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Structural, Dielectric and magnetic Properties of (Ho, Ti) Modified BFO

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Abstract. $Bi_{0.80}Ho_{0.20}Fe_{0.80}Ti_{0.20}O_3$multiferroicswas synthesized by method of mixed-oxide route. The XRD,dielectric properties and magnetic measurements of the compound were carried out. The X-ray structural analysis shows mixed phase.Rietveld refinement of the XRD patterns deduce that the found it fit by the mixed phase setting of rhombohedral R3c and trielinic P1 space group. The change in crystal structure is attributed to the distortion of FeO_6 octahedra due to replacing a part of B- site Fe ions by Ti ions. Magnetic evaluation were performed at room temperature up to an external magnetic field of 16kOe.It was observed that the Ti co-dopingshows a significant role for the improving multiferroics properties.

INTRODUCTION

The materials in which at least two of ferroelectric, ferromagnetic and ferro-elastic ordering exhibit in the same phasesimultaneously have been under concentrated study recently [1-2].These materials have greatuse in the large magneto electric effect and have potential application which include information storage, spintronic devices, sensors etc. $BiFeO_3$ (BFO) belongs to this class [3] at room temperature. It is only single phase fascinating multiferroic material because of its high ferroelectric Curie temperature, (T_c=1143 K) and antiferromagnetic (AFM) Neel temperature (T_N =643K) [3-4]. The simultaneous doping of titanium and lanthanide can enhance together electrical and magnetic properties of $BiFeO_3$.Some other exciting results also have been reported in literature for $BiFeO_3$ when codoped with La and Ti;Dy and Ti[5].In this study, we have fabricated $BiFeO_3$ ceramics with codoping of Ho and Ti and found enhancement in electrical and magnetic properties.

Various attempts have been made by many researchers to enhance the multiferroicscharacteristics of BFO by co-doping at the sites A and B simultaneously. As Ho possesses high magnetic moment, so Bi has been substituted with it in the present work and therefore, co-doped $BiFeO_3$ceramic samples in which doping is done by Ho at A-site and Ti at B-site.

EXPERIMENTAL DETAILS

High quality oxide powders of Bi_2O_3, Ho_2O_3 ,Ti_2O_3 and Fe_2O_3 procured from Sigma Aldrich, their particular amount in stochiometric ratio was grounded thoroughly with the help of mortar and pestle for 2 hours and then calcinated for 3 hours at 400°C. The calcinated compound then grounded for 1 hour and sintered for 1 hour at 820°C in an alumina crucible. Structural analysis were performed using X-ray diffraction (XRD) using Rigaku-Miniflex II Desktop X-Ray diffractometer, scanning electron microscopy. The quality XRD pattern was further analyzed using a Rietveld refinement and Edper program in FullProf suite software. Micrographs evaluation were carried out using JEOL scanning electron microscope (SEM), respectively. Magnetization measurements were performed at room temperature using vibrating sample magnetometer (VSM) (model Lakeshore,7304).

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Sample	Model	Cell (Å)	Atom	x	y	Z	R-factor
	R3c	a= 5.5693	Bi/Ho	0.0000	0.0000	0.02485	
	(66.42%)	b= 5.5693	Fe/Ti	0.0000	0.0000	0.25115	
		c=13.6702	O	-0.1984	1.6068	0.7148	R_p=4.90
$Bi_{0.80}Ho_{0.20}$		V= 367.204(Å^3)					
$Fe_{0.80}Ti0_{.20}O_3$	P1	a= 4.3307	Bi/Ho	0.16159	7.85772	0.37914	R_{wp}=6.27
	(33.58%)	b= 4.0994	Fe/Ti	0.63868	8.46743	0.91230	
		c =3.8903	O1	1.5028	1.8327	0.1741	χ^2=4.88
		V= 68.2819(Å^3)	O2	2.8796	0.7321	-1.0982	
			O3	-1.2690	1.1918	5.6569	

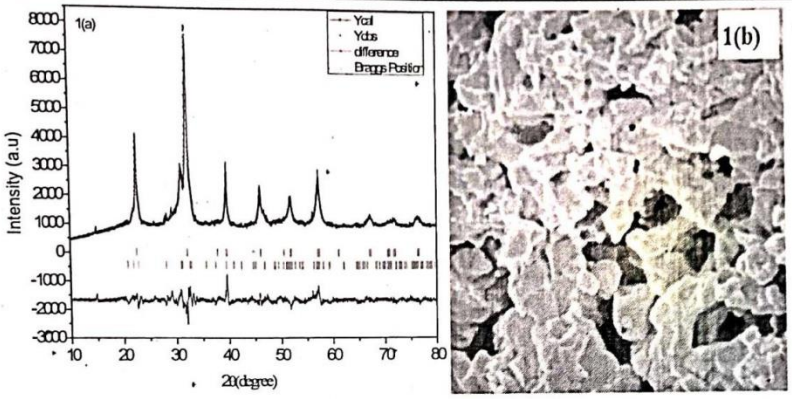

Fig 1.The Rietveld refined XRD patterns and 1(b) SEM micrographs of$Bi_{0.80}Ho_{0.}20Fe_{0.80}Ti0_{.20}O_3$ ceramic.

Fig. 1 shows the Rietveld refined XRD spectrums of $Bi_{0.80}Ho_{0.20}Fe_{0.80}Ti_{0.20}O_3$ The Rietveld refinement of XRD pattern was best fitted by the mixed phase assumption including rhombohedral R3c (≈66.42%) and triclinic P1 (≈33.58%).

The parameters obtained from refinement are summarized in Table I.

Table 1. Rietveld refined structural parameters of Bi0.80Ho0.20Fe0.80Ti0.20O3 of XRD.

Fig. 1(b) explain scanning electron micrographs (SEM) of $Bi_{0.80}Ho_{0.20}Fe_{0.80}Ti_{0.20}O_3$. The micrographs represent the dense and uniform morphology of the sample. It signifies that Ti doping suppressesthe growth of grainsresulting in small grain sizes of highly doped sample reflects in the SEM micrographs. Another possible reason of decrease in grain sizesis the dissimilarity in the ionic radius of Bi^{3+} and Ti^{3+}. Earlier studies suggested that the reduction in the grain size is ascribed to the suppression of oxygen vacancies with the Ti doping. Since the motion of oxygen vacancies during the sintering mechanismare responsible forgrowth of grains.Structural symmetry for (Ni, Co, Cd, Nd, Ho with Ti) co-doped BFO is summerized in Table 2.

TABLE 2. Structural symmetry for (Ni,Co,Cd,Nd,Ho with Ti) co-doped BFO is summerized.

S. No.	Compounds Name	XRD Structure	Average Crystallite Size	Reference
1.	$Bi(Ni_{1/4}Ti_{1/4}Fe_{1/2})O_3$	Orthorhombic Symmetry	28 nm	[2]
2.	$Bi(Ni_{0.45}Ti_{0.45}Fe_{0.10})O_3$	Tetragonal Symmetry	30 nm	[4]
3.	$Bi(Ni_{0.40}Ti_{0.40}Fe_{0.20})O_3$	Orthorhombic Symmetry	36 nm	[1]
4.	$Bi(Co_{1/4}Ti_{1/4}Fe_{1/2})O_3$	Orthorhombic Symmetry	30 nm	[3]
5.	$Bi_{0.90}Nd_{0.10}Fe_{0.93}Ti_{0.07}O_3$	Triclinic Symmetry	--	[5]
6.	$Bi_{0.80}Ho_{0.20}Fe_{0.80}Ti_{0.20}O_3$	Triclinic+ Orthorhombic Symmetry	26 nm	Present work

MAGNETIC ANALYSIS

Prestine BFO exhibiting a spatially modulated spin configuration along with G-type antiferromagnetic ordering which does not permitthe resulting net magnetization [2].On the basis of various reports it is concluded that Tico-doping at B-site of BFO is very effective in order to enhance the magnetic properties of BFO.Fig. 2 shows *M-H* hysteresis curves of the synthesised sample with a maximum field of ±10kOe at room temperature.The magnetic parameters calculated from *M-H* loop and comparison with published report are listed in Table3

TABLE 3. Comparison between magnetic parametters for co-doping (Ti) BFO.

S. No.	Compounds Name	Magnetic Parameters		Reference
		M_S(emu/g)	H_C(Oe)	
1.	$Bi(Ni_{1/4}Ti_{1/4}Fe_{1/2})O_3$	0.131	298.98	[2]
2.	$Bi(Ni_{0.40}Ti_{0.40}Fe_{0.20})O_3$	0.363	389	[1]
3.	$Bi(Co_{1/4}Ti_{1/4}Fe_{1/2})O_3$	2.66	653.75	[3]
4.	$Bi_{0.80}Ho_{0.20}Fe_{0.80}Ti_{0.80}O_3$	0.144	67.77	Present work

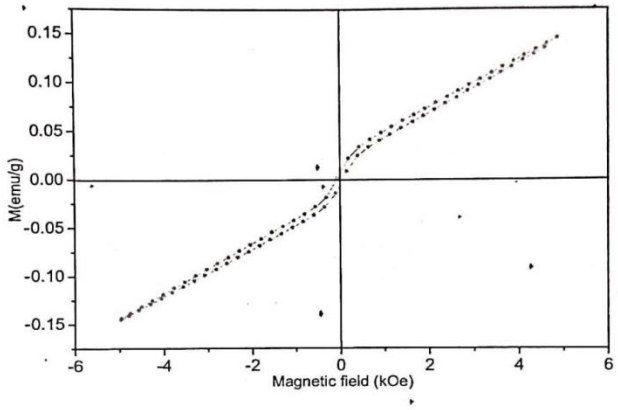

Fig 2 M-H hysteresis loop recorded at room temperature of $Bi_{0.80}Ho_{0.20}Fe_{0.80}Ti_{0.20}O_3$

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