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DIELECTRIC PROPERTIES OF BARIUM STRONTIUM TITANATE CERAMICS AT 20 Hz TO 1 MHz

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ABSTRACT

Perovskite-based ferroelectrics of Barium Strontium Titanate (BST; x=0.3-0.7) have been prepared using conventional solid-state method. The XRD showed that BST ceramics were perovskite structure without occurring secondary phase after sintered at 1200°C. However, sample x=0.3 was tetragonal phase while x=0.4-0.7 were cubic phase due to the ease of tetragonal-cubic phase transition as the strontium content increased. BST were frequency and temperature dependent. However, dielectric constant of $Ba_{0.6}Sr_{0.4}TiO_3$ decreased with increasing of measuring temperature. This was due to the occurrence of impurities which diffused the dielectric constant. Beside this, non-homogeneous distribution of Ba^{2+} and Sr^{2+} would also produce the diffused phase transition response. $Ba_{0.5}Sr_{0.5}TiO_3$ had the highest dielectric constant.

Keywords: barium strontium titanate; solid-state; dielectric properties;

INTRODUCTION

Recently, many researches were done on the properties of Barium Strontium Titanate (BST) ceramics. BST is a perovskite-based ferroelectric with solid solution material composed of barium titanate and strontium titanate [1-2]. It is probable for use in capacitor, DRAM applications, and microwave applications such as phase shifters, filters, resonators, and antennas [3-6] due to its unique properties which are high tunability, high dielectric constant and low dielectric loss at room temperature [2, 5, 7-8].

Several processing techniques such as conventional solid-state [1-5, 9-12, 16], sol-gel [13], and hydrothermal methods [6, 14-15] have been used to produce BST ceramics. Conventional solid-state method usually produces larger grain size and is easily contaminate during the grinding and heat treatment process. Sol-gel method needs expansive chemicals and is sensitive to moisture while hydrothermal method capable to produce nano-crystalline powders at low temperature [6, 15].

In this research, $Ba_{1-x}Sr_xTiO_3$ with x=0.3-0.7 are prepared using conventional solid-state method. This paper reports the results of the dielectric measurement on BST ceramics sintered at 1200°C at various temperatures from 30°C to 100°C.

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EXPERIMENTAL DETAILS

The Barium Strontium Titanate ($Ba_{1-x}Sr_xTiO_3$ with x=0.3-0.7) were prepared using conventional solid state reaction method. $BaCO_3$ (95%), $SrCO_3$ (99.9%), and TiO_2 (99.7%) were used as starting materials. The powder was calcined in air at 900°C for 10 hours. After that, the powder was grinded and pressed into pellet shape. The pellet was sintered at 1200°C for 10 hours and then cooled to room temperature in the furnace.

The crystalline structures of the samples were examined by X-ray diffraction (XRD, Philips) using Cu Kα radiation at room temperature with the range 20°-80°. The dielectric properties of the samples were determined using the HP 4284A LCR Meter in the frequency range 20 Hz to 1 MHz at 30°C–100°C at 10°C intervals.

RESULTS AND DISCUSSION

The X-ray diffraction patterns of $Ba_{1-x}Sr_xTiO_3$ ceramics with x=0.3-0.7 are shown in Figure 1. It shows the BST ceramics are perovskite structure without occurring secondary phase. This result indicates that a complete solid BST has formed during sintering process at high temperatures [16]. The crystal structures of BST ceramics for x=0.3 is tetragonal phase while cubic phase for x=0.4-0.7. The diffraction peaks shift towards to higher diffraction angles with the increasing of strontium content. This may be due to the ease of tetragonal-cubic phase transition with the increasing of strontium content. However, the lattice constants increase with the decreasing of strontium content since the ionic radius of barium is larger than strontium [4].

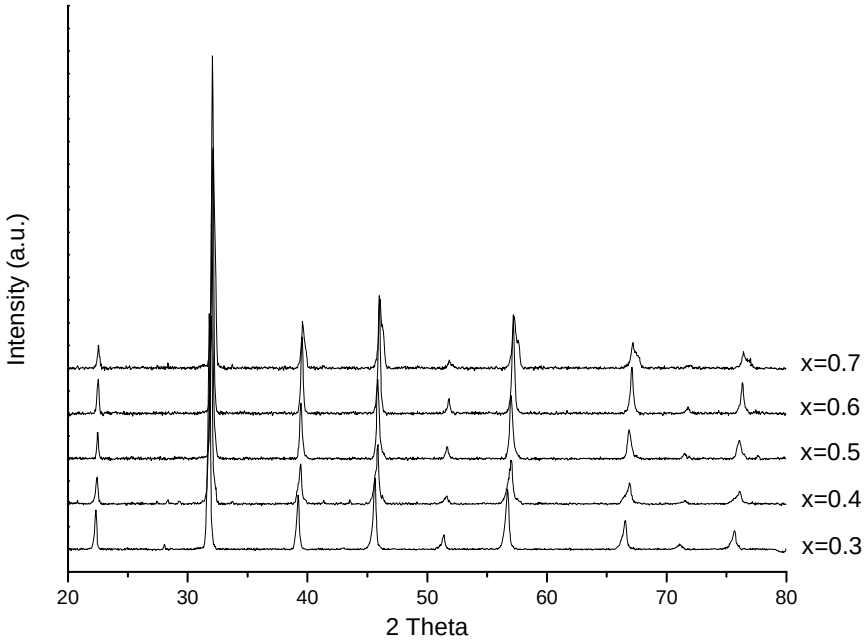

Figure 1: XRD patterns for BST samples with different compositions

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Figure 2 shows the dielectric constant of $Ba_{1-x}Sr_xTiO_3$ ceramics with x=0.3-0.7 measured at different temperatures at 1 kHz. $Ba_{0.6}Sr_{0.4}TiO_3$ is temperature independent as shown in figure below. For BST with x=0.4-0.7, the dielectric constants are increasing with the increases of temperature yet decreasing for BST with x=0.3. Impurity could possibility cause diffused dielectric constant. The diffused phase transition response could happen due to the non-homogeneous distribution of Ba^{2+} and Sr^{2+} [10]. $Ba_{0.5}Sr_{0.5}TiO_3$ has the highest dielectric constant which is ~$5x10^4$ at 300°C. These shows that it can produce better dielectric constant at higher measuring temperatures compared other compositions.

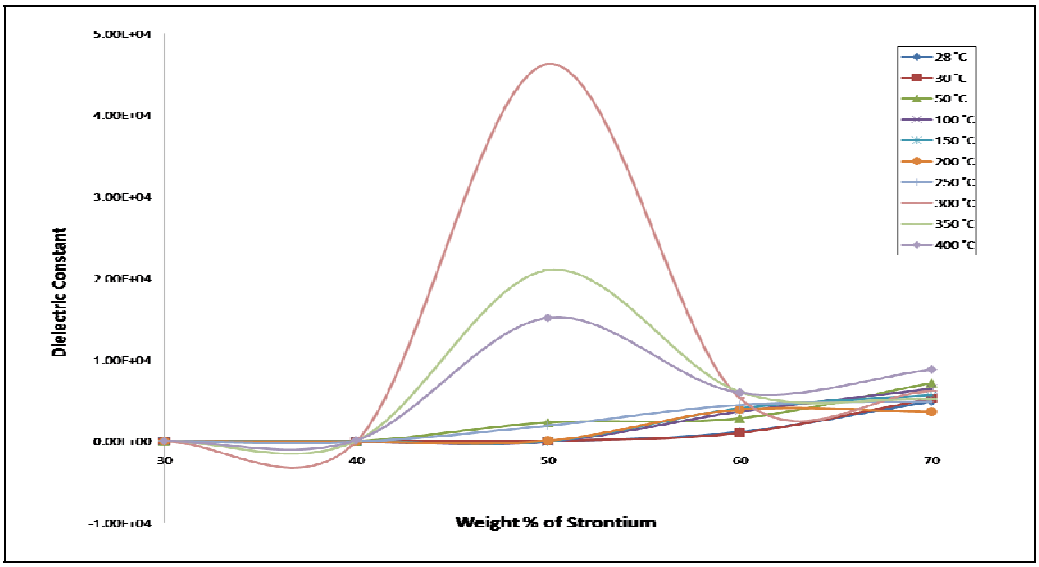

Figure 2: Dielectric constant of BST measured at different temperatures at 1 kHz

Figure 3 shows the dielectric constant of $Ba_{0.5}Sr_{0.5}TiO_3$ measured at different temperatures. $Ba_{0.5}Sr_{0.5}TiO_3$ has the highest dielectric constant which is approximately 10^5 at low frequency. The dielectric constant decreases with the increment of frequency. This may probably due to the occurring of interfacial polarization. On the other hand, the dielectric constant increases with the increment of temperature. However, the increment is low at the higher frequencies due to the mechanical limitation happen where lack of interfacial polarization occurs at higher frequencies.

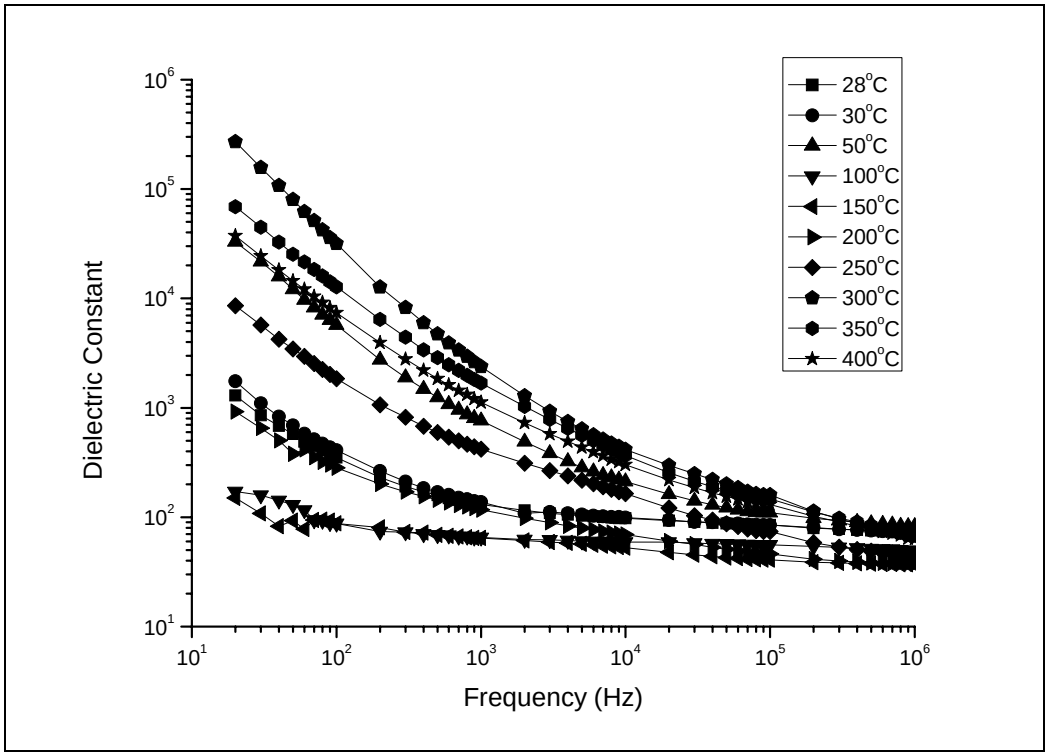

Figure 3: Dielectric constant of $Ba_{0.5}Sr_{0.5}TiO_3$ measured at different temperatures

CONCLUSION

In the present investigation, the dielectric properties of $Ba_{1-x}Sr_xTiO_3$ ceramics with x=0.3-0.7 have exhibited frequency and temperature dependence. $Ba_{0.5}Sr_{0.5}TiO_3$ produced the highest dielectric constant which is approximately 10^5 at low frequency.

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