Antiferroelectric energy storage density

Are antiferroelectrics a promising material with high energy density?
Continued efforts are being devoted to find materials with high energy density,and antiferroelectrics (AFEs) are promisingbecause of their characteristic polarization-electric field (P - E) double hysteresis loops schematized in Fig. 1a (ref. 4).

What are the advantages of antiferroelectric materials for energy storage?
Among numerous dielectric materials for energy storage application,the antiferroelectric (AFE) materials exhibit exceptional benefits compared to other dielectric categories,such as linear dielectric and ferroelectrics,due to the unique double polarization-electric field (P - E) loop with high Pm and low Pr[9].

Why do antiferroelectric ceramics have high energy storage performance?
It is obvious from the equation that obtaining high energy storage performance requires the lowest possible Pr and the highest possible Pm with E. Antiferroelectric (AFE) ceramics possess high Pm and almost zero Pr due to the electric field-induced phase transition(AFE-FE) resulting in unique double hysteresis ,,.

Are antiferroelectric capacitors good 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 energy densities in rare earth substituted bismuth ferrite,and propose a simple model to assess the storage properties of a general antiferroelectric material.

What is the WREC of antiferroelectric multilayer ceramics?
Fu et al. developed the (Pb 0.97 La 0.02) (Zr 0.5 Sn 0.4 Ti 0.1)O 3 AFE ceramics and studied the phase transition behavior and energy storage properties,realizing the Wrec of 2.38 J/cm 3with the i of 65.5 % . Yang et al. reported a Wrec of 9.4 J/cm 3 with i of 86.5 % in PBLZST/PCLZST antiferroelectric multilayer ceramics at 278 kV/cm .

How to modulate antiferroelectric-like properties?
Inspired by the above properties, a strategy is proposed to modulate antiferroelectric-like properties via introducing Ca 0.7 La 0.2 TiO 3 (CLT) into Bi 0.395 Na 0.325 Sr 0.245 TiO 3 (BNST) ((1- x)BNST- x CLT, x = 0.10, 0.15, 0.20, 0.25).

Moreover, the recoverable energy density was 10.8 J/cm 3 at 600 kV/cm, which is 42% higher than that of the pure PZO films. The results demonstrate that adding an appropriate amount of noble metal NPs in antiferroelectric thin films is an effective method to improve the energy storage properties.

Lead-free dielectric ceramics with high recoverable energy density are highly desired to sustainably meet the future energy demand. AgNbO3-based lead-free antiferroelectric ceramics with double ferroelectric hysteresis loops have been proved to be potential candidates for energy storage applications. Enhanced energy storage performance with recoverable ...

It can be seen that the energy storage density and BDS of this work are superior to previous works and have great potential to become environmentally friendly materials. ... Novel $(1-x)NaNbO_3-xBi_{2/3}HfO_3$ based, lead-free compositions with stable antiferroelectric phase and high energy density and switching field. Chem. Eng. J., 457 (2023 ...

Antiferroelectrics (AFEs) are promising candidates in energy-storage capacitors, electrocaloric solid-cooling, and displacement transducers. As an actively studied lead-free antiferroelectric (AFE ...

The $NaNbO_3$ antiferroelectrics have been considered as a potential candidate for dielectric capacitors applications. However, the high-electric-field-unstable antiferroelectric phase resulted in low energy storage density and efficiency. Herein, good energy storage properties were realized in $(1-x)NaNbO_3-xNaTaO_3$ ceramics, by building a new phase boundary.

The enhanced energy storage density of 28.2 J/cm^3 at 2410 kV/cm has been achieved in $PbZrO_3/PbZr_{0.52}Ti_{0.48}O_3$ bilayer film at 20°C, which is higher than that of individual $PbZr_{0.52}Ti_{0.48}O_3$ film (15.6 J/cm^3).

As a result, the nanocomposite films exhibited an impressive discharged energy density of 18.2 J/cm^3 along with a remarkably enhanced energy storage efficiency of 70 % near the high electrical breakdown strength of 594.7 MV/m when the fillers content was 3 wt%, which was far surpassed the pristine PVDF (U_d = 5.34 J/cm^3 and i = 51.8 % ...

Antiferroelectric (AFE) HfO_2/ZrO_2-based thin films have recently emerged as a potential candidate for high-performance energy storage capacitors in miniaturized power electronics.However, the materials suffer from the issues of the trade-off between energy storage density (ESD) and efficiency, as well as the difficulty in scaling up of the film thickness.

Dielectric capacitors have attracted extensive attention due to their high power density along with fast charge/discharge rate. Despite the high energy storage performance were obtained in lead-based ceramics, we still need to find lead-free ceramic alternatives considering the environmental requirements, and $AgNbO_3$ has received extensive attention owing to its ...

[1, 4-8] Recent studies focused on the enhancement of the energy-storage density of dielectric thin-film capacitors by using advanced materials and novel device architectures, [9, 10] employing also ferroelectric (FE), antiferroelectric (AFE), or relaxor-ferroelectric (RFE) materials.

Antiferroelectric (AFE) materials exhibit outstanding advantages against linear or ferroelectric (FE) dielectrics in high-performance energy-storage capacitors. However, their ...

Though prolonged efforts in this area have led to certain progress and the discovery of more than 100 antiferroelectric materials over the last 70 years, some scientific and technological issues remain unresolved. ... For instance, an ultrahigh recoverable energy-storage density of >10 J/cm 3 and energy efficiency of >80% were achieved in ...

High energy storage density in NaNbO 3 antiferroelectrics with double hysteresis loop. Author links open overlay panel Li Ma a b 1, Zhenpei Chen a 1, Gengguang Luo a 1, ... An unconventional transient phase with cycloidal order of polarization in energy-storage antiferroelectric PbZrO 3. Adv Mater, 32 (9) (2020), Article 1907208. View in Scopus ...

PbZrO3-based antiferroelectric (AFE) ceramic materials have emerged as potential candidates for the next generation of high-energy multilayer ceramic capacitors (MLCCs) because of their distinctive characteristics of double hysteresis loops. The energy storage efficiency of orthorhombic AFE ceramics with ultrahigh storage density is relatively low, which ...

The inset in (e) shows the energy storage density (W s, J cm -3), ... X. K. et al. An unconventional transient phase with cycloidal order of polarization in energy-storage antiferroelectric PbZrO 3.

Antiferroelectric (AFE) materials serve as the crucial ingredients used for dielectric capacitors, solid-state refrigeration and energy storage devices 1,2,3.The unique characteristic of AFEs is ...

The increasing need for energy storage devices is rapidly expanding with the development of modern electrical technologies. Dielectric capacitors have garnered considerable interest due to their ultrahigh energy storage power density and fast charge/discharge rate. 1-3 The main parameters for evaluating the performance of dielectric capacitors include energy ...

Antiferroelectric (AFE) ceramic materials possess ultrahigh energy storage density due to their unique double hysteresis characteristics, and PbZrO 3 is one of the promising systems, but previous materials still suffer from the problem that energy storage density and energy storage efficiency can hardly be improved synergistically. In this work, a multiple ...

Dielectric capacitors with high power density and excellent temperature stability are highly demanded in pulsed power systems. AgNbO 3-based lead-free antiferroelectric ceramics have been proven to be a promising candidate for energy storage applications.Nevertheless, the recoverable energy storage density (W rec) still needs to be further improved to meet the ...

The saturation polarization strength and the energy storage density increased with increasing Zr content, reaching peak value of 36 mC/cm2 and 9.5 J/cm3 at 0.49 and 0.55, respectively, and then decreased with a further increase of the Zr content. ... Yang T, Zhang S (2019) Ultrahigh energy-storage density in antiferroelectric ceramics with ...

Using a three-pronged approach -- spanning field-driven negative capacitance stabilization to increase intrinsic energy storage, antiferroelectric superlattice engineering to ...

Besides, a new lead-free relaxor AFE ceramic of 0.76NaNbO 3-0.24(Bi 0.5 Na 0.5)TiO 3 has reached a high energy-storage density of 12.2 J/cm 3 with high BDS and high P max [31]. These materials with high energy-storage density own certain parameters that help for energy-storage density, such as high e, high P max, low DE, high switching field ...

Among them, AgNbO 3-based ceramics present excellent energy storage performance and have achieved great improvement recently. In 2016, the energy-storage performance of the pristine AgNbO 3 ceramics with a W rec of 2.1 J/cm 3 was firstly reported [15]. In 2017, a high W rec up to 4.2 J/cm 3 was achieved in Ag(Nb,Ta)O 3 ceramic [16].

In this work, we show that the stability of antiferroelectric characteristics can be significantly improved by chemical co-substitution with Sm 3+ and Ta 5+ ions in the A- and B-site, respectively. As a consequence, a remarkably improved energy storage density up to 4.87 J cm -3 was achieved in (Sm 0.02 Ag 0.94)(Nb 0.9 Ta 0.1) ...

AgNbO 3-based antiferroelectric ceramics can be used to prepare dielectric ceramic materials with energy storage performance.However, their efficiency is much lower than that of relaxors, which is one of the biggest obstacles for their applications. To overcome this problem, AgNbO 3 ceramics co-doped with Eu 3+ and Ta 5+ at the A- and B-sites were prepared in this work.

The utilization of antiferroelectric (AFE) materials is commonly believed as an effective strategy to improve the energy-storage density of multilayer ceramic capacitors (MLCCs). Unfortunately, the inferior energy conversion efficiency (i) leads to high energy dissipation, which severely restricts the broader applications of MLCCs due to the ...

With an ever increasing dependence on electrical energy for powering modern equipment and electronics, research is focused on the development of efficient methods for the generation, storage and distribution of electrical power. In this regard, the development of suitable dielectric based solid-state capacitors will play a key role in revolutionizing modern day ...

Energy storage materials and their applications have long been areas of intense research interest for both the academic and industry communities. Dielectric capacitors using antiferroelectric materials are capable of displaying higher energy densities as well as higher power/charge release densities by comparison with their ferroelectric and linear dielectric ...

Similar to PbZrO 3 (PZ) AFEs, PbHfO 3 (PH) was also belonging to the ABO 3 perovskite structure. The PH-based AFEs are new AFE energy storage materials discovered in recent years. PH has two temperature-induced phase transitions: antiferroelectric phase (AFE1) with orthorhombic (Pbam) symmetry to intermediate antiferroelectric phase (AFE2) at 433 K ...

In addition, an ultrahigh energy storage density of 12.2 J cm -3 was achieved in (Bi 0.5 Na 0.5)TiO 3-NaNbO 3 ceramics, where the relaxor component (Bi 0.5 Na 0.5)TiO 3 was added into NaNbO 3 ...

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