DIELECTRIC MEASUREMENTS ON Sm MODIFIED $Bi_4Ti_3O_{12}$ NOVEL CERAMIC

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Abstract

Three-layered novel compound namely Sm modified $Bi_4Ti_3O_{12}$ ($Sm_{0.37}Bi_{3.63}Ti_3O_{12}$) was prepared by conventional solid state route. Dielectric measurements were made in the temperature range RT-520^oC at different frequencies. The dielectric peaks of three-layered compound were found to broad unlike the other ferroelectric compounds. This kind of diffusive behavior of the title compound is explained on the basis of modified Curie-Weiss law, and an attempt is made to understand the results.

Keywords: *Sm modified $Bi_4Ti_3O_{12}$ ($Sm_{0.37}Bi_{3.63}Ti_3O_{12}$), Curie-Weiss law*

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1. INTRODUCTION

Perovskite ferroelectric materials are excellent candidatures for data-storage memory devices [1]. Among the perovskites, layered-perovskite structure ferroelectric abbreviated 'BLSF' are potential candidatures for piezoelectric devices applications under high temperature and frequency conditions on account of high Curie temperature, low dielectric constant, low-dissipation factor, low ageing rate, high dielectric break down strength, strong anisotropy electromechanical coupling factor and low temperature coefficient of resonant frequency [2,3]. The general formula of the BLSF materials is consist of $(Bi_2O_2)^{2-}$ layeres interleaved with perovskite slabs $(A_{n-1}B_nO_{3n+1})^{2-}$. Park et al reported that $Bi_{3.75}La_{0.25}Ti_3O_{12}$ (BLT) is a 'future promising lead free-non-volatile ferroelectric random access memory device materials' [4-6]. This prompts for a search for new BLSF materials, which commensurate to the present existing materials such as PZT. Considering in this direction an attempt is made in the present investigation.

2. EXPERIMENTAL

The title compound was prepared by solid-state route. Reactants powders (Bi_2O_3, Sm_2O_3 and TiO_2 were mixed thoroughly and ball-milled for 18 hours in acetone media by taking in stoichiometric ratios. The mixture was pre-sintered at 900^oC for 2 hours. To obtain dense pellets, the pre-sintered powder was pressed into circular pellets and subjected to final-sintering at 1050^oC. The phase formation for the sample was confirmed by the X-ray diffraction studies. The X-ray diffractogram of the samples were taken using the Cu-k radiation, using Rigaku –Miniflex-600,X-ray diffractometer, Cu-Kα, λ= 1.5406 A˚, 20˚-80˚, step size 2θ = 0.02^o step time = 0.15 sec. is shown in the fig 1. The lattice parameters were evaluated based on the standard (parent) compound. The details were summarized in table 1.

Dielectric measurements were obtained by using the HP 4192 A analyzer at different frequencies, with two terminal texture. Before obtaining the data, samples were coated with silver past on both sides of the pellets and annelid at 550^oC for 30 minutes.

3. RESULTS AND DISCUSSION

The variation dielectric constant with temperature at different frequencies is shown in the fig 2. From the plots, it is observed that the peaks are found to shift towards lower temperature with increasing frequency. This behavior shows a deviation from normal ferroelectric behavior. To correlate the transition temperatures, the variation of dielectric loss against temperatures is shown in fig 3. Some class of ferroelectric materials show absence of dielectric peaks and may observe in strong dispersion in the dielectric loss response functions. The substitution of Sm for Bi may cause depressive stressing the perovskite unit cell, as a result leading to the distortion in the structure. The increase in Curie temperature of SBT, compared to BLT is attributed to the increase the structural distortion. Due to the different ionic radii of Sm &Bi and a tilt in TiO_6 octahedra buckle causes an increase in the transition temperature value. The overlap population defined by Withers et al reported that the displacement of the Sm-Ti-O perovskite blocks with regards the Bi_2O_2 layers might contribute large polarization (ferroelectric properties) in the materials. In other words, the displacement of Sm ions in the ab-plane is dominant rather than the displacement of the Bi ions in ab-plane. However the overlap population of Ti-O in the present compound clusters is related to the displacement of Ti ions in the ab-plane. Therefore, the difference in the transition temperature is mainly due to the displacement of Ti ion in the TiO_6 octahedra rather than the differences in the ionic charges of all ions.

The broad dielectric nature which is observe in all the samples in the present investigation is due to the existence of compositional heterogeneity as mentioned earlier by us in similar compounds [7].The presence Sm and Bi at A site and multi valent ions of Ti^{3+} and Ti^{4+} at B site favors the existence of polar regions in the materials. These Polar Regions are dynamically disordered by thermal motion until temperatures are far related to the transition temperature values. This intern leads to a broad spectrum in the dielectric spectroscopic plots. However at higher temperatures, the oxygen octahedra become oxygen deficient and these oxygen ions constitutes best candidatures for ionic migration.

High dielectric constant values of the present samples are ascribed to the polycrystalline nature of the samples and this was being direct consequence of grain morphology. The ferroelectric state may result of either defect concentration or high charge mobility in these materials and easy recovery of oxygen vacancies from the traps. Consequently no space charge is build up at the interfaces and may result to high (good) ferroelectric nature.

Table 1 Lattice parameters of SBT and parent compound (BIT)

S.No	Sample	Lattice parameters (A^o)			Theoritical Density (gr/cm^3)
		a	b	c	
1	SBT	5.4420	5.4051	32.7626	7.928
2	BIT Parent compound	5.4461	5.4091	32.822	8.05

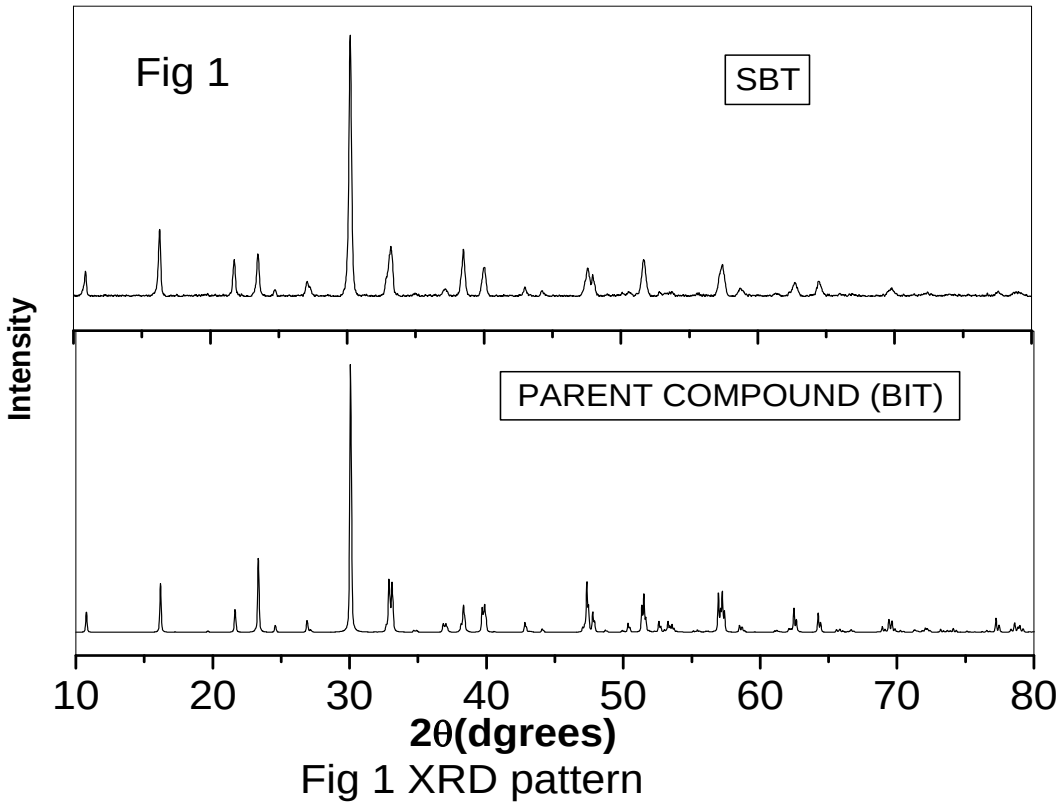

Fig 1 XRD pattern

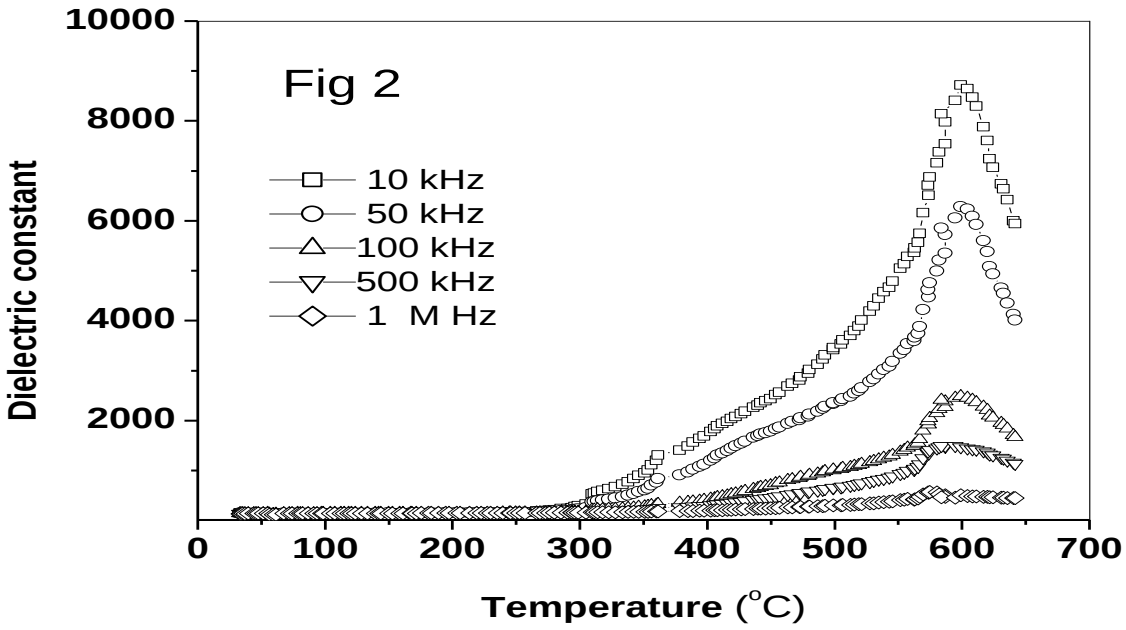

Fig 2 Dielectric constant vs. temperature

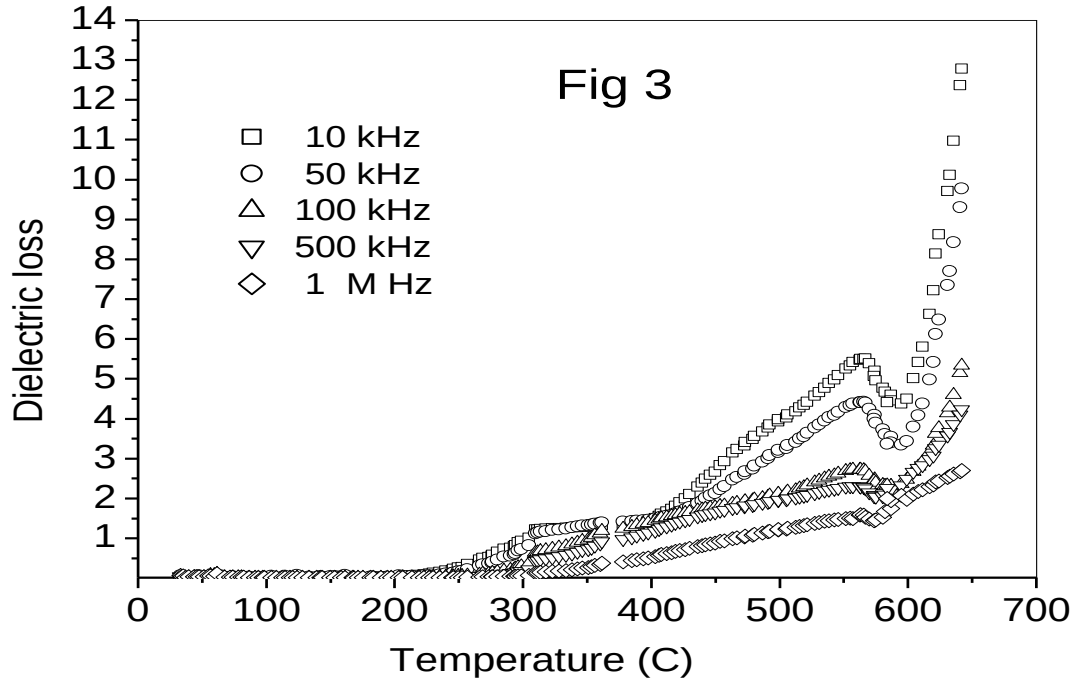

Fig 3 Dielectric loss vs. temperature

4. CONCLUSION

The results conclude that the oxygen vacancy plays predominant role in dielectric process at higher temperatures. The variation of dielectric constant and loss with temperature plots concludes that the conductivity is mainly governed by the long-range ordering of the ferroelectric dipoles. The diffused kind behavior is attributed to the disordering induced by Sm^{3+} ion for partially substituting Bi^{3+} site in Bi_2O_2 layers. Frequency dependent nature suggests that the Ti ion transport mechanism is more dominated through hopping between the Ti^{3+} and Ti^{4+}.

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