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Enhanced piezoelectric properties and fatigue-free behavior of lead-free piezoelectric xBaZrO3-(0.85-x)BaTiO3-0.15CaTiO3 ceramics

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Lead-free xBaZrO3-(0.85-x)BaTiO3-0.15CaTiO3; x = 0.00-0.20 (xBZ) ceramics were successfully prepared using the conventional solid-state reaction method. X-ray diffraction data showed a pure-phase perovskite structure for compositions up to $x < 0.200$. At room temperature, x-ray diffraction patterns of ceramics with the composition range of $0.00 \leq x < 0.10$ possess tetragonal structure. Mixed-phase coexistence of tetragonal and rhombohedral phases were found at $0.10 \leq x \leq 0.15$ and transformed to cubic for $x > 0.125$ according to the lowered Curie temperature. Raman scattering showed mixed phases of tetragonal and orthorhombic phases. Temperature-dependent dielectric data shows anomaly phase transitions determined by composition changes. Phase diagram was provided according to temperature-dependent dielectric data. Compositions near composition-induced phase transition provided enhanced ferroelectric and piezoelectric properties. Unipolar electric field induced strain of $x = 0.125$ ceramic shows surprisingly high longitudinal piezoelectric coefficient (d_{33}^*) of 2244 pm/V at relatively low electric field of 5 kV/cm. Fatigue measurement carried out on the morphotropic phase boundary composition showed a small degradation in maximum strain after 106 cycles using an applied field of 20 kV/cm at 10 Hz.

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