

Which lead-free bulk ceramics are suitable for electrical energy storage applications?

Here, we present an overview on the current state-of-the-art lead-free bulk ceramics for electrical energy storage applications, including SrTiO₃, CaTiO₃, BaTiO₃, (Bi_{0.5} Na_{0.5})TiO₃, (K_{0.5} Na_{0.5})NbO₃, BiFeO₃, AgNbO₃ and NaNbO₃-based ceramics.

Why do we need lead-free ceramics?

Owing to the current global scenario of environmental pollution and the energy crisis, the development of new dielectrics using lead-free ceramics for application in advanced electronic and energy storage systems is essential because of the high power density and excellent stability of such ceramics.

Does lead-free bulk ceramics have ultrahigh energy storage density?

Significantly, the ultrahigh comprehensive performance ($W_{rec} \sim 10.06 \text{ J cm}^{-3}$ with $\eta \sim 90.8\%$) is realized in lead-free bulk ceramics, showing that the bottleneck of ultrahigh energy storage density ($W_{rec} \geq 10 \text{ J cm}^{-3}$) with ultrahigh efficiency ($\eta \geq 90\%$) simultaneously in lead-free bulk ceramics has been broken through.

Are lead-free anti-ferroelectric ceramics suitable for energy storage applications?

At present, the development of lead-free anti-ferroelectric ceramics for energy storage applications is focused on the AgNbO₃ (AN) and NaNbO₃ (NN) systems. The energy storage properties of AN and NN-based lead-free ceramics in representative previous reports are summarized in Table 6.

How stable is energy storage performance for lead-free ceramics?

Despite some attention has been paid to the thermal stability, cycling stability and frequency stability of energy storage performance for lead-free ceramics in recent years, the values of W_{rec} , cycle numbers and frequency are often less than 5 J cm^{-3} , 10^6 , and 1 kHz , respectively.

How can BT-based lead-free ceramics improve energy storage performance?

To better optimize the energy storage performance of BT-based lead-free ceramics, B. Liu et al. coated BT with Al₂O₃ and SiO₂ using the chemical coating method and reduced the average grain size below 200 nm. This led to improved breakdown strength (190 kV cm^{-1}) and enhanced energy storage density (0.725 J cm^{-3}). Q.

Both large maximum polarization and high applied electric field can be achieved in lead-free ceramics via layered structure optimization strategy, resulting in ultrahigh recoverable energy storage de...

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Early dielectric capacitors (capacitors for short) are based on the dielectrics such as wax-impregnated paper and mica. Currently, commercially available solid-state capacitors ...

At present, the application of dielectric energy-storage ceramics is hindered by their low energy density and the fact that most of them contain elemental lead. Therefore, lead ...

Fig. 6 (e) illustrates the energy storage performance of BT, NN, KNN, BNT, and BFO-based lead-free energy storage ceramics reported in recent years (further information is ...

In this review, we present perspectives and challenges for lead-free energy-storage MLCCs. Initially, the energy-storage mechanism and device characterization are introduced; then, dielectric ceramics for energy ...

However, relatively low recoverable energy storage density (W_{rec}) or energy storage efficiency (?) of lead-free ceramic capacitors severely narrow their application areas ...