INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title:		Preparation and characterization of lead free $(K_{0.5}Na_{0.5})$ NbO_3 ferroelectric bulk and thin films
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SHORT ABSTRACT

This thesis reports the successful synthesis of pure and rare-earth oxides (Dy_2O_3 and Gd_2O_3) contained KNN ceramics using conventional solid state reaction method. The effect of calcination and sintering temperatures on structural, microstructural, dielectric and ferroelectric properties has been investigated. The KNN ceramics were calcined at 700 ^oC and sintered at 1050 ^oC exhibited the orthorhombic structure with good dielectric properties (ε_r = 577, $tan\delta$ = 0.05 at 1MHz) and ferroelectric properties ($2P_r$ = 19.09 μC/cm^2 and $2E_c$ = 21.95 kV/cm). The KNN + 1.0 wt.% Gd_2O_3 (KNN1G) ceramics displayed the better dielectric (ε_r = 1112, $tan\delta$ = 0.03 at 1MHz) and ferroelectric ($2P_r$ = 31.46 μC/cm^2 and $2E_c$ =15.23 kV/cm) properties. The KNN + 0.5 wt.% Dy_2O_3 (KNN05D) ceramics also shown the improved electrical properties (ε_r = 677, $tan\delta$ = 0.01 at 1MHz, $2P_r$ = 27.36 μC/cm^2 and $2E_c$ =15.46 kV/cm) as compared to pure KNN ceramics. The relaxor behaviour in the KNN based ceramics was analyzed using Vogel-Fulcher law and modified Curie-Weiss law. The temperature dependent AC-conductivity was analyzed using variable range hopping model. The optimized compositions of pure KNN, KNN05D, and KNN1G ceramics were chosen to make the target for the deposition of thin films by RF magnetron sputtering method under different oxygen mixing percentages (OMP). The effect of OMP on structural, microstructural, optical and dielectric properties of the films studied systematically. The films deposited under pure oxygen plasma are highly oriented in (001) crystallographic direction and exhibited the higher tetragonality ratio and uniform grain size. The higher refractive index n_{700} = 2.21 obtained for KNN05D thin film as compared to KNN1G (2.19) and KNN (2.07) thin films, whereas the lower bandgap obtained for the KNN1G film (4.20 *eV*) as compared to KNN05D (4.28 *eV*) and KNN (4.29 *eV*) films deposited under pure oxygen plasma. The dispersion in the refractive index was analyzed using Wemple - DiDomenico single-oscillator model. The KNN05D thin films exhibited the larger values of nonlinear refractive index (n_2 = 7.04×10^{-6} cm^2/W), nonlinear absorption (β_{eff} = 1.70 cm/W), and third order nonlinear susceptibility ($|\chi^{(3)}|$ = 1.40×10^{-3} esu), whereas KNN1G films also displayed the larger values of n_2 = 2.46×10^{-5} cm^2/W, β_{eff} = 5.07 cm/W and $|\chi^{(3)}|$ = 4.41×10^{-3} esu for the films deposited under pure oxygen plasma. The KNN05D films exhibited the better dielectric properties at low frequencies (ε_r = 343 and $tan\delta$ = 0.045 @ 1MHz) as well as at microwave frequencies (ε_r = 307 and $tan\delta$ = 0.014 @ 10 GHz), which is attributed to the higher tetragonality ratio. The obtained results indicate that the rare-earth oxide contained KNN ceramics and thin films have the applications in nonlinear photonic and microwave tunable device applications.