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Influence of BaSnO₃ additive on the energy storage properties of Na_{0.5}Bi_{0.5}TiO₃-based relaxor ferroelectrics

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Abstract: (1- x)NBT- x BSN ($0.1 \leq x \leq 0.35$) ceramics were prepared by solid state methods and their energy storage properties and high-temperature capacitor applications were systematically investigated. All samples showed a perovskite structure and the structure transformed to lower symmetry orthorhombic phase ($x \geq 0.1$) from rhombohedral phase ($x < 0.1$) to with the addition of BSN. The more addition content of BSN significantly decreases phase transition temperature T_m of NBT ceramics. The $x=0.25$ sample exhibits a stable relative permittivity of $1605 \pm 15\%$ in a broad temperature range of 38 °C to 319 °C. With increasing BSN concentration, the slope of the P - E loops and the energy loss gradually decreases. When $x=0.25$, a high breakdown strength of 190 kV/cm and the maximum discharge energy density of 1.91 J/cm³ were obtained, of which the energy efficiency was as high as 86.4%. Thus, it was believed that our work could provide a significant guidance for designing the new system for energy storage.

Keywords: solid state reaction; relaxor behavior; energy density; lead-free

Introduction

Capacitors play a key role in most power electronics used to deliver very large amounts of energy in a very short time. The exploration of high energy storage density dielectric materials has become a research hotspot recently, mainly driven by the increasing demands for miniaturization of power electronics [1]. Generally, lead-contained dielectric materials have larger energy storage density [2-4]. However, increasing environmental awareness will limit the use of this material. Therefore, it is necessary to develop lead-free materials with high energy storage density [5-7].

Recently, advances in high-energy-density dielectrics have focused on Na_{0.5}Bi_{0.5}TiO₃ (NBT) based relaxor ferroelectrics because of the high maximum polarization ($P_m=43 \mu\text{C}/\text{cm}^2$) under its dielectric breakdown strength (E_b) of 12 kV/mm, low sintering temperature (~ 1100 °C) [8]. However,

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