

Can ferroelectric materials be used for energy harvesting and sensing?

Ferroelectric materials have attracted significant interest due to their wide potential in energy harvesting, sensing, storage, and catalytic applications. For monolithic and dense ferroelectric materials, their performance figures of merit for energy harvesting and sensing are limited by their high relative

Why is ferroelectrics a promising energy storage material?

Due to its properties of high energy density, wide operating temperature range T , quick charge-discharge ability and extended active life t , ferroelectrics is a kind of prospective and promising energy storage material [7, 8, 9, 10, 11, 12, 13].

What is a ferroelectric element in a high power system?

The ferroelectric element of a high power system is a source of prime electrical energy, and also it is a high-voltage/high-current generator, and a non-linear dielectric capacitive energy storage unit that become a part of the load circuit during operation of the system.

Are defects in ferroelectric materials important?

While defects within ferroelectric materials may introduce complexities, including potential material aging and impacts on structural, phase transition, and polar ordering, the strategic incorporation of specific defects may lead to unforeseen advantages.

How can energy storage and conversion be realized in ferroelectrics?

Scientific Reports 15, Article number: 7446 (2025) Cite this article The energy storage and conversion in ferroelectrics can be realized through the microstructures of polar domains and domain walls, which resulting in the transformations from macro/microdomains to nanodomains or forming complex polar topologies.

What are the applications of porous ferroelectric materials?

Applications of porous ferroelectric materials in specific fields are then summarized. Finally, conclusions and future perspectives for porous ferroelectric materials are provided. Ferroelectric materials have attracted significant interest due to their wide potential in energy harvesting, sensing, storage, and catalytic applications.

BiFeO_3 -based lead-free ferroelectric is considered a potential candidate for energy storage applications owing to its high spontaneous polarization. To tackle the compromise between high polarization and energy storage density, NaNbO_3 (NN) was introduced into $0.7\text{BiFeO}_3\text{-}0.3\text{Ba}(\text{Hf}_{0.05}\text{Ti}_{0.95})\text{O}_3$ (BF-BHfT) ceramics, where Nb^{5+} ions enter the BF ...

In the present work, the synergistic combination of mechanical bending and defect dipole engineering is demonstrated to significantly enhance the energy storage performance of freestanding ferroelectric thin films, ...

Porous non-polar polymers that exhibit ferroelectric-like behaviour when subjected to a high electric field can be classified as ferroelectret materials [1]. Ferroelectrets are a class of piezoelectrically-active polymer foam whereby a gas, such as air, within a macro-sized pore space (typically $> 1 \mu\text{m}$) can be subject to electrical breakdown during the application of a high ...

Electrochemical energy storage systems with high efficiency of storage and conversion are crucial for renewable intermittent energy such as wind and solar. [[1], [2], [3]] ...

1 Introduction. It is well known that the study of ferroelectric (FE) materials starts from Rochelle salt, $\text{KNaC}_4\text{H}_4\text{O}_6 \cdot 4\text{H}_2\text{O}$ (potassium sodium tartrate tetrahydrate), [1] which is the first compound discovered by ...

In recent years, dielectric capacitors with high energy storage density have been developed. They include linear dielectrics (LD), ferroelectrics (FE), relaxor ferroelectrics (RFE) and antiferroelectrics (AFE), among which RFE and AFE are outstanding candidates for dielectric capacitors due to their high energy storage density [14]. Lead based ferroelectric materials ...

Ceramic-based dielectrics have been widely used in pulsed power capacitors owing to their good mechanical and thermal properties. $\text{Bi}_{0.5}\text{Na}_{0.5}\text{TiO}_3$ -based (NBT-based) solid solutions exhibit relatively high polarization, which is considered as a promising dielectric energy storage material. However, the high remnant polarization and low energy efficiency limit ...

Due to high power density, fast charge/discharge speed, and high reliability, dielectric capacitors are widely used in pulsed power systems and power electronic systems. However, compared with other energy storage devices such as batteries and supercapacitors, the energy storage density of dielectric capacitors is low, which results in the huge system volume when applied in pulse ...

energy storage efficiency is considered one of the most important indicators of ferroelectric energy storage ceramics, which is why relaxor ferroelectric ceramics are attracting increasingly more attention in applications of energy storage devices. 20-25 Such energy storage densities can be easily calculated from electric hysteresis loops.

Next-generation advanced high/pulsed power capacitors rely heavily on dielectric ceramics with high energy storage performance. Although high entropy relaxor ferroelectric exhibited enormous ...

Dielectric capacitors have been widely studied because their electrostatic storage capacity is enormous, and they can deliver the stored energy in a very short time. Relaxor ferroelectrics-based dielectric capacitors have ...

To deep understand and optimally design the energy storage properties of dielectrics with the ferroelectric

nano-to-macro structural transformation and nano vortex ...

The energy storage density was calculated according to the polarization-electric field hysteresis loops, which were characterized by a Radiant Precision Premier LC ferroelectric material test system (Radiant Technologies Inc, USA) at 10 Hz. All the samples were immersed in silicone oil to avoid surface flashover in the process.

Dielectric constant (K) and breakdown field strength (E_b) are the two key parameters determining the energy density of dielectric materials [13]. For linear dielectrics (e.g., polypropylene), the stored energy density is proportional to K and scales quadratically with the applied electric field. The U_d of BOPP is limited by the low K (~ 2.2), despite the high E_b (700 ...

Among the well-known lead-free ceramic dielectric materials, $\text{Sr}_{0.7}\text{Bi}_{0.2}\text{TiO}_3$ (SBT) is a typical relaxor component. It combines the advantages of low loss and P_r of linear dielectrics with a high dielectric constant and maximum polarization strength, making it a promising energy storage material. However, it exhibits a significant charge imbalance [11]. K ...

Although NaNbO_3 -based antiferroelectric ceramic is considered as a potential lead-free energy storage material, the field-driven antiferroelectric-ferroelectric phase transition greatly hinders its energy storage performance. Here the strategy of synergetic phase-structure construction and relaxation regulation is proposed to solve this issue. The strategy is conducted via A/B-site ...

Ferroic materials have been of great importance in the latest several decades due to great application potential in extensive applications. By fabricating the ferroelectrics to different scales, the ferroelectric-based devices can be used in different fields such as transportation, pulsed power application, oil exploration, advanced wearable devices and integrated circuit, as ...

The optimal energy storage density of 1.39 J/cm^3 with an energy storage efficiency of 78.3% was obtained at $x = 6$ due to high maximum polarization and enhanced breakdown strength. The results demonstrate that ...

a, P-E loops in dielectrics with linear, relaxor ferroelectric and high-entropy superparaelectric phases, the recoverable energy density U_d of which are indicated by the grey, light blue and ...

The limited energy storage performance of dielectric capacitors constrains their utilization in the realm of pulsed power system. In this contribution, the $(1-x)\text{Bi}_{0.5}\text{Na}_{0.5}\text{TiO}_{3-x}\text{SrTiO}_3$ (BNT- x ST) solid-solution thin films were prepared on FTO glass substrates using a facile sol-gel method to address this issue. The effects of composition on phase structure, ...

What interests us is that the permanent dipole of ferroelectric ceramic materials, as a stronger Lewis acid-base than the constituent atoms of non-ferroelectric materials [33], [34], [35], can promote the dissociation of lithium salts. In addition, the built-in electric field generated by spontaneous polarization is expected to facilitate

Li + ion transport and subsequently improve ...

The PbZrO₃-based antiferroelectric films are one of the most promising materials because of their superior electrical property and dipole dynamic regarding to the pulse power system and technology [[1], [2], [3]]. For dielectric-type energy storage material, it is rather critical to enhance the polarization intensity and endurance of electric field to improve the energy ...

In the past, most researchers analyzed energy storage performance of ferroelectric materials through P-E loops. In this paper, combining P-E loops, I-E curves and Raman ...

Ferroelectric materials have attracted significant interest due to their wide potential in energy harvesting, sensing, storage, and catalytic applications. For monolithic and dense ferroelectric materials, their performance figures of merit ...

P(VDF-HFP), a ferroelectric copolymer of PVDF, is renowned for its exceptional polarization capacity, making it a preferred material in energy storage polymers. However, its low breakdown strength ...

The mainstream dielectric capacitors available for energy storage applications today include ceramics, polymers, ceramic-polymer composites, and thin films [[18], [19], [20]]. Among them, dielectric thin films have an energy storage density of up to 100 J/cm³, which is due to their breakdown field strength typically exceeding 500 kV/mm. The ability to achieve ...

An atomistic effective Hamiltonian technique is used to investigate the finite-temperature energy storage properties of a ferroelectric nanocomposite consisting of an array ...

Ferroelectric Materials for Energy Harvesting and Storage is the first book to bring together fundamental mechanisms for harvesting various abundant energy sources using ferroelectric and piezoelectric materials. The authors discuss strategies of designing materials for efficiently harvesting energy sources like solar, wind, wave, temperature ...

In the past years, several efforts have been devoted to improving the energy storage performance of known antiferroelectrics. Polymers and ceramic/polymer composites can present high breakdown fields but store ...

In this work, we propose a novel method to prepare high energy density, thickness-scalable ferroelectric film capacitors on Si, using a simple perovskite of BaTiO₃ at a low processing temperature of 350 °C. This is achieved by using an in-situ grown, (100)-textured template layer of conductive perovskite LaNiO₃, which promotes a conformal sputter-growth ...

The improvement in energy storage performance of ferroelectric (FE) materials requires both high electric breakdown strength and significant polarization change. The phase-field method can couple the

multi-physics-field factors. It can realize the simulation of electric breakdown and ...

Volume 45, Issue 6, June 2025, 117219. Dielectric, ferroelectric, and energy storage properties of BNBTA-xSLZT lead-free ceramics. Author links open overlay panel Han-li Lian a, ... which can be used as one candidate for capacitor energy storage ...

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