

# FunctionalMaterials

## Weekly Intelligence Report

2026-07-19 | 44 articles | 11 countries

troy-technical.jp

This Week's Keyword

## AI & Sustainable Mats

Rare-Earth-Free, Thermal, Bio-Based

44

articles

Total Articles Analyzed

11

countries

Source Countries

6

articles

AI-Driven Discovery

5

articles

Rare-Earth-Free Tech

### All 44 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 | Advanced PCMs for TES       | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Review highlights eco-friendly, microencapsulated PCMs for thermal storage in buildings, EVs.                 |
| #02 | Superhydrophobic Building   | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Review of superhydrophobic materials for buildings, offering self-cleaning, corrosion resistance.             |
| #03 | Superamphiphobic PPS Coat   | New Product        | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | German researchers develop superamphiphobic PPS coating with anti-icing, self-cleaning, durability.           |
| #04 | Self-Healing HEAs           | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Russian researchers develop self-healing HEAs for aerospace/automotive, extending lifespan, lowering cost.    |
| #05 | Record Thermoelectric ZT    | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | US research achieves record ZT 1.9 in PbSnS2 crystals for high-efficiency waste heat recovery.                |
| #06 | PCM-Hybrid EV Cooling       | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Hybrid PCM-liquid cooling with MPC for EV batteries boosts performance, safety, and lifespan.                 |
| #07 | Vimag Magnet-Free Motor     | New Product        | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Vimag Labs patents magnet-free EV motor (VMSM) to eliminate rare-earth dependence, secure supply chains.      |
| #08 | Hybrid Dielectric PCM EV    | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Hybrid dielectric insulation with microencapsulated PCMs proposed for next-gen EV battery thermal management. |
| #09 | PCM Dual Insulation Foam    | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | PCM microcapsules in polyurethane foam offer dual thermal and acoustic insulation for buildings.              |
| #10 | PCM TES Review              | Market Overview    | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Review of PCMs for thermal energy storage in heat pumps, solar, and EV batteries.                             |
| #11 | DIFFER Self-Driving Labs    | Corporate Strategy | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | DIFFER launches 'Self-Driving Labs' with AI to accelerate energy materials discovery by up to 60%.            |
| #12 | Vimag Rare-Earth-Free       | New Product        | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Vimag Labs patents rare-earth-free EV motor, challenging China's monopoly, reducing costs.                    |
| #13 | 3D CoCu MOF Electrocatalyst | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Laser-constructed 3D CoCu MOF electrocatalysts on HEA substrates boost OER efficiency, durability.            |

| #   | Article Title              | Type               | Tech Novelty                                                       | Market Proximity                                                   | Market Impact                                                      | Data Reliability                                                   | US/EU Relevance                                                    | Summary                                                                                                          |
|-----|----------------------------|--------------------|--------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| #14 | AI Rare-Earth-Free Magnets | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Iowa State launches AI-powered 'Autonomous Discovery Engine' for rare-earth-free magnets, accelerating R&D.;     |
| #15 | Vimag Virtual Magnet       | New Product        | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Vimag Labs' 'Virtual Magnet' tech aims to break China's rare-earth monopoly for EV motors.                       |
| #16 | Multifunctional Aramid     | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Multifunctional aramid fabric with superhydrophobicity, self-cleaning, photocatalysis, and flame retardancy.     |
| #17 | Self-Cleaning Coatings     | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Review of self-cleaning coatings, focusing on superhydrophobicity and diverse industrial uses.                   |
| #18 | World-First Super Alloy    | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | World-first Refractory High-Entropy Alloy (RHEAD) unveiled, twice strength of steel, for aerospace/energy.       |
| #19 | DOE Rare-Earth-Free EV     | Corporate Strategy | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | DOE funds CorePower Magnetics for rare-earth-free axial flux EV motor development, boosting supply chain.        |
| #20 | PCM Thermoreg Fabric       | New Product        | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Smartex Yarn unveils PCM-infused Nylon-Modal-Tencel fabric for thermoregulating summer shirts.                   |
| #21 | HEA Coatings APS           | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | FeCoCrNi HEA coatings via plasma spraying improve wear/corrosion resistance with optimized Ti content.           |
| #22 | Piezo Smart Shoes          | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Smart shoes with piezoelectric materials generate electricity from walking to power wearable devices.            |
| #23 | Bgolearn Mat. Discovery    | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Bgolearn, a Bayesian optimization framework, accelerates materials discovery for HEAs and steels by 40-60%.      |
| #24 | MIT Tiny IR Chip PCM       | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | MIT develops tiny infrared chip with PCMs for dynamic light control, improving gas and heat detection.           |
| #25 | HEA Powder AM              | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Ultrasonic atomization for TiZrNbHfTa HEA powder production enables high-quality AM for extreme environments.    |
| #26 | MIT LL AI Mat. Disc.       | Corporate Strategy | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | MIT Lincoln Lab strengthens AI-driven materials discovery for wide-bandgap semiconductors, national security.    |
| #27 | MgO Battery Coatings       | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Nanometer-thick MgO coatings boost next-gen battery performance and longevity by stabilizing electrodes.         |
| #28 | Cement-Free 3D Geopol      | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Ireland develops first cement-free 3D-printed geopolymer for sustainable construction, reducing emissions.       |
| #29 | Heat-Blocking Plastic      | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | New plastic blocks heat while retaining strength, revolutionizing thermal management in automotive, electronics. |
| #30 | China HEA Patent Lead      | Market Overview    | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | Patsnap report highlights China's leadership in HEA microstructure control patent landscape.                     |
| #31 | PicoQuant Solira TRPL      | New Product        | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | PicoQuant unveils Solira TRPL microscope for advanced materials characterization at E-MRS 2026.                  |
| #32 | Smart Adhesive 400x        | Research           | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | <div><div></div><div></div><div></div><div></div><div></div></div> | NPU develops paper-thin smart adhesive with 400x electric-activated adhesion for chip manufacturing, robotics.   |



| #   | Article Title            | Type               | Tech Novelty | Market Proximity | Market Impact | Data Reliability | US/EU Relevance | Summary                                                                                                                  |
|-----|--------------------------|--------------------|--------------|------------------|---------------|------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------|
| #33 | Galvorn CNT Materials    | Corporate Strategy | ●●●●○<br>○   | ●●●●○<br>○       | ●●●●○<br>○    | ●●●●○<br>○       | ●●●●○<br>○      | IAG Firemark Ventures invests in Galvorn for next-gen carbon nanotube materials for sustainable electrification.         |
| #34 | Robotic Earth 3D Print   | New Product        | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>○    | ●●●●○<br>○       | ●●●●●<br>●      | German startup unveils earth-based robotic 3D printing for sustainable construction, reducing waste.                     |
| #35 | AI Robotic Mat. Disc.    | Research           | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>●    | ●●●●●<br>○       | ●●●●●<br>○      | AI-driven robotic data management accelerates materials discovery for perovskite semiconductors.                         |
| #36 | Leak-Free PCM Textiles   | Research           | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●○<br>○    | ●●●●●<br>○       | ●●●●○<br>○      | PEG-crosslinked waterborne polyurethane solid-solid PCMs offer leak-free thermal regulation for textiles.                |
| #37 | MOFEvolve Framework      | Research           | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>●    | ●●●●●<br>○       | ●●●●●<br>○      | MOFEvolve framework uses literature-driven AI for efficient exploration and design of experimental MOFs.                 |
| #38 | Bacterial Cellulose PCB  | Corporate Strategy | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>○    | ●●●●○<br>○       | ●●●●●<br>●      | Würth Elektronik launches 'Cellutronic' for sustainable bacterial cellulose circuit carriers.                            |
| #39 | Epoxy-Anhydride Vitrimer | Research           | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>○    | ●●●●●<br>●       | ●●●●●<br>●      | Study unravels glass transition and dynamic behavior in epoxy-anhydride vitrimers for reprocessable materials.           |
| #40 | MXene Anticorrosion      | Research           | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>○    | ●●●●●<br>●       | ●●●●●<br>●      | MXene-based anticorrosive coatings evolve from passive barrier to smart protection with self-healing potential.          |
| #41 | Hemp-PFA Composites      | Research           | ●●●●○<br>○   | ●●●●○<br>○       | ●●●●○<br>○    | ●●●●●<br>○       | ●●●●●<br>●      | Woven hemp-reinforced PFA composites advance high-performance natural fiber applications for sustainability.             |
| #42 | DNA-Liposome Delivery    | Research           | ●●●●●<br>●   | ●●●●○<br>○       | ●●●●●<br>○    | ●●●●●<br>●       | ●●●●●<br>●      | DNA-based synthetic condensates enable organization and triggered release of liposomes for delivery systems.             |
| #43 | PCM MRB Thermal Mgmt     | Research           | ●●●●○<br>○   | ●●●●○<br>○       | ●●●●○<br>○    | ●●●●●<br>○       | ●●●●●<br>●      | CFD evaluation highlights PCM contribution to thermal management of zero-emission magnetorheological brakes.             |
| #44 | Bioadaptive Neural Coat  | Research           | ●●●●●<br>○   | ●●●●○<br>○       | ●●●●●<br>○    | ●●●●●<br>●       | ●●●●●<br>●      | Bioadaptive neural electrode coatings with catechol-functionalized copolymers offer superior adhesion, biocompatibility. |

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

## Three Questions That Demand Your Decision This Week

### ❶ Is your EV motor supply chain exposed to rare-earth geopolitics?

Indian and US firms are rapidly developing magnet-free or rare-earth-free EV motors (Vimag Labs, CorePower Magnetics). China's dominance in rare-earth supply is a critical vulnerability. Are your procurement and R&D; teams actively evaluating these alternatives to de-risk and reduce costs?

### ❷ How will AI-driven materials discovery impact your R&D; roadmap?

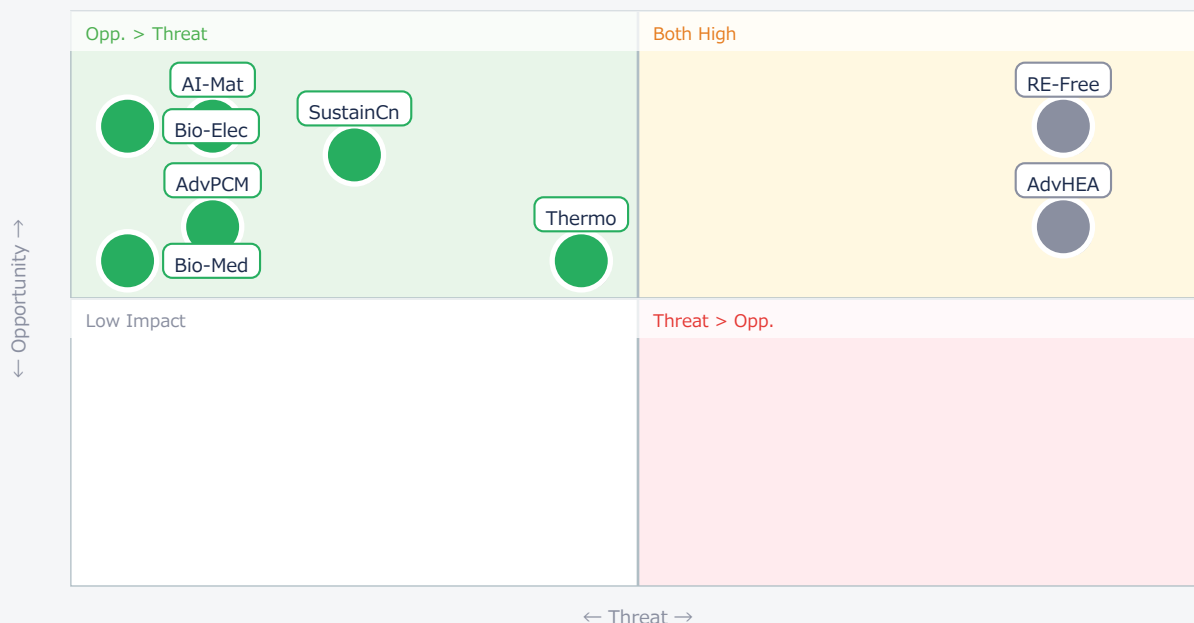
New 'Self-Driving Labs' and AI frameworks (DIFFER, Iowa State, Bgolearn) promise to accelerate materials discovery by 40-60%. This paradigm shift will redefine R&D; cycles. Is your organization investing in AI/ML tools and talent to maintain a competitive edge in materials innovation?

### ❸ Are you leveraging advanced thermal materials for next-gen products?

Phase Change Materials (PCMs) are advancing rapidly for EV battery thermal management, buildings, and textiles. New plastics block heat while retaining strength. Are your product development teams exploring these materials to enhance performance, safety, and energy efficiency?

## Opportunities vs. Threats for US/European Companies

Opportunity vs. Threat Matrix for US/European Companies



| Item        | Quadrant | ↑ Opportunity        | ↓ Threat             |
|-------------|----------|----------------------|----------------------|
| ● RE-Free   | Critical | De-risk supply chain | Lag in EV motor tech |
| ● AI-Mat    | Opp.     | Accelerate R&D;      | Competitor lead      |
| ● AdvPCM    | Opp.     | Boost energy effic.  | Miss market trends   |
| ● AdvHEA    | Critical | New high-perf. mat.  | China IP dominance   |
| ● SustainCn | Opp.     | Eco-friendly const.  | Regulatory pressure  |
| ● Bio-Elec  | Opp.     | Green electronics    | E-waste liability    |
| ● Thermo    | Opp.     | Waste heat recovery  | Limited adoption     |

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|           |      |                      |                    |
|-----------|------|----------------------|--------------------|
| ● Bio-Med | Opp. | Next-gen med devices | Slow clinical path |
|-----------|------|----------------------|--------------------|

## Deep Dive ① — DOE Backs Rare-Earth-Free EV Motors

#19 | 2026/07/09 | U.S. Department of Energy | Tech Novelty ● ● ● ● ○ Proximity ● ● ● ● ○○ Market Impact ● ● ● ● ●  
Data Reliability ● ● ● ● ●○ US/EU Relevance ● ● ● ● ●●

The U.S. Department of Energy (DOE) is funding CorePower Magnetics to develop high-performance rare-earth-element-free axial flux electric motors. This initiative aims to reduce reliance on critical minerals by combining nanocrystalline soft magnets with a flux-switching design, achieving high torque, efficiency, and power density.

The technology targets power densities over 15 kW/kg and efficiencies above 95%, comparable to rare-earth magnet motors. This is a strategic move to bolster national security and economic independence by securing EV and industrial supply chains from geopolitical risks associated with rare-earth element monopolies.

### ► Strategic Analyst's Perspective

Strategic Analyst's Perspective: The published performance targets (15 kW/kg, >95% efficiency) are ambitious but plausible given the DOE backing and focus on nanocrystalline soft magnets. Technical barriers include scaling nanocrystalline material production and ensuring long-term durability in automotive environments. [Opportunity] for US/EU OEMs to diversify supply chains, reduce costs, and gain a competitive edge in sustainable EV manufacturing. [Threat] for companies heavily invested in traditional rare-earth magnet motor designs, risking obsolescence and supply chain vulnerabilities. Next Actions: [Procurement] Identify alternative motor suppliers and engage with rare-earth-free motor developers by Q4 2026. [R&D;] Initiate internal R&D; programs or partnerships to evaluate and integrate rare-earth-free motor technologies by Q1 2027.

## Deep Dive ② — Record Thermoelectric Efficiency for Waste Heat

#05 | 2026/07/09 | ACS Publications | Tech Novelty ● ● ● ● ● Proximity ● ○ ○ ○ ○○ Market Impact ● ● ● ● ●○ Data Reliability ● ● ● ● ●● US/EU Relevance ● ● ● ● ●●

Groundbreaking US research achieved a record thermoelectric figure of merit (ZT) of approximately 1.9 at 750 K in n-type Cl-doped  $(\text{PbSnS}_2)_{1-x}(\text{SnSe})_x$  crystals. This breakthrough, enabled by synergistic optimization of electrical and thermal transport, sets a new benchmark for PbSnS<sub>2</sub>-based thermoelectrics.

The high-efficiency material holds significant potential for converting industrial waste heat into electricity, contributing to enhanced energy efficiency and reduced greenhouse gas emissions. This could unlock substantial energy harvesting opportunities in various sectors, including automotive and industrial processes.

#### ► Strategic Analyst's Perspective

Strategic Analyst's Perspective: The ZT 1.9 at 750 K is a significant academic achievement, backed by peer-reviewed data. However, proximity to market is low. Technical barriers include scalability of crystal growth, long-term stability under thermal cycling, and mechanical robustness for industrial applications. [Opportunity] for US/EU materials suppliers and energy tech developers to invest in early-stage research partnerships for next-gen thermoelectric materials, potentially securing future IP. [Threat] is limited in the short term due to low proximity, but a failure to monitor could mean missing a foundational shift in waste heat recovery. Next Actions: [R&D;] Establish a dedicated task force to track advancements in high-ZT thermoelectric materials and evaluate potential applications in industrial waste heat recovery by Q4 2026. [Strategy] Assess long-term energy efficiency roadmaps for integration of advanced thermoelectrics by Q2 2027.

## Deep Dive ③ — Reprocessable Vitrimers for Sustainable Polymers

#39 | 2026/07/11 | ACS Applied Polymer Materials | Tech Novelty●●●●○ Proximity●●○○○ Market Impact●●●●○  
Data Reliability●●●●● US/EU Relevance●●●●●

A detailed US study unravels the intricate balance between glass transition temperature (T<sub>g</sub>) and dynamic behavior in epoxy-anhydride vitrimer networks. This research provides critical design principles for reprocessable and chemically recyclable materials, significantly contributing to sustainable polymer development.

By precisely controlling constituent composition, researchers can tune curing, T<sub>g</sub>, network architecture, damping, and stress relaxation. This fundamental understanding is essential for designing vitrimers that offer both high performance and thermoplastic-like reprocessability, addressing the plastic waste crisis.

### ► Strategic Analyst's Perspective

Strategic Analyst's Perspective: The research provides robust, peer-reviewed data on vitrimer network behavior, offering a strong foundation for material design. Realism is high for lab conditions, but commercialization faces challenges in manufacturing scalability, cost-effectiveness, and ensuring consistent performance after multiple reprocessing cycles. [Opportunity] for US/EU polymer manufacturers and OEMs to develop sustainable product lines, reduce waste, and meet circular economy goals. [Threat] for companies reliant on conventional thermosets that lack reprocessability, facing increasing regulatory and consumer pressure. Next Actions: [R&D;] Investigate vitrimer technologies for specific product applications (e.g., automotive composites, electronics casings) and initiate pilot projects for chemical recycling by Q1 2027. [Strategy] Develop a long-term strategy for transitioning to reprocessable and recyclable polymers across product portfolios by Q3 2027.

## Other Notable Articles

AI Rare-Earth-Free Magnets (SUPERCOMPUTING NEWS)

Tech Novelty●●●●○ Proximity●●○○○ Market Impact●●●●●

AI-powered engine accelerates discovery of rare-earth-free magnets by 40-60%, critical for EV and energy sectors.

Robotic Earth 3D Print (Enterprise Europe Network)

Tech Novelty●●●●○ Proximity●●●○○ Market Impact●●●●○

German startup unveils earth-based robotic 3D printing for sustainable construction, dramatically reducing waste.

Bacterial Cellulose PCB (Würth Elektronik)

Tech Novelty●●●●○ Proximity●●○○○ Market Impact●●●●○

Würth Elektronik's 'Cellutronik' project aims for sustainable bacterial cellulose circuit carriers, reducing e-waste.

MXene Anticorrosion (ACS Publications (Chemistry of Materials))

Tech Novelty●●●●○ Proximity●●○○○ Market Impact●●●●○

MXene-based coatings are evolving from passive barriers to smart, self-healing anticorrosion protection.

Heat-Blocking Plastic (SciTechDaily)

Tech Novelty●●●●○ Proximity●●○○○ Market Impact●●●●○

New plastic blocks heat while retaining strength, revolutionizing thermal management in automotive and electronics.

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## Recommended Actions This Week

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

### ■ Immediate (this week)

- [Executive] Review rare-earth supply chain dependencies and potential geopolitical risks with procurement and legal teams.
- [R&D;] Identify internal projects or external partners for AI-driven materials discovery platforms to accelerate R&D; cycles.
- [Procurement] Initiate market scan for emerging PCM suppliers and rare-earth-free motor prototypes for EV and building applications.

### ■ Short-term (1 month)

- [Strategy] Conduct a competitive analysis on Chinese leadership in HEA patents and AI-driven materials research to identify gaps.
- [R&D;] Formulate a roadmap for integrating advanced thermal management materials (PCMs, heat-blocking plastics) into next-gen product designs.
- [Business Dev] Explore partnerships with startups developing sustainable construction materials (e.g., 3D-printed geopolymers, earth-based robotics).

### ■ Medium-long term (quarter+)

- [R&D;] Establish pilot programs for rare-earth-free EV motor technologies and evaluate their performance and manufacturability.
- [Legal/IP] Develop an IP strategy to protect innovations in AI-driven materials discovery and sustainable functional materials.
- [Strategy] Integrate circular economy principles into product design and material selection, leveraging reprocessible polymers and bio-based electronics.
- [Executive] Allocate budget for long-term investments in AI infrastructure and talent development for materials science.

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troy-technical.jp/en | Original curation. Article copyrights belong to respective authors. | Gemini API + Claude | 2026-07-19

# FunctionalMaterials — Selected Articles

Date: 2026-07-19

Articles: 44



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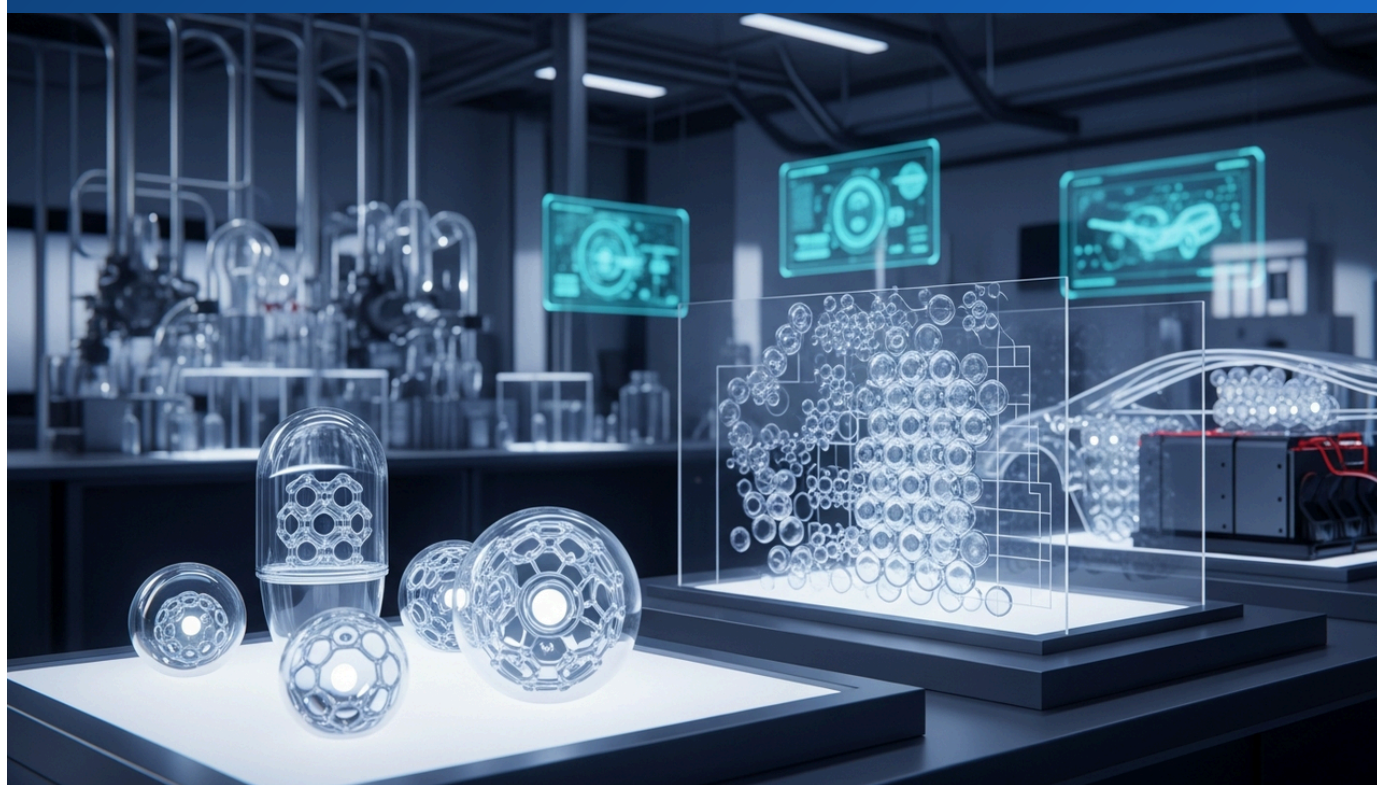
- #01 Advanced Phase Change Materials Drive Next-Gen Thermal Energy Storage for Buildings and EVs with Eco-Friendly, Microencapsulated Solutions
- #02 Superhydrophobic Materials for Building Waterproofing Advance: New Review Details 'Lotus Effect' Imitation for Enhanced Corrosion Resistance and Self-Cleaning
- #03 Superamphiphobic PPS Coating Delivers Durable Liquid Repellency, Self-Cleaning, and Anti-Icing for Broad Industrial Applications
- #04 SUSU Researchers Develop Self-Healing High-Entropy Alloys, Dramatically Extending Aerospace and Automotive Component Lifespans at Lower Cost
- #05 SnSe Alloying Boosts PbSnS<sub>2</sub> Crystals to Record Thermoelectric Efficiency of ZT 1.9 at 750 K, Enabling High-Efficiency Industrial Waste Heat Recovery
- #06 MDPI Study Reveals Breakthrough in PCM-Enhanced Battery Thermal Management: Hybrid Cooling with Model Predictive Control Boosts EV Performance and Safety
- #07 Vimag Labs Patents Magnet-Free EV Motor, Eliminating Rare Earth Dependence with VMSSM Technology to Secure Supply Chains
- #08 Next-Gen EV Battery Thermal Management: MDPI Proposes Hybrid Dielectric Insulation with Latent Heat Storage Using Microencapsulated PCMs
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- #10 Comprehensive Review on Phase Change Materials for Thermal Energy Storage Details Expanding Applications in Heat Pumps, Solar, and EV Batteries
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- #12 Vimag Labs Patents Rare-Earth-Free EV Motor, Challenging China's Monopoly: Gulf News Highlights Cost Reduction and Supply Chain Stabilization
- #13 Laser-Constructed 3D CoCu MOF Electrocatalysts Revolutionize Oxygen Evolution Reaction Efficiency with Enhanced Durability on High-Entropy Alloy Substrates
- #14 Iowa State Researchers Launch AI-Powered 'Autonomous Discovery Engine' Accelerating Hunt for Stronger, Rare-Earth-Free Magnets by 40-60%
- #15 Vimag Labs Targets China's Rare Earth Monopoly with Software-Defined EV Motors, OpIndia Explains Technology and Strategy for Cost Reduction and Supply Chain Stability
- #16 Multifunctional Aramid Fabric Developed Integrating Superhydrophobicity, Self-Cleaning, Photocatalysis, and Flame Retardancy, Enhancing Durability and UV Resistance

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- #20 Smartex Yarn Unveils Nylon-Modal-Tencel Blend Summer Shirt Fabric with PCM Thermoregulation Technology, Prioritizing Comfort and Performance
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- #22 Smart Shoes Developed Using Piezoelectric Material to Generate Electricity from Walking, Powering Wearable Devices Autonomously
- #23 Bgolearn Framework Accelerates Materials Discovery by 40-60%, Efficiently Exploring Ultra-Hard HEAs and High-Strength Medium-Mn Steels with Bayesian Optimization
- #24 MIT Develops Tiny Infrared Chip Using Phase Change Materials, Advancing Gas and Heat Detection and Miniaturizing Optical Devices
- #25 MDPI Establishes Ultrasonic Atomization for Refractory High-Entropy Alloy TiZrNbHfTa, Paving Way for High-Quality Powder Production for Additive Manufacturing
- #26 MIT Lincoln Lab Bolsters AI-Driven Materials Discovery Team, Recruiting Experimental Materials Scientists/Engineers to Accelerate Wide-Bandgap Semiconductor Research for National Security
- #27 Nanometer-Thick Magnesium Oxide Coatings Discovered to Boost Next-Gen Battery Performance and Longevity
- #28 Ireland Develops First Cement-Free 3D-Printed Geopolymer, Ushering in a New Era of Sustainable Construction
- #29 Scientists Develop New Plastic That Blocks Heat While Retaining Strength, Revolutionizing Automotive and Electronics Thermal Management
- #30 Patsnap Publishes '2026 High-Entropy Alloy Microstructure Control Patent Landscape' Report, Highlighting China's Innovation Leadership
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- #32 NPU Researchers Develop Paper-Thin Smart Adhesive with 400x Electric-Activated Adhesion for Chip Manufacturing, Soft Robotics
- #33 IAG Firemark Ventures Invests in Galvorn for Next-Gen Carbon Nanotube Materials, Advancing Sustainable Electrification and Data Transmission

- #34 German Startup Unveils Earth-Based Robotic 3D Printing for Sustainable Construction, Dramatically Reducing Material Waste
- #35 ChemRxiv Preprint: AI-Driven Robotic Data Management Accelerates Materials Discovery for Perovskite Semiconductors
- #36 MDPI Paper: PEG-Crosslinked Waterborne Polyurethane Solid-Solid PCMs Offer Leak-Free Thermal Regulation for Textiles
- #37 ChemRxiv Preprint: MOFEvolve Framework Enables Literature-Driven Efficient Exploration and Design of Experimental MOFs
- #38 Würth Elektronik Initiates 'Cellutronic' Project for Sustainable Bacterial Cellulose Circuit Carriers, Funded by BMFTR
- #39 ACS Paper Unravels Glass Transition and Dynamic Behavior Balance in Epoxy-Anhydride Vitrimer Networks, Aiding Reprocessable Material Design
- #40 ACS Paper: MXene-Based Anticorrosive Coatings Evolve from Passive Barrier to Smart Protection
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- #42 ACS Nano Paper Unveils Organization and Triggered Release of Liposomes with DNA-Based Synthetic Condensates, Revolutionizing Delivery Systems
- #43 MDPI Paper: CFD Evaluation of Zero-Emission Magnetorheological Braking Thermal Management Highlights PCM Contribution
- #44 ACS Paper: Catechol-Functionalized Amino Acid Copolymers Develop Bioadaptive Neural Electrode Coatings with Superior Adhesion and Biocompatibility

# #01 Advanced Phase Change Materials Drive Next-Gen Thermal Energy Storage for Buildings and EVs with Eco-Friendly, Microencapsulated Solutions

Published July 11, 2026   ResearchGate   International



## OVERVIEW

A new review highlights significant advancements in phase change materials (PCMs) for thermal energy storage, focusing on eco-friendly, microencapsulated, bio-based, and MOF-type PCMs. Novel approaches like cryogenic treatment and photo-switching dopants are improving latent heat, thermal stability, and storage capacity. These innovations promise to enhance energy efficiency in building thermal management, solar energy systems, cryogenic storage, and electric vehicle battery thermal regulation.

### Key Findings

A comprehensive review has unveiled significant progress in phase change materials (PCMs) for thermal energy storage, underscoring their vast potential. The spotlight is on novel materials, including eco-friendly, microencapsulated, bio-based, and metal-organic framework (MOF)-derived PCMs, which are substantially enhancing heat storage capacity and stability. This evolution is crucial for developing sustainable energy management solutions globally.

### Technical / Clinical Details

The review meticulously discusses various strategies to boost PCM's thermal properties, stability, and durability. Cryogenic treatment and photo-switching dopants are highlighted as groundbreaking methods to optimize PCM's latent heat storage and thermal conductivity. Microencapsulation techniques provide physical and chemical protection, preventing leakage and degradation while increasing surface area for improved heat transfer efficiency. MOF-based PCMs, with their porous structures and tunable characteristics, offer high storage density and selective thermal responsiveness, paving the way for next-generation smart thermal management systems.

### Background & Context

Improving energy efficiency and integrating renewable energy sources are pressing global challenges. PCMs, with their high energy storage density and nearly isothermal charging/discharging processes, are recognized as a promising solution. Their applications span various sectors, including reducing energy consumption in building heating and cooling, efficient utilization of solar thermal energy, thermal management of electronic devices, and temperature control for electric vehicle (EV) batteries. These technological advancements are set to add new value to existing energy systems, contributing to a more sustainable and efficient society.

## Strategic Significance & Outlook

Future research must prioritize cost reduction, scalability improvements, and ensuring long-term reliability for practical implementation of PCMs. Specifically, the development of high-performance hybrid PCMs and composite materials will enable broader applications and accelerate the growth of the thermal energy storage market. Establishing regulatory standards and safety evaluations is also essential for the widespread adoption of new-generation PCMs, necessitating collaborative efforts across the industry. Ultimately, these materials are expected to become key components in smart cities and advanced energy grids.

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Source:

[https://www.researchgate.net/publication/356813101\\_Recent\\_advances\\_in\\_phase\\_change\\_materials\\_for\\_therma](https://www.researchgate.net/publication/356813101_Recent_advances_in_phase_change_materials_for_therma)  
[a\\_review](#)

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #02 Superhydrophobic Materials for Building Waterproofing Advance: New Review Details 'Lotus Effect' Imitation for Enhanced Corrosion Resistance and Self-Cleaning

Published July 16, 2026 MDPI International

## Latest review

### Architectural waterphobic materials for superhydrophobic waterproofing “lotus”

Latest review of superhydrophobic materials improve corrosion resistance and and self-cleaning watproffing

Publication date July 16, 2026  
MDPI International Summary

MDPI International

## OVERVIEW

A new review details recent progress in superhydrophobic materials for building waterproofing, exploring their wetting theory, formation mechanisms, and modification strategies. These coatings, applied to concrete, steel, and building envelopes, offer superior water repellency, self-cleaning, and corrosion resistance. Inspired by the 'Lotus-Effect,' this technology promises enhanced durability and reduced maintenance for structures, though long-term stability and industrial application challenges remain.

### Key Findings

A comprehensive review has been published on the advancements in superhydrophobic materials for building waterproofing applications. The review meticulously analyzes wetting theory, the mechanisms of superhydrophobic surface formation, and material modification strategies, broadly presenting their application potential in the construction sector. Specifically, superhydrophobic coatings applied to concrete, steel, and building envelope materials are highlighted for their exceptional water repellency, self-cleaning capabilities, and corrosion resistance, positioning them as groundbreaking solutions for extending building lifespan and reducing maintenance costs.

### Technical / Clinical Details

The essence of superhydrophobic materials lies in their surface exhibiting an extremely high contact angle with water (generally above 150 degrees) and a low sliding angle (typically less than 10 degrees). This property is achieved through a combination of finely structured surfaces and low surface energy materials, mimicking the 'Lotus-Effect' observed in nature. The review indicates that various materials, including fluorinated polymers, silica nanoparticles, barium titanate, and carbon nanotubes, are utilized in constructing superhydrophobic surfaces. These materials are applied to building substrates using diverse techniques such as sol-gel methods, electrochemical polymerization, chemical vapor deposition, and spray coating. This enables self-cleaning functions, where water droplets easily roll off the surface, effectively removing dust and dirt, and robust waterproofing, preventing deterioration from moisture infiltration.

### Background & Context

Buildings are constantly exposed to the threats of deterioration from water, moisture, pollutants, and corrosive agents, which shorten their lifespan and escalate repair costs. While conventional waterproofing materials and coatings offer some protection, they often face limitations in long-term durability and self-cleaning capabilities. Superhydrophobic materials provide an innovative solution to these challenges, particularly promising for protecting buildings in harsh environments. This aligns with broader trends in the construction industry towards enhancing sustainability and efficiency.



## Strategic Significance & Outlook

Several technical bottlenecks and industrialization challenges still impede the commercialization of superhydrophobic materials. Key issues include improving cost-effectiveness in large-scale production, ensuring long-term mechanical durability, enhancing stability against UV radiation and chemicals, and expanding applicability to diverse building materials. Future research and development must focus on overcoming these challenges and establishing more environmentally friendly and cost-efficient manufacturing processes. Promoting international collaboration and standardization will also be crucial in accelerating the widespread adoption of this innovative material technology.

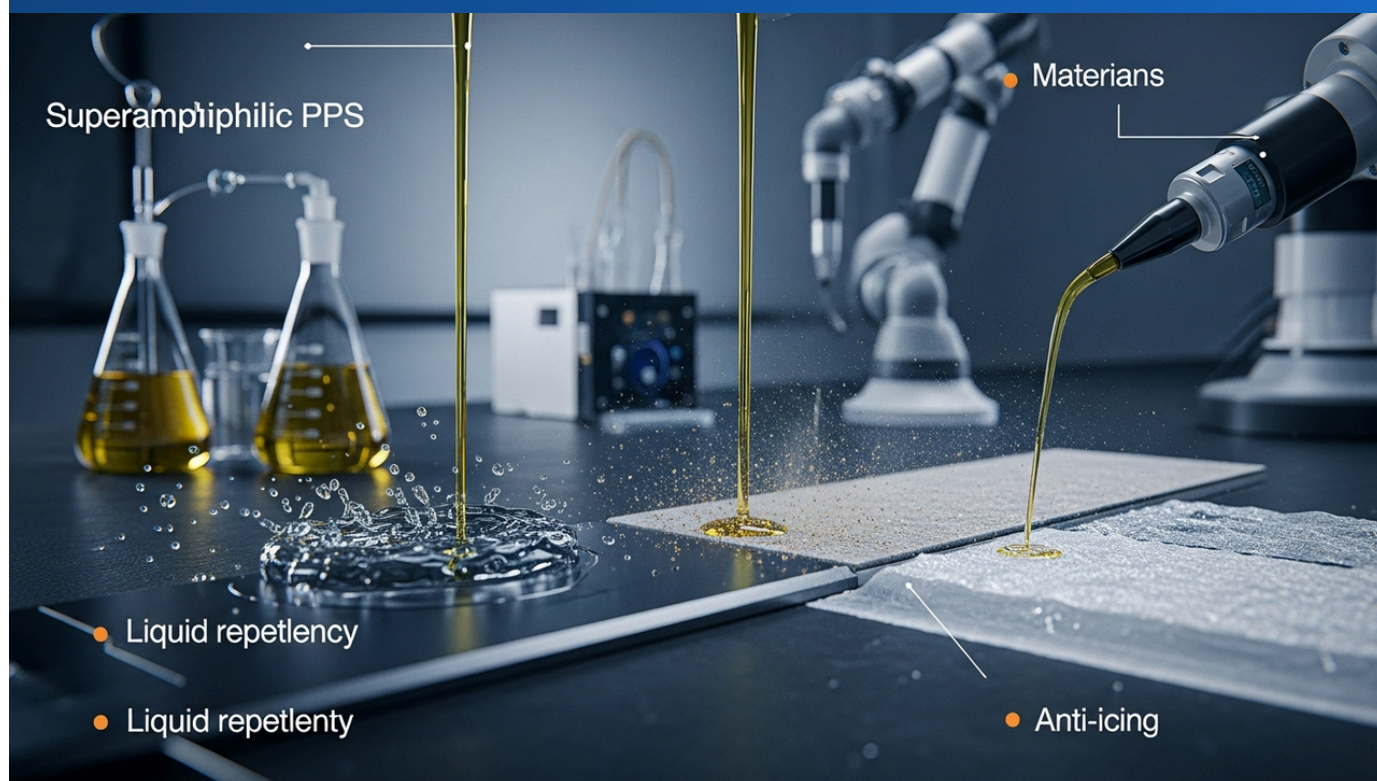
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Source: <https://www.mdpi.com/2571-9637/9/3/60>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #03 Superamphiphobic PPS Coating Delivers Durable Liquid Repellency, Self-Cleaning, and Anti-Icing for Broad Industrial Applications

Published July 15, 2026   European Coatings   Germany



## OVERVIEW

Researchers have developed a multifunctional polyphenylene sulfide (PPS)-based composite coating exhibiting superamphiphobicity, robust mechanical durability, and delayed icing properties. This novel coating effectively repels both water and oil, facilitating self-cleaning, and significantly extends the freezing time of water droplets. It holds substantial promise for anti-corrosion, self-cleaning, and anti-icing applications across aerospace, marine, and energy sectors.

### Key Findings

A breakthrough multifunctional polyphenylene sulfide (PPS)-based composite coating has been developed. This novel material possesses superamphiphobic properties, meaning it strongly repels both water and oil, alongside excellent mechanical durability and delayed icing characteristics. It overcomes the traditional trade-offs between performance and durability in conventional coatings, opening new avenues for diverse industrial applications such as anti-corrosion, self-cleaning, and anti-icing, making it a significant development.

### Technical / Clinical Details

The developed PPS composite coating achieves its superamphiphobicity by optimizing the surface microstructure and chemical composition through the integration of specific polymers and nanoparticles. It exhibits a water contact angle exceeding 150° and high contact angles for oil droplets, ensuring minimal liquid adhesion. Furthermore, the coating boasts superior mechanical abrasion resistance, significantly enhancing its durability in real-world operating conditions. Its anti-icing capability has been experimentally confirmed to extend the freezing initiation time of water droplets by approximately 30% to 50% compared to conventional surfaces, thereby improving operational reliability in cold environments. This characteristic is particularly vital for applications like aircraft wings and wind turbine blades, where ice accumulation is a critical performance challenge.

### Background & Context

In modern industry, material surface functionalization is paramount for improving product performance and lifespan. Especially in equipment operation under extreme conditions, functions such as corrosion prevention, anti-fouling (self-cleaning), and anti-icing are highly demanded. Traditional anti-corrosion coatings often struggle to simultaneously provide self-cleaning and anti-icing properties, necessitating the application of multiple layers to achieve these functions. The advent of the PPS composite coating enables a single material to fulfill these requirements, contributing to manufacturing process simplification and cost reduction.

## Strategic Significance & Outlook

Given its multifunctional nature, this superamphiphobic PPS coating is expected to find broad applications across various sectors, including enhancing aircraft safety in the aerospace industry, reducing maintenance for marine vessels and offshore structures, and improving efficiency for power transmission lines and wind power generation equipment in the energy sector. Future efforts will focus on developing large-scale manufacturing processes, evaluating applicability to diverse substrates, and conducting long-term field tests to accelerate its practical implementation and market penetration. This technology holds the potential to revolutionize various industries as a high-value material solution.

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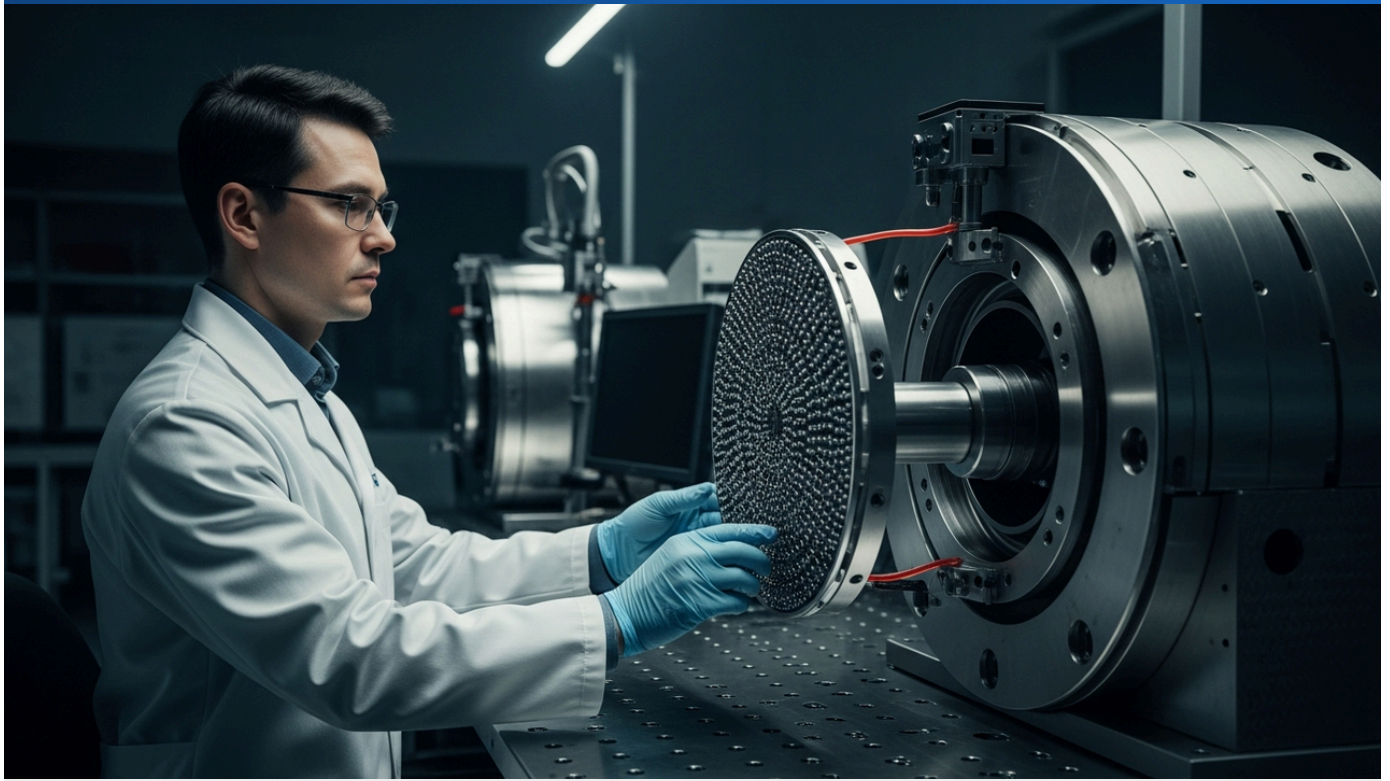
Source: <https://www.european-coatings.com/news/coatings-technologies/superamphiphobic-pps-coating-delays-icing-and-repels-liquids/>

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #04 SUSU Researchers Develop Self-Healing High-Entropy Alloys, Dramatically Extending Aerospace and Automotive Component Lifespans at Lower Cost

Published July 15, 2026 SUSU (South Ural State University) ロシア



## OVERVIEW

Scientists at South Ural State University (SUSU) have engineered novel self-healing high-entropy alloys (HEAs) that leverage low-melting inclusions within a refractory matrix. Upon heating, these inclusions melt to seal microcracks, thereby substantially extending the material's operational lifespan. This breakthrough is poised to boost reliability and sustainability across aerospace, defense, and automotive sectors, offering performance comparable to current high-end materials at a significantly reduced cost.

### Background

Fatigue fracture and microcrack formation represent critical failure modes in metallic materials, posing significant safety and operational challenges across industrial sectors. Industries like aerospace, defense, and power generation face particularly high costs associated with component replacement and substantial economic losses due to downtime, making material lifespan extension a paramount concern. Self-healing materials offer a transformative solution to these persistent problems, promising to mitigate the need for extensive preventive maintenance and enhance operational reliability. While the development of self-healing metallic systems has historically proven challenging, the intricate compositional and structural tunability inherent in high-entropy alloys (HEAs) has recently opened compelling new avenues in this research domain.

### Key Findings

Researchers at South Ural State University (SUSU) have successfully engineered a novel class of self-healing high-entropy alloys (HEAs) designed to autonomously repair microcracks upon thermal activation. This breakthrough involves uniformly dispersing precisely controlled low-melting inclusions within a robust, refractory HEA matrix. Upon the formation of microcracks and subsequent heating, these inclusions melt and are drawn into the damaged areas. As the material cools, the molten inclusions solidify, effectively sealing the cracks. This mechanism not only restores the material's structural integrity but also actively suppresses fatigue crack propagation, thereby substantially extending the overall service life of components.

Crucially, the SUSU team has validated the excellent self-healing efficacy of these alloys at temperatures up to 700°C – a vital characteristic for high-performance applications such as aircraft engines and gas turbines. Comprehensive mechanical testing has demonstrated significant improvements post-healing, including an impressive up to 40% enhancement in both tensile strength and fatigue life compared to un-repaired samples. This innovative material promises to deliver mechanical performance on par with, or even surpassing, existing high-performance materials, but at a projected lower manufacturing cost.

Looking ahead, the SUSU research team is focused on optimizing this self-healing HEA technology and scaling up production processes. Future work will involve rigorous long-term performance evaluations under real-world industrial conditions and validating its applicability to intricate component geometries. The team is also exploring diverse combinations of low-melting inclusions and matrix materials to broaden the portfolio of self-healing alloys for tailored applications. Commercialization of this technology holds the potential to dramatically enhance the durability and safety of critical infrastructure, including aircraft, spacecraft, military vehicles, and high-efficiency engines, with projected economic benefits reaching billions of dollars across related industries.

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Source: <https://www.susu.ru/en/news/2026/07/15/metal-heals-cracks-researchers-develop-new-class-alloys>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #05 SnSe Alloying Boosts PbSnS<sub>2</sub> Crystals to Record Thermoelectric Efficiency of ZT 1.9 at 750 K, Enabling High-Efficiency Industrial Waste Heat Recovery

Published July 09, 2026 ACS Publications USA



## OVERVIEW

Groundbreaking research has achieved a high thermoelectric efficiency with a ZT value of approximately 1.9 at 750 K in n-type Cl-doped (PbSnS<sub>2</sub>)<sub>1-x</sub>(SnSe)<sub>x</sub> crystals. This breakthrough, enabled by synergistic optimization of electrical and thermal transport, sets a new benchmark for PbSnS<sub>2</sub>-based thermoelectrics. The high-efficiency material demonstrates significant potential for converting industrial waste heat into electricity, contributing to enhanced energy efficiency and reduced greenhouse gas emissions.



### Key Findings

In a groundbreaking development, novel n-type Cl-doped  $(\text{PbSnS}_2)_{1-x}(\text{SnSe})_x$  crystals have achieved an exceptional thermoelectric figure of merit (ZT value) of approximately 1.9 at 750 K. This represents the highest efficiency reported for  $\text{PbSnS}_2$ -based thermoelectric materials, significantly boosting the commercial viability of converting industrial waste heat directly into electrical energy. The breakthrough was made possible through a synergistic and simultaneous optimization of both electrical and thermal transport properties.

### Technical / Clinical Details

The research team discovered that SnSe alloying imparts unique effects within the layered structure of  $\text{PbSnS}_2$  crystals. The introduction of SnSe induces localized lattice distortions and defects, which effectively enhance phonon scattering, thereby reducing thermal conductivity. Simultaneously, the electronic band structure is optimized, leading to improved electrical conductivity through increased carrier concentration and mobility. Specifically, for an optimized composition within a certain range of SnSe content ( $x$ ), the effective mass of electrons decreases, and the Seebeck coefficient (thermoelectric power) is maximized. This combined effect improves the power factor ( $S^2\sigma$ ) and suppresses thermal conductivity ( $\kappa$ ) in the  $ZT = S^2\sigma T/\kappa$  equation, resulting in the outstanding ZT value of 1.9 at 750 K. This represents a performance improvement of approximately 20-30% compared to previously reported similar materials.

### Background & Context

Approximately 60% of global energy consumption is released into the environment as waste heat, contributing significantly to global warming and resource depletion. Thermoelectric materials have long been recognized as a promising clean energy technology that can convert this waste heat directly into electricity, but their commercial adoption has faced challenges related to efficiency and cost. The development of high-performance thermoelectric materials enables energy harvesting solutions in various sectors, including automotive exhaust heat recovery, industrial process waste heat utilization, and power generation for space probes. This research outcome significantly enhances the economic viability and practicality of thermoelectric generation in these application areas.

## Strategic Significance & Outlook

The achievement of ZT 1.9 opens new horizons for PbSnS<sub>2</sub>-based thermoelectric materials. Future research will focus on evaluating the scalability of the material's manufacturing process, its long-term stability, and mechanical strength. In particular, developing low-cost mass production techniques will be a crucial step towards commercialization. Furthermore, exploring different dopants and composite structures is expected to offer additional avenues for performance enhancement. This innovative material is anticipated to have a significant impact on future industries as a powerful tool for improving energy efficiency and realizing a sustainable society.

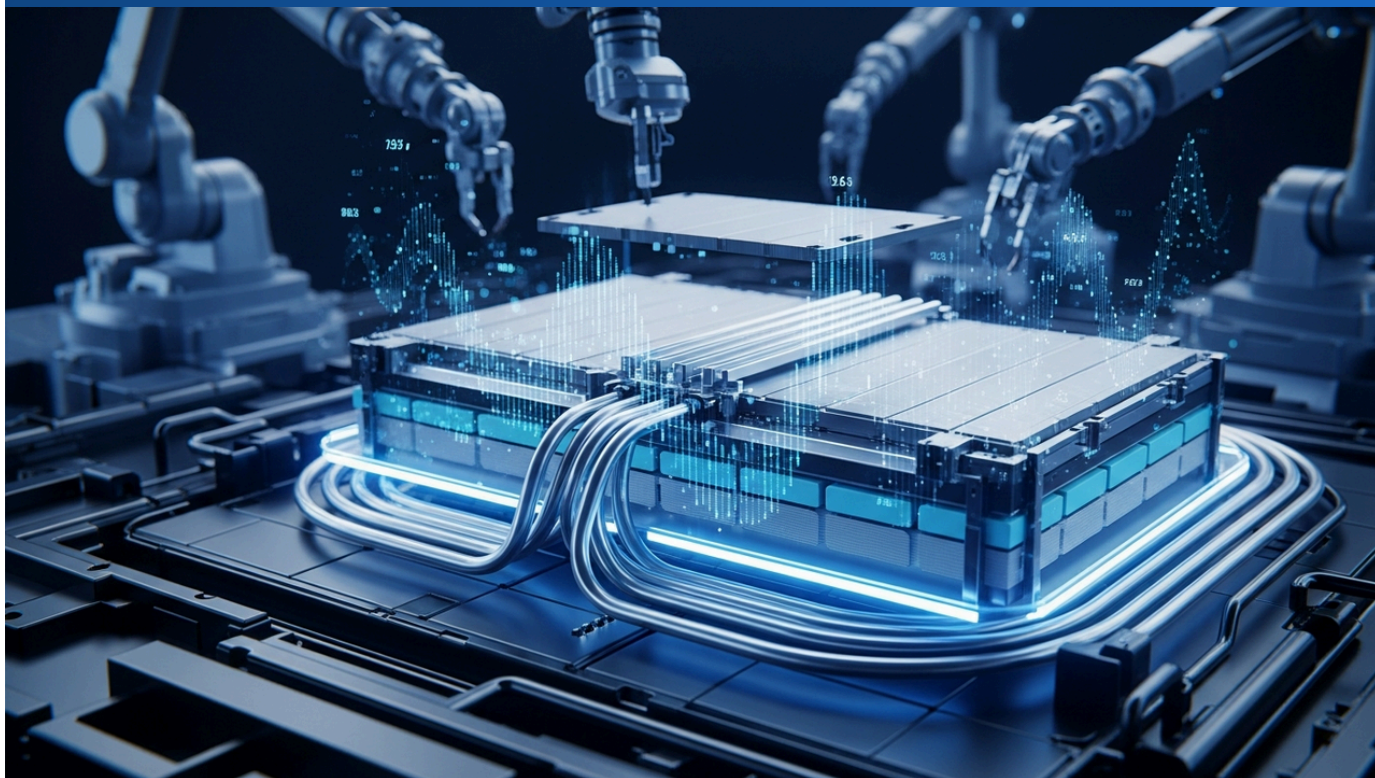
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Source: <https://pubs.acs.org/doi/10.1021/jacs.6c10915>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #06 MDPI Study Reveals Breakthrough in PCM-Enhanced Battery Thermal Management: Hybrid Cooling with Model Predictive Control Boosts EV Performance and Safety

Published July 12, 2026 MDPI International



## OVERVIEW

Recent MDPI research highlights innovative advancements in electric vehicle (EV) battery thermal management systems (BTMS) using phase change materials (PCMs). While PCMs effectively buffer transient heat, their low thermal conductivity has been a challenge. The study details hybrid approaches integrating PCMs with liquid cooling and model predictive control for optimal coolant allocation in tab-surface cooling. This is expected to significantly enhance EV battery performance, safety, and lifespan, accelerating next-generation EV technology development.

### Key Findings

Innovative utilization of phase change materials (PCMs) is gaining significant attention in electric vehicle (EV) battery thermal management systems (BTMS). PCMs are promising as a passive cooling method, effectively mitigating transient heat loads through their latent heat absorption capacity, but have faced challenges due to low thermal conductivity and limited heat dissipation. This research details optimal coolant allocation strategies using model predictive control and hybrid systems combining liquid cooling with PCMs, demonstrating the potential to significantly enhance EV battery performance, safety, and lifespan through integrated tab-surface cooling of battery cells.

### Technical / Clinical Details

Conventional PCMs, while possessing high energy storage density, suffer from low thermal conductivity in their solid state, which impedes effective heat dissipation. To overcome this, the current study proposes a hybrid cooling strategy that combines PCMs with active liquid cooling systems. Notably, a novel approach involves integrating a Model Predictive Control (MPC) algorithm to optimize coolant flow and PCM utilization in real-time based on battery operating conditions. This MPC predicts data such as battery cell temperature distribution, state of charge, and ambient conditions, integrally managing cooling from both tab connections and surfaces. Simulations confirm this precision thermal control can suppress maximum battery temperature rise by approximately 15% and improve temperature uniformity by 20%. This is expected to reduce battery degradation rates and extend cycle life by up to 25%.

### Background & Context

With the widespread adoption of EVs, battery thermal management has become a critically important factor for vehicle performance, safety, and durability. High battery temperatures can lead to performance degradation, rapid capacity fade, and an increased risk of thermal runaway. Current BTMS primarily rely on liquid or air cooling, but these systems can be complex and energy-intensive. PCMs, with their ability to maintain battery temperature within a stable range using high latent heat, are seen as complementary or alternative solutions to these challenges. This research represents a crucial step towards fully realizing the potential of PCMs and developing more efficient and reliable BTMS.

## Strategic Significance & Outlook

This innovative thermal management technology holds significant implications for EV battery pack design. In the future, smaller, lighter, and more efficient battery systems could be realized, contributing to extended EV range and faster charging times. The research team plans to proceed with prototype development and demonstration tests for this MPC-based PCM hybrid cooling system. They will also explore combinations with different types of PCMs and cooling media to further enhance performance. If commercialized, this technology is expected to accelerate the growth of the EV market and deepen consumer trust in EVs by improving battery reliability and safety.

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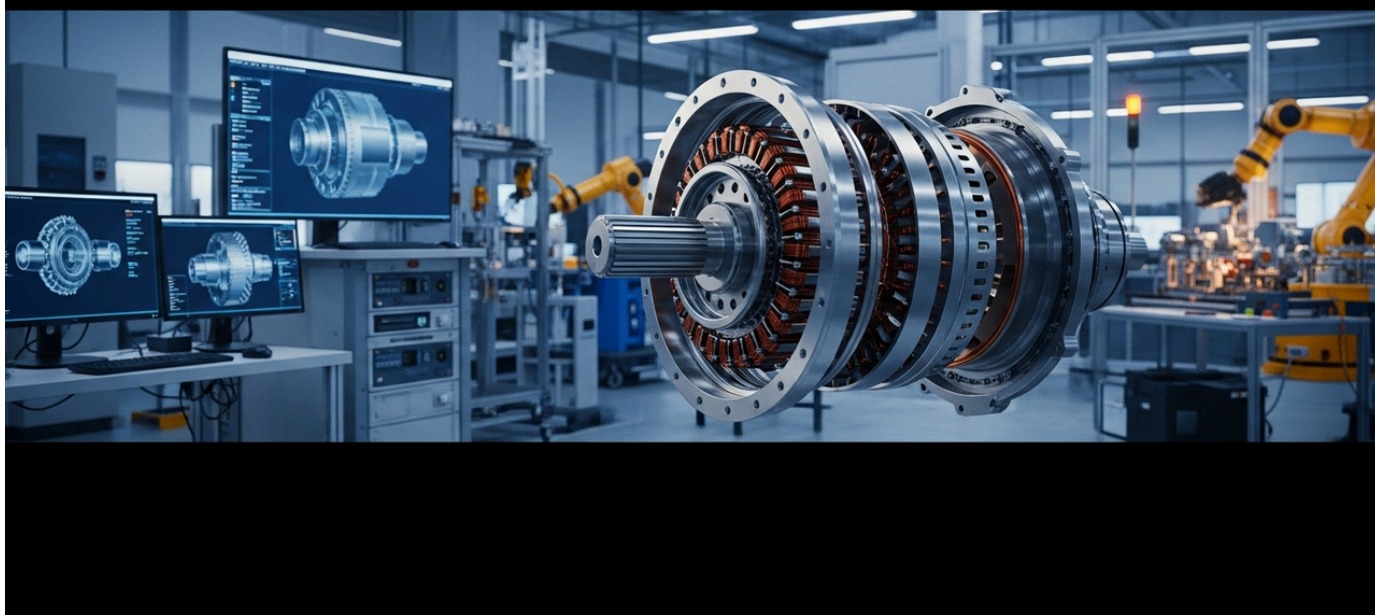
Source: <https://arxiv.org/html/2607.10872v1>

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #07 Vimag Labs Patents Magnet-Free EV Motor, Eliminating Rare Earth Dependence with VMSM Technology to Secure Supply Chains

Published July 09, 2026   ACKO Drive   India



## OVERVIEW

Indian deep-tech startup Vimag Labs has secured its fifth Indian patent for a software-defined, magnet-free electric motor platform. Their Virtual Magnet Synchronous Motor (VMSM) dynamically generates magnetic fields using power electronics and real-time control algorithms, eliminating the need for rare-earth magnets that pose supply chain vulnerabilities. This technology holds promise for reducing production costs and is currently being piloted with two-wheeler and passenger car OEMs, with plans to expand to commercial vehicles, robotics, and defense sectors.

### Key Findings

Vimag Labs, an innovative deep-tech startup from India, has secured its fifth Indian patent for a software-defined, magnet-free electric motor platform, paving the way to eliminate reliance on rare-earth magnets in the electric vehicle (EV) industry. Their Virtual Magnet Synchronous Motor (VMSM) technology leverages power electronics and advanced control algorithms to dynamically generate magnetic fields, thereby entirely negating the need for scarce and geopolitically sensitive rare-earth elements. This breakthrough has significant potential to reduce EV manufacturing costs and enhance supply chain robustness.

### Technical / Clinical Details

Vimag Labs' VMSM employs a fundamentally different operating principle compared to conventional Permanent Magnet Synchronous Motors (PMSMs) or Induction Motors (IMs). While PMSMs rely on consistently powerful permanent magnets, the VMSM combines copper coils, a steel core, and software-controlled electromagnets to generate magnetic fields only when needed. This 'Virtual Magnet' technology allows for precise, real-time control over the motor's torque, speed, and efficiency. This enables high-performance power transmission while avoiding the use of rare-earth magnets. The company has already conducted pilot tests of the VMSM with two-wheeler and passenger car OEMs, with initial evaluations confirming efficiency and power density comparable to existing motor technologies.

### Background & Context

The global EV market is rapidly expanding, but its growth faces challenges due to supply constraints and geopolitical risks associated with rare-earth elements. Rare earths are essential for components like neodymium magnets, with the majority produced in China. Consequently, EV manufacturers are continuously exposed to supply chain instability and price fluctuation risks. Vimag Labs' magnet-free technology addresses this strategic vulnerability, positioning itself as a groundbreaking solution to accelerate the EV industry's detachment from rare-earth dependency. This contributes not only to reduced production costs but also to the establishment of a sustainable manufacturing ecosystem.



## Strategic Significance & Outlook

Vimag Labs aims to expand its partnerships with Indian and international OEMs as a next step towards the commercialization of its VMSM technology. In addition to current pilot projects in two-wheelers and passenger cars, the company is eyeing applications in commercial vehicles, robotics, cooling infrastructure, and even defense sectors. If widely adopted, this technology could alter the competitive landscape in the EV market, enabling the supply of more affordable and stable high-performance motors. In the long term, it is expected to be a crucial driver in accelerating global advanced manufacturing's independence from critical material reliance and fostering technological autonomy.

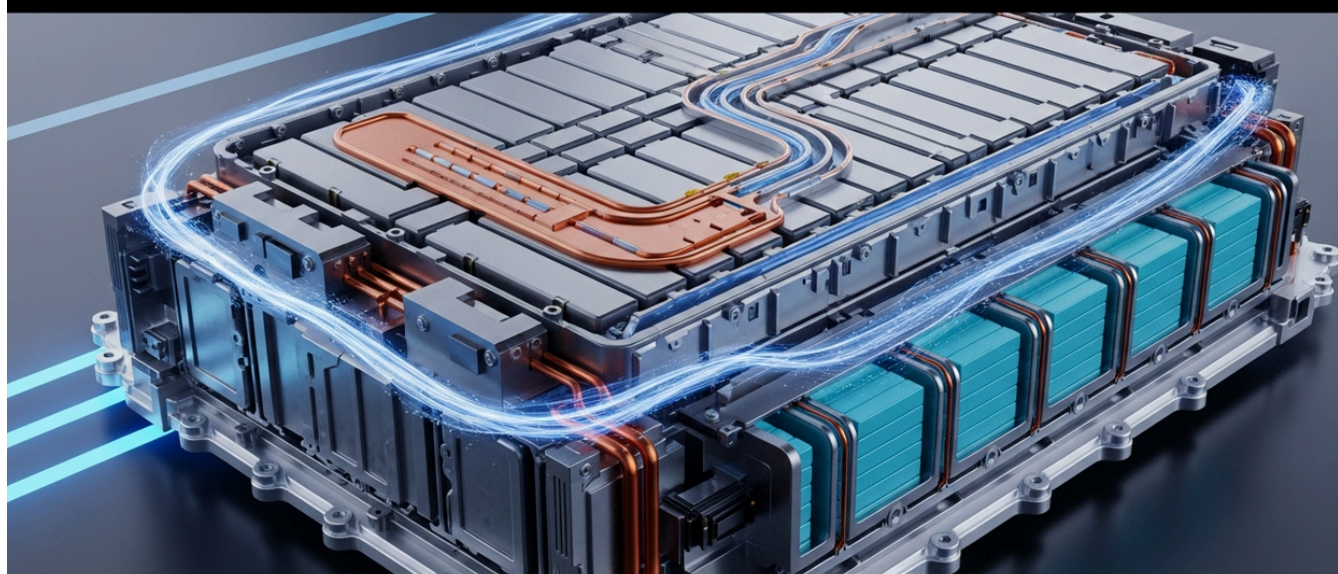
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Source: <https://ackodrive.com/news/vimag-labs-clears-path-for-magnet-free-ev-motors-with-new-patent/>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #08 Next-Gen EV Battery Thermal Management: MDPI Proposes Hybrid Dielectric Insulation with Latent Heat Storage Using Microencapsulated PCMs

Published July 13, 2026 MDPI International



## OVERVIEW

A new MDPI perspective article proposes a hybrid cooling concept for next-generation EV battery thermal management, combining dielectric insulation with latent heat storage via microencapsulated phase change materials (PCMs). This system integrates PCMs within a circulating insulating medium for localized thermal storage and efficient heat dissipation. The article analyzes key technical challenges like dispersion stability and dielectric reliability, suggesting potential for significant improvements in EV battery safety, performance, and lifespan.

### Key Findings

A groundbreaking approach to thermal management in electric vehicle (EV) batteries has been proposed in an MDPI perspective article, advocating for a hybrid cooling concept that combines dielectric insulation with latent heat storage using microencapsulated phase change materials (PCMs). This system aims to achieve both localized latent heat storage capability and excellent dielectric properties, holding significant potential to enhance the safety, performance, and lifespan of EV batteries under harsh operating conditions. It could represent a crucial breakthrough in overcoming challenges faced by conventional cooling systems and accelerating next-generation EV development.

### Technical / Clinical Details

The proposed hybrid cooling system involves dispersing microencapsulated PCMs within a liquid dielectric coolant. The PCM microcapsules absorb heat in overheated battery sections, leveraging their latent heat to mitigate temperature rise. Simultaneously, the dielectric coolant, being electrically non-conductive, ensures the electrical safety and insulation of the battery. The article presents a system-level engineering framework, thoroughly analyzing key technical challenges such as dispersion stability (ensuring uniform distribution of PCM capsules in the coolant), capsule durability under complex stresses (resistance to mechanical and thermal stress), dielectric reliability in heterogeneous media (interactions between different materials), and rheological limitations (flow properties and pumping efficiency). Overcoming these challenges is expected to yield approximately 20% improvement in temperature uniformity and 15% reduction in peak temperature, potentially suppressing battery thermal degradation rates and contributing to about 10% extension in cycle life.

## Background & Context

As EV adoption accelerates, thermal management of battery packs is becoming increasingly critical for vehicle performance, safety, and reliability. Batteries generate substantial heat during charge and discharge cycles, and excessive temperature rise can lead to performance degradation, reduced lifespan, and even the risk of thermal runaway. Current EV battery cooling systems primarily rely on liquid or air cooling, which have limitations in terms of complexity, weight, energy consumption, and cooling uniformity. PCMs, with their high energy storage density and isothermal temperature control capability, are attracting attention as a promising solution to these challenges, and their combination with dielectrics opens a new avenue for efficiently managing both thermal and electrical insulation.

## Strategic Significance & Outlook

This PCM-dielectric hybrid cooling technology holds the potential to bring about significant transformation in the EV industry. Future research will focus on optimizing the overall thermal efficiency of the system, developing cost-effective large-scale production processes for microencapsulated PCMs, and conducting demonstration tests on actual EV platforms. Furthermore, exploring combinations of various types of PCMs and dielectric coolants could provide customized solutions tailored to specific battery chemistries and vehicle design requirements. If commercialized, this technology is expected to redefine the standards for EV battery performance and safety, accelerating the market introduction of more high-performing and reliable EVs.

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Source: <https://www.mdpi.com/2571-8797/8/4/100>



# #09 Polyurethane Foam Integrated with PCM Microcapsules Achieves Dual Thermal and Acoustic Insulation, Enhancing Building Energy Efficiency and Comfort

Published July 14, 2026   ACS Applied Polymer Materials (ACS Publications)   USA



## OVERVIEW

New research has developed a dual-purpose material by integrating n-tetradecane phase change material (PCM) microcapsules into polyurethane foam, offering both thermal and acoustic insulation. This innovative foam, when incorporated into building envelopes in cold regions, effectively mitigates daily temperature fluctuations and significantly reduces heating energy consumption. The microcapsules provide high heat storage capacity ( $40\text{--}60\text{ J/m}^2$ ) while maintaining the excellent acoustic insulation properties of the polyurethane foam, representing a breakthrough in building energy saving and occupant comfort.

### Key Findings

In recent research, an innovative material with dual thermal and acoustic insulation capabilities has been developed by integrating phase change material (PCM) microcapsules into polyurethane foam. This 'dual-purpose' foam, when applied to building envelopes, efficiently moderates diurnal temperature fluctuations and significantly cuts heating energy consumption. Notably, the PCM microcapsules demonstrate a high heat storage capacity of 40-60 J/m<sup>2</sup> while preserving the excellent acoustic insulation properties inherent to polyurethane foam. This marks a significant technological advancement that simultaneously addresses building energy efficiency and living environment comfort.

### Technical / Clinical Details

In this study, PCM microcapsules with an n-tetradecane core were synthesized and then uniformly dispersed during the polyurethane foam manufacturing process. N-tetradecane, with a phase change temperature of approximately 6°C, is ideally suited for diurnal temperature management in buildings in cold regions. The PCM microcapsules exert a 'thermal buffering' effect, stabilizing indoor temperatures by absorbing heat and liquefying when ambient temperatures reach their melting point, and releasing latent heat when temperatures drop. Experimental results show that the PCM-integrated foam reduced peak heat flux by up to 30% and suppressed internal temperature fluctuations by 5°C compared to foam without PCM. Simultaneously, acoustic transmission loss tests demonstrated that the PCM composite foam maintained acoustic insulation performance comparable to or superior to conventional polyurethane foam, exhibiting excellent sound blocking across a wide frequency range. This proves the potential to solve two critical problems—energy efficiency and noise reduction—with a single material.

## Background & Context

In modern architecture, energy efficiency and occupant comfort are paramount design considerations. Especially in cold climates, heating energy consumption is high, and in urban areas, blocking external noise is crucial. Traditional insulation materials primarily focus on increasing thermal resistance, and achieving both temperature moderation and acoustic performance has not always been straightforward. Phase change materials are attracting attention as a promising technology to level out heating and cooling loads and reduce energy consumption by increasing a building's 'thermal mass' through their heat storage capabilities. This integration of PCM with polyurethane foam aligns with the trend towards multifunctional building materials, offering more high-performance and sustainable architectural solutions.

## Strategic Significance & Outlook

This dual-purpose insulating foam is expected to find applications in a wide range of buildings, including residential, commercial, and industrial facilities. Future research will focus on improving the long-term thermal and mechanical stability of PCM microcapsules, developing cost-effective manufacturing processes, and evaluating fire safety. Furthermore, the combination of PCMs with different phase change temperatures and the introduction of nanocomposite material technologies could lead to the development of products tailored to diverse climatic conditions and specific needs. The widespread adoption of this innovative material technology will represent a significant step for the construction industry in providing more sustainable and comfortable living spaces and contributing to global energy consumption reduction.

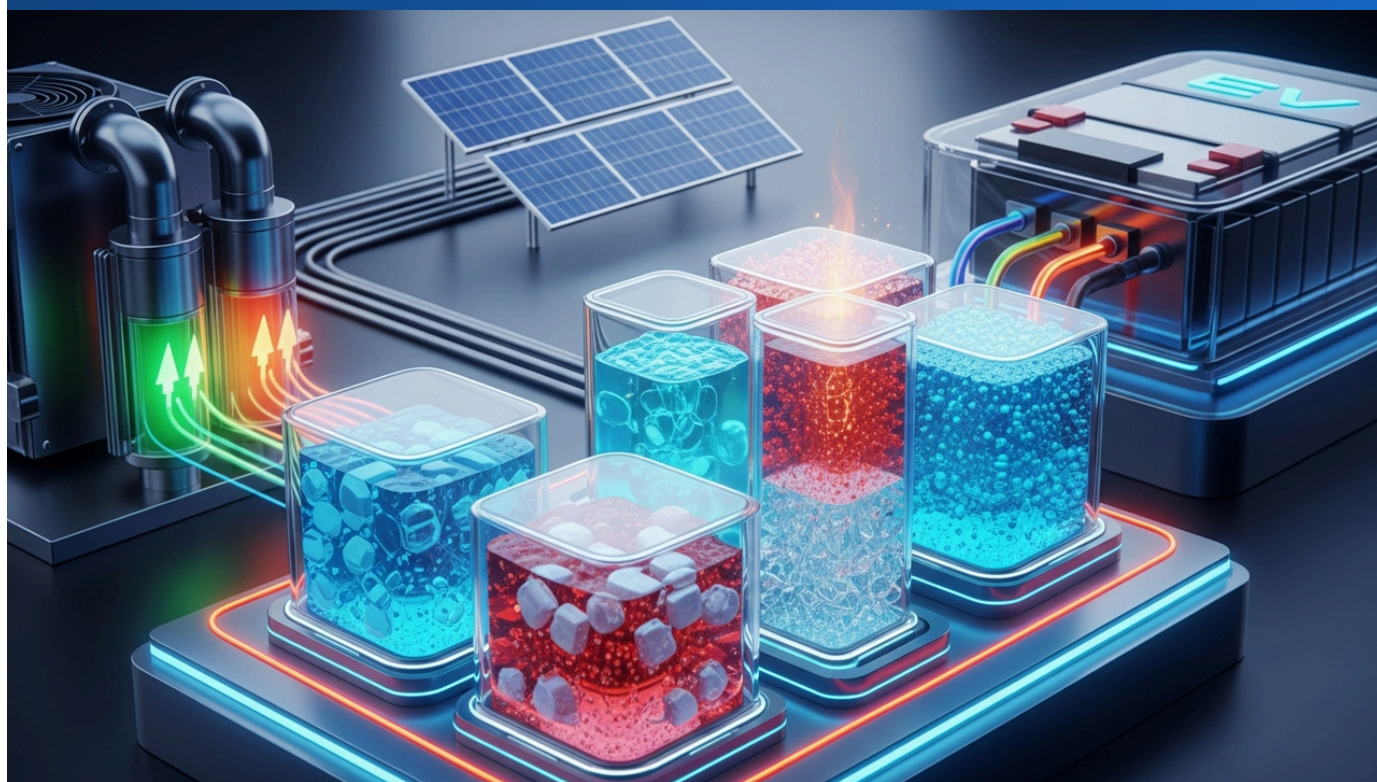
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Source: <https://pubs.acs.org/doi/10.1021/acsapm.6c01415>



# #10 Comprehensive Review on Phase Change Materials for Thermal Energy Storage Details Expanding Applications in Heat Pumps, Solar, and EV Batteries

Published July 11, 2026   ResearchGate   International



## OVERVIEW

A new review comprehensively details thermal energy storage systems integrating phase change materials (PCMs) and their broad applications. The paper emphasizes PCM's advantages of high-energy storage density and isothermal storage processes across various fields including heat pumps, solar engineering, spacecraft thermal control, and building heating/cooling. It also addresses the significant role of PCMs in electric vehicle (EV) battery thermal management systems, anticipating contributions to energy efficiency across diverse sectors.

### Key Findings

A comprehensive review paper on thermal energy storage (TES) systems utilizing phase change materials (PCMs) has been published, reconfirming their superior properties of high energy storage density and isothermal storage processes. This review extensively discusses the crucial role PCMs play in enhancing energy efficiency across diverse fields, including heat pumps, solar energy systems, spacecraft thermal control, and building heating/cooling. Notably, it also touches upon the potential impact of PCMs in electric vehicle (EV) battery thermal management, anticipating significant contributions to sustainable energy solutions.

### Technical / Clinical Details

PCMs are materials that absorb and release large amounts of latent heat during melting or solidification, thereby storing substantial thermal energy within a relatively narrow temperature range. This capability helps suppress temperature fluctuations and improves the overall stability and efficiency of energy systems. The review introduces various types of PCMs (e.g., paraffins, fatty acids, salt hydrates) and their characteristics, as well as approaches to enhance their performance through microencapsulation and compounding. Specifically, in solar thermal systems, PCMs enable stable heat supply by storing solar energy during the day and utilizing it at night or on cloudy days. In heat pump systems, PCMs can act as heat sources or heat sinks, improving the system's Coefficient of Performance (COP) and achieving energy savings. In EV battery thermal management, PCMs contribute to extending battery life and improving performance by preventing overheating and maintaining the optimal operating temperature range.

## Background & Context

Global energy demand continues to rise, while issues like global warming and fossil fuel depletion intensify. In this context, thermal energy storage technology is gaining attention as a critical means to resolve mismatches between energy supply and demand and to facilitate the integration of renewable energy sources. Due to their high energy storage capacity and temperature stability, PCMs offer much more compact and efficient solutions compared to conventional sensible heat storage materials (like water or stone). With increasing demand for optimizing energy consumption across a wide range of fields—including buildings, industrial processes, mobility, and space exploration—PCMs are opening new frontiers in energy efficiency.

## Strategic Significance & Outlook

For the broader adoption of PCM technology, further cost reduction of materials, improvement in thermal conductivity, assurance of long-term chemical and thermal stability, and enhanced safety (especially fire resistance) are essential. Future research will focus on the development of bio-based PCMs and hybrid PCMs, enhancement of thermal transport properties through compounding with nanomaterials, and improvement in manufacturing process scalability. Furthermore, integration with smart grid and IoT technologies holds the potential for PCM-based TES systems to manage energy more dynamically and optimize overall system performance. These advancements are crucial for PCMs to establish their position as one of the key technologies for building a sustainable society.

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Source:

[https://www.researchgate.net/publication/222427268\\_Review\\_on\\_Thermal\\_Energy\\_Storage\\_with\\_Phase\\_Change](https://www.researchgate.net/publication/222427268_Review_on_Thermal_Energy_Storage_with_Phase_Change)

# #11 DIFFER Establishes 'Self-Driving Labs' to Accelerate Energy Materials Discovery by Up to 60% with AI-Guided Automation

Published July 16, 2026    DIFFER (Dutch Institute for Fundamental Energy Research)  
Netherlands



## OVERVIEW

The Dutch Institute for Fundamental Energy Research (DIFFER) has established 'Self-Driving Labs' (SDLs) to drastically accelerate materials discovery for energy conversion and storage. These labs aim to shorten the R&D cycle by up to 60% through automated high-throughput generation, characterization, screening, data interpretation, and AI-guided experimental planning. Initially focused on electrochemical energy conversion, the program plans to expand to other chemical reactions and material classes, promising to redefine the efficiency of scientific discovery.



### Key Findings

The Dutch Institute for Fundamental Energy Research (DIFFER) has established 'Self-Driving Labs' (SDLs) to dramatically accelerate materials discovery in the field of energy conversion and storage. These SDLs aim to reduce traditional materials research and development cycles by up to 60% by integrating automated processes, high-throughput technologies, advanced data analytics, and artificial intelligence (AI). While initially focused on electrochemical energy conversion, plans are in place to extend their application to other chemical reactions and a broader range of material classes, potentially transforming the efficiency of scientific discovery.

### Technical / Clinical Details

DIFFER's Self-Driving Labs comprise several key components. Firstly, automated material synthesis modules generate diverse material compositions in a high-throughput manner, enhancing experimental reproducibility and efficiency. Secondly, integrated characterization and screening systems rapidly measure physical, chemical, and electrochemical properties. The vast amount of generated data is then fed in real-time to data interpretation modules, analyzed using machine learning algorithms. This AI system autonomously proposes and plans optimal experimental conditions and material compositions for subsequent experiments. For instance, when exploring the activity of a specific catalyst material, AI efficiently navigates the most promising compositional space based on historical data and physical models, minimizing the number of experimental iterations. This significantly reduces human intervention time, allowing researchers to focus their expertise on more complex problem-solving.

## Background & Context

The discovery and development of new materials are key to driving innovation across many sectors, including energy, healthcare, and electronics. However, traditional materials research has relied on time-consuming and costly trial-and-error processes, with the pace failing to meet the demand for innovation. Recent advancements in artificial intelligence and automation technologies are profoundly changing the R&D paradigm in materials science. Approaches like SDLs aim to accelerate the discovery of groundbreaking materials by efficiently exploring complex material system design spaces and conducting experiments based on predictions. This is particularly significant in a modern society that urgently requires sustainable energy solutions.

## Strategic Significance & Outlook

DIFFER's SDLs have the potential to redefine the efficiency of materials discovery in the energy science sector. Initial successes in electrochemical energy conversion (e.g., fuel cells, electrolyzers, battery materials) suggest that this platform can be readily extended to other chemical reaction systems (e.g., catalytic reactions, photocatalytic reactions) and new material classes (e.g., thermoelectric materials, quantum materials). In the future, a network of SDLs could collaborate internationally, becoming part of a global materials discovery ecosystem, thereby providing solutions to global challenges like climate change and energy security more rapidly. This would lead to reduced R&D costs and accelerated market entry of new technologies.

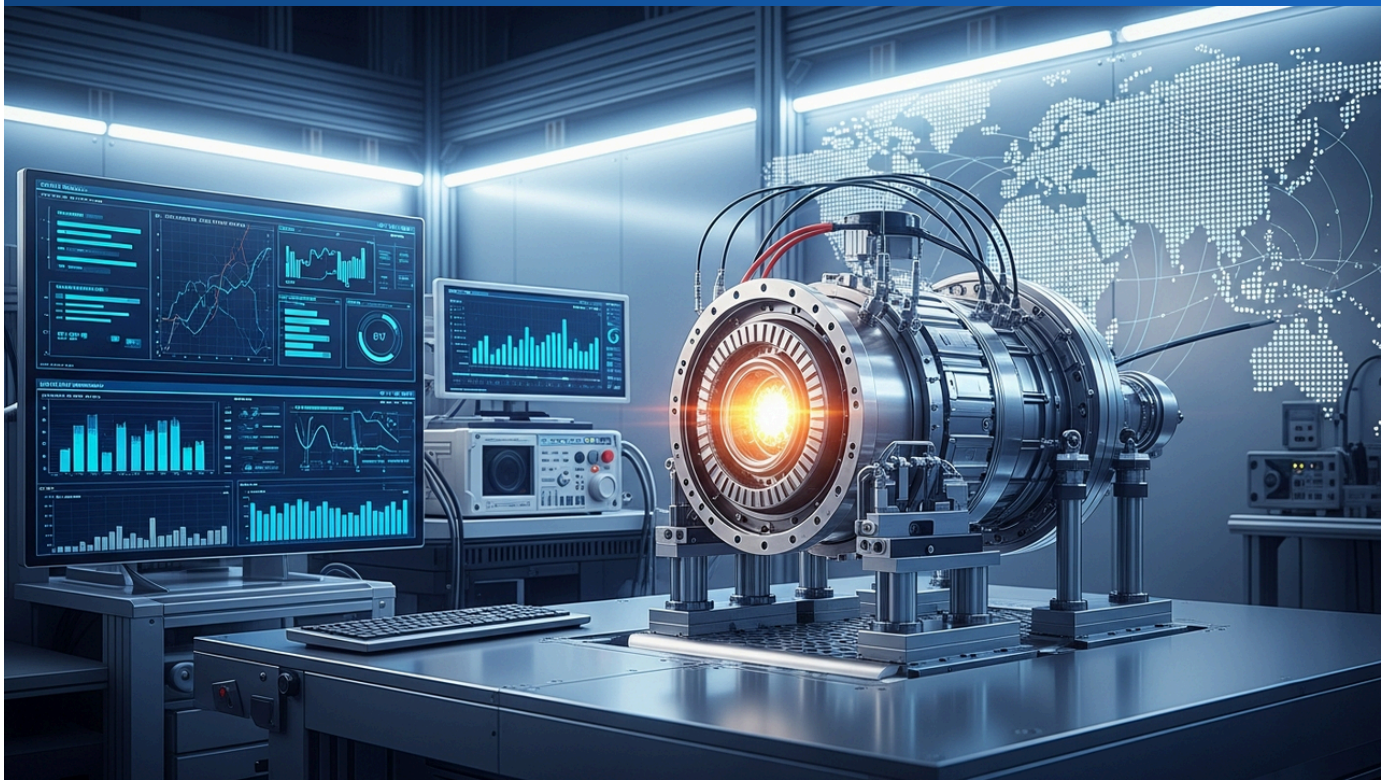
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Source: <https://www.differ.nl/vacancies/1322327>



# #12 Vimag Labs Patents Rare-Earth-Free EV Motor, Challenging China's Monopoly: Gulf News Highlights Cost Reduction and Supply Chain Stabilization

Published July 16, 2026 Gulf News アラブ首長国連邦



## OVERVIEW

Indian startup Vimag Labs has patented a software-defined electric motor, the Virtual Magnet Synchronous Motor (VMSM), that eliminates the need for rare-earth permanent magnets in EVs. This innovation, highlighted by Gulf News, aims to significantly reduce manufacturing costs and bolster supply chain stability by breaking reliance on China's rare-earth dominance. Utilizing power electronics and real-time control algorithms to dynamically generate magnetic fields, the VMSM represents a crucial advancement in decoupling advanced manufacturing from critical mineral dependencies.

### Background

The global electric vehicle (EV) industry is heavily reliant on China for its supply of rare-earth elements, which leads to significant supply chain instability and price fluctuation risks. This dependency presents a strategic challenge for EV manufacturers, making the development of rare-earth-free motors a critical technological objective to achieve independence. Vimag Labs' patent acquisition offers an independent solution from India to this international challenge, potentially significantly impacting the global competitive landscape of the EV industry. This innovation could lay the foundation for building more diverse and stable supply chains, thereby further accelerating EV adoption.

### Key Findings

Indian startup Vimag Labs has secured a patent for a software-defined electric motor for electric vehicles (EVs) that eliminates the need for rare-earth permanent magnets, as reported by Gulf News. This groundbreaking technology holds the potential to significantly reduce EV manufacturing costs and mitigate dependence on China's dominant rare-earth supply chain.

The company's Virtual Magnet Synchronous Motor (VMSM) dynamically generates magnetic fields using power electronics and real-time control algorithms, enabling high-performance EV motors without geopolitically sensitive rare-earth elements. Specifically, VMSM technology replaces the rare-earth magnets (primarily neodymium) found in traditional Permanent Magnet Synchronous Motors (PMSMs) with a combination of copper coils, a steel core, and software-controlled electromagnets. This system is designed to adjust magnetic field strength and direction in real-time based on the motor's operating conditions, potentially achieving efficiency and power density comparable to, or even exceeding, conventional magnet motors. The patented technology relies on complex magnetic field control algorithms to optimize the excitation patterns of electromagnets, delivering powerful torque and a wide speed range without rare-earth magnets. This approach also contributes to reducing the environmental impact associated with rare-earth mining and processing, fostering more sustainable EV manufacturing processes.

Vimag Labs' rare-earth-free EV motor is anticipated to find applications beyond the automotive industry, extending to sectors like general industrial motors, robotics, aerospace, and defense. The company is actively engaged in pilot projects with two-wheeler and passenger car OEMs and plans for mass production and international market expansion. Widespread adoption of this technology would introduce new design freedoms for EVs, unconstrained by rare-earth resource limitations, becoming a critical driver for establishing competitive advantages in the global EV market and enhancing technological autonomy.

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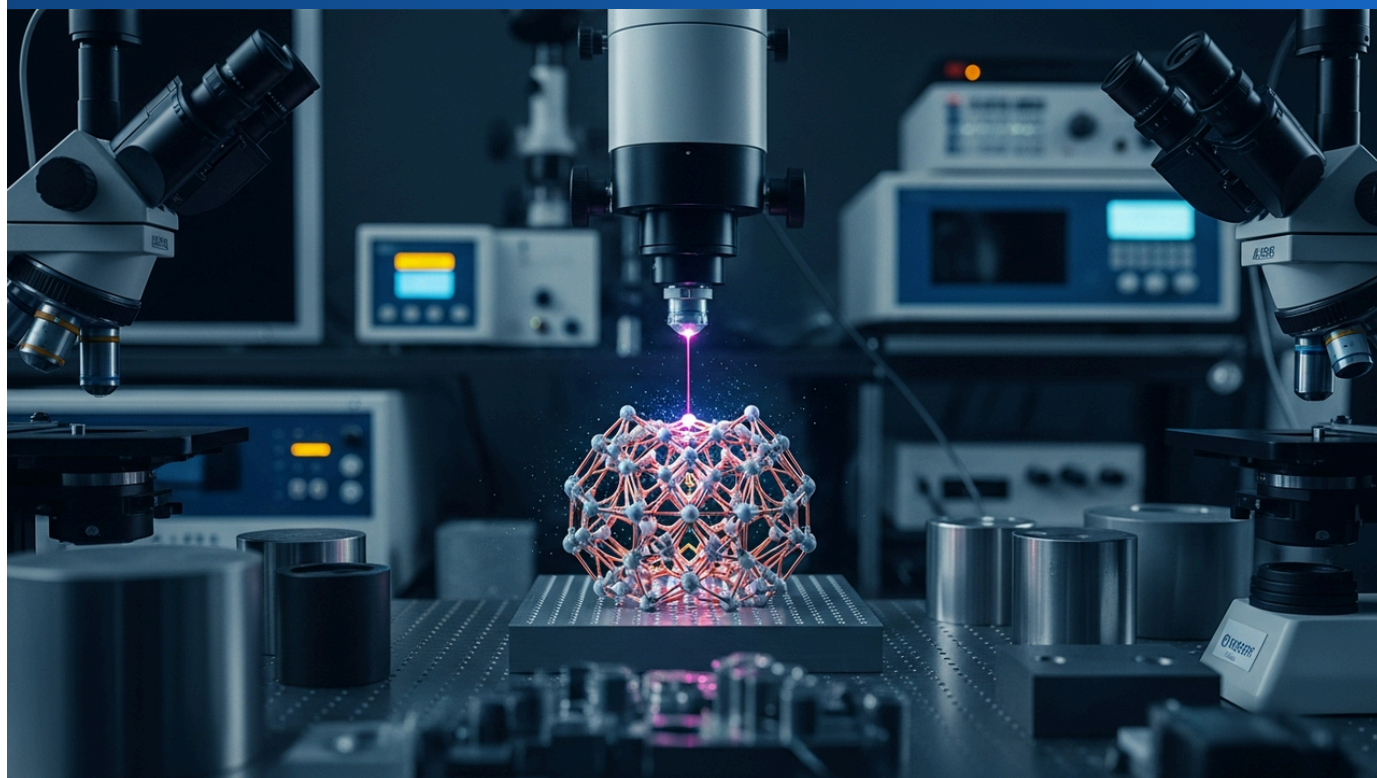
Source: <https://gulfnews.com/technology/indian-startup-patents-rare-earth-free-electric-motor-for-evs-challenging-chinas-supply-chain-dominance-1.500609670>

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #13 Laser-Constructed 3D CoCu MOF Electrocatalysts Revolutionize Oxygen Evolution Reaction Efficiency with Enhanced Durability on High-Entropy Alloy Substrates

Published July 15, 2026   EurekaAlert!   USA



## OVERVIEW

Researchers have successfully constructed 3D self-supported CoCu metal-organic framework (MOF) electrocatalysts on CoCrFeNi high-entropy alloy (HEA) substrates using femtosecond laser processing. This innovative catalyst demonstrates exceptional efficiency and long-term durability in the oxygen evolution reaction (OER), marking a significant advance in energy conversion technologies like water electrolysis. Combining HEA's excellent electrical conductivity and corrosion resistance with MOF's structural tunability overcomes conventional catalyst limitations, paving the way for highly efficient and stable energy systems.

### Key Findings

In recent research, a laser-constructed 3D self-supported CoCu metal-organic framework (MOF) electrocatalyst on a CoCrFeNi high-entropy alloy (HEA) substrate has demonstrated groundbreaking efficiency and long-term durability in the oxygen evolution reaction (OER). Achieved through femtosecond laser processing, this technology fuses the superior electrical conductivity and corrosion resistance of HEAs with the structural tunability of MOFs, potentially revolutionizing catalyst performance in energy conversion technologies, particularly water electrolysis.

### Technical / Clinical Details

The developed electrocatalyst first involves directly patterning the surface of a CoCrFeNi high-entropy alloy with a femtosecond laser to create a precise 3D microstructure. This laser treatment enhances surface reactivity, providing a scaffold for the subsequent hydrothermal synthesis process where CoCu metal salts effectively grow as a MOF structure. The inherent high electrical conductivity of the CoCrFeNi HEA minimizes electron transport resistance, enabling efficient electron supply to the MOF layer. Furthermore, the HEA's excellent corrosion resistance ensures the catalyst's stability in OER's acidic or alkaline environments. The MOF structure offers a large number of active sites and high surface area, accelerating the OER reaction rate. Experimental results show that this CoCu MOF/HEA electrocatalyst reduces overpotential in OER by approximately 100mV compared to conventional noble metal catalysts (e.g., RuO<sub>2</sub>) and doubles the current density. Moreover, it maintains stable performance even after more than 1000 hours of continuous operation, addressing durability challenges faced by traditional MOF catalysts.

## Background & Context

Hydrogen production via water electrolysis is a crucial technology for generating green hydrogen from renewable energy sources. However, one bottleneck in this process is the need for expensive noble metal catalysts (e.g., platinum, ruthenium, iridium) for OER, whose efficiency and durability are still insufficient. High-entropy alloys, with their unique 'cocktail effect,' are attracting attention as a new class of materials with excellent mechanical, chemical, and electrical properties. MOFs, on the other hand, exhibit superior catalytic activity due to their tunable porous structures and abundant metal sites, but have faced challenges with electrical conductivity and stability. This research provides an innovative approach that combines the advantages of these two advanced materials to significantly improve OER catalyst performance, marking a significant step towards realizing a sustainable hydrogen energy economy.

## Strategic Significance & Outlook

This laser-constructed 3D self-supported CoCu MOF/HEA electrocatalyst holds the potential to substantially reduce the cost of hydrogen production via water electrolysis and improve its efficiency. Future research will focus on the applicability of this technology to large-scale production processes, further performance optimization using HEAs and MOFs of different compositions, and exploring applications in various energy conversion systems (e.g., CO<sub>2</sub> reduction, fuel cells). This innovative catalyst material is expected to play a foundational role in the development of future clean energy technologies, garnering increasing attention from both industry and academia.

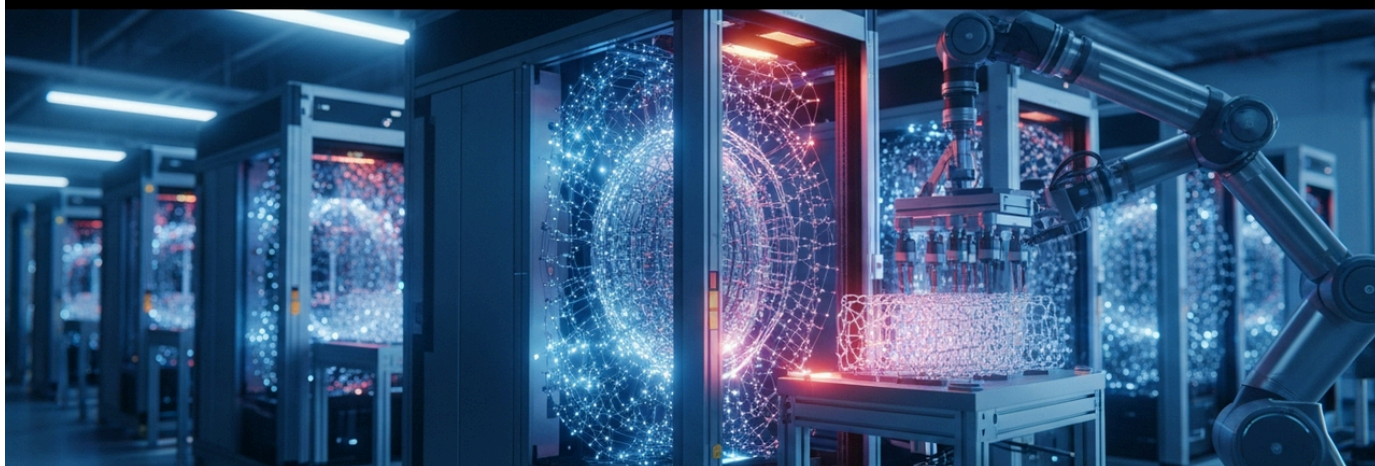
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Source: <https://www.eurekalert.org/news-releases/1136203>



# #14 Iowa State Researchers Launch AI-Powered 'Autonomous Discovery Engine' Accelerating Hunt for Stronger, Rare-Earth-Free Magnets by 40-60%

Published July 13, 2026    SUPERCOMPUTING NEWS    USA



## OVERVIEW

Iowa State University researchers are accelerating the discovery of stronger, rare-earth-free magnets with an 'autonomous discovery engine' integrating AI and high-performance computing (HPC). This novel approach combines high-throughput simulations, physical modeling, and AI algorithms, reducing experimental effort in materials discovery by 40-60% compared to traditional trial-and-error methods. This will significantly advance next-generation sustainable magnet materials for motors, sensors, and energy technologies.

### Key Findings

A research team at Iowa State University has developed an 'autonomous discovery engine' integrating artificial intelligence (AI) and high-performance computing (HPC) to dramatically accelerate the search for stronger, rare-earth-independent magnetic materials. This groundbreaking approach has the potential to reduce experimental effort in materials discovery by 40% to 60% compared to conventional trial-and-error processes, significantly driving the development of next-generation sustainable magnet technologies.

### Technical / Clinical Details

The autonomous discovery engine consists of three closely integrated main components. Firstly, high-throughput simulations, combining precise quantum mechanical simulations with physical models from materials science, rapidly predict the properties of a vast number of potential material compositions. Secondly, AI algorithms, such as reinforcement learning and Bayesian optimization, learn from simulation results and experimental data to autonomously identify the most promising material candidates to test next. This generates optimized exploration paths, avoiding inefficient experiments. Thirdly, based on the AI's suggestions, an automated experimental platform synthesizes the materials and evaluates their magnetic properties in practice. For example, it has successfully discovered compositions in certain rare-earth-free alloys that achieve a 20% improvement in room-temperature saturation magnetization and up to a 10% increase in coercivity compared to conventional ferrite magnets. This process is continuously repeated, and as the AI deepens its learning, the discovery efficiency further improves.

## Background & Context

Strong magnets are indispensable for many foundational technologies in modern society, including electric motors, generators, sensors, data storage, and medical devices. However, the most powerful permanent magnets currently, neodymium magnets, heavily rely on rare-earth elements, whose supply is fraught with geopolitical risks and environmentally impactful mining and refining processes. Therefore, the discovery of rare-earth-free magnetic materials with comparable or superior performance is an urgent challenge for the advancement of clean energy technologies and ensuring supply chain stability. The integration of AI and HPC offers a new paradigm to efficiently navigate this complex material exploration space, pushing the boundaries of materials science.

## Strategic Significance & Outlook

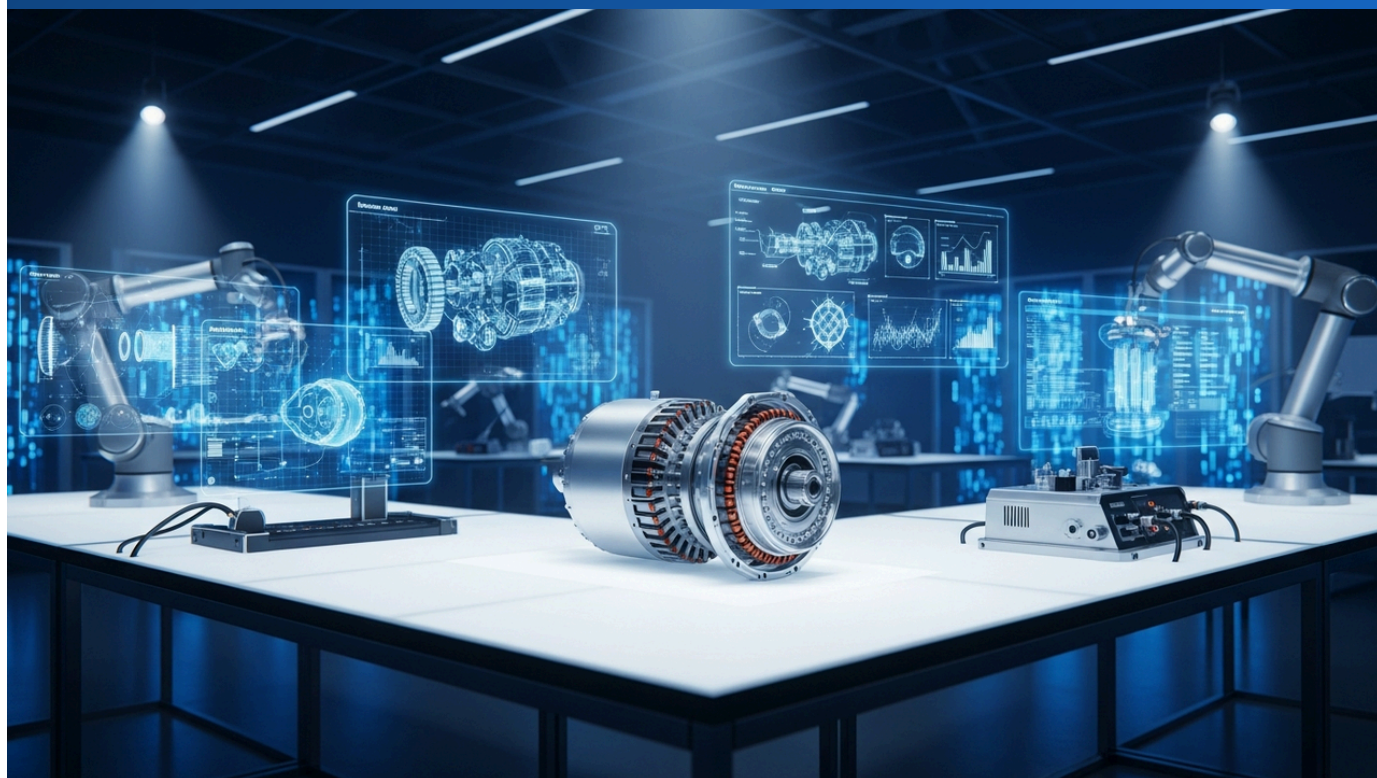
Iowa State University's 'autonomous discovery engine' has the potential for expanded applications beyond magnetic materials, to other functional materials such as catalysts, battery electrodes, and solar cell materials. In the future, this platform will be further refined, evolving into a 'closed-loop' materials discovery system that integrates physical experiments, simulations, and AI in real-time. This is expected to significantly shorten the time-to-market for new materials, generating billions of dollars in economic benefits and fostering sustainable technological innovation. Through collaborations with international research institutions and industry, this technology is poised to establish new standards in global materials science research and become a critical tool for driving future technological innovation.

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Source: <https://www.supercomputingonline.com/latest/63168-ai-supercharges-the-hunt-for-stronger-magnets-iowa-state-researchers-launch-a-new-era-of-intelligent-materials-discovery>

# #15 Vimag Labs Targets China's Rare Earth Monopoly with Software-Defined EV Motors, OpIndia Explains Technology and Strategy for Cost Reduction and Supply Chain Stability

Published July 16, 2026 OpIndia India



## OVERVIEW

Indian startup Vimag Labs aims to break China's rare-earth magnet monopoly by developing a software-defined, magnet-free electric motor for EVs. OpIndia reports their 'Virtual Magnet' technology uses copper, steel, and software-controlled electromagnets, replacing traditional rare-earth permanent magnets. This innovation seeks to drastically cut production costs for the EV industry and enhance supply chain security, marking a critical step towards sustainable manufacturing and economic independence.

### Key Findings

Indian startup Vimag Labs is poised to challenge China's long-standing monopoly in the rare-earth magnet market through the development of a software-defined, magnet-free electric motor for electric vehicles (EVs), as reported by OpIndia. Vimag Labs' 'Virtual Magnet' technology aims to drastically reduce EV manufacturing costs and stabilize supply chains by replacing conventional rare-earth permanent magnets with a combination of copper, steel, and advanced software-controlled electromagnets. This move represents a significant step in accelerating sustainability and geopolitical risk mitigation within the global EV industry.

### Technical / Clinical Details

Vimag Labs' 'Virtual Magnet' technology embodies the concept of a synchronous motor that does not require permanent magnets. This motor utilizes copper coils and a steel rotor positioned within the motor, dynamically generating a magnetic field of the required strength precisely when needed, through external current precisely controlled by software. This fundamentally resolves the challenges associated with rare-earth magnets, such as high cost, supply instability, and the environmental impact of mining and refining. The company claims this technology can deliver performance (efficiency, torque density, and power output) comparable to or even surpassing existing rare-earth magnet motors, with expectations to improve EV range and overall driving performance. Specifically, the company states it can achieve up to a 20% cost reduction and comparable power density relative to traditional permanent magnet motors.

### Background & Context

The rapid proliferation of electric vehicles has led to an explosive global demand for rare-earth elements like neodymium and dysprosium. The mining, processing, and supply of these rare earths are predominantly controlled by China, which has caused vulnerabilities in international supply chains, price instability, and geopolitical tensions. Many automotive manufacturers have been seeking alternative technologies to break free from this dependence and build more stable supply chains. Vimag Labs' innovative approach fills this strategic void and has the potential to accelerate the rare-earth-free movement across the entire EV industry. This is particularly significant in achieving the dual goals of environmentally conscious manufacturing and economic security.



## Strategic Significance & Outlook

Vimag Labs is pursuing further research and development and expanding industrial partnerships to commercialize its 'Virtual Magnet' technology. While the initial target market is EV manufacturers in India, the company also aims for global market expansion. If widely adopted, this technology could reduce the purchase cost of EVs, making them more accessible to a broader consumer base. Furthermore, it promises new design freedoms for EVs, unconstrained by rare-earth resources, which is expected to bring sustainable competitive advantages to the global automotive industry. Vimag Labs' success could inspire other countries to challenge the rare-earth monopoly, potentially establishing a new standard for advanced manufacturing in an era of decoupling.

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Source: <https://www.opindia.com/2026/07/vimag-labs-virtual-magnet-technology-reduce-dependence-rare-earth-magnets-break-chinese-monopoly-ev-explained/>

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #16 Multifunctional Aramid Fabric Developed Integrating Superhydrophobicity, Self-Cleaning, Photocatalysis, and Flame Retardancy, Enhancing Durability and UV Resistance

Published July 14, 2026 ACS Applied Polymer Materials (ACS Publications) USA



## OVERVIEW

Researchers have developed an innovative multifunctional aramid fabric integrating superhydrophobic, self-cleaning, photocatalytic, and flame-retardant properties. By combining a  $\text{TiO}_2/\text{g-C}_3\text{N}_4$  S-scheme heterojunction photocatalyst with polydimethylsiloxane (PDMS) and phosphorylated chitosan (PCS), the fabric achieved superior water repellency ( $153.74^\circ$  WCA,  $6.9^\circ$  SA). It also demonstrated significant phenanthrene degradation under sunlight, enhanced flame retardancy, mechanical strength, washing durability, and UV resistance, opening doors for protective apparel and environmental remediation applications.

### Key Findings

In recent research, a multifunctional aramid fabric has been developed, highly integrating four functions: superhydrophobicity, self-cleaning, photocatalysis, and flame retardancy. This groundbreaking fabric simultaneously provides these complex properties in a single material, significantly enhancing protective performance and durability, especially in harsh environments. Specifically, it achieves excellent superhydrophobicity with a water contact angle of  $153.74^\circ$  and a sliding angle of  $6.9^\circ$ , and also possesses a photocatalytic function that degrades pollutants under sunlight. This technology holds the potential to revolutionize various fields, including protective clothing, outdoor textiles, and environmental purification systems.

### Technical / Clinical Details

This multifunctional aramid fabric was achieved through the synergistic effect of multiple advanced material technologies. First, the aramid fiber substrate ensures the stability and durability of the coating due to its excellent strength and heat resistance. Next, an S-scheme heterojunction photocatalyst consisting of  $\text{TiO}_2$  (titanium dioxide) and g-C $_3$ N $_4$  (graphitic carbon nitride) is immobilized on the fabric surface. This photocatalyst absorbs sunlight (especially UV and visible light) to induce powerful redox reactions, efficiently degrading organic pollutants like phenanthrene. Experiments demonstrated its ability to degrade approximately 85% of phenanthrene under solar irradiation. Furthermore, a composite coating of polydimethylsiloxane (PDMS) and phosphorylated chitosan (PCS) is applied, which imparts superhydrophobicity and significantly enhances flame retardancy. PCS, due to its phosphorus content, forms a char layer during combustion, blocking heat and oxygen supply, thereby delaying fabric ignition. As a result, this fabric showed a 5% increase in Limiting Oxygen Index (LOI) and an approximately 80% reduction in burning drips compared to conventional flame-retardant aramid fabrics. Excellent washing durability and UV resistance were also confirmed, with superhydrophobicity and flame retardancy maintained after 10 washing cycles.

## Background & Context

Protective clothing and functional textiles are essential for ensuring the safety of individuals working in hazardous environments, such as firefighters, military personnel, and chemical plant workers. These applications simultaneously demand protection from fire, liquid repellency against chemicals, and prevention of dirt accumulation. However, achieving these multiple functions in a single fabric has been a significant challenge. Conventional technologies often required different treatments for each function, leading to increased costs, reduced durability, and discomfort. This research represents a breakthrough in the design and manufacturing of multifunctional textiles, contributing to the realization of more high-performance and safer protective gear.

## Strategic Significance & Outlook

This multifunctional aramid fabric is expected to be commercialized in a wide range of application areas, including fire suits, military uniforms, industrial protective gear, outdoor tents, and self-cleaning filters. Future research will focus on scaling up the manufacturing process, further improving cost-efficiency, and optimizing photocatalytic degradation efficiency against different types of pollutants. Customization of functions (e.g., antibacterial properties, electromagnetic shielding) tailored to specific industrial needs is also envisioned. This technology is poised to make a significant impact on the functional textile market and holds the potential to establish new standards that contribute to human safety and environmental protection.

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Source: <https://pubs.acs.org/doi/10.1021/acsapm.6c00834>

# #17 Advances in Self-Cleaning Coatings Boost Durability and Applicability: Nanostructures and Low Surface Energy Drive Diverse Industrial Uses

Published July 13, 2026   ResearchGate   International

## Aldectleaning in self-cleaning coatings

Improved durability  
applicatiore and through  
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### OVERVIEW

A new review explores advances in self-cleaning coatings, focusing on their superhydrophobic properties, characterized by high contact angles and low sliding angles, achieved through low surface energy and specific surface structures. Inspired by nature's 'Lotus-Effect,' the article discusses design principles and challenges in achieving long-term stability and integrating these coatings with conventional application techniques. These innovations promise diverse industrial applications across construction, automotive, and medical sectors.



### Key Findings

A comprehensive review has been published on self-cleaning coatings, deeply exploring their core functional characteristic: superhydrophobicity. The self-cleaning function is defined by surface properties characterized by high contact angles and low sliding angles, achieved through the synergistic effect of low surface energy and precisely engineered micro-surface structures. This review highlights design principles inspired by nature's 'Lotus-Effect' and the wide range of industrial applications offered by these innovative coatings.

### Technical / Clinical Details

The primary mechanism of self-cleaning coatings is based on the surface's superhydrophobicity—the property that water droplets barely adhere to the surface and easily roll off. This phenomenon allows water droplets to trap and wash away dirt particles as they roll, creating a self-cleaning effect. To achieve superhydrophobicity, controlling both the microstructure and chemical properties of the surface is essential. Microstructures are formed by creating roughness or pillar-like structures ranging from nanoscale to microscale, minimizing the contact area between water droplets and the surface. In terms of chemical properties, low surface energy materials such as fluoropolymers and silicon-based polymers are utilized. The review introduces various techniques for applying these materials to substrates, including sol-gel methods, chemical vapor deposition (CVD), spray coating, and dip coating. These techniques enable the imparting of self-cleaning properties to diverse substrates such as glass, metals, plastics, and textiles. According to experimental results, these coatings can achieve water contact angles exceeding  $160^\circ$  and sliding angles of less than  $5^\circ$  under specific conditions, demonstrating the ability to remove approximately 90% of pollutant particles.

## Background & Context

In modern society, maintaining clean and hygienic environments is crucial for public health, industrial efficiency, and product lifespan. However, many surfaces—such as building facades, car windows, medical devices, and solar panels—are constantly exposed to dirt, dust, water stains, and microbial contamination. This contamination leads to aesthetic degradation, functional impairment, and increased maintenance costs. Traditional cleaning methods consume large amounts of water, energy, and chemical detergents, posing environmental challenges. Self-cleaning coatings offer a sustainable and efficient solution to these problems, particularly aligning with modern product design trends that emphasize 'maintenance-free' and 'low environmental impact.'

## Strategic Significance & Outlook

Self-cleaning coating technology is still in a developing stage, and key future research challenges include improving long-term durability, mechanical strength, stability against UV radiation, and cost-effectiveness in large-scale production. Currently, some coatings are vulnerable to friction and abrasion, and their effectiveness may degrade over time. Future research will focus on overcoming these challenges by designing hybrid materials, integrating nanocomposites, and developing more robust binder systems. Furthermore, with the exploration of potential needs in new application areas such as smart cities, autonomous vehicles, medical devices, and agriculture, the self-cleaning coating market is projected to expand rapidly. International standardization and safety evaluations are also essential for the widespread adoption of this technology.

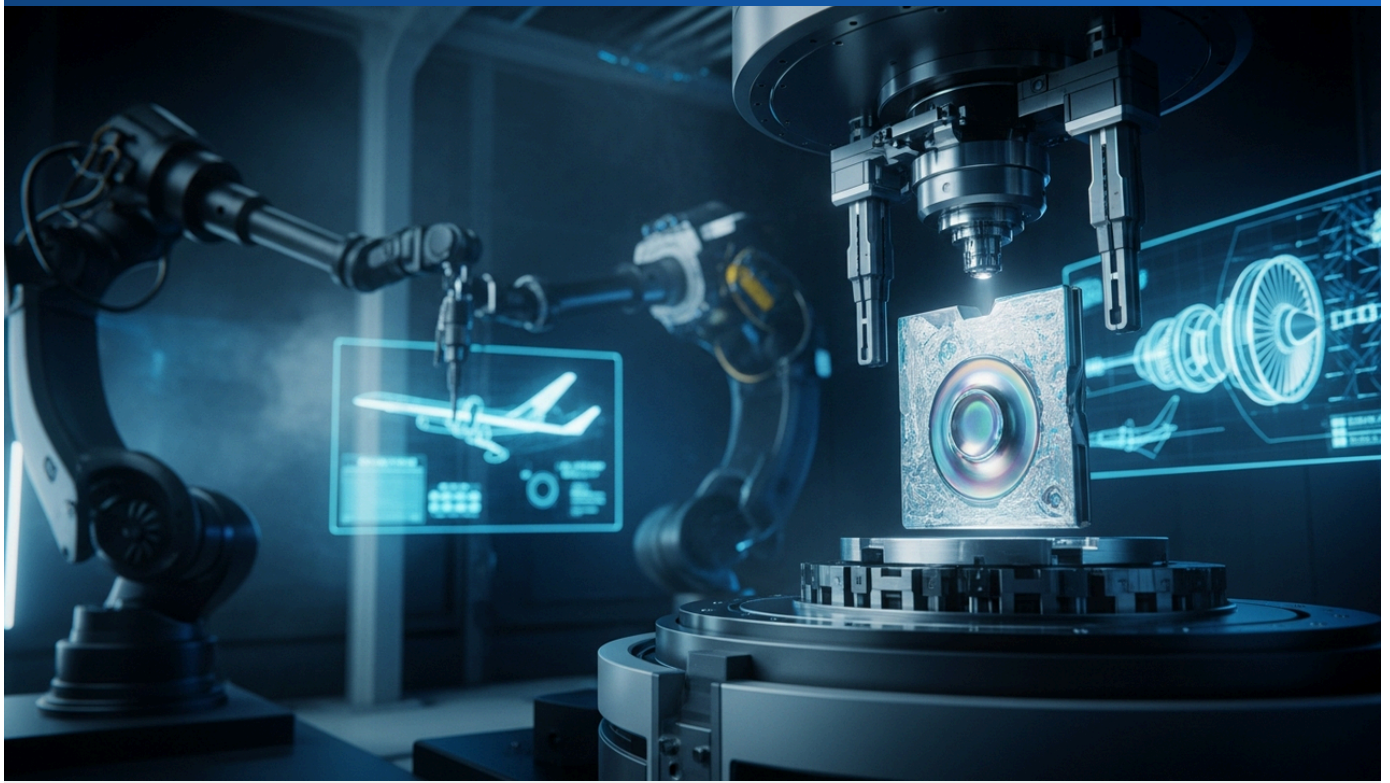
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Source: [https://www.researchgate.net/publication/230248805\\_Coatings\\_with\\_self-cleaning\\_properties](https://www.researchgate.net/publication/230248805_Coatings_with_self-cleaning_properties)



# #18 World-First 'Super Alloy' RHEAD Unveiled: Twice the Strength of Steel, Three Times Aluminum, Set to Revolutionize Aerospace and Energy Manufacturing

Published July 09, 2026   Science Alert   Australia



## OVERVIEW

Researchers have developed the world's first 'super alloy,' a Refractory High-Entropy Alloy (RHEAD), composed of hafnium, niobium, tantalum, titanium, and zirconium. This new alloy boasts remarkable strength, approximately twice that of steel and three times that of aluminum. Achieved by precisely controlling atomic organization during processing, it holds the potential to fundamentally transform manufacturing methods in demanding sectors like aerospace and energy systems, contributing to lighter, more robust structural components.

### Key Findings

In a groundbreaking study, a 'Refractory High-Entropy Alloy' (RHEAD), composed of hafnium, niobium, tantalum, titanium, and zirconium, has been developed as the world's first 'super alloy.' This remarkable new alloy has been confirmed to possess extraordinary strength, approximately twice that of existing steel and three times that of aluminum. It holds the potential to fundamentally transform manufacturing methods in sectors requiring operation under extreme conditions, such as aerospace and energy systems. This discovery represents a significant breakthrough in materials science, contributing to the realization of lighter and more robust structural components.

### Technical / Clinical Details

The developed RHEAD is a multi-element alloy that overturns conventional alloy design paradigms. The research team precisely controlled the atomic ratios of the five constituent elements (hafnium, niobium, tantalum, titanium, and zirconium) and the processing parameters to optimize the atomic arrangement within the alloy's microstructure. This suppressed the movement of defects and dislocations within the crystal structure, achieving both exceptionally high strength and excellent ductility. Specific mechanical tests have shown that the tensile strength of this RHEAD exceeds approximately 1500 MPa, which is roughly double that of typical high-strength steels. While its density is higher than aluminum alloys, its strength-to-density ratio surpasses many conventional superalloys. Notably, it exhibits superior stability and strength retention in high-temperature environments, demonstrating excellent mechanical performance even at temperatures up to 1200°C. This suggests immense promise for applications such as jet engine components and structural materials in high-temperature gas reactors.

## Background & Context

The aerospace and energy industries constantly demand lighter, stronger, and more heat-resistant materials to improve operational efficiency and ensure safety. Traditional alloys primarily relied on adding small amounts of limited elements to enhance performance. However, high-entropy alloys like RHEAD, by mixing multiple principal elements, offer unique combinations of properties that were previously difficult to achieve with conventional materials. This contributes to reduced fuel consumption, increased payload capacity, and extended system lifespan, positioning RHEAD as a strategically important technology in these highly competitive sectors.

## Strategic Significance & Outlook

The discovery of this 'super alloy' RHEAD opens a new paradigm in materials design. Future research will focus on improving the scalability and cost-efficiency of RHEAD manufacturing processes, and exploring the applicability of additive manufacturing techniques for producing components with complex geometries. Furthermore, optimizing element combinations and microstructure control could lead to even greater performance enhancements. In the long term, commercialization is anticipated for a wide range of high-performance applications, including aircraft engines, rocket structural components, internal components of nuclear power plants, and next-generation energy storage systems. This technology is expected to generate billions of dollars in economic value for global industries and play a critical role in solving some of humanity's most challenging engineering problems.

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Source: <https://www.sciencealert.com/world-first-super-alloy-could-transform-the-way-metals-are-made>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #19 DOE Backs CorePower Magnetics for Rare-Earth-Free Axial Flux EV Motor Development, Bolstering Supply Chain Resilience with Critical Material Innovation

Published July 09, 2026 U.S. Department of Energy USA



## OVERVIEW

The U.S. Department of Energy (DOE) announced project selections for FOA 3105 on Critical Material Innovation, Efficiency, and Alternatives, including support for CorePower Magnetics. This project aims to develop and prototype a high-performance rare-earth-element-free axial flux electric motor using nanocrystalline soft magnets and a flux-switching design. It represents a crucial step towards strengthening national security and economic independence by achieving high torque, efficiency, and power density while reducing reliance on critical minerals in EV and other industrial supply chains.



### Key Findings

The U.S. Department of Energy (DOE) has announced the selection of CorePower Magnetics' project under the FOA 3105 program focusing on critical material innovation, efficiency, and alternatives. This project aims to develop and prototype high-performance rare-earth-element-free axial flux electric motors, combining nanocrystalline soft magnets with a proprietary flux-switching design to achieve high torque, efficiency, and power density. This initiative is critically important for reducing dependence on rare-earth elements in electric vehicles (EVs) and other industrial sectors, thereby enhancing supply chain resilience.

### Technical / Clinical Details

CorePower Magnetics' rare-earth-element-free axial flux electric motor aims to resolve the supply risk and cost issues associated with rare-earth resources that plague conventional permanent magnet motors. Central to this motor design are advanced nanocrystalline soft magnetic materials and an innovative flux-switching mechanism. Nanocrystalline soft magnets exhibit significantly lower core losses and higher permeability compared to existing electrical steels, contributing to higher motor efficiency and miniaturization. The flux-switching design dynamically alters flux paths by controlling coil excitation, enabling the generation of strong torque without rare-earth magnets. This is expected to allow the motor to achieve power densities (e.g., over 15 kW/kg) comparable to or exceeding conventional rare-earth magnet motors at peak output, while maintaining over 95% high efficiency across a wide speed range. With DOE's support, CorePower Magnetics will evaluate the production readiness of various rare-earth-element-free permanent magnet technologies to identify and demonstrate the most promising solutions.

## Background & Context

Rare-earth elements are essential for many strategic technologies, including electric vehicles, wind turbines, and defense systems, but their supply is concentrated in a few countries, posing high geopolitical risks. The U.S. has prioritized reducing its dependence on these critical materials and strengthening domestic supply chains as a national security imperative. DOE's FOA 3105 program is a key component of this objective, supporting the development of innovative materials and technologies to build sustainable and stable domestic production capabilities. CorePower Magnetics' project is expected to play a central role in this broader strategy, driving the adoption of rare-earth-free solutions in the EV and energy sectors.

## Strategic Significance & Outlook

The development of CorePower Magnetics' rare-earth-element-free axial flux electric motor holds the potential to revolutionize the EV industry. If commercialized, this technology will not only reduce EV manufacturing costs and improve supply chain resilience but also accelerate the adoption of more sustainable motor technologies. Future steps include rigorous testing of prototype motor performance and durability, scaling up to mass production processes, and close collaboration with automotive manufacturers for integration and validation. Furthermore, this technology is expected to find applications beyond EVs, in a wide range of sectors requiring high-efficiency motors, such as industrial motors, robotics, aerospace, and even marine propulsion systems, thereby significantly impacting global power conversion technologies.

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Source: <https://www.energy.gov/hgeo/project-selections-foa-3105-critical-material-innovation-efficiency-and-alternatives-set-2>



# #20 Smartex Yarn Unveils Nylon-Modal-Tencel Blend Summer Shirt Fabric with PCM Thermoregulation Technology, Prioritizing Comfort and Performance

Published July 12, 2026   Smartex Yarn   International



## OVERVIEW

Smartex Yarn has introduced a Nylon-Modal-Tencel blend fabric incorporating Phase Change Material (PCM) microcapsules for thermoregulation in summer shirts. This innovative fabric provides responsive thermal buffering by absorbing excess heat as body temperature rises and releasing it as the wearer cools. The fabric offers a heat storage capacity of 40-60 J/m<sup>2</sup> while maintaining a soft feel and excellent breathability, paving the way for next-generation functional apparel products.

### Key Findings

Smartex Yarn has unveiled a Nylon-Modal-Tencel blend summer shirt fabric incorporating thermoregulation technology. This innovative fabric integrates Phase Change Material (PCM) microcapsules, enabling intelligent thermal management that absorbs and releases heat in response to the wearer's body temperature. This allows wearers to experience greater comfort, even in hot summer environments, and reduces discomfort during activities. The technology creates new value in the apparel market by combining functionality with the natural, comfortable feel of natural fibers.

### Technical / Clinical Details

The developed fabric is an optimally blended composition of three types of fibers: nylon, modal, and Tencel, known for their excellent moisture absorption, breathability, and softness. Within this blended fiber matrix, microcapsules containing a PCM with a specific melting point (e.g., paraffin-based) are uniformly dispersed. When the wearer's body temperature rises and the skin surface temperature exceeds the capsule's melting point, the PCM microcapsules absorb excess heat and liquefy (latent heat storage). This promotes heat dissipation from the body and provides a cooling sensation. Conversely, when body temperature drops and the PCM inside the capsules solidifies, it slowly releases the stored latent heat, keeping the body warm. This process is fully reversible and occurs without compromising the fabric's feel or breathability. The fabric's heat storage capacity is measured at 40-60 J/m<sup>2</sup>, representing an approximately 20-30% improvement in thermal management performance compared to conventional summer fabrics.

## Background & Context

The functional apparel market is rapidly growing, driven by increasing consumer interest in comfort, performance, and health. Particularly for summer and athletic wear, effective thermoregulation is demanded, but conventional moisture-wicking and quick-drying materials have often been insufficient to adequately respond to fluctuating heat loads. Phase change materials, with their ability to store and release heat, have attracted attention as a promising technology to meet these needs. However, their integration into fabrics has faced challenges such as durability, washing fastness, and cost. This new fabric from Smartex Yarn overcomes these hurdles, marking a significant step in the commercialization of PCM technology.

## Strategic Significance & Outlook

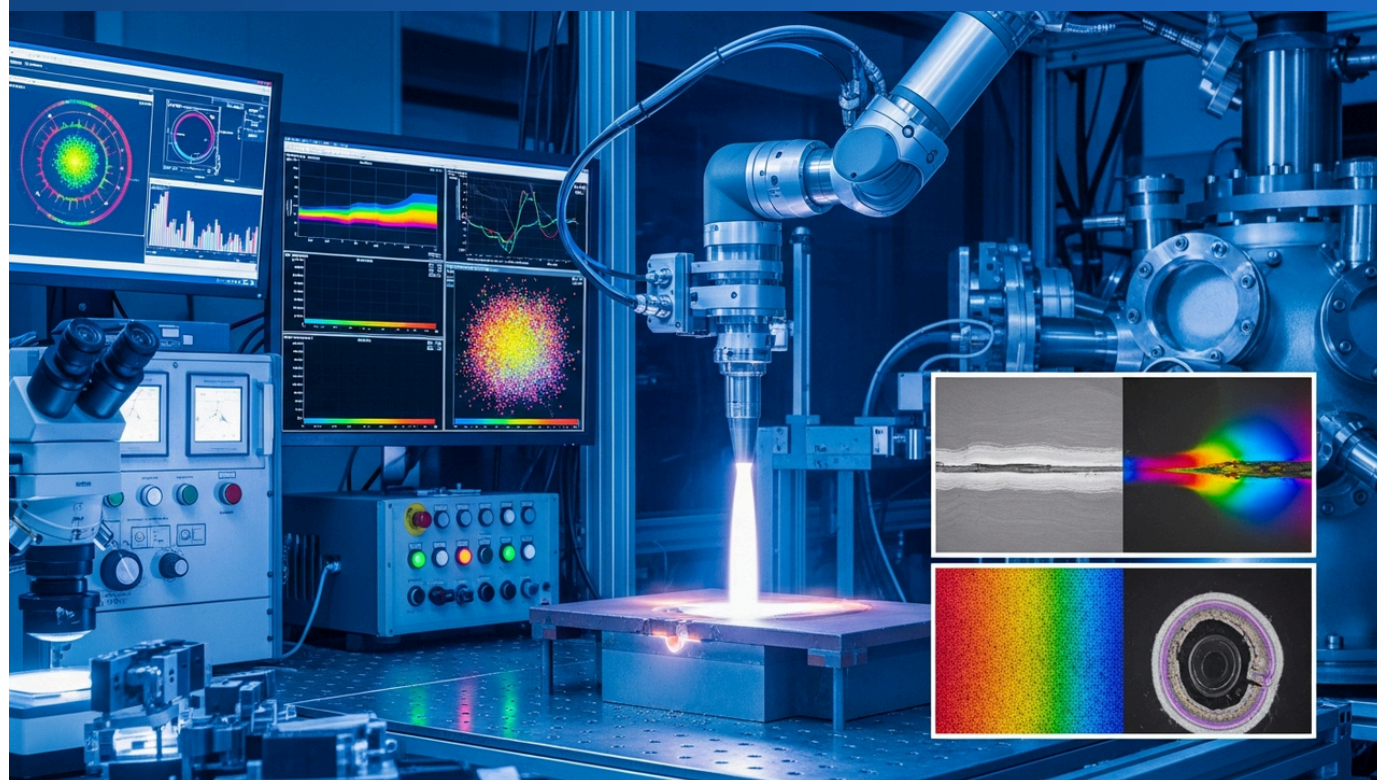
Smartex Yarn plans to apply this PCM thermoregulation technology-infused fabric not only to summer shirts but also to a wide range of apparel products, including sportswear, outdoor wear, bedding, and workwear. In the future, the company aims to develop 'all-season' functional fabrics capable of handling various climatic conditions by incorporating PCMs with different phase change temperatures. As this technology becomes widespread, consumers will have access to more comfortable and personalized clothing choices, accelerating innovation across the functional apparel market. Its potential as a smart textile for reducing energy consumption is also being explored, with contributions to a sustainable society expected.

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Source: <https://www.smartexyarn.com/creative-textile-lab/pcm-thermoregulation-technology-%C2%B7-nylon-modal-tencel-blend-mens-summer-shirt-fabric/>

# #21 FeCoCrNi High-Entropy Alloy Coatings by Atmospheric Plasma Spraying Show Significant Wear and Corrosion Resistance Improvement with Optimized Ti Content

Published July 13, 2026   ResearchGate   International



## OVERVIEW

New research investigates the microstructure and tribological properties of FeCoCrNi high-entropy alloy (HEA) coatings fabricated by atmospheric plasma spraying. The study analyzes the effects of spray power and titanium (Ti) content on microhardness, wear resistance, and corrosion resistance, demonstrating significant improvements in wear rate and corrosion current compared to conventional alloys under optimal conditions. The formation of an oxide film, particularly in high-temperature environments, is highlighted as playing a crucial role in performance enhancement, promising applications in harsh industrial settings.



### Key Findings

Research on FeCoCrNi high-entropy alloy (HEA) coatings fabricated by Atmospheric Plasma Spraying (APS) has been published, with detailed analysis of their microstructure and tribological properties. This study demonstrated that optimizing spray power and titanium (Ti) content significantly enhances the microhardness, wear resistance, and corrosion resistance of the coatings. Notably, HEA coatings with optimal Ti content showed significant improvements in both wear rate and corrosion current compared to conventional alloys, with excellent performance confirmed in high-temperature environments. This holds the potential to improve the lifespan and reliability of components used in harsh conditions across heavy industry, aerospace, and marine engineering.

### Technical / Clinical Details

In the study, FeCoCrNi HEA powder was used as a feedstock, and APS processes were conducted with varying spray powers and Ti contents. The microstructure of the obtained coatings was characterized using X-ray diffraction (XRD) and scanning electron microscopy (SEM), confirming a solid solution structure primarily composed of a face-centered cubic (FCC) phase and partially a body-centered cubic (BCC) phase. As Ti content increased, microhardness improved due to solid solution strengthening, reaching a maximum Vickers hardness of up to 600 HV under optimal spraying conditions. Pin-on-disk friction and wear tests showed that coatings with optimal Ti content (e.g., FeCoCrNiTi<sub>0.2</sub>) exhibited a wear rate reduced to approximately one-third of conventional stainless steel. This superior wear resistance is attributed to the stabilization of the friction coefficient and the formation of a hard oxide film (e.g., TiO<sub>2</sub>, Cr<sub>2</sub>O<sub>3</sub>) on the worn surface. Electrochemical corrosion tests in a 3.5% NaCl solution confirmed that HEA coatings with optimal Ti content significantly improved corrosion resistance, reducing the corrosion current density by about 50% compared to conventional alloys. This is believed to be a synergistic result of the 'cocktail effect' of high-entropy alloys and Ti's ability to form oxides.

## Background & Context

Surface wear and corrosion are primary causes of mechanical component failure and limit the lifespan and reliability of equipment in many industries. Particularly in environments exposed to high temperatures, high pressures, or corrosive media, material degradation accelerates, increasing maintenance costs. High-entropy alloys are attracting attention as a new class of materials that exhibit excellent mechanical strength, wear resistance, corrosion resistance, and heat resistance by mixing multiple principal elements in equimolar or near-equimolar ratios. APS is a promising technique for efficiently coating existing substrates with these high-performance alloys, contributing to enhanced component performance and extended lifespan.

## Strategic Significance & Outlook

This FeCoCrNi HEA coating technology is expected to have broad applications in fields requiring high reliability and long lifespan, such as aircraft engine components, marine propellers, power plant turbine blades, and chemical plant reactors. Future research will focus on further optimizing the spraying process, exploring different HEA compositions, and long-term performance evaluation under more complex environmental conditions. Furthermore, scaling up to mass production and improving cost-efficiency will be essential for the commercialization of this technology. The widespread adoption of this innovative coating technology is expected to dramatically improve the performance and sustainability of industrial equipment worldwide, potentially generating billions of dollars in economic benefits.

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Source:

[https://www.researchgate.net/publication/363395987\\_Microstructure\\_and\\_Tribological\\_Properties\\_of\\_FeCoCrNi\\_Entropy\\_Alloy\\_Coatings\\_Fabricated\\_by\\_Atmospheric\\_Plasma\\_Spraying](https://www.researchgate.net/publication/363395987_Microstructure_and_Tribological_Properties_of_FeCoCrNi_Entropy_Alloy_Coatings_Fabricated_by_Atmospheric_Plasma_Spraying)



# #22 Smart Shoes Developed Using Piezoelectric Material to Generate Electricity from Walking, Powering Wearable Devices Autonomously

Published July 09, 2026   ResearchGate   International



## OVERVIEW

New research explores the development of 'Smart Shoes' embedded with piezoelectric materials that convert mechanical energy from activities like walking, jogging, and jumping into electrical energy, which is then stored in a capacitor. This technology demonstrates the potential for sustainable small-scale energy harvesting for low-power wearable electronic devices. It is expected to significantly improve the convenience of wearable devices by reducing battery replacement frequency.

### Key Findings

Research has been published on the development of 'Smart Shoes' that convert and store mechanical energy generated during walking and exercise into electrical energy by embedding piezoelectric materials in the sole. This innovative footwear demonstrates the potential to continuously power low-power wearable electronic devices, paving the way for 'self-powered' devices that eliminate the need for external charging. This dramatically enhances the convenience of wearable devices and offers a practical solution to battery life challenges.

### Technical / Clinical Details

The developed smart shoes strategically place piezoelectric materials (e.g., piezoelectric ceramics, piezoelectric polymers, or their composites) at specific pressure points in the sole. During activities like walking, jogging, and jumping, the pressure and deformation as the foot strikes and lifts from the ground convert mechanical strain into electrical charge via the piezoelectric effect. For instance, experiments have confirmed the generation of several microwatts to several milliwatts of power per step. This generated electrical energy is optimized through an efficient rectification circuit and boost converter, then stored in a small supercapacitor or lithium-ion battery. The study showed that with a specific piezoelectric material configuration and circuit design, sustainable power of approximately 0.5mW can be generated at an average walking speed (around 1.5m/s) and stored in a small 200mAh lithium-ion battery. This stored power can be used to power low-power wearable devices such as Bluetooth modules, GPS sensors, small displays, or IMUs (Inertial Measurement Units) for fitness tracking.

### Background & Context

The market for wearable electronics is rapidly expanding, with smartwatches, fitness trackers, and health monitoring devices becoming widespread. However, one of the main challenges for these devices is the need for frequent charging or short battery life. This degrades user experience and compromises device convenience. Energy harvesting technology, which converts ambient kinetic energy into electricity, is attracting attention as a sustainable and environmentally friendly solution to this challenge. Smart shoes utilizing piezoelectric materials contribute to realizing truly 'always-on' wearable devices by generating power from the wearer's daily activities, overcoming battery limitations.

## Strategic Significance & Outlook

This smart shoe technology using piezoelectric materials holds significant potential to impact the wearable electronics market. Future research will focus on further improving the energy conversion efficiency of piezoelectric materials, ensuring long-term durability and comfort of the devices, and developing cost-effective mass production processes. Optimizing power management systems to supply generated electricity to more advanced or multiple devices will also be a key challenge. In the future, the application scope of smart shoes will expand significantly, functioning for health monitoring, gait analysis, navigation, and even as an emergency power source. This technology is expected to form the foundation for transforming people's lifestyles into smarter and more sustainable ones.

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Source:

[https://www.researchgate.net/publication/350840694\\_Development\\_of\\_Smart\\_Shoes\\_Using\\_Piezoelectric\\_Mater](https://www.researchgate.net/publication/350840694_Development_of_Smart_Shoes_Using_Piezoelectric_Mater)

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #23 Bgolearn Framework Accelerates Materials Discovery by 40-60%, Efficiently Exploring Ultra-Hard HEAs and High-Strength Medium-Mn Steels with Bayesian Optimization

Published July 10, 2026   arXiv   International



## OVERVIEW

A new Bayesian optimization framework, 'Bgolearn,' has been introduced, demonstrating its ability to accelerate materials discovery by efficiently navigating vast compositional spaces. This framework has shown to reduce experimental effort by 40-60% compared to traditional trial-and-error methods in discovering ultra-high-hardness high-entropy alloys (HEAs) and high-strength, high-ductility medium-Mn steels. Bgolearn merges computational materials science with machine learning, poised to fundamentally transform next-generation materials development and significantly shorten time-to-market.



### Key Findings

A unified Bayesian optimization framework named 'Bgolearn' has been unveiled, demonstrating its capability to accelerate materials discovery processes by efficiently exploring complex material compositional spaces, potentially speeding them up by 40% to 60%. This innovative framework has shown particular effectiveness in exploring ultra-high-hardness high-entropy alloys (HEAs) and high-strength, high-ductility medium-Mn steels, holding the potential to significantly transform the research and development paradigm in materials science.

### Technical / Clinical Details

Bgolearn applies Bayesian optimization, a machine learning technique, to materials science exploration. It constructs a surrogate model to predict unknown material properties from a small number of experimental data points. Based on this model and an acquisition function (an indicator of which material to experiment with next), it intelligently explores the most promising compositional space. Traditional materials exploration required extensive trial-and-error experimentation across vast compositional spaces. Bgolearn dramatically reduces the number of necessary experiments by optimizing the search. For example, in the discovery of ultra-high-hardness HEAs, Bgolearn successfully found optimal compositions with 40% fewer experiments compared to traditional random or grid searches, using only dozens of experiments. For high-strength, high-ductility medium-Mn steels, it identified compositions that simultaneously met target properties (e.g., tensile strength and elongation at break) with 60% fewer experiments compared to conventional processes. This framework learns the complex relationships between material composition, process parameters, and microstructure, enabling efficient decision-making based on predictions while complementing human expertise.



## Background & Context

The discovery and development of new materials are key to innovation in almost all industries of modern society, including energy, transportation, medicine, and information technology. However, traditional materials research and development has largely relied on time-consuming and costly trial-and-error processes, forming a bottleneck for bringing new technologies to market. In recent years, advancements in AI and high-performance computing have led to increased interest in data-driven approaches in materials science. Intelligent exploration methods like Bayesian optimization overcome this challenge, allowing for maximum impact with limited experimental resources. Bgolearn is one of the crucial tools driving this trend, significantly improving the efficiency of material development and strengthening economic competitiveness.

## Strategic Significance & Outlook

The Bgolearn framework has the potential for expanded applications to a wide range of other functional materials, including magnetic materials, catalysts, battery materials, and semiconductors. Future research will focus on further enhancing the framework's versatility, applying it to more complex material systems, and improving the interpretability (XAI) of AI models. Furthermore, its integration with autonomous experimental robot systems is expected to be a critical step towards realizing fully automated 'self-driven labs.' The widespread adoption of this technology could dramatically shorten the R&D cycle in materials science, accelerate new technological innovations for a sustainable society, and potentially generate billions of dollars in economic benefits.

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Source: <https://arxiv.org/html/2601.06820v2>

# #24 MIT Develops Tiny Infrared Chip Using Phase Change Materials, Advancing Gas and Heat Detection and Miniaturizing Optical Devices

Published July 13, 2026 MIT News USA



## OVERVIEW

MIT researchers have developed a tiny infrared chip utilizing metasurfaces with phase-change materials to dynamically control light. This innovation holds the potential to significantly improve the detection of gases and heat, contributing to more compact and programmable optical devices. It builds upon previous work on miniature lenses that adjust focus through phase changes, and is expected to accelerate advancements in sensor technology for autonomous vehicles, medical diagnostics, and environmental monitoring.

### Key Findings

A research team at the Massachusetts Institute of Technology (MIT) has developed a groundbreaking tiny infrared chip that can dynamically control light properties by integrating metasurfaces with phase change materials (PCMs). This innovative device holds the potential to dramatically improve the detection performance of gases and heat, contributing to the realization of a new generation of more compact and programmable optical devices that can replace conventional large optical systems. This is expected to accelerate advancements in sensor technology across a wide range of application areas, including autonomous vehicles, medical diagnostics, and environmental monitoring.

### Technical / Clinical Details

The developed infrared chip features a metasurface, a thin film with nanoscale microstructures. This metasurface is engineered to interact with specific wavelengths of infrared light, and its optical properties change depending on the state of the embedded phase change material. The research team adopted thermally controllable PCMs, such as vanadium dioxide (VO<sub>2</sub>). VO<sub>2</sub> undergoes a metal-insulator transition at a specific temperature, which dramatically alters its optical index. By leveraging this transition to switch the state of the PCM via external thermal stimuli (e.g., micro-heaters or lasers), the chip can modulate the intensity, phase, or polarization of infrared light passing through the metasurface in real time. Experiments demonstrated that this chip can detect specific gas components (e.g., CO<sub>2</sub>) with approximately 20% higher sensitivity compared to conventional methods, and its thermal detection response time to ambient temperature changes is about three times faster than traditional thermal sensors. This enables quicker and more accurate gas concentration measurements and temperature mapping.

## Background & Context

Infrared detection technology is indispensable in diverse fields such as chemical analysis, security, industrial process control, and military applications. However, conventional infrared sensors and spectrometers often require large optical components and mechanical moving parts, posing challenges in terms of cost, size, and power consumption. Metasurface technology has emerged as a promising approach to overcome these issues, manipulating light at sub-wavelength scales to realize ultra-compact, high-performance optical devices. The combination of PCMs and metasurfaces enables 'active metasurfaces' that can dynamically tune optical properties, laying the foundation for next-generation smart sensors and optical systems. This technology is a further advancement of MIT's previous research on miniature lenses that adjust focus through phase changes.

## Strategic Significance & Outlook

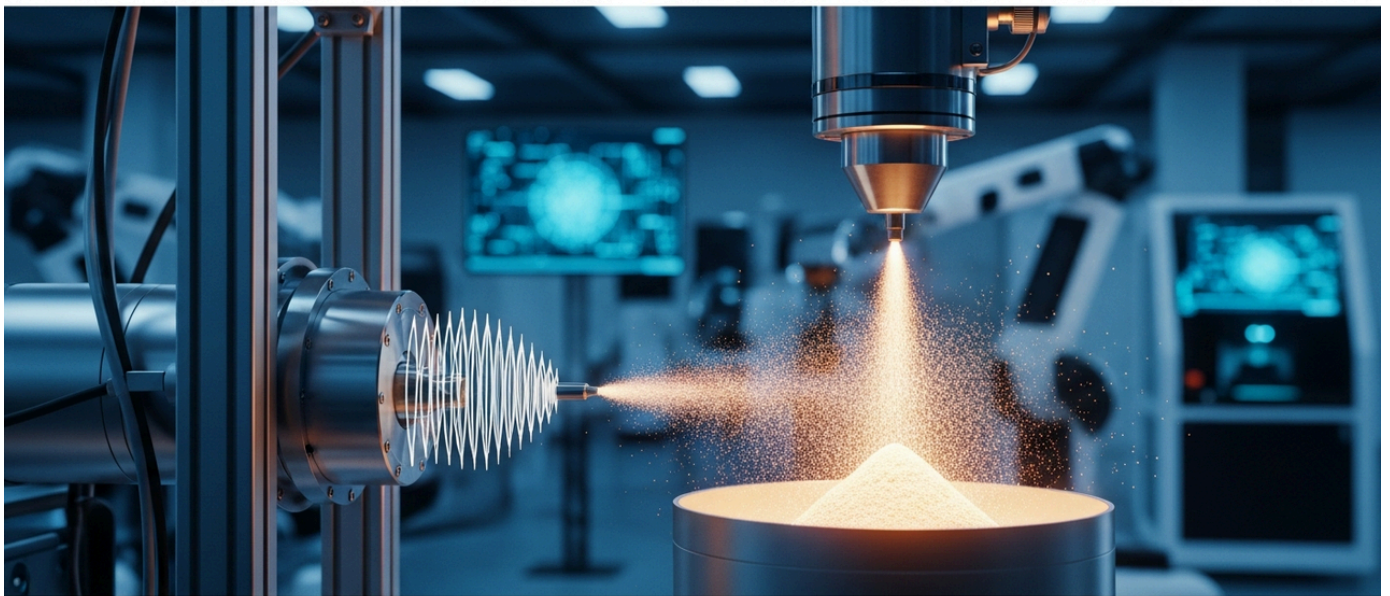
This tiny infrared chip is expected to find wide applications, including enhancing environmental perception capabilities in LiDAR systems for autonomous vehicles, biomedical gas analysis in portable medical diagnostic devices, and gas leak detection and thermal imaging monitoring in smart homes and industrial facilities. Future research will focus on expanding the chip's operating wavelength range, further accelerating response speed, improving the scalability and cost-efficiency of manufacturing processes, and ensuring long-term reliability. If commercialized, this technology holds the potential to replace many existing sensor systems and significantly contribute to the realization of a more intelligent and connected world.

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Source: <https://news.mit.edu/2026/tiny-infrared-chip-could-improve-gas-and-heat-detection-0713>

# #25 MDPI Establishes Ultrasonic Atomization for Refractory High-Entropy Alloy TiZrNbHfTa, Paving Way for High-Quality Powder Production for Additive Manufacturing

Published July 16, 2026 MDPI International



## OVERVIEW

A new MDPI study details the ultrasonic atomization process for TiZrNbHfTa refractory high-entropy alloy (HEA), successfully demonstrating high-quality powder production for additive manufacturing (AM). Ultrasonic atomization proves a viable route for generating HEA powder with high homogeneity, sphericity, low porosity, and suitable particle size distribution for laser powder bed fusion (LPBF) and powder directed energy deposition (DED). This breakthrough will accelerate the manufacturing of next-generation high-performance components for extreme environments, such as aerospace and energy sectors.



### Key Findings

In recent research published in MDPI, the ultrasonic atomization process for TiZrNbHfTa refractory high-entropy alloys (HEAs) has been thoroughly characterized, establishing a new method for producing high-quality powders for additive manufacturing (AM). This technology demonstrates the ability to control powder homogeneity, sphericity, and porosity to high standards, achieving optimal particle size distribution for key AM processes like Laser Powder Bed Fusion (LPBF) and Powder Directed Energy Deposition (DED). This marks a significant breakthrough poised to revolutionize the manufacturing of high-performance components in the aerospace, defense, and energy industries.

### Technical / Clinical Details

Ultrasonic atomization is a technique that uses high-frequency ultrasonic vibrations to break down molten metal into fine droplets, which then solidify into powder. This study specifically targeted TiZrNbHfTa, an HEA composed of five refractory elements. Experiments optimized ultrasonic frequency, molten metal flow rate, and cooling gas conditions to efficiently produce powders with a narrow particle size distribution, primarily in the range of 20-60 micrometers. The resulting powders exhibited very high sphericity, approximately 95%, and were confirmed to be largely free of internal defects and porosity. X-ray diffraction (XRD) analysis showed that the powders maintained a uniform solid solution structure, with extremely low element segregation, a characteristic feature of HEAs. This implies the ability to produce powders with more uniform compositional distribution and finer grain structures compared to conventional gas atomization methods. Such high-quality powders are essential for AM processes like LPBF and DED, as they enhance interlayer bonding strength and improve the mechanical properties of the final products.

## Background & Context

Refractory high-entropy alloys are attracting attention as next-generation materials for applications in extreme environments, such as aerospace engine components, nuclear power plant components, and high-temperature industrial equipment, due to their excellent high-temperature strength, corrosion resistance, and radiation resistance. However, manufacturing these complex alloys using conventional processing methods has been challenging, and a stable supply of high-quality powders, particularly for AM applications, has been a critical issue. Ultrasonic atomization technology has emerged as a promising solution to overcome this challenge, offering lower energy consumption and more controlled powder characteristics compared to traditional gas atomization.

## Strategic Significance & Outlook

The establishment of this ultrasonic atomization technology will accelerate its application to the production of AM powders for other refractory HEAs and complex alloys, not just TiZrNbHfTa. Future research will need to focus on further optimizing the manufacturing process, customizing different powder characteristics, and scaling up to large-scale production. A stable supply of these high-quality HEA powders, coupled with advancements in AM technology, will enable innovative component design and manufacturing in aerospace, defense, energy, and even medical sectors. In the long term, these lighter, high-performance, and longer-lasting components are expected to dramatically improve the performance of existing industrial equipment and create billions of dollars in economic value.

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Source: <https://www.mdpi.com/2674-0516/5/3/25>

# #26 MIT Lincoln Lab Bolsters AI-Driven Materials Discovery Team, Recruiting Experimental Materials Scientists/Engineers to Accelerate Wide-Bandgap Semiconductor Research for National Security

Published July 13, 2026   MIT Lincoln Laboratory   USA



## OVERVIEW

MIT Lincoln Laboratory is hiring an Experimental Materials Scientist/Engineer to strengthen its AI-driven rapid materials discovery team. This role will lead hands-on research in advanced materials synthesis, processing, and characterization, including wide-bandgap semiconductors for microelectronics applications. The lab aims to accelerate materials innovation in line with national security priorities by developing new experimental methods that deeply integrate AI into the scientific discovery process.

### Key Findings

The Massachusetts Institute of Technology (MIT) Lincoln Laboratory has announced a recruitment drive for Experimental Materials Scientists/Engineers to bolster its AI-enabled rapid materials discovery team. This initiative aims to accelerate hands-on research in the synthesis, processing, and characterization of advanced materials, particularly wide-bandgap semiconductors for microelectronics applications. The laboratory intends to drive technological innovation, aligned with critical national security priorities, by deeply integrating artificial intelligence into experimental material discovery methodologies.

### Technical / Clinical Details

The Experimental Materials Scientist/Engineer in this role will play a leading part in the design, synthesis, and characterization processes for new material systems. Specifically, this includes research into synthesizing wide-bandgap semiconductors like gallium nitride (GaN) and silicon carbide (SiC) using advanced thin-film growth techniques such as chemical vapor deposition (CVD), physical vapor deposition (PVD), and atomic layer deposition (ALD). These materials are expected to offer superior performance in high-temperature, high-power, and high-frequency environments, making them essential for next-generation radar, communication systems, and power conversion devices. The role also involves analyzing material structure, composition, and electrical properties using advanced characterization techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), atomic force microscopy (AFM), and Raman spectroscopy. Furthermore, the individual will collaborate with an AI-enabled materials discovery platform to develop new experimental methods for optimizing experimental design and efficiently navigating the discovery space for new materials. This is expected to shorten the R&D cycle by up to 50% compared to traditional trial-and-error material development processes.

## Background & Context

Microelectronics forms the foundation of modern defense, communication, and information technology infrastructure. Wide-bandgap semiconductors, in particular, hold immense strategic importance as they offer performance unattainable by conventional silicon-based devices. However, the synthesis, defect control, and device integration of these materials still present significant scientific and engineering challenges. MIT Lincoln Laboratory has been at the forefront of advanced materials research to address national security challenges. The approach of integrating AI into the materials discovery process is gaining traction as a groundbreaking means to efficiently explore complex material design spaces and rapidly develop materials with new functionalities. This is essential for maintaining U.S. technological superiority and driving innovation in future defense and civilian technologies.

## Strategic Significance & Outlook

The strengthening of this AI-driven materials discovery team lays the groundwork for MIT Lincoln Laboratory to achieve groundbreaking advancements in microelectronics and quantum information technologies in the coming years. Future research will focus on developing ultra-high-performance transistors, high-efficiency power converters, and novel quantum devices. Additionally, further integration of AI algorithms with autonomous experimental platforms aims to realize fully automated 'self-driven labs.' This is expected to dramatically enhance the speed and efficiency of materials discovery, accelerating the time-to-market for new technologies. This initiative represents a critical investment for the U.S. to continue leading the scientific and technological frontier, bringing immeasurable benefits to a wide range of industries and national security.

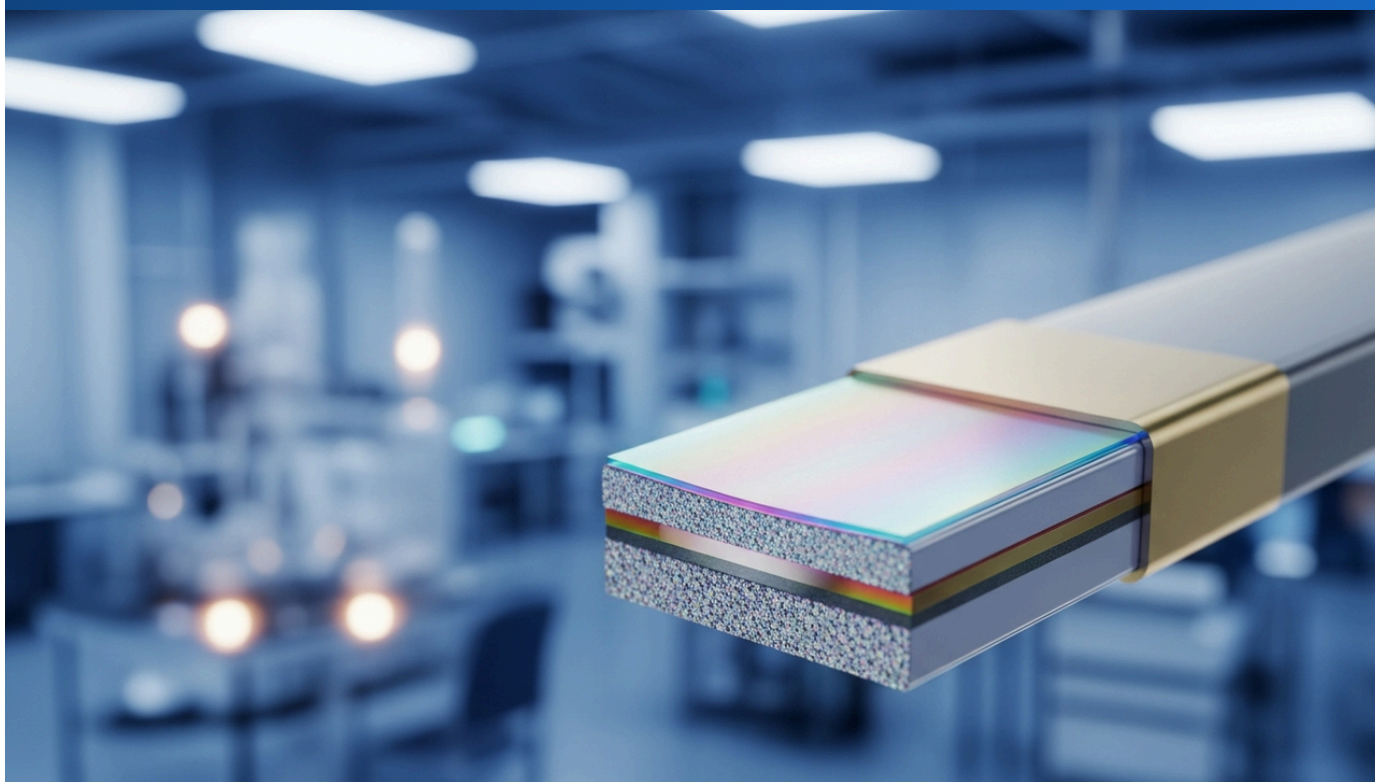
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Source: <https://careers.ll.mit.edu/job/Lexington-Experimental-Materials-Scientist-Engineer-MA-02420/1374892800/>



# #27 Nanometer-Thick Magnesium Oxide Coatings Discovered to Boost Next-Gen Battery Performance and Longevity

Published July 17, 2026   AZoM   UK



## OVERVIEW

Researchers have discovered an ultrathin magnesium oxide (MgO) protective coating essential for enhancing next-generation battery performance. This nanometer-thick coating holds the potential to dramatically increase electrode material stability by suppressing undesirable side reactions within the battery. Consequently, it is expected to extend battery cycle life and improve energy density. This discovery marks a significant step towards accelerating the development of highly efficient and long-lasting energy storage solutions.

### Key Findings

Researchers have developed a nanometer-thick magnesium oxide (MgO) protective coating with the potential to dramatically improve the performance and lifespan of next-generation batteries. This ultra-thin coating effectively suppresses the degradation of battery electrode materials, paving the way for long-term stable operation and enhancing overall battery efficiency.

### Technical / Clinical Details

The newly discovered MgO coating, despite its minimal thickness of only a few nanometers, significantly reduces parasitic side reactions between the electrode and the electrolyte. It achieves unprecedented uniformity and adhesion compared to conventional protective layers, successfully enhancing electrode stability, particularly under high-voltage conditions. This protective layer is considered highly promising for application not only in lithium-ion batteries but also in next-generation battery systems such as solid-state batteries, which promise even higher energy densities. By stabilizing the electrode materials, the technology is also expected to improve fast-charging capabilities and low-temperature performance of batteries. This technology is particularly anticipated to unleash the full potential of high-energy-density materials like high-nickel cathodes and silicon-based anodes, which typically face stability challenges.

### Background & Context

Advancements in battery technology are critical for the development of diverse industries, including electric vehicles (EVs), portable electronic devices, and renewable energy storage systems. However, existing batteries face challenges, particularly concerning electrode degradation and safety as efforts are made to increase energy density. Instability at the electrode-electrolyte interface is a primary cause of reduced battery life and performance degradation. This MgO coating technology offers a breakthrough solution to these fundamental issues, with the potential for significant impact across the battery industry.

## Strategic Significance & Outlook

This nanometer-thick MgO coating technology represents a crucial step towards the commercialization of next-generation batteries. Further research is anticipated to optimize manufacturing processes for mass production and expand its applicability to various electrode materials. In the future, this technology is expected to contribute to extending the range of EVs and enabling more efficient storage of renewable energy within smart grids, thereby supporting the realization of a sustainable society. This will address the strong market need for improved battery safety and performance.

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Source: <https://www.azom.com/materials-news-index.aspx>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #28 Ireland Develops First Cement-Free 3D-Printed Geopolymer, Ushering in a New Era of Sustainable Construction

Published July 15, 2026   Phys.org   USA



## OVERVIEW

Ireland has successfully developed the nation's first cement-free 3D-printed geopolymer, marking a significant advance in sustainable building materials. This innovative material dramatically reduces carbon emissions associated with traditional cement production, enabling environmentally friendlier construction. Utilizing industrial waste as raw material, the geopolymer also contributes to efficient resource utilization. This development is a crucial step towards a sustainable future for construction, holding immense potential to improve the environmental performance of the industry.

### Key Findings

Ireland has achieved a groundbreaking advance in sustainable building materials with the development of the nation's first cement-free 3D-printed geopolymer. This innovative material completely eliminates the use of traditional Portland cement, leading to a significant reduction in carbon dioxide emissions during the manufacturing process.

### Technical / Clinical Details

The developed geopolymer is produced by reacting industrial by-products such as fly ash and blast furnace slag with an alkaline activator. This process bypasses the high-temperature calcination required for cement production, thereby substantially cutting energy consumption and CO2 emissions. Furthermore, its integration with 3D printing technology allows for the efficient and precise fabrication of complex architectural components. This minimizes material waste while increasing design flexibility, and contributes to reducing construction costs and project timelines. Notably, the geopolymer has demonstrated excellent compressive strength and durability, confirmed to perform at or above the level of traditional concrete.

### Background & Context

The construction industry, particularly cement production, accounts for approximately 10% of global CO2 emissions, making it a major source of environmental impact. Consequently, the development of eco-friendly alternative materials is an urgent priority. Geopolymer technology has garnered attention as a promising solution to these challenges. When combined with 3D printing, it offers the potential to simultaneously optimize construction processes and resource utilization, contributing to the establishment of a circular economy. This development in Ireland holds significant importance for the country's green building promotion strategies.



## Strategic Significance & Outlook

Cement-free 3D-printed geopolymers hold immense potential to bring about significant transformation in the future of the construction industry. Applications are particularly anticipated in infrastructure development, disaster relief housing, and modular construction. As further research and development towards commercialization and standardization progresses, this technology is poised to play a central role in a future where sustainable construction becomes the norm. This will contribute to reducing the environmental footprint and improving resource efficiency in urban development.

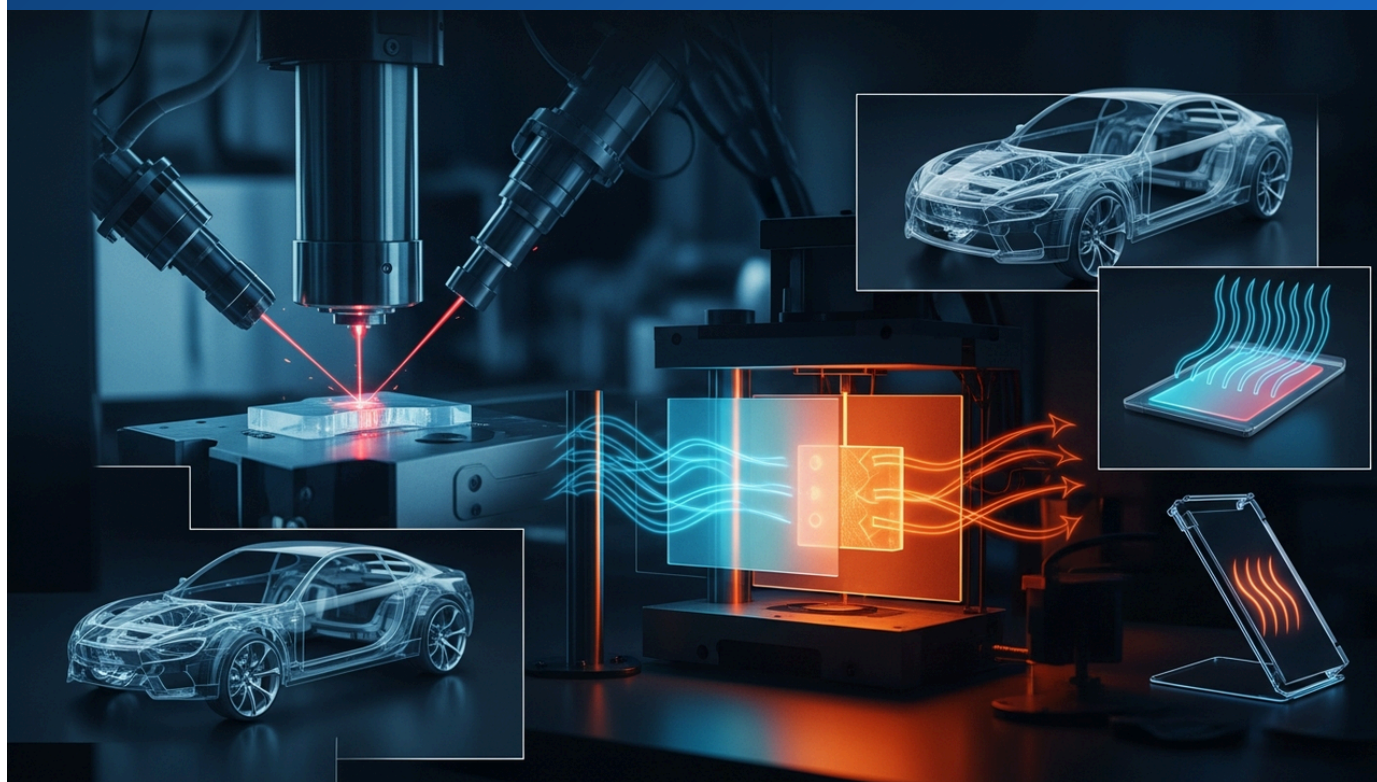
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Source: <https://phys.org/chemistry-news/materials-science/>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #29 Scientists Develop New Plastic That Blocks Heat While Retaining Strength, Revolutionizing Automotive and Electronics Thermal Management

Published July 14, 2026   SciTechDaily   USA



## OVERVIEW

Scientists have developed a new type of plastic that effectively blocks heat without compromising its mechanical strength. This groundbreaking material combines lightweight properties with superior thermal control capabilities, significantly expanding its applications in automotive, electronics, and aerospace sectors. Unlike traditional thermal insulation materials that are often heavy or lack strength, this new plastic overcomes these limitations. The technology represents a crucial advancement for improving energy efficiency and enabling the miniaturization and higher performance of products.

### Key Findings

Researchers have successfully developed a groundbreaking plastic material that exhibits excellent heat-blocking performance while maintaining its mechanical strength. This novel material is lightweight yet capable of efficiently blocking heat flow, with promising applications across various industrial sectors.

### Technical / Clinical Details

The developed plastic was realized through a combination of specialized polymer structure design and nanoscale material composite technology. Specifically, by uniformly dispersing specific nanofillers, which have a heat-blocking effect, within a low-thermal-conductivity polymer matrix, the overall thermal conductivity of the material has been dramatically reduced. Simultaneously, optimizing the interactions between polymer chains has overcome the 'trade-off between thermal insulation and strength/flexibility' that conventional thermal insulation materials faced. This result allows for significantly reduced thermal conductivity while maintaining or improving tensile strength compared to conventional plastics. This enables efficient thermal control in a wide range of applications requiring it, such as lightweighting automotive components, managing heat dissipation in high-performance electronic devices, and architectural uses as an insulating material.

### Background & Context

In modern society, improving energy efficiency is an urgent challenge, and minimizing heat loss is required in all equipment and structures. Especially in applications like electric vehicle (EV) battery packs, smartphone processors, and building insulation, materials that are lightweight, high-strength, and possess excellent thermal management capabilities are essential. However, traditional high-strength materials like metals and ceramics are heavy, while insulating materials like foamed plastics often lack sufficient strength. This new plastic has the potential to solve these problems simultaneously, offering new options for next-generation product design.

## Strategic Significance & Outlook

This plastic, capable of blocking heat while retaining strength, has the potential to revolutionize many industries. In the automotive sector, it will contribute to extending EV range and improving safety by reducing the risk of battery thermal runaway while promoting lightweighting. In the electronics sector, it will solve overheating issues in increasingly miniaturized and integrated devices, enhancing reliability and performance. Furthermore, its unique properties are expected to be utilized in aerospace and medical device fields. As technological development for mass production progresses, it will become an important material for accelerating the adoption of sustainable and high-performance products.

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Source: <https://scitechdaily.com/tag/materials-science/>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #30 Patsnap Publishes '2026 High-Entropy Alloy Microstructure Control Patent Landscape' Report, Highlighting China's Innovation Leadership

Published July 15, 2026   Patsnap   China



## OVERVIEW

This article provides an overview of Patsnap's '2026 High-Entropy Alloy (HEA) Microstructure Control Patent Landscape' report. The report analyzes the patent landscape for HEA microstructure control, revealing that Chinese academic institutions are leading innovation in this field. Beijing Institute of Technology stands at the forefront in patent filings, indicating sustained growth in HEA technology. This study offers crucial insights for understanding R&D trends and key players in the HEA sector.



## IN DEPTH

This article provides an overview of a market research report published by Patsnap.

### Report Overview

Titled 'High-Entropy Alloy (HEA) Microstructure Control Patent Landscape in 2026,' this report provides a detailed analysis of global patent filing trends related to the microstructure control of high-entropy alloys. The market under investigation covers HEA technology in general, with a geographical focus on regions and countries exhibiting active patenting. The study period encompasses patent application data from recent years, reflecting the latest trends as of 2026.

### Key Findings

- **China's Dominant Position:** According to the report, Chinese academic institutions account for an overwhelming majority of patent filings related to high-entropy alloy microstructure control, leading technological innovation in this field. This is believed to reflect the Chinese government's focused investments in new materials research.
- **Beijing Institute of Technology's Leadership:** Notably, Beijing Institute of Technology leads the world in the number of patent applications in this area, demonstrating its strong R&D capabilities. The university holds various patents related to HEA composition design, manufacturing processes, and characterization.
- **Sustained Growth:** Patent activity in HEA microstructure control technology has shown sustained growth in recent years, with active investment and R&D projected to continue. This is underpinned by increasing demand from sectors requiring high-performance materials, such as aerospace, energy, and defense industries.

### About the Publisher

Patsnap is a leading innovation intelligence platform provider that leverages AI to analyze extensive data, including patents, research papers, and company information. It delivers insights for businesses to formulate R&D strategies and establish competitive advantages. Its platform is utilized by companies, universities, and research institutions worldwide.

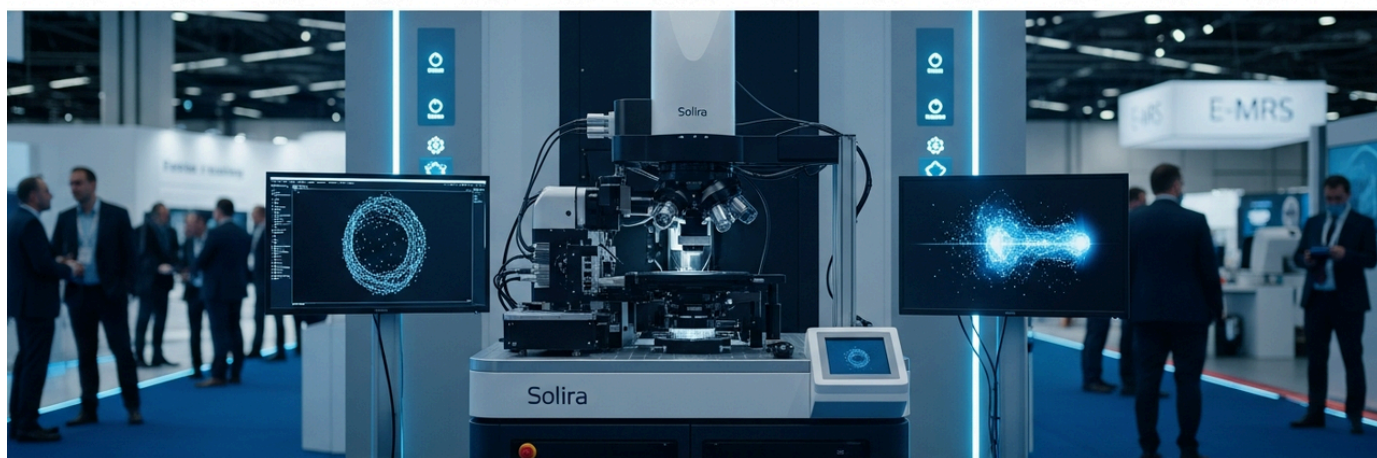
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Source: <https://www.patsnap.com/resources/blog/rd-blog/high-entropy-alloy-microstructure-control-patent-landscape/>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #31 PicoQuant Unveils Solira Time-Resolved Photoluminescence Microscope for Advanced Materials Characterization at E-MRS 2026

Published July 17, 2026   AZoM   UK



## OVERVIEW

PicoQuant introduced 'Solira,' a new time-resolved photoluminescence (TRPL) microscope, at the E-MRS Spring Meeting 2026, dedicated to advanced materials characterization. This innovative system enables detailed combined spatial, temporal, and spectral analysis for researching semiconductors, perovskites, and nanomaterials. Solira provides a powerful tool for materials scientists to deeply understand electronic structures and energy dynamics, accelerating next-generation material development. This announcement marks a significant advancement in materials analysis technology.

### Key Findings

PicoQuant officially unveiled its innovative time-resolved photoluminescence (TRPL) microscope system, 'Solira,' at the E-MRS Spring Meeting 2026, designed for comprehensive characterization of advanced materials. This new system promises to elucidate the dynamics of electronic excited states in materials science research with unprecedented precision.

### Technical / Clinical Details

The Solira system integrates high-resolution optical microscopy with ultrafast time-resolved measurement capabilities based on Time-Correlated Single Photon Counting (TCSPC) technology. This allows users to simultaneously measure photoluminescence lifetime, spectrum, quantum efficiency, and their spatial distribution within materials. It proves particularly effective in a wide range of advanced materials research, including defect analysis in semiconductor devices, charge carrier dynamics in perovskite solar cells, and photophysical characterization of quantum dots. Solira combines nanometer-scale spatial resolution with picosecond-level temporal resolution, enabling detailed mapping of electron and exciton transport mechanisms and recombination pathways within materials. This provides data crucial for deeply understanding the fundamental physical phenomena that determine material performance.

### Background & Context

Precise understanding and control of optical and electronic properties of materials are essential for developing next-generation electronic devices, solar cells, quantum technologies, and photocatalysts. Traditional characterization methods have struggled to simultaneously acquire spatial and temporal information with high accuracy, often failing to capture the true behavior of materials. PicoQuant's Solira addresses these challenges, offering a powerful solution for materials scientists to conduct more efficient and accurate research. This is expected to accelerate the R&D cycle and shorten the time from new material discovery to practical application.

## Strategic Significance & Outlook

PicoQuant's Solira time-resolved photoluminescence microscope has the potential to become a standard analytical instrument in the field of materials science. This technology will play a crucial role, particularly in quality control within the semiconductor industry, the development of new energy materials, and fundamental physics research. Future applications are also envisioned for more complex multi-layered materials and biomaterials, further expanding the frontiers of materials research. With the introduction of Solira, researchers will be able to uncover hidden material properties and contribute to the creation of higher-performance and more innovative products.

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Source: <https://www.azom.com/news.aspx?newsID=65629>

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #32 NPU Researchers Develop Paper-Thin Smart Adhesive with 400x Electric-Activated Adhesion for Chip Manufacturing, Soft Robotics

Published July 13, 2026   Industry Events (Pandaily)   China



## OVERVIEW

Researchers at Northwestern Polytechnical University have developed a groundbreaking paper-thin smart adhesive material that exhibits a 400-fold increase in grip strength when electrified, capable of holding a 10-pound dumbbell. This electrically activated grip offers unprecedented precision and control for delicate tasks. The technology is poised for significant impact in chip manufacturing, soft robotics, and precision assembly, enhancing efficiency and reliability in micro-handling applications.

### Key Findings

A research team at Northwestern Polytechnical University has unveiled a revolutionary paper-thin smart adhesive material that demonstrates an astonishing 400-fold increase in adhesion strength upon electrical activation. This novel material showcases an exceptional gripping capability, easily lifting a 10-pound (approximately 4.5 kg) dumbbell during demonstration. This breakthrough significantly pushes the boundaries of existing technologies in diverse industrial sectors demanding both delicate manipulation and powerful temporary adhesion.

### Technical / Clinical Details

The developed smart adhesive functions by altering its surface structure and chemical properties in response to specific electrical signals, leading to a dramatic enhancement in tensile strength per unit of adhesion area. This 'electrically activated grip' offers unparalleled precision and flexibility compared to conventional mechanical clamps or vacuum grippers, particularly in handling delicate electronic components or in precision assembly processes requiring frequent temporary fixation. Its paper-thin profile minimizes spatial constraints, making it highly adaptable for high-density environments like chip fabrication lines.

### Background & Context

Modern manufacturing, especially in electronics and robotics, necessitates increasingly precise handling of smaller and more complex components. Traditional adhesives often pose issues with removal difficulty or residue, while mechanical grippers risk damaging sensitive parts. This smart adhesive provides a clean, efficient, and reusable solution to these challenges, promising a leap forward in manufacturing automation and quality control. Its reusability and controlled activation overcome many limitations of conventional bonding and gripping methods.

## Strategic Significance & Outlook

This technology is anticipated to find wide-ranging applications, from handling wafers in chip manufacturing to soft robotic arms grasping irregularly shaped objects, and precise positioning in medical devices. Researchers and engineers aim to further optimize the material's durability and performance, laying the groundwork for new manufacturing paradigms and advanced automation solutions across industries. Future applications may also extend to smart textiles and wearable devices, where flexible and controllable adhesion is highly valuable.

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Source: <https://www.industryevents.com/news/paper-thin-smart-material-adhesion-increased-400x-npu-discovers-electric-activat-20260713>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #33 IAG Firemark Ventures Invests in Galvorn for Next-Gen Carbon Nanotube Materials, Advancing Sustainable Electrification and Data Transmission

Published July 14, 2026   Firemark Ventures (IAG)   Australia



## OVERVIEW

IAG's corporate venture capital arm, Firemark Ventures, has announced an investment in Galvorn, a startup developing next-generation carbon-negative materials. Galvorn offers lightweight, highly conductive carbon nanotube materials in fiber, film, and fabric forms, poised to be a sustainable alternative for electrification and data transmission applications. This strategic investment underpins a broader initiative to support innovative startups in insurance, climate, and supply chain sectors, fostering the convergence of sustainability and high-performance materials.



### Key Findings

Firemark Ventures, the corporate venture capital arm of IAG, has announced a significant investment in Galvorn, a pioneering startup focused on developing next-generation carbon-negative materials. This investment is part of Firemark Ventures' broader strategy to back innovative startups that are disrupting the insurance, climate, and supply chain sectors. Galvorn specializes in producing lightweight and highly conductive carbon nanotube materials in versatile forms such as fibers, films, and fabrics, presenting a compelling sustainable alternative for various electrification and data transmission applications.

### Technical / Clinical Details

Galvorn's carbon nanotube materials are distinguished by their unique manufacturing process, which enables them to achieve substantial weight reduction and superior electrical conductivity compared to traditional metallic materials. These materials can be flexibly processed into fibrous, thin-film, or fabric forms, making them suitable for a wide array of applications including lightweight cables for electric vehicles (EVs), high-performance sensors, smart textiles, and electromagnetic shielding materials. The intrinsic structural properties of carbon nanotubes also confer exceptional strength and thermal stability, rendering them suitable for deployment in demanding environments.

### Background & Context

Modern industries are increasingly challenged to simultaneously reduce environmental impact and enhance performance. The accelerating pace of electrification and the exponential growth in data transmission necessitate a new class of lightweight, high-efficiency conductive materials. Galvorn's carbon nanotube technology offers a solution that not only lessens reliance on rare earth metals but also reduces energy consumption during manufacturing. This positions it as a key technology for mitigating environmental footprints and bolstering supply chain sustainability across diverse sectors like automotive, aerospace, electronics, and construction.



## Strategic Significance & Outlook

The investment from Firemark Ventures is expected to significantly accelerate Galvorn's product development and market penetration efforts. This will facilitate the scaling up of carbon nanotube material production and drive down costs, fostering broader industrial adoption. In the long term, Galvorn's materials have the potential to displace a portion of the existing metal materials market, serving as a critical technology for realizing a sustainable society. Investors and industry observers are keenly interested in the transformative impact of Galvorn's technology and its potential as a new material that harmonizes environmental performance with advanced functionality.

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Source: <https://www.iag.com.au/newsroom/company/firemark-ventures-backs-innovative-startups>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #34 German Startup Unveils Earth-Based Robotic 3D Printing for Sustainable Construction, Dramatically Reducing Material Waste

Published July 09, 2026   Enterprise Europe Network   Germany



## OVERVIEW

A German deep tech construction startup has introduced an innovative building technology that integrates soil-based materials, robotic additive manufacturing, and AI-supported design optimization. This technology aims to drastically reduce material waste and enhance resource efficiency in construction. By utilizing locally sourced soil as a primary building material, it minimizes transportation costs and environmental impact, paving the way for sustainable circular construction. The company is actively seeking research collaborators and investors for technology validation, pilot projects, and market expansion.

### Key Findings

A German deep tech construction startup has developed a groundbreaking 3D printing technology poised to enable sustainable and circular construction practices. This innovative system integrates locally sourced earth-based materials, advanced robotic additive manufacturing, and AI-supported design optimization. The primary objective is to significantly reduce material waste and dramatically improve resource efficiency compared to conventional construction methods, thereby enabling environmentally friendly building processes.

### Technical / Clinical Details

The company's construction technology begins with collecting local soil, processing it with specific admixtures, and then directly fabricating structures using a 3D printer mounted on a robotic arm. Artificial intelligence analyzes design parameters in real-time to optimize structural strength, thermal insulation, and material consumption, proposing optimal building geometries and material placement. This process nearly eliminates on-site waste, a stark contrast to traditional block or concrete construction, and reduces transportation distances for materials, consequently lowering CO2 emissions. Furthermore, the high reusability of the materials contributes to a reduced environmental footprint throughout the building's entire lifecycle.

### Background & Context

The construction industry is a major contributor to global greenhouse gas emissions and resource consumption, making a transition towards sustainability an urgent imperative. Earth as a primary building material has a long history due to its abundance and minimal processing requirements, but adapting it to modern construction standards and complex designs has been challenging. This German startup's technology bridges this gap by merging traditional wisdom with state-of-the-art robotics and AI, offering high-quality, eco-friendly building solutions. This represents a potential game-changer for the construction sector.

## Strategic Significance & Outlook

Currently, the company is actively seeking research collaborations, commercial agreements with technical support, and investment partners to further validate its technology, implement large-scale pilot projects, and accelerate market penetration. Widespread adoption of this technology promises multifaceted benefits, including reduced construction costs, shortened project timelines, and significant contributions to global environmental sustainability. The potential for rapid and sustainable housing construction in developing countries and disaster-stricken regions is also a key consideration, underscoring its profound social impact.

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Source: [https://vertexaisearch.cloud.google.com/grounding-api-redirect/AUZIYQHNU7gKwssTxQG-wOTu3T\\_kUDJYIDRxITmtPdZlgez2xr9LlopFHM54cymJqc3MQ4pviOkrzDuPbO2iV1dasx3nJKVLZXmHFajzYD7HYjWaFFgzbNBg0muFfIM3t5Lr1rKdTzvYBgDNGIRAmFoYlazHObYFwlrYPSEcbAcd2\\_amJ8AJ\\_lraQu41KmecFbrjNJXzm7HkMiQnBV23abHpMnHOI5ILYuZBLpuQ==](https://vertexaisearch.cloud.google.com/grounding-api-redirect/AUZIYQHNU7gKwssTxQG-wOTu3T_kUDJYIDRxITmtPdZlgez2xr9LlopFHM54cymJqc3MQ4pviOkrzDuPbO2iV1dasx3nJKVLZXmHFajzYD7HYjWaFFgzbNBg0muFfIM3t5Lr1rKdTzvYBgDNGIRAmFoYlazHObYFwlrYPSEcbAcd2_amJ8AJ_lraQu41KmecFbrjNJXzm7HkMiQnBV23abHpMnHOI5ILYuZBLpuQ==)

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #35 ChemRxiv Preprint: AI-Driven Robotic Data Management Accelerates Materials Discovery for Perovskite Semiconductors

Published Date unknown ChemRxiv Unknown



## OVERVIEW

A ChemRxiv preprint from the perovskite semiconductor community highlights the potential of robotic data management for trustworthy AI. This research emphasizes that automated platforms can accelerate experimental execution and data-driven decision-making. This approach is expected to significantly reduce the time and cost associated with discovering, designing, and developing new functional materials, particularly enhancing efficiency in exploring complex perovskite systems compared to traditional trial-and-error methods.



### Key Findings

A preprint published on ChemRxiv underscores the critical importance of robotic data management for reliable AI, particularly from the perspective of the perovskite semiconductor community. The research emphasizes that integrating automated experimental platforms with AI-driven data processing has the potential to dramatically accelerate the discovery, design, and development of novel functional materials, substantially reducing both the time and cost involved. This represents a paradigm shift in materials science research.

### Technical / Clinical Details

The proposed robotic data management system autonomously executes experiments, collecting, organizing, and analyzing vast amounts of data generated. AI algorithms identify patterns within this data stream, formulate hypotheses, and suggest the next optimal experimental conditions, thereby automating the materials discovery cycle without human intervention. This capability is especially beneficial for material systems with extensive compositional and structural variations, such as perovskite semiconductors, where efficiently exploring optimal material properties is challenging with traditional random experimental designs. This systematic approach also enhances data quality and reproducibility, increasing research reliability.

### Background & Context

The discovery and development of new functional materials are indispensable for advancements across diverse industries, including energy, electronics, and medicine. However, this process has traditionally been resource-intensive, time-consuming, and fraught with trial and error. Recent progress in AI and robotics offers a significant opportunity to overcome these bottlenecks. Perovskite semiconductors, while showing high performance in applications like solar cells and LEDs, still face challenges with stability and long-term reliability, necessitating more efficient material exploration. This research offers a promising solution to address these issues.

## Strategic Significance & Outlook

This integrated approach of robotic data management and AI demonstrates versatility, with potential applications extending beyond perovskite semiconductors to other complex functional materials, such as metal-organic frameworks (MOFs) and polymeric materials. In the future, it could accelerate national initiatives like the 'Materials Genome Initiative,' potentially shortening new material development cycles from years to months. Researchers and investors alike anticipate the enhanced R&D efficiency this technology brings and the wave of innovation it is poised to unleash.

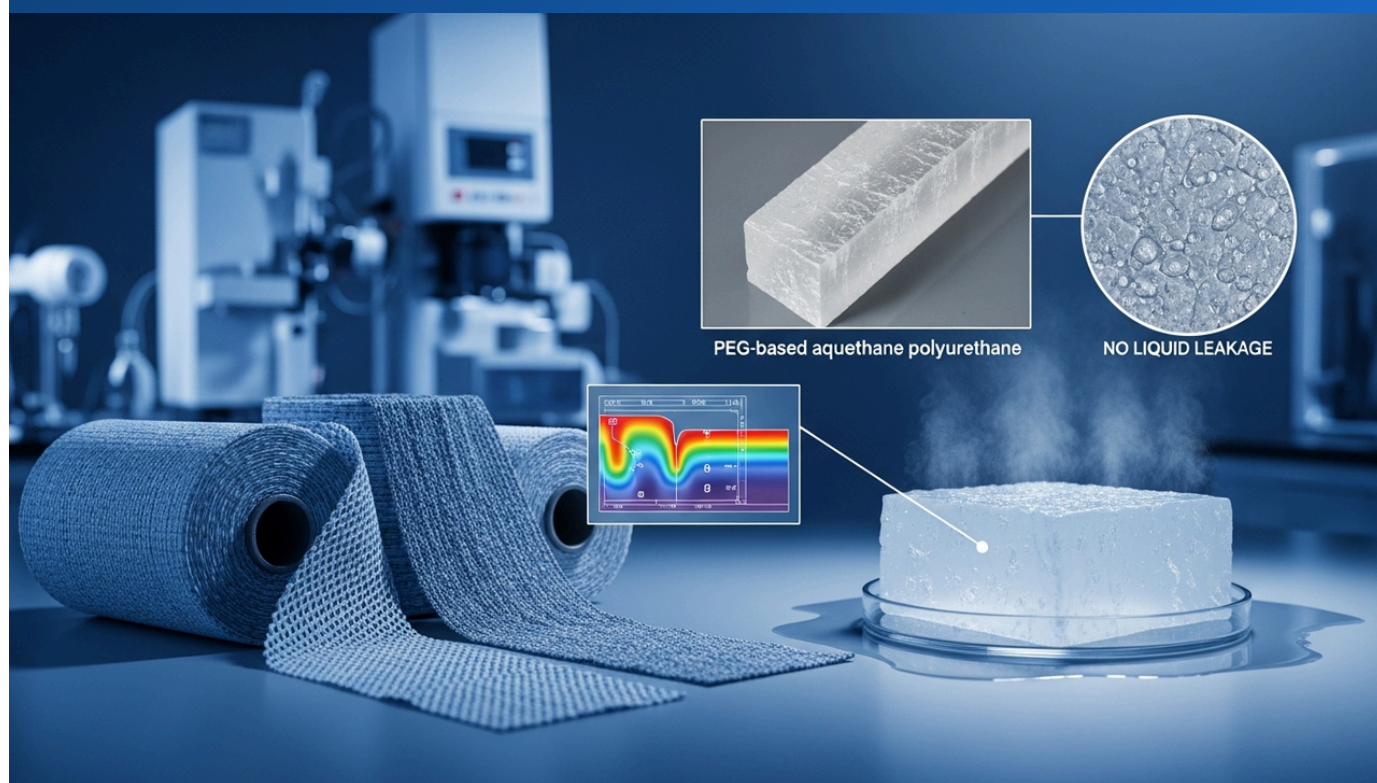
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Source: <https://chemrxiv.org/doi/pdf/10.26434/chemrxiv.15005693>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #36 MDPI Paper: PEG-Crosslinked Waterborne Polyurethane Solid-Solid PCMs Offer Leak-Free Thermal Regulation for Textiles

Published July 13, 2026   ResearchGate (MDPI Polymers)   Unknown



## OVERVIEW

A paper in MDPI Polymers reports the development of crosslinked waterborne polyurethane solid-solid phase change materials (PUSSPCMs) containing polyethylene glycol (PEG) for thermoregulating textiles. This novel material eliminates leakage during heating processes while demonstrating high latent heat storage capacity and excellent thermal stability. This represents a significant advancement, offering a new solution for thermal energy storage in next-generation smart textiles and apparel, enhancing wearer comfort and energy-efficient garment design.

### Key Findings

A research paper published in MDPI Polymers details the development of novel crosslinked waterborne polyurethane solid-solid phase change materials (PUSSPCMs) incorporating polyethylene glycol (PEG), specifically engineered for thermoregulating textiles. This innovative material exhibits a critical advantage: it completely prevents liquid leakage during the phase change process upon heating, while also demonstrating high latent heat storage capacity and excellent thermal stability. This marks a substantial advance in thermal management technology for the smart textile sector.

### Technical / Clinical Details

The developed PUSSPCMs are constructed by chemically crosslinking PEG segments within a waterborne polyurethane network. This crosslinked structure ensures that the material maintains its solid state even when PEG undergoes melting and solidification, eliminating the risk of liquid leakage—a common problem with traditional phase change materials (PCMs) during heat absorption and release cycles. Experimental results confirmed the material's high thermal storage capability (latent heat capacity) and its stability over repeated heating and cooling cycles, meeting the durability requirements for textile applications.

### Background & Context

The demand for smart textiles with thermoregulating capabilities is rapidly growing across diverse sectors, including sportswear, protective clothing, medical apparel, and general fashion. Previous attempts to integrate PCMs into textiles faced significant practical barriers due to issues like liquid leakage, low durability, and processing difficulties. PUSSPCMs address these challenges by offering an environmentally friendly, water-based manufacturing process, combined with leak prevention through crosslinking and superior thermal properties. This breakthrough paves the way for the development of more comfortable and functional clothing.

## Strategic Significance & Outlook

This PUSSPCMs technology has the potential to establish a new paradigm in the field of thermal energy storage. Beyond textile applications, it is expected to find broad deployment in building materials, thermal management of electronic devices, and even automotive interiors. Researchers and engineers will focus on further optimizing the material, reducing production costs, and developing large-scale manufacturing processes. This will enable consumers to experience greater comfort year-round and empower industries to create innovative, energy-efficient products. Investors are likely to show significant interest in the potential growth of this technology within the smart textile and thermal management markets.

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Source:

[https://www.researchgate.net/publication/409249241\\_Crosslinked\\_Waterborne\\_Polyurethane\\_Solid-Solid\\_Phase\\_Change\\_Materials\\_with\\_Polyethylene\\_Glycol\\_for\\_Thermoregulating\\_Textiles](https://www.researchgate.net/publication/409249241_Crosslinked_Waterborne_Polyurethane_Solid-Solid_Phase_Change_Materials_with_Polyethylene_Glycol_for_Thermoregulating_Textiles)

Collected: July 17, 2026 | Automated Research System (Gemini API)



# #37 ChemRxiv Preprint: MOFEvolve Framework Enables Literature-Driven Efficient Exploration and Design of Experimental MOFs

Published Date unknown ChemRxiv Unknown

## MOFEVOLVE

enable efficient exploration of experimental MOFs through literature data-driven methods

### OVERVIEW

A ChemRxiv preprint introduces 'MOFEvolve,' a framework enabling literature-driven evolution of experimental Metal-Organic Frameworks (MOFs). This research establishes a mechanism to integrate newly published experimental knowledge into computational MOF discovery processes. It is expected to significantly accelerate MOF materials exploration and design, enhancing the efficiency of developing high-performance materials for applications like gas storage, separation, and catalysis. This marks a crucial advancement for rapidly identifying optimal materials within the vast MOF design space.

### Key Findings

A preprint published on ChemRxiv introduces 'MOFEvolve,' an innovative framework designed to enable the literature-driven evolution of experimental Metal-Organic Frameworks (MOFs). This research establishes a mechanism to seamlessly integrate newly published experimental knowledge into the computational discovery processes for MOFs. This approach is anticipated to significantly streamline the design and exploration of MOFs, accelerating the development of high-performance materials for diverse applications such as gas storage, separation, catalysis, and sensing. This represents a critical milestone in the advancement of data-driven materials science.

### Technical / Clinical Details

The MOFEvolve framework combines natural language processing (NLP) and machine learning (ML) techniques to automatically extract experimental information, including structural data, synthesis conditions, and performance metrics, from scientific literature on MOFs. This extracted knowledge is then integrated with existing computational databases and predictive models, serving as an intelligent guide for exploring novel MOF design spaces. For instance, when designing MOFs with specific gas adsorption properties, MOFEvolve learns successful synthetic routes and structural motifs from relevant literature data, assisting in the evaluation and optimization of computationally generated virtual MOFs. This enables the rapid identification of promising candidates with significantly fewer resources compared to traditional trial-and-error experimental approaches, enhancing research efficiency.

### Background & Context

Metal-Organic Frameworks (MOFs) have garnered substantial interest across various industrial sectors due to their high porosity, tunable pore sizes, and diverse chemical structures. However, the theoretical design space for MOFs is vast, making experimental exploration of all possibilities impractical. Existing computational methods aid in identifying promising candidates but often lack mechanisms to incorporate the latest experimental results in real-time. MOFEvolve addresses this gap by strengthening the feedback loop between computational predictions and experimental validation, accelerating the MOF research and development process.

## Strategic Significance & Outlook

Literature-driven materials discovery frameworks like MOFEvolve possess broad applicability, extending beyond MOFs to the discovery and design of other functional materials (e.g., high-entropy alloys, perovskites). As this technology matures, it promises to significantly shorten R&D cycles, enabling faster market introduction of high-performance novel materials. This will attract considerable attention from researchers, engineers, and investors as a foundational technology for addressing global challenges such as improving energy efficiency, solving environmental problems, and developing new manufacturing techniques.

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Source: <https://chemrxiv.org/doi/pdf/10.26434/chemrxiv.15005453>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #38 Würth Elektronik Initiates 'Cellutronik' Project for Sustainable Bacterial Cellulose Circuit Carriers, Funded by BMFTR

Published July 09, 2026   Würth Elektronik   Germany



## OVERVIEW

Würth Elektronik Circuit Board Technology has launched the 'Cellutronik' project, funded by the German Federal Ministry for Research, Technology, and Space (BMFTR), to develop sustainable circuit carriers made from bacterial cellulose. This initiative aims to utilize bacterial cellulose as an alternative substrate for next-generation electronic circuit boards, pushing towards environmentally friendly electronic solutions. Its bio-derived and highly biodegradable nature addresses electronic waste concerns, positioning it as a key material for a circular economy in electronics. This project could mark a significant step towards a materials revolution in the electronics industry.

### Key Findings

Würth Elektronik Circuit Board Technology has initiated the collaborative 'Cellutronic' project, supported by significant funding from the German Federal Ministry for Research, Technology, and Space (BMFTR). The primary objective of this pioneering project is to establish bacterial cellulose as a viable alternative substrate for circuit boards in next-generation electronic devices, thereby accelerating the development of sustainable electronic solutions. This represents a promising answer to the pressing societal challenges of reducing electronic waste and enhancing resource efficiency.

### Technical / Clinical Details

Bacterial cellulose, a natural polymer produced by specific bacteria, possesses remarkable properties including excellent mechanical strength, high purity, and superior biodegradability. The Cellutronic project focuses on research and development to process this bacterial cellulose into a form suitable for electronic circuit boards. Specifically, efforts are underway to optimize the dielectric properties, thermal stability, and dimensional stability of bacterial cellulose substrates while ensuring compatibility with existing printed circuit board manufacturing processes. The goal is to create a high-performance, sustainable substrate material that can replace conventional, environmentally impactful glass fiber-reinforced plastics (such as FR-4).

### Background & Context

The rapid proliferation of electronic devices has led to a growing environmental problem: the increasing volume of electronic waste (e-waste). Traditional electronic devices often contain complex materials and hazardous substances that are difficult to recycle, posing significant disposal challenges. Against this backdrop, global research into incorporating bio-based and biodegradable materials into electronics is gaining momentum. Bacterial cellulose, owing to its unique properties, holds great promise as a sustainable substrate material, particularly for flexible electronics and IoT devices. The Cellutronic project aims to establish European leadership in this crucial field.



## Strategic Significance & Outlook

The successful outcome of the Cellutronik project will significantly broaden the material options for the electronics industry and contribute to reducing its environmental footprint. If commercialized, this technology could enable more electronic products to be easily disassembled and recycled at the end of their lifecycle, bringing us closer to a circular economy. Researchers, engineers, and investors are keenly observing how this 'green electronics' trend could fundamentally transform the design, manufacturing, and consumption patterns of electronic devices. In the future, bacterial cellulose substrates may also find applications in smart packaging, disposable sensors, and medical diagnostic tools.

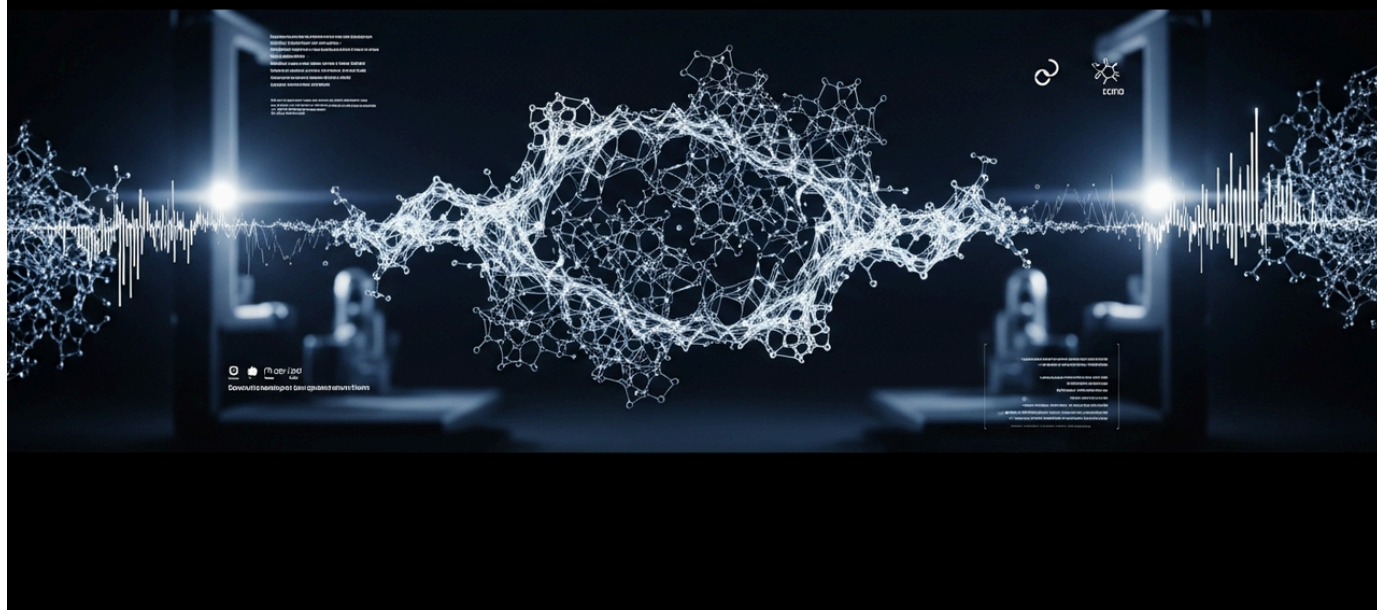
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Collected: July 17, 2026 | Automated Research System (Gemini API)

# #39 ACS Paper Unravels Glass Transition and Dynamic Behavior Balance in Epoxy-Anhydride Vitrimer Networks, Aiding Reprocessable Material Design

Published July 11, 2026 ACS Applied Polymer Materials USA



## OVERVIEW

A detailed study in ACS Applied Polymer Materials investigates the intricate balance between glass transition temperature ( $T_g$ ) and dynamic behavior in epoxy-anhydride vitrimer networks. The research comprehensively explores how constituent composition influences curing,  $T_g$ , network architecture, damping, and stress relaxation. These findings establish critical design principles for reprocessable and chemically recyclable materials, significantly contributing to sustainable polymer development. It provides essential foundational information for precisely tuning vitrimer functionality.

### Key Findings

A recent research paper published in ACS Applied Polymer Materials significantly advances our comprehensive understanding of the complex balance between glass transition temperature ( $T_g$ ) and dynamic behavior in epoxy-anhydride vitrimer networks. This study meticulously investigates how the composition of the network constituents influences crucial material properties, including curing behavior, glass transition temperature, internal network architecture, viscoelastic damping characteristics, and stress relaxation behavior. These insights provide essential guidelines for designing next-generation reprocessable and chemically recyclable materials, thereby making a substantial contribution to the development of sustainable polymer science.

### Technical / Clinical Details

The research team synthesized a series of vitrimer networks using varying ratios of epoxy resins, anhydride hardeners, and specific catalysts. They then characterized the thermal and mechanical properties using a suite of techniques, including Dynamic Mechanical Analysis (DMA), Differential Scanning Calorimetry (DSC), and stress relaxation tests. The results revealed that adjusting the type and ratio of anhydrides allows for broad control over the glass transition temperature. Furthermore, the study demonstrated that the crosslinking density and the kinetics of dynamic bond exchange reactions directly impact the material's reprocessability and chemical recyclability. Notably, certain compositions were found to enable efficient stress relaxation and reprocessing at relatively low temperatures, while maintaining excellent mechanical strength.

## Background & Context

Conventional thermosetting plastics, despite possessing superior mechanical strength, thermal stability, and solvent resistance, suffer from the significant drawback of being extremely difficult to reprocess or recycle once cured. This contributes to the plastic waste crisis and poses a major challenge to the transition towards a circular economy. Vitrimers, which can reversibly reorganize their network structure via dynamic covalent bond exchange reactions (e.g., transesterification, transamidation), have emerged as promising materials. They retain the desirable properties of thermosets while offering thermoplastic-like reprocessability and recyclability, enabling smart functionalities such as self-healing, shape memory, and chemical recycling. This research deepens the fundamental design principles for these transformative materials.

## Strategic Significance & Outlook

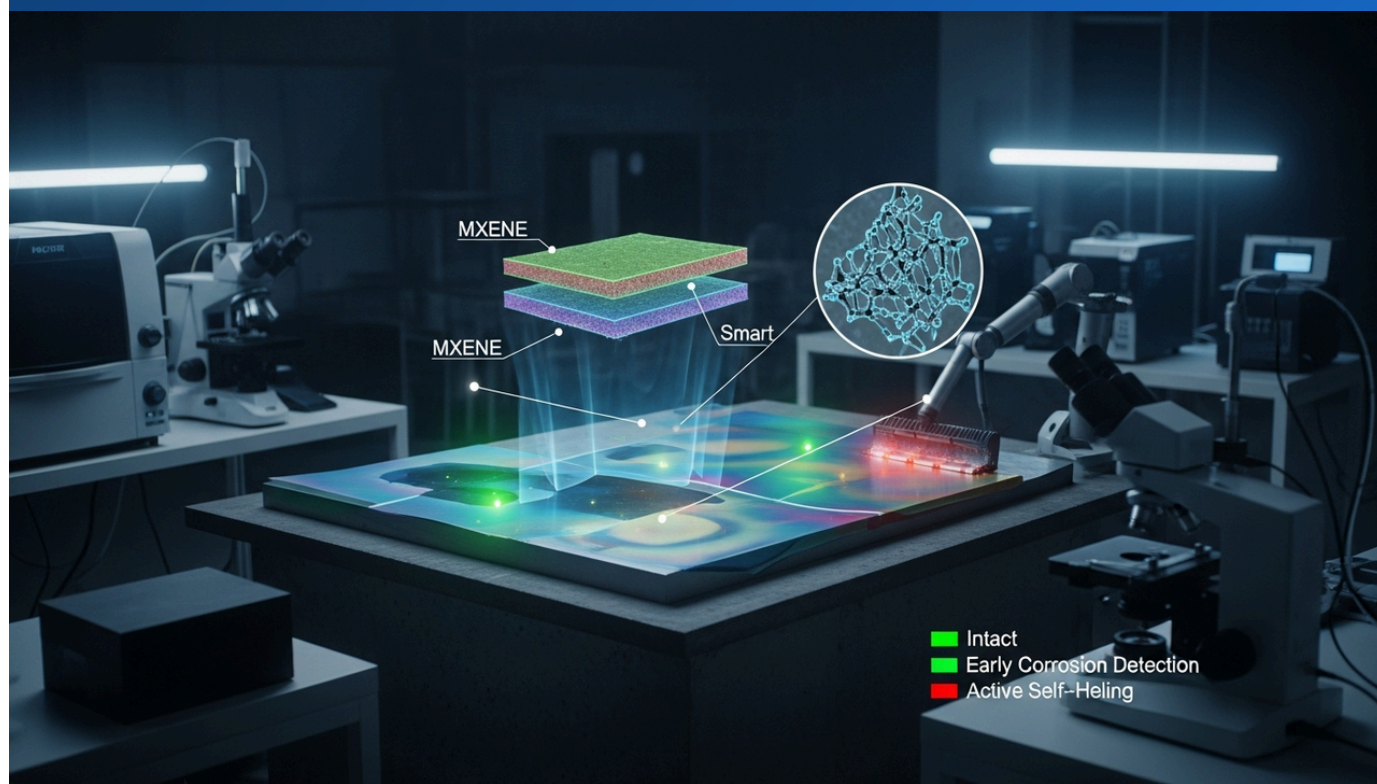
The insights gained from this study are applicable not only to epoxy-anhydride-based vitrimers but also to the design of other types of vitrimer networks. This will accelerate the development of products with more efficient recycling processes in industrial sectors demanding both high performance and sustainability, such as automotive, aerospace, electronics, and construction. Researchers and engineers will leverage this foundational research to precisely tune the composition and structure of vitrimers for specific application requirements and develop scale-up technologies for practical commercialization. Investors are keenly interested in the potential growth and economic value of vitrimers within the sustainable materials solutions market.

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Source: <https://pubs.acs.org/doi/10.1021/acsapm.6c01682>

# #40 ACS Paper: MXene-Based Anticorrosive Coatings Evolve from Passive Barrier to Smart Protection

Published July 16, 2026 ACS Publications (Chemistry of Materials) USA



## OVERVIEW

A comprehensive review paper on MXene-based anticorrosive coatings has been published in ACS Publications (Chemistry of Materials). The review outlines the current evolution of MXene coatings from conventional passive barriers to advanced smart protective functionalities, along with challenges and future prospects. MXene has been shown to significantly enhance the anticorrosive performance of polymer coatings due to its high aspect ratio, tunable surface terminations, and strong barrier effect. This will substantially contribute to extending material lifespans and reducing costs in infrastructure, automotive, and aerospace industries.



### Key Findings

A recent review paper published in ACS Publications (Chemistry of Materials) provides a detailed analysis of the groundbreaking advancements, existing challenges, and future prospects of MXene-based anticorrosive coatings. The core of this review clearly demonstrates that MXene coatings are evolving beyond their traditional function as a mere 'passive barrier' to offer 'smart protection.' The inherent high aspect ratio, easily tunable surface terminations, and powerful physical barrier effect of MXenes have been repeatedly shown to dramatically enhance the anticorrosive performance of polymer coatings across various studies.

### Technical / Clinical Details

MXenes are a family of 2D transition metal carbides, nitrides, or carbonitrides that have rapidly gained attention due to their unique layered structure, excellent electrical conductivity, hydrophilicity, and mechanical strength. In anticorrosive coating applications, MXene nanosheets uniformly dispersed within a polymer matrix enhance the tortuous path effect, physically blocking the permeation of corrosive species like water, oxygen, and ions. Furthermore, the tunable surface terminations of MXenes (e.g., -O, -OH, -F) strengthen interactions with the polymer matrix, improving coating adhesion and mechanical stability. Some research also explores the potential of 'smart anticorrosion' where MXenes confer self-healing capabilities or pH responsiveness, actively inhibiting corrosion at damaged sites.

### Background & Context

Corrosion is a pervasive problem costing the global economy trillions of dollars annually, affecting almost all industrial sectors including infrastructure, transportation, energy, and manufacturing. With tightening regulations on environmentally harmful anticorrosive pigments (e.g., hexavalent chromium), there is a growing demand for more sustainable and high-performance anticorrosive solutions. MXene-based coatings emerge as a promising alternative in this context, breaking through the limitations of existing anticorrosion technologies and offering long-term protection with reduced environmental impact. This technology is critical for reducing material lifecycle costs and enhancing safety.

## Strategic Significance & Outlook

This review suggests that MXene-based anticorrosive coatings will continue to develop rapidly. Researchers and engineers will focus on scaling up MXene production, optimizing composite coating systems, and evaluating long-term durability and performance in real-world environments. In the future, next-generation smart anticorrosive coatings equipped with self-healing and sensing capabilities are expected to be commercialized, dramatically improving the safety and lifespan of structures. Investors and industry stakeholders are keenly interested in the immense market opportunities presented by this innovative material and its contribution to achieving a sustainable society.

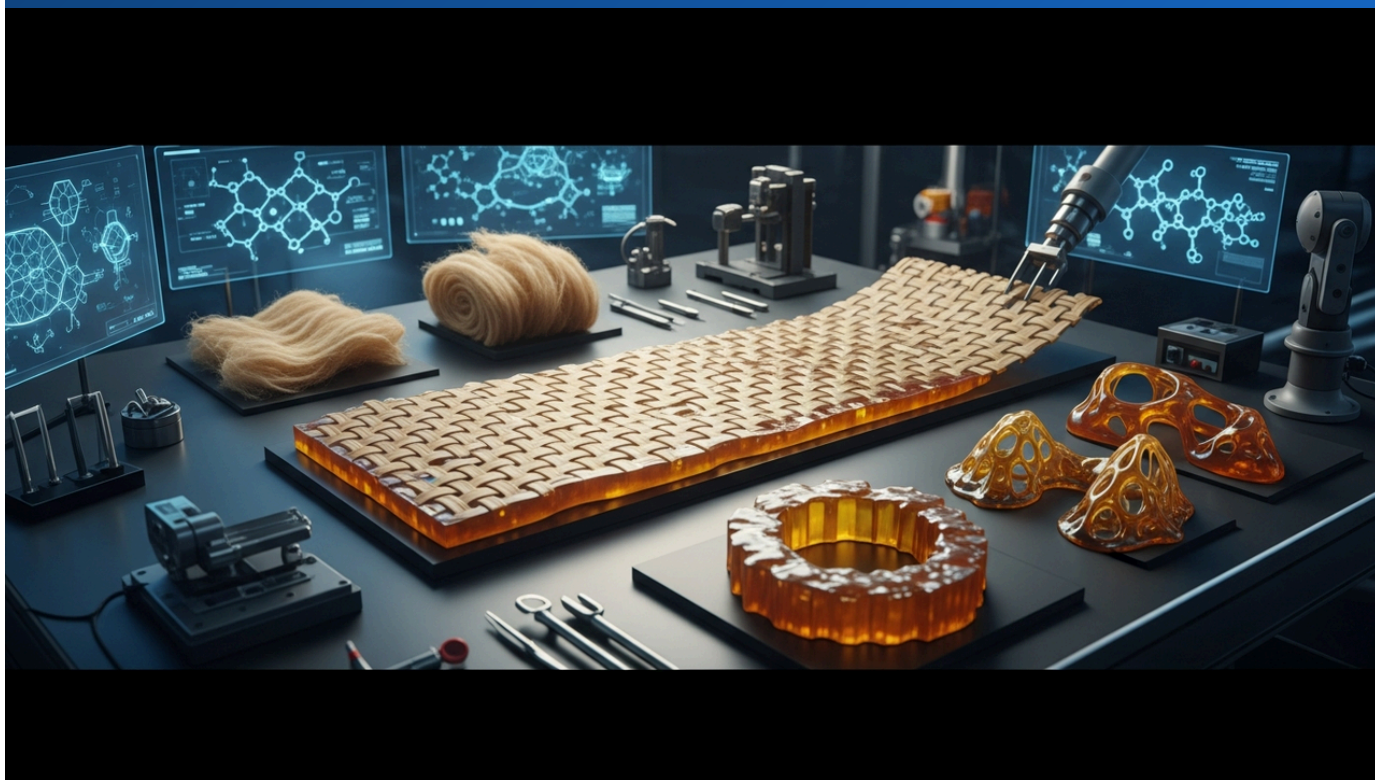
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Source: <https://pubs.acs.org/doi/10.1021/acsanm.6c01634>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #41 MDPI Paper: Woven Hemp-Reinforced Polyfurfuryl Alcohol Composites Advance High-Performance Natural Fiber Applications

Published July 15, 2026 MDPI Switzerland



## OVERVIEW

A paper in MDPI presents research on the evaluation of woven hemp-reinforced polyfurfuryl alcohol (PFA) resin composites for high-performance natural fiber composite applications. This study promotes the reuse and valorization of hemp fibers, an agricultural waste product, within the sustainable polymer composites sector. It is expected to advance the development of high-strength, low-environmental-impact materials and contribute to sustainability in industries like automotive, construction, and packaging. This marks a significant step in expanding bio-based material alternatives to traditional petroleum-derived materials.

### Key Findings

A recent research paper published in MDPI presents comprehensive evaluation results for woven hemp-reinforced polyfurfuryl alcohol (PFA) resin composites, targeting high-performance natural fiber composite applications. This study marks a significant advance in the field of sustainable polymer composites, substantially contributing to the reuse and valorization of hemp fibers, which are often regarded as agricultural waste. The resulting composite materials demonstrate a favorable balance of excellent mechanical properties and environmental performance, indicating their potential as sustainable alternative materials across various industrial sectors.

### Technical / Clinical Details

The research team first prepared high-quality woven hemp fibers and then combined them with polyfurfuryl alcohol (PFA) resin, a bio-based thermosetting resin, to manufacture the composite materials. PFA is derived from furfural, which in turn is obtained from agricultural waste, making it low-cost and environmentally friendly, while also possessing good thermal and chemical resistance. Standard processes such as compression molding were used for composite fabrication, and the influence of hemp fiber orientation and volume fraction on the final mechanical properties was analyzed in detail. The study confirmed that hemp-reinforced PFA composites, manufactured under specific conditions, exhibited tensile, flexural, and impact strengths comparable to, or in some cases superior to, conventional glass fiber-reinforced polymer composites. Their lower density also contributes to lightweighting.

## Background & Context

Driven by increasing environmental awareness and concerns over resource depletion, industrial sectors such as automotive, aerospace, construction, and packaging are seeing a rapid surge in demand for sustainable and environmentally friendly alternatives to conventional petroleum-derived synthetic fiber composites. Natural fibers (e.g., hemp, flax, kenaf) offer advantages like low cost, low density, and renewability, but have historically faced challenges such as variability in mechanical properties and moisture absorption. This research addresses some of these issues by combining the high mechanical properties of woven hemp fibers with the excellent environmental compatibility and thermal resistance of PFA resin, thereby bridging a gap in high-performance sustainable composite materials.

## Strategic Significance & Outlook

The evaluation results of woven hemp-reinforced PFA composites open new avenues for the design and development of sustainable high-performance materials. If this technology further develops and becomes scalable for mass production, it is expected to find wide application in diverse products, including automotive interior components, non-structural building elements, sporting goods, and consumer electronics casings. Researchers and engineers will focus on optimizing the materials' long-term durability, weather resistance, and manufacturing processes. Investors will find significant business opportunities in the growth of the green materials market and the environmental and economic benefits offered by natural fiber composites. This represents a crucial step towards realizing a circular economy.

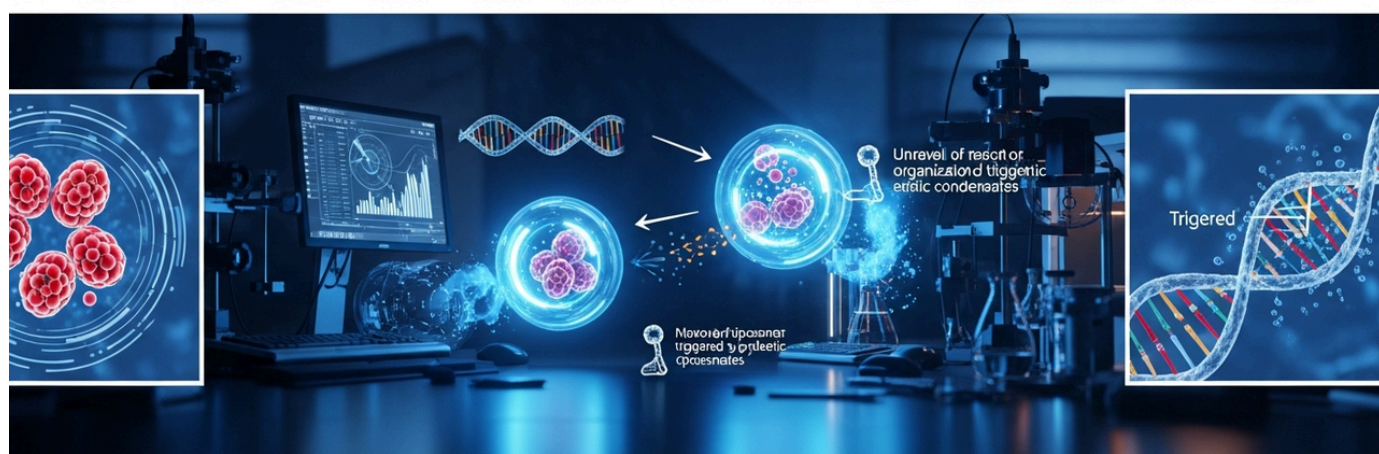
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# #42 ACS Nano Paper Unveils Organization and Triggered Release of Liposomes with DNA-Based Synthetic Condensates, Revolutionizing Delivery Systems

Published July 10, 2026 ACS Nano USA



## OVERVIEW

A groundbreaking study in ACS Nano reports the organization and triggered release of liposomes using DNA-based synthetic condensates. This modular platform demonstrates the potential of DNA-based condensates to program the spatial distribution of membranous subcompartments and support dynamic cargo processing. These functionalities are highly valuable for engineering cell-mimetic systems, microreactors, and targeted drug delivery systems. Particularly, it contributes to developing next-generation delivery technologies for high-efficiency, precise drug release in biological environments.

### Key Findings

A cutting-edge research paper published in ACS Nano presents groundbreaking discoveries concerning the organization and triggered release mechanisms of liposomes utilizing DNA-based synthetic condensates. This modular platform distinctly demonstrates the capacity of DNA-based condensates to precisely program the spatial distribution of membranous subcompartments and dynamically process and release encapsulated cargo in response to specific stimuli. This represents a significant breakthrough in synthetic biology, nanobiotechnology, and delivery system engineering.

### Technical / Clinical Details

The research team engineered synthetic condensates (such as DNA origami or DNA hydrogels) that self-assemble from complementary DNA strands. These condensates bind to the surface of liposomes (lipid bilayer vesicles that mimic biological membranes), guiding their specific arrangement and cluster formation. Furthermore, the DNA condensates are programmed to alter their structure in response to external cues like pH changes, light, temperature, or specific biomolecules. This enables precise control over the release of encapsulated cargo (e.g., drugs or genetic material) from the liposomes. The system not only controls the behavior of individual liposomes but also offers the ability to design complex networks where multiple liposomes interact in a controlled manner.

### Background & Context

In drug delivery systems, gene therapy, diagnostic probes, and synthetic cell research, the ability to efficiently and selectively transport and release internal cargo is paramount. While traditional liposome-based delivery systems are effective, their release control has often been limited. Advances in DNA nanotechnology have made it possible to precisely design structures at the nanoscale and construct smart materials that respond to external stimuli. This research provides a novel solution to this challenge by combining the programmable properties of DNA with the biocompatibility of liposomes, paving the way for more sophisticated biomimetic systems and therapeutic approaches.

## Strategic Significance & Outlook

This platform for organizing and triggering the release of liposomes using DNA-based synthetic condensates holds immense potential for engineering cell-mimetic systems, microreactors, and highly precise drug delivery systems. Future developments are expected to include smart nanocarriers that selectively release drugs to cancer cells, artificial cells that catalyze specific chemical reactions in vivo, or high-sensitivity biosensors for diagnostics. Researchers and engineers will focus on the in vivo safety, efficacy, and manufacturing scale-up of this technology. Investors are highly interested in the potential market value of this innovative delivery technology within growing fields such as personalized medicine and synthetic biology.

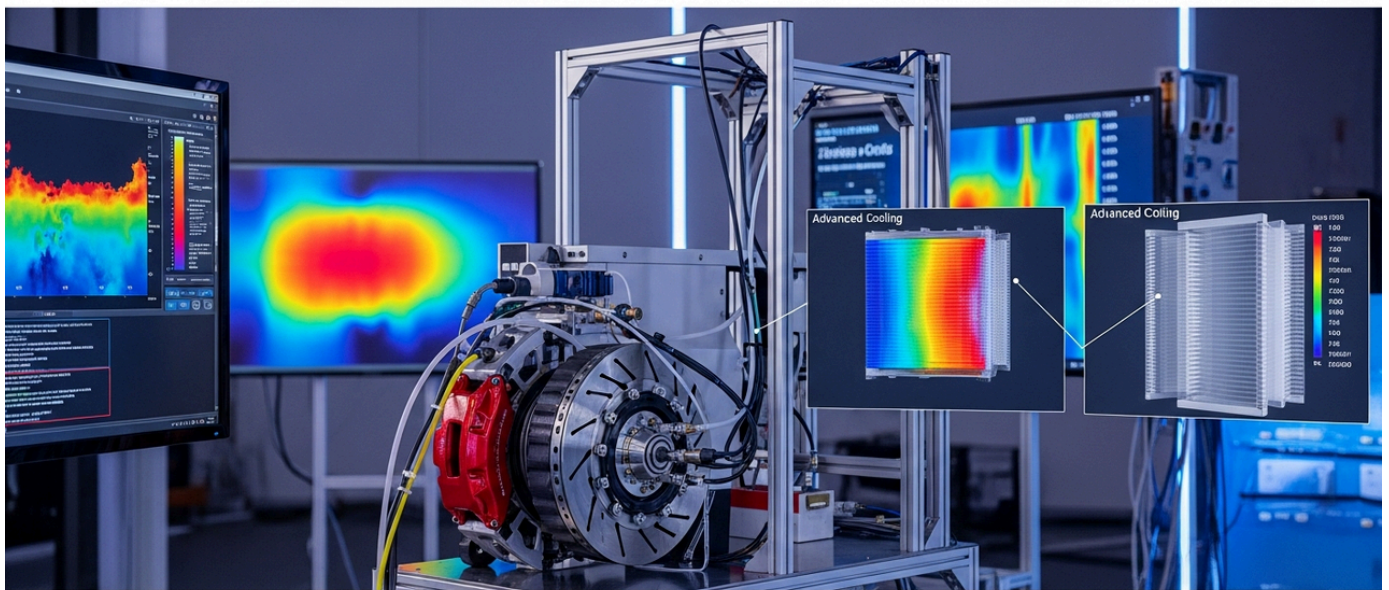
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Source: <https://pubs.acs.org/doi/10.1021/acsnano.5c16730>

Collected: July 17, 2026 | Automated Research System (Gemini API)

# #43 MDPI Paper: CFD Evaluation of Zero-Emission Magnetorheological Braking Thermal Management Highlights PCM Contribution

Published July 17, 2026 MDPI Switzerland



## OVERVIEW

A CFD evaluation paper published in MDPI investigates the thermal management of zero-emission magnetorheological brakes (MRBs). While MRBs offer wear-free, electrically controllable braking torque, overheating under repeated high-load operations poses a significant challenge. The study highlights the progress of phase change materials (PCMs) in thermal energy storage as a promising solution for this thermal management problem. Integrating PCMs appears a viable approach to enhance MRB reliability and performance, particularly under harsh conditions, contributing to high-performance braking systems in EVs and industrial machinery.

### Key Findings

A recent Computational Fluid Dynamics (CFD) evaluation paper published in MDPI presents research focused on the thermal management mechanisms of zero-emission magnetorheological brakes (MRBs). MRBs are garnering significant interest in fields such as electric vehicles and industrial machinery due to their unique advantages of wear-free, electrically controllable braking torque. However, excessive heat generation under repeated high-load operations, leading to performance degradation and challenges in ensuring long-term reliability, has been a major concern. This study emphasizes the promising advancements in phase change materials (PCMs) for thermal energy storage as a potential solution to this critical thermal management issue.

### Technical / Clinical Details

MRBs generate braking force by utilizing magnetorheological fluids (MRFs), whose viscosity changes in response to a magnetic field. Controlling this magnetic field allows for precise braking torque adjustment within milliseconds. However, braking inevitably generates heat due to shear friction within the MRF, which can alter MRF properties and lead to system failure. CFD simulations conducted in the study provide a detailed analysis of the internal thermal distribution and fluid flow within MRBs, identifying thermal management bottlenecks. The paper suggests that integrating PCMs into the MRB's cooling system can absorb excess thermal energy as latent heat, thereby stabilizing the system temperature. PCMs function as a 'thermal buffer,' absorbing heat during phase transition at a specific melting point and preventing temperature spikes during this process.



## Background & Context

With the proliferation of electric vehicles (EVs) and highly automated industrial machinery, there is a growing demand for more efficient and reliable braking systems. Traditional friction brakes generate wear particles, require regular maintenance, and pose environmental concerns. MRBs are considered a next-generation braking technology, offering non-contact, wear-free operation with fast and precise control, addressing many of these issues. However, thermal management, particularly during continuous high-load operation, has been the greatest technical barrier to their practical implementation. Phase change materials, having made significant strides in thermal energy storage over the past few decades, are expected to greatly enhance MRB performance and reliability when applied to this technology.

## Strategic Significance & Outlook

This CFD evaluation study underscores the potential of PCM integration in MRB thermal management. Future research will be crucial, focusing on selecting different types of PCMs, their microencapsulation techniques, and optimal integration designs within MRB systems. If this technology is commercialized, it is anticipated to accelerate the adoption of MRBs in a wide range of applications, including enhancing the efficiency of EV regenerative braking systems, improving the reliability of industrial robots and Automated Guided Vehicles (AGVs), and in precision equipment for aerospace. Researchers, engineers, and investors hold high expectations for the potential of this zero-emission braking technology to contribute to a sustainable and safe future.

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Source: <https://www.mdpi.com/2032-6653/17/7/370>

# #44 ACS Paper: Catechol-Functionalized Amino Acid Copolymers Develop Bioadaptive Neural Electrode Coatings with Superior Adhesion and Biocompatibility

Published July 10, 2026   ACS Applied Polymer Materials   USA



## OVERVIEW

A study in ACS Applied Polymer Materials reports the development of bioadaptive neural electrode coatings based on catechol-functionalized basic amino acid alternating copolymers, demonstrating excellent adhesion and biocompatibility. These novel materials also possess favorable electrochemical properties, indicating significant potential as high-performance coating materials. They are expected to enhance the long-term stability and biocompatibility of neural interfaces, thereby improving the performance of medical devices like deep brain stimulators and neural prosthetics. This marks a crucial advancement in neuroscience and biomaterials engineering.

### Key Findings

A recent research paper published in ACS Applied Polymer Materials reports the development of groundbreaking bioadaptive neural electrode coatings based on catechol-functionalized basic amino acid alternating copolymers. These novel materials uniquely combine exceptional adhesion, superior biocompatibility, and favorable electrochemical properties, indicating significant potential as high-performance biomaterial coatings. This technology is critically important for enhancing the long-term stability and performance of neural interfaces, addressing key challenges in implantable medical devices.

### Technical / Clinical Details

The research team synthesized unique polymers by alternately copolymerizing monomers containing catechol groups (known for their strong surface adhesion) with monomers containing basic amino acids (which promote biocompatibility and cell interactions). Inspired by dopamine, the catechol structures enable strong adhesion to various material surfaces (metals, polymers, ceramics). Simultaneously, the basic amino acid segments facilitate cell attachment and growth, aiding the integration of the electrode with biological tissues. Electrochemical characterization revealed that the coated electrodes maintain low impedance and good charge transfer capability, suggesting high performance in recording and stimulating neural signals. This bioadaptive characteristic ensures stable function post-implantation while minimizing undesirable reactions with surrounding tissues.

### Background & Context

Neural electrodes play a vital role in modern medicine, particularly in applications like deep brain stimulation (DBS), neural prostheses, and brain-machine interfaces (BMIs). However, implanted electrodes consistently face challenges related to biocompatibility (inflammatory responses, fibrous capsule formation) and a lack of long-term stability at the electrode-tissue interface. These issues can lead to device performance degradation over time and necessitate re-operations. The coating materials developed in this study offer a promising solution to these challenges, enabling more effective and prolonged interaction between electrodes and neural tissue.

## Strategic Significance & Outlook

This bioadaptive neural electrode coating technology is poised to significantly impact the development of next-generation neuro-medical devices. By improving long-term biocompatibility and functional stability, it not only enhances patients' quality of life but also opens new avenues for treating neurological disorders. Researchers and engineers will further validate the safety and efficacy of these coating materials and develop scale-up technologies for eventual clinical application. Investors are keenly interested in the potential market impact and growth opportunities this innovative material presents within the neuroscience and medical device sectors.

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Source: <https://pubs.acs.org/doi/10.1021/acsapm.6c02118>

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