REVIEW OF RESEARCH

INVESTIGATIONS OF FERROELECTRIC HYSTERESIS ON $BaLa_2Ti_3O_{10}$ – $Ba_{0.7}Sr_{0.3}TiO_3$ COMPOSITES

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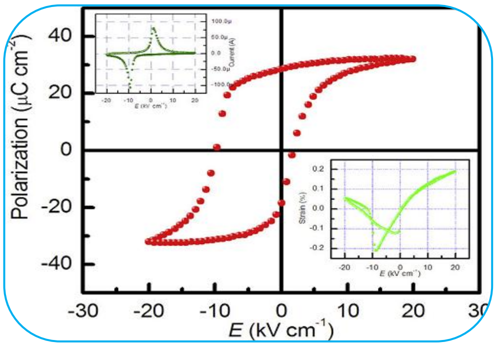

ABSTRACT:

Ferroelectricity is a characteristic of few materials that have a spontaneous electric polarization and it can be reversed by the application of an external electric field. Ferroelectricity was discovered in 1920 in Rochelle salt by Valasek.When most materials are polarized, the polarization induced, P, is almost exactly proportional to the applied external electric field E; so the polarization is a linear function. This is called dielectric polarization. Some materials, known as Paraelectric materials, show a more enhanced nonlinear polarization. The electric permittivity, corresponding to the slope of the polarization curve, is not constant as in dielectrics but is a function of the external electric field. In addition, ferroelectric materials give a spontaneous nonzero polarization even after the applied field E is made to be zero. The distinguishing feature of ferroelectrics is that the spontaneous polarization can be reversed by a suitably strong applied electric field in the opposite direction; the polarization is therefore dependent not only on the current electric field but also on its history, yielding a hysteresis loop.

In this paper we have synthesized ferroelectric materials $Ba_{0.7}Sr_{0.3}TiO_3$(BST) and $BaLa_2Ti_3O_{10}$ (BLT) by hydroxide co precipitation method.Both the material confirms their single phase formation by XRD data and composites are made in proportion from zero to hundred percent. The scanning electron microscopy gives the average grain size in the range of 1μm. The ferroelectric hysteresis loop study was carried out by modified Sawar and Tower circuit. The ferroelectric hysteresis loop gives the values of saturation polarization, remnant polarization and coercive field. These values are suggestive to have the composite material for good candidate of ferroelectric memory device.

KEYWORDS: *Barium Strontium Titanate, Barium Lanthanum Titanate, Composites, Ferroelectric hysteresis etc.*

1. INTRODUCTION:

When intensity of the magnetizing field is gradually increased, the magnetic flux density *B* rises to a maximum value, at which all of the atomic magnets are aligned in the same direction. When the magnetizing field is decreased, the magnetic flux density decreases, with lagging behind the change in field strength *H*. In fact, when *H* has decreased to zero, *B* still has a positive value called the remanence or retentivity. Magnetic flux density *B* does not become zero until in field strength *H* has reached a negative value. The value of in field strength *H* for which magnetic flux density *B* is zero is called the coercive force. Further increase of *H* in the negative direction causes the flux density to reverse and finally to reach saturation again. The cycle may be continued so that the graph of the flux density lagging behind the field strength appears as a complete loop, known as a hysteresis loop of magnetic field. Similar analogy can be applied to electric field and we get electric hysteresis loop of polarisation versus Electric field. Normally those materials are known as ferroelectric materials having polarisation effect. Barium titanate is first ferroelectric material having potential applications. Modification of similar material is of hot topic in the field of ferro and dielectric materials for their potential use in device fabrication. We tried to synthesis the two materials such as $BaLa_2Ti_3O_{10}$ and $Ba_{0.7}Sr_{0.3}TiO_3$ to study their individual parameters and effect of compositions.

2. EXPERIMENTAL:

The raw materials like Barium Nitrate [$Ba(NO_3)_2$], Lanthanum acetate [$C_6H_9LaO_6.H_2O$], Potassium Titanate [$K_2Ti.O(C_2O_4)_2.2H_2O$] and Potassium Hydroxide [KOH] were weighed out in stoichiometric proportions and dissolved in distilled water separately by constant stirring. These solutions are then mixed to form the precipitate of BLT. A similar process is adopted to form the BST material. The detailed synthesis process is explained elsewhere (1). After making the BLT and BST composites were prepared with different percentage of BST i.e. 25%BST+75%BLT, 50%BST+50%BLT and 75%BST+25%BLT.The structural characterization of synthesized samples were made using X-ray diffraction (XRD) pattern. The morphological study of the prepared samples is carried out using Scanning Electron Microscopy (SEM) by exposing the samples with 20 KV as an excitation voltage.

3. RESULT AND DISCUSSION:

3.1. XRD: **T**he X-ray diffraction patterns of all samples for pure BST, BLT and Composites. All the sintered samples showed the typical XRD patterns and no additional peaks are observed. The crystal structure and lattice parameters are in good agreement with the reported data (2). For 25%BST+75%BLT the structure is similar to BLT and for 25% BLT+75% BST structure is similar to BST. For 50%BST+50%BLT mixed phases are seen as it is expected for composite materials. X Ray diffraction plots are shown in figure1.

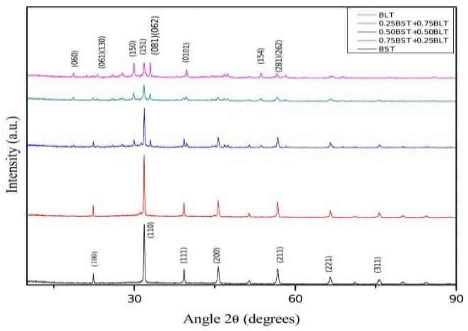

FIG. 1 X-RAY DIFFRACTION PATTERN OF BST-BLT COMPOSITES.

3.2. SEM: Using scanning electron microscopy the surface morphology of the materials synthesized has been studied, which confirms that the material formed is sufficiently dense. Figure 2 shows the microstructure of synthesized samples. Though the high temperature sintering limits the grain size of material in few micrometers, the hydroxide co precipitation has brought down the grain size less than 1μm and it is confirmed by scanning electron microscope. It is interesting to note that few micrographs have shown the rod like structure and its average width is in the range100 to 120 nm. Average length of these rods is 3 μm. The minimum length of rod is less than 1μm and it seems to have maximum up to 5 μm also. Most of the grains are in cubical in nature but few flowers like structure suggest the low temperature sintering will result into more appreciable structure in the Nano scale range.

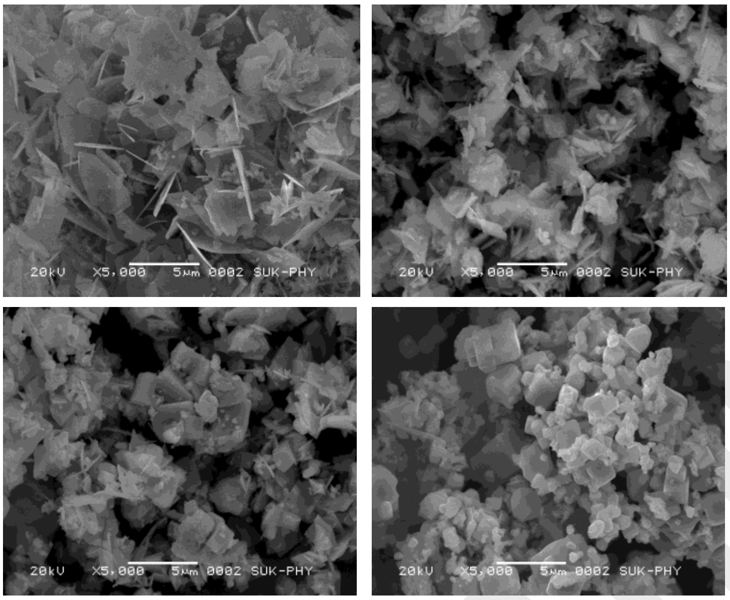

FIGURE 2 SCANNING ELECTRON MICROGRAPH OF BST- BLT COMPOSITES

3.3. Ferroelectric Hysteresis: The plot of P versus E in which the material is polarized in one direction and then in opposite direction is called the hysteresis curve of the specimen. When a piece of ferroelectric material initially un-polarized, is subjected to a gradually increasing electric field, the polarization P varies with E.A material is said to be spontaneously polarized when electric field E is zero but polarization P is not zero. This phenomenon is called spontaneous polarization. Figure 3 shows the Schematic of a Sawyer Tower circuit for P-E loop measurements. Figure 4 gives actual measurement plotof P vs E loop for all the samples. Almost all the samples shows the constant Remanance of 0.007 $\mu C/cm^2$.literaure survey suggests that among the A site as well as A and B site doped material gives B site doping have lower coercive field(3-6). The measurement on composite gives increase in coercive field with increasing concentration of BST. This has limited to 75 % of BST in 25 % BLT composites. The further fine tuning of Composite percentage may give still increased value of Coercive filed and exact proportion of composite percentage. The table 1 gives the detail of variation in Coercive field with Applied Electric Field.

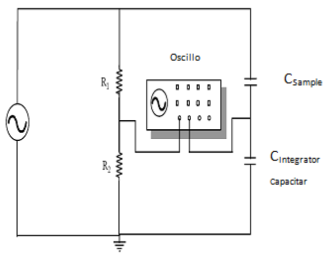

Fig.3 Schematic of a Sawyer Tower circuit

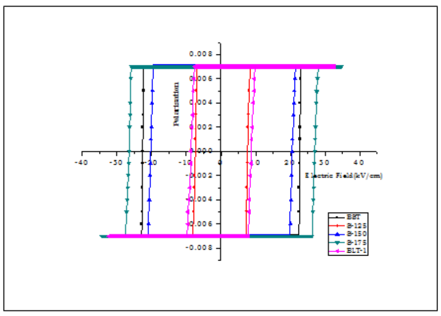

Fig.4 Hysteresis loop (P vs E plot) for BST-BLT composites

Sr.No.	Series	Code	Remnance $(P_r)\mu C/cm^2$	Coercivity (E_c) kV/cm	E_{Max} kV/cm
1	$BaLa_2Ti_3O_{10}$	BLT-1	0.007	8.668	32.449
2	$(0.25)Ba_{0.7}Sr_{0.3}TiO_3 + (0.75)BaLa_2Ti_3O_{10}$	S-125	0.007	7.557	25.528
3	$(0.50)Ba_{0.7}Sr_{0.3}TiO_3 + (0.50)BaLa_2Ti_3O_{10}$	S-150	0.007	20.387	29.110
4	$(0.75)Ba_{0.7}Sr_{0.3}TiO_3 + (0.25)BaLa_2Ti_3O_{10}$	S-175	0.007	26.760	34.503
5	$Ba_{0.7}Sr_{0.3}TiO_3$	BST	0.007	22.628	24.928

4. CONCLUSION:

The single phase material of $BaLa_2Ti_4O_{12}$and $Ba_{0.7}Sr_{0.3}TiO_3$havingless than one micron grain size can be synthesized by hydroxide co- precipitation. The composites of above materials gives considerable rise in dielectric properties. For 75% BST and 25% BLT composites, the room temperature relative permittivity goes beyond 100. To have the fine tuning of dielectric rise, one has to study the composite of these materials between 50% to 100% BST with smaller steps.

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