

Effect of Bi₄Zr₃O₁₂ on the properties of (K_xNa_{1-x})NbO₃ based ceramics

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Abstract. KNN-based ceramics modified with small amounts of Bi₄Zr₃O₁₂ (BiZ) has been synthesized using high-throughput experimentation (HTE). The results from X-ray diffraction show that for samples with base composition (K_{0.5}Na_{0.5})NbO₃ (KNN), the phase present changes from orthorhombic to pseudo-cubic with more than 0.2 mol% BiZ addition; for samples with base composition (K_{0.48}Na_{0.48}Li_{0.04})(Nb_{0.9}Ta_{0.1})O₃ (KNNLT), the phase present changes from a mixture of orthorhombic and tetragonal symmetry to pseudo-cubic with more than 0.4 mol % while for samples with base composition (K_{0.48}Na_{0.48}Li_{0.04})(Nb_{0.86}Ta_{0.1}Sb_{0.04})O₃ (KNNLST), the phase present is tetragonal with <0.3 mol% BiZ addition and transforms to pseudo-cubic with more dopant addition. The microstructures of the samples show that addition of BiZ decreases the average grain size and increases the volume of pores at the grain boundaries. The values of dielectric constant for KNN and KNNLT compositions increase slightly with BiZ addition while that for KNNLST decreases gradually with BiZ addition. The dielectric loss values are between 0.02 and 0.04 for KNNLT and KNNLST compositions while they are ~ 0.05 for KNN samples. The resistivity values increases with BiZ addition and values in the range of 10¹⁰ Ω cm and 10¹² Ω cm are obtained. The piezoelectric charge coefficient (d_{33}^*) is highest for KNNLST samples and decreases gradually from ~400 pm/V to ~100 pm/V with BiZ addition.

Keywords: KNN ceramics; high-throughput experimentation; Bi₄Zr₃O₁₂; ferroelectrics; lead-free

1. Introduction

Increasing awareness of the harmful effects of lead-based ferroelectric materials and subsequent legislations restricting their usage has led to the search for suitable replacement materials (Council 2003). Some lead-free ferroelectric ceramics are currently being investigated with a view to improving their properties in order to replace Pb(Zr_xTi_{1-x})O₃ (PZT)-based ceramics currently used to make actuators, sensors and other electromechanical devices (Dittmer *et al.* 2012, Jo *et al.* 2012, Li *et al.* 2013, Lily *et al.* 2013, Nath and Prasad 2012, Takenaka *et al.* 1997, Wang

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