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Surface deformation of $BaSrTiO_3$ by DEHI technique

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ABSTRACT

We have employed ceramic method to prepare BaSrTiO3 samples. Structural, surface morphological studies have been carried out using x-ray diffraction (XRD) and scanning electron microscope (SEM), respectively. Off-axis Double exposure holographic interferometry (DEHI) technique has been used to study the surface deformation of $BaSrTiO_3$ *at different temperatures.*

Key words: Surface deformation, Double exposure, $BaSrTiO_3$, XRD, SEM

INTRODUCTION

Speckle photography and Holographic interferometry were successfully demonstrated with a BSO crystal [1,2]. Since then, materials such as $LiNbO_3$, $BaTiO_3$ etc. have found potential use in image processing, speckle photography, and holographic interferometry [3-5]. The attractive features of these materials are high resolution and real-time processing. Time-average as well as double exposure recordings were performed with $LiNbO_3$, $BaTiO_3$ etc. as recording media for static deformation measurements and vibration analysis [6]. The applications of these materials are characterized by slow response times, requiring longer exposures.

Recently, BaSrTiO3 (BST) has attracted considerable attention in tunable microwave devices and dynamic random access memories. BST room temperature permittivity can be tailored over a broad range by changing the Sr concentration [7]. The change in the composition leads to cell parameters variation, which results in various distortions [8]. Subsequently, studies on the doping in BaTiO3 are therefore needed. In the present paper, we have explored an impact of temperature on surface deformation of $Ba_{1-x}Sr_xTiO_3$ (x = 0.4, 0.8) samples using double exposure holographic interferometry (DEHI) technique [9,10].

MATERIALS AND METHODS

Ferroelectric samples with composition $Ba_xSr_{1-x}TiO_3$ (where x = 0.4, 0.8) were prepared by standard ceramic method using AR grade starting materials BaO_2, $SrCO_3$ and TiO_2. The appropriate raw materials were mixed in their required molar proportions and ground in agate mortar for three hours. A little amount of acetone was added for homogenous mixing. The powder mixture was pressed into the pellets of diameter 3cm and thickness of about 3mm using a hydraulic press. The pressed pellets were then presintered at 700^0C for about 12 hours in a muffle furnace. The pellets were allowed to cool down to room temperature. The cooled pellets were crushed and again grounded in a mortar and pestle for 1 hour. The powder was then added with a binder saturated solution of polyvinyl alcohol in appropriate proportion. The pellets of the sample were again made using a die and hydraulic press. The pellets were heated at 450^0C for 5 hours for binder burn out and then the final firing was carried out at 700^0C for 12 hours in a muffle furnace. The pellets were allowed to cool down to room temperature to yield the end product. The amounts of raw materials taken to prepare a particular sample are: (A_6, B_6) = $Ba_xSr_{1-x}TiO_3$ with (x=0.4, 0.8). The BST samples were characterized by using x-ray diffractometer (Philips Model PW 3710) with Cu Kα (λ=1.5406 A^0). Scanning electron microscope (SEM) was used to study surface morphology of BST samples (Model JEOL JSM 6360).

Surface deformation studies of BST samples were carried out by using DEHI technique. The experimental setup for recording hologram of the $BaSrTiO_3$ Pallet is as shown in Figure 1.

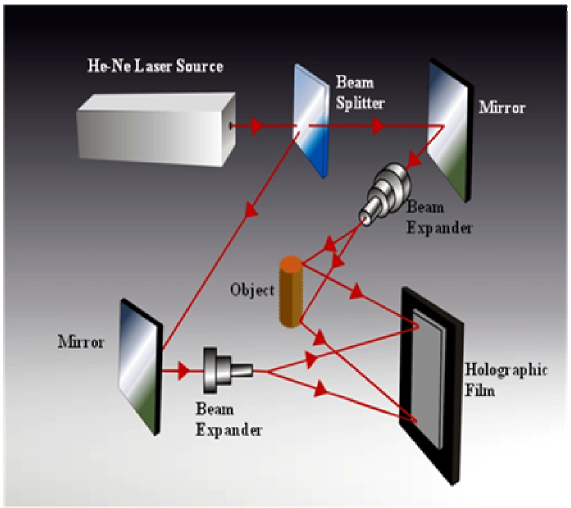


Figure 1 Experimental setup for recording hologram

Light from the laser source is passed through beam splitter. The 50% of light get transmitted and allowed to incident on the mirror. It illuminates the BST pallet. The diffused light from the BST pallet gets incident on holographic plate, which is called as an object beam. Another 50% reflected beam is incident on holographic plate, which is called as reference beam. Initially, BST pallet as an object was recorded on holographic film at room temperature. Secondly, the holographic film was exposed at different temperatures and holograms are recorded for A_6 and B_6 BST samples.

RESULTS AND DISCUSSION

Figure 2 shows the BST samples (A_6 and B_6) confirmed by XRD. Dominant plane (110) has been used to calculate the crystallite size of BST samples. The crystallite size 30 nm and 35 nm for A_6 and B_6 samples are observed. Figure 3 shows the SEM photographs of A_6 and B_6 BST samples. It is clear from Figure 3 that all the BST particles are nearly spherical and rounded in shape with uniform distribution. Further, 0.3 μm to 0.35 μm average particle size for A_6 and B_6 samples has been observed.

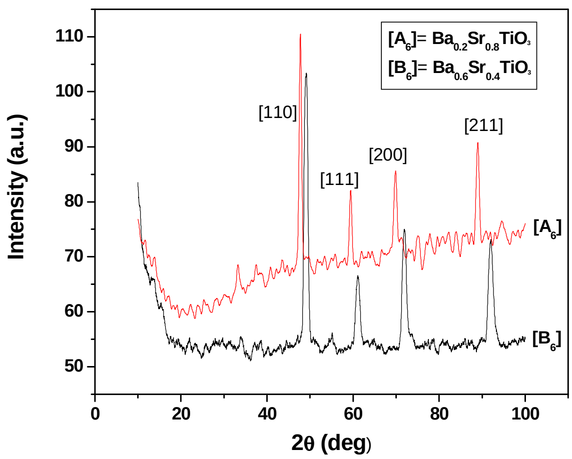


Figure 2 XRD patterns of BST samples

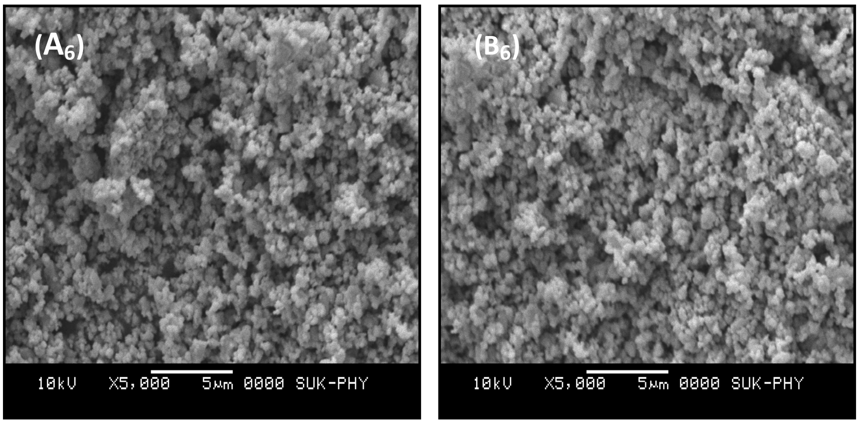
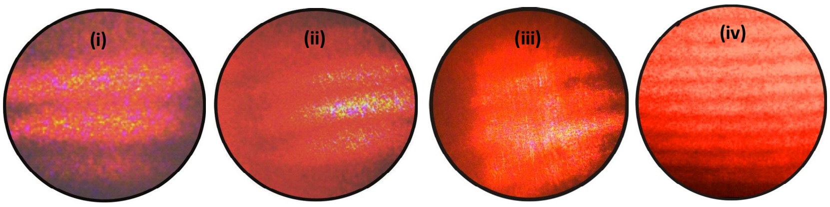
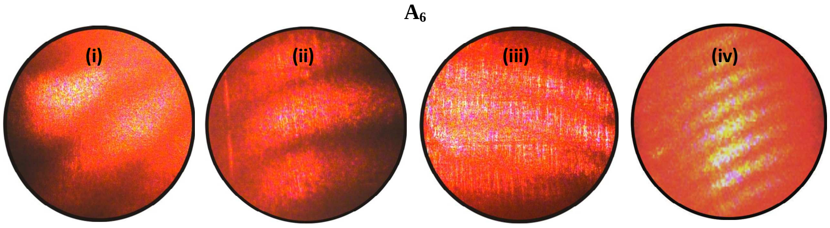


Figure 3 SEM images of BST samples

The recorded holograms at different temperatures (50^{0}C, 60^{0}C, 70^{0}C, 100^{0}C) for A6 and B6 BST samples are displayed in Figure 4. Table shows the number of interference fringes formed, surface deformation in µm and fringe width in cm for A6 and B6 BST samples.



A_6



B_6

Figure 4 Holograms recorded for BST samples

Table: Number of fringes, surface deformation and fringe width for BST samples

Sr. No.	Applied Temperatures (^{0}C)	No. of Fringes n		Surface deformation (µm)		Fringe width (cm)	
		A_6	B_6	A_6	B_6	A_6	B_6
1	50	2	3	71.5045	107.2567	0.374	0.318
2	60	3	4	107.2567	143.0090	0.311	0.284
3	70	4	5	143.0090	178.7613	0.282	0.278
4	100	7	9	250.2658	321.7703	0.202	0.145

From the table, it is observed that as temperature increases, the number of fringes localized on the surface of for both A6 and B6 samples increases. Increase in surface deformation and decrease in fringe width with temperature is noteworthy. It is also evident from table that for a particular temperature, number of fringes localized on the surface and surface deformation is greater for B_6 sample than A_6 but fringe width is smaller.

CONCLUSION

In conclusion, DEHI technique is successfully employed to study the surface deformation of BST samples at different temperatures. It is found that DEHI is a simple technique to determine fringe width and temperature play vital role in the surface deformation studies.

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