

STRUCTURAL PROPERTIES OF Ba_{0.9}Sr_{0.1}TiO₃ FERROELECTRIC MATERIALS

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ABSTRACT

Objective: Ferroelectric materials are polar materials characterized by a transition to a paraelectric, nonpolar phase at a temperature at which their dielectric permittivity presents a maximum. Ferroelectric materials exhibit spontaneous polarization, the direction of which can be switched by applying an external electric field. Ferroelectric materials are a sub class of Pyroelectrics and Piezoelectrics.

Materials and Methods: Ferroelectrics (Ba_{0.9}Sr_{0.1}TiO₃) (BST) were prepared by a conventional standard double sintering ceramic method. The structural properties of ferroelectrics were investigated.

Result: The X-ray diffraction analysis was carried out to find the planes and calculate the lattice parameters, X-ray density, bulk density, intensity of highest peak and porosity of the ferrite and ferroelectrics.

Conclusion: The analysis of X-ray diffraction pattern shows that the prepared Ba_{0.9}Sr_{0.1}TiO₃ sample possesses Pervoskite tetragonal spinel structure. No other impurity phase was detected.

Keywords: - X-ray diffraction, lattice parameters, X-ray density, bulk density and porosity.

INTRODUCTION

Ferroelectric materials are polar materials characterized by a transition to a Paraelectric, Nonpolar phase at a temperature at which their dielectric permittivity presents a maximum. [1-2].

Some of the literature was written by protagonists of the facts here related. Ferroelectric, from the German "ferroelektrisch" was a term coined in 1912 by Erwin Schrodinger [3-5]. In fact, ferroelectric materials are a subclass of Pyroelectrics and Piezoelectrics. Pyroelectricity is known since ancient times (IV century BC) [6], first observed in Tourmaline, and rediscovered much later in the XVIII century being formulated by Brewster in 1824 [7]. Piezoelectricity was demonstrated in 1880 by P. J. and P. Curie [8] in Rochelle salt crystals (sodium potassium tartrate tetra hydrate). The first application was seen in SONAR technology during World War I. A few years after the introduction of piezoelectricity [9]. In 1935 another ferroelectric material was considered, the potassium dihydrogen phosphate (KDP), and finally in the 1940 the consideration of the ferroelectric properties in Perovskite oxides, namely barium titanate (BaTiO₃), started a new era in ferroelectricity [10].

We present here a historical introduction that summarizes a selection of comments and reviews found in the literature [11-12]. Some of the literature was written by protagonists of the facts here related. Ferroelectric, from the German "ferroelektrisch" was a term coined in 1912 by Erwin Schrodinger [13-15].

Ferroelectric materials exhibit spontaneous polarization, the direction of which can be switched by applying an external electric field. In fact, ferroelectric materials are a sub class of Pyroelectrics and Piezoelectrics. Pyroelectricity is known since ancient times (IV century BC) [16], first observed in Tourmaline, and rediscovered much later in the XVIII century being formulated by Brewster in 1824 [17]. In the case of crystals the direction of the dipole moment lies along one of the so-called polar axis, which is usually one of the high symmetry directions of the unit cell [18-19].

In the present study, strontium doped barium titanate (BaSrTiO₃) was used as a ferroelectric phase. Barium titanate BaTiO₃ is a ferroelectric material with a perovskite structure. It is first

discovered piezoelectric ceramic in cubic structure above Curie temperature (T_c), 120°C. Cubic BaTiO₃ is non ferroelectric because the centers of positive charges overlap as the ions are symmetrically arranged in the unit cell. Below T_c, it has tetragonal structure, in which the O²⁻ ions in the BaTiO₃ crystal are shifted in the negative c-direction, while the Ti⁴⁺ ions are shifted in the positive c-direction. It results an electric dipole along the c-axis. Therefore, BaTiO₃ is ferroelectric in tetragonal structure. BaTiO₃ was widely used in composites, electronic devices. BaSrTiO₃ [BST] has been considered to be an important ferroelectric material for tunable microwave devices because of its high dielectric constant, low dielectric loss and variable Curie temperature from 30 to 400 K, depending on the composition of strontium [20-24]. The substitution of Sr in BaTiO₃ in small amount can increase resistivity, high dielectric constant, etc and therefore it can be used in composites of ferrite and ferroelectric for enhancing the magnetoelectric (ME) coefficient. In the present paper the structural properties of Ba_{0.9}Sr_{0.1}TiO₃ are reported.

MATERIALS AND METHODS

Preparation of Ferroelectric material

Ferroelectric (Ba_{0.9}Sr_{0.1}TiO₃) were prepared by standard double sintering ceramic method. The ferroelectric was prepared following the same route by mixing AR grade BaCO₃, SrCO₃ and TiO₂ in their appropriate molar proportions and presintered at 950°C for 12h. After cooling the sample is ground for 4-5 h and post sintered at 1020°C for 16 h. The pellets having 3-4 mm thickness and 10 mm diameter were prepared using the hydraulic press.

Characterizations

The crystal structure of the obtained powders was analyzed by the X-ray diffraction (Phillips Model- PW3710) with the CuKα (λ=1.5406 Å) radiation at room temperature for the 2θ range from 20° to 80° and the scanning rate was 1°/min. The X-diffraction pattern (Fig.1) of the calcined powder synthesized using standard ceramic technique shows that the final product is Ba_{0.9}Sr_{0.1}TiO₃ with Pervoskite tetragonal spinel structure.

RESULTS

All the peaks that appear in the XRD pattern of ferroelectric have been identified; the occurrence of peaks with specific indices confirms the formation of Pervoskite tetragonal structure. The analysis of X-ray diffraction pattern shows that the final product is $(\text{Ba}_{0.9}\text{Sr}_{0.1}\text{TiO}_3)$ with the reflection (100), (101), (111), (200), (210), (211), (221), (220) and (301) planes for ferroelectric phase. All these reflections belong to tetragonal structure.

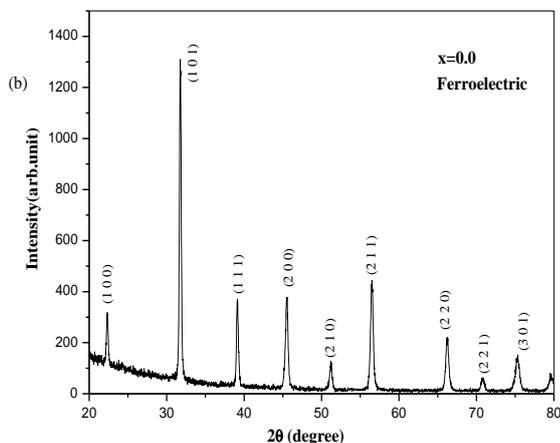


Fig. 1: XRD Patterns of $\text{Ba}_{0.9}\text{Sr}_{0.1}\text{TiO}_3$ Ferroelectrics

Table 1: The Structural Parameters of Ferroelectric Materials

Parameters	Ferroelectrics ($\text{Ba}_{0.9}\text{Sr}_{0.1}\text{TiO}_3$)
Lattice parameters (a) (Å)	a= 3.9821, c = 3.9978
Bulk density(db) (gm/cm^3)	3.08
Porosity (P) (%)	56.809
Intensity of highest Peak (I) (A.U.)	1310
Molecular weight (M)	272.24

DISCUSSION

The analysis of X-ray diffraction pattern shows that the prepared $\text{Ba}_{0.9}\text{Sr}_{0.1}\text{TiO}_3$ sample possesses Pervoskite tetragonal spinel structure. No other impurity phase was detected. The XRD data was

used to calculate lattice constants, bulk density, porosity, Molecular weight and the intensity of the major peak (101) for ferroelectric is shown in the table 1.

CONCLUSION

The X-diffraction pattern of the calcined powder synthesized using standard ceramic technique shows that the final product is $\text{Ba}_{0.9}\text{Sr}_{0.1}\text{TiO}_3$ with Pervoskite tetragonal spinel structure.

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