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Non-equivalent Ionic Dopants and Their Impacts on Properties of Potassium Sodium Niobate-based Lead-free Ceramics

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Abstract: In the work, $(1-x)(\text{K}_{0.48}\text{Na}_{0.52})(\text{Nb}_{0.96}\text{Sb}_{0.04})\text{O}_3-x(\text{Bi}_{0.5}\text{K}_{0.5})_{0.7}\text{Ca}_{0.3}\text{ZrO}_3$ [(1-x)KNNS-xBKCZ] lead-free piezoceramics are prepared to investigate location and associated impacts of non-equivalent ionic dopants on phase transition and property enhancement. Results of XRD refinement and analysis of transmission electron microscopes (TEM) strongly prove that Rhombohedral-Tetragonal (R-O-T) phase coexistence for $0 \leq x \leq 0.04$. According to lattice parameters, R phase should be ascribed to lattice deformation subjected to shear stress owing to the cooperation of multiple ionic dopants in A sites and B sites. Based on the variation of temperature-dependent capacitances with the frequencies and atomic-resolution HR-O-TEM image, much more oxygen vacancies are investigated because of major substitution of Ca^{2+} in B site, which leads to an obvious decrease of T_C in (1-x)KNNS-xBKCZ besides c/a of O phase. Additionally, domain wall motion is demonstrated to become easier through calculating intrinsic piezoelectric response using Rayleigh law and consequently, piezoelectric properties of (1-x)KNNS-xBKCZ are greatly enhanced ($d_{33} \sim 440$ pC/N and $d^*_{33} \sim 500$ pm/V) in R-O-T phase coexistence region.

Keywords: Piezoelectric materials; Lead-free ceramics; Dopants; Electrical properties; Curie temperature

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