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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*)($K_{0.48}Na_{0.52}$)($Nb_{0.96}Sb_{0.04}$)O_3-*x*($Bi_{0.5}K_{0.5}$)$_{0.7}Ca_{0.3}ZrO_3$ [(1-*x*)KNNS–*x*BKCZ] 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–*x*BKCZ 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–*x*BKCZ are greatly enhanced (d_{33}~440 pC/N and d^*_{33}~500 pm/V) in R-O-T phase coexistence region.

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