Functional materials

Weekly Intelligence Report

2026-05-31 | 24 articles | 11 countries

troy-technical.jp

This Week's Keyword

AI Materials Discovery

Accelerating R&D & autonomous labs

24 articles	11 countries	40 %	<5 years
Total Articles Analyzed	Source Countries	Strength Boost (Wearable)	Catalyst Discovery Time

All 24 Articles This Week — 5-Axis Evaluation Matrix

How to read columns — Tech Novelty: degree of breakthrough Market Proximity: closeness to commercialization Market Impact: industry-wide effect Data Reliability: quantitative data & peer review US/EU Relevance: direct impact on US/European companies & supply chains

#	Article Title	Type	Tech Novelty	Market Proximity	Market Impact	Data Reliability	US/EU Relevance	Summary
#01	Tescan Orage™ 2 Ga+ FIB-SEM	New Product	●●●●○	●●●●○	●●●○○	●●●●○	●●●●●	Tescan's new Ga+ FIB-SEM accelerates TEM sample preparation by 40%, enhancing nanoscale characterization for advanced materials.
#02	PicoQuant Solira TRPL	New Product	●●●●○	●●●●○	●●●○○	●●●●○	●●●●●	PicoQuant's Solira microscope integrates multiple TRPL methods for comprehensive photophysical characterization of advanced materials.
#03	AI for Semicon Discovery	Research	●●●●●	●●○○○	●●●●○	●●○○○	●●●●○	AI system from Australia/UAE accelerates gallium-based semiconductor material discovery by orders of magnitude.
#04	Smart Mat. Fruit Harvest	Review	●●●○○	●●○○○	●●○○○	●●●○○	●●●○○	Review highlights smart materials (SMAs, EAPs) for flexible fruit harvesting robot end-effectors, noting commercialization challenges.
#05	Cooperative Host Molecules	Research	●●●●●	●○○○○	●●○○○	●●●●●	●●●○○	Japanese team visualizes cooperative behavior in macrocyclic host molecules, enhancing molecular capture for future sensors.
#06	AI in Scientific Discovery	Analysis	●●●●○	●●○○○	●●●●○	●●○○○	●●●●●	Stanford HAI discusses AI transforming scientific discovery, with autonomous AI agents and virtual labs accelerating research.
#07	Harvard Robot Muscles	Research	●●●●●	●●○○○	●●●●○	●●○○○	●●●●●	Harvard 3D prints human-like robot muscles using helically aligned LCEs, enabling complex, tunable movements.
#08	Interpretable AI for Mat.	Research	●●●●○	●●○○○	●●●●○	●●○○○	●●●●●	US MIRAGE project uses interpretable AI to unlock fatigue and self-healing mechanisms in advanced materials.
#09	AI Quantum Lab (Qumus)	Research	●●●●●	●●○○○	●●●●○	●●○○○	●●●●●	Stanford's autonomous AI 'Qumus' fabricates graphene transistors, accelerating quantum materials discovery without human intervention.
#10	SNU Artificial Muscle	Research	●●●●●	●●○○○	●●●●○	●●○○○	●●●●○	Seoul National University develops an intelligent artificial muscle integrating actuation and sensing using LCEs and liquid metal.
#11	Megalibraries for AI Data	Research	●●●●○	●●○○○	●●●●○	●●○○○	●●●●●	Northwestern shows megalibraries generate vast, high-quality data for AI-driven materials discovery, accelerating R&D.;
#12	Fujifilm PFAS-Free PBO	New Product	●●●○○	●●●●○	●●●●○	●●●●○	●●●●○	Fujifilm unveils PFAS-free PBO for advanced semiconductor packaging, addressing environmental regulations and customer demand.

#	Article Title	Type	Tech Novelty	Market Proximity	Market Impact	Data Reliability	US/EU Relevance	Summary
#13	IIT Jodhpur Borophene	Research	●●●●●	●○○○○	●●○○○	●●○○○	●●●○○	IIT Jodhpur scientists atomically engineer borophene, unlocking its potential for high-performance batteries and sensors.
#14	NANOSFUN Nanostructures	Research	●●●○○	●●○○○	●●●○○	●●○○○	●●●●●	Spanish NANOSFUN group advances molecular nanostructures for brain disease therapy and energy-efficient chromogenic devices.
#15	AeroVironment Ceramics	Corporate Strategy	●●●○○	●●○○○	●●●●○	●●●●○	●●●●●	AeroVironment wins $20M contract to advance ceramic materials and CMCs for US Air Force/Space Force, using 3D printing.
#16	Argonne Catalyst Discovery	Research	●●●●○	●●○○○	●●●●○	●●●●○	●●●●●	Argonne leads a $2.8M project using AI and autonomous labs to accelerate catalyst discovery from 15-20 years to under five.
#17	Unfrustrated Self-Morphing	Research	●●●●●	●○○○○	●●○○○	●●●●●	●●●○○	Research reveals 3D director fields for stress-free self-morphing in bulk LCEs, advancing artificial muscle design.
#18	Harbin Underwater Robotics	Research	●●●○○	●●○○○	●●●○○	●●○○○	●●●○○	Harbin Engineering develops underwater soft robotic end-effectors with SMAs, EAPs, and distributed sensing for delicate manipulation.
#19	SnS2 Ultralow Thermal Cond.	Research	●●●●●	●○○○○	●●●○○	●●●●●	●●●●●	Dual-ion substitutions in SnS2 induce ultralow thermal conductivity via lattice softening, critical for thermoelectric materials.
#20	VOC-Free Coatings (POSS)	Research	●●●●○	●●○○○	●●●○○	●●●●●	●●●●○	Water-soluble NPOSS enables multiscale-reinforced, VOC-free waterborne coatings via concurrent coalescence and crosslinking.
#21	Collapsible Robot End-Eff.	Analysis	●●●○○	●●○○○	●●●○○	●●○○○	●●●○○	Smart materials like SMAs enable collapsible robotic end-effectors to navigate compact spaces and then rigidize for tasks.
#22	KIMM Wearable Fabric Robot	Research	●●●●○	●●○○○	●●●●○	●●○○○	●●●●○	KIMM develops a wearable fabric robot using SMA smart threads, boosting user strength by 40% for medical and industrial use.
#23	Covestro AI Materials	New Product	●●○○○	●●●●○	●●●●○	●●●●○	●●●●●	Covestro showcases high-performance engineering plastics and TPUs for AI infrastructure and embodied intelligence at COMPUTEX 2026.
#24	UncorrelaTEd Thermoelectric	Research	●●●●○	●●○○○	●●●○○	●●○○○	●●●●●	German UncorrelaTEd project develops liquid-contact porous thermoelectric materials for efficient waste heat to electricity conversion.

●●●●○ High ●●●○○ Med-High ●●○○○ Med ●○○○○ Low | Yellow highlight = featured article

Three Questions That Demand Your Decision This Week

❶ Is your R&D; strategy leveraging AI for materials discovery?

Multiple reports (#03, #06, #09, #11, #16) highlight AI's transformative role in accelerating materials R&D;, from semiconductors to catalysts, by orders of magnitude. Are you investing in autonomous labs and high-throughput data generation (megalibraries) to stay competitive, or risking being outpaced by Asian and US national lab initiatives?

❷ How exposed is your supply chain to PFAS regulations?

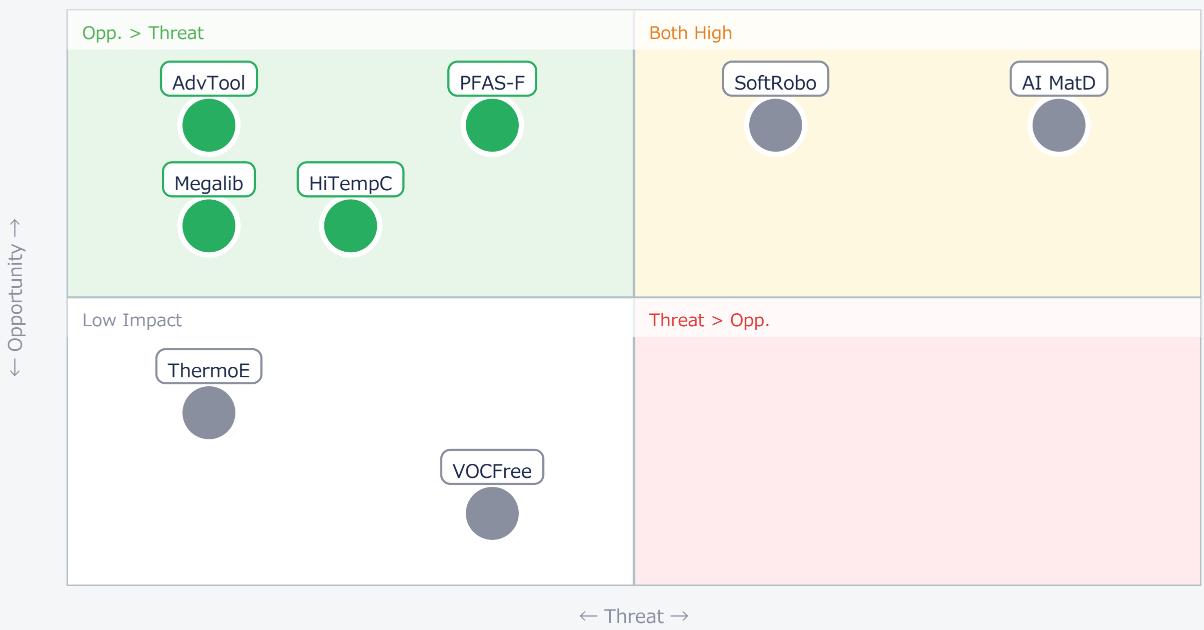
Fujifilm's PFAS-free PBO for semiconductor packaging (#12) signals a critical shift driven by tightening global regulations. Are your procurement teams actively auditing existing materials and securing alternative, compliant suppliers to avoid future disruptions and maintain market access in key regions like the EU and US?

❸ Are you prepared for the soft robotics revolution?

Breakthroughs in 3D printed LCE muscles (#07), integrated actuation/sensing (#10), and wearable SMA robots (#22) promise human-like dexterity and strength augmentation. Does your product roadmap account for these advancements in medical devices, industrial automation, and consumer electronics, or will competitors capture this emerging market?

Opportunities vs. Threats for US/European Companies

Opportunity vs. Threat Matrix for US/European Companies



Item	Quadrant	↑ Opportunity	↓ Threat
● AI MatD	Critical	Accelerate R&D;	Lagging discovery
● SoftRobo	Critical	New products	Competitor lead
● PFAS-F	Opp.	Compliance	Market loss
● AdvTool	Opp.	R&D; efficiency	Outdated labs
● HiTempC	Opp.	Defense contracts	Tech gap

● Megalib	Opp.	AI data supply	Data bottleneck
● ThermoE	Ref.	Waste heat conv.	Limited impact
● VOCFree	Ref.	Eco-coatings	Niche market

Deep Dive ① — AI Autonomous Experimenter for Quantum Materials

#09 | 2026/05/25 | AZoM | Tech Novelty●●●●● Proximity●●○○○ Market Impact●●●●○ Data Reliability●●○○○ US/EU Relevance●●●●●

Stanford researchers introduced Qumus, an autonomous AI experimenter combining generative AI with robotics to independently generate hypotheses, execute experiments, correct errors, and analyze data in quantum materials labs. This system achieved the first AI-driven fabrication of complex atomically thin nanodevices, including graphene field-effect transistors, establishing a self-improving framework.

Qumus accelerates quantum materials discovery without human intervention, addressing the complexity and time-consuming nature of exploring, synthesizing, characterizing, and fabricating devices from 2D materials like graphene. This paradigm shift allows for rapid iteration and optimization of experimental strategies.

▶ Strategic Analyst's Perspective

Strategic Analyst's Perspective: The claim of fully autonomous AI fabricating complex nanodevices is a significant leap, though the 'orders of magnitude' acceleration is qualitative. Technical barriers include ensuring robustness, reproducibility, and handling unexpected experimental outcomes without human oversight. [Opportunity] for US/EU R&D; labs and materials suppliers to integrate similar autonomous systems, drastically shortening discovery cycles for advanced materials and quantum technologies. [Threat] is that Asian competitors, already strong in materials science, could rapidly adopt and scale such AI-driven platforms, creating a significant competitive advantage. Next actions: [R&D;] Form a task force to evaluate autonomous lab technologies and pilot AI integration in a specific materials discovery workflow by Q4 2026.

Deep Dive ② — 3D Printed Human-Like Robot Muscles

#07 | 2026/05/28 | Futuro Prossimo | Tech Novelty●●●●● Proximity●●○○○ Market Impact●●●●○ Data Reliability●●○○○ US/EU Relevance●●●●●

Harvard University researchers developed a novel 3D printing technology to create robot muscles mimicking human movement by co-printing liquid crystal elastomers (LCEs) with passive materials. A key innovation is using a rotating nozzle to helically align LCE molecules, enabling precise control over bending and twisting for complex, naturalistic robotic motions.

This method allows for tunable helical actuation, overcoming limitations of conventional LCE actuators that were restricted to simple elongation or bending. It paves the way for soft robots with multi-directional deformation capabilities, crucial for delicate operations in medicine, exploration, and prosthetics.

▶ Strategic Analyst's Perspective

Strategic Analyst's Perspective: The concept of 3D printing LCEs with helical alignment for human-like motion is highly novel. While the article is a press release, the technical approach is sound. Remaining barriers include scaling up printing, improving response speed, and ensuring durability for practical applications. [Opportunity] for US/EU OEMs and device manufacturers in medical robotics, prosthetics, and industrial soft grippers to integrate this technology for superior product performance and new functionalities. [Threat] is that competitors who invest early in LCE material science and advanced additive manufacturing could establish IP dominance and market leadership in next-gen soft robotics. Next actions: [R&D;] Initiate internal research on LCE 3D printing and helical actuation, targeting proof-of-concept for a specific soft robot application by mid-2027. [Business Dev] Explore partnerships with Harvard or other LCE specialists.

Deep Dive ③ — Fujifilm's PFAS-Free PBO for Semiconductors

#12 | 2026/05/26 | Business Wire | Tech Novelty●●●○○ Proximity●●●●○ Market Impact●●●●○ Data Reliability●●●●○ US/EU Relevance●●●●○

Fujifilm will unveil PFAS-free PBO (polybenzoxazole) materials from its ZEMATES™ product line at ECTC 2026. These photosensitive insulating materials are used in advanced semiconductor packaging, from power semiconductors to high-performance AI chips. The new formulation meets growing regulatory and customer demand for environmentally friendly materials.

This development is a strategic response to tightening global regulations on per- and polyfluoroalkyl substances (PFAS) due to environmental persistence and health concerns. The PFAS-free PBO aims to retain the excellent electrical, thermal, and mechanical properties of conventional PBO while significantly reducing environmental impact.

▶ Strategic Analyst's Perspective

> Strategic Analyst's Perspective: Fujifilm's announcement of a PFAS-free PBO is highly credible, given their established position in materials for semiconductor packaging. This is a direct response to clear regulatory and market drivers, making it a near-term commercial reality. Technical barriers would primarily be ensuring seamless drop-in compatibility and long-term reliability for diverse packaging processes. [Opportunity] for US/EU materials suppliers to develop and commercialize their own PFAS-free alternatives, and for OEMs to secure compliant supply chains, enhancing brand value. [Threat] is significant for any US/EU company still reliant on PFAS-containing PBOs, risking regulatory non-compliance, market exclusion, and supply chain disruption. Next actions: [Procurement] Conduct an immediate audit of all semiconductor packaging and critical component materials for PFAS content and identify alternative suppliers by Q3 2026. [R&D;] Prioritize development of PFAS-free material solutions to match or exceed Fujifilm's offering.

Other Notable Articles

Tescan's New Orage™ 2 Ga+ FIB-SEM Sets New Standard for Automated TEM Sample Preparation (AZoM)
Tech Novelty●●●●○ Proximity●●●●○ Market Impact●●●○○

New EU-made FIB-SEM offers 40% faster TEM sample prep, critical for advanced materials and semiconductor R&D.;

AI Accelerates Scientific Discovery, Driving Autonomous Labs and Human-AI Collaboration (Stanford HAI)
Tech Novelty●●●●○ Proximity●●○○○ Market Impact●●●●○

Stanford highlights AI's role in autonomous labs and virtual research, transforming scientific discovery across fields.

AeroVironment Secures $20M Contract to Advance Ceramic Materials for U.S. Air Force and Space Force (AeroVironment)
Tech Novelty●●●○○ Proximity●●○○○ Market Impact●●●●○

US defense contract for high-temp ceramics and CMCs using 3D printing signals critical material needs for aerospace.

Covestro Unveils High-Performance Materials for AI Infrastructure and Embodied Intelligence at COMPUTEX 2026 (Covestro)
Tech Novelty●●○○○ Proximity●●●●○ Market Impact●●●●○

German supplier showcases engineering plastics and TPUs for AI servers and soft robotics, emphasizing sustainability.

Recommended Actions This Week

Action recommendations based on article evaluation matrix and opportunity/threat analysis.

Immediate (this week)

- [Executive] Review current AI/ML investment strategy for materials R&D;, comparing against autonomous lab advancements in US/Asia.
- [Procurement] Initiate an urgent audit of all semiconductor packaging and critical component materials for PFAS content and compliance risks.
- [R&D;] Identify internal projects where AI-driven hypothesis generation or autonomous experimentation could yield 10x acceleration.

Short-term (1 month)

- [R&D;] Task a team to evaluate new advanced characterization tools (e.g., Tescan FIB-SEM, PicoQuant TRPL) for efficiency gains in materials analysis.
- [Strategy] Assess the competitive landscape in soft robotics and advanced actuators, particularly for medical, industrial, and defense applications.
- [Business Dev] Explore potential partnerships or licensing opportunities with leading research institutions in AI for materials science and soft robotics.

Medium-long term (quarter+)

- [R&D;] Develop a roadmap for integrating high-throughput data generation (e.g., megalibraries) with AI platforms to scale materials discovery efforts.
- [Supply Chain] Establish a long-term strategy for transitioning to PFAS-free materials across all relevant product lines, including alternative supplier development.
- [Strategy] Investigate the long-term implications of AI-driven materials design on product lifecycles, IP strategy, and market differentiation.

FunctionalMaterials — Selected Articles

Date: 2026-05-31

Articles: 24

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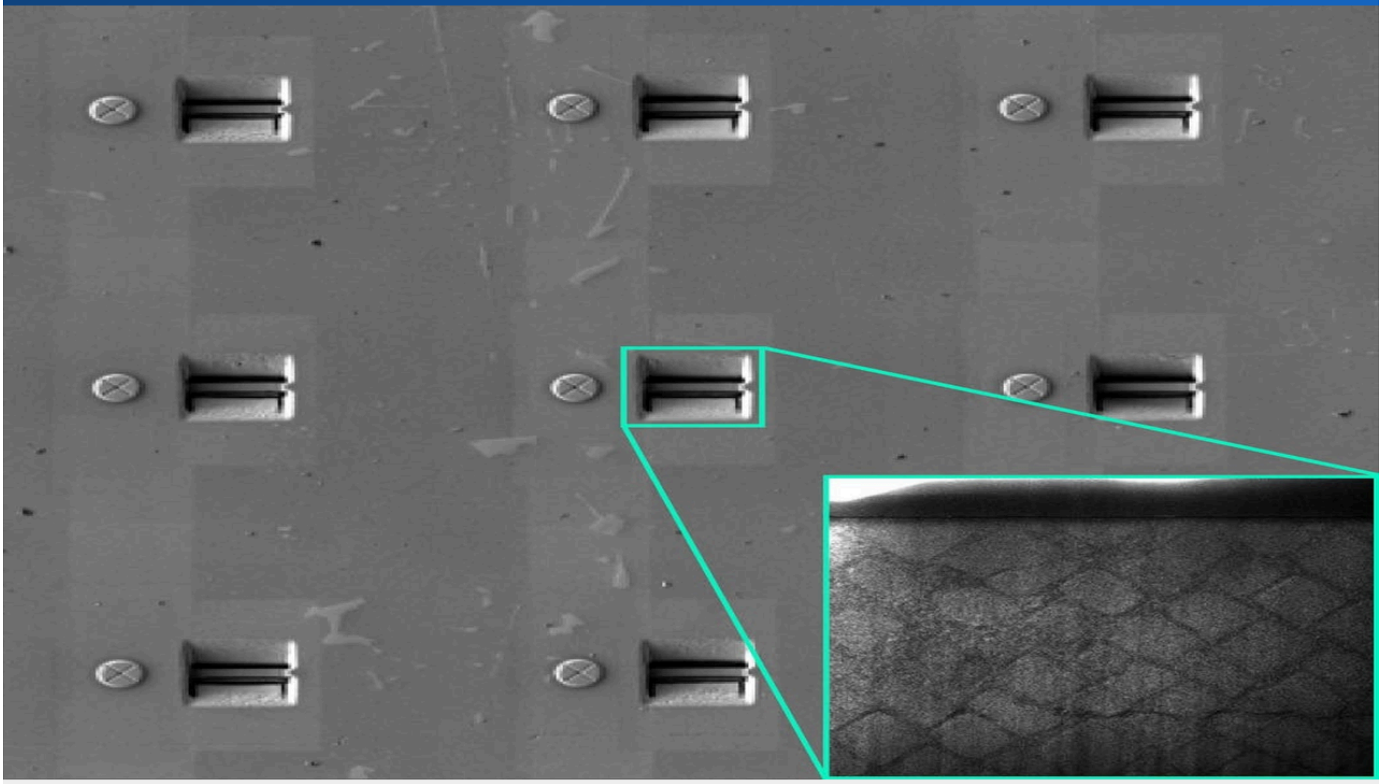
Tescan's Orage™ 2 Ga+ FIB-SEM Redefines Automated TEM Sample Preparation

Published Published May 28, 2026 AZoM チェコ



OVERVIEW

Tescan has launched Orage™ 2, a next-generation Ga+ FIB-SEM column integrated into its AMBER 2 platform, designed to revolutionize TEM sample preparation and nanoscale characterization in advanced materials science. This system innovatively combines low-keV FIB resolution with high beam current, achieving up to 40% faster milling speeds compared to conventional Ga+ FIB-SEM systems while maintaining the exquisite precision required for ultra-thin TEM lamellae. The Orage™ 2 significantly streamlines research workflows, enabling more rapid and higher-quality sample creation for accelerated material analysis and discovery.

Background: Challenges in High-Precision TEM Sample Preparation

Nanoscale characterization of materials using Transmission Electron Microscopy (TEM) is indispensable across diverse fields, including semiconductors, metals, and composites. However, preparing ultra-thin, high-quality lamellae suitable for TEM observation is a highly demanding and time-consuming process. Achieving precise fabrication without inducing damage, especially for complex structures or delicate materials, remains a significant challenge. While conventional Focused Ion Beam-Scanning Electron Microscope (FIB-SEM) systems have evolved, there has been a persistent demand for further enhancements in both speed and precision to meet the growing needs of advanced materials research.

Key Findings: Orage™ 2 Establishes a New Benchmark in Automated TEM Sample Production

Tescan, headquartered in the Czech Republic, has introduced the Orage™ 2, a cutting-edge Ga+ FIB-SEM column integrated into its AMBER 2 platform. The Orage™ 2 aims to revolutionize automated TEM sample preparation processes, addressing the rigorous requirements of modern materials science research. A hallmark of this system is its unique design, which simultaneously achieves high-resolution ion beam performance at low kiloelectronvolt (keV) energies and superior high-beam current capabilities. This enables milling speeds up to 40% faster than traditional Ga+ FIB-SEM systems, all while meticulously maintaining the nanometer-level precision essential for crafting ultra-thin TEM lamellae. Consequently, researchers can obtain high-quality samples more rapidly, leading to a substantial efficiency gain in their material characterization workflows.

Technical Significance and Outlook

The introduction of Orage™ 2 establishes a new industry standard in automated TEM sample preparation, poised to profoundly impact materials science research. Its capacity for rapid and high-precision sample fabrication will accelerate research cycles, particularly in areas such as defect analysis of next-generation semiconductor devices, microstructural evaluation of novel materials, and nanotechnology development. This allows researchers to analyze a greater volume of samples more efficiently and gain deeper insights into material structure-property relationships more swiftly. Moving forward, advanced FIB-SEM technologies like Orage™ 2 are expected to form a foundational pillar for driving innovation across a broad spectrum of fields, from material design to the optimization of manufacturing processes, fostering significant technological advancements.

Source: https://www.azom.com/news.aspx?newsID=65483

PicoQuant Introduces Solira: A Novel Time-Resolved Photoluminescence Microscope for Advanced Materials Characterization

Published May 28, 2026 Spectroscopy Online Germany

OVERVIEW

PicoQuant has launched Solira, a new modular upright microscope designed for time-resolved photoluminescence (TRPL) and comprehensive materials characterization. Solira supports a wide range of advanced material systems, including semiconductors, perovskites, nanomaterials, LEDs, and quantum emitters. Unveiled at the E-MRS Spring Meeting 2026, the system integrates multiple advanced methodologies such as TRPL imaging, carrier diffusion mapping, and correlation measurements onto a single platform.

IN DEPTH

Background: Importance of Advanced Material Characterization and Existing Limitations

Advanced materials like semiconductors, quantum dots, and perovskites are crucial for progress in electronics, photonics, and energy conversion. Maximizing their performance necessitates a precise understanding of their photophysical properties, including exciton lifetimes, charge carrier dynamics, and defect presence. While time-resolved photoluminescence (TRPL) is a powerful technique for these investigations, conventional systems often struggle to integrate multiple measurement methods. This presents challenges in terms of flexibility for diverse material systems and the speed of data acquisition and analysis.

Key Findings: Solira's Multifunctional TRPL Capabilities

PicoQuant, a German company, has unveiled Solira, a new time-resolved photoluminescence (TRPL) microscope. Solira is a modular upright microscopy system engineered for comprehensive photophysical characterization of advanced materials. This new instrument is specifically designed to accommodate a broad spectrum of material systems, including semiconductors, perovskites, nanomaterials, LEDs, and quantum emitters. Its primary innovation lies in integrating multiple advanced measurement techniques, such as TRPL imaging, carrier diffusion mapping, and correlation measurements based on Time-Correlated Single Photon Counting (TCSPC), onto a single, unified platform. This integration allows researchers to perform efficient and multi-faceted material characterization without the need to transfer samples between different experimental setups. Solira made its global debut at the E-MRS Spring Meeting 2026, where its innovative capabilities were widely showcased.

Technical Significance and Outlook

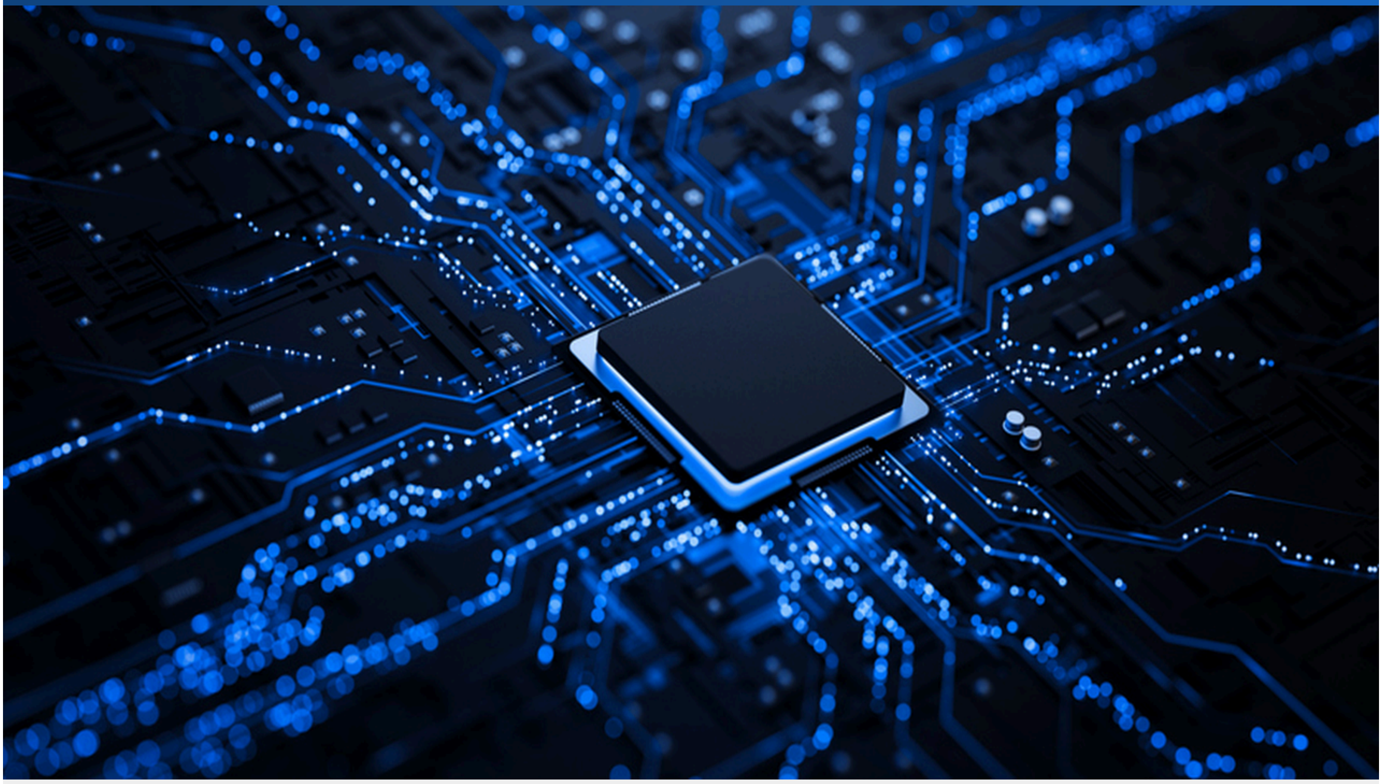
The introduction of Solira marks a significant leap forward in the fields of time-resolved spectroscopy and microscopy. Its multi-functionality within a single platform enables researchers to achieve a deeper and broader understanding of material photophysical behavior. This will accelerate material design and optimization across various application areas. For instance, it can aid in optimizing charge carrier transport mechanisms in next-generation solar cell materials, enhancing the efficiency of quantum emitters in quantum information science, and elucidating emission mechanisms for high-performance LED development. Solira is expected to boost the pace and quality of advanced materials research, serving as a critical foundation for the development of next-generation devices.

Source: https://www.spectroscopyonline.com/view/picoquant-launches-solira-a-new-instrument-in-time-resolved-photoluminescence-microscopy

Collected: May 30, 2026 | Automated Research System (Gemini API)

AI Accelerates Next-Gen Semiconductor and Electronic Materials Discovery by Orders of Magnitude

Published May 25, 2026 Flinders News Australia



OVERVIEW

An international team from Flinders University (Australia) and Khalifa University (UAE) is leveraging an AI system to accelerate the development of next-generation gallium-based semiconductor materials several times faster than traditional methods. This machine learning platform acts as a "smart materials discovery engine," drastically reducing the time required for complex computational and laboratory experiments. The AI learns hidden chemical rules governing gallium-based material behavior, enabling it to predict novel material compositions with desired electronic properties, thereby accelerating semiconductor innovation.

IN DEPTH

Background: Evolution and Bottlenecks in Semiconductor Material Development

In modern society, computer chips and electronic materials form the bedrock of advanced technologies such as AI, IoT, and high-speed communications. Further evolution of these technologies critically depends on the development of higher-performance and more energy-efficient semiconductor materials. Gallium-based semiconductors, in particular, are strong candidates for next-generation devices due to their high electron mobility and advantageous bandgap characteristics. However, the discovery and optimization of new materials traditionally involve exploring an enormous number of compositional and structural combinations, making conventional experimental and computational methods incredibly time-consuming and costly. This bottleneck has significantly limited the pace of technological innovation.

Key Findings: AI as a "Smart Materials Discovery Engine"

An international collaborative research team comprising Flinders University in Australia and Khalifa University in the United Arab Emirates has developed a groundbreaking "smart materials discovery engine" utilizing artificial intelligence (AI) to overcome these challenges. This machine learning platform possesses the autonomous capability to learn complex, hidden chemical rules that govern the behavior of gallium-based materials. Whereas traditional materials development required extensive trial-and-error and detailed simulations, this AI engine efficiently predicts new material compositions with specific desired electronic properties based on historical data and underlying physical laws. This approach has successfully dramatically reduced the number of necessary computational and laboratory experiments, shortening the development period by orders of magnitude compared to conventional methods.

Technical Significance and Outlook

This AI-driven material discovery platform heralds a new paradigm in semiconductor material development. The significant acceleration of the development cycle will hasten the market introduction of next-generation computer chips and contribute to the realization of cutting-edge technologies like high-performance AI accelerators and quantum computing. Furthermore, this approach is not limited to gallium-based materials but can be applied to the exploration of various other functional materials. This promises the creation of energy-efficient devices, novel sensors, and innovative electronic components that were previously unimaginable. The synergy of AI and materials science is poised to become a powerful engine driving future technological innovation, contributing to the realization of a more sustainable and high-performance society.

Source: https://news.flinders.edu.au/blog/2026/05/26/ai-speeds-up-discovery-of-next-gen-computer-chips-and-electronic-materials/

Smart Materials Driving Innovation in Fruit Harvesting Robotics End-Effectors: A Review

Published May 26, 2026 MDPI Switzerland

OVERVIEW

A comprehensive review examines the application of smart materials like Shape Memory Alloys (SMAs), Electroactive Polymers (EAPs), and Ionic Polymer-Metal Composites (IPMCs) in fruit harvesting robot end-effector technologies. While SMAs offer structural simplicity and quiet operation, their slow thermal response limits commercial viability. Overall, smart materials are recognized for their potential to enable miniaturization, integration, and enhanced flexibility in end-effector designs, addressing critical challenges in automated agriculture.

IN DEPTH

Background: The Imperative of Automated Fruit Harvesting and End-Effector Challenges

Driven by labor shortages and the pressing need for increased agricultural efficiency, automated fruit harvesting has become a critical global challenge. A key component determining the performance of harvesting robots is the "end-effector," which is responsible for gripping and harvesting fruit without causing damage. End-effectors must meet several demanding requirements: delicate force control for handling soft fruits, flexibility to accommodate various fruit shapes and sizes, and rapid operation. Traditional rigid robotic hands have struggled to fulfill all these requirements, prompting the search for more advanced materials and designs to achieve precision and gentleness.

Key Findings: Smart Materials Revolutionizing End-Effector Design

A review article published by MDPI provides a detailed analysis of the application of smart materials in end-effector technologies for fruit harvesting robots. The review highlights several types of smart materials:

- **Shape Memory Alloys (SMAs):** These alloys offer structural simplicity, high power density, and silent operation, holding promise for biomimetic movements. However, their thermal activation leads to relatively slow response times, posing a challenge for meeting the speed requirements of commercial harvesting.
- **Electroactive Polymers (EAPs):** Often called "artificial muscles," EAPs can undergo significant deformation when an electric voltage is applied. They contribute to flexible and lightweight end-effector designs, but high driving voltages and durability can be limiting factors.
- **Ionic Polymer-Metal Composites (IPMCs):** IPMCs can deform substantially under low voltages and are also promising for underwater operation. Nevertheless, performance degradation in dry environments and manufacturing costs remain challenges.

The review concludes that these materials enable the miniaturization, lightweighting, and increased flexibility of end-effectors, facilitating the development of more delicate and intelligent harvesting operations.

Technical Significance and Outlook

This review clearly delineates the potential and limitations of smart materials in the design of fruit harvesting robot end-effectors. The integration of smart materials is essential for enhancing the "dexterity" of robots, allowing them to sense the softness and shape of fruit and adjust gripping force accordingly. Moving forward, crucial research and development efforts will focus on improving response speed, ensuring durability, and establishing low-cost mass production techniques for smart material-based end-effectors. Furthermore, the combination of multiple smart materials in hybrid end-effectors and the optimization of gripping strategies through AI will be key to dramatically improving harvesting efficiency and quality in future agricultural robotics.

Source: https://www.mdpi.com/1424-8220/26/11/3382

Revealing Cooperative Behavior in Macrocyclic Host Molecules Enhances Surface-Based Molecular Capture

Published May 27, 2026 Asia Research News Japan

OVERVIEW

A Japanese research team discovered that macrocyclic host molecules exhibit cooperative behavior in guest molecule capture when densely packed on a solid surface. This phenomenon, where the host molecules' individual capture abilities are enhanced collectively, was directly visualized at the single-molecule level using atomic force microscopy (AFM) techniques. This insight provides crucial guidance for designing next-generation chemical sensors, separation systems, and storage materials.

IN DEPTH

Background: Fundamental Principles of Molecular Recognition and Functional Materials

Molecular recognition, the selective binding and recognition of specific molecules by others, underpins various functional materials used in chemical sensors, pharmaceuticals, and separation processes. Macrocyclic host molecules, with their large cyclic structures, are particularly effective in encapsulating guest molecules within their cavities, enabling highly efficient molecular capture and selective transport. However, the exact mechanisms by which these molecules behave on solid surfaces and interact cooperatively to express their functions have not been fully understood. A deeper understanding of molecular arrangement and interactions on surfaces is essential for designing high-performance functional materials.

Key Findings: AFM Visualizes Single-Molecule Cooperative Behavior

A collaborative research team from multiple Japanese institutions (Osaka University, Tokyo Institute of Technology, Hiroshima University, and Kyushu University) experimentally demonstrated that macrocyclic host molecules immobilized on a solid surface exhibit "cooperative behavior" in guest molecule capture, but only when densely assembled. They successfully employed two atomic force microscopy (AFM) techniques—non-contact AFM and jump-scan AFM—to directly observe, at a single-molecule level, structural changes in host molecules and their interactions with guest molecules. Specifically, they proved that when host molecules are densely packed on a surface, their individual capture capabilities are enhanced beyond what they would exhibit in isolation, leading to more efficient guest molecule encapsulation. This cooperativity is believed to be induced by subtle structural changes and electronic interactions between adjacent host molecules.

Technical Significance and Outlook

This discovery provides new insights into the design principles of molecular assemblies and will significantly impact future functional materials development. The understanding that molecules can function not only individually but also collectively to enhance overall performance offers direct applications. For instance, it can be utilized in designing next-generation chemical sensors for ultra-sensitive detection of trace substances, advanced separation membranes for efficient isolation of specific compounds, or materials for effective gas and drug storage and release. Particularly in bottom-up approaches that leverage molecular self-assembly on surfaces to precisely construct nanostructures with targeted functions, controlling this cooperative behavior becomes a critical factor. In the future, applying this principle is expected to accelerate the creation of high-performance smart materials with diverse applications in environmental monitoring, medical diagnostics, and the energy sector.

Source: https://www.asiaresearchnews.com/content/revealing-molecular-cooperation-macrocyclic-host-molecules-work-together-surface

Collected: May 30, 2026 | Automated Research System (Gemini API)

AI Accelerates Scientific Discovery, Driving Autonomous Labs and Human-AI Collaboration

Published May 27, 2026 Stanford HAI USA

OVERVIEW

Stanford HAI's AI+Science conference discussed how AI is fundamentally transforming scientific discovery. While AI accelerates hypothesis generation, experimental design, and data analysis, some projects are advancing towards fully autonomous AI agents conducting research independently in 'virtual labs.' This evolution demonstrates AI's potential to open new scientific frontiers through collaborative human-AI efforts, allowing researchers to focus on higher-level conceptual challenges.

IN DEPTH

Background: The Transformative Era of Scientific Discovery

Contemporary science faces immense challenges stemming from the generation of vast datasets, complex simulations, and extensive experimental explorations. Traditional scientific methodologies have struggled to cope with these demands and dramatically accelerate the pace of discovery. The rapid advancement of artificial intelligence (AI) has the potential to fundamentally alter this landscape, transforming how scientists conduct research. AI is now capable of extracting patterns from complex datasets, generating new hypotheses, optimizing experimental designs, and even autonomously executing experiments.

Key Findings: Autonomous AI Agents and the Rise of "Virtual Labs"

The AI+Science conference hosted by Stanford HAI delved into how AI is contributing to every stage of scientific discovery. A key theme was the transition of AI beyond a mere research tool to a more profound role as an “autonomous scientific agent.” For instance, Professor James Zou from Stanford University is pioneering research towards a “virtual lab” concept, where AI agents autonomously run research group meetings and independently design new antibodies. These AI agents autonomously iterate through cycles of generating new hypotheses from existing knowledge bases, planning optimal experimental pathways, predicting outcomes through simulations, and finally analyzing the results to learn. This paradigm allows researchers to concentrate on higher-level conceptual challenges, while AI handles data-driven, iterative tasks.

Technical Significance and Outlook

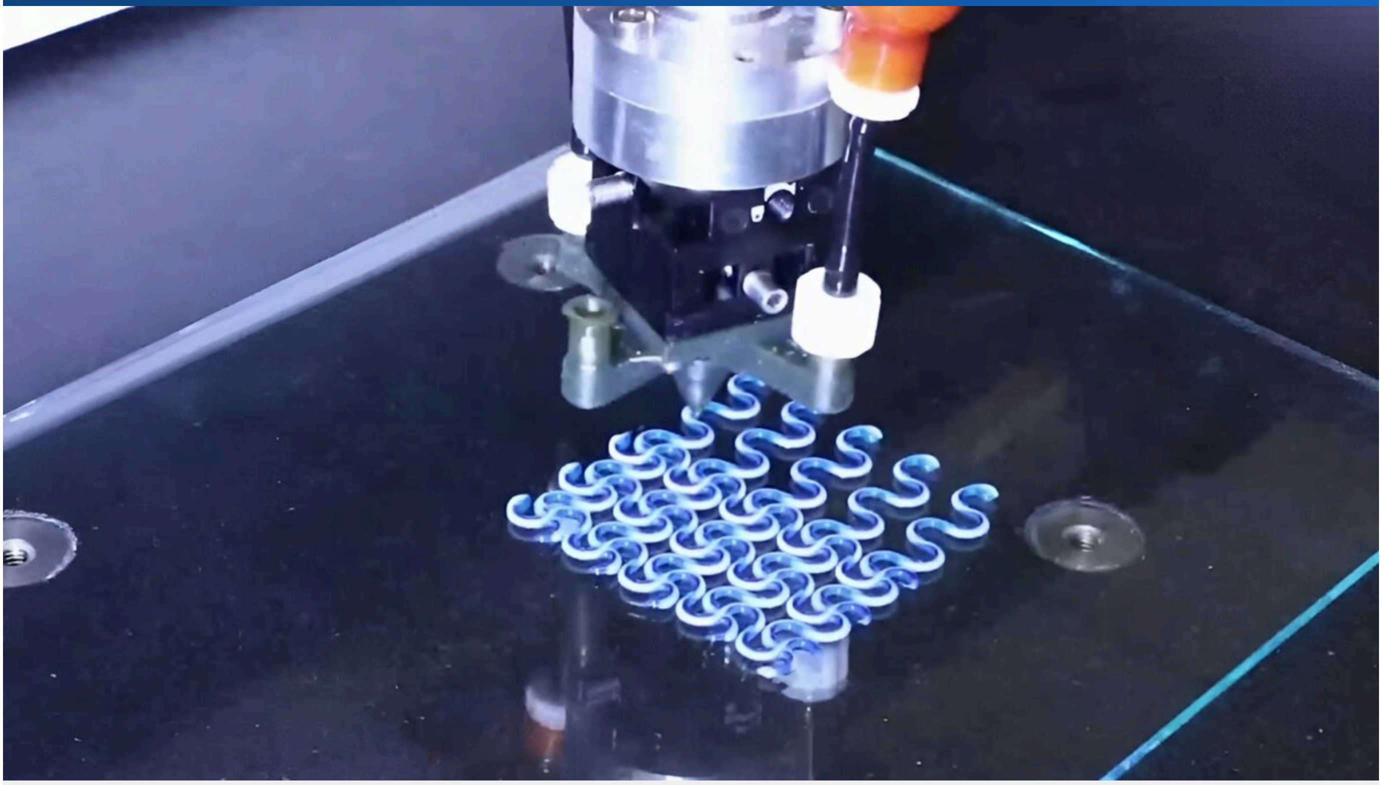
The deep integration of AI into the scientific discovery process is crucial not only for accelerating research but also for enabling the understanding of previously intractable complex systems and facilitating unexpected discoveries. AI-driven “virtual labs” in fields such as materials science, biology, chemistry, and physics will dramatically streamline the screening of vast numbers of candidate materials, accelerate drug development, and enable rapid validation of new theories. Furthermore, AI's ability to analyze data free from human cognitive biases holds the potential to uncover relationships and patterns that have been overlooked by existing knowledge. However, ethical considerations, data transparency, and the division of labor between humans and AI in such autonomous systems require ongoing discussion and careful consideration. In the future, seamless collaboration between AI and human researchers, maximizing each other's strengths, will further expand the frontiers of scientific understanding.

Source: https://hai.stanford.edu/news/how-ai-is-transforming-scientific-discovery-while-keeping-humans-at-the-center

Collected: May 30, 2026 | Automated Research System (Gemini API)

Harvard Researchers Develop 3D Printing Method for Human-Like Robot Muscles with Tunable Helical Actuation

Published May 28, 2026 Futuro Prossimo USA



OVERVIEW

Harvard University researchers developed a novel 3D printing technology combining two flexible elastomers to create robot muscles mimicking human movement. The method co-prints liquid crystal elastomers (LCEs), which contract with specific temperature changes, alongside passive, deformation-resistant materials. A key innovation is the use of a rotating nozzle to helically align LCE molecules during printing, enabling precise control over the direction and intensity of bending and twisting, crucial for achieving complex, naturalistic robotic motions.

IN DEPTH

Background: Advancements in Soft Robotics and Actuator Challenges

Soft robots, composed of flexible materials, hold significant promise for applications across various fields, including medicine, exploration, and human-robot collaboration, due to their ability to adapt to complex environments and safely handle delicate objects. However, designing actuators—the "muscles" that power soft robots—has been challenging. These actuators need to simultaneously achieve high power density, rapid response, and complex multi-directional deformation capabilities akin to human muscles. While 3D printing offers advantages in creating intricate shapes, the technology for integrating different functional materials to produce multi-functional actuators in a single step has been nascent.

Key Findings: Helically Aligned LCEs via Composite 3D Printing

To address these challenges, a research team at Harvard University has developed an innovative technology for integrally 3D printing two types of flexible elastomers. At the core of this technology is the combination of "Liquid Crystal Elastomers (LCEs)," which contract in response to specific temperature changes, and "passive elastomers," which provide structural stability and resist deformation. The researchers successfully used a custom-designed rotating nozzle to precisely align LCE molecules in a "helical" pattern during the 3D printing process. This helical alignment dramatically influences the actuator's motion. While conventional LCE actuators were primarily limited to simple elongation or bending, the helical structure now enables the generation of complex, multi-directional deformations such as predictable and controlled twisting and bending in response to thermal stimuli. This breakthrough paves the way for creating "muscles" that mimic the intricate movements of a human arm or fingers using a single actuator.

Technical Significance and Outlook

This composite 3D printing technology opens new avenues for soft robot actuator design. The ability to precisely control the molecular alignment of LCEs allows for unprecedented customization of a robot's direction, speed, and intensity of movement. This promises diverse applications, such as enhancing the ability of surgical robots to perform more delicate operations, enabling prosthetic limbs to achieve more natural movements, or allowing exploration robots navigating debris in disaster zones to adapt more flexibly to their environment. Furthermore, this technology accelerates the development of bio-inspired robots that mimic the complex functions of human muscles, laying the foundation for soft robots to perform a wider range of tasks. In the future, integrating thermal-responsive LCEs with other smart materials like photo-responsive or electro-responsive elements could lead to the creation of even more advanced and multi-functional artificial muscles.

Source: https://en.clickpetroleoegas.com.br/a-new-3d-printing-technology-promises-to-give-robots-muscles-similar-to-humans-asaf04/

Collected: May 30, 2026 | Automated Research System (Gemini API)

Interpretable AI Unlocks Fatigue and Self-Healing Mechanisms in Advanced Materials Research

Published May 25, 2026 Lab Manager USA

OVERVIEW

The MIRAGE project, a collaboration of US National Labs and USC, launched to deepen understanding of material fatigue and self-healing processes through interpretable AI and high-performance computing. This initiative integrates AI-driven simulations with guided experiments to identify fundamental drivers of fatigue, building a comprehensive reference library and efficient models for material behavior simulation. The focus on explainable AI aims to demystify AI's decision-making, fostering trust and deeper scientific insight into complex material phenomena.

IN DEPTH

Background: The Complex Mechanisms of Material Fatigue and Self-Healing

In various high-performance industries, such as aerospace, automotive, and energy, material fatigue represents a critical challenge significantly impacting the reliability and lifespan of structures. The mechanisms of crack initiation and propagation due to fatigue are complex, involving numerous interconnected factors like material microstructure, stress states, and environmental conditions. Furthermore, self-healing materials, which have garnered recent attention for their ability to autonomously repair damage, contribute to extended material lifespan and enhanced safety. However, their repair mechanisms are also intricate, requiring extensive experimentation and analysis for complete understanding and accurate prediction. Traditional analytical methods have struggled to pinpoint the root causes of these complex phenomena and precisely predict future material behavior.

Key Findings: The MIRAGE Project and Explainable AI Integration

To address these challenges, the "MIRAGE" project was launched, bringing together researchers from leading U.S. national laboratories (Argonne, Sandia, Los Alamos, and Lawrence Livermore National Laboratories) and the University of Southern California. MIRAGE uniquely integrates "Explainable AI (XAI)" with high-performance computing into materials science research. While conventional AI models offer high predictive accuracy, their decision-making processes have often been a "black box." XAI aims to explain AI's decision-making mechanisms in a human-understandable format. The project combines AI-driven simulations with "guided experiments," where AI proposes the next experimental conditions, to identify fundamental physical and chemical factors in material fatigue processes and self-healing mechanisms. This approach allows AI to analyze complex relationships between material microstructure and macroscopic behavior, uncovering hidden mechanisms that drive fatigue and repair. Ultimately, the project aims to systematize these insights into a comprehensive reference library and develop predictive models capable of efficiently simulating material behavior.

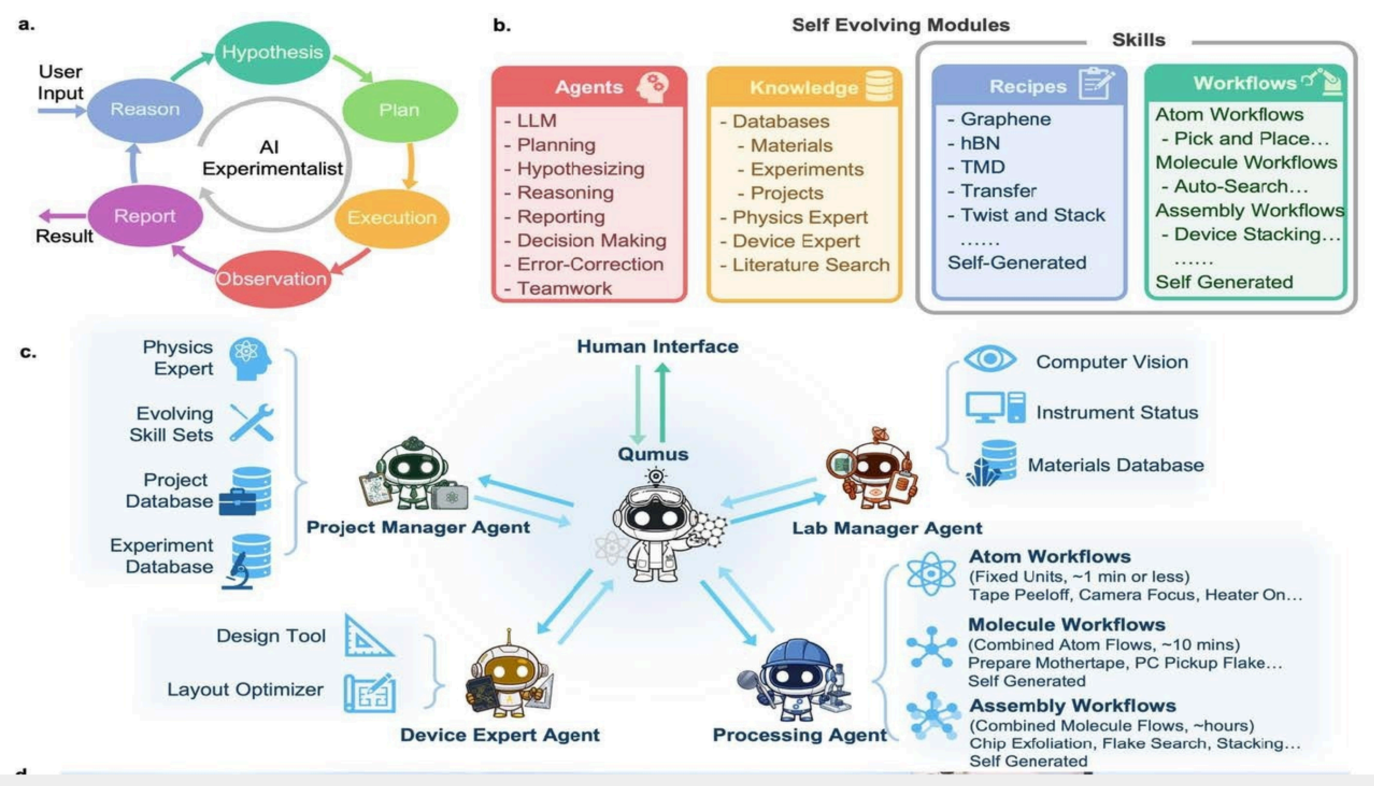
Technical Significance and Outlook

The MIRAGE project is set to evolve AI's role in materials science from merely a data analysis tool to a partner that accelerates discovery. The utilization of interpretable AI is crucial for scientists to trust AI's predictions and deepen their physical insights behind them. This enables researchers to gain a profound understanding of "why" specific materials fatigue or "how" they self-heal. These insights will directly contribute to the design of structural materials with superior fatigue resistance, the development of efficient self-healing materials, and the creation of highly reliable material systems for extreme environments. In the future, the technologies and knowledge developed within MIRAGE are expected to not only enhance the safety and longevity of critical infrastructure such as aircraft, nuclear power plants, and spacecraft but also significantly shorten the design cycle for new functional materials, profoundly impacting materials engineering as a whole.

Source: https://www.labmanager.com/how-interpretable-ai-could-transform-materials-r-d-35416

AI Enters Quantum Materials Lab, Autonomously Builds Graphene Transistor for Accelerated Discovery

Published May 25, 2026 AZoM USA



OVERVIEW

Researchers have introduced Qumus, an autonomous and physically embodied AI experimenter in quantum materials, combining generative AI with robotics to independently generate hypotheses, execute experiments, correct errors, and analyze data. Qumus achieved the first AI-driven fabrication of complex atomically thin nanodevices, including graphene field-effect transistors, demonstrating a self-improving framework to accelerate quantum materials discovery without human intervention.

IN DEPTH

Background: Complexity and the Need for Automation in Quantum Material Development

Quantum materials, exemplified by graphene and other atomically thin two-dimensional (2D) materials, hold promise for transformative applications in next-generation electronics, photonics, and quantum computing. However, the processes of exploring, synthesizing, characterizing, and fabricating devices from these materials are incredibly complex, demanding significant time and specialized expertise. Particularly, the fabrication of nanodevices requiring atomic-level precision often relies heavily on skilled human labor, thereby limiting the pace of research and development. Against this backdrop, automating and intelligentizing research processes has become an urgent imperative for accelerating discovery in the field of quantum materials.

Key Findings: Autonomous AI Experimenter "Qumus" Fabricates Graphene Transistors

To address these challenges, researchers at Stanford University have developed and introduced "Qumus," an autonomous AI experimenter, into quantum materials laboratories. Qumus is a system integrating generative AI with advanced robotics, capable of independently executing the entire scientific discovery cycle—from hypothesis generation, experimental planning, execution, data analysis, error correction, to generating new hypotheses—all without human intervention. Its most groundbreaking achievement is the first AI-driven fabrication of complex atomically thin nanodevices, including graphene field-effect transistors. This demonstrates that AI can function not merely as an analytical tool but as an autonomous "scientist" that physically operates in an experimental environment and produces results. Qumus has established a self-improving framework that refines its experimental strategies through trial and error, accelerating the discovery and optimization of quantum materials through efficient learning.

Technical Significance and Outlook

The introduction of Qumus holds the potential to fundamentally transform the research paradigm in quantum materials science. Its ability to autonomously conduct complex experiments and discover new materials and devices with minimal human intervention will dramatically increase the speed of research and development. This will accelerate the exploration of novel quantum materials such as graphene, topological insulators, and superconductors, contributing to the realization of high-performance sensors, energy-efficient devices, and future quantum computing systems. In the future, autonomous AI experimenters like Qumus are expected to be applied to fields beyond materials science (e.g., drug discovery and catalyst design), serving as a foundation to streamline the entire scientific discovery process. However, ethical considerations, the limits of AI's "understanding," and the optimization of human-AI collaboration will require continued careful consideration.

Source: https://www.azom.com/news.aspx?newsID=65475

Seoul National University Develops Integrated Artificial Muscle with Co-Located Actuation and Sensing

Published May 28, 2026 EurekAlert! / Seoul National University South Korea

OVERVIEW

A Seoul National University research team developed an intelligent artificial muscle integrating actuation and sensing within a single material system. This system incorporates liquid metal channels into liquid crystal elastomers (LCEs), allowing it to contract in response to electrical stimulation while simultaneously measuring internal force and length in real-time. This advance is critical for humanoid robots, rehabilitation devices, and soft robotic grippers handling delicate objects.

IN DEPTH

Background: The Challenge of Integrating Actuation and Sensing in Soft Robotics

Soft robots, owing to their flexibility and adaptability to environments, hold significant promise for diverse applications, including safe human interaction and delicate object manipulation. However, conventional actuators (moving parts) and sensors have typically been designed and integrated as separate components. This approach often increases system complexity, weight, and volume, while also limiting response speed and flexibility. To achieve the kind of natural, integrated movement and sensing characteristic of human muscles, fundamental innovation at the material level was required.

Key Findings: Integrated Artificial Muscle via LCEs and Liquid Metal Channels

A research team at Seoul National University has developed a groundbreaking "intelligent artificial muscle" that addresses this long-standing challenge. This system ingeniously combines "Liquid Crystal Elastomers (LCEs)," smart materials that deform significantly in response to thermal or electrical stimuli, with "liquid metals," known for their high electrical conductivity. The researchers adopted a unique approach of integrating fine liquid metal channels within the LCE material. With this structure, when an electrical stimulus is applied to the artificial muscle, the LCE contracts, and simultaneously, the shape of the liquid metal channels changes. This change in shape, in turn, alters the electrical resistance in real-time. By measuring this change in electrical resistance, the system can precisely sense how much the artificial muscle has contracted or how much force is being exerted. In essence, both actuation and sensing functions are achieved simultaneously and seamlessly within a single material system.

Technical Significance and Outlook

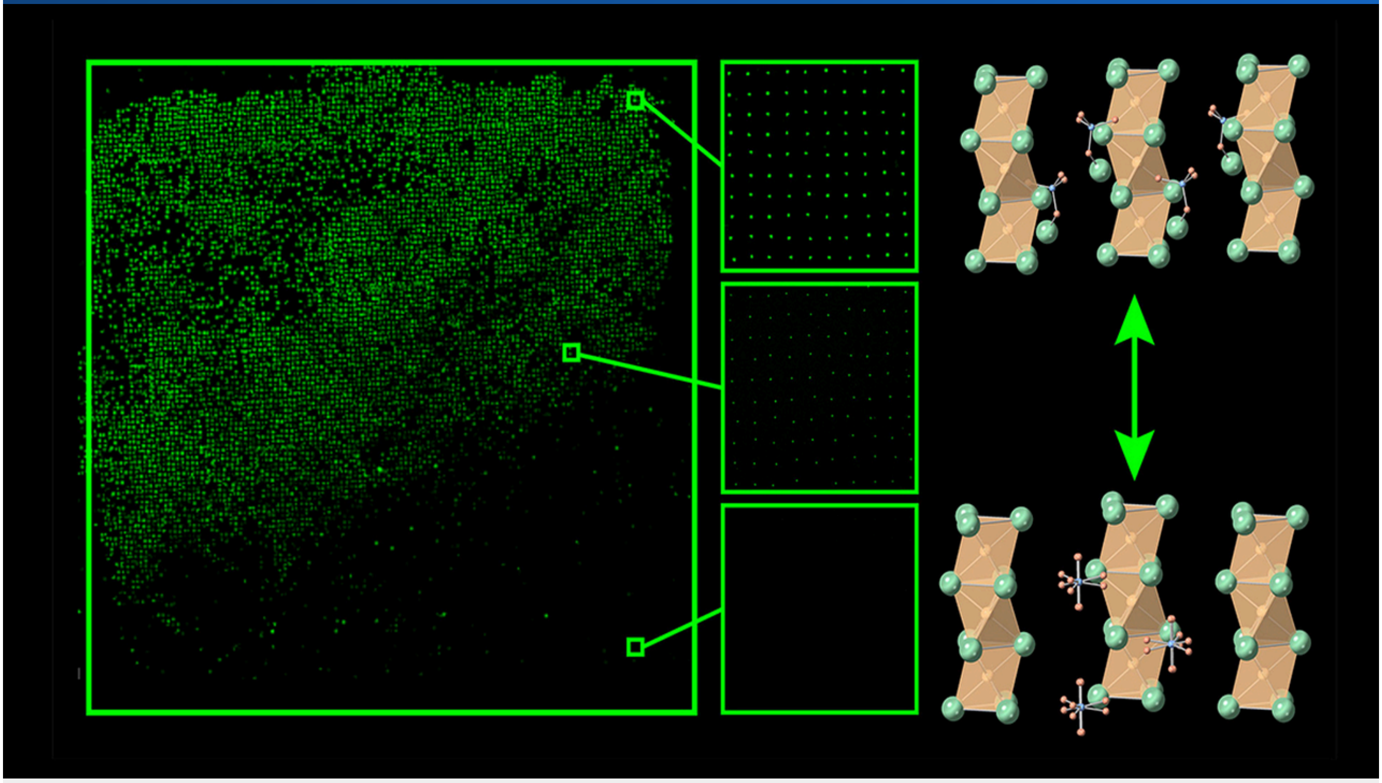
The integration of actuation and sensing represents a paradigm shift in soft robotics engineering. This intelligent artificial muscle provides a foundation for robots to interact more intuitively with their environment. For example, in humanoid robots mimicking the human skeleton and muscles, it can enable more natural and smooth movements along with delicate haptic feedback. In rehabilitation devices, it allows for optimal assistive force provision while monitoring patient movement and muscle strength in real-time. Furthermore, soft robotic grippers can achieve more precise force adjustments to handle delicate objects like fruits without damage. This technology eliminates the need for complex and costly external sensors, simplifying soft robot design and contributing to lightweighting and reduced power consumption. In the future, this integrated artificial muscle is expected to be applied across a wide range of fields, including wearable devices, medical diagnostics, and exploration robots, becoming an indispensable component for next-generation human augmentation technologies and autonomous systems.

Source: https://www.labmate-online.com/news/news-and-views/5/breaking-news/advances-in-soft-robotics-combine-movement-and-sensing-in-artificial-muscle/67537

Collected: May 30, 2026 | Automated Research System (Gemini API)

Megalibraries Spearhead Autonomous Materials Discovery, Outpacing Self-Driving Labs in High-Quality Data Generation for AI

Published May 26, 2026 Northwestern University (via News) USA



OVERVIEW

Northwestern University's Professor Chad Mirkin demonstrated that megalibraries, a high-throughput materials platform, are positioned to generate vast, high-quality data essential for AI-driven autonomous discovery more effectively than traditional self-driving labs. This technology synthesizes millions of material candidates on a single chip simultaneously, dramatically accelerating the exploration of new materials. This approach provides the crucial, high-quality datasets needed to train AI systems, exploring chemical possibilities at a scale previously impractical with conventional trial-and-error methods.

IN DEPTH

Background: Data Supply Challenges in AI-Driven Materials Science

Artificial intelligence (AI) is anticipated as a powerful tool to accelerate the process of discovering new materials in materials science. Particularly, the concept of "Self-Driving Labs," where AI autonomously plans, executes, and learns from experiments, holds the potential to significantly transform the research and development paradigm. However, for these AI systems to function effectively and explore unknown territories, vast and high-quality datasets are indispensable. In traditional laboratory-scale experiments, generating the volume of data required to efficiently train AI has been a bottleneck, hindering rapid and comprehensive data acquisition. A new approach was needed to cover the vast design space of material compositions, structures, and properties.

Key Findings: High-Throughput Data Generation with Megalibraries

Addressing this data supply challenge, a research team led by Professor Chad Mirkin at Northwestern University demonstrated that a high-throughput materials platform known as "Megalibraries" offers a compelling solution. Megalibrary technology enables the simultaneous synthesis and evaluation of millions of different material compositions and structural candidates on a single, small chip. This capability allows for exhaustive exploration of the material compositional space at a scale physically impossible with conventional experimental methods, efficiently generating data on the properties of each material candidate. These extensive datasets serve as an ideal information source for training machine learning models within AI systems. The research team clarified that the high-quality data generated by megalibraries provides the foundation for AI to learn complex physicochemical laws of materials and autonomously predict and design new materials with desired properties. This suggests that megalibraries, as a data generation strategy, can complement and sometimes surpass the capabilities of self-driving labs in maximizing AI's potential.

Technical Significance and Outlook

The integration of megalibrary technology with AI promises to dramatically enhance the speed and efficiency of discovery in materials science. High-throughput data generation capabilities provide crucial input for AI to build more robust and versatile material design models. This will accelerate the development of new materials in various fields, including high-performance alloys, efficient catalysts, next-generation electronic materials, and innovative pharmaceuticals. Particularly in the exploration of complex multi-component materials that were previously difficult to discover, or materials with unexpected functionalities, the combination of AI and megalibraries will be a powerful tool. This approach establishes a new research paradigm where materials scientists integrate physical experimentation, computational science, and AI insights to design materials more rapidly and rationally, contributing to shorter product development cycles in industry. In the future, further advancements in the synergy between megalibraries and autonomous AI systems could realize true "autonomous discovery," designing, synthesizing, and evaluating entirely new materials without human intervention.

Source: https://www.mccormick.northwestern.edu/news/articles/2026/05/megalibraries-in-pole-position-for-autonomous-discovery-over-self-driving-labs/

Fujifilm to Unveil PFAS-Free PBO for Advanced Semiconductor Packaging at ECTC 2026

Published May 26, 2026   Business Wire   Japan

OVERVIEW

Fujifilm announced it will present its latest advanced packaging research and showcase PFAS-free PBO (polybenzoxazole) materials from its ZEMATES™ product line at ECTC 2026. ZEMATES™ consists of photosensitive insulating materials used as insulation layers across various semiconductor packaging processes, from power semiconductors to high-performance AI chips. The company developed its PFAS-free PBO formulation to meet growing regulatory and customer demand for environmentally friendly materials, without relying on PFAS-containing raw materials.

IN DEPTH

Background: Evolution of Semiconductor Packaging and PFAS Regulatory Landscape

Modern semiconductor devices relentlessly pursue higher performance, greater integration, and lower power consumption, necessitating advanced packaging technologies. Insulation materials, crucial for protecting inter-chip wiring and providing electrical insulation, directly impact device reliability and performance. Per- and polyfluoroalkyl substances (PFAS) have historically been widely used in many semiconductor materials due to their excellent electrical and thermal properties. However, growing concerns about their environmental persistence and potential health impacts have led to tightening global regulations, making the transition to PFAS-free materials an urgent priority for the industry.

Key Findings: Fujifilm's PFAS-Free PBO "ZEMATES™"

Fujifilm has announced that it will present its latest advanced packaging research findings and exhibit its "PFAS-free PBO (polybenzoxazole)" from the ZEMATES™ product line at the Electronic Components and Technology Conference (ECTC 2026), held from May 26-29 in Orlando, Florida. The ZEMATES™ series comprises photosensitive insulating materials used as insulation layers across a broad range of semiconductor packaging processes, from power semiconductors to high-performance AI semiconductors. Fujifilm has developed a proprietary PBO formulation that is entirely independent of PFAS-containing raw materials. This represents a significant strategic initiative to address both escalating environmental regulations and strong customer demand for PFAS-free materials. The new PFAS-free PBO retains the excellent electrical properties, thermal stability, and mechanical strength of conventional PBO while significantly reducing environmental impact.

Technical Significance and Outlook

Fujifilm's development of PFAS-free PBO will substantially contribute to reducing the environmental footprint and enhancing supply chain sustainability in the semiconductor industry. This technology provides a critical solution for semiconductor manufacturers to develop high-performance, next-generation devices while complying with environmental regulations. The transition to PFAS-free materials is not merely about regulatory compliance; it also enhances corporate brand value and builds consumer trust. In the future, the application of this PFAS-free technology across a wider range of semiconductor materials is expected to significantly reduce the overall environmental footprint of the industry. Fujifilm is poised to contribute to both a sustainable society and high-performance electronics through innovation in materials technology.

Source: https://www.businesswire.com/news/home/20260522225282/en/Fujifilm-Presents-Latest-Advanced-Packaging-Research-Results-and-Will-Introduce-PFAS-Free-PBO-at-ECTC-2026

Collected: May 30, 2026 | Automated Research System (Gemini API)

IIT Jodhpur Scientists Atomically Engineer Borophene, Unlocking Potential for Next-Gen Energy and Sensors

Published May 25, 2026 Press Information Bureau India

OVERVIEW

Researchers at IIT Jodhpur's NanoSense Lab are redefining materials science by atomically designing advanced materials, focusing on borophene—one of the world's lightest and most promising 2D materials. Borophene holds vast potential for high-performance batteries, supercapacitors, advanced gas sensors, and nanoelectronics, proving particularly attractive for ultra-fast energy storage devices. This work represents a significant step towards realizing futuristic 'wonder materials' through atomic-scale engineering.

IN DEPTH

Background: The Frontier of 2D Materials and Borophene's Potential

Since the discovery of graphene, two-dimensional (2D) materials have revolutionized materials science, opening new possibilities across electronics, energy, and sensor technologies. These materials, owing to their atomic-scale thickness, possess unique physical and chemical properties that enable functionalities unattainable with conventional bulk materials. Among them, "borophene," a 2D material composed solely of boron atoms, is theoretically predicted to exhibit exceptionally unique properties, including higher electrical conductivity than graphene, superior mechanical strength, and excellent catalytic activity, due to its diverse atomic arrangements and electronic structures. However, its stable synthesis and characterization have presented significant challenges, requiring further research for practical application.

Key Findings: IIT Jodhpur's Pioneering Borophene Research

Researchers at the NanoSense Lab at the Indian Institute of Technology Jodhpur (IIT Jodhpur) are making groundbreaking advancements in the atomic-scale design and synthesis of materials, aiming to redefine the future of materials science. They are particularly focused on borophene, exploring techniques to construct this "wonder material" atom by atom. The research team has successfully grown stable single-layer and few-layer borophene by employing deposition techniques under ultra-high vacuum conditions and utilizing computational science-based crystal growth simulations. This achievement has enabled them to unravel the intrinsic electronic structures and mechanical properties of borophene in detail, experimentally verifying theoretical predictions. Their research strongly suggests the diverse application possibilities of borophene, especially its potential as an ultra-fast energy storage device.

Technical Significance and Outlook

IIT Jodhpur's research on borophene holds paramount significance for the development of next-generation functional materials. Given borophene's high electrical conductivity, large surface area, and the rich bonding versatility of boron atoms, a wide range of applications are anticipated:

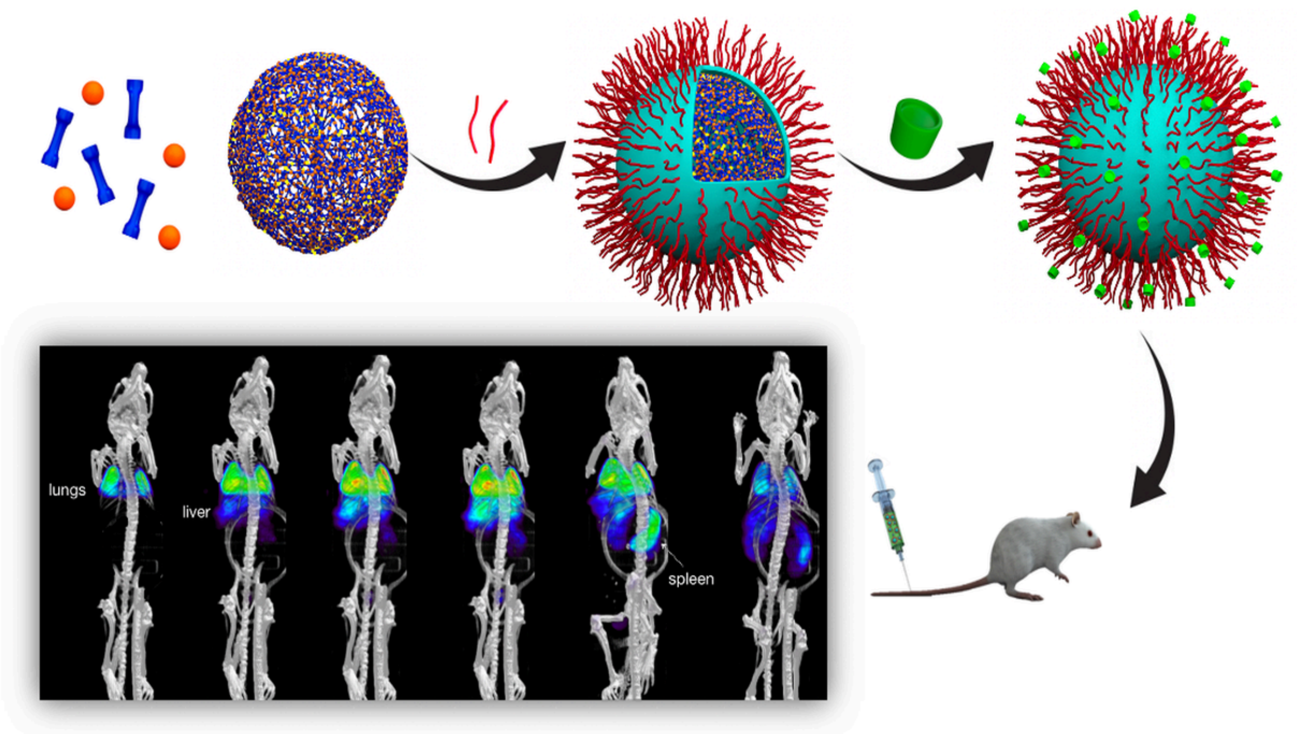
- **High-Performance Batteries and Supercapacitors:** Enabling ultra-fast charging/discharging capabilities and high energy densities, dramatically improving the performance of electric vehicles and portable electronic devices.
- **Advanced Gas Sensors:** Detecting specific gas molecules at extremely low concentrations, contributing to environmental monitoring and medical diagnostics.
- **Nanoelectronics:** Serving as a foundational material for ultra-compact, high-speed transistors and flexible circuits, potentially surpassing graphene.
- **Self-Glowing Roads:** Leveraging boron's unique optical properties, the research hints at new materials for enhancing nighttime visibility in road surfaces.

This research deepens the understanding of borophene's synthesis techniques and fundamental physical properties, laying a strong foundation for realizing these innovative applications. In the future, the development of prototype devices utilizing borophene is expected to accelerate, leading to breakthroughs in materials science, electronics, and energy sectors.

Source: https://www.pib.gov.in/PressReleasePage.aspx?PRID=2265027

Bio-Inspired Nanostructures: Advancing Smart Materials for Brain Therapy and Sustainable Energy

Published Published May 22, 2026 NANOSFUN (UAB) スペイン



OVERVIEW

The NANOSFUN group pioneers the development of molecular nanostructures that mimic nature's responsiveness, creating 'smart' materials capable of reacting to external stimuli. Their dual focus includes nanoscale functional polymers for groundbreaking brain disease therapy and regenerative medicine, alongside chromogenic and emissive nanomaterials designed for highly energy-efficient devices. This innovative research, exemplified by Dr. Claudio Roscini's participation in SustainableNano, highlights the group's commitment to both scientific advancement and societal impact.

IN DEPTH

Background: The Promise of Novel Functional Materials Unlocked by Nanotechnology

Nanotechnology, through its unparalleled ability to precisely control materials at the nanoscale, offers the transformative potential to engineer new functionalities and properties unattainable with conventional bulk materials. Of particular interest are functional nanomaterials developed through bio-inspired approaches, as well as those exhibiting 'smart' responsiveness—materials that inherently alter their properties in reaction to external stimuli. Such innovations are poised to drive significant advancements across medicine, energy, and environmental sectors. However, the efficient design and synthesis of these sophisticated materials, coupled with the precise control over their functions, demand a deep understanding at the molecular level and advanced technical expertise.

Key Findings: Diverse Research Frontiers of the NANOSFUN Group

The NANOSFUN (Nanostructured Functional Materials) group, based at the Universitat Autònoma de Barcelona (UAB) in Spain, stands as a pioneering research entity in this burgeoning field. Their overarching research objective is to develop molecular nanostructures that possess nature-inspired properties and respond intelligently to external stimuli such as heat, light, and electric fields. Specifically, their efforts are concentrated along two primary research thrusts:

- **Nanoscale functional polymers for brain disease therapy and regenerative medicine:** The group is developing biocompatible polymer materials specifically engineered to navigate the complex and unique environment of the brain. These materials hold promise for advanced drug delivery systems, serving as scaffolds for precise cell growth, and actively promoting neural regeneration. Their technologies encompass the incorporation of bioactive molecules to induce specific cellular responses and imparting smart responsiveness for targeted action on lesioned areas, minimizing off-target effects.

- **Chromogenic and emissive nanomaterials for energy-efficient devices:** Nanomaterials capable of controlled color changes (chromogenic) or efficient light emission (emissive) are highly anticipated for a wide array of energy-saving applications. These include next-generation smart windows, high-efficiency LEDs, advanced sensors, and innovative displays. NANOSFUN is actively pushing the boundaries in the synthesis, comprehensive characterization, and seamless device integration of these materials to dramatically improve energy conversion efficiency and accelerate the realization of sustainable technologies.

Furthermore, Dr. Claudio Roscini exemplifies the group's active contribution to the global academic community, having presented their cutting-edge research findings at the inaugural SustainableNano conference.

Technical Significance and Outlook

The NANOSFUN group's research extends beyond the mere synthesis of novel materials; it makes significant contributions to elucidating the underlying molecular-level design principles and the mechanisms governing functional expression. This foundational knowledge is crucial for enabling the development of highly tailored solutions for specific medical needs—such as targeted therapy for aggressive brain tumors—and critical energy challenges, like enhancing solar power generation efficiency. Particularly, the synergistic fusion of bio-inspired approaches with smart responsiveness is rapidly emerging as a mainstream trend in the future of functional materials. Looking ahead, their research is expected to forge new paradigms in disease treatment and provide an indispensable foundation for the realization of next-generation devices that dramatically reduce energy consumption. Moreover, the group's active participation in discussions surrounding the societal and ethical dimensions of technology, as evidenced by their involvement in social science activities, underscores a commitment to the sustainable and responsible development of nanotechnology.

Source: https://nanosfun.com/

AeroVironment Secures $20M Contract to Advance Ceramic Materials for U.S. Air Force and Space Force

Published May 28, 2026 AeroVironment USA

OVERVIEW

AeroVironment won a $20 million contract from the U.S. Air Force Research Laboratory (AFRL) to advance next-generation ceramic and ceramic matrix composite (CMC) materials. The 39-month agreement aims to accelerate the development of high-temperature materials and manufacturing processes for extreme aerospace and defense applications. The project will apply advanced additive manufacturing, 3D printing, and sensor integration techniques to create lightweight, heat-resistant structures for critical national security needs.

IN DEPTH

Background: Demand for High-Performance Materials in Extreme Environments

In the aerospace and defense sectors, high-performance materials capable of withstanding extreme high-temperature environments, such as hypersonic flight, atmospheric reentry, and space, are indispensable. Specifically, components for aircraft engines, thermal shields for hypersonic weapons, and structural elements of spacecraft require materials that combine lightweight properties with exceptional strength and heat resistance. Ceramic materials and ceramic matrix composites (CMCs) are considered promising due to their superior thermal and corrosion resistance, but they present challenges related to manufacturing complexity, brittleness, and cost, necessitating further research and development. Strengthening domestic advanced materials development capabilities is also an urgent priority within U.S. national defense strategy.

Key Findings: AeroVironment's Contract for Next-Generation Ceramic Materials Research

AeroVironment, headquartered in California, announced that it has been awarded a $20 million contract from the U.S. Air Force Research Laboratory (AFRL)'s Materials and Manufacturing Directorate. This contract is for the advancement of next-generation ceramic and ceramic matrix composite (CMC) materials research and development. The 39-month agreement has the explicit objective of accelerating the development of high-temperature materials and their manufacturing processes for extreme aerospace and defense applications, such as those used in hypersonic environments. In this project, AeroVironment will actively apply advanced additive manufacturing, 3D printing technologies, and sensor integration techniques. By utilizing these technologies, the company aims to create components and structures that are lightweight yet possess unparalleled heat resistance and structural integrity.

Technical Significance and Outlook

This contract holds critical significance for enhancing U.S. defense capabilities. The high-temperature ceramic materials and CMCs developed by AeroVironment have the potential to significantly improve the performance of next-generation aircraft, missiles, and spacecraft. The utilization of additive manufacturing and 3D printing technologies enables the rapid and efficient production of complex-shaped parts, increasing design freedom. Furthermore, sensor integration technology allows for real-time monitoring of material conditions, contributing to improved safety and reliability. This is expected to extend operational lifespans in extreme environments and enable more predictable material behavior. In the future, these technologies will likely be applied to the commercial aerospace industry and other high-temperature sectors, establishing new standards for high-performance materials. This initiative will also strengthen the domestic advanced materials supply chain, contributing to national security and economic independence.

Source: https://www.avinc.com/2026/05/28/av-awarded-20-million-contract-to-advance-ceramic-materials-research-for-the-u-s-air-force-and-space-force/

Argonne National Laboratory to Lead $2.8M Project for Accelerated Catalyst Discovery via AI and Autonomous Labs

Published May 28, 2026 Argonne National Laboratory USA

OVERVIEW

Argonne National Laboratory secured $2.77 million from ARPA-E to lead the Accelerated Catalyst Design Foundry (ACDF) project. ACDF aims to shorten industrial catalyst discovery and commercialization from 15-20 years to under five years by integrating AI, autonomous labs, rapid testing, and pilot-scale evaluation. The project specifically focuses on developing catalysts to convert waste into valuable products like methanol and ethanol, addressing critical sustainability and efficiency challenges.

IN DEPTH

Background: Delays in Industrial Catalyst Development and Environmental Challenges

In modern industrial processes, catalysts play an indispensable role in improving chemical reaction efficiency, reducing energy consumption, and lowering environmental impact. However, the process from the discovery of a new industrial catalyst to its commercialization typically takes a long period, often 15 to 20 years, posing a bottleneck for many technological innovations. Particularly, in pursuit of a sustainable society, the development of catalysts capable of efficiently producing high-value products (e.g., methanol, ethanol) from waste (e.g., carbon dioxide, biomass-derived compounds) is an urgent challenge. Traditional catalyst development has largely relied on trial-and-error, consuming vast amounts of time and resources.

Key Findings: ACDF Project Integrates AI and Autonomous Labs for Catalyst Discovery

To address this long-standing challenge, the U.S. Department of Energy's Argonne National Laboratory announced it has secured $2.77 million in funding from the Advanced Research Projects Agency-Energy (ARPA-E) to lead the "Accelerated Catalyst Design Foundry (ACDF)" project. The ACDF project aims to dramatically accelerate the catalyst discovery process by integrating cutting-edge technologies. Its core components include:

- **Artificial Intelligence (AI):** AI extracts patterns from vast experimental data and simulation results, efficiently predicting new catalyst candidates.
- **Autonomous Laboratories:** Combining robotic technology with automated experimental setups, these labs rapidly execute AI-proposed experiments without human intervention and collect data.
- **Rapid Testing and Pilot-Scale Evaluation:** Newly developed catalyst candidates undergo rapid performance evaluation not only at lab scale but also at a more practical pilot scale. This helps identify and resolve scale-up challenges early in the commercialization process.

Through this integrated approach, ACDF aims to significantly reduce the timeline from the discovery of new industrial catalysts to commercialization from the current 15-20 years to less than 5 years. In the initial phase, the project will focus on developing catalysts for synthesizing valuable chemical products like methanol and ethanol from waste (e.g., CO2 from industrial emissions, agricultural waste).

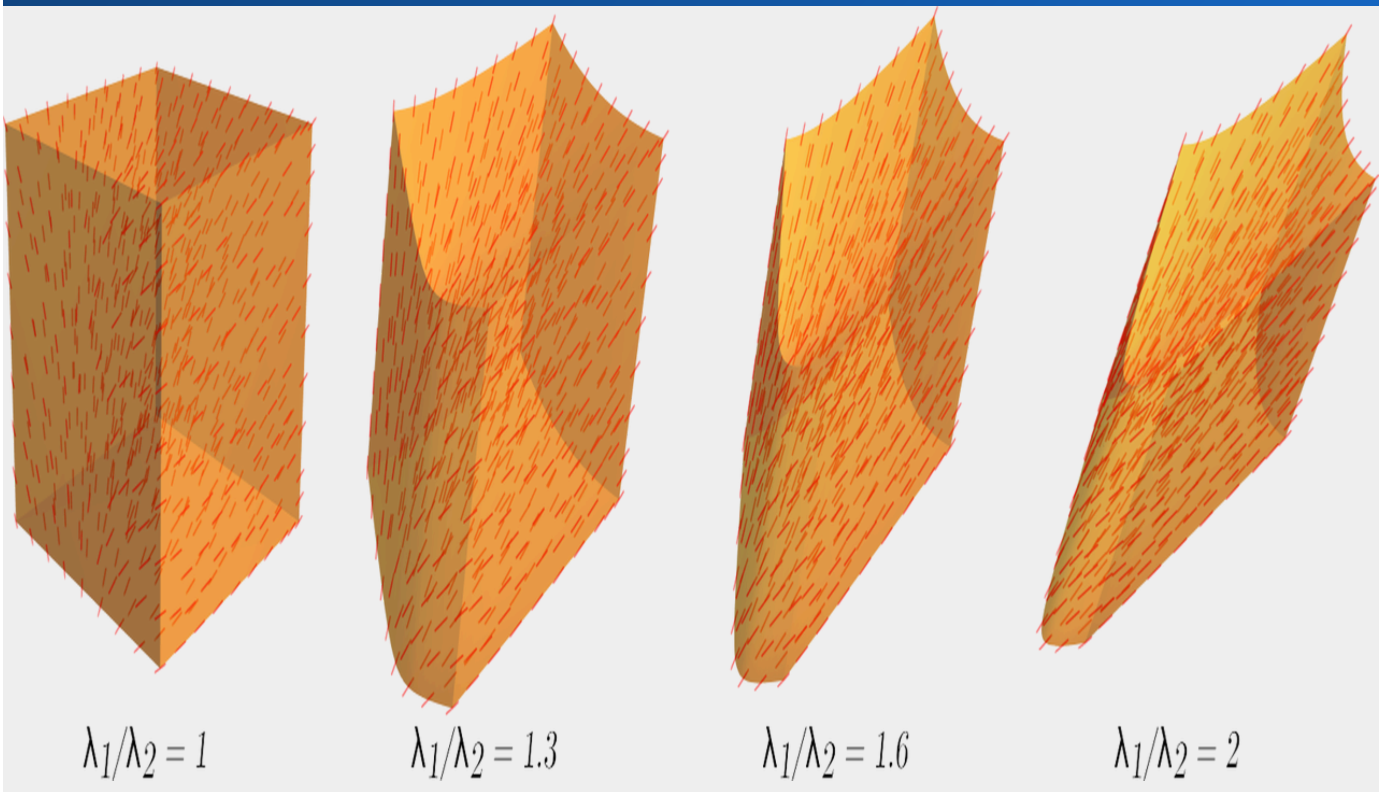
Technical Significance and Outlook

The ACDF project holds the potential to fundamentally transform the paradigm of research and development in catalyst science. The integration of AI and autonomous laboratories enables more rapid and comprehensive exploration of the catalyst design space than ever before, accelerating the discovery of higher-performance and more sustainable catalysts. This technology will significantly contribute to solving global challenges such as improving energy efficiency in the chemical industry, reducing greenhouse gas emissions, and effectively utilizing waste. Particularly, the technology for producing chemical products from waste is a crucial step towards realizing a circular economy. In the future, the knowledge and technologies cultivated through ACDF are expected to be applied to catalyst development in various fields, including pharmaceuticals, materials science, and environmental remediation, driving innovation across a wide range of industries. This project will serve as a powerful example of how AI and automation can accelerate scientific discovery.

Source: https://www.anl.gov/article/argonne-to-lead-28m-project-to-accelerate-catalyst-discovery

Unfrustrated Self-Morphing: New 3D Director Fields Enable Stress-Free Deformation in Bulk Liquid Crystal Elastomers

Published May 24, 2026 arXiv International



OVERVIEW

This arXiv preprint investigates a family of 3D director fields that enable self-morphing in bulk liquid crystal elastomers (LCEs) without geometric frustration. Extending prior research on thin LCE sheets, this study applies a geometric approach to bulk LCEs. By examining Ricci curvature, researchers formulated the minimal conditions for a 3D nematic director field to undergo stress-free, unfrustrated deformation, providing a theoretical foundation for more complex and efficient LCE actuators.

IN DEPTH

Background: Shape Change in Liquid Crystal Elastomers and Geometric Constraints

Liquid crystal elastomers (LCEs), known as "smart materials," are expected to have diverse applications in soft robotics, artificial muscles, and self-folding structures due to their ability to undergo large, reversible shape changes in response to external stimuli like heat, light, and electric fields. LCE shape changes are driven by the reorientation of internal liquid crystal molecules (mesogens). However, especially in bulk LCEs (materials with significant three-dimensional thickness), achieving complex 3D shape changes often leads to the accumulation of internal stress and strain—a phenomenon known as geometric frustration. This has hindered the free shape change of LCEs and limited their performance. Most prior research has focused on thin LCE sheets, where shape change is relatively easier to control.

Key Findings: Formulating 3D Director Fields for Unfrustrated Shape Change

The research presented in this arXiv preprint explores a novel geometric approach to enable "unfrustrated self-morphing" in bulk liquid crystal elastomers. The research team meticulously analyzed how the "director field," which describes the orientation pattern of liquid crystal molecules within the LCE, influences the material's shape change. They identified a family of ideal director fields (3D nematic director fields) that allow LCEs to self-morph into desired three-dimensional shapes without accumulating internal stress. Specifically, by examining the concept of "Ricci curvature" from Riemannian geometry, they for the first time clearly formulated the minimal mathematical conditions that a 3D nematic director field must satisfy to undergo stress-free, i.e., geometrically unfrustrated, deformation. This establishes a theoretical foundation for achieving free shape change without external constraints, by precisely designing the internal molecular orientation of the material.

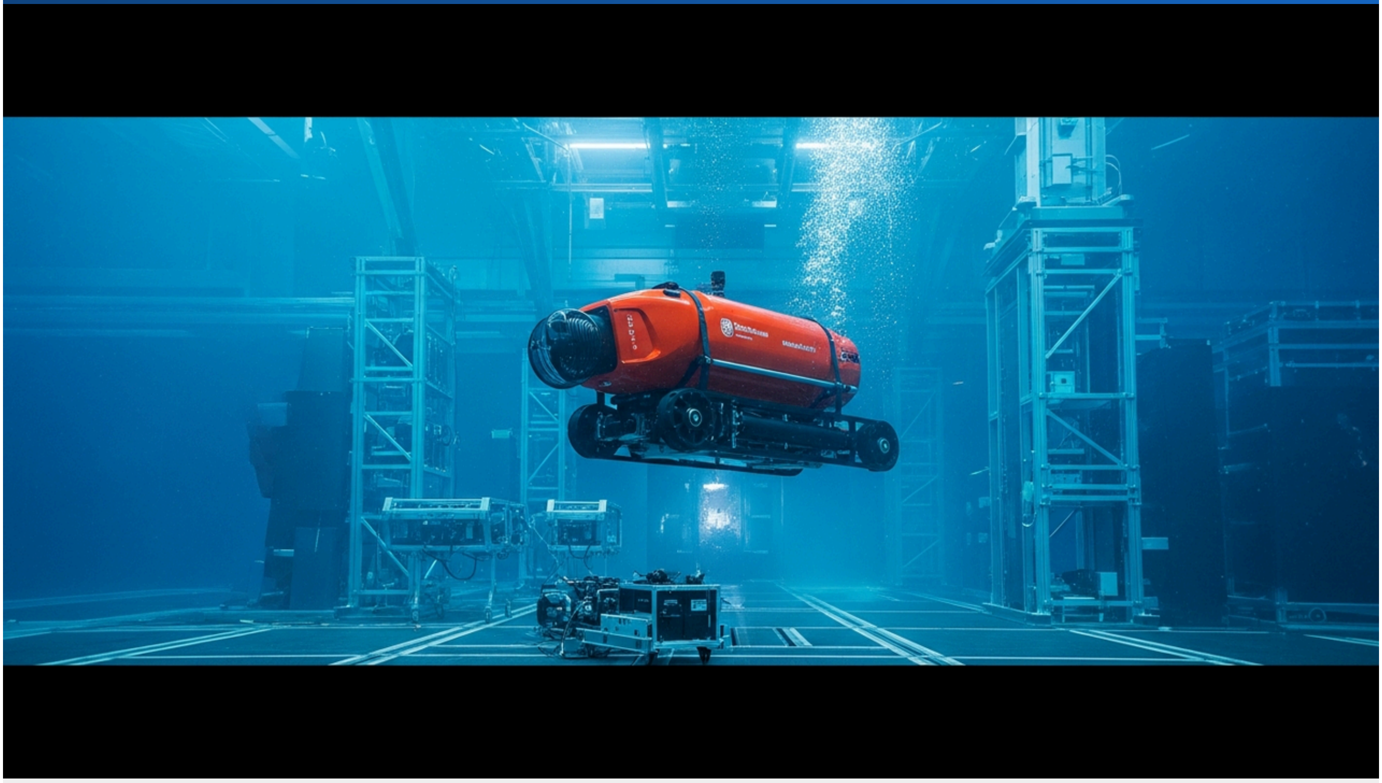
Technical Significance and Outlook

This research brings a groundbreaking advancement to the design and application of bulk liquid crystal elastomers. With the establishment of design principles for director fields that avoid geometric frustration, soft robots and artificial muscles will be able to achieve more complex and natural movements with higher efficiency and durability. For example, this will accelerate the development of multi-degree-of-freedom actuators that combine more intricate bending, twisting, and elongation, or smart structures that form specific three-dimensional geometries through self-assembly. This theoretical framework is directly applicable to LCE design optimization, providing crucial guidance to maximize the material's potential. In the future, building upon this insight, a diverse range of next-generation smart materials with unprecedented functionalities—such as medical devices (e.g., implantable soft robots), wearable devices, smart textiles, or dynamically changing architectural materials—are anticipated. Stress-free deformation also contributes to extended material lifespan, marking a significant step towards practical implementation.

Source: https://arxiv.org/html/2605.25187v1

Harbin Engineering University Advances Underwater Robotic End-Effectors with Soft Robotics and Smart Materials

Published May 25, 2026   PatSnap Eureka (Harbin Engineering University)   China



OVERVIEW

Research from Harbin Engineering University focuses on soft robotics for underwater manipulation, utilizing flexible materials and pneumatic actuation. Their end-effectors incorporate Shape Memory Alloys (SMAs) and Electroactive Polymers (EAPs) to maintain flexibility and responsiveness in cold underwater conditions. These systems feature a distributed sensing network providing tactile feedback across the end-effector surface, enabling gentle handling of marine specimens and delicate underwater structures, addressing critical challenges in deep-sea exploration.

IN DEPTH

Background: Challenges of Robotic Manipulation in Harsh Underwater Environments

Underwater operations span a wide range of tasks, including ocean exploration, subsea infrastructure maintenance, and biological specimen collection. However, the harsh underwater environment, characterized by cold temperatures, high pressure, limited visibility, and communication difficulties, makes precise robotic manipulation exceedingly challenging. Especially when handling delicate marine organisms or fragile underwater structures, rigid conventional robotic arms carry a high risk of causing damage. Therefore, the development of end-effectors capable of flexible and precise force control has become an urgent priority.

Key Findings: Underwater End-Effectors with Soft Robotics and Smart Materials

A research team at Harbin Engineering University in China has developed innovative soft robotics technology specifically designed for underwater manipulation. Central to their research is an end-effector that combines flexible materials with a pneumatic actuation system. This end-effector integrates smart materials such as Shape Memory Alloys (SMAs) and Electroactive Polymers (EAPs). SMAs possess the property of shape memory and recovery in response to temperature changes, enabling reliable movements in underwater operations. EAPs, on the other hand, function as "artificial muscles" that deform significantly with electrical stimulation, contributing to delicate grip force adjustment. The combination of these materials allows the end-effector to maintain its flexibility and rapid responsiveness even in cold underwater environments.

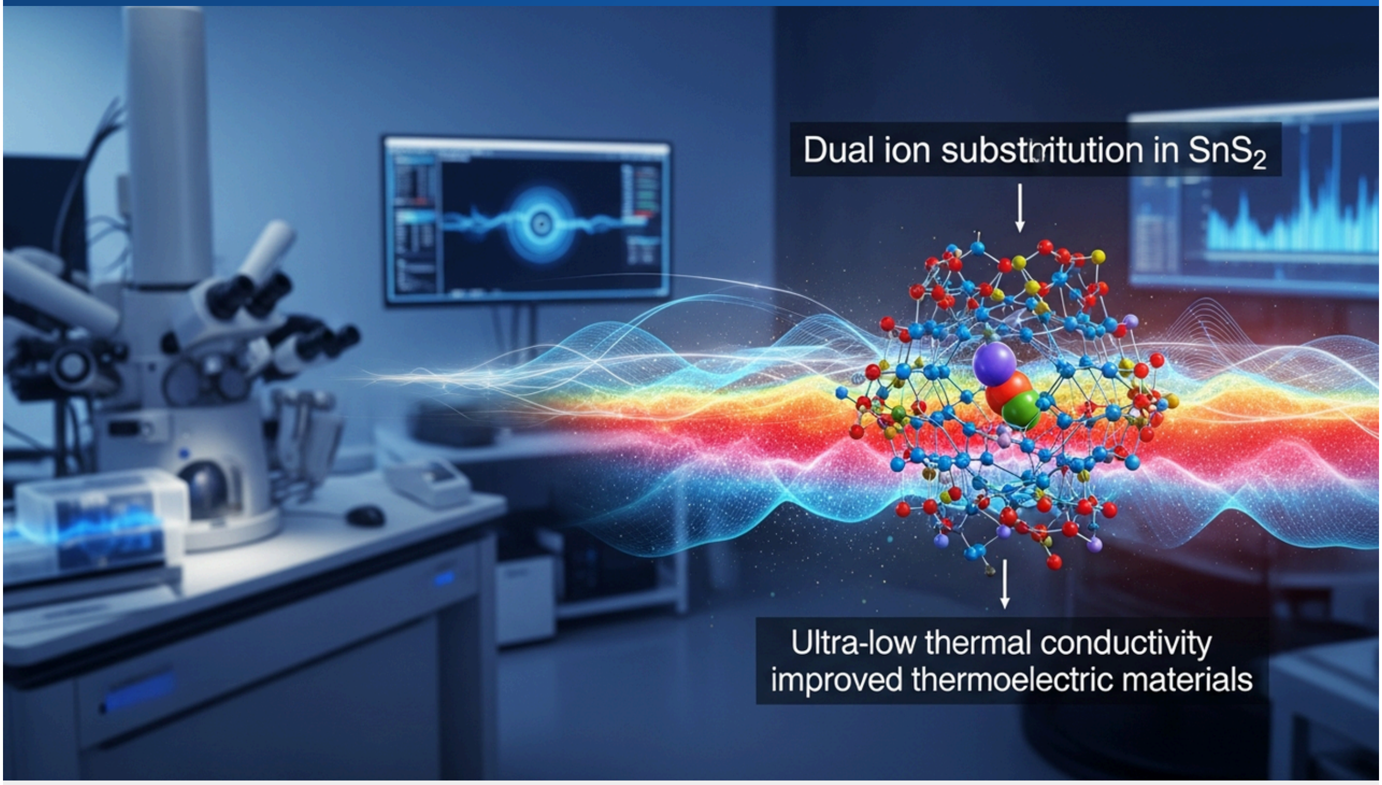
Technical Significance and Outlook

Furthermore, a groundbreaking aspect of this end-effector is its integrated distributed sensing network across its entire surface. This network detects pressure and strain in real-time when the end-effector contacts an object, providing haptic-like feedback to the robot's control system. This enables the robot to estimate the hardness and shape of the gripped object and automatically adjust its gripping force accordingly, acquiring "dexterity." This technology offers significant advantages in fields requiring precise and gentle operations, such as the collection of delicate marine specimens by marine biologists or the handling of fragile artifacts in underwater archaeology. In the future, this underwater soft robotic end-effector technology is expected to provide innovative solutions across a wide range of underwater applications, including deep-sea exploration, subsea cable laying and maintenance, offshore resource extraction, and underwater disaster response robots, thereby significantly contributing to the advancement of marine science and engineering.

Source: https://eureka.patsnap.com/report-optimizing-robotic-end-effectors-for-underwater-use-cases

Dual-Ion Substitutions in SnS2 Induce Ultralow Thermal Conductivity through Lattice Softening and Anion Dimerization

Published May 22, 2026 ACS Publications USA



OVERVIEW

A first-principles study revealed that dual-ion substitutions in SnS2 lead to lattice softening and anion dimerization, resulting in ultralow thermal conductivity. This phenomenon primarily stems from increased phonon scattering due to mass and bonding differences, offering critical guidance for enhancing thermoelectric material performance. Such materials are promising candidates for designing highly efficient thermoelectric devices with applications in waste heat recovery and advanced energy conversion technologies.

IN DEPTH

Background: Importance of Thermoelectric Materials and Challenges in Thermal Conductivity

Thermoelectric materials, capable of directly converting temperature differences into electrical energy and vice-versa, are gaining attention as clean energy technologies in fields like waste heat recovery, solid-state cooling, and sensors. A crucial metric for thermoelectric material performance is the dimensionless figure of merit (ZT), and to maximize it, achieving both high electrical conductivity and low thermal conductivity is ideal. Specifically, reducing thermal conductivity is essential to suppress heat flow within the material and efficiently utilize temperature differences. However, since electrical and thermal conductivities are often correlated, simultaneously optimizing both has been a significant challenge in material design.

Key Findings: Dual-Ion Substitution and Ultralow Thermal Conductivity in SnS2

This first-principles study, published in ACS Publications, focused on tin disulfide (SnS2), a layered semiconductor material, and explored a new strategy to improve its thermoelectric properties. The research team adopted an approach called "dual-ion substitution," where two different types of ions are simultaneously substituted into the crystal lattice of SnS2. Theoretical calculations and simulations revealed that this dual-ion substitution induces significant changes in the material's lattice structure:

- **Lattice Softening:** Substituted ions create inhomogeneities in the bonding with surrounding atoms, reducing the overall stiffness of the crystal lattice. This impedes the propagation of lattice vibrations (phonons).
- **Anion Dimerization:** Under specific conditions, anions (negatively charged ions) form pairs, causing local structural distortions and irregularities. This also effectively increases phonon scattering.

These synergistic effects dramatically reduce the thermal conductivity of SnS2, demonstrating that "ultralow thermal conductivity," previously difficult to achieve, can be realized. This reduction in thermal conductivity is primarily attributed to the significant increase in phonon scattering caused by differences in atomic mass and disorder in bonding introduced by the substitutions.

Technical Significance and Outlook

These research findings open new avenues for the design principles of high-efficiency thermoelectric materials. The elucidation of the mechanisms of lattice softening and anion dimerization through dual-ion substitution provides specific design guidelines for reducing thermal conductivity while maintaining electrical properties. This insight could be applied to optimize thermoelectric performance not only in SnS_2 but also in other layered compounds and semiconductor materials. Materials with ultralow thermal conductivity will have a significant impact in areas such as:

- **Waste Heat Recovery Systems:** Efficiently converting untapped thermal energy from factories and vehicles into electricity, improving energy efficiency.
- **Energy Conversion Technologies:** Expanding the utilization of renewable energy sources through the realization of high-efficiency thermoelectric power generation devices.
- **Solid-State Cooling Devices:** Applied to environmentally friendly cooling technologies that do not use refrigerants like CFCs.

In the future, based on the design principles presented in this study, the development of higher-performance and practical thermoelectric materials is expected to accelerate, contributing to the realization of a sustainable energy society.

Source: https://pubs.acs.org/doi/10.1021/acsaem.6c01045

Water-Soluble POSS Enables Multiscale-Reinforced, VOC-Free Waterborne Coatings via Concurrent Coalescence and Crosslinking

Published May 26, 2026 ChemRxiv International

OVERVIEW

This preprint reports that water-soluble amine-functionalized polyhedral oligomeric silsesquioxane (NPOSS) facilitates concurrent coalescence and crosslinking in epoxy-functionalized core-shell microsphere latex. NPOSS temporarily plasticizes latex particles to promote coalescence while allowing inter-particle diffusion before crosslinking, due to its moderate reactivity. This process yields a multiscale-reinforced structure—molecular-scale covalent networks, nanoscale chemical heterogeneity, and micrometer-scale compositional homogeneity—applicable to VOC-free waterborne thermoset coatings.

IN DEPTH

Background: Demand for High-Performance VOC-Free Waterborne Coatings

In contemporary society, driven by stricter environmental regulations and increased awareness of sustainability, there is a rapidly growing demand for eco-friendly coating materials that emit zero volatile organic compounds (VOCs). Industries such as construction, automotive, and electronics specifically seek waterborne coatings that offer excellent mechanical strength, chemical resistance, and durability, while also being VOC-free. However, developing high-performance waterborne thermoset coatings has presented technical challenges in appropriately controlling latex particle coalescence and crosslinking to form uniform, robust films. It has been particularly difficult to construct multiscale reinforcement structures, spanning from molecular to micrometer scales, in a single process.

Key Findings: Concurrent Coalescence and Crosslinking with Water-Soluble NPOSS

This preprint, published on ChemRxiv, reports a groundbreaking process that utilizes water-soluble amine-functionalized polyhedral oligomeric silsesquioxane (NPOSS) as a key component to promote both coalescence and crosslinking simultaneously and in a controlled manner within epoxy-functionalized core-shell microsphere latex. NPOSS, owing to its water solubility and moderately reactive amine functional groups, exhibits unique capabilities:

- **Temporary Plasticization and Enhanced Coalescence:** NPOSS temporarily acts as a plasticizer for latex particles, increasing the flexibility of their surfaces. This facilitates more intimate contact between particles and promotes efficient coalescence (fusion) as water evaporates after application.
- **Inter-particle Diffusion Before Crosslinking:** NPOSS allows sufficient time for diffusion between particles at the interface before complete crosslinking. This is crucial for polymer chains from different particles to intermingle, forming a more uniform and robust network.

- **Construction of Multiscale-Reinforced Structures:** The introduction of NPOSS results in a final coating film that exhibits a unique structure reinforced at multiple scales: a molecular-scale covalent network, nanoscale chemical heterogeneity (microphase separation of NPOSS and polymer), and micrometer-scale compositional homogeneity (uniform latex coalescence).

This entire process is achieved within a completely VOC-free waterborne system, significantly contributing to the reduction of environmental impact.

Technical Significance and Outlook

This concurrent coalescence and crosslinking process, utilizing water-soluble NPOSS, suggests a new direction for the development of high-performance VOC-free waterborne thermoset coatings. Coating films with precisely controlled multiscale reinforcement structures can achieve unprecedented mechanical strength, abrasion resistance, and durability, thereby improving performance across a wide range of application fields. Specific applications are anticipated in areas such as:

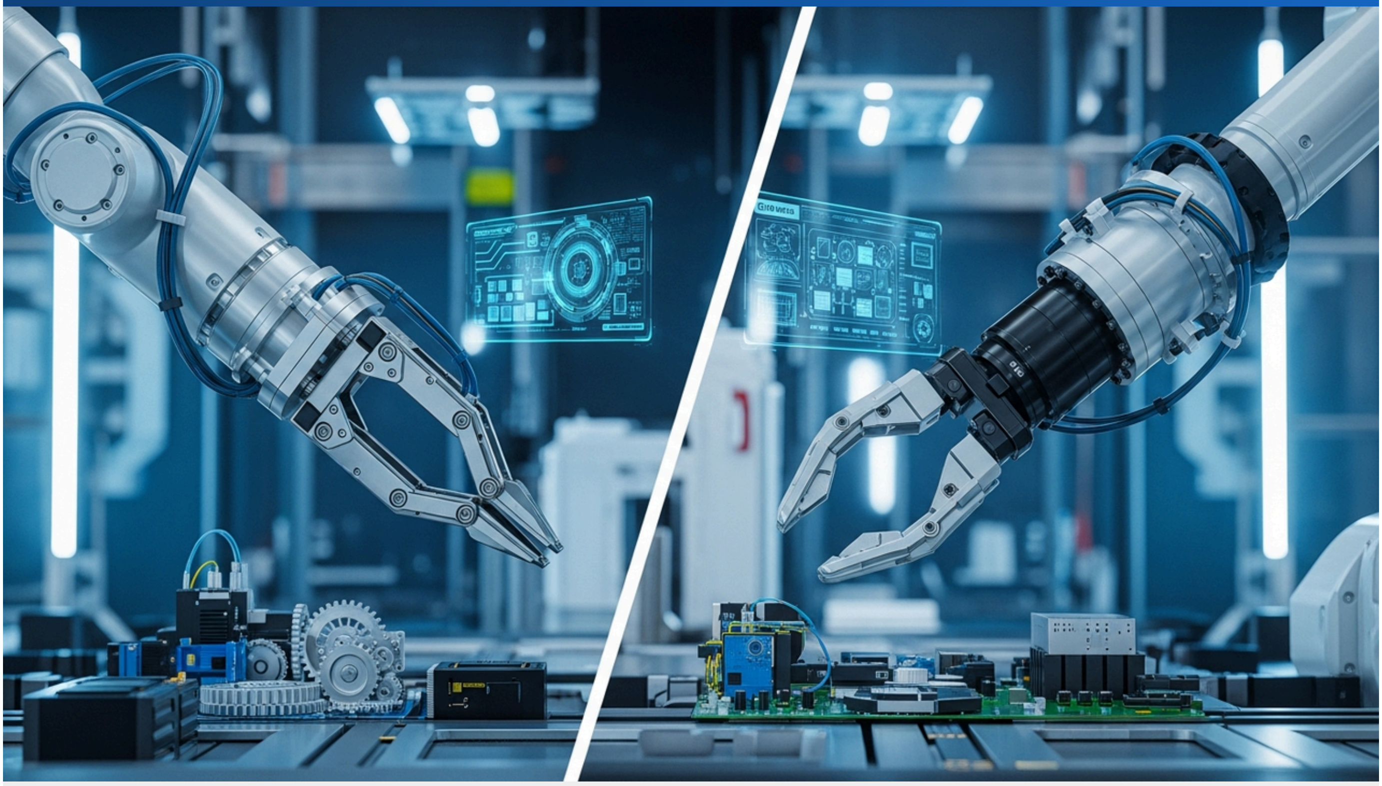
- **Automotive Coatings:** Durable and weather-resistant films with low environmental impact.
- **Industrial Protective Coatings:** Protection for equipment and structures in harsh environments.
- **Insulating Coatings for Electronic Components:** Enabling high-reliability and environmentally friendly electronic devices.

This technology serves as an excellent example of achieving both precise molecular-level control in material design and environmentally conscious, sustainable manufacturing processes. In the future, multifunctional hybrid materials like NPOSS are expected to be key to developing next-generation environmentally friendly, high-performance materials.

Source: https://chemrxiv.org/doi/10.26434/chemrxiv.15003850

Collapsible vs. Rigid Robotic End-Effectors: Smart Materials Revolutionize Compact Space Operations

Published May 25, 2026 PatSnap Eureka International



OVERVIEW

This article compares collapsible and rigid robotic end-effectors for compact spaces, highlighting how smart materials like shape memory alloys (SMAs) and advanced polymer composites have significantly enhanced collapsible mechanisms. Nickel-titanium alloy-based actuators, in particular, can switch between rigid and flexible states via thermal activation, offering superior performance in compact applications by allowing robots to navigate confined areas and then stabilize for precise tasks.

IN DEPTH

Background: Robotic Operations in Confined Spaces and End-Effector Design Challenges

Robotic operations in confined and narrow spaces—such as those encountered in space exploration, medical surgery, precision inspection, and disaster response—are becoming increasingly important. In these applications, robot end-effectors (the manipulators at the end of an arm) must simultaneously possess accessibility to the workspace, precise operability, and robustness. However, rigid end-effectors are limited in their ability to pass through narrow passages or bypass complex obstacles due to their fixed shape. Conversely, fully flexible end-effectors often suffer from reduced operational precision or the inability to exert necessary gripping force. Overcoming this trade-off to develop end-effectors that function efficiently in confined spaces has been a long-standing challenge.

Key Findings: Evolution of Collapsible End-Effectors through Smart Materials

This article compares two main approaches for robotic end-effectors in compact spaces: traditional "rigid" end-effectors and the increasingly prominent "collapsible" end-effectors. The development of collapsible mechanisms has been significantly driven by breakthroughs in smart materials like Shape Memory Alloys (SMAs) and advanced polymer composites.

- **Utilization of Shape Memory Alloys (SMAs):** Specifically, nickel-titanium (NiTi) alloy-based actuators can switch their physical state between "rigid" and "flexible" through thermal activation. This allows the end-effector to fold flexibly to navigate narrow spaces and then regain rigidity to perform precise tasks once it reaches the working position. This property enables the simultaneous achievement of flexibility and operability, which was impossible with conventional rigid monolithic structures.
- **Advanced Polymer Composites:** These lightweight and high-strength materials are used as structural components in collapsible mechanisms, contributing to the overall lightweighting and enhanced durability of the end-effector.

The integration of these smart materials has enabled collapsible end-effectors to demonstrate superior performance in both accessibility and operability for compact applications.

Technical Significance and Outlook

Collapsible robotic end-effectors represent a significant technological advancement for dramatically improving operational capabilities in extreme or confined environments. This opens new possibilities in fields such as:

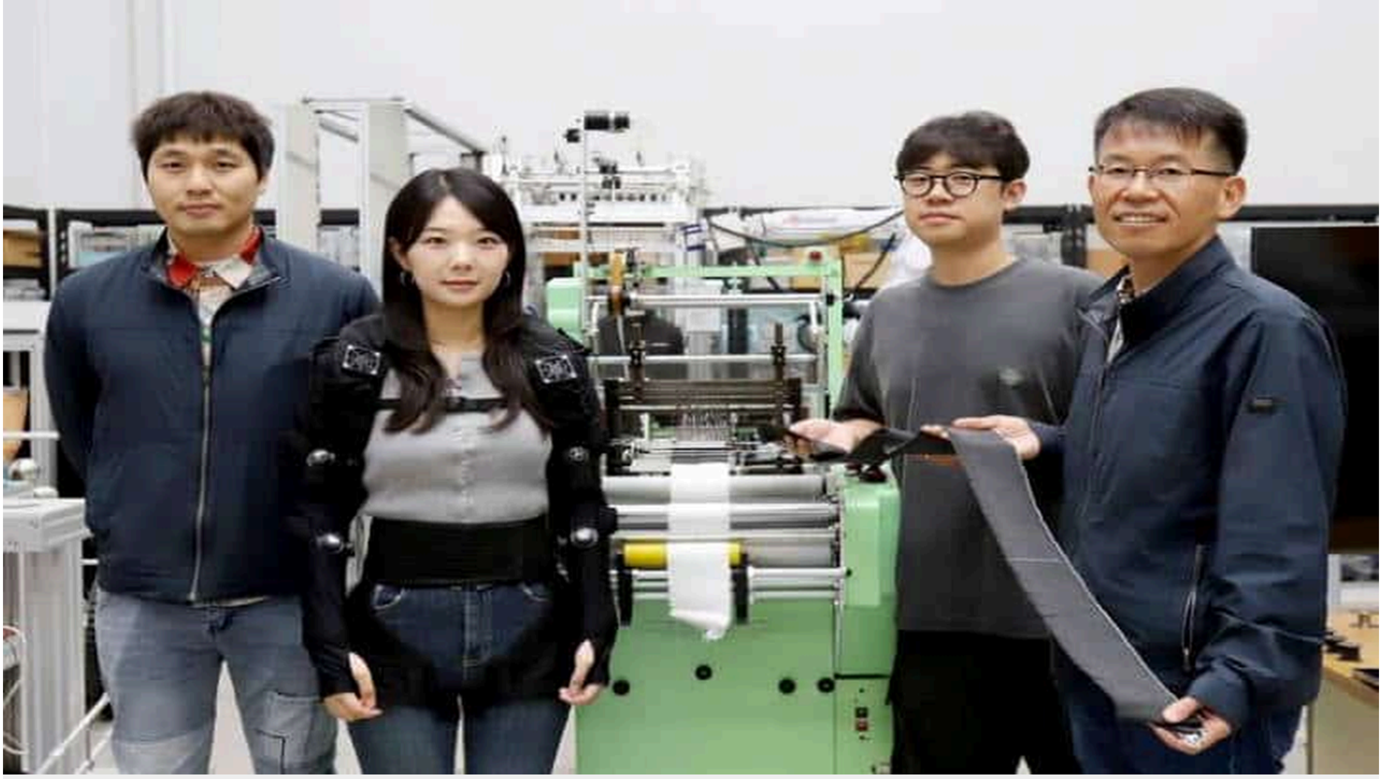
- **Medicine:** Small, flexible endoscopes and surgical instruments for minimally invasive surgery.
- **Inspection and Maintenance:** Robots for inspecting the interior of aircraft engines or narrow cracks in infrastructure.
- **Space Exploration:** Arms for spacecraft with limited payload and deployment space.
- **Disaster Response:** Robots designed to traverse debris-filled gaps for search and rescue operations.

Future research will focus on further improving response speed, enhancing energy efficiency, and developing more complex collapsible mechanisms with higher degrees of freedom. Furthermore, combining these with AI is expected to lead to more intelligent end-effectors that autonomously recognize their environment and determine optimal shape changes and operational strategies. This will further expand the contribution of robots in hazardous areas inaccessible to humans and in tasks requiring high precision.

Source: https://eureka.patsnap.com/report-compare-collapsible-vs-rigid-robotic-end-effectors-for-compact-spaces

KIMM Develops Wearable Fabric Robot with SMA Smart Threads, Boosting User Strength by 40%

Published May 27, 2026 Futuro Prossimo South Korea



OVERVIEW

A research team at KIMM (Korea Institute of Machinery & Materials) developed 'smart threads' from coiled 25-micrometer shape memory alloy (SMA) wires, mimicking biological muscle fibers. Wearable robots woven with these threads support user movements, providing a 40% increase in strength. The artificial muscles' contraction is thermally activated, promising applications in medical and rehabilitation fields, such as soft exoskeletons for assisting shoulder joints in neuromuscular disease patients.

IN DEPTH

Background: Challenges in Wearable Robotics and Actuators

The increasing elderly population, labor shortages, and the need for rehabilitation support for patients with neuromuscular diseases are driving the growing importance of wearable robots. However, existing wearable robots often contain many rigid components, making them heavy and bulky, which poses challenges for natural fit and comfortable wear on the human body. Furthermore, actuators—the components that generate movement—have struggled to combine high power output with flexibility, limiting their ability to provide natural and efficient assistance akin to human muscles.

Key Findings: KIMM's SMA "Smart Threads" and Wearable Robot Development

To overcome these challenges, a research team at the Korea Institute of Machinery & Materials (KIMM) has developed a groundbreaking wearable robot technology. The core innovation lies in precisely processing ultra-fine "Shape Memory Alloy (SMA)" wires, just 25 micrometers in diameter, into coiled structures. This creates "smart threads" that possess elastic properties and high power output closely resembling human muscle fibers. These SMA wires contract when thermally activated, generating force much like a contracting muscle. The research team constructed a flexible wearable robot by weaving these smart threads using a special method to effectively support human movement. Remarkably, users wearing this robot have reported an astonishing increase in physical strength by up to 40%.

These smart threads possess the following characteristics due to their high power density and flexibility:

- **High Output:** Generates strong contraction force with minimal thermal stimulation.
- **Flexibility:** Being fibrous, they conform naturally to the body like fabric, offering comfortable wear.
- **Lightweight and Compact:** Eliminates the need for bulky motors or gears, allowing for a lighter and more compact overall system.

Specifically, applications as soft exoskeletons to assist shoulder joints in patients with neuromuscular diseases are anticipated to improve daily living activities and enhance rehabilitation outcomes.

Technical Significance and Outlook

The wearable robot utilizing SMA smart threads developed by KIMM represents a major breakthrough in the convergence of actuator technology and wearable devices. Its ability to integrate naturally with the human body and provide powerful yet flexible assistance enables innovative applications across various fields:

- **Medical and Rehabilitation:** Assisting mobility for patients with muscle weakness, improving joint range of motion, and preventing falls.
- **Industrial and Caregiving:** Power-assist suits for lifting heavy loads, reducing caregiver burden.
- **Sports and Entertainment:** Performance-enhancing sportswear, immersive VR/AR experiences.

Future research will focus on further improving the response speed of SMAs, enhancing energy efficiency, and ensuring durability for prolonged continuous use. Furthermore, integrating sensor technology and AI is expected to lead to the evolution of "smart" wearable robots that can more accurately interpret user intent and provide assistance with optimal timing and strength. This technology marks a powerful step towards realizing a future society where humans and machines cooperate more seamlessly.

Source: https://en.futuroprossimo.it/2026/05/robot-indossabile-in-tessuto-ti-da-il-40-di-forza-in-piu/

Collected: May 30, 2026 | Automated Research System (Gemini API)

Covestro Unveils High-Performance Materials for AI Infrastructure and Embodied Intelligence at COMPUTEX 2026

Published May 27, 2026   Covestro   Germany

OVERVIEW

Covestro showcased 'The Material Effect' at COMPUTEX 2026, featuring high-performance material solutions for AI infrastructure and embodied intelligence. The company demonstrated how engineering plastics and TPUs enable innovations in AI computing, embodied intelligence, and connected devices. This presentation focused on material solutions designed to meet evolving demands for performance, sustainability, and supply reliability in the rapidly advancing AI and IoT sectors.

IN DEPTH

Background: Technological Evolution in the AI Era and the Role of Materials

The rapid advancement of artificial intelligence (AI) technology demands high-performance hardware and reliable infrastructure across all sectors, from AI servers in data centers to robots and smart devices. Particularly, with the increase in AI computing power, challenges such as rising heat generation and power consumption have become apparent. To overcome these, materials with excellent heat dissipation, durability, insulation, and lightweight properties are essential. Furthermore, as sustainability demands grow, environmentally friendly materials and stable supply chains are also critical considerations.

Key Findings: Covestro's High-Performance Material Solutions for AI Infrastructure

Covestro, a leading German chemicals company, prominently displayed its high-performance material solutions for AI infrastructure and embodied intelligence (e.g., robots, IoT devices) at COMPUTEX 2026 in Taipei, under the theme "The Material Effect." The company showcased key materials from its diverse product portfolio and their applications:

- **Engineering Plastics:** Polycarbonates and their alloys, boasting high strength, rigidity, and excellent heat resistance, are used in server racks, cooling systems, and AI accelerator housings, contributing to improved durability and reliability. Their high rigidity and dimensional stability are particularly crucial for supporting precise electronic components.
- **Thermoplastic Polyurethanes (TPU):** Known for flexibility, abrasion resistance, and shock absorption, TPUs are utilized in cable insulation, connectors, and housings for wearable devices, offering durability and design freedom. They are also promising for soft body parts of robots with embodied intelligence and as protective materials for sensors.
- **Sustainable Solutions:** Solutions that reduce environmental impact, such as recyclable, bio-based, or CO2-utilized materials, were also highlighted. This demonstrates Covestro's commitment to pursuing sustainability at the material level, addressing the challenge of increased power consumption brought about by AI technology.

These materials aim to ensure the performance required for AI technological advancement while balancing energy efficiency and environmental considerations.

Technical Significance and Outlook

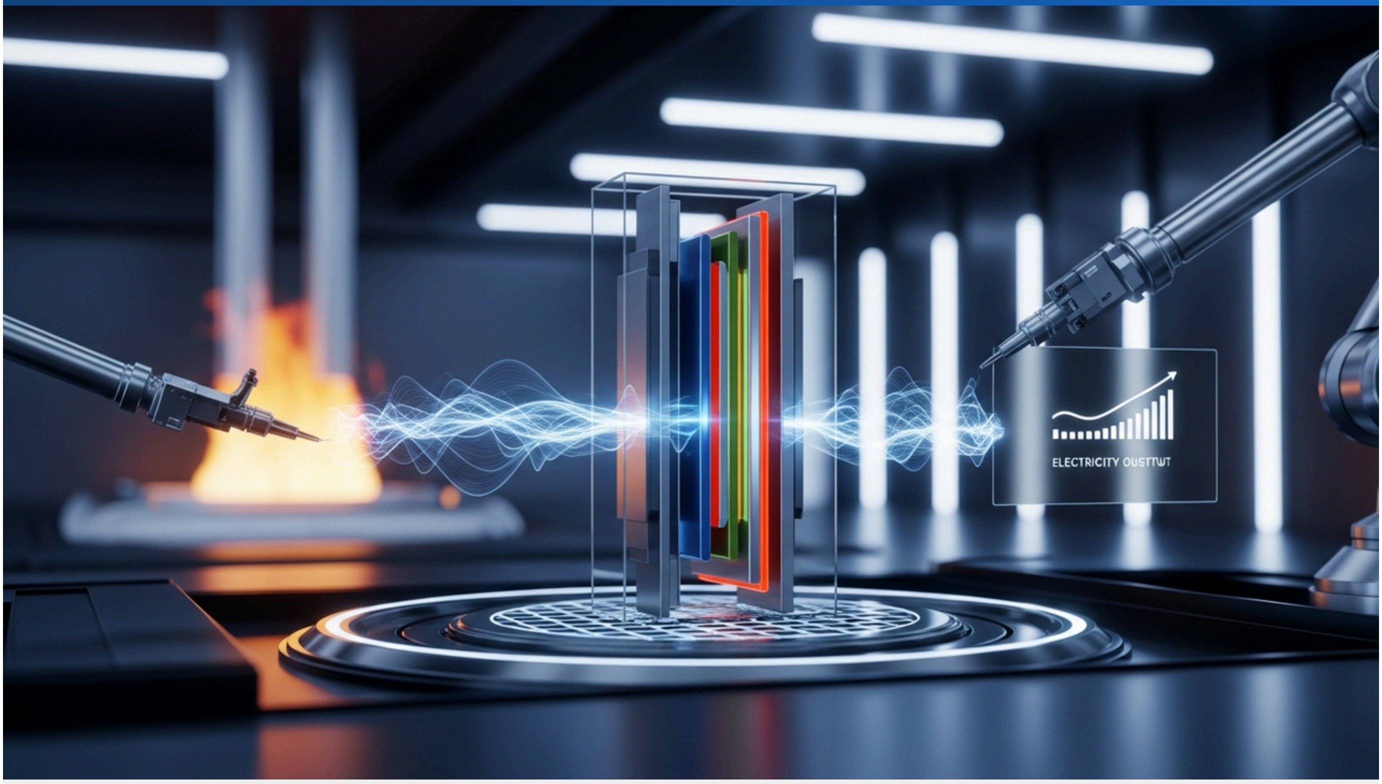
Covestro's exhibit at COMPUTEX 2026 clearly illustrates the central role of materials science in hardware innovation during the AI era. High-performance engineering plastics and TPUs are indispensable for managing thermal issues in AI servers and enhancing their reliability. For embodied intelligence devices and connected devices, the flexibility, durability, and lightweight nature of materials enable more human-like interactions and widespread deployment. In the future, these material solutions will accelerate the further enhancement of AI computing capabilities, improve energy efficiency in data centers, and foster the development of IoT ecosystems such such as smart cities and smart factories. Covestro is expected to contribute to building the physical foundation of a future society driven by AI and IoT, realizing sustainable and high-performance next-generation technologies through material innovation.

Source: https://www.covestro.com/press/covestro-presents-the-material-effect-during-computex-2026-high-performance-solutions-for-ai-infrastructure-and-embodied-intelligence/

Collected: May 30, 2026 | Automated Research System (Gemini API)

UncorrelaTEd Project Advances Thermoelectric Materials for Converting Waste Heat to Electricity

Published May 28, 2026 pyl.isop-hamburg.de Germany



OVERVIEW

The UncorrelaTEd project focuses on developing technology to efficiently convert heat into electricity by bringing porous thermoelectric materials into contact with liquids. The goal is to enable self-powered, battery-free sensors utilizing body heat or industrial waste heat. The project is advancing different families of thermoelectric materials, including bismuth telluride alloys, oxides, and polymers, aiming for practical applications across diverse sectors.

IN DEPTH

Background: Harnessing Untapped Waste Heat and the Need for Self-Powered Devices

Vast amounts of waste heat are generated globally from industrial processes, and even ubiquitous heat sources like human body temperature represent untapped energy. Efficiently converting this heat into electrical energy would significantly contribute to improving energy efficiency and achieving a sustainable society. Particularly, with the proliferation of IoT devices and wearable sensors, there is a growing demand for "self-powered sensors" that eliminate the need for battery replacement or charging. Thermoelectric conversion technology offers a promising solution to this need, but conventional thermoelectric materials have historically faced challenges in conversion efficiency, cost, and flexibility.

Key Findings: UncorrelaTEd Project's Liquid-Contact Thermoelectric Conversion Technology

The "UncorrelaTEd (Uncorrelated Transport in Thermoelectric Energy Converters)" project, involving Isop-Hamburg in Germany, is dedicated to developing innovative thermoelectric technology for efficient heat-to-electricity conversion. The core of this project lies in a novel approach: directly contacting porous thermoelectric materials with liquids (e.g., ionic liquids or water-based electrolytes). At this contact interface, a temperature gradient drives the movement of ions within the liquid, generating electrical energy. This liquid-contact approach potentially enables the achievement of both high conversion efficiency and stability under specific environmental conditions, which has been difficult with conventional solid-only thermoelectric devices.

The project is developing diverse families of thermoelectric materials, including:

- **Bismuth Telluride Alloys:** Known for high thermoelectric conversion efficiency in relatively low-temperature ranges.
- **Oxides:** Excellent high-temperature stability, with potential for composition from inexpensive and abundant elements.
- **Polymers:** Flexible materials, anticipated for applications in wearable devices and other flexible electronics.

Through the optimization and combination of these materials, the project aims to improve overall thermoelectric performance, ultimately realizing battery-free, self-powered sensors and small devices that can continuously supply power from various heat sources, such as human body heat and industrial waste heat.

Technical Significance and Outlook

The outcomes of the UncorrelaTEd project open new possibilities for thermoelectric conversion technology, significantly contributing to solving energy challenges and advancing IoT devices. The combination of porous thermoelectric materials and liquids may offer unique properties (e.g., larger Seebeck coefficients, superior mechanical flexibility) not achievable with traditional solid-based thermoelectric elements. This technology is expected to find applications in fields such as:

- **Wearable Electronics:** Smartwatches and health monitors powered by body heat.
- **Industrial IoT Sensors:** Sensor networks that operate autonomously using waste heat from factory equipment.
- **Smart Buildings:** Power generation or thermal management systems utilizing temperature differences across windows or walls.

Future research will focus on improving material durability, further enhancing conversion efficiency, and ensuring manufacturability for mass production. This project is expected to drive innovation in both the science and engineering of thermoelectric materials, laying the foundation for a more environmentally friendly and convenient society.

Source: https://pyl.isop-hamburg.de/buviakk