



Cryogenic Magnetocaloric Materials and Systems for Efficient Hydrogen Liquefaction Cooling

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BACKGROUND

Efficient refrigeration, in the range of 10-40 K, is increasingly important for emerging technologies including hydrogen liquefaction, superconducting systems, cryogenic sensors, and quantum platforms. Current cryogenic cooling technologies typically rely on vapor compression and expansion cycles, which can be energy intensive, mechanically complex, and difficult to scale efficiently for certain applications. In contrast, magnetocaloric refrigeration uses solid materials to enable cooling without conventional refrigerants or compressor-based cycles. However, development of practical cryogenic magnetocaloric materials remains challenging. Magnetic Refrigeration (MR) has received increasing attention for hydrogen liquefaction, as it can achieve a higher coefficient of performance (COP) at cryogenic temperatures than vapor-compression systems.

DESCRIPTION

Researchers at the University of California, Santa Barbara have utilized europium hexaboride (EuB6) to enable highly efficient solid-state cryogenic cooling through a giant magnetocaloric effect in the 10-40 K temperature range. Unlike conventional vapor-compression refrigeration systems, this technology employs the magnetocaloric effect within the temperature range relevant for hydrogen liquefaction, superconducting systems, quantum technologies, and cryogenic sensing. EuB6 demonstrates record performance with large isothermal entropy change and adiabatic temperature change and suggests that refrigeration systems based on this material could achieve higher cooling capacity per unit mass, which is highly attractive for practical system designs. This discovery not only advances solid-state cryogenic refrigeration but also introduces materials design principles to identify and develop further high-performance cryogenic magnetocaloric materials and related cooling systems.

ADVANTAGES

- ▶ Exceptionally large magnetocaloric response with high entropy and temperature changes at moderate magnetic fields
- ▶ Compact, vibration-free solid-state refrigeration eliminating the need for conventional refrigerants or compressors
- ▶ Improved energy efficiency compared to traditional vapor-compression cryogenic cooling methods
- ▶ Broadly applicable across multiple low-temperature technologies and industries
- ▶ Material design strategy enabling discovery of additional high-performance magnetocaloric materials
- ▶ Reduced system size, weight, and cost due to high cooling capacity per unit mass

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OTHER INFORMATION

KEYWORDS

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cryogenic cooling

CATEGORIZED AS

- ▶ **Materials & Chemicals**
- ▶ [Other](#)
- ▶ [Superconductors](#)

RELATED CASES

2026-831-0

- ▶ Environmentally friendly refrigeration with fewer moving parts and lower maintenance requirements

APPLICATIONS

- ▶ Hydrogen liquefaction and large-scale hydrogen storage and transport
- ▶ Cryogenic gas processing and thermal management
- ▶ Superconducting systems and quantum computing platforms
- ▶ Low-temperature sensing, detectors, and instrumentation
- ▶ Aerospace and space exploration cryocooling
- ▶ Scientific and industrial cryogenic refrigeration systems
- ▶ Development of energy-efficient, compact refrigerant devices for emerging technology markets

PATENT STATUS

Patent Pending

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ [Metal-Elastomer Composite Edge Seal for Vacuum Insulated Glass Windows](#)

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