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Structural evolution and dopant occupancy preference of yttrium-doped potassium sodium niobate thin films

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Abstract

Sodium potassium niobate (KNN) is the most promising candidate for lead-free piezoelectric material, owing to its high Curie temperature and piezoelectric coefficients among the non-lead piezoelectric. Numerous studies have been carried out to enhance piezoelectric properties of KNN through composition design. This research studied the effects of yttrium concentrations and lattice site occupancy preference in KNN films. For this research, the yttrium-doped KNN thin films (mol% = 0, 0.1, 0.3, 0.5, 0.7 and 0.9) were fabricated using the sol-gel spin coating technique and had revealed the orthorhombic perovskite structures. Based on the replacement of Y³⁺ ions for K⁺/Na⁺ ions, it was found that the films doped with 0.1 to 0.5 mol% of yttrium had less lattice strain, while films with more than 0.5 mol% of Y³⁺ ions had increased strain due to the tendency of Y³⁺ to occupy the B-site in the perovskite lattice. Furthermore, by analysing the vibrational attributes of octahedron bonding, the dopant occupancy at A-site and B-site lattices could be identified. O-Nb-O bonding was asymmetric and became distorted due to the B-site occupancy of yttrium dopants at high dopant concentrations of > 0.5 mol%. Extra conduction electrons had resulted in better resistivity of 2.153x 10(6) Omega at 0.5 mol%, while higher resistivity was recorded for films prepared with higher concentration of more than 0.5 mol%. The introduction of Y³⁺ improved the grain distribution of KNN structure. Further investigations indicated that yttrium enhances the surface smoothness of the films. However, at high concentrations (0.9 mol%), the yttrium increases the roughness of the surface. Within the studied range of Y³⁺ (.), the film with 0.5 mol% Y³⁺ represented a relatively desirable improvement in dielectric loss, tan delta and quality factor, Q(m.).

Keywords

Author Keywords: KNN; Yttrium; Thin film; Doped; Structural; Lattice; Occupancy

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