Optimization of Sintering Conditions and Structural Characterization of Neodymium Doped $SrBi_2Nb_2O_9$ (SBN) Ceramics

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Abstract- SBN ceramics with a nominal composition ($Sr_{1-3x/2}$ Nd_x) Nb_2O_6, doped with neodymium (0, 2, 4 and 6 and 8 mol %) were obtained by the solid-state method. Another set of samples was prepared by adding 4 % excess bismuth oxide in order to investigate the effect of excess bismuth on the temperature of formation of the prepared ceramics. The influence of the cationic substitution on the structural orientation, microstructure and dielectric performance has been studied in the present paper. Dielectric measurements were carried out on the as sintered as well as the annealed samples using HIOKI 3532 LCR impedance analyzer in 50^0C to 500 °C temperature range at various frequencies in the span of 100 Hz to 1 MHz. Structural characterizations revealed that the single-phase formation was maintained up to 4 % of Nd doping in SBN; however, the structural symmetry destroyed with further increase in the doping concentration. Also, the long duration annealing had a great effect on the phase formation of the ceramics.

Ferroelectrics are excellent candidates for applications in data storage in digital memory systems, in addition to many other important applications such as piezoelectrics, pyroelectrics, and electro-optics for sensors and actuators [1-2]. In comparison with isotropic perovskite ferroelectrics, typically Pb(Zr, Ti)O_3 (PZT), bismuth layered structured ferroelectrics (BLSF), such as $SrBi_2Nb_2O_9$ (SBN) or $SrBi_2Ta_2O_9$ (SBT), offer several advantages like fatigue-free, low operation voltage, and independence of ferroelectric properties with film thickness. On of the problem of layered perovskite ceramics is that their synthesis demands higher processing temperature with subsequent annealing in oxidizing atmosphere in order to achieve optimum ferroelectric properties. Therefore, methods to produce high-density ceramics at reduced sintering temperatures and shorter durations are needed to obtain high-quality SBT ceramics with optimum ferroelectric properties. There exists a good possibility for various dopings in the bismuth oxide layer or within perovskite unit cell of BLSF for tailoring its properties. The present work is to report the influences of neodymium (Nd) doping and post-sintering annealing on the structural and dielectric properties of SBN ceramics. In addition, attention was paid to the effects of Nd doping and post-sintering annealing on the crystallinity and microstructure of SBN ceramics. The influences of post sintering annealing and Nd doping on the properties of grains and grain boundary of SBN ceramics have been elaborated. Polycrystalline strontium bismuth niobate, $SrBi_2Nb_2O_9$ (SBN), and strontium neodymium bismuth niobate, ($Sr_{1-3x/2}$ Nd_x) Nb_2O_6 (SNdBN), samples were prepared by solid-state reaction sintering. The starting materials used were $SrCO_3$, Nd_2O_3, Bi_2O_3, and Nb_2O_5 (Aldrich Chem. Co.), all with a purity of 99%. The powders were weighed according to their stoichiometric ratio and were admixed with approximately 4 wt.% excess Bi_2O_3, which was to compensate weight loss of Bi_2O_3 due to its high vapor pressure. Simultaneously, one batch of samples was prepared without adding the excess bismuth as it may sometime settle on the grain boundaries and affect the dielectric properties of the ceramics. Futher, the temperature, amount of bismuth and the oxidation/reduction treatment conditions were optimized to obtain better dielectric properties in Nd doped SBN ceramics. Structural characterizations revealed that phase formation was incomplete even in the samples with excess bismuth and complete crystallization was achieved only after annealing. The samples prepared without additional bismuth have also found to achieve a single phase after 60h of annealing.

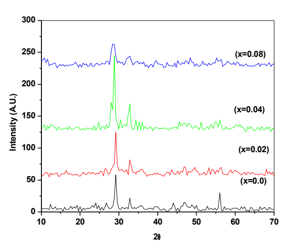

Figure 1 XRD pattern of ($Sr_{1-3x/2}$ Nd_x) Nb_2O_6 with excess Bismuth (as sintered)

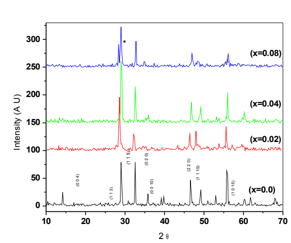

Figure 2 XRD pattern of ($Sr_{1-3x/2}$ Nd_x) Nb_2O_6 with excess Bismuth (after 60h annealing)

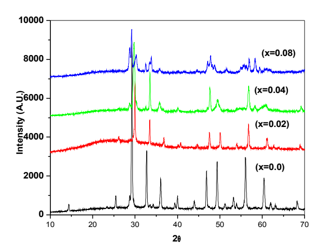

Figure3 XRD pattern of ($Sr_{1-3x/2}$ Nd_x) Nb_2O without excess Bismuth (after 60h annealing)

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[2] D.H. Bao, Z.H. Wang, W. Ren, L.Y. Zhang, X. Yao, Ceram. Int. 25 (1999) 261–265.