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Improved temperature stability and high piezoelectricity in lead-free barium titanate-based ceramics

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Abstract

To achieve high piezoelectricity and the corresponding good temperature stability of $BaTiO_3$ (BT) ceramics, a new system of $(1\text{-}x\text{-}y)BaTiO_3$–$yCaTiO_3$–$x(BaZr_{1-z}Hf_z)O_3$ (BT-yCT-xBZH$_z$) was designed. The O-T phase boundary was observed at $0.065 \leq x \leq 0.085$, $0.08 \leq y \leq 0.12$ and $0 \leq z \leq 1.0$ near room temperature. Due to the O-T phase boundary, the enhancement of electrical properties (d_{33}=500 pC/N, k_p=0.52, P_r=14.0 μC/cm^2 and ε_r=2800), large strain (~0.23%) and d_{33}^*=1100 pm/V (10 kV/cm) can be obtained. Moreover, temperature-dependent electrical properties were investigated in detail, and a reliable performance was realized due to high T_C (>100 °C). The d_{33}^* was demonstrated to be temperature-insensitive from 16 °C to 60 °C (varying less than 7%), which is superior to the reported BT-based ceramics. Besides, d_{33} and P_r fluctuate less than 22% in this temperature range, also showing an usable stability. We believe that this work can be beneficial to facilitate an increasing adoption of lead-free BT-based piezoceramics for practical applications.

Keywords: Barium titanate; Phase boundary; High Curie temperature; Temperature stability; Electrical properties