**Ultrawide-temperature-stable high-entropy relaxor ferroelectrics for energy-efficient capacitors**

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**Abstract**

The development of dielectric ceramics that simultaneously achieve high energy density and ultra-broad temperature stability remains a fundamental challenge for advanced electrostatic capacitors. Here, we report a high-entropy engineering strategy that transforms conventional relaxor ferroelectric BT-Bi(Mg0.5Zr0.5)O3 into entropy-stabilized BT-H through a dual-phase cationic disorder modulation. By maximizing configurational entropy, this approach induces atomic-scale lattice heterogeneity with reduced size of polar units, and establishes temperature-adaptive multiphase coexistence structure, effectively decoupling polarization configuration from thermal fluctuations. Consequently, the optimized BT-H ceramics exhibit extraordinary recoverable energy density (Wrec) of 8.9 J cm-3, near ideal conversion efficiency (η) of ~ 97.8 % and superior temperature stability of ΔWrec ~±9 % and Δη ~ ±4.8% over a ultrawide operational range (-85-220 ºC). This work validates the entropy-mediated cocktail effect, demonstrating that leveraging high-entropy materials to design capacitors with superior integrated energy storage performance is an advanced and viable strategy.

**Keywords:** Energy storage, high-entropy, relaxor ferroelectric, temperature stability