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High Piezoelectric and Magnetic Performance Achieved in the Lead-free BiFeO3-BaTiO3 Cceramics by Defect Engineering

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Abstract : Defect engineering approach is a well-established approach for the customization of functional properties of perovskite ceramics. In modern technology, the high multiferroic properties for elevated temperature applications are greatly demanding. In this work, the Bi-nonstoichiometric lead-free 0.67Biy-xSmxFeO3-0.33BaTiO3 ceramics (Sm-doped BF-BT for Bi-excess; y = 1.03 and Bi-deficient; y = 0.975 with x = 0.00, 0.04 and 0.08) were design for the high-temperature multiferroic property. Enhanced piezoelectric (d33 ~ 250 pC/N and d33* ~350 pm/V) and magnetic properties (Mr ~ 0.25 emu/g) with a high Curie temperature (TC ~ 465 ℃) were obtained in the Bi-deficient pure BF-BT ceramics. With Sm-doping (x = 0.04), the TC decrease to ~350 ℃ a significant improvement occurred in the d33* to 504 pm/V and 450 pm/V for Bi-excess and Bi-deficient compositions, respectively. The structural origin of the enhanced piezoelectric strain performance is related to the soft ferroelectric effect by Sm-doping and reversible phase transition from the short-range relaxor ferroelectric state to the long-range order under the applied electric field. However, a slight change occurs in the Mr ~0.28 emu/g value with Sm-doping for Bi-deficient ceramics, whereas the Bi-excess ceramics shows completely paramagnetic behavior. Hence, the origin of high magnetic properties in the Bi-deficient BF-BT ceramics is mainly attributed to the proposed double exchange mechanism. We believe that this strategy will provide a new perspective for the development of lead-free multiferroic ceramics for high-temperature applications.

Keywords : BiFeO3-BaTiO3, lead-free piezoceramics, magnetic properties, defect engineering
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