

# Antiferroelectric ceramics in energy storage principle





## Overview

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Abstract Lead-based antiferroelectric (AFE) material with high power density has received extensive attention for potential applications in the energy storage devices.

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Antiferroelectric (AFE) ceramics exhibit significant potential for diverse applications in pulsed power capacitors, chiefly owing to their electric field-induced AFE-ferroelectric (FE) phase transitions. However, their lower intrinsic breakdown strength (BDS) frequently results in dielectric.

NaNbO<sub>3</sub> (NN) has potential applications in energy storage devices due to its antiferroelectricity and environmentally friendly characteristics, but its low dielectric breakdown field strength (Eb) and energy storage efficiency (η) limit practical applications. In this study, the structure and.

“Nature Energy” Atomically-dispersed iron sites with a nitrogen-carbon coating as highly active and durable oxygen reduction catalysts for fuel cells

Do antiferroelectric ceramics release a high energy density?

However, conventional antiferroelectric ceramics are capable of releasing only 70-80% of the energy during the charging-discharging cycles, limiting their practical applications. Herein, we propose a novel approach using heterogeneous dipolar structures in PbHfO<sub>3</sub>-based AFE ceramics to achieve remarkable energy density.

Why do antiferroelectric compositions improve thermal stability and energy storage performance?

This indicates an improvement in the stability of the antiferroelectric phase,



ensuring that compositions maintain the excellent thermal stability and energy storage performance at high temperature. The  $\epsilon_r$  and  $\tan\delta$  of all compositions measured within the frequency range from 1 kHz to 1000 kHz at ambient temperature are shown in Fig. 4(f).

How to improve energy storage performance of a ceramics?

In this study, multiple optimization strategies were used to improve the energy storage performance of AN ceramics. First, Ta<sup>5+</sup> was introduced to B-sites to suppress polarization and improve AFE stability and breakdown field strength ( $E_b$ ). Then, Bi<sup>3+</sup> and Ca<sup>2+</sup> were incorporated into the A-site.

Can PbHfO<sub>3</sub>-based antiferroelectric ceramics achieve remarkable energy density?

However, conventional antiferroelectric ceramics are capable of releasing only 70-80% of the energy during the charging-discharging cycles, limiting their practical applications. Herein, we propose a novel approach using heterogeneous dipolar structures in PbHfO<sub>3</sub>-based AFE ceramics to achieve remarkable energy density.

How strong are antiferroelectric composite ceramics?

The (Pb<sub>0.98</sub>La<sub>0.02</sub>)(Zr<sub>0.7</sub>Sn<sub>0.3</sub>)<sub>0.995</sub>O<sub>3</sub>-Al<sub>2</sub>O<sub>3</sub> antiferroelectric composite ceramics, containing 5vol% parallel-aligned Al<sub>2</sub>O<sub>3</sub> plates, demonstrate a remarkable enhancement in breakdown strength from 390 to 570 kV cm<sup>-1</sup>.

What is the difference between a ferroelectric and an antiferroelectric?

In contrast, ferroelectrics (FEs) possess a high  $P_m$  but low  $P_r$  and  $E_b$ . Antiferroelectrics (AFEs) display double hysteresis loops due to their antiparallel dipoles, resulting in a high  $P_m$  and nearly zero  $P_r$ , making them ideal candidates for energy storage among various dielectric materials.



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### Relaxor antiferroelectric ceramics with ultrahigh efficiency for ...

Abstract cy in energy storage capacitors minimizes energy dissipatio improves device durability. A new efficiency-enhancement strategy for antiferroelectric through forming solid solutions wit ...

### Enhanced electrical energy storage performance in $\text{NaNbO}_3$ ...

Enhanced electrical energy storage performance in  $\text{NaNbO}_3$ -based antiferroelectric ceramics modified with Sr (Mg  $1/3$  Nb  $2/3$ )O  $3$  Published: 09 September 2025 ...



### Antiferroelectric ceramic capacitors with high energy-storage ...

Antiferroelectric ceramics, thanks to their remarkable energy storage density  $W$ , superior energy storage efficiency  $i$ , and lightning-fast discharging speed, emerge as the ...

### $\text{NaNbO}_3$ -based antiferroelectric multilayer ceramic capacitors for energy

Antiferroelectric materials feature electric-field-induced phase transitions followed by a large polarization change characterized by double



polarization hysteresis loops. ...



### Local defect structure design enhanced energy storage ...

Enhanced energy storage properties and antiferroelectric stability of Mn-doped  $\text{NaNbO}_3$ - $\text{CaHfO}_3$  lead-free ceramics: Regulating phase structure and tolerance factor



### Origin of superior energy storage performance in antiferroelectric

Antiferroelectric relaxors (AFR) have attracted increasing attention for their potential to achieve large energy storage density and high efficiency simultaneously. However, ...



### Enhancing energy storage performance of antiferroelectric ...

The application of Sodium niobate ( $\text{NaNbO}_3$ , NN) ceramics with antiferroelectric (AFE) crystal phase faces the severe limitations in low energy density and efficiency due to the instability of ...





### **Ferroelectric/paraelectric superlattices for energy storage**

In the past years, several efforts have been devoted to improving the energy storage performance of known antiferroelectrics. Polymers and ceramic/polymer composites ...



### **AgNbO<sub>3</sub> antiferroelectric film with high energy storage performance**

Abstract Antiferroelectric materials with double hysteresis loops are attractive for energy storage applications, which are becoming increasingly important for power electronics ...

### **Ordering-Structured Antiferroelectric Composite Ceramics for ...**

In this study, inspired by the layered architecture of natural nacre and with the guidance of phase-field simulations, a strategy of constructing a nacre-like layered structure is ...



### [Anti-Ferroelectric Ceramics for High Energy Density ...](#)

The article begins with a general introduction discussing the need for high energy density capacitors, the present solutions being used to ...



Nature Energy:?????????Fe-N-C??? ...

???, ?????????????????? ? Nature Energy ?????"  
Atomically-dispersed iron sites with a nitrogen-carbon coating as highly active ...



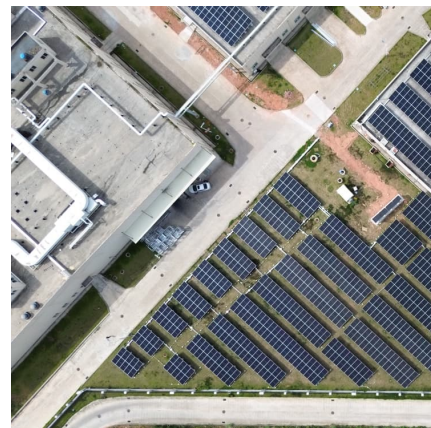
**NaNbO3-based short-range antiferroelectric ceramics with ...**

Lead-free NaNbO<sub>3</sub> (NN) antiferroelectric ceramics provide superior energy storage performance and good temperature/frequency stability, which are solid candidates for ...



**Ultrahigh energy storage density in lead-free relaxor antiferroelectric**

These results not only suggest that the NaNbO<sub>3</sub>-based relaxor antiferroelectric ceramics are promising candidates for advanced energy storage capacitors, but also provide ...





[Excellent energy storage performance of lead-based ...](#)

Abstract Lead-based antiferroelectric (AFE) material with high power density has received extensive attention for potential applications in the energy storage devices.

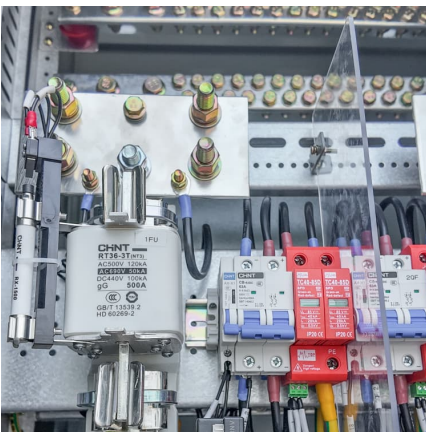
**Progress and perspectives in dielectric energy storage ceramics**

This review investigates the energy storage performances of linear dielectric, relaxor ferroelectric, and antiferroelectric from the viewpoint of chemical modification, ...



**Ordering-Structured Antiferroelectric Composite Ceramics for Energy**

Abstract Dielectric capacitors possessing high power density and ultrashort discharge time are valuable for high-power energy storage applications. However, achieving ...



**Local heterogeneous dipolar structures drive gigantic capacitive ...**

Herein, we propose a novel approach using heterogeneous dipolar structures in PbHfO<sub>3</sub>-based AFE ceramics to achieve remarkable energy density.



### Improving energy density and efficiency in antiferroelectric-based

Greatly enhanced energy storage and discharge properties of AgNbO<sub>3</sub> ceramics with a stable antiferroelectric phase and high breakdown strength using hydrothermally ...



### Ferroelectric/paraelectric superlattices for energy storage

In the past years, several efforts have been devoted to improving the energy storage performance of known antiferroelectrics. Polymers and ...



### [Improved energy storage performance of NaNbO<sub>3</sub>-based](#)

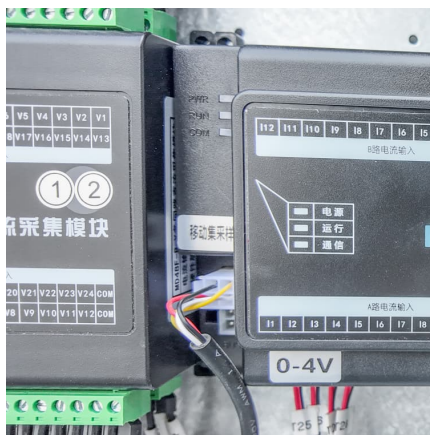
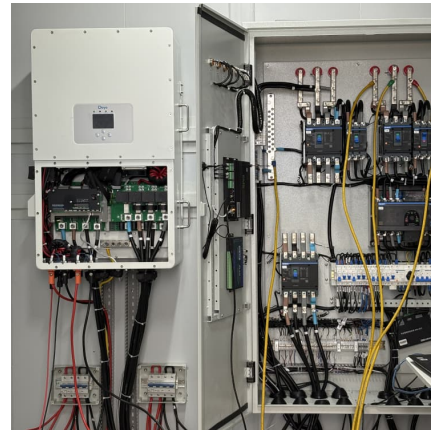
Abstract NaNbO<sub>3</sub> -based antiferroelectric ceramics are promising candidates for high-performance energy storage capacitors due to their environmental friendliness and low ...





### Significantly enhanced energy storage performance achieved by ...

AgNbO<sub>3</sub> antiferroelectric materials have garnered significant research interest for applications in high-power energy-storage systems. However, the high manufacturing cost due to expensive ...



### [Improved energy storage properties achieved in ...](#)

With the increase in environment protection requirements and the development of pulse-power technology, environmentally friendly antiferroelectric materials ...

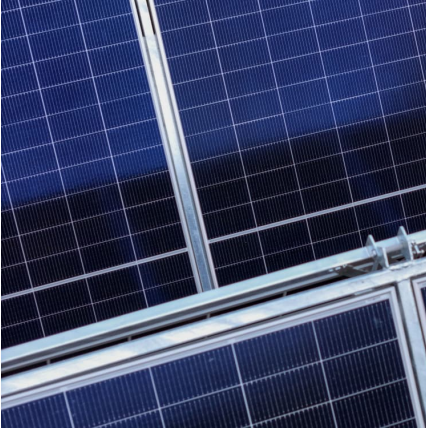
### Designing lead-free antiferroelectrics for energy storage

Antiferroelectric capacitors hold great promise for high-power energy storage. Here, through a first-principles-based computational approach, authors find high theoretical ...



### [Enhanced Energy Storage Properties of the Relaxor ...](#)

In this work, we introduce a high entropy effect in designing a relaxor ferroelectric (RFE)-antiferroelectric (AFE) crossover ceramic by ...



### **Synergistic optimization strategy enhanced the energy storage**

Due to the continuous popularization of electronic facilities and the increasing requirements for the green environment, the development of lead-free ceramics is more in line ...



### **Utilizing ferrorestorable polarization in energy-storage ceramic**

Ceramic capacitors are promising candidates for energy storage components because of their stability and fast charge/discharge capabilities.

### Ultrahigh Energy Storage Density and Efficiency

Energy storage systems are crucial in modern technology, especially for electric vehicles and photovoltaic systems that demand superior ...





### **Superior energy storage performances in AgNbO<sub>3</sub>-based ...**

However, from a practical application perspective, addressing the challenges of insufficient energy storage density ( $W_{rec}$ ) and efficiency ( $\eta$ ) of AN is essential. In this study, ...

### **Optimizing energy storage performance of lead zirconate-based**

Abstract Dielectric energy storage has gained considerable significance owing to the high energy requirements of human society. Lead zirconate-based (PZ) antiferroelectric ...



### **Superior Temperature Sensing and Capacitive Energy-Storage ...**

Abstract The ultrafast charge/discharge rate and high power density (PD) endow lead-free dielectric energy storage ceramics (LDESCs) with enormous application potential in electric ...

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