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Structural and dielectric properties of (bspt - lsmo) composites

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ABSTRACT
The paper discuses mainly, Crystal structure, Microstructure and Dielectric properties of (BSPT - LSMO) composites in (BSPTx) -(LSMO) composites. BSPTx powder is synthesized using solid state reaction method. While, LSMO is synthesized using hydroxide co-precipitation route. The (BSPTx- LSMO) composites are produced by mixing the respective powder and sintering at 1100^0C. The resulting composites are investigated for crystal structure, microstructure and dielectric properties. The results are understood employs a qualitative approach.

Keywords: BSPT-LSMO,.Crystalstructure, Microstructure and Dielectric properties.

INTRODUCTION

$Ba_{(1-x)}Sr_xTiO_3$ (BSTx) is known to be an important ferroelectric material having applications in multilayer super capacitor, tunable filter, tunable dielectric resonator, Ferroelectric Random Access Memory (FRAM) etc. devices [1-4]. BST0.3 is known to possess a very high value of dielectric constant at its Tc (~ 35^0C) [5-7]. Therefore, the BSTx compositions are widely studied for x in the vicinity of 0.3. It is already reported that substitution of Pb in $BaTiO_3$ (BT) or BST is already reported to show an increase in transition temperature [8-11].

It is reported that, because of substitution of Pb at 0.2, Tc of BT or BST raises up to nearly 75^0C [8]. Another virtue of substitution of Pb is that the Pb at 0.2 causes an increase in the value of ε, while keeping the loss tangent tan δ sufficiently low [9].

$La_{0.7}Sr_{0.3}MnO_3$ (LSMO) is an ortho-ferrite which is known to exhibit interesting CMR behaviour in the vicinity of its Tc nearly 367^0k [12]. In addition to this the LSMO is known to possess a useful value of coefficient of Magnetostriction [13,14]. Therefore present paper reports structural properties, microstructure and dielectric properties of y (BSPT-LSMO) composites for y = 0.1, 0.175 and 0.25 and x = 0.2, 0.25, 0.3, 0.35 and 0.4.

METHODOLOGY

Synthesis of BSPT and LSMO:

$Ba_{0.8-x}Sr_xPb_{0.2}TiO_3$ (BSPTx) compositions were synthesized using solid state reaction method. Details of synthesis of BSPTx is already reported else were [9]. The $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) was synthesized using hydroxide co-precipitation route [15]. $La(C_2H_3O_2)_3.H_2O$, $Sr(NO_3)_2$, $KMnO_4$, and $MnCl_2.4H_2O$ were used as precursors. The precursors were dissolved in distilled water to form 40mM/L solutions of the precursors. The solutions were mixed together and precipitation was carried out using KOH and NH_4OH as precipitating agent. The ratio of $KMn0_4$: $MnCl_2$ was so selected that the resulting precipitate contains Mn^{+3}: Mn^{+4} in the proportion 7:3. Here $KMnO_4$ was used as an oxidizing agent. The precipitate was washed thoroughly using NH_4OH solution with PH nearly equal to 9.5. The precipitate was filtered and subjected for calcinations at 900 ^{0}C for 12h and final sintering was carried out at 1100 ^{0}C for 8h.

Formation of composites:

The BSPT and LSMO composites are formed bearing formula.

y (BSPTx - LSMO) = (1 – y) BSPTx + y LSMO

Where y = 0.1, 0.175 and 0.25. and x = 0.2, 0.25, 0.3,0.35 and 0.4. The sintered powder of LSMO and BSPT was ground together thoroughly using ethanol as a medium in Agate Mortar and pistol. Using the ground mixture, the pellets of diameter 1.2 cm were formed. The pellets are sintered at 1100^oC for 6h to form desired composites. The parent compositions BSPT and LSMO as well as their composites were investigated for the structural properties using X-ray powder diffract meter. For the dielectric measurements, impedance analyzer was used. The measurements were carried out in the frequency range from 1KHz to 1MHz.

RESULTS AND DISCUSSION

Structural properties

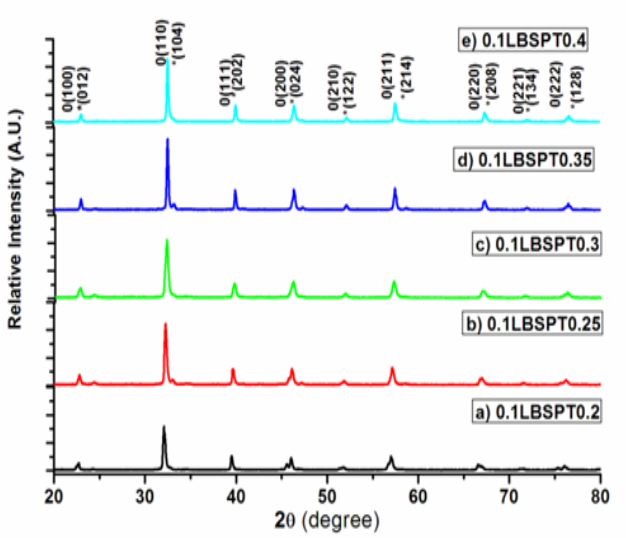

Fig. 1: X - Ray Diffractograms of y(BSPTx- LSMO) composites, with y = 0.1 and x = 0.2, 0.25, 0.3, 0.35 and 0.4.

Fig. 1 shows X ray diffractograms of the y(BSPTx-LSMO) composites with y = 0.1 and x = 0.2, 0.25, 0.3, 0.35 and 0.4. It could be seen that the peaks corresponding to BSPT & LSMO could be separately identified in the XRDs especially for 2θ greater than 40^0. In fig. 1 the reflections corresponding to the LSMO are labeled with a ' * ' while the reflections of BSPTx are labeled with '0'. Therefore, from the fig. 1, it is seen that the composites are biphase systems and no peaks corresponding to any impurity phase is seen in the X ray diffractograms. Further, it is observed that the nature of the X ray diffractograms is independent of level of substitution of LSMO, except for the ratio of the intensities of reflections of LSMO and BSPT.

Microstructure:

Fig. 2 a, b, c, d and e show SEM images of y(BSPTx-LSMO), where y = 0.1 and x = 0.2, 0.25, 0.3, 0.35 and 0.4 respectively. From the fig. 2 it could be seen that the majority of the grains posses particle size between 2 to 2.5μm. Further, it is also observed that the grains are well separated from each other for x ≤ 0.3. However, for x = 0.35 and 0.4 a tendency of agglomeration of grains is seen. Similar behaviour is already reported earlier for x = 0.35 in case of BSPTx compositions [9].

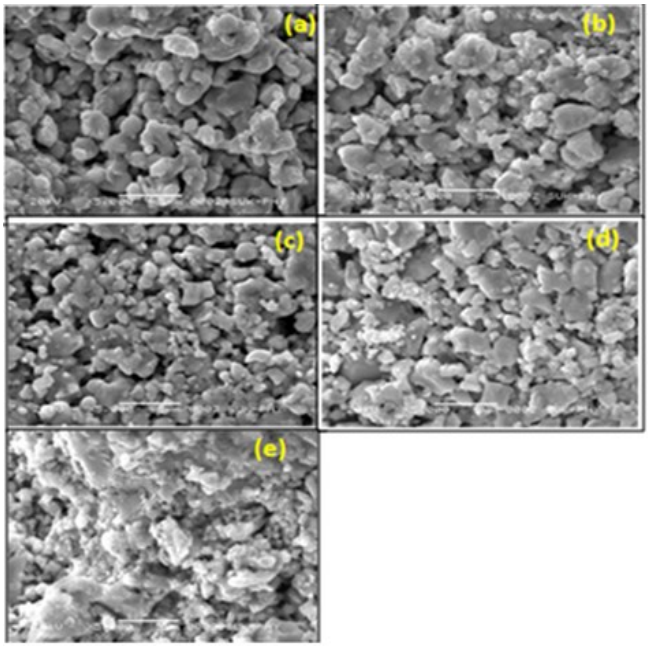

Fig. 2 (a), (b), (c), (d) and (e) SEM images of y(BSPTx-LSMO) composites, where y = 0.1 and x = 0.2, 0.25, 0.3, 0.35 and 0.4 respectively

Therefore the agglomeration appears to be a material property of BSPT, than being a property of composite formation.

Variation of Dielectric Constant ε as a Function of Frequency:

Fig. 3(a) shows variation of dielectric constant ε as a function of frequency, log f, for 0.1LBSPTx, for x = 0.2, 0.25, 0.3, 0.35 and 0.4. From the fig. 3(a) it is seen that the ε for all the frequencies between 1kHz to 1MHz, increase with increasing x. Here the ε is measured as a relative values with respect to the dielectric constant of the free space. The ε for 0.1LBSPTx for x = 0.3, 0.35 and 0.4 show presence of inter and intra grain interfacial polarization. Here the frequency dispersion of ε is larger as compared to the frequency dispersion observed in case of 0.1LBSPTx for x= 0.2 and 0.25.

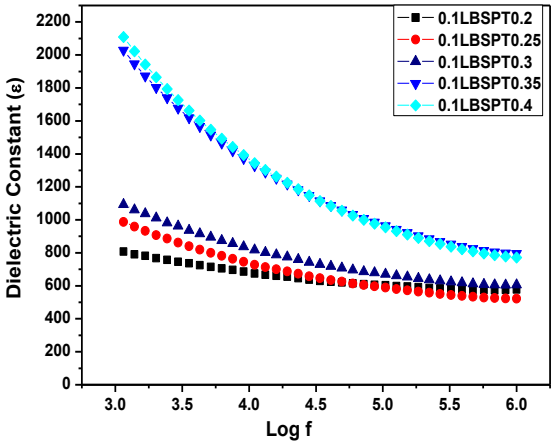

Figure 3 (a):Variation of dielectric (ε) with Log f for 0.1LBSPTx composites,for x = 0.2, 0.25, 0.3, 0.35 and 0.4.

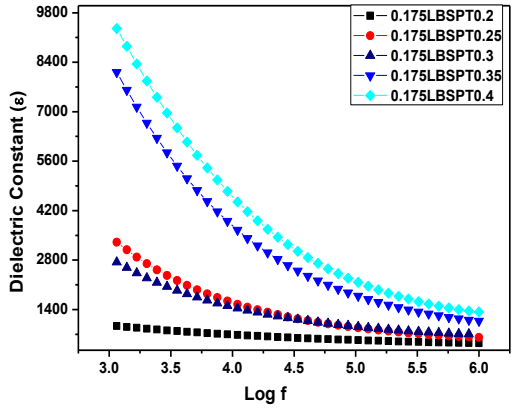

Figure 3(b) : Variation of dielectric (ε) with Log f for 0.175LBSPTx composites, for x = 0.2, 0.25, 0.3, 0.35 and 0.4.

Fig. 3(b) shows variation of dielectric constant ε as a function of frequency, log f, for 0.175LBSPTx, for x = 0.2, 0.25, 0.3, 0.35 and 0.4. From fig. 3(b) it is seen that the ε for all the frequencies between 1kHz to 1MHz, increase with increasing x. Here the ε is measured as a relative values with respect to the dielectric constant of the free space. The ε for 0.175LBSPTx for x = 0.35 and 0.4 show presence of inter and intra grain interfacial polarization. Here the frequency dispersion of ε is larger as compared to the frequency dispersion observed in case for 0.175LBSPTx for x= 0.2 0.25, and 0.3. Fig. 3(c) shows variation of dielectric constant ε as a function of frequency, log f, for 0.25LBSPTx, for x = 0.2, 0.25, 0.3, 0.35 and 0.4. figure 3(c) shows variation

of dielectric constant ε as a function of frequency log f, for 0.25LBSPTx, with x = 0.2, 0.25, 0.3, 0.35 and 0.4, is similar to the behaviour as shown in figure 3(b).

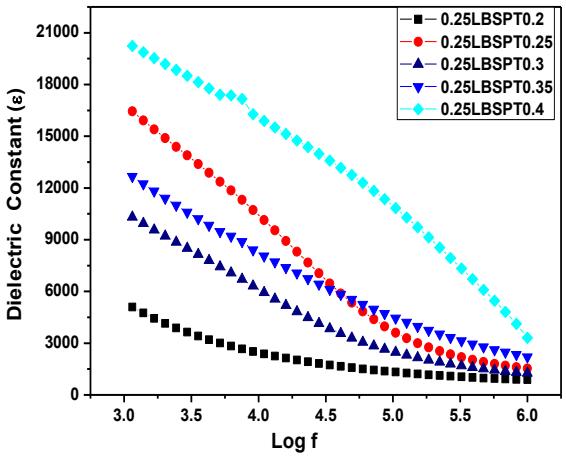

Figure 3(c) : Variation of dielectric (ε) with Log f for 0.25LBSPTx composites, for x =0.2, 0.25, 0.3, 0.35 and 0.4.

CONCLUSION

The present investigation shows that the BSPTx ferroelectric compositions are useful ferroelectric materials to form a ferroelectric phase of ME composites. LSMO is already known to be a useful CMR and Magnetostrictive material. The composites of BSPTx and LSMO are observed to be simultaneously ferroelectric and ferromagnetic.

Conflicts of interest: The authors stated that no conflicts of interest.

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