future of Capturing Memories

In Beijing, a fascinating trend is emerging—3D scanning studios that transform people into miniature sculptures. Instead of a flat photo, you can now hold a detailed, 3D-printed version of yourself in the palm of your hand. Would you do it?

Is 3D photography the next step in how we preserve memories? We've evolved from paintings to photographs 📷, then to videos 🎥, and now immersive experiences like VR. It seems we're always chasing more lifelike ways to capture moments.

But what if we go even further... Imagine family portraits that move—like something out of science fiction. Holographic memories, interactive photo albums, or even sensory memory capsules that capture sights, sounds, and scents. The way we document life is evolving rapidly.

My3dselfie.com

Custom miniature replicas from photos

3d selfie is an ultra-realistic mini replica doll of you made only from a few photographs. Here at My3dSelfie, we transform some of your best 2d pictures into physical 3d printed figurines. It's always fascinating to have your own 3d selfie miniature being added to your collectible dolls and statues. These 3d figurines of you can be tailor-made by our team as per your specific requirements. It will certainly build an emotional connect with your loved ones, and can be the most unique custom gift for them.

My3dSelfie is the world's first to create a 3d selfie replica with highest accuracy. Usually Our 3d figurines range from 5 to 12 inches in height, however depending on your requirements we can make them in any size. We always recommend a relatively larger size as bigger the size, better the detailing can be done by us.

Now all you need to do is upload your photos, select the size of your 3d printed selfie, and place your order. Once your order is placed your lifelike 3d figurine from these photographs will be carved in sandstone material by our team and delivered to your doorstep.

3d Selfie is a unique personalized gift perfectly crafted with precision leveraging the combination of technology and art to celebrate every human relationship and occasion.

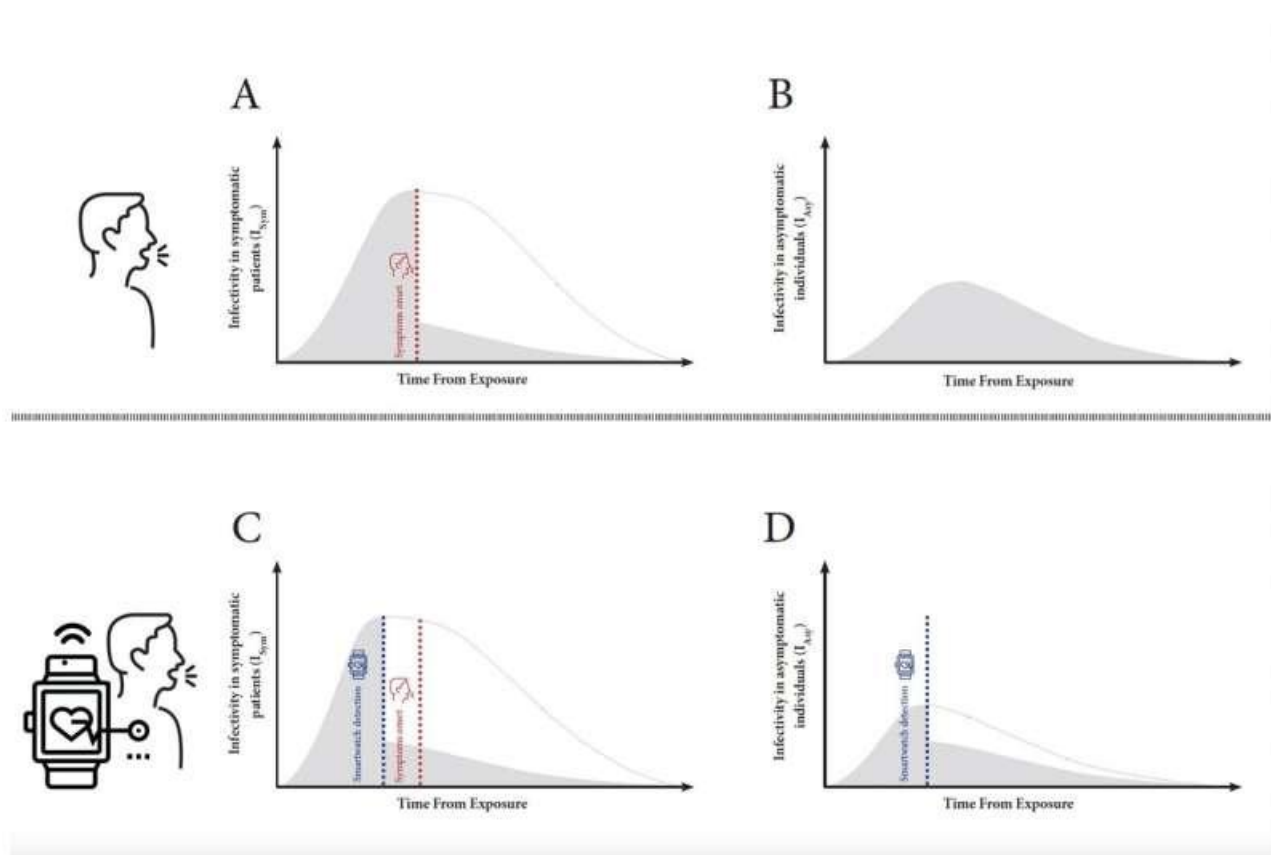
Order your own personalized 3d selfie miniature online, and we will deliver it in 3 to 5 weeks anywhere in the world. Create an impeccable memory of moments with your friends, family, and loved ones in the form of our 3d Selfie figurines. Don't let anything stop you from buying happiness

The Selfie Of The Future Is A 3D Figure

MARCH 4, 2025

Flattening the curve: How smartwatches could help stop a pandemic before it even begins

by [Aalto University](#)



An illustrative figure highlighting the impact of early detection via smartwatch on viral spread. The image shows how the model can capture both symptomatic (A and C) and asymptomatic cases (B and D). Credit: Märt Vesinurm et. al / Aalto University 2025
Early detection of sickness is critical for preventing its spread—whether it's COVID-19, influenza or the common cold. Yet, many illnesses are at their most contagious before people even know they're sick. Research shows that 44% of COVID-19 infections were spread several days before the sufferer came down with symptoms.

Now, researchers at Aalto University, Stanford University and Texas A&M, have released a study that models how smartwatches could provide a simple and effective way to

dramatically minimize the unwitting spread of disease in pre-symptomatic or asymptomatic people.

The research, published in [PNAS Nexus](#), reveals a powerful new tool for [pandemic](#) management.

"Unlike during the pandemic, we now have concrete data on how pandemics develop, and how effective different measures are at curbing the spread. Add to this that wearable technology is now extremely effective when it comes to detecting the very early physiological signs of infection, and we are much better prepared," says Märt Vesinurm, from Aalto University in Finland.



A graphic for use with "Terminating Pandemics with Smartwatches," by Märt Vesinurm, Martial Ndeffo-Mbah, Dan Yamin, and Margaret L. Brandeau. Credit: Natali Tamir

How an early 'ping' could flatten the curve

Numerous studies have proven the accuracy of wearable devices when it comes to recognizing the physiological markers of various illnesses several days before the wearer themselves.

For example, everyday smartwatches can tell with 88% accuracy—from respiration and [heart rate](#), skin temperature and other markers—if you're coming down with COVID-19. And their accuracy rises to 90% accuracy for the flu, Vesinurm says.

On average, people reduce social contact by between 66–90% from the point when they realize they're sick, even when not in a pandemic situation.

"Even at the lower end of compliance, if people receive and act on an earlier warning by self-isolating, the impact is significant. Even just a 66–75% reduction in social contacts soon after detection by smartwatches—keeping in mind that that's on a par with what you'd

normally do if you had cold symptoms—can lead to a 40–65% decrease in [disease transmission](#) compared to someone isolating from the onset of symptoms," says Vesinurm.

Notably, the research shows that higher compliance, such as that seen in a pandemic situation, could effectively stop a disease in its tracks. So, could smartwatches help us manage the potential H5N1 (avian flu) epidemic?

"I see no reason why not," says Vesinurm. "As we gather more specific data about how different illnesses affect these measurements, there's no reason we couldn't distinguish between diseases, from bird flu and HIV to the common cold, especially when used in conjunction with advanced machine learning methods and other data from the user."

Towards smarter pandemic policies

The team of researchers are the first to take real-world data from numerous peer-reviewed epidemiological, biological and behavioral studies, drawing it together to mathematically model how infection spreads at a population level. Through this powerful combination of data and tech, Vesinurm foresees a future in which smartwatches change the way we deal with pandemics, at both individual and policy levels.

"People are used to wearable devices and they're likely to trust them. While they're not yet diagnostic, they could help make unpopular approaches like masks, lockdowns, and invasive testing more targeted and less of a blunt instrument," he says.

An [early warning](#) from your smartwatch would be the cue to take other actions, like getting a PCR test, wearing a mask, or "not visiting your grandma." The action would depend on the social context at the time and an individual's assessment of risk.

Having this information not only empowers individuals to make choices that keep their loved ones or community safe, but it also gives decision-makers a powerful tool.

"It could be that governments find it most cost-effective in a pandemic situation to provide every person who wants one with a smartwatch—although, of course, this comes with its own ethical considerations," says Vesinurm. "Either way, with early detection literally at our fingertips, I see a lot of reason to hope."

More information: Terminating Pandemics with Smartwatches, *PNAS Nexus* (2025). DOI: [10.1093/pnasnexus/pgaf044](https://doi.org/10.1093/pnasnexus/pgaf044). [academic.oup.com/pnasnexus/art ... 93/pnasnexus/pgaf044](https://academic.oup.com/pnasnexus/article/3/1/1/6666666)

Journal information: *PNAS Nexus*

Provided by [Aalto University](#)

Smart contact lenses

Dubai-based startup Xpanceo is aiming to fit smart features including an "extended reality" display, health monitoring and wireless power reception into a flexible contact lens.

Demonstrator models at their stand show off proofs of concept for each of the capabilities that co-founder Roman Axelrod says they want to pack into a single prototype device "by the end of 2026".

For now the devices are relatively clunky, with a large metal coil needed to receive the wireless power to light up a single pixel on one demonstration lens.

Those components would be miniaturized using "two-dimensional materials... only one atom thick," Axelrod said.

"That is the scientific know-how that differentiates us".

MARCH 5, 2025

'High agency': What the science says about the latest tech buzzword

by Katharine H. Greenaway, [The Conversation](#)



Credit: Caspar David Friedrich / The Conversation, [CC BY-SA](#)

In 218 BC, the Carthaginian general Hannibal crossed the Alps against the advice of his men, who claimed it was impossible. "Aut inveniam viam, aut faciam," Hannibal is said to have replied: "I shall either find a way, or make one."

Though apocryphal, Hannibal's bold statement captures a trait much sought in the tech industry today: "high agency." This means being able to [positively influence](#) yourself or the world around you.

Psychologists use a range of other terms to refer to this kind of trait—including [perceived control, mastery, and efficacy](#). All of them boil down to being able to achieve the things you want, when you want.

Recognizing agency

In the [business world](#), the term high agency is used in much the same way as "disruptor," "game-changer" and "self-starter" were before it. As you might expect from those comparisons, high agency is a catch-all phrase for people who [see and take opportunities](#) where others see roadblocks.

More than this, high agency describes a person who [creates](#) their own opportunities where there appear to be none.

High agency is beneficial in more than the professional sphere, however.

Research shows that feeling able to achieve important goals is a building block for motivation in most domains of life, including [education](#), [health](#) and [political action](#). This is because people who feel "in control" set higher goals, are more committed those goals, and exert greater effort to achieve those goals than people who feel "out of control."

Agency differs by demographic, including factors such as age. Some research suggests people feel [more in control](#) of their life circumstances and outcomes in middle age than in old age.

Socioeconomic factors such as education, income and work history also play a role. Put simply, people who are ["better off"](#) feel more agentic.

Mental health seems to be both an [outcome and a predictor](#) of high agency. People who are less depressed feel more in control of their lives, and those who feel more in control are less depressed.

Rethinking agency

The concept of "high agency" is an amalgamation of, or an umbrella term for, a range of traits that psychologists have studied for decades. Related concepts include the prized ["growth mindset"](#) (the belief that one's talents are developable rather than innate), ["proactivity"](#) (acting in advance of, rather than reacting to, situations), and the somewhat

controversial "grit" (perseverance in the pursuit of long-term goals). Note, however, that [some argue](#) grit is just a rebranded version of the personality trait "conscientiousness."

High agency, as the tech world sees it, appears to borrow from all these concepts, wrapped up in one convenient package. Agentic people are those who see possibility where others see barriers, take action rather than wait to be told what to do, and aren't afraid to go after what they want.

These traits are also stereotypically associated with particular people in society: members of advantaged majority groups, such as men, those with high socioeconomic status, and white people.

In many ways, high-agency behavior is an act of privilege. It involves trusting that others will react well to your efforts to try a new approach or disrupt the status quo.

The reality is that the way other people respond will depend at least in part on factors outside our control. This may be particularly true for less privileged people, who tend to [see less opportunity](#) to exert choice and influence the world due to the [very real structural barriers](#) they face. This means acting "high agency" may be a risk for some people: actions that see one person praised as a "game changer" could easily see another labeled a "troublemaker."

Taken to an extreme, high agency could read as "alpha"—the kind of person who takes charge and is a natural leader. Alpha is a gendered term, most commonly applied with a suffix such as male, bro or dude.

The [already male-dominated](#) tech industry should be wary of baking gendered traits into personnel selection procedures. If high agency is understood to mean a certain type of *person* rather than just a type of *personality*, it could be a problem for equity, diversity and inclusion initiatives.

Realizing agency

Given the rising value of high agency in professional settings—not to mention its personal emotional and motivational benefits—you might wonder how people can become more agentic.

Many proponents of high agency [emphasize its value](#) for looking at the world in a different way. So too it might be valuable to look at high agency in a different way: not what makes an individual agentic, but what are the conditions that allow agency to thrive.

Research shows that [certain types of environments](#) set people up for success. Environments that allow people to thrive are those that meet three [basic psychological needs](#).

The first is the need for autonomy: the ability to freely choose what we do and when we do it. The second is the need for competence: the feeling of being capable of performing

desired actions. Finally, there is the need for relatedness: the feeling of being connected to others.

These needs can be fostered by the work environment. (Google famously [adopts similar motivational workplace practices](#).) People can also adapt themselves by "job crafting" to help create the conditions conducive to success.

While high agency may seem like an innate personality trait, [emerging research](#) suggests the people around us may be a powerful source of personal agency. People who are better able to influence their own outcomes are often those who [can turn to, or recruit, others](#) to help them achieve those outcomes.

Paradoxically, this means that "high agency" might not (just) be a quality of you personally, but a quality of the people around you.

Provided by [The Conversation](#)

HydroBlade: The future of eFoil technology by Pelagion

June 1, 2024



The Pelagion HydroBlade is a high-performance eFoil that offers advanced stability for a unique water gliding experience. Images courtesy Pelagion

Pelagion, an emerging player in marine technology, is making notable advancements with its latest product, the HydroBlade. This innovative eFoil (electric [hydrofoil](#)) offers a unique personal e-mobility experience, allowing users to glide smoothly above the water's surface. As a subsidiary of Automatic Manufacturing Systems, Inc. (AMS), Pelagion leverages its extensive engineering and manufacturing expertise to deliver a product aimed at enhancing water sports activities.

The HydroBlade concept

The HydroBlade was designed by CEO Jamie Schlinkmann and a team of multidisciplinary engineers. The product features a dual mast assembly, enabling effortless floating and improved maneuverability. This design allows riders to experience the sensation of flying above the water, providing a unique experience.

Pelagion's engineering excellence and manufacturing capabilities underpin the development of the HydroBlade. The company integrates mechanical and electrical engineering, software development, and battery design to bring this product to market.

Technical specifications

The HydroBlade comes with several key specifications:



The Pelagion HydroBlade can reach impressive speeds of up to 70 km/h, offering a thrilling ride above the water.

Size: The main hull measures 1.75 meters, with an operating length ranging from 2.0 to 3.5 meters.

Weight: The total weight of the HydroBlade is 104 kilograms (approx. 229 lbs).

Run Time: It offers a runtime of up to 4 hours on a single charge.

Speed: The HydroBlade can reach speeds of up to 70 kilometers per hour (approx. 43 mph).

Hull Material: Constructed from an impact and chip-resistant ABS skin with a composite structure, the hull is lightweight and durable. Secondary flotation inside enhances safety.

Motor: Dual motors with peak ratings of 8kW and continuous ratings of 5kW each power the HydroBlade.



The Pelagion HydroBlade features dual motors and 5.5kWh batteries, delivering up to 4 hours of continuous runtime.

Battery: The device uses dual 5.5kWh batteries, each weighing 29 kilograms (approx. 64 lbs).

Charger: A 1600W charger supports 100-250VAC input, offering a maximum charge time of less than 4 hours per battery.

User Interface: The HydroBlade's interface is accessible via a phone app with Bluetooth connectivity. It provides data on battery state of charge (SoC), state of health (SoH), range, and telemetry. Additional features include navigation, music, and other phone functions. A handlebar phone mount is included, though customers need to provide their own phone, preferably in an IP68 rated case for water resistance.

These specifications highlight the HydroBlade's focus on performance, safety, and user convenience.



Setting up the Pelagion HydroBlade, ready to test its advanced eFoil tech on the water.

Development process and feedback

Pelagion has incorporated extensive testing and feedback into the development of the HydroBlade. Following successful demonstrations, the company engaged with a broader audience to gather valuable insights and refine the product design. This approach has allowed Pelagion to make informed adjustments, bringing the HydroBlade closer to a production-ready configuration.

Jamie Schlinkmann, CEO, emphasized the importance of this collaborative process: “Our commitment to involving a broader audience in our development process reflects our dedication to delivering a product that exceeds expectations.” By incorporating diverse perspectives, Pelagion aims to enhance the quality of its products and foster a sense of ownership and community among stakeholders.



The HydroBlade’s dual mast assembly allows effortless gliding over water, with gentle blade movements enhancing maneuverability.

The feedback has been instrumental in fine-tuning the HydroBlade’s performance metrics, particularly regarding battery life and maximum speed. As Pelagion approaches the final stages of development, the company is focused on optimizing these aspects to ensure the HydroBlade meets user expectations.

Commitment to transparency and innovation

Pelagion maintains a commitment to transparency, innovation, and excellence throughout the HydroBlade’s development. The company is dedicated to providing accurate and reliable data on performance metrics and keeping potential customers informed about progress and updates.

As a subsidiary of AMS, founded in 1997, Pelagion benefits from a solid foundation in engineering and manufacturing. AMS has a long history of creating bespoke solutions across various industries, particularly in adhesive component placement.



The Pelagion HydroBlade's user interface, accessible via a phone app, provides real-time data on battery life, range, and telemetry.

Pricing and availability

The HydroBlade is anticipated to be priced at \$20,000. This reflects the advanced technology, engineering expertise, and high-quality materials used in its production.

Pelagion is moving forward with the final stages of development and is excited to bring the HydroBlade to market. The company remains committed to delivering a product that offers high performance and a unique user experience.

Conclusion

Pelagion's HydroBlade signifies a notable development in eFoil technology, providing a new and thrilling experience for water sports enthusiasts. With its advanced specifications and user-friendly features, the HydroBlade is poised to become a significant product in the market. As Pelagion finalizes development and prepares for production, interest in this innovative product continues to grow.

Source: [Pelagion](#)

Is HydroBlade eFoil Technology the Future of Open Water Sports?

Aug 1, 2024

Hydrofoiling Just Got More Interesting With the Hydroblade eFoil



HydroBlade (media by Pelagion)

Introduction

Imagine the thrill of slicing through water, feeling the rush of wind against your face, and knowing that every exhilarating moment is eco-friendly. Welcome to the world of the unique [HydroBlade eFoil](#), a groundbreaking innovation in watersports that combines cutting-edge technology with environmental responsibility. The HydroBlade, designed by Florida startup Pelagion, isn't just a watercraft; it's entirely different if you can't tell by the looks. With its powerful electric **dual motors** and unique hydrofoil design, this machine delivers unparalleled control and speed while eliminating harmful emissions.

Whether you're an eco-conscious adventurer, a watersport enthusiast, or a tech-savvy consumer, the HydroBlade promises an experience that redefines the boundaries of excitement and sustainability. In this post, we'll explore the many facets of HydroBlade, from its environmental impact and technical advancements to the user experience and future market prospects. Get ready to discover why the HydroBlade is another welcome entry into the future of watersports.



Hydrofoiling (media by Pelagion)

The Environmental Impact

The HydroBlade stands as a beacon of hope for eco-friendly watersports. Traditional watercraft often rely on fossil fuels, contributing significantly to water and air pollution. However, the HydroBlade is a game-changer in this regard. Its electric dual motors operate without emitting harmful pollutants, making it a cleaner alternative for thrill-seekers who care about the planet.

By leveraging hydrofoiling technology, the HydroBlade substantially reduces the energy required to operate, minimizing its environmental footprint. The welcome art of Hydrofoiling lifts the watercraft above the water's surface, reducing drag and allowing for smoother, more efficient travel. This process conserves less energy and reduces the impact on marine life and ecosystems.

For eco-conscious adventurers, the HydroBlade offers a guilt-free way to enjoy high-speed water adventures. It's a testament to how advanced technology can promote sustainable practices without compromising performance or excitement.

Technical Advancements

At the heart of the HydroBlade lies a suite of technical innovations that set it apart from conventional watercraft. The dual 5kW (8kW peak) electric motors are central to its design, providing robust power and ensuring a smooth, silent ride. Unlike traditional engines, these electric motors require minimal maintenance and have a longer lifespan, offering a more reliable and cost-effective solution for watersport enthusiasts.

Another standout feature is the hydrofoil design. Hydrofoils lift the watercraft out of the water, reducing drag and allowing for faster speeds with less energy consumption. This design enhances performance and makes the HydroBlade incredibly maneuverable, providing riders with a level of control that standard watercraft can't match.

Additionally, the HydroBlade has advanced steering capabilities, allowing for precise turns and agile movements. Whether navigating tight corners or speeding through open waters, the HydroBlade responds with precision, making each ride an unforgettable experience.

User Experience

One of the most compelling aspects of the HydroBlade is the rider's experience. From the moment you step onto the HydroBlade, you're in for a ride. The dual electric motors provide instant torque, propelling you forward with an exhilarating speed of up to 70km/hr (43mph). The hydrofoil design lifts you above the water, creating a sensation of gliding through the air while standing.



HydroBlading (media by Pelagion)

Control and maneuverability are where the HydroBlade truly shines. The advanced steering system allows for effortless turns and quick adjustments, giving riders a sense of mastery over their environment. Whether you're a seasoned watersport enthusiast or a newcomer looking for an adrenaline rush, the HydroBlade offers a user-friendly experience that caters to all skill levels.



HydroBlade (media by JC)

Furthermore, the quiet operation of the electric motors means you can enjoy the sounds of nature without the intrusive noise of a conventional engine. Given that the HydroBlade is powered by two 5.5kWh batteries, it has a total runtime of up to 4 hours. This means you can spend an extended period out on the open water. This harmonious blend of speed, control, range, and tranquility makes the HydroBlade a standout choice for anyone looking to elevate their water sporting adventures.

The HydroBlade's telemetrics are made to be accessed through a user-provided smartphone. The phone holder is located just above the handlebars, and the company recommends a waterproof case (of course).



Smartphone (media by Pelagion)

Market Adoption and Future Prospects

The market for the HydroBlade eFoil is rapidly expanding, driven by a growing demand for eco-friendly and high-performance watercraft. Early adopters, particularly among eco-conscious adventurers and tech enthusiasts, have quickly recognized the benefits of foiling machines such as this.

However, like any revolutionary product, the HydroBlade faces its share of challenges. The initial cost of adoption can be a barrier for some, with the unit estimated to cost around \$20,000. The long-term savings on fuel and maintenance will help to offset this. Additionally, as with any new technology, there is a learning curve, but the user-friendly design of the HydroBlade should help to mitigate this.

Looking ahead, the future of electrified watersports appears bright, with innovations coming to the forefront every day. Advances in battery technology and renewable energy sources are likely to enhance the capabilities and accessibility of products like the HydroBlade further. With growing environmental awareness and technological innovation driving the market, the HydroBlade is poised to lead the way in sustainable water sports.

Conclusion

The [HydroBlade](#) represents a radical advancement in watersports, offering a unique blend of thrilling performance and eco-friendly design. For eco-conscious adventurers, watersport enthusiasts, and tech-savvy consumers, the HydroBlade is more than just a watercraft; it's a vision of the future. With its powerful electric dual motors, hydrofoil design, and advanced steering capabilities, the HydroBlade delivers an unparalleled experience that redefines what's possible on the water.

By significantly reducing emissions and conserving energy, the HydroBlade is a testament to how technological innovation can drive sustainable practices. Its user-friendly design makes it accessible to riders of all skill levels, ensuring everyone can enjoy unparalleled control and exhilaration.

As the market continues to evolve, the HydroBlade is set to become a leading force in electrified watersports. It is another exciting choice for those looking to make a positive impact without sacrificing the thrill of adventure.

MARCH 7, 2025

Entangled polymers and nanosheets create skin-like, self-healing hydrogel

by [Aalto University](#)



Artistic representation of hydrogels in a Möbius ring formed through self-healing. Credit: Margot Lepetit / Aalto University

We all encounter gels in daily life—from the soft, sticky substances you put in your hair to the jelly-like components in various foodstuffs. While human skin shares gel-like characteristics, it has unique qualities that are very hard to replicate. It combines high stiffness with flexibility, and it has remarkable self-healing capabilities, often healing completely within 24 hours of an injury.

Until now, artificial gels have either managed to replicate this high stiffness or natural skin's self-healing properties, but not both. Now, a team of researchers from Aalto University and the University of Bayreuth are the first to develop a hydrogel with a unique structure that overcomes earlier limitations, opening the door to applications such as [drug delivery](#), [wound healing](#), soft robotics sensors and artificial skin.

In the study, the researchers added exceptionally large and ultra-thin specific clay nanosheets to hydrogels, which are typically soft and squishy. The result is a highly ordered

structure with densely entangled polymers between nanosheets, not only improving the mechanical properties of the hydrogel but also allowing the material to self-heal.

The research is [published](#) in *Nature Materials*.

Healing via 'entanglement'

The secret of the material lies not only in the organized arrangement of the nanosheets, but also in the polymers that are entangled between them—and a process that's as simple as baking. Postdoctoral researcher Chen Liang mixed a powder of monomers with water that contains nanosheets. The mixture was then placed under a UV lamp—similar to that used to set gel nail polish.

"The UV-radiation from the lamp causes the individual molecules to bind together so that everything becomes an elastic solid—a gel," Liang explains.

"Entanglement means that the thin polymer layers start to twist around each other like tiny wool yarns, but in a random order," adds Hang Zhang, from Aalto University. "When the polymers are fully entangled, they are indistinguishable from each other. They are very dynamic and mobile at the [molecular level](#), and when you cut them, they start to intertwine again."

Four hours after being cut with a knife, the material is already 80 to 90% self-healed. After 24 hours, it is typically completely repaired. Furthermore, a one-millimeter-thick [hydrogel](#) contains 10,000 layers of nanosheets, which makes the material as stiff as [human skin](#), and gives it a comparable degree of stretch and flexibility.

"Stiff, strong and self-healing hydrogels have long been a challenge. We have discovered a mechanism to strengthen the conventionally soft hydrogels. This could revolutionize the development of new materials with bio-inspired properties," says Zhang.

Gaining inspiration from nature

"This work is an exciting example of how [biological materials](#) inspire us to look for new combinations of properties for [synthetic materials](#). Imagine robots with robust, self-healing skins or synthetic tissues that autonomously repair," says Olli Ikkala, from Aalto University.

Even though there may be some way to go before real-world application, the current results represent a pivotal leap. "It's the kind of fundamental discovery that could renew the rules of material design," says Prof. Ikkala.

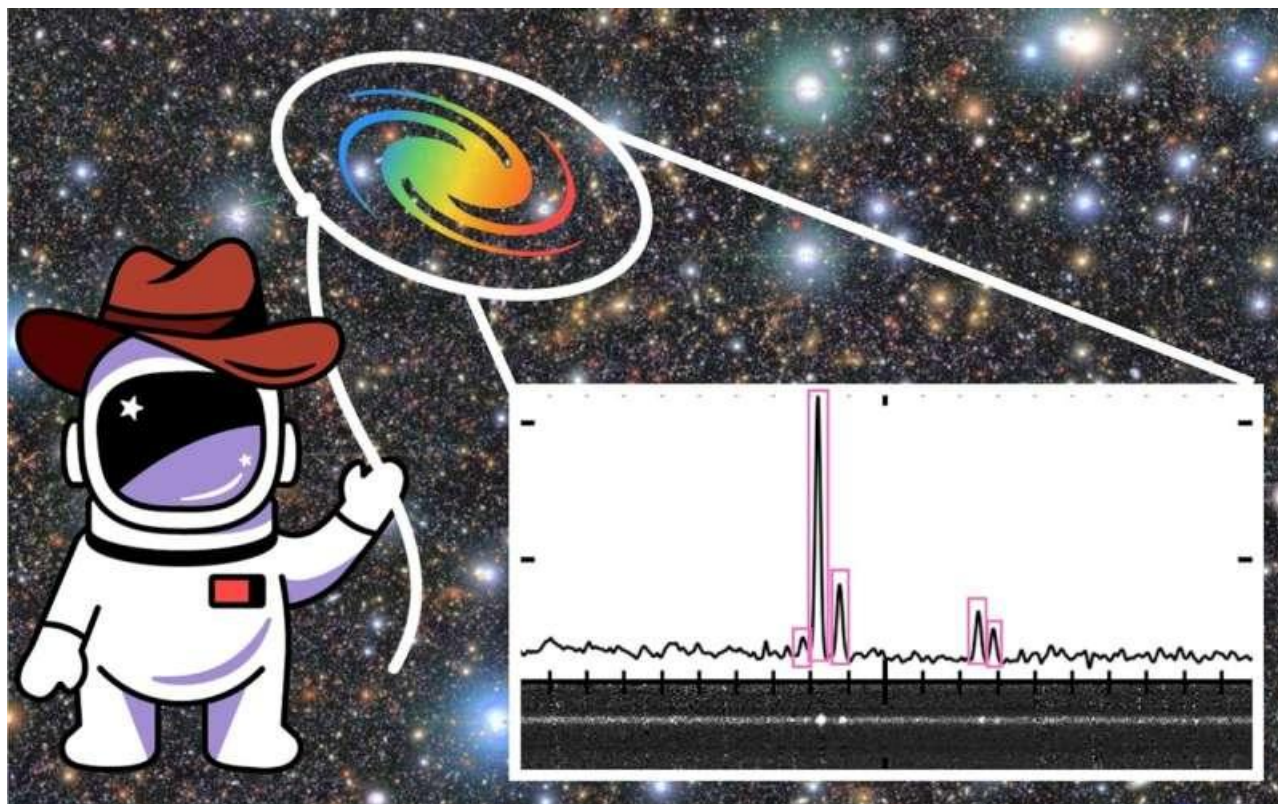
The collaboration was led by Dr. Hang Zhang, Prof. Olli Ikkala and Prof. Josef Breu. The synthetic clay nanosheets were designed and manufactured by Prof. Josef Breu at the University of Bayreuth in Germany.

More information: 'Stiff and self-healing hydrogels by polymer entanglements in co-planar nanoconfinement, *Nature Materials* (2025). [DOI: 10.1038/s41563-025-02146-5](https://doi.org/10.1038/s41563-025-02146-5)

MARCH 7, 2025

Volunteers achieve 200,000 galaxy classifications in citizen scientist project

by [NASA](#)



At Redshift Wrangler, anyone with a smartphone or laptop can help clock the expansion of the universe using light from distant galaxies. Credit: Sadie Coffin

A "classification" is when a volunteer or citizen scientist finishes marking up or sorting one image or other piece of data. Each classification done by volunteers for the [Redshift Wrangler](#) project tells us something about the distance and age of a far-away galaxy, bringing us one step closer to understanding how galaxies evolve. These volunteers have met a major milestone: 200,000 classifications completed.

That's not all. The Redshift Wrangler project has received over 3,000 comments on Zooniverse talk boards, and has begun preparing a paper on their first batch of 11,000 galaxies. The paper will incorporate data from the DEep Imaging Multi-Object Spectrograph

(DEIMOS) from NASA's Keck Observatory Archive, as well as data from the Gemini and Subaru telescopes.

"NASA's citizen science is a blessing, as I've found the Redshift Wrangler project to be such a rewarding experience," said project volunteer, Baba Karthik Kalapatapu.

"This project holds special meaning for me, as I had the unforgettable experience of visiting the Mauna Kea observatories, where I watched the Gemini North and Keck telescopes power on at sunset. I never could have imagined that I'd one day be working with data from those very telescopes—an incredible full-circle moment in my journey into understanding the cosmos."

Provided by [NASA](#)

This Hub Motor Concept Does Much More than Drive the Wheels

- **German supplier Continental says it is close to production for wheel hub motors that integrate braking, whether the customer wants disc or drums, or hydraulic or dry brake-by-wire.**
- **Conti will package its brake components with a patented dual-rotor, radial-flux motor, supplied by DeepDrive, to drive the wheels.**
- **The technology will be road-ready soon, the partners say, and a contract is close to being signed with a European automaker for production to begin in 2028.**

The concept of an electric motor packaged within the wheel hub of a battery-electric vehicle—instead of positioned conventionally under the hood in place of an internal-combustion engine—is not new. [Ferdinand Porsche showcased the technology](#) more than 120 years ago.

What is new, however, is word that longtime German automotive supplier Continental is on the cusp of landing a contract to not only manufacture this technology for a production vehicle but to take a further step and integrate braking elements with each motor at each hub.

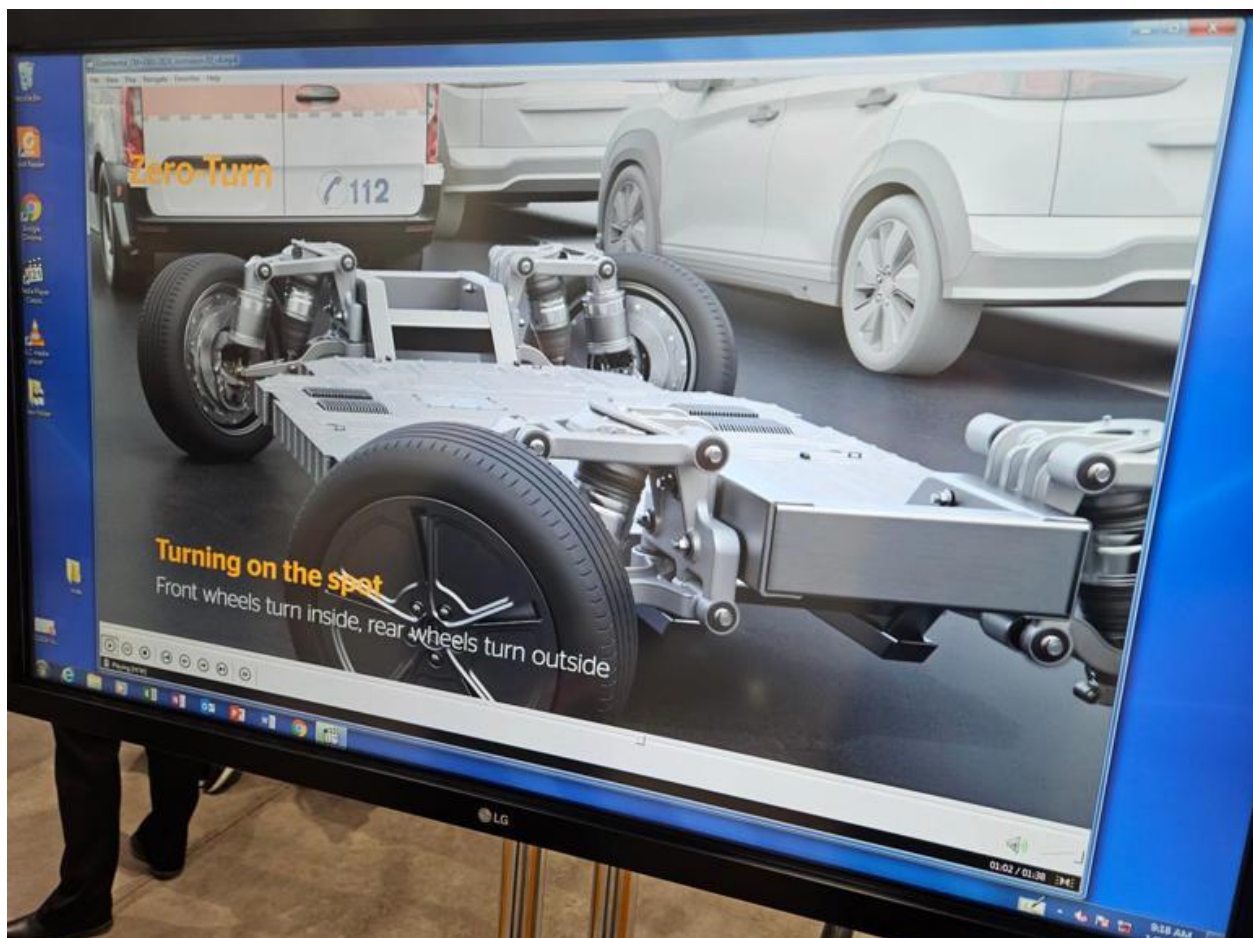
Beyond the packaging benefits and the reduction in overall mass, Conti says this Drive-Brake Unit approach can boost vehicle efficiency and allow for a smaller

battery, perhaps even at the same price as packaging an EV the conventional way, while integrating all-wheel drive and torque vectoring.

Continental has a long history building and selling automotive components such as brakes and electronics (and Continental tires, too), so the hydraulic braking side of this new Drive-Brake Unit comes from Conti while the propulsion components come from another German company.

Based in Munich, motor producer DeepDrive partnered with Conti to develop a compact wheel hub drive that is efficient, powerful, good for all light vehicles, and cost-effective in production, the companies say. On a system basis, the target is to match the price of [conventional motors and brakes for today's EVs](#).

As a startup, DeepDrive is only three years old, but it brings innovative technology: a patented dual-rotor, radial-flux motor that can be packaged as a central drive unit—which is common today—or as a wheel hub drive in series production vehicles.



Conti says the Drive Brake Unit enables groundbreaking steering and chassis control.© Continental

Conti engineers say the technology will be road-ready with state-of-the-art brake technology soon, and a contract is very close to being signed with a European automaker for production to begin in 2028.

Whether Continental will be first to market with the technology remains to be seen, as ZF, ADVICS and others surely are working in a similar direction.

While this first application will rely on hydraulic braking, the company says the technology works with dry brake-by-wire systems as well, whether the automaker wants to use drum or disc brakes.

You might think packaging would be tight for both a motor and braking components at each hub, but Continental actually says a further step is possible to also integrate chassis components, such as air suspension hardware, in a compact unit directly on the wheel.

Conti handles the overall integration of DeepDrive's technology and the industrialization of the corner module.

And while the auto industry has been migrating from drum to disc brakes for decades, [drum brakes are actually experiencing a renaissance](#) in the modern EV era because they are less prone to corrosion (but do tend to overheat moreso than disc brakes).



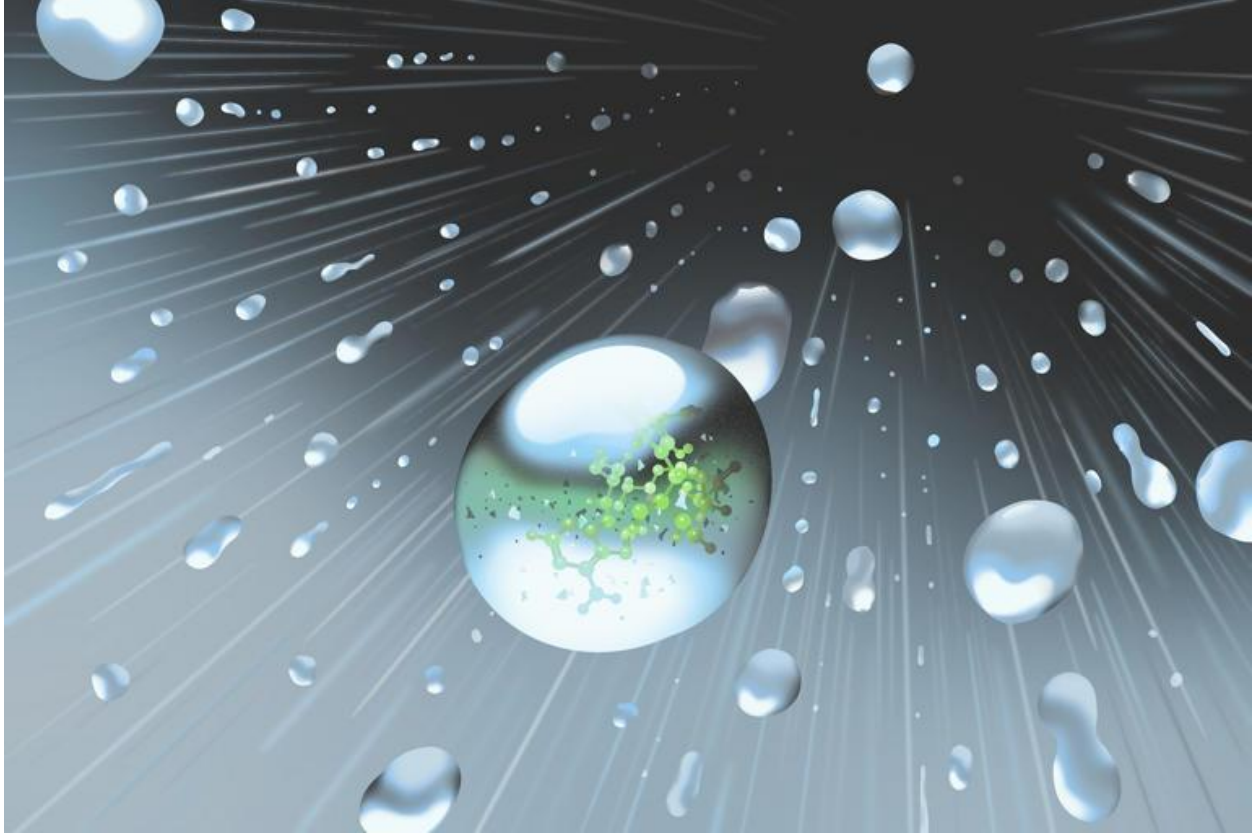
Exploded view of Continental's Drive Brake Unit with patented dual-rotor, radial-flux motor© Continental

"With EVs, electric motors handle a lot of deceleration," Peter Olejnik, head of innovation for chassis systems for Conti North America, tells *Autoweek* during the supplier's recent tech expo.

"You lift off the accelerator and the motor is no longer creating energy but functioning as a generator, allowing energy to be captured and sent back to the battery through regenerative braking," he says.

So friction braking is only used when absolutely needed in today's EVs, which means sometimes the rear brakes are barely used at all. "So you get corrosion on rear disc brakes, and you need an expensive coating on disc brakes to stave off that corrosion," Olejnik says. Meanwhile, **drum brakes are better protected** from the environment, less expensive, and don't rust out as quickly, he says. For this reason, Conti will begin producing drum brakes for a battery-electric truck in 2026. Do you think a wheel hub motor with integrated braking is a smart technology for next-generation EVs?

We got rid of acid rain. Now something scarier is falling from the sky.



We got rid of acid rain. Now something scarier is falling from the sky.

In the 1970s, acid rain was [one of the most serious](#) environmental [threats](#) in North America and Europe. The air was so laden with pollution from coal power plants and cars at the time that it turned the rain toxic. Downpours killed fish, destroyed forests, eroded statues, and damaged buildings, sparking public outcry.

"Acid rain is a particularly alarming demonstration of the simple adage that what goes up must come down," former Colorado Senator Gary Hart [said](#) in 1979.

"With acid rain," he said, "what comes down is much worse than what went up — worse in its potential damage to trees and crops, worse in its potential damage to fresh-water lakes and fish and tourism."

A few decades later, acid rain had largely disappeared.

Beginning around 1990, the US and Europe passed legislation that limited the amount of acid-forming pollutants — such as sulfur dioxide and nitrogen oxides — that power plants could emit. Laws requiring car manufacturers to put catalytic converters into new vehicles, which reduced harmful emissions, were also taking effect. That brings us to today: While precipitation in [some regions](#) is still unnaturally acidic, on the whole, acid rain is largely a problem of the past and a major environmental success story.

Now, however, there's another problem with our rain — and it's even more alarming.

While precipitation has become less acidic, a growing body of evidence suggests that it's now full of many other pollutants that pose a risk to public health, including microplastics. And unlike the compounds that cause acid rain, these pollutants are almost impossible to get rid of.

The new pollutants in our rain

As government regulators focused on reigning in air pollution, companies were busy generating new sources of pollution, including plastics and PFAS, the so-called [forever chemicals](#). PFAS, which stands for perfluoroalkyl and polyfluoroalkyl substances, are a large group of compounds used, among other things, to make fabric stain-resistant and pans nonstick.

Over time, these modern-era substances — which famously take decades to millennia to degrade — have leached into the environment, reaching every corner of the planet, no matter how tall or deep. Microplastics, PFAS, and some other compounds, such as pesticides, are now so widespread that they've essentially become part of our biome, not unlike bacteria or fungi.

They're so common, in fact, that they're even found in the rain.

A [number of studies](#), for example, have [documented](#) microplastics in rain falling all over the world — even in remote, unpopulated regions. For one 2020 [analysis](#) in the journal *Science*, researchers documented microplastics in rainwater that fell on several national parks and wilderness areas in the Western US. Most of the plastic bits were microfibers, such as those shed from polyester sweaters or carpeting on the floor of a car. The researchers estimated that more

than 1,000 metric tons of plastic from the atmosphere fall on parks in the West each year, including both as rainfall and as dry dust. That's equivalent to roughly 120 to 300 million plastic water bottles, according to the study.

The largest source of those microplastics was highways, said Janice Brahney, a biogeochemist at Utah State University who led the *Science* study. Roads are often littered with plastic waste that gets broken down by cars and kicked up into the air. Those particles are typically lighter than soil, so once they become airborne, they can easily move around in the atmosphere and get grabbed by rain as it falls.

Another important source of plastic rain is the ocean, Brahney said. Several million tons of plastic enter the ocean each year, much of which breaks down into microplastics. When waves crash on the beach or bubbles burst on the sea surface, it sends microscopic plastic particles into the air.

Plastic rain is an environmental threat that's harder to fix than the last one. "It's much worse than the acid rain problem," Brahney said. "With acid rain, we could stop emitting acid precursors and then acid rain would stop falling. But we can't stop the microplastic cycle anymore. It's there and it's not going away."

The story of PFAS is similarly bleak: Researchers have detected these chemicals in rain across the planet from the US and Sweden to China and even Antarctica, often at levels above drinking water guidelines. For a [study published in 2024](#) — titled "It's raining PFAS in South Florida" — researchers analyzed rainwater that fell around Miami and found more than 20 PFAS compounds, including PFOS and PFOA. Although these two PFAS were phased out in the US years ago due to public health concerns, the researchers still found them at concentrations beyond government health advisory levels for drinking water, underscoring the remarkable persistence of forever chemicals.

For another [article](#), published in 2022, scientists reviewed studies of PFAS in rainwater and similarly found concentrations of these chemicals at levels above what US and Danish regulators say is safe for drinking water. The authors concluded that, based on health advisories, no untreated rainwater would be considered safe to drink.

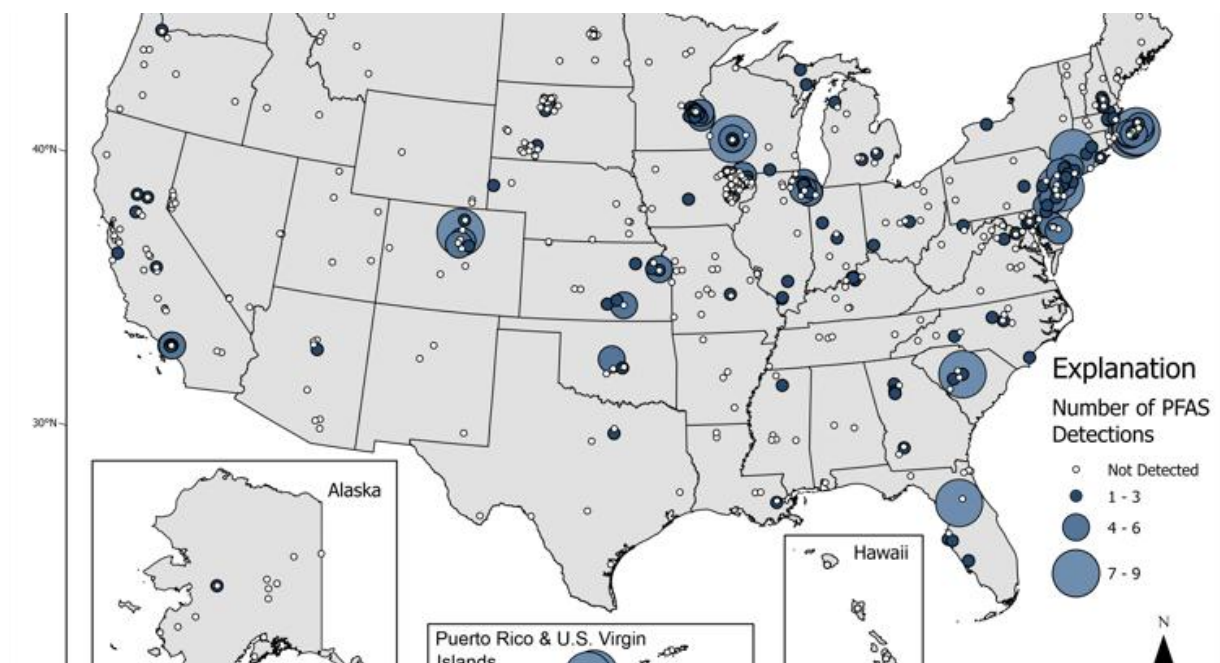
"For us to get rid of PFAS, we probably have to go back in time," said Natalia Soares Quinete, a chemist at Florida International University who was involved in

the 2024 study. Even though the government is increasingly regulating PFAS, she said, “I don’t see us completely getting rid of those chemicals.”

Is the rain dangerous?

The good news is that most people — especially in wealthy countries like the US — don’t rely on untreated rainwater. What is concerning is that rain ends up in groundwater, rivers, and reservoirs that feed into municipal water systems.

Treatment plants help a lot, typically [removing](#) upwards of [70 percent](#) of microplastics in water, but some still pass through. A study [published earlier this year](#), for example, found a small amount of microplastics in bottled water and tap water in France. Similarly, typical filtration plants for municipal water remove some but not all PFAS. Authors of a [2023 study](#) by the US Geological Survey, a federal agency, estimate that at least 45 percent of the country’s tap water has at least one type of PFAS present.



We got rid of acid rain. Now something scarier is falling from the sky.

Treatment facilities don’t have the technology to treat all of the microplastic compounds, let alone the technology to measure them, Brahney said. “There are tens of thousands of chemicals involved, and we only understand a fraction of them,” she said.

Whether or not you're at risk from microplastics, PFAS, and other chemicals is all about exposure — how much of those substances you're breathing in or consuming. There's not much of them in a single glass of tap or a bottle of water. The problem is that there are many other pathways that these pollutants can take to enter your body, such as through food. And over time they add up.

How to protect yourself from polluted rain

Avoid drinking untreated rainwater and eating snow, no matter how pristine it looks! If you can afford to filter your water, you should.

Standard filters like reverse osmosis — which runs water through a semi-permeable membrane — typically remove a large portion of [microplastics](#) and [PFAS](#).

Some countertop [pitcher filters](#) also remove at least some PFAS (e.g., [Zero Water](#)) and microplastics (e.g., [LifeStraw](#)), though they vary a lot. Consumer Reports also has a [great guide](#) to getting PFAS out of your water.

Opt for tap over bottled water to avoid ingesting microplastics. Tap water is also way [better for the planet](#).

A [recent study](#) found that the human brains contain as much as a typical [plastic spoon's worth of microplastic](#), by weight. Scientists still don't understand what impact that might have on human health, but [they suspect](#) that microplastics could be linked to cancer, heart and kidney disease, and Alzheimer's.

Meanwhile, nearly all Americans have a measurable amount of PFAS in their blood, [according to](#) US health officials, though concentrations of some of them — including PFOA and PFOS — are declining. On the whole, forever chemicals [are associated with](#) a range of ailments including increased cholesterol, decreases in birth weight, and kidney cancer.

All of these contaminants can also be [harmful to wildlife](#), which unlike most of us, do rely on untreated water. [One study](#), for example, linked exposure to PFAS to impaired immune systems in alligators. "If we have these contaminants in our rainwater they're getting into our groundwater," Brahney said. "They're infiltrating our soils. Every organism is interacting with rainwater."

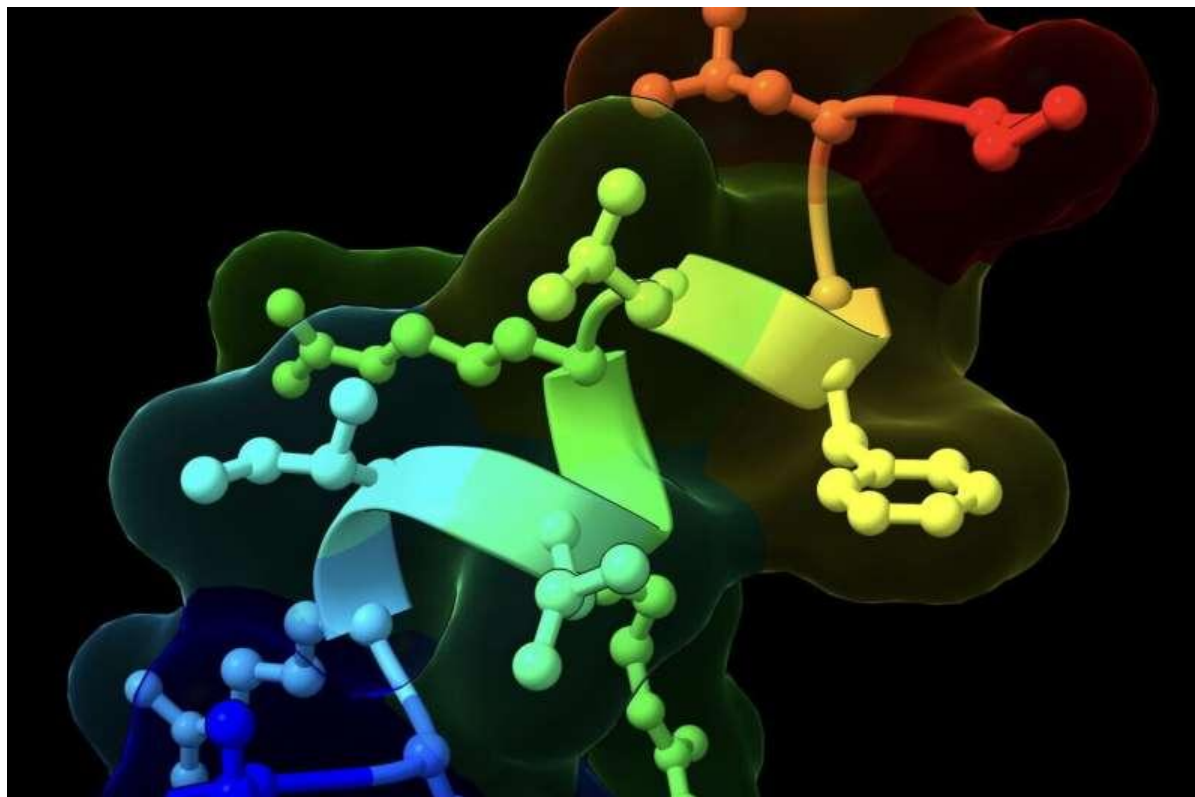
Ultimately, what all of this research reveals is that the planet is dirty, even if the filth can be hard to see. These chemicals are in the rain because they're abundant in the environment — and they're in the environment because they're in the rain. And while there's ongoing research, we don't yet fully understand how those pollutants impact our bodies and our ecosystems. We just know they'll be around for a very, very long time.

"To be honest, I cry, because there's no walking this back," Brahney said of microplastic pollution. "These particles don't break down at a time scale that would be relevant. So yeah, we're not escaping that."

MARCH 6, 2025

Naturally occurring molecule rivals Ozempic in weight loss, sidesteps side effects

by Krista Conger, [Stanford University Medical Center](#)



The 12-amino-acid BRP peptide (spheres are atoms and sticks are bonds) suppresses appetite and reduces weight gain in mice and pigs without causing nausea or food aversion. Credit: Katrin Svensson/Stanford Medicine

A naturally occurring molecule identified by Stanford Medicine researchers appears similar to semaglutide—also known as Ozempic—in suppressing appetite and reducing body weight. Notably, testing in animals also showed that it worked without some of the drug's side effects, such as nausea, constipation and significant loss of muscle mass.

The newly discovered molecule, BRP, acts through a separate but similar metabolic pathway and activates different neurons in the brain—seemingly offering a more targeted approach to body weight reduction.

"The receptors targeted by semaglutide are found in the brain but also in the gut, pancreas and other tissues," said assistant professor of pathology Katrin Svensson, Ph.D.

"That's why Ozempic has widespread effects, including slowing the movement of food through the digestive tract and lowering blood sugar levels. In contrast, BRP appears to act specifically in the hypothalamus, which controls appetite and metabolism."

Svensson has co-founded a company to launch clinical trials of the molecule in humans in the near future.

Svensson is the senior author of the [research](#), which was published in *Nature*. Senior research scientist Laetitia Coassolo, Ph.D., is the lead author of the study.

The study would not have been possible without the use of [artificial intelligence](#) to weed through dozens of proteins in a class called prohormones.

Prohormones are biologically inert molecules that become active when they are cleaved by other proteins into smaller pieces called peptides; some of these peptides then function as hormones to regulate complex biological outcomes, including [energy metabolism](#), in the brain and other organs.

Each prohormone can be divided in a variety of ways to create a plethora of functional peptide progeny. But with traditional methods of protein isolation, it's difficult to pick peptide hormones (which are relatively rare) out of the biological soup of the much more numerous natural byproducts of protein degradation and processing.

The researchers focused on the prohormone convertase 1/3 (also known as PCSK1/3), which separates prohormones at specific amino acid sequences and is known to be involved in human obesity.

One of the peptide products is glucagon-like peptide 1, or GLP-1, which regulates appetite and blood sugar levels; semaglutide works by mimicking the effect of GLP-1 in the body. The team turned to artificial intelligence to help them identify other peptides involved in energy metabolism.

Peptide Predictor

Instead of manually isolating proteins and peptides from tissues and using techniques like [mass spectrometry](#) to identify hundreds of thousands of peptides, the researchers designed a computer algorithm they named "Peptide Predictor" to identify typical prohormone convertase cleavage sites in all 20,000 human protein-coding genes.

They then focused on genes that encode proteins that are secreted outside the cell—a key characteristic of hormones—and that have four or more possible cleavage sites. Doing so narrowed down the search to 373 prohormones, a manageable number to screen for their biological effects.

"The algorithm was absolutely key to our findings," Svensson said.

Peptide Predictor predicted that prohormone convertase 1/3 would generate 2,683 unique peptides from the 373 proteins. Coassolo and Svensson focused on sequences likely to be biologically active in the brain. They screened 100 peptides, including GLP-1, for their ability to activate lab-grown neuronal cells.

As expected, the GLP-1 peptide had a robust effect on the [neuronal cells](#), increasing their activity threefold over control cells. But a small peptide made up of just 12 amino acids bumped up the cells' activity 10-fold over controls. The researchers named this peptide BRP based on its parent prohormone, BPM/retinoic acid inducible neural specific 2, or BRINP2 (BRINP2-related-peptide).

When the researchers tested the effect of BRP on lean mice and minipigs (which more closely mirror human metabolism and eating patterns than mice do), they found that an intramuscular injection of BRP prior to feeding reduced food intake over the next hour by up to 50% in both animal models.

Obese mice treated with daily injections of BRP for 14 days lost an average of 3 grams—due almost entirely to fat loss—while control animals gained about 3 grams over the same period. The mice also demonstrated improved glucose and insulin tolerance.

Behavioral studies of the mice and pigs found no differences in the treated animals' movements, water intake, anxiety-like behavior or fecal production. And further studies of physiological and brain activity showed that BRP activates metabolic and neuronal pathways separate from those activated by GLP-1 or semaglutide.

The researchers hope to identify the cell-surface receptors that bind BRP and to further dissect the pathways of its action. They are also investigating how to help the peptide's effects last longer in the body to allow a more convenient dosing schedule if the peptide proves to be effective in regulating human body weight.

"The lack of effective drugs to treat obesity in humans has been a problem for decades," Svensson said. "Nothing we've tested before has compared to semaglutide's ability to decrease appetite and body weight. We are very eager to learn if it is safe and effective in humans."

Researchers from the University of California, Berkeley; the University of Minnesota; and the University of British Columbia contributed to the work.

Svensson and Coassolo are inventors on patents regarding BRP [peptides](#) for metabolic disorders. Svensson is a co-founder of Merrifield Therapeutics.

More information: Laetitia Coassolo et al, Prohormone cleavage prediction uncovers a non-incretin anti-obesity peptide, *Nature* (2025). DOI: [10.1038/s41586-025-08683-y](https://doi.org/10.1038/s41586-025-08683-y)

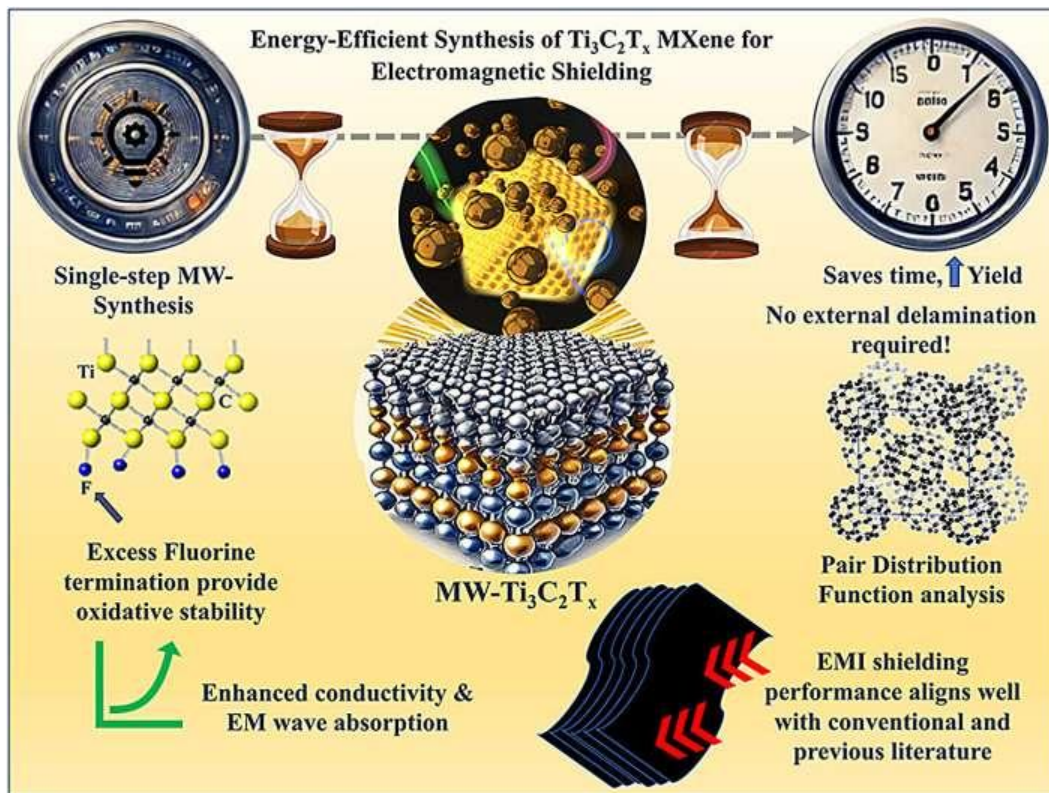
Journal information: [Nature](#)

Provided by [Stanford University Medical Center](#)

MARCH 10, 2025

Microwave synthesis produces MXene 25 times faster than traditional methods while using 75% less energy

by Kaitlyn Landram, [Carnegie Mellon University Mechanical Engineering](#)



Credit: *Materials Science in Semiconductor Processing* (2024). DOI:

10.1016/j.mssp.2024.108966

MXene is a lightweight two-dimensional (2D) material capable of protecting everything—including spacecraft, mechanical components, and maybe even people—from harmful radiation. Because traditional synthesis requires multi-step processes that can take up to 40 hours, MXene is difficult to produce.

By introducing a rapid single-step microwave synthesis method, researcher Reeja Jayan has reduced MXene production time to 90 minutes and cut [energy consumption](#) by 75%.

"Our work has implications for the global production of chemicals because almost a third of greenhouse gas emissions come from chemical manufacturing and production," said Jayan, a professor of mechanical engineering at Carnegie Mellon University.

The research, [published](#) in *Materials Science in Semiconductor Processing*, also demonstrates a unique ability to customize MXene's composition to change the type of radiation against which the material can protect. To date, the team has tested their material across the X-band—[radio frequencies](#) ranging from 8.0–12.0 GHz—but to protect against electronic materials in [outer space](#), more testing against cosmic radiation is needed.

Credit: Carnegie Mellon University Mechanical Engineering

"We assumed that because we sped up the process, we would lose some of the shielding performance in return," said Jayan. "We were pleasantly surprised that although there were subtle structural differences, we didn't see any shielding efficiency tradeoff at the lab scale."

Moving forward, Jayan will test her synthesis process at a larger scale. In partnership with an aerospace materials manufacturer, her team will integrate MXene into test panels for radiation testing.

"We've developed a low-carbon process that significantly saves energy. If it can be scaled up now, more than ever before, we stand to create a critically needed and substantial environmental impact."

More information: H. Renuka et al, Energy-efficient synthesis of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene for electromagnetic shielding, *Materials Science in Semiconductor Processing* (2024). DOI: [10.1016/j.mssp.2024.108966](https://doi.org/10.1016/j.mssp.2024.108966)

Provided by [Carnegie Mellon University Mechanical Engineering](#)

MARCH 10, 2025

How government and industry can team up to make the technology safer without hindering innovation

by Paulo Carvão, [The Conversation](#)



Credit: Pixabay/CC0 Public Domain

Imagine a not-too-distant future where you let an intelligent robot manage your finances. It knows everything about you. It follows your moves, analyzes markets, adapts to your goals and invests faster and smarter than you can. Your investments soar. But then one day, you wake up to a nightmare: Your savings have been transferred to a rogue state, and they're gone.

You seek remedies and justice but find none. Who's to blame? The robot's developer? The artificial intelligence company behind the robot's "brain"? The bank that approved the transactions? Lawsuits fly, fingers point, and your lawyer searches for precedents, but finds none. Meanwhile, you've lost everything.

This is not the [doomsday scenario of human extinction](#) that some people in the AI field have warned could arise from the technology. It is a more realistic one and, in some cases, already present. AI systems are already making life-altering decisions for many people, in areas ranging from education to hiring and [law enforcement](#). Health insurance companies [have used AI tools](#) to determine whether to cover patients' medical procedures. People [have been arrested](#) based on faulty matches by facial recognition algorithms.

By bringing government and industry together to develop policy solutions, it is possible to reduce these risks and future ones. I am a former IBM executive with decades of experience in digital transformation and AI. I now [focus on tech policy](#) as a senior fellow at Harvard Kennedy School's Mossavar-Rahmani Center for Business and Government. I also advise tech startups and invest in venture capital.

Drawing from this experience, my team spent a year [researching a way forward](#) for AI governance. We conducted interviews with 49 tech industry leaders and members of Congress, and analyzed 150 AI-related bills introduced in the last session of Congress. We used this data to develop a model for AI governance that fosters innovation while also offering protections against harms, like a rogue AI draining your life savings.

Striking a balance

The increasing use of AI in all aspects of people's lives raises a new set of questions to which history has few answers. At the same time, the urgency to address how it should be governed is growing. [Policymakers appear to be paralyzed](#), debating whether to let innovation flourish without controls or risk slowing progress. However, I believe that the binary choice between regulation and innovation is a false one.

Instead, it's possible to chart a different approach that can help guide innovation in a direction that adheres to existing laws and societal norms without stifling creativity, competition and entrepreneurship.

Bloomberg Intelligence analyst Tamlin Bason explains the regulatory landscape and the need for a balanced approach to AI governance.

The [U.S. has consistently demonstrated](#) its ability to drive economic growth. The American [tech innovation system](#) is rooted in entrepreneurial spirit, public and [private investment](#), an open market and legal protections for intellectual property and trade secrets. From the early days of the Industrial Revolution to the rise of the internet and modern digital technologies, the U.S. has maintained its leadership by balancing economic incentives with strategic policy interventions.

In January 2025, President Donald [Trump issued an executive order](#) calling for the development of an AI action plan for America. My team and I have developed an AI governance model that can underpin an action plan.

A new governance model

Previous presidential administrations have waded into AI governance, including the Biden administration's [since-recinded executive order](#). There has also been an increasing number of regulations concerning AI passed [at the state level](#). But the U.S. has mostly avoided imposing regulations on AI. This hands-off approach stems in part from a disconnect between Congress and industry, with each doubting the other's understanding of the technologies requiring governance.

The industry is divided into distinct camps, with smaller companies allowing tech giants to lead governance discussions. Other contributing factors include ideological resistance to regulation, geopolitical concerns and insufficient coalition-building that have marked past technology policymaking efforts. Yet, our study showed that both parties in Congress favor a uniquely American approach to governance.

Congress agrees on extending American leadership, addressing AI's infrastructure needs and focusing on specific uses of the technology—instead of trying to regulate the technology itself. How to do it? My team's findings led us to develop the [Dynamic Governance Model](#), a policy-agnostic and nonregulatory method that can be applied to different industries and uses of the technology. It starts with a legislative or executive body setting a policy goal and consists of three subsequent steps:

1. Establish a public-private partnership in which public and private sector experts work together to identify standards for evaluating the policy goal. This approach combines industry leaders' technical expertise and innovation focus with policymakers' agenda of protecting the public interest through oversight and accountability. By integrating these complementary roles, governance can evolve together with technological developments.
2. Create an ecosystem for audit and compliance mechanisms. This market-based approach builds on the standards from the previous step and executes technical audits and compliance reviews. Setting voluntary standards and measuring against them is good, but it can fall short without real oversight. Private sector auditing firms can provide oversight so long as those auditors meet fixed ethical and professional standards.
3. Set up accountability and liability for AI systems. This step outlines the responsibilities that a company must bear if its products harm people or fail to meet standards. Effective enforcement requires coordinated efforts across institutions. Congress can establish legislative foundations, including liability criteria and sector-specific regulations. It can also create mechanisms for ongoing oversight or rely on existing government agencies for enforcement. Courts will interpret statutes and resolve conflicts, setting precedents. Judicial rulings will clarify ambiguous areas and contribute to a sturdier framework.

Benefits of balance

I believe that this approach offers a balanced path forward, fostering [public trust](#) while allowing innovation to thrive. In contrast to conventional regulatory methods that impose blanket restrictions on industry, like the one adopted by the [European Union](#), our model:

- is incremental, integrating learning at each step.
- draws on the existing approaches used in the U.S. for driving public policy, such as competition law, existing regulations and civil litigation.

- can contribute to the development of new laws without imposing excessive burdens on companies.
- draws on past voluntary commitments and industry standards, and encourages trust between the public and private sectors.

The U.S. has long led the world in technological growth and innovation. Pursuing a public-private partnership approach to AI governance should enable policymakers and industry leaders to advance their goals while balancing innovation with transparency and responsibility. We believe that our [governance](#) model is aligned with the Trump administration's goal of removing barriers for industry but also supports the public's desire for guardrails.

Provided by [The Conversation](#)

This article is republished from [The Conversation](#) under a Creative Commons license. Read the [original article](#).

MARCH 10, 2025

Sex workers in research study call for greater legal protections against sexual violence

by [University of Strathclyde, Glasgow](#)



Sex workers should be empowered to set boundaries, access justice, and receive specialist support, according to a [new study](#) examining sexual violence in the sex industry across four legal jurisdictions.

The recommendations were made by [sex workers](#) involved in the study, which found that those working in decriminalized or legalized settings—such as New Zealand and Nevada's managed brothels—are better able to negotiate consent and seek support when violations occur.

By contrast, those in criminalized settings face legal barriers that leave them more vulnerable and less likely to report abuse.

Legal protections

Researchers from the Universities of Strathclyde and Leicester; Queen's University, Belfast; the University of Nevada, Las Vegas; and the University of Otago, undertook interviews with more than 100 criminal justice professionals, [support workers](#), and more than 700 sex workers to look at the situation in four different jurisdictions: the U.S., where the sale and purchase of sexual services is illegal in most states; Nevada, where sex work is legal in certain counties but strictly regulated within brothels; the United Kingdom, where the sale of sexual services is legal but working in brothels is not; and New Zealand, where sex work is decriminalized.

They found that consent negotiation is shaped by the legal frameworks in each jurisdiction—sex workers in decriminalized settings have greater awareness of their legal rights and are better able to assert boundaries, including citing [legal protections](#) to clients.

Violations such as non-payment and "stealthing"—non-consensual condom removal—are widespread: 76% of survey respondents who had experienced an incident reported a payment issue, while 44% had experienced stealthing. Many workers viewed these acts as violence, yet legal recognition and enforcement vary by country.

Distrust of authorities is a key barrier to reporting—92% of survey respondents did not formally report the last boundary violation they experienced, citing a lack of trust in law enforcement and the criminal justice system.

Policy reforms

Professor Teela Sanders, in the School of Criminology at the University of Leicester, said, "Stigma against sex workers—particularly in criminalized and partially criminalized settings—can be embedded within essential services such as health care and policing. This stigma often leads to compounded harm for sex workers, further alienating them from the services they need.

"This study highlights an urgent need for legal and policy reforms to protect sex workers' rights and empower them to set and maintain boundaries, while providing effective mechanisms for redress."

Key recommendations include ensuring survivors have choice and control in reporting, building trust through specialist support, and forming partnerships between mainstream services and sex worker-led organizations. The research also calls for full decriminalization of sex work to improve protections and access to justice.

Deputy Chief Constable Dan Vajzovic, of the UK's National Police Chiefs' Council, said, "Across society, we need to do more to tackle violence against women and girls; this is especially true when considering under-protected communities such as sex workers. I welcome this contribution to strengthening our [knowledge base](#) and hope that it allows consideration of whether better legislative frameworks can be developed."

Can We Please Get EV Motors Out of the Actual Car?

Porsche raced hub motors 127 years ago. Now Orbis offers the torque, cost, and unsprung weight that may finally move motors back out to our wheels.



Can We Please Get EV Motors Out of the Actual Car?

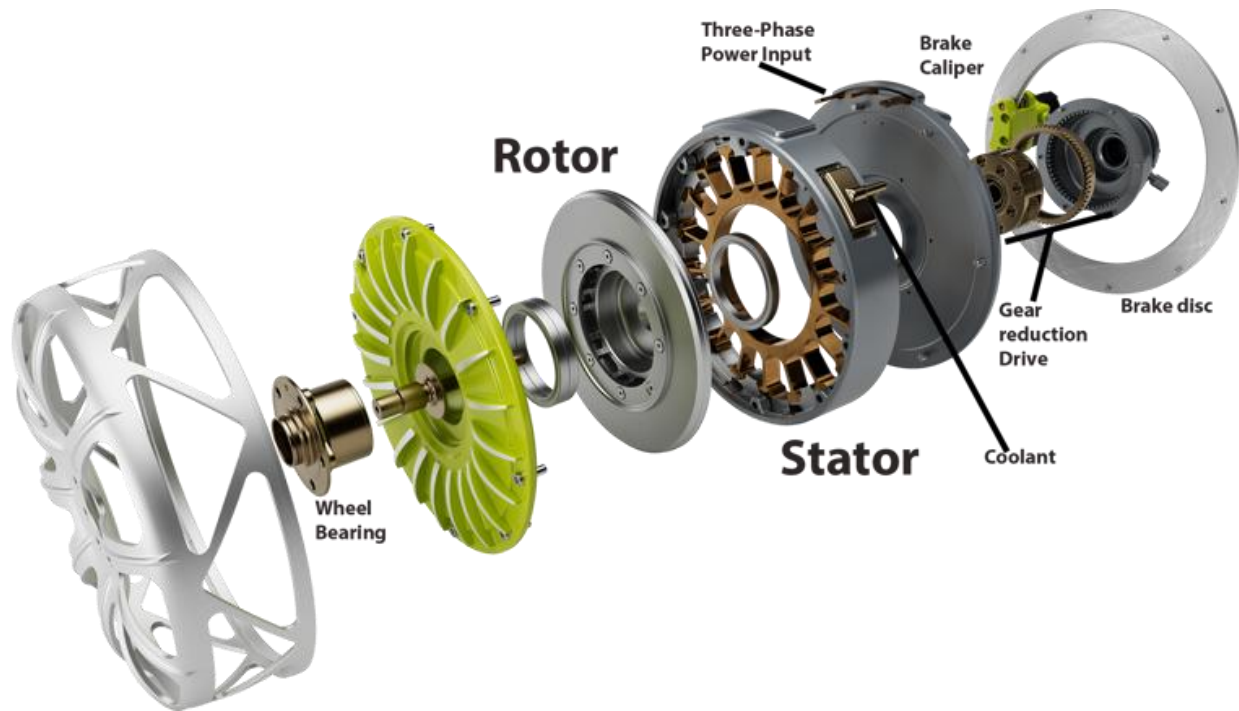
Nineteenth-century electric cars were as likely to use inboard motors as they were wheel-hub motors. [OG car-guy Ferdinand Porsche](#) raced a wheel-hub-motored EV in Vienna, Austria, in 1897, and [Lohner](#) and others built production

versions from 1900 to 1920. [Porsche](#) employed a direct drive that eliminated the friction of a geared or chain drive, but his motors also lacked the torque multiplication such drives offer. So the copper and iron required to generate sufficient torque to accelerate his heavy batteries resulted in *320-pound* motors.

That much [unsprung weight](#) seriously degrades a vehicle's ride quality and dynamic handling while adding considerable cost, and motors at the wheels experience way more shock, vibration, and risk of contamination. As a result, few EVs have used wheel-hub motors since. (Lightyear and [Lordstown Motors produced a few such vehicles before going bankrupt](#), each using Elaphe wheel-hub motors.) But recent developments indicate the concept is ripe for a renaissance—like the \$30 million investment BMW just made in hub motor supplier DeepDrive.

[Back in 2018, Orbis Wheels](#) demonstrated a hub-mounted motor that solved Porsche's torque-multiplication problem by driving a pinion gear that spun a ring gear on the wheel. [We tested Orbis' proof-of-concept vehicle](#), a Honda Civic Type R with two 50-hp/70-lb-ft e-bike motors driving the rear wheels. They shaved 1.7 seconds off the 0–60 time. By also employing a small brake caliper engaging the inside of a larger-diameter, thinner, wheel-mounted rotor, weight savings in the brake system effectively offset the motor's unsprung weight.

That setup was hopelessly noisy and fragile, but continuous innovation and development has refined it sufficiently that it's now attracting OEM and aftermarket production interest.



Orbis Innovation No. 1: Modular Tunable Axial Flux Motor

"Pancake" style [axial-flux motors](#) sandwich a disc-like permanent-magnet rotor between stator discs. Orbis' version is tunable in two ways: For the strongest, skinniest setup imaginable, spec a single rotor fitted with rare-earth magnets. Applications with a bit more depth but less budget to work with can fit a second rotor and use domestic ferrite magnets. Orbis can fine-tune output by blending rare-earth and ferrite magnets on the rotors. Reducing rare-earth materials lowers cost and sourcing woes, reduces heat generated, improves efficiency, and allows motors to cope better with "field weakening" at higher speeds (stator field strength drops, lowering torque while maintaining constant power). This allows one basic design to deliver between 184 and 738 lb-ft.

Orbis Innovation No. 2: Planetary Torque Multiplication

Those figures sound impressive in our motor-shaft output frame of reference, but today’s EV motors power a reduction drive that multiplies the torque—typically by something like 8:1. Orbis achieves torque multiplication at the wheel hub using a simple planetary reduction gear that fits roughly the space otherwise consumed by a halfshaft’s constant-velocity joint and provides multiplication This is not a new idea: In 1884, Missourian Wellington Adams was awarded U.S. patent US300827A for a similar concept applied to an electric train wheel motor. Today such reduction gearing is somewhat common in e-bikes, but no other established player in the EV wheel-motor game uses it. And Orbis’ internal gearing solution already meets OEM noise targets.

Three Important Variables

OEMs looking to get an affordable PHEV to market can electrify an undriven axle with two rare-earth-free single-rotor 184-lb-ft motors capable of delivering between 922 and 1,936 lb-ft to the axle, depending on gearing. Switching to rare-earth magnets *or* adding a second pair of rotors doubles those numbers; *doing both* doubles them again. These two little wheel-hub motors therefore can simulate a single inboard motor running 8:1 gearing that makes between 115 and 968 lb-ft.

Orbis Electric Output, lb-ft				
Single Rotor	Dual Rotor			
Output at the motor	184	369	369	738

Axle	2.50:1 motor gear	922	1,844	1,844	3,688
-------------	--------------------------	-----	-------	-------	-------

Torque	5.25:1 motor gear	1,936	3,872	3,872	7,744
---------------	--------------------------	-------	-------	-------	-------

With 0 percent rare-earth magnets (e.g. ferrite)

With 100 percent rare-earth magnets (e.g. neodymium)

Unsprung Mass and Performance

A major global OEM held an event to evaluate hub-motor options for electrifying existing vehicles, inviting DeepDrive, Elaphe, Protean, and Orbis. Before evaluating these motors, it outfitted a combustion sports car from its range with about 50 pounds of dead weight added to each wheel at one axle. Only three participants could correctly identify which of two otherwise identical cars bore the added unsprung mass.

Still, extensive experience optimizing torque per mass gave Orbis a specific-torque advantage, delivering 49 to 117 percent better wheel-torque/weight than its direct-drive competitors. Orbis' demo motors added about 25 pounds at each corner, but production-grade ones would only add about 5 pounds, and the car should end up at least 50 to 100 pounds lighter. These savings enable switching from NMC batteries to cheaper, bulkier, heavier iron-phosphate chemistry with little or no range, cost, weight, or packaging penalty.



Exploded View© Frank Markus,Manufacturer,Ryan Lugo



Orbis Electric Motor Wheel And Upright Assembly Back V1© Frank Markus,Manufacturer,Ryan Lugo



Orbis Electric Motor Wheel Assembly Front V1© Frank Markus,Manufacturer,Ryan Lugo

Meet the autonomous digital twins that will run smart cities and pilot drones

“We move toward a future where machines can act and adapt without waiting for human input,” the researchers explained.

Updated: Mar 11, 2025

A team of scientists claim they have developed a new AI-assisted digital twin model that can adapt and control the physical machines its paired to in real-time.

In a study published in the journal *IEEE Access*, the team explains that the new concept could alter the way smart cities operate in the future. It could allow smart autonomous systems to fully visualize entire infrastructures.

This could have wide-ranging implications for logistics, public transport, healthcare, defense, and other sectors.

An autonomous digital twin

Digital twins are one-to-one digital replicas of machines in the physical world. They are twinned with real objects and are constantly updated with a stream of data. This allows scientists and engineers to visualize and assess the state of the machine with this wealth of data.

Now, the scientists behind the new study have developed a method that allows digital twins to act autonomously. In their paper, they introduced the concept of Intelligent Acting Digital Twins (IADT).

“Imagine a drone chasing an enemy aircraft. A traditional digital twin would simulate different scenarios and suggest possible moves,” Dr. Ahcene Bounceur, the lead author of the study, explained in a [press statement](#). “But with IADT, the digital twin can actually autonomously control the drone, learning from human pilots and eventually making its own decisions.”

The team behind the new concept believes it can have a wide-ranging impact on the manufacturing industry, as well as in other spheres.

“Bridging the gap between virtual and physical, and by learning from humans and acting independently, IADT could be useful in many fields — health care, smart cities, self-driving cars, and improving real-time responses even in the event of a disaster,” Dr.

Bounceur, from the University of Sharjah's College of Computing and Informatics in the United Arab Emirates (UAE), continued.

In their paper, the scientists claim they have validated their concept via several tests using the digital twin simulation platform, CupCarbon.

"These implementations demonstrate how the IADT integrates virtual and physical components to create a unified and effective framework, offering a significant advancement in the application of digital twin technology across various domains," they wrote.

The future of smart cities

The thinking behind the IADT concept is that smart cities will increasingly need to process vast amounts of data. Allowing digital twins to act autonomously could have implications for city infrastructure management, the healthcare industry, emergency response, and defense.

The study's co-author, Mostefa Kara of King Fahad University of Petroleum and Minerals in Saudi Arabia, stated, "A true digital twin should not just mirror the real world — it should interact with it, adapt to it, and even control it. That's what we have achieved with IADT."

"The future isn't just automation, it's intelligence. We are building systems that don't just follow commands, but understand their environment, make decisions, and act in real-time," he continued.

In the paper, the authors explain that they envision IADT eventually eliminating the need for direct human intervention. "By combining machine learning, AI, and digital twins, we move toward a future where machines can act and adapt without waiting for human input," they explain.

All of this draws up some serious logistical and even ethical questions. Will autonomous smart cities become so complex that even the most intelligent human beings don't fully understand their inner workings?

This is already the case on a smaller scale with Large Language Models ([LLMs](#)), such as ChatGPT. Scientists have claimed they [don't fully understand](#) how some of these models reason and learn.

World's first titanium heart patient walks free after surviving 100+ days

BiVACOR's titanium artificial heart uses a magnetically suspended motor to pump blood, preventing mechanical wear and failure.

Updated: Mar 12, 2025



The artificial heart uses magnets to circulate blood smoothly instead of pumping it.

Australia has marked a historic moment in medical innovation with the successful implantation of the BiVACOR Total Artificial Heart.

A man who received the device in a six-hour surgery last November has become the first patient in the world to be discharged from the hospital with it. He lived with the high-tech heart for over 100 days before receiving a donor transplant.

The procedure was performed at St Vincent's Hospital in Sydney, where cardiothoracic surgeon Dr. Paul Jansz led the surgery. The BiVACOR heart, made from titanium, was

implanted as a temporary solution until a donor heart became available. However, doctors believe it has the potential to serve as a permanent replacement for failing human hearts.

Ad ends in 15

“There were definitely nerves, especially when Daniel [Timms, who invented BiVACOR] flicked the switch and turned it [the artificial heart] on,” Jansz said. He described the device as “the Holy Grail,” emphasizing that it cannot fail or be rejected by the body.

Engineering innovation: the role of magnetic levitation

The BiVACOR artificial heart employs a magnetically levitated rotor to pump blood, eliminating mechanical wear and extending device longevity. This innovation ensures smooth, continuous [blood circulation](#), reducing the risk of clot formation and structural degradation over time.

The device is the brainchild of Australian biomedical engineer Daniel Timms, who has dedicated his career to artificial heart development. His inspiration stemmed from childhood experiences working with his plumber father, experimenting with water pumps.

Timms credits early engineering explorations at local hardware stores as pivotal to the BiVACOR’s evolution. “We had a goal between us—can we get the largest receipt at Bunnings?” he recalled, as [reported](#) by the *Australian Broadcasting Corporation*. “We were trying to buy as much as we could to progress this along.”

His father’s death from [heart failure](#) strengthened his dedication to making the device accessible.

Artificial heart trials expand in the U.S.

The patient who received the BiVACOR heart was a man in his 40s from New South Wales, facing severe heart failure. Before the implantation, he struggled with simple tasks like walking to the bathroom and was unlikely to survive long enough for a donor heart to become available.

With the BiVACOR heart, he lived for over 100 days before receiving a successful heart transplant. “A quarter of the people waiting for a transplant [used to] die — that’s changed now with devices like this,” Jansz emphasized.

The U.S. has also begun trialing BiVACOR. The [first implant](#) took place at the Texas Heart Institute in July 2024. Since then, four more patients have received the device while

waiting for transplants, though none were discharged from the hospital like the Australian patient.

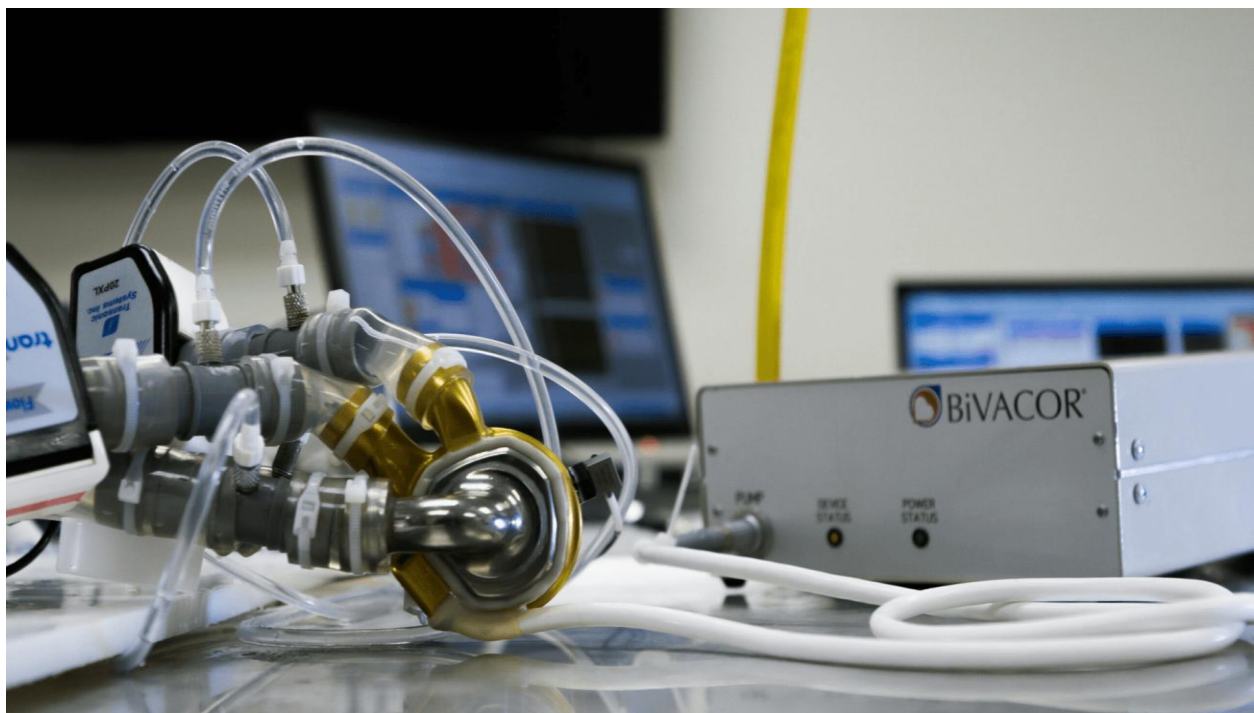
Timms believes that in the next few years, artificial hearts will become more common. “We just need to make more devices, that’s the only limitation right now ... we are ramping up manufacturing so they are sitting on the shelf ready and waiting.”

A small yet powerful life-saving device

Weighing only 1.43 pounds (650 grams), the BiVACOR heart is small enough to fit inside a 12-year-old. Patients reportedly cannot feel it inside their bodies. The device is powered by an external rechargeable battery that connects through a wire in the chest. The battery lasts four hours and alerts the user when it needs replacing.

Future improvements may allow patients to charge the device wirelessly, similar to mobile phone chargers.

The groundbreaking procedure was performed at the same hospital where Australia’s first heart transplant took place in 1968. St Vincent’s Hospital has played a vital role in pioneering cardiac treatments, including Australia’s first successful heart transplant in 1984 by Victor Chang.



It delivers over 12 L/min, providing enough cardiac output for an active adult male.

Image credit: [BiVACOR](#)

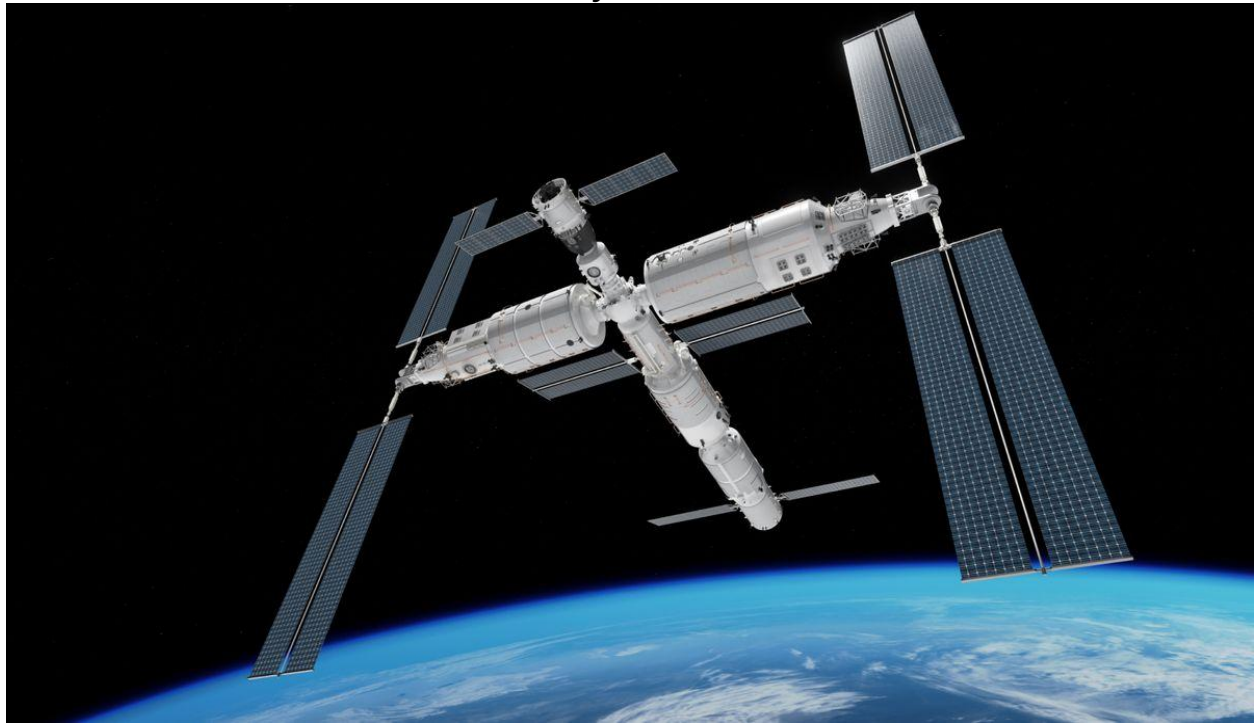
Doctors at Melbourne's Alfred Hospital are now undergoing training to perform their first BiVACOR implant by mid-2025.

Heart failure remains a serious health crisis in Australia, claiming about 5,000 lives each year. The BiVACOR artificial heart offers new hope for those who cannot wait for a donor.

With Australia [facing](#) a 5% decline in overall organ transplants and a 19% drop in heart transplants last year, solutions like BiVACOR could revolutionize treatment for heart failure patients worldwide.

China creates powerful spy satellite capable of seeing facial details from low orbit

New laser-based imaging technology is reportedly capable of capturing millimeter resolution from over 60 miles away.



(Image credit: xia yuan/Getty Images)

Scientists in [China](#) have created a satellite with laser-imaging technology powerful enough to capture human facial details from more than 60 miles (100 kilometers) away.

This breakthrough represents a performance increase of 100 times or more compared to leading spy cameras and traditional telescopes, according to a report on the new technology in the [South China Morning Post](#).

Amongst a broad gamut of potential applications, the technology could allow operators to surveil foreign satellites to a previously impossible level of detail. The researchers at China's Academy of Sciences' Aerospace Information Research Institute outlined their findings in a new study published in the [Chinese Journal of Lasers](#) (Issue 52, Volume 3). According to the [South China Morning Post](#), the scientists conducted a test across Qinghai Lake in the northwest of the country with a new system based on synthetic aperture lidar (SAL), a type of laser radar capable of constructing two-dimensional or three-dimensional images.

How this new powerful spy satellite works

SAL relies on the motion of an object (like a satellite) to provide finer resolution images than other, beam-scanning radar imagery systems. Previous SAR systems have relied on

microwave radiation, which has longer wavelengths, which results in lower resolution images.

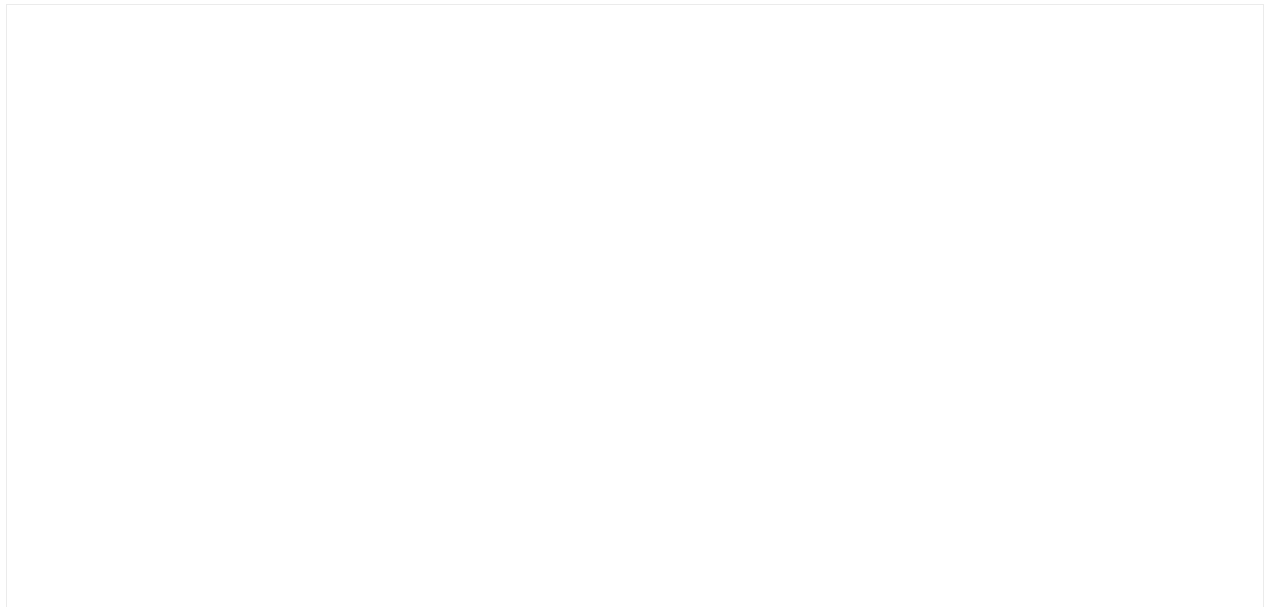
However, this new system operates at optical wavelengths, which have much shorter wavelengths than microwaves and produce clearer images (though microwaves are better for penetrating into materials, because their longer wavelengths aren't scattered or absorbed as easily).

During the test, which targeted arrays of reflective prisms placed 63.3 miles (101.8 km) away from the lidar system, the device detected details as small as 0.07 inches (1.7 millimeters) and measured distances to within 0.61 inches (15.6 mm).

This is a huge leap forward from previous milestones, like a [2011 test](#) conducted by defense firm Lockheed Martin that was able to achieve an azimuth resolution of 0.79 inches (2 centimeters) from only 1 mile (1.6 km) away, or a Chinese test where scientists achieved a then-best 1.97 inch (5 cm) resolution at a distance of 4.3 miles (6.9 km).

To achieve this latest breakthrough, the Chinese team split the laser-beam driving the lidar system across a 4x4 micro-lens array, which in turn expanded the system's optical aperture — the opening that controls the amount of light entering a camera system — from 0.68 to 2.71 inches (17.2 mm to 68.8 mm). In this way, researchers could bypass the tradeoff of field of vision versus size of aperture, which has historically restricted such camera systems.

It's important to note that testing took place during near perfect weather and atmospheric conditions with steady wind and limited cloud cover. Inclement weather or other impairments to visibility could significantly impact the system's precision and reliability.



US fought secret wars to reverse-engineer UFOs, shocking documentary unveils alien truth

“UAPs are real, they’re here, and they’re not human,” new film reveals shocking evidence.

Updated: Mar 10, 2025

Representational image of aliens in the parallel universe.

For many years, Americans have sought answers to various unnatural phenomena in the last century. One of the most awaited approvals that citizens desire from the government is the truth behind aliens.

The government has not provided answers to the people of the U.S. and the world regarding the secrets it holds, despite testimonies from several officials affirming that aliens do exist.

However, an upcoming documentary, “The Age of Disclosure,” promises to disrupt decades of secrecy surrounding Unidentified Anomalous Phenomena (UAP).

The documentary

Set to premiere during the opening weekend of the SXSW Film Festival at Austin’s historic Paramount Theater, the film, directed and produced by Dan Farah, aims to unveil an 80-year cover-up regarding non-human intelligence and the covert efforts by major global powers to reverse-engineer extraterrestrial technology.

The documentary features testimonies from 34 senior members of the U.S. government, military, and intelligence communities, all of whom claim direct knowledge of UAPs.

Among them are high-ranking officials such as Secretary of State Marco Rubio, Senators Kirsten Gillibrand and Mike Rounds, and Jim Clapper, the former Director of National Intelligence.

The documentary also includes comments from former Department of Defense officials, NASA researchers, and military eyewitnesses, offering new perspectives.

Experts featured in the film make definitive statements asserting the existence of non-human intelligence and the presence of unidentified craft that defy known human technology.

What do officials say?

Lue Elizondo, a former Pentagon's Advanced Aerospace Threat Identification Program (AATIP) member, stated in the trailer, "Humanity is not the only intelligence in the universe."

Similar declarations came from astrophysicist Eric Davis, quantum physicist Hal Puthoff, and CIA veterans, further backing the documentary's central claims.

According to the documentary, the U.S. government has conducted a secretive technological arms race with rival nations to recover and exploit non-human craft.

"We learned that the U.S. government was involved in a long-running secret war with other nations to collect and reverse-engineer vehicles not made by humans," one expert [said](#).

Another warned of the geopolitical consequences: "The first country that cracks the code on this technology will be the leader for years to come."

Beyond the military and strategic implications, "The Age of Disclosure" addresses the ethical concerns of removing such knowledge from the public.

Several figures in the documentary highlight the [dangers](#) of an unchecked governmental apparatus that withholds paradigm-shifting discoveries.

"It's not acceptable to have secret parts of government that no one ever sees," one official said.

Another warned, "You better be careful about a government that doesn't trust its people because there's no telling what they'll pull on you."

Alien knowledge

The documentary also explores the potential benefits of disclosing such knowledge.

Technology derived from non-human sources could revolutionize clean energy and fundamentally alter the trajectory of human civilization.

"You had information being locked away that could change the trajectory for species," one scientist remarked, while another said, "It has so many beneficial impacts, including clean energy."

The release of “The Age of Disclosure” coincides with recent legislative efforts in the U.S. Senate to declassify government-held UAP knowledge.

The UAP Disclosure Act was designed to compel the public release of such information.

However, the act has faced significant resistance from vested interests and concerns over societal preparedness.

“The American public has a right to learn about [technologies](#) of unknown origins, non-human intelligence, and unexplainable phenomena,” an expert argued.

“The Age of Disclosure” challenges the status quo of governmental secrecy regarding extraterrestrial phenomena by compiling the testimonies of high-ranking officials, intelligence operatives, and scientific experts.

As the trailer concludes, “The time has come.”

NASA scientist creates fuel-free space rocket

A NASA scientist has successfully created a rocket that operates without using fuel.

Dr. Charles Buhler, an engineer and co-founder of Exodus Propulsion Technologies, revealed that his team had defied the laws of physics by developing a fuel-free propulsion system.

After decades of research and experimentation, Charles Buhler believes this breakthrough will change the game and reshape propulsion technology.

"The most important message to convey to the public is that a major discovery has occurred," he said.

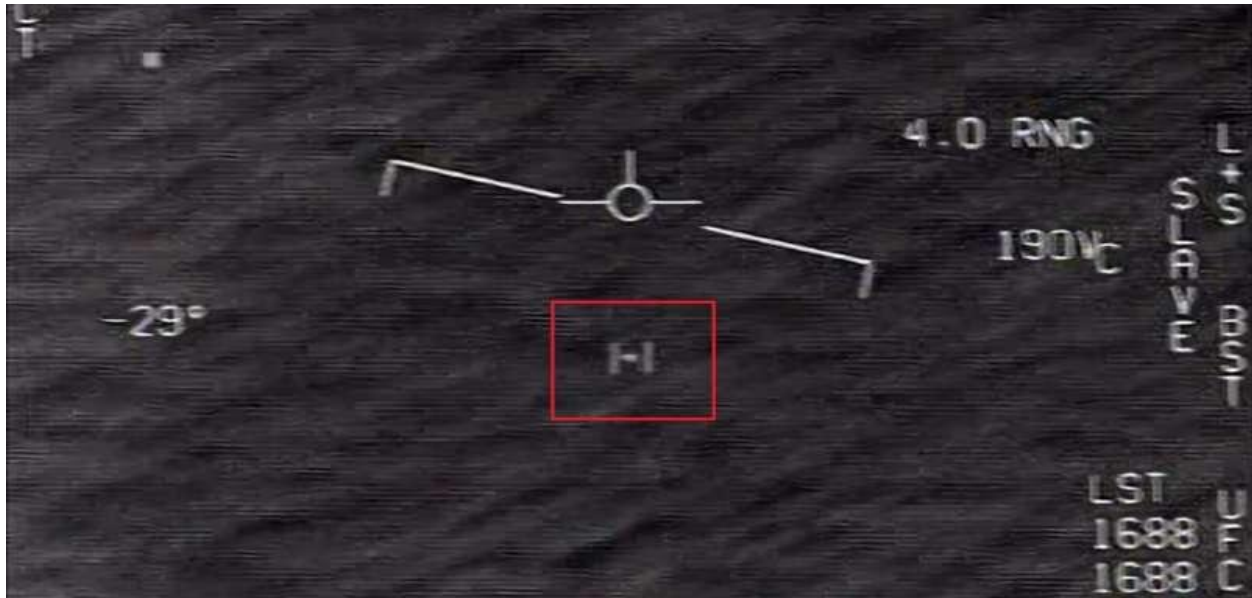
This revolutionary system generates thrust using electric fields rather than expelling mass, marking a radical departure from traditional propulsion methods.

Charles Buhler has also expressed his openness to collaborating with others to further improve and refine this groundbreaking technology.

FEBRUARY 19, 2025

What would actual scientific study of UAPs look like?

by Evan Gough, [Universe Today](#)



U.S. Navy video of an anomalous object, known as the GOFAST UFO (highlighted by a red box), includes data about the circumstances of the detection. New research says we need a focused scientific effort aimed at UAP. Credit: U.S. Navy

For those who missed the memo, UFOs (unidentified flying objects) are now called UAPs (unidentified aerospace-undersea phenomena). The term UFO became so closely tied to alien spacecraft and fantastical abduction stories that people dismissed the idea, making any serious discussion difficult. The term UAP is a broader term that encompasses more unexplained objects or events without the alien spaceship idea truncating any useful or honest discussion.

While the name change is helpful, it's just the beginning. We need a way to study UAPs scientifically, and new research shows us how.

Though the idea of alien spacecraft visiting us isn't always taken very seriously, the effort to document UAP and understand them goes back decades. In current times, governments around the world have made more serious efforts to understand what's behind the phenomena. Most notably, NASA recently initiated a study into UAP called the Unidentified Anomalous Phenomena Independent Study and released its final report in September 2023.

New research aims to explore past efforts, dispel some misunderstandings, and enable future research into UAP.

The research is titled "The New Science of Unidentified Aerospace-Undersea Phenomena (UAP)." The lead author is Kevin Knuth from the Department of Physics at the State University of New York at Albany. The research is [available](#) on the *arXiv* preprint server.

"After decades of dismissal and secrecy, it has become clear that a significant number of the world's governments take unidentified aerospace-undersea phenomena (UAP), formerly known as unidentified flying objects (UFOs), seriously—yet still seem to know little about them," the authors write. "As a result, these phenomena are increasingly attracting the attention of scientists around the world, some of whom have recently formed research efforts to monitor and scientifically study UAP."

The authors review about 20 historical studies, some done by governments and others by private researchers, between 1933 and the present. Countries include the U.S., Canada, France, Russia, and China. Their goal is to summarize and clarify the scientific narrative around UAPs. "Studies range from field station development and deployment to the collection and analysis of witness reports from around the world," the authors write.



Many UAP have good explanations, like this image from the Apollo 16 mission to the moon that shows what may look like a flying saucer. In 2004, NASA said it was the spacewalk floodlight/boom that was attached to the Apollo spacecraft. Credit: NASA

The main obstacle to studying UAPs is that they're neither repeatable nor controllable. Another problem is that witness reports are unreliable, often explained away as natural phenomena, or dismissed outright by citizens, scientists, and governments. This has dissuaded serious discussion and study and left us in "a rather disconcerting state of ignorance," the authors write.

Ignorance is seldom desirable, though it can sometimes provide a false sense of relief. Being disconcerted is likewise undesirable. What can be done?

"The problem and opportunity that we face today is that the situation has changed dramatically," according to the authors. We now know that the US Defense Intelligence Agency (DIA) conducted a covert, six-year program called the Advanced Aerospace Threat Identification Program (AATIP) to study UAP. With 50 full-time investigators, the AATIP dwarfed other UAP efforts.

The AATIP focused on military-only encounters and considered things like psychic and paranormal phenomena correlated with UAP events. The AATIP created a massive amount of data on UAP that encompassed more than 200,000 cases. (Alarming, the effort also produced more than 200 research papers, some over 100 pages long, and none of them have ever been seen by the public or by the US Congress.)

Discover the latest in science, tech, and space with over **100,000 subscribers** who rely on Phys.org for daily insights. Sign up for our [free newsletter](#) and get updates on breakthroughs, innovations, and research that matter—**daily or weekly**.

Subscribe

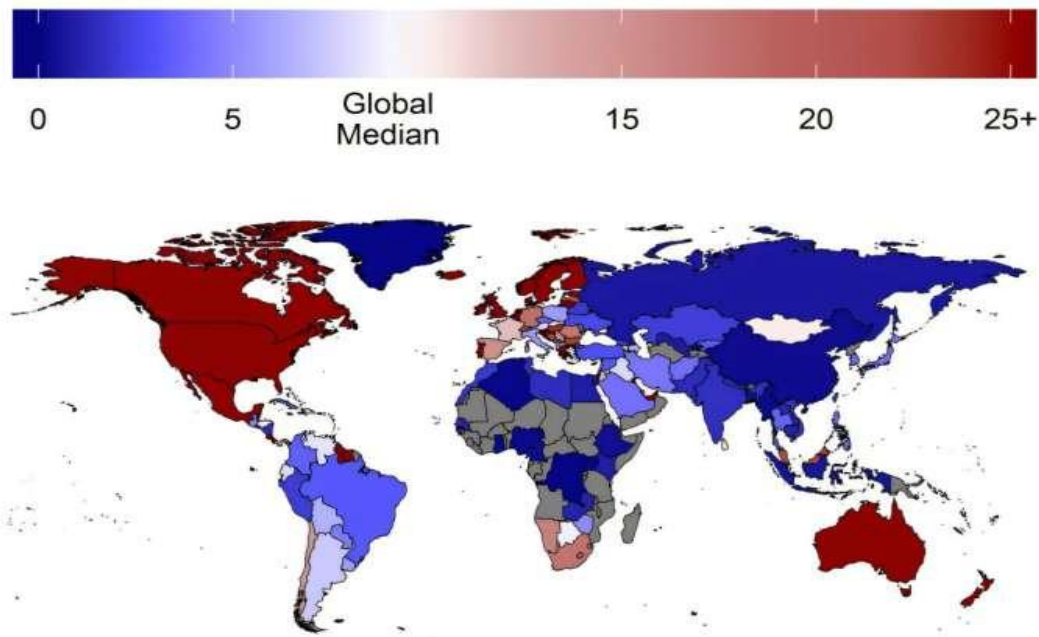
This proves that the effort to study and understand UAP has gained traction and moved from the fringe to the mainstream. It's a signal that UAP research could see increased funding and resources. According to the researchers, that means there needs to be a coordinated effort. The effort needs to be scientific, and data needs to be shared among researchers.

"It is generally agreed that the optimal methodology to study UAP relies on many different types of instruments, spatially separated, to dramatically reduce the possibility of error," the authors write. "This is the only way in which the scientific community will recognize truly anomalous data." The authors say that multi-messenger astronomy, in which objects are studied across wavelengths with multiple telescopes, is a good model for the future study of UAP.

Rigor is required for UAP studies and data to be taken seriously. One group arguing in favor of more UAP scientific research is the UAlbany-UAPx Collaboration, an organization that the lead author of this research, Kevin Knuth, is involved with. They developed rigorous definitions of what detections constitute a UAP and recommended that "at least two of each type of sensor and 2+ distinct sensor types" be used in the effort to study UAP.

The future effort to understand UAP must migrate in from the fringes and adhere to scientific standards in other disciplines. "This way, one rigorously quantifies the meaning of extraordinary evidence, in the same way it has been done historically by particle physicists, who have established a very high bar to clear," the authors write.

UFO Sightings Per 10M People



The geographic distribution of UFO sightings. One of the puzzling things about sightings is that they're not distributed in any way that makes sense. Does culture play a role? Credit: sammonfort3

The researchers also explain how our burgeoning fleet of satellites could play a larger role in the study of UAP. "UAP researchers are now considering the air and space domains as open-air laboratories, utilizing these vast environments for systematic scientific inquiry," they write.

Throughout most of history, [satellite data](#) has been restricted to large governments and their defense and military organizations. But their monopoly on the data is withering away. Satellite imagery and data are routinely shared with the public and are freely available for scientific use. Coinciding with greater accessibility is greater quality.

"Thanks to significant technological advancements and the proliferation of commercial satellite services, access to satellite data has expanded dramatically. In addition, rapid advances in information and communication technologies have opened new avenues for many more actors," the authors explain.

Though current satellites aren't aimed at studying UAP, their sensors can be used to examine environments near reported UAP. This brings up another parallel between astronomy and UAP. We have telescopes that scan the sky for transients and when they detect one, they send out urgent messages to other telescopes suited for follow-up observations. The same arrangement could work in the study of UAP.

Advancements in science and astronomy can also benefit the study of UAP. Tools such as cloud computing, artificial intelligence (AI), and machine learning (ML) now enable scientists to gather, store, transmit, and analyze data more efficiently than ever before," the authors

write. There's an ongoing democratization of data sharing that can be leveraged in the study of UAP.

UAP are not one thing. Only a dedicated, serious effort to understand them as they appear can determine if there's something there deserving of deeper study. The authors argue that a "paradoxical loop of dismissal in mainstream science" is preventing progress. The paper outlines a way to cancel that paradox based on the sound methods of the scientific method.

The problem is that detecting them scientifically requires a very wide net of detectors and significant resources over long periods of time. That, again, parallels how we do other science. "Only long-term, transgenerational research programs, such as enjoyed by many research programs well established and stabilized within academic science now for many decades, can possibly yield the proper data on which a potential resolution to UAP can be founded," the authors write.

However, we're not starting from scratch.

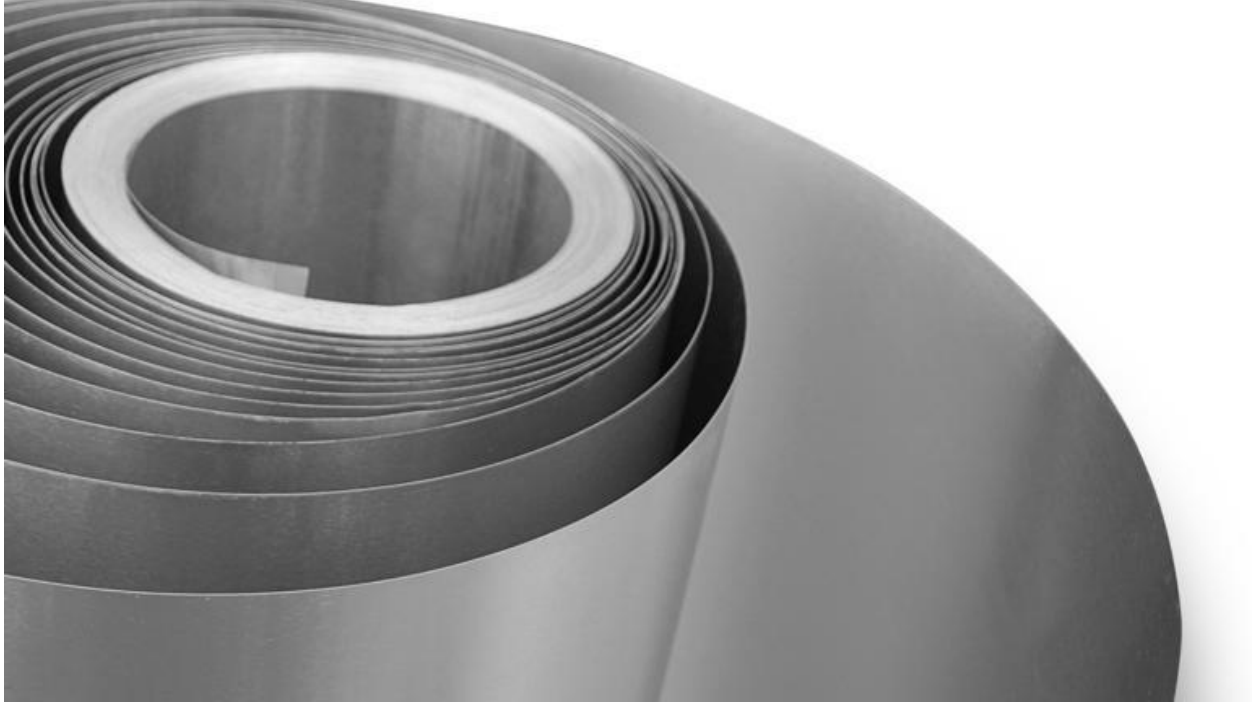
"Our aim here is to enable future studies to draw on the great depth of prior documented experience," the researchers explain.

More information: Kevin H. Knuth et al, The New Science of Unidentified Aerospace-Undersea Phenomena (UAP), *arXiv* (2025). DOI: [10.48550/arxiv.2502.06794](https://doi.org/10.48550/arxiv.2502.06794)

Journal information: [arXiv](#)

Provided by [Universe Today](#)

Metal sheets 100,000x thinner than a hair developed, can transform electronics



Metal sheets 100,000x thinner than a hair developed, can transform electronics

Scientists have made metal sheets that are just a few atoms thick. Using their new method, researchers developed 2D sheets of bismuth, gallium, indium, tin, and lead that were hundreds of thousands of times thinner than a human hair, according to the latest study.

Developed by researchers from Chinese Academy of Physics, the ultra-thin metal sheets also offer exceptionally high electrical conductivity.

Scientists have revealed that once metals are thinned down to make sheets just one or a few atoms thick, their properties change drastically because of a phenomenon called quantum confinement.

Resulting properties are potentially useful

Published in the journal [Nature](#), the study reveals that the resulting properties are potentially useful, but such 2D metals are difficult to stabilize at micrometer

dimensions or greater sizes because the atoms tend to adopt their naturally occurring 3D arrangements and oxidize readily in air.

Chinese scientists' new process for squeezing metals down to atomic thicknesses uses a benchtop hydraulic press.

Their low-tech approach produces air-stable 2D crystals with dimensions greater than 100 micrometres, which is a substantial improvement over what can be made using more expensive and complex techniques, according to the [study](#).

Method can be applied to any metal

Researchers revealed that the method can be applied to any metal with a low melting point.

A reviewer underlined that the Chinese team isn't the first to produce atomically thin metals. However, their results stood out because the new method [produces](#) "large-scale, truly 2D metals" compared to previous techniques.

"This is just a starting point," said Javier Sanchez-Yamagishi, a physicist who studies 2D materials at the University of California "Now, other people can step in and start studying the metal sheets' properties."

Javier also highlighted that the stability and large sizes of these materials open up many possibilities for integrating them with other materials and for making new electrical or photonic devices.

Feat could revolutionize the way electronic devices are made

Some experts believe the feat could revolutionize the way electronic devices are made, from low-power transistors to next-generation chips and supersensitive detectors. Applying their technique, the team created sheets of five different metals just a few atoms thick, measuring a couple of hundred micrometres wide – remarkably large for a material so thin, reported [SCMP](#).

To make an ultrathin metal sheet, the team heated a droplet of the metal between two sapphire anvils, which were pressed together as the metal cooled (see 'Putting the squeeze on'). Because MoS₂ interacts more strongly with metal than with sapphire, the researchers could pry the resulting sandwich of MoS₂–metal–MoS₂ sheets out of the apparatus like a panini from a press.

Guangyu Zhang, who studies nanomaterials at the Chinese Academy of Sciences in Beijing, and his team created sheets of five different metals just a few atoms thick, measuring a couple of hundred micrometres wide – remarkably large for a material so thin.

Unproven Einstein theory of 'gravitational memory' may be real after all, new study hints

A team of theoretical physicists has proposed a new way to test one of the most intriguing predictions of Einstein's theory of [general relativity](#): gravitational memory.

This effect refers to a permanent shift in the fabric of the universe caused by the passage of space-time ripples known as gravitational waves. Although these waves have [already been detected](#) by observatories such as the Laser Interferometer Gravitational-Wave Observatory (LIGO) and the Virgo interferometer, the waves' lingering imprint remains elusive.

The researchers suggest that the cosmic microwave background — a faint glow left over from the [Big Bang](#) — might carry the signatures of powerful gravitational waves from distant black hole mergers. Studying these signals could not only confirm Einstein's prediction but also shed light on some of the most energetic events in the universe's history.

"The observation of this phenomenon can provide us with more knowledge of different fields of physics," [Miquel Miravet-Tenés](#), a doctoral student at the University of Valencia and a co-author of the study, told Live Science via email. "Since it is a direct prediction of Einstein's theory of general relativity, its observation would serve as a confirmation of the theory, much like the observation of gravitational waves by LIGO, Virgo and KAGRA [the Kamioka

Gravitational Wave Detector] has done! It can also be used as an additional tool to study some astrophysical scenarios, since it can contain information about the type of events that generate memory, such as supernovae or [black hole](#) collisions."

How gravitational waves leave a mark on the cosmos

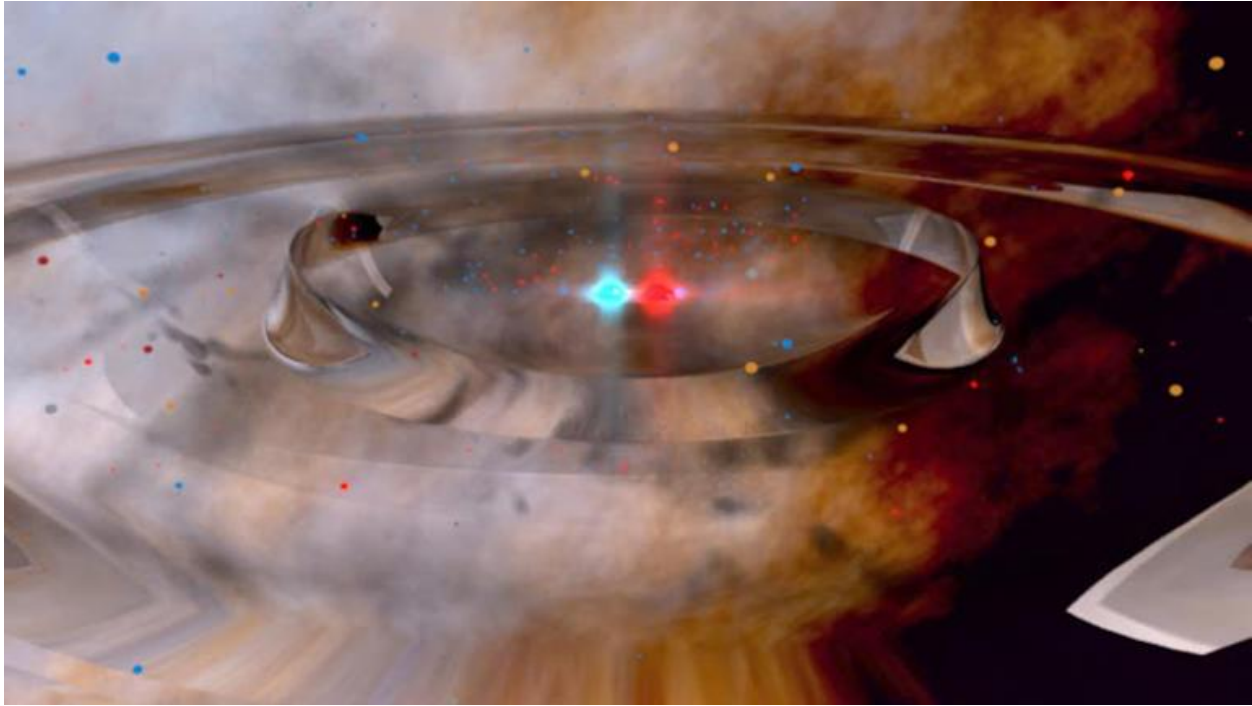
According to general relativity, massive objects warping space-time can generate ripples that travel across the universe at the [speed of light](#). These gravitational waves arise when massive bodies accelerate, such as when two black holes [spiral inward and merge](#).

Unlike ordinary waves that pass through matter and leave it unchanged, gravitational waves can permanently alter the structure of space-time itself. This means that any objects they pass through, including elementary particles of light known as [photons](#), may experience a lasting change in velocity or direction. As a result, the light traveling across the cosmos could carry a memory of past gravitational-wave events imprinted in its properties.

The researchers explored whether this effect could be observed in the cosmic microwave background — a relic radiation field that has been traveling through space since the universe was just a fraction of a percent of its current age. Subtle shifts in the temperature of this radiation could hold clues about gravitational waves from ancient black hole mergers.

"We can learn plenty of things," [Kai Hendriks](#), a doctoral student at the Niels Bohr Institute at the University of Copenhagen and another co-author of the study, told Live Science in an email. "For example, measuring gravitational memory in a gravitational wave signal gives us more information about the properties of the two black holes that produced this signal; how heavy those black holes were or how far away they are from us."

But the implications extend beyond individual black hole mergers. If the imprint of gravitational memory can be detected in the cosmic microwave background, it could reveal whether supermassive black holes merged more frequently in the early universe than they do today. This could offer new insight into how galaxies and black holes have evolved over cosmic time.



An illustration of gravitational waves rippling away from two merging black holes (Image credit: NASA Goddard)

Measuring the imprint

To determine whether the memory effect could be detected, the team calculated how black hole mergers influence the cosmic microwave background. Their analysis showed that these violent events should leave behind measurable changes in the background radiation, with the strength of the signal depending on how massive the black holes were and how frequently such mergers occurred throughout history.

"The wavelength of light is directly related to its temperature — small wavelength means high temperature and large wavelength means low temperature," [David O'Neill](#), a doctoral student at the Niels Bohr Institute and another co-author of the study, told Live Science in an email. "Some of the light affected by the gravitational wave memory becomes 'hotter' while some of the other light becomes 'colder.' The regions of hot and cold light form a kind of pattern in the sky. We predict this pattern to be present in the cosmic microwave background, albeit quite faint."

Although current telescopes that are capable of detecting microwave radiation, such as the Planck satellite, have mapped the cosmic microwave background in exquisite detail, the temperature shifts caused by gravitational wave memory are expected to be extremely small — on the order of a trillionth of a degree. This makes them difficult to observe with existing technology. However, future telescopes with greater sensitivity may be able to detect these subtle distortions, providing a new way to probe the invisible gravitational influences that have shaped the universe.

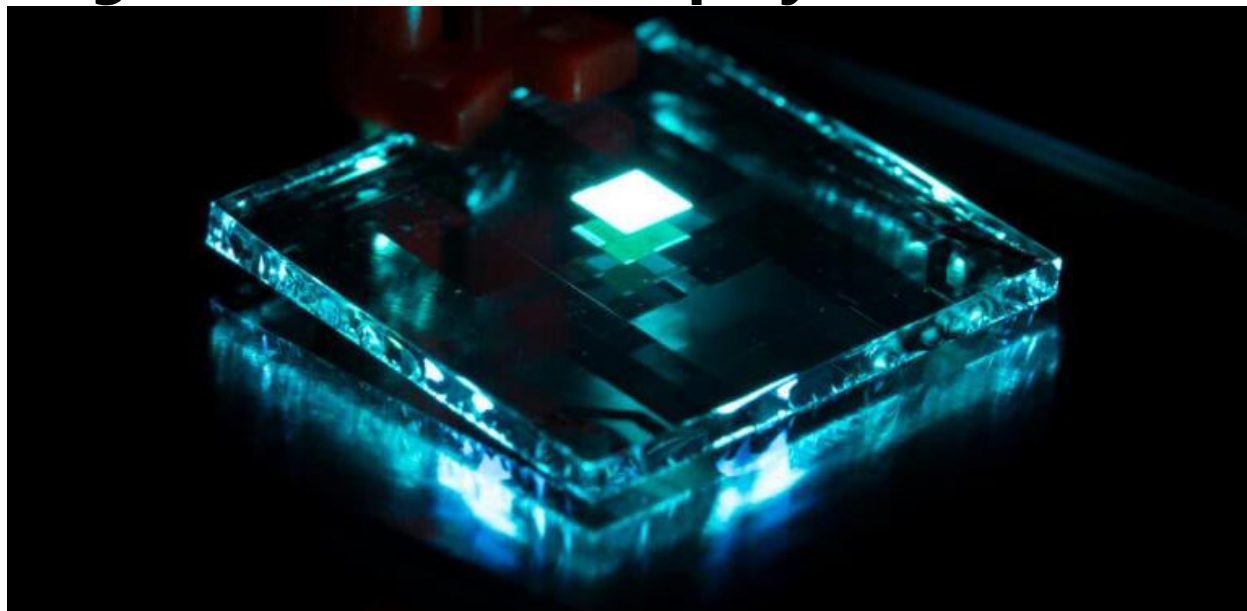
Refining the models for future tests

While the study demonstrates that gravitational wave memory should leave a trace in the cosmic microwave background, the researchers acknowledge that their calculations were based on simplified assumptions. More refined models will be needed before definitive predictions can be made.

For instance, the team initially assumed that all merging black holes had the same mass, whereas in reality, their masses can vary significantly. Supermassive black holes range from a few million to [tens of billions of times the mass of the sun](#), meaning that their influence on the cosmic microwave background will also differ. Accounting for this variation will be important in future studies.

"Right now, the effect we're studying is incredibly subtle. However, it's possible that in certain regions of the sky, it could be unexpectedly strong," Hendriks said. "To explore this, we need more advanced models that take into account the entire evolution of the universe. So not an easy task! But this could bring us closer to detecting this cosmic imprint and uncovering new insights into the evolution of the universe."

New discovery substantially increases the brightness of OLED displays



The picture shows a standard blue OLED with a width of 15 mm and an emitting pixel width of 2 mm. A polariton OLED would be obtained by replacing the thin films below and above with a semi-transparent material with a thickness of 10-100 nm. It would be impossible to separate them from the image. (CREDIT: Mikael Nyberg and Manish Kumar)© The Brighter Side of News

[Organic light-emitting diodes](#) (OLEDs) are transforming modern lighting and display technology with their slim profile, lightweight structure, and flexible designs. Unlike traditional light sources, OLEDs emit their own light without requiring a backlight, making them ideal for high-definition screens in smartphones, laptops, and TVs.

However, a fundamental limitation restricts their brightness. Due to spin statistics, only 25% of the electrical excitations produce light efficiently, while the remaining 75% exist in dark triplet states that typically fail to contribute to illumination.

This inefficiency affects OLED brightness, making them dimmer than traditional LEDs. Scientists are now looking at quantum physics to solve this issue, particularly by harnessing special hybrid light-matter states known as [polaritons](#).

The Role of Polaritons in OLED Efficiency

Polaritons form when organic molecules interact with confined light between two semi-transparent mirrors. This coupling creates new quantum states that can influence energy transfer inside OLEDs. By fine-tuning these states, researchers have discovered that dark triplet states can be converted into bright polaritons, significantly improving light output.



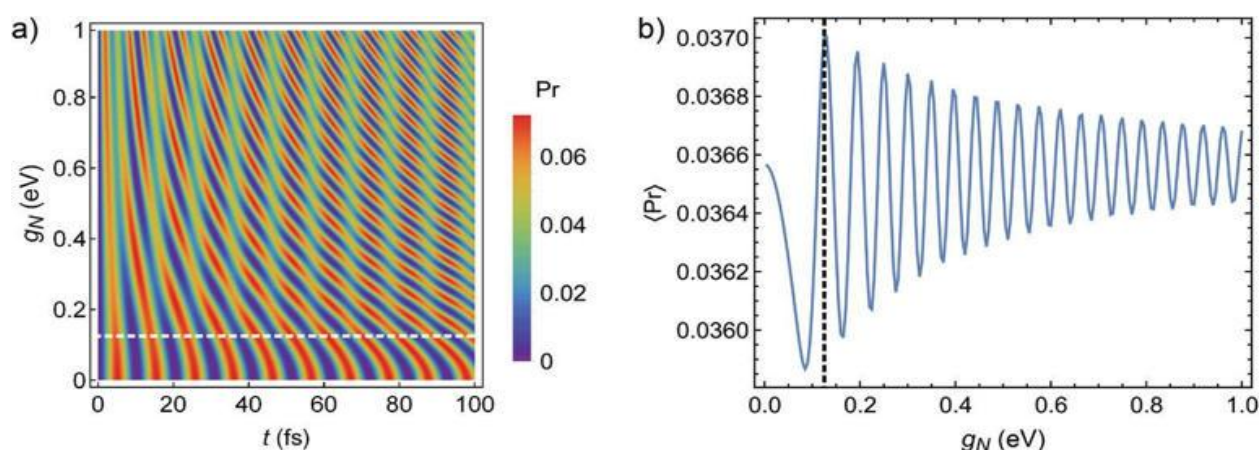
The Samsung S95F flagship OLED TV, on display at CES 2025. (CREDIT: CC BY-SA 4.0)© The Brighter Side of News

A study led by researchers from the University of Turku, Finland, and [Cornell University](#), USA, developed a theoretical model predicting substantial brightness increases in OLEDs by leveraging polaritons. The team explored how the number of coupled molecules influences this effect. "While the general idea of using polaritons in OLED technology is not entirely original, a theory that examines the boundaries of performance gains has been missing. In this work, we carefully examined where the polariton sweet spot lies in different scenarios," said Associate Professor Konstantinos Daskalakis from the [University of Turku](#).

Their findings revealed that strong coupling works best when only a single molecule is involved. With this setup, the dark-to-bright conversion rate increased by an astonishing factor of 10 million.

However, when too many molecules were coupled, the polaritonic effect diminished significantly. This means that merely adding mirrors to OLEDs will not enhance efficiency unless single-molecule strong coupling is achieved. “The next challenge is to develop feasible architectures facilitating [single-molecule](#) strong coupling or invent new molecules tailored for polariton OLEDs. Both approaches are challenging, but as a result, the efficiency and brightness of OLED displays could be significantly improved,” Daskalakis explained.

Another issue is material selection. The effectiveness of polaritonic OLEDs depends on the specific organic molecules used. These materials must not only support strong light-matter interactions but also retain their stability and efficiency over time. Discovering new organic compounds capable of maintaining high performance under real-world conditions is crucial to making this technology viable.



Probability of singlet pairs outside the capture radius (i.e., probability of not getting SSA) as a function of coupling strength and time. (CREDIT: Advanced Optical Materials)© The Brighter Side of News

The widespread adoption of OLEDs has been hindered by efficiency and brightness limitations compared to inorganic LEDs. However, advances in polariton physics and TADF research could soon change this landscape. By finding ways to harvest triplet states effectively, OLEDs may achieve unprecedented levels of [brightness](#) and efficiency.

This research lays the foundation for OLEDs that are not only more efficient but also capable of achieving performance levels once thought impossible.

If successfully implemented, these developments could lead to brighter, longer-lasting, and more energy-efficient displays, revolutionizing the future of screen technology.