# The Effect of Heating the Composite Material BSF and BST Varying Temperatures for Magnetic Properties Created by the Method of Mechanical Alloying

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# The effect of heating the composite material BSF and BST varying temperatures for magnetic properties created by the method of mechanical Alloying.

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**Abstract** In this research carried out investigations on the magnetic properties of the composite BSF-BST (ferromagnetic and ferroelectric) prepared by the method of milling and sonication. The result of the basic material milling BSF and BST process and obtained particle size for the material was nearly 20- 4 µm . Analyzed by X-Ray Crystal size of 27 nm was found in $B_7S_3T$, to $B_7S_3F$ in which mean crystallite size of only 18 nm. Morphology of composite particles can be seen from the results of SEM. Heating at 1000 and 1100$^o$C temperature for 2 hours and its the magnetic properties changes of the material BSHF is indicated to changes in the intrinsic coercivity of 320.4 kA / m to 126 kA / m and the rising value of remanence Mr, also an increase in the saturation value Ms from 0.1263 to 0.1662 T. And we hope this materials can be promoted as multiferroic material.

**Key word** : Magnetic properties, (Ba,Sr) hexaferrite, (Ba,Sr) Titanate, ball milling, particle size.

## 1. Introduction

Studies of multiferroic phenomena have been driven by novel materials. For potential device applications, there is a continued push to develop materials with magnetic transitions above room temperature. Presently, type II multiferroics with strong coupling between ferroelectric and magnetic order parameters appear very promising. Theory has been playing an increasing role in predicting new materials with strong coupling between ferroelectric and magnetic order parameters [1].

Among the multiferroic materials, if the material is composed of ferromagnetic and ferroelectric, better known as Magnetoelektrik (ME). In These materials we can expect the coupling between the magnetic and ferroelectric properties as well as their control by the application of magnetic and / or electric fields [2].

Magneto-electric materials have great potential for applications in actuators and sensors with high sensitivity. However, there are very few natural magneto-electrics that exhibit both ferromagnetic and ferroelectric behavior at room temperature [3]. This is because the distortion is very large off-center on the ferroelectric behavior is usually not in accordance with the d-level, partially filled which is a prerequisite for ferromagnetic behavior [4]. Magnetoelektrik materials typically synthesized by sintering routes such as sintering solid.

In this research, observation of the material Barium strontium titanate, $BaSrTiO_3$ (denoted as BST), and Barium Strontium hexaferit, with the chemical formula $BaSrFe_{12}O_{19}$ (denoted as BSF) at temperatures of 1000 and 1100°C, and analyzed by PSA, X-Ray diffraction, SEM and Permagraph. Perovskite ferroelectric material widely studied and considered a good material, used in piezoelectric applications [5]. At high temperatures $BaSrTiO_3$ adopt ferroelectric per cubic phase where large barium ions surrounded by 12 nearest neighbor oxygen and titanium ions each have six oxygen ions in octahedral coordination. Ferromagnetic materials BSHF is one of the magnetic material of the most robust, widely used in permanent magnets, magnetic recording media, and microwave applications, because it is quite large anisotropy of crystal magneto, the Curie temperature is high, the magnetization is relatively large, as well as stability excellent chemical and corrosion resistance[5]. BSF crystallizes in a hexagonal structure with 64 ions per unit cell at 11 locations of different symmetry. 24 Fe 3+ atoms are distributed over five different sites: three octahedral sites (12k, 2a, and 4f2), one of the tetrahedral sites (4f1), and a bi pyramid sites (2b). the crystal structure is called magneto structure, which can be described as a stacking sequence of basic blocks S and R plumbed [6] . In this study expected to look different of structural and magnetic properties of maerial composites with composition $Ba_{(1-x)}Sr_{(x)}TiO_3$-$Ba_{(1-x)}Sr_{(x)}$ $Fe_{12}O_{19}$ composite system (containing 50 wt.% ($Ba_{(1-x.)}Sr_{(x)}Fe_{12}O_{19}$) and 50% by weight ($Ba_{(1-x)}Sr_{(x)}TiO_3$), with the notation ($B_{(1-x)}S_XF$) - ($B_{(1-x)}$ $S_xT$) for x = 0.3, 0.5, 0.7 at 1000 and 1100°C [7].

## 2. Numerical Method

From the process of milling, followed by particle measurement of composite material (BSF-BST) with PSA (Particle Size Analyzer). Additional analysis by XRD was performed on un overlapping diffraction peak employing step scanning and calculation for crystallite size determination using *Debye Scherer* formula[3], [8].

d = 0.9 x λ / β x cos q (1)

where d is the mean crystallite size, λ is the X-ray wavelength, β is the full width at half maximum (FWHM) of a diffraction peak after correcting for instrumental peak broadening (β expressed in radians), θ is the Bragg angle. Peak broadening due to lattice strain was neglected. The surface morphology and grain distribution is done by using SEM (scanning electron microscope). Measurements carried out on coercivity magnetic properties, the magnetic moments and the values of remanence was recorded at room temperature. Measurements of electrical Magneto performed as discussed in our previous report[9], [10].

## 3. Results and Discussion

The particle size and the investigation stating the respective size of the base material is composite ($B_{(1-x)}$ $S_XF$ and $B_{(1-x)}S_XT$ (where x = 0.3) in the analysis using PSA obtained particle size 4-20 μm with time variations miling 10 hours for 60 hours. Included in Figure 1 is the average value of the crystal (or grain) size of the material is milled sintered to each sample $B_{(1-x)}$ $S_XT$ and $B_{(1-x)}S_XF$. the crystal size of 27 nm was found in $B_7S_3T$ when compared with $B_7S_3F$ the size of the crystals are only 18 nm. the results for both mean particle and crystal size of the two types of samples, and clearly indicates that the material ispromoted by mechanical alloying are in the area of nano in which materials with size below ~ 30 nm are commonly found in $B_{(1-x)}$ $S_XF$ and below ~ 20 nm in the sample $B_7S_3T$.

**Figure 2** is a diffraction results for samples with a ratio of 1: 1 composition between $B_{(1-x)}S_XT$ and $B_{(1-x)}$ $S_XF$ (where x = 0.3, 0.5, 0.7) is a composite material. All of the diffraction peaks were identified and found that the intensity is composed of a mix between a diffraction intensity $B_{(1-x)}$ $S_XT$ and that of $B_{(1-x)}$ $S_X$ F. No other picture that was found and thus sintering at 1000°C and 1100°C for 2 hours with composite materials has produced a two-phase mixture consisting of $Ba_{(1-x)}S_XT$ and that of $Ba_{(1-x)}S_XF$ phase. We have repeated the same procedure for the average particle and crystal size determination and evaluation results are summarized in Figure 3.

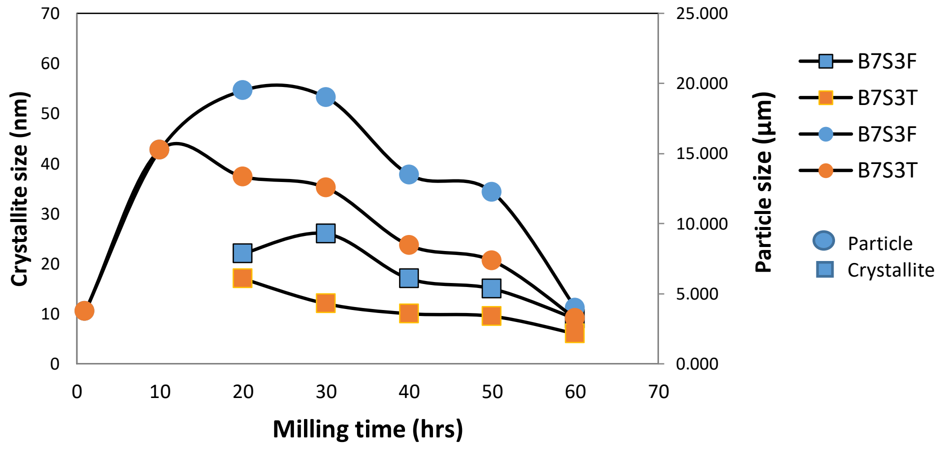



**Figure. 1**. *Mean Crystallite (♦) and Mean Particle (•) sizes of $B_7S_3T$ and $B_7S_3F$ prepared by mechanical alloying*

Crystallite nucleation during sintering at 1000°C for 2 hours is determined by the size of the particle but with the level of size reduction is low, as seen in Figure 1, the mean crystal size to $B_7S_3T$ is about 350 times smaller than the average size of the particles composite particles and to $B_7S_3F$ crystal size is about 700 times smaller than the average particle size.

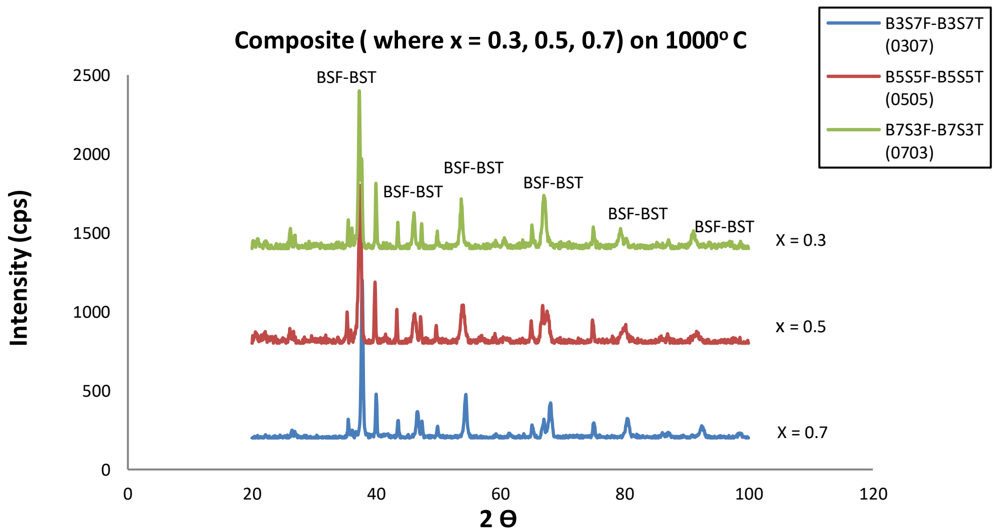



**Figure 2.** X ray diffraction patterns for $(Ba_{(1-x)}Sr_{(x)}Fe_{12}O_{19})$-$(Ba_{(1-x)}Sr_{(x)}TiO_3)$ composite on 1000°C conventionally sintered

X-ray diffraction pattern of the composite ($Ba_{(1-x)}Sr_{(x)}Fe_{12}O_{19}$)-($Ba_{(1-x)}Sr_{(x)}TiO_3$) (where x = 0.3, 0.5, 0.7 ), diffraction sintered material are shown in Figures 2 and 3. All peaks can be indexed as each phase $B_{(1-x)}$ $S_X$T (ferroelectric) and $B_{(1-x)}S_X$F (ferromagnetic). Interestingly, no differences were noted in the peak position for conventional sintering (CS), and except for a few changes in peak intensity

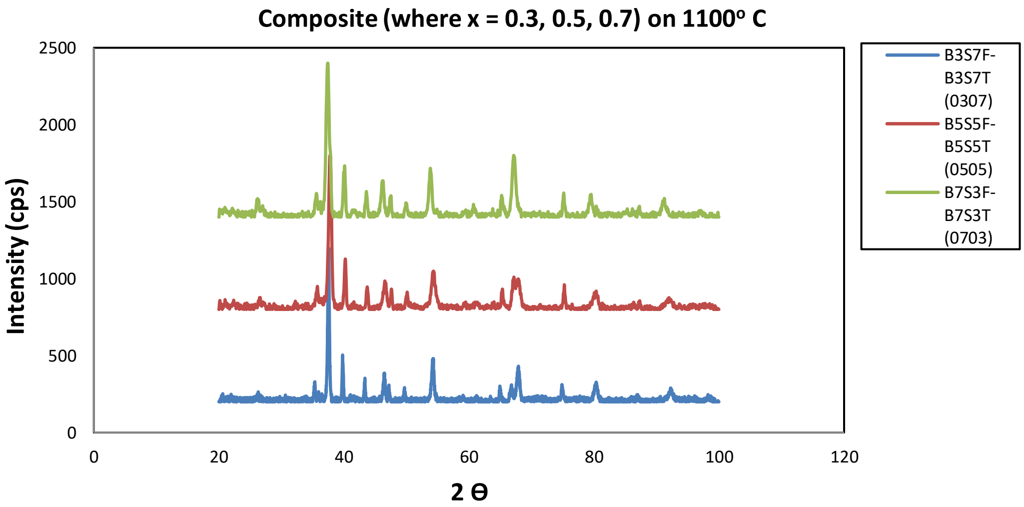
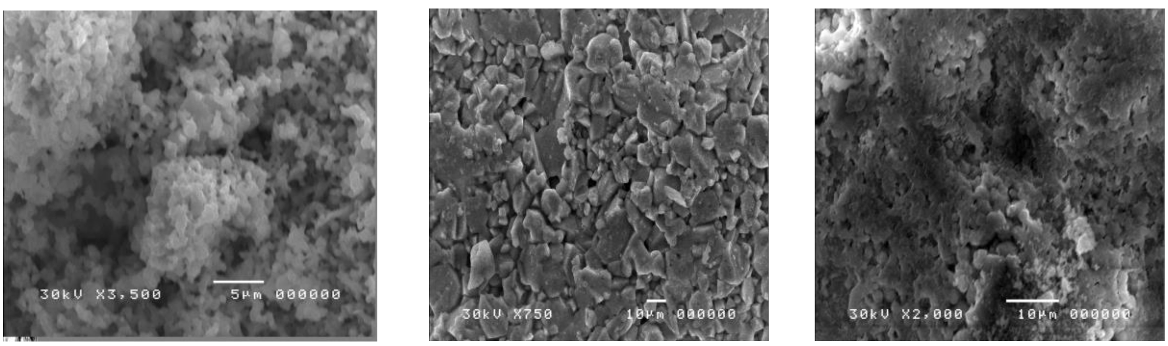



**Figure 3.** X ray diffraction patterns for ($Ba_{(1-x)}Sr_{(x)}Fe_{12}O_{19}$ )-( $Ba_{(1-x)}Sr_{(x)}TiO_3$ ) composite on 1100°C conventionally sintered

**Figure 4** shows the results of SEM, from conventional sintered composite samples (Ba (0.7) Sr (0.3) Fe12O19) - (Ba (0.7) Sr (0.3) TiO3). It is observed that the grains are distributed evenly across the sample. Grain samples are formed in a more compacted. In addition, the presentation of a sample, all grain BST and BSHF maintained, causing splinters / good surface. These results indicate that short period of detention is an important factor to get 0.5B7S3T-0.5B7S3F composites with a uniform and fine grains with a conventional sintering process.




a). Composite $B_7S_3F$ –$B_7S_3T$ b.).$B_7S_3F$ c.).$B_7S_3T$

**Figure 4.** The SEM images of a). Composite $B_7S_3F$ –$B_7S_3T$ , b.).$B_7S_3F$, c.).$B_7S_3T$

In pictures 5 and 6 below show that the effect of the sintering temperature of the composite materials B (1-x) SXF-B (1-x) SXT with variations of x = 0.3, 0.5, 0.7. the sintering temperature of 1000° C in getting value composite magnetic properties are listed in Table 1, and sintering temperature 1100°C in Table 2.

Table 1. The value of magnetic properties influence of sintering temperature 1000°C

| Material | Ms [T] | Mr [T] | Mr/Ms % | Hcj kA/m | Hmax kA/m |
|---|---|---|---|---|---|
| $B_3S_7T$-$B_3S_7F$ | 0.1011 | 0.0773 | 0.76459 | 330.7 | 1032 |
| $B_5S_5T$-$B_5S_5F$ | 0.1171 | 0.0843 | 0.719898 | 318.1 | 1279 |
| $B_7S_3T$-$B_7S_3F$ | 0.1263 | 0.0887 | 0.702296 | 320.4 | 1247 |

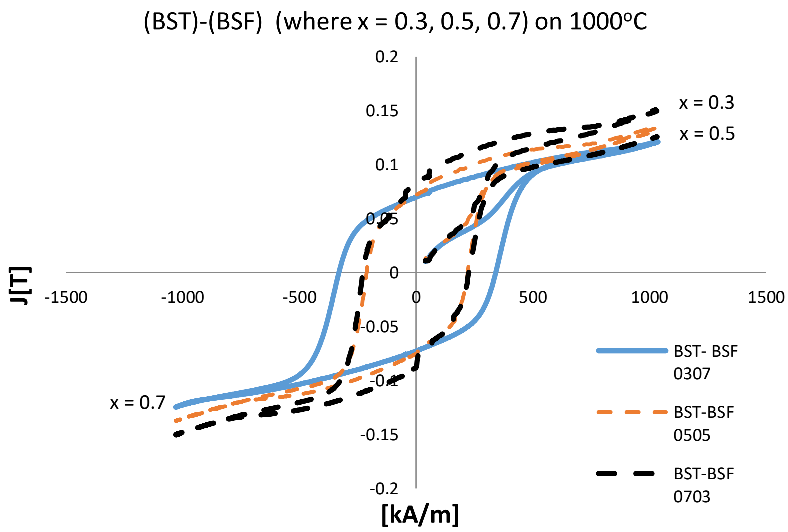



**Figure 5** . The composite with variation of composition x = 0.3, 0.5, and 0.7 influenced on sintering temperature 1000°C

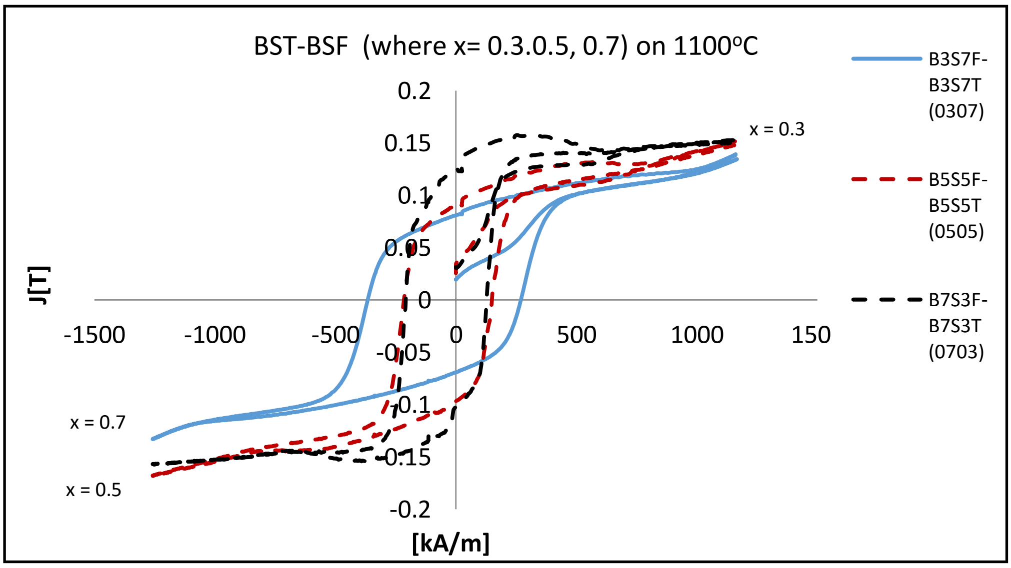



**Figure 6** . The composite with variation of composition x = 0.3, 0.5, and 0.7 influenced on sintering temperature 1100°C

Table 2. The value of magnetic properties influence of sintering temperature 1100°C

| Materials | Ms [T] | Mr [T] | Mr/Ms % | Hc kA/m | Hmax kA/m |
|---|---|---|---|---|---|
| $B_3S_7T$-$B_3S_7F$ | 0.1306 | 0.0791 | 0.605666 | 315.328 | 1161 |
| $B_5S_5T$-$B_5S_5F$ | 0.1500 | 0.0943 | 0.628667 | 230.435 | 1343 |
| $B_7S_3T$-$B_7S_3F$ | 0.1662 | 0.1291 | 0.776594 | 126.193 | 1471 |

There has been growing interest in the study of multiferroic materials, a special class of materials in which two or three kinds of order parameters i.e., ferroelectric, ferromagnetic and ferroelastic The multiferroic of the composite material indicated not also with magnetic properties but also with electric properties.

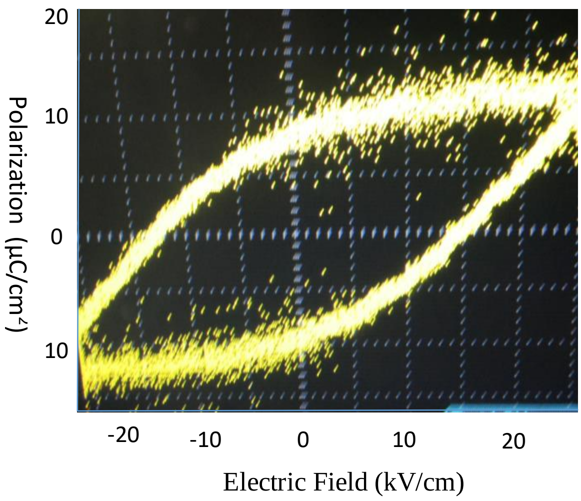



**Figure 6** . Electric properties of composite with variation of composition x = 0.3, 0.5, and 0.7

## 5. Conclusion

The influence of temperature on material BSF-BST with composition x = 0.3, 0.5, 0, heated at 1000 and 1100oC give effect to the magnetic properties, is indicated by the change in the value of coercivity, decreased from 320 kA / m up to 126 193 kA / m, as well as increase the value of remanent 0.1291 [T], and the saturation value reached 0.1662 [T].

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