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Concomitant structural and ferroelectric properties of $Sr_2Bi_4Ti_5O_{18}$ ceramics sintered with $(K_{0.41}Na_{0.53}Li_{0.06})(Nb_{0.89}Sb_{0.06}Ta_{0.05})O_3$ perovskite☆

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ABSTRACT

Lead free piezoelectric ceramics with the composition(1-*x*) $Sr_2Bi_4Ti_5O_{18}$+ *x* $[(K_{0.41}Na_{0.53}Li_{0.06})(Nb_{0.89}Sb_{0.06}Ta_{0.05})O_3]$ (where x = 0, 0.05, 0.10, 0.15 and 0.20) were synthesized using the pre-reacted $Sr_2Bi_4Ti_5O_{18}$(SBT) and $[(K_{0.41}Na_{0.53}Li_{0.06})(Nb_{0.89}Sb_{0.06}Ta_{0.05})O_3]$(KNLNST) powders via solid-state reaction carried out at 1130 °C. Based on X-ray diffraction studies it was confirmed that only less than 0.15 mol of KNLST was soluble in the SBT phase. Raman spectra analyses for these samples revealed that A and B site cations from KNLNST perovskite phase were found to occupy A and B site cations of SBT. There was an increase in the grain size with the increase in *x* and grains with plate-like morphology were seen in these samples when observed through a scanning electron microscope (SEM). The measured values of relative permittivity (rational electric permittivity) (300 at 1 MHz), dielectric loss (0.013 at 1 MHz), and maximum polarization (5.95 μC/cm^2) for the samples with the composition $x = 0.2$ were found to be superior to that of undoped SBT. The decrease in Curie temperature with the increase in *x* for all the samples under study was confirmed through temperature-dependent dielectric measurements.

1. Introduction

The ferroelectric and piezoelectric materials have drawn much attention for the invention of excellent piezoelectric properties of lead-based ($PbZr_{1-x}Ti_xO_3$) ceramics since the 1950s. These materials are extensively used for multilayer ceramic capacitors, tunable capacitors for microwave technologies, sensors, dynamic random access memories, transducers, actuators, and a few other electronic device applications [1–4]. But unfortunately, lead-based materials are non-environmental friendly due to their toxicity, and many countries around the globe banned the use of lead-based materials for several applications, even though they exhibited excellent properties. In recent years the researchers have developed various eco-friendly lead-free piezoelectric materials akin to that of lead-based piezoelectric materials in terms of their performance [5–10]. Among the lead-free piezoelectric ceramics, the Aurivillius family of oxides are considered as most promising candidates owing to their high Curie temperatures, superior polarization fatigue resistance, high resistivity, and stable piezoelectric properties at high temperatures [11,12].

Generally, Aurivillius family oxides adopt orthorhombic structures consisting of alternate$(Bi_2O_2)^{2+}$ layers and $[A_{n-1}B_n\,O_{3n+1}]^{2-}$perovskite-like slabs stacked along the *c*-axis, where A represents the mono-,di-,trivalent ion or combinations of them, B represents the tetra-, Penta-, hexavalent ions and *n* is an integer that represents the number of BO_6octahedra in $[A_{n-1}B_n\,O_{3n+1}]^{2-}$ between the $(Bi_2O_2)^{2+}$layers [13–15]. Among them, $Sr_2Bi_4Ti_5O_{18}$ (SBT) is an $n = 5$ member of the bismuth layered structure ferroelectric (BLSF) material, which is one of the most promising candidates for the high-temperature piezoelectric device and ferroelectric non-volatile random access memory device applications [12,16,17]. A specific site (A/B) substitution in SBT plays a crucial role to achieve better piezoelectric and ferroelectric properties [18–23]. For instance, higher Curie temperature, the improved ferroelectric and

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