SYNTHESIS AND STRUCTURAL CHARACTERIZATION OF 0.50($Ba_{0.9}Sr_{0.1}TiO_3$) / 0.50($COFe_2O_4$) ME COMPOSITES

D.R.Sapate

Sant Ramdas Arts, Commerce and Science College, Ghansawangi,Jalna – 431209 (M.S.) India.

***Abstract*:**
The composites containing the two individual phases viz. ferrite ($CoFe_2O_4$) and ferroelectric ($Ba_{0.9}Sr_{0.1}TiO_3$) were prepared by standard double sintering ceramic method. Magnetoelectric (ME) composites of (x) $CoFe_2O_4$ + (1-x) $Ba_{0.9}Sr_{0.1}TiO_3$ with x = 0.0, 0.5 and x=1.0 were prepared by a conventional standard ceramic method. The X-ray diffraction analysis was carried out to confirm the phases formed during sintering and also to calculate the structural and lattice parameters.

Index terms*: *Magnetoelectric composites, X-ray diffraction, lattice constant etc.

1. INTRODUCTION

The magnetoelectric composites with piezoelectric and magnetostrictive material are of interest as transducers, which transform changes in a magnetic field into electric voltage and vice versa [1–3]. It can be used as a magnetic field sensor for an alternative tool of the Hall sensor for magnetic field measurement, or as an electric current measurement. Multiferroic materials have drawn many interests due to their potential multi-functional applications on transducers, sensors, and actuators [4, 5]. These materials can not only simultaneously exhibit ferroelectric and magnetic properties, but also a magnetoelectric (ME) effect between the electric and magnetic polarizations [6].Among various materials, $CoFe_2O_4$ (CFO) and $Ba_{0.9}Sr_{0.1}TiO_3$ (BST), as good examples of respective ferromagnetic and ferroelectric materials, have been intensively investigated for their large magnetostrictive coefficient and piezoelectric coefficient. The work available in literature about composites is mostly of Ni, Co, Ni–Cu–Zn, Ni–Co–Cu ferrites used as ferromagnetic phase and $Sr_{0.5}Ba_{0.5}Nb_2O_6$, $Ba_{0.9}Sr_{0.1}TiO_3$, ($Ba_{0.6}Sr_{0.4}$) TiO_3, $PbZr_{0.2}Ti_{0.8}O_3$, etc. -used as ferroelectric phase [7-11]. There are various methods used for synthesis of magnetoelectric composites such as sol-gel Method [12, 13], weight chemical method [14-15] and ceramic method [16-18] etc. Among these, ceramic method is widely used. This method is easy of cost and gives the fine nature of the ferrite as well as ferroelectric particles. In the present paper the synthesis and structural characterization of (x) $CoFe_2O_4$+ (1-x) $Ba_{0.9}Sr_{0.1}TiO_3$ composites with x = 0.0 (ferroelectric), x=1.0 (ferrite) and x= 0.5 (composites) are reported.

II.EXPERIMENTAL TECHNIQUES

Materials

The composites containing the two individual phases viz. ferrite ($CoFe_2O_4$) and ferroelectric ($Ba_{0.9}Sr_{0.1}TiO_3$) were prepared by standard double sintering ceramic method. The ferrite phase was prepared through solid-state reaction using AR grade CoO and Fe_2O_3 in appropriate molar proportions as starting materials.

Preparation of Composite Material

These basic oxides were mixed and ground in agate mortar for couple of hours and presintered at 950^0C for12h. The presintered sample is reground again for 4h and finally post sintered at 1100^0C for 24 h in programmable furnace. The ferroelectric phase was prepared following the same route by mixing AR grade $BaCO_3$, $SrCO_3$ and TiO_2 in their appropriate molar proportions and presintered at 950^0C for 12h. After cooling the sample is ground for 4-5 h and post sintered at 1020^0C for 16 h. The ME composites were prepared by mixing 50 mole % of $CoFe_2O_4$ phase with 50 mole% of $Ba_{0.9}Sr_{0.1}TiO_3$ phase respectively. The composite mixtures were presintered at 1100^0C for 16 h. The pellets having 3-4 mm thickness and 10 mm diameter were prepared using the hydraulic press. The flow chart of preparation of ME composite is as shown in fig.1

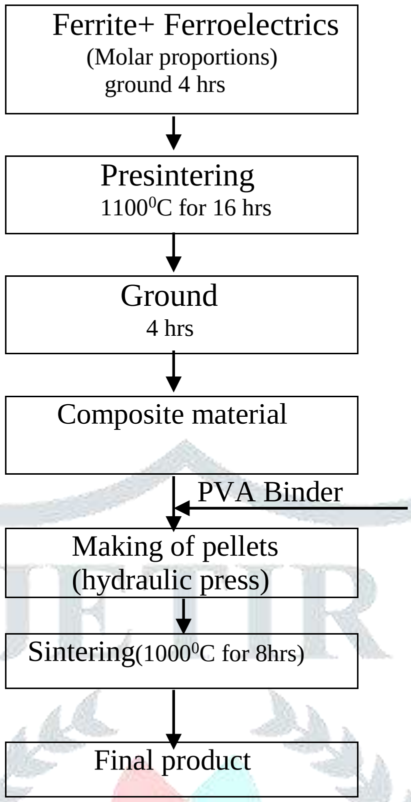

Fig (1) Flow chart of ME composite material synthesis by ceramic method

Characterization techniques

The samples were characterized by using X-ray diffractometer using CuKα radiations (λ= 1.5406 A^0). The crystal structure of the obtained composite powder was analyzed by the X-ray diffraction radiation at room temperature. The X-ray diffraction patterns were recorded at room temperature using Cu-Kα (λ=1.5406A^0) radiations and in the 2θ range of 20^0 to 80^0.Using XRD Data various structural parameters such as Lattice constant, unit cell volume, Experimental density (d_B), X-ray density (d_x) and Porosity (P %) of(x) $CoFe_2O_4$+ (1- x) $Ba_{0.9}Sr_{0.1}TiO_3$ ME composites etc. parameters were calculated.(Table 1 and Table 2)

III. RESULTS AND DISCUSSION

X-ray diffraction (XRD) analysis

Figure 1 shows the room temperature X-ray diffraction pattern of composite material. It is clearly seen that two phases viz. ferroelectric and ferrite phases can be clearly identified in the composites. No phases other than $Ba_{0.9}Sr_{0.1}TiO_3$ ferroelectric and $CoFe_2O_4$ ferrite were observed. This suggests that no significant chemical reaction has taken place during sintering, retaining the presence of distinct ferroelectric and ferrite phases. This is very important for the preparation of ferroelectric–ferrite composite materials so that the magnetic properties of ferroelectric and ferrite phases do not degrade on sintering. The intensity of the highest peak such as (311) for ferrite and (101) for ferroelectric depend on their individual phase fraction in the composite. The values of structural parameters of the present samples were compared with the literature values. It is found from the comparison that the structural parameters like lattice constant of the present samples are closer to the standard values than that of the literature values.

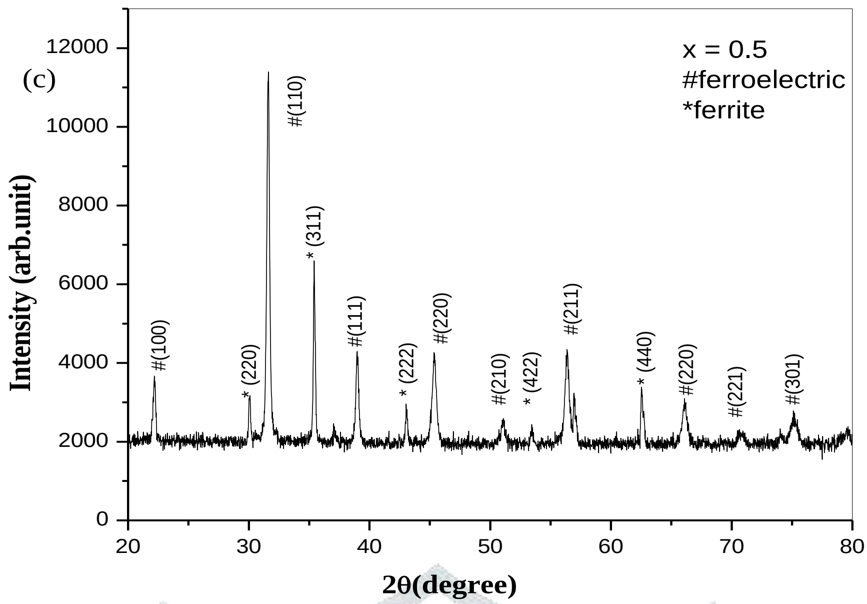

Fig. 1 XRD patterns of (x) $CoFe_2O_4$+ (1−x) $Ba_{0.9}Sr_{0.1}TiO_3$ ME Composites for x= 0.5

Table 1 The calculated values of Lattice parameter (a), Unit cell volume (V) of (x) $CoFe_2O_4$+ (1−x) $Ba_{0.9}Sr_{0.1}TiO_3$ ME Composites for x= 0.5

Table 2 .Experimental density (d_B), X-ray density (d_x) and Porosity (P %) of(x) $CoFe_2O_4$+ (1- x) $Ba_{0.9}Sr_{0.1}TiO_3$ ME composites

Ferrite Content(x)	(d_B) gm/cm^3	(d_x) gm/cm^3	(P) %
0.5	5.48	6.36	13.83

IV. CONCLUSION

The structural characterization proves that ferrite shows single phase cubic spinel structure, ferroelectric shows tetragonal structure and their composite shows separate phases of ferrites and ferroelectrics. The results obtained from X-ray diffraction study are in good agreement with standard data. All the diffraction peaks are the characteristics of constituent phases confirms the spinel cubic and tetragonal pervoskite crystal structure.

Ferrite content x	Lattice parameters (A^0)			(c/a)	Volume (V)(A^0)^3	
	Ferrite (a)	Ferroelectric phase			Ferrite a^3	Ferroelectric a^2c
		a	**c**			
0.5	8.397	3.9821	3.9977	1.0039	592.069	63.392

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