iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4299

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Preparation and Characterization of Bismuth Ferrite Nanoparticle Using Sol–Gel Method

A. Bismibanu[1], M. Alagar[2], J.S. Mercy Jebaselvi[3], C. Gayathri[4]
[1]*Department of Physics, The Standard Fireworks Rajaratnam College for Women, Sivakasi - 626123, Tamilnadu, India.*
[2]*Center for Research and Post Graduate studies in Physics, Ayya Nadar Janaki Ammal College, Sivakasi-626124, India.*
[3, 4]*PG Student, Department of Physics, The Standard Fireworks Rajaratnam College for Women, Sivakasi - 626123, Tamilnadu, India.*

Abstract: ***Nano precursor of bismuth ferrite oxide was synthesized by Sol-Gel method from bismuth and ferrite. $BiFeO_3$ nanoparticle was prepared by calcination of the precursor at 600^oC for 4 h in Muffle Chamber. The synthesized sample was characterized by X-ray diffraction (XRD) and Vibrating Sample Magnetometer (VSM).***
Keywords: Nanoparticle, synthesis, XRD, VSM, Bismuth, Ferrite.

I. INTRODUCTION

Muilti ferroic materials are of particular interest due to the co-existence of ferromagnetic and ferroelectric properties. Among varies multiferroics, bismuth iron oxide ($BiFeO_3$/ BFO) is the only material that shows both ferroelectric and antiferromagnetic properties at room temperature [1].There is an increasing need for magnetic nanoparticles for different application that could be solved through high-performance technique producing large quantities of nanoparticles. In particular, bismuth nano particles are expected to play important role in a variety of relevant applications like an enhancing spontaneous magnetization, high super conductivity, high tech magnetic tape, photovoltaics, spintronics, and field of magnetism. This ferroic material can be synthesized by different methods such as Co-precipitation method, Sol-Gel technique, Microwave Assisted method, Hydrothermal, Solvo thermal, Micro emulsion methodsand Sono chemical synthesis.

Among these methods, Sol-Gel technique is one of the methods to synthesis nano particles are very simple and relatively clean materials. BFO nano particle is prepared by sol-gel technique using bismuth nitrate and ferric nitrate is dissolved with distilled water, nitric acid and citric acid.The synthesized bismuth ferrite (BiFeO3) nano-particle was characterized by X-Ray Diffraction (XRD) and Vibrating Sample Magnetometer (VSM).

Bismuth ferrites are one of the new classes of metal oxides have anti-ferromagnetic with a high Neel temperature T_N~643K and ferroelectric with high curie temperature T_C~1103K[2].Unit cell of BiFeO3 can be described by hexagonal, rhombohedral and pseudo-cubic structure, where $[111]_{hex} \parallel [111]_{rh} \parallel [001]_{pc}$[4]. From a structural point of view, the room-temperature structure of BFO is a highly rhombohedrally distorted perovskite with space group R3c [3].

II. EXPERMENTAL PROCEDURE

A. Synthesis of $BiFeO_3$ Nano particle

To prepare BFO nanoparticle, the molar ratio of the ions to the citric acid is maintained as 1:1. Bismuth trinitrate pentahydrate [$Bi(NO_3)_3.5H_2O$]and ferrictrinitrate nanohydrate [$Fe(NO_3)_3 \cdot 9H_2O$] were dissolved in 80 ml of distilled water with magnetic stirring to get homogeneous solution Nitric acid and citric acid were used without purification and de-ionized water was used for the sample preparation.Finally Ethylene glycol added drop wise to the stirring solution and the mixture was stirred for 2 hours.The solution is heated to 80 °C with constant stirring for the solvent evaporation. The yellow gel is formed and gradually transformed to xerogel. The residual organic precursor present in the sample is removed by heating at 250 °C for 2 h which yields a brown-coloured fine particle. The as-prepared bismuth ferrite is annealed at 600 °C in air atmosphere for 4 hours. The volatile matters such moisture and other unwanted components were removed [6].Finally, to get the $BiFeO_3$ nano particle.

III. RESULTS AND DISCUSION

A. X-ray Diffraction

X-ray Diffraction is analization to determine the crystalline phases of the core-shell nano particle. The X-ray Pattern of Synthesized Bismuth ferrite Powder is shown in Fig. 1. The observedpeaks in the XRD patterns could be identified to be rhombohedra distorted perovskite structure of $BiFeO_3$ withspace group R3c according to (ICDD No 86-1518)[3]. The prominent peaks in XRD plots are

similar to various (hkl) planes of Bismuth ferrite Nanoparticles thus confirming the synthesis.The broadness in the XRD is due to the presents of impurity. The average grain size (D) was calculated using Debye Scherer's formula as in equation from the Full Width at Half Maxima (FWHM) of the high intense peak from XRD data.

$$D=k\lambda/\beta\cos\theta \text{ (nm)} \text{ ---------- (1)}$$

Where,
k - The constant shape factor (0.9)
λ- The wavelength of X-rays (1.5406Åfor Cu kα)
θ - The Bragg's angle and
β - The FWHM

Intensities of diffraction peak as the function of angle 2θ.The crystallite size for the peak (012)was 24.4 nm, determined using Scherer equationwith high intensity peak at 2θ = 31.93° (104), (110) is index for rhombohedral structure.Beside these prominent peaks, some other peaks of $Bi_2Fe_4O_9$ were observed in low intensity [3]. It is obvious from the XRD studies that BFO nanoparticles are highlycrystallized and exhibit a single-phase perovskite structure. The commonly observed byproducts like Bi2Fe4O9,located at 2θ =27.97° (120), (121), (211). Hence, the XRD studies proved the synthesized BiFeO3 is highly crystalline and high purity.

The dislocation density (δ) is used to determine the amount of defects presents in the growth of the sample which are determined using the following equation.

$$\delta = \frac{1}{D^2} \text{ ---------- (2)}$$

The lattice strain (ε) is determine by the tangent formula,

$$\varepsilon = \beta/(4\tan\theta) \text{ ---------- (3)}$$

Obtain the value of dislocation density and lattice strain is found to be $1.679 * 10^{15}$ $(lines/m^2)$ and 0.0041 respectively

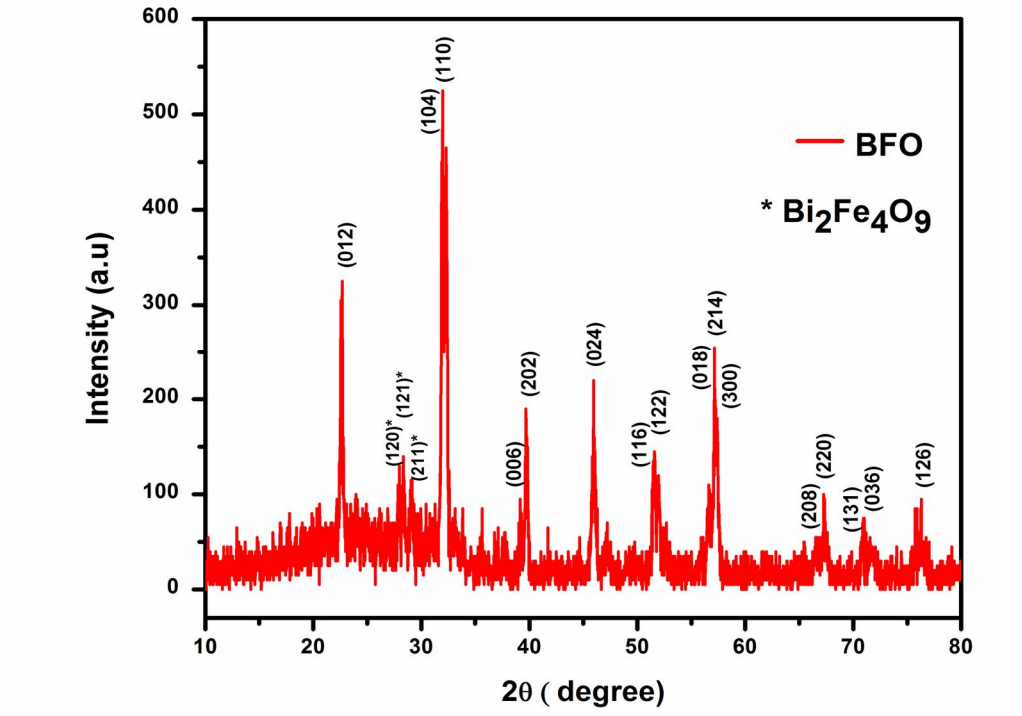


Fig. 2 XRD pattern of BFO measured at room temperature

TABLE 1
Crystalline Size, Dislocation Density and Lattice Strain of Bismuth Ferrite nanoparticle

Nanoparticle	Crystalline Size (D) nm	Dislocation Density (δ) 10^{15} $(lines/m^2)$	Lattice Strain (ε)
Bismuth Ferrite	24.4	1.679	0.0041

The Crystalline Size, Dislocation Density and Lattice Strain of prepared Bismuth Ferrite nanoparticle is shown in the Table 1.

B. Vibrating Sample Magnetometer

The magnetization curve is the undoped nanocrystalline BFO sample with maximum field of ±15 kOe. It clearly exhibits saturation at higher magnetic field. Fig. 2 shows that M-H curve for bismuth iron oxide nanoparticle prepared using sol-gel method.

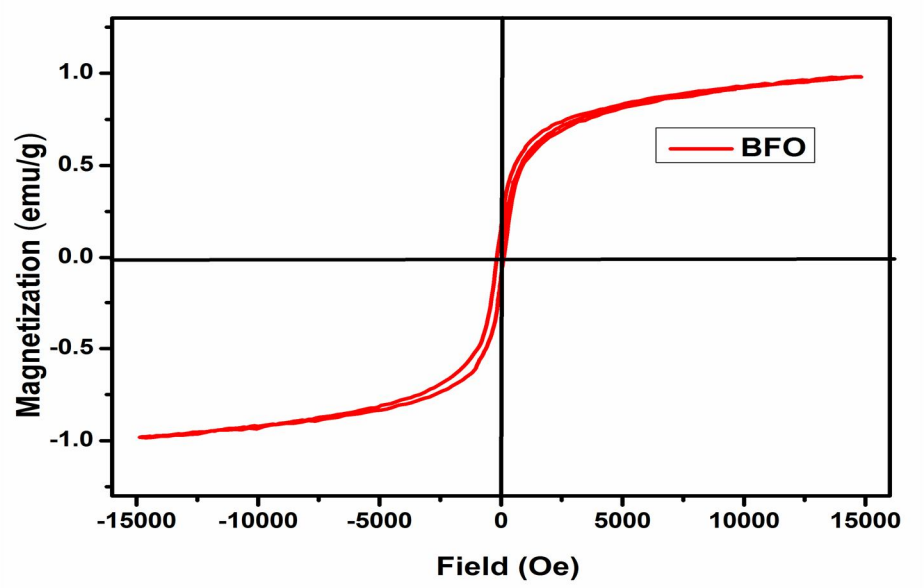


Fig. 2 VSM for BFO measured at room temperature

The pure BFO nanoparticle shows the small spontaneous magnetization in contrary to antiferromagnetic bulk BFO. The ferromagnetic behavior in BFO arises due to suppression of the known spiral spin structure, presence of oxygen vacancies, valance fluctuation of Fe^{3+} and Fe^{2+} cations [1]. In bulk BFO, the presence of spiral spins arrangement of wave- length 62nmisresponsibleforthesuppressionof magnetization. From the XRD analysis, it is found that the crystalline size of sample is in the nanometer range and also less than 62 nm [5].

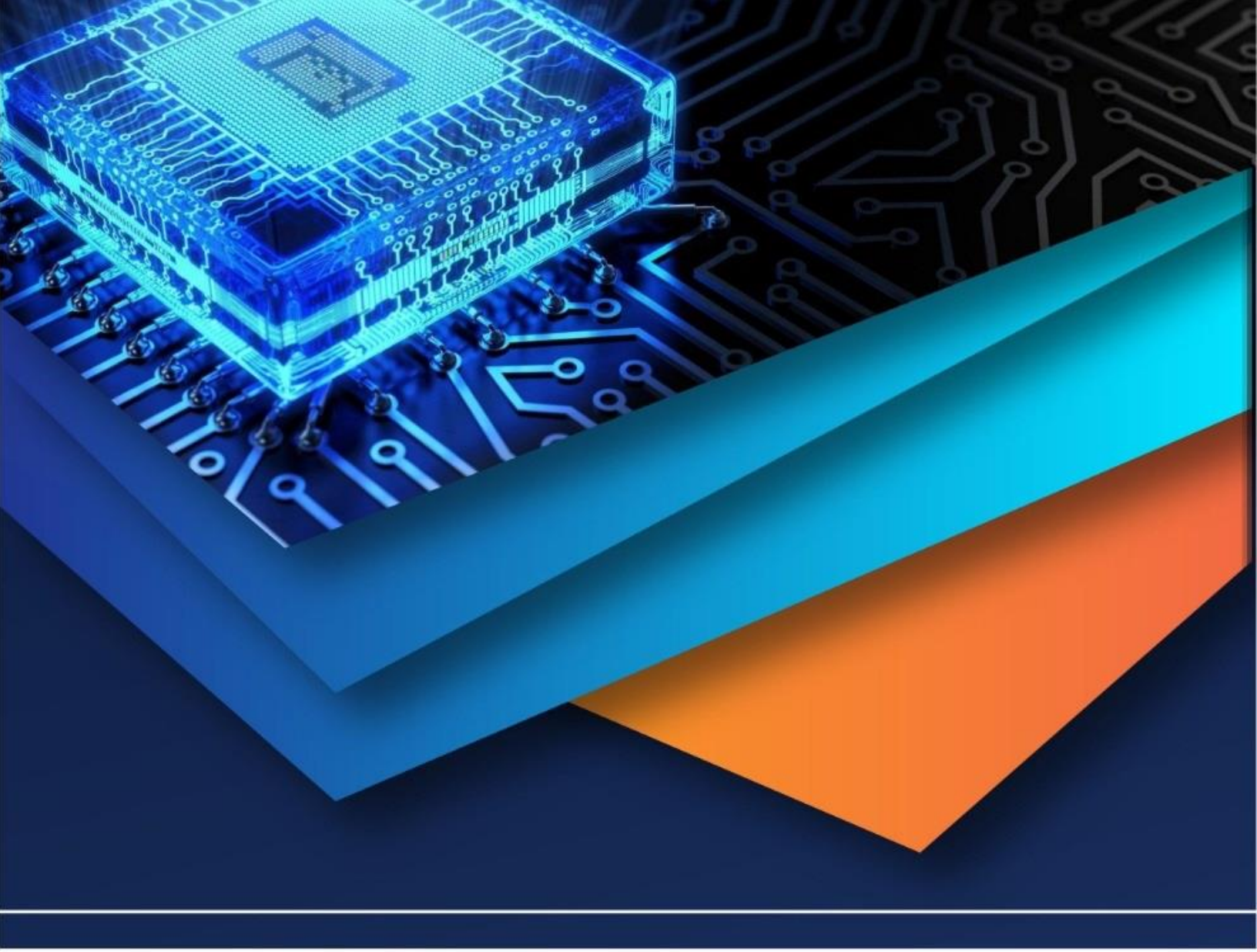
This happens due to the external surface spin contribution in comparison to the bulk perovskite ferrite. Crystalline size obtain from XRD for the undoped (pure) BFO is about 24.4nm which the undoped nanocrystalline bismuth ferrite exhibits nearly zero coercive field. From M-H curve analysis remenent magnetization (M_r) is measured around 0.3359 emu/g at zero external applied field and saturation magnetization (M_s) of about 0.9859 emu/g.

IV. CONCLUSIONS

Bismuth ferrite oxide ($BiFeO_3$) was prepared using Sol-Gel method.The XRD data analysis confirms that the prepared sample is bismuth ferrite oxide nanoparticle and also the size of the particle is found to be 24.4 nm which is the range between nanometer. From the study of the grain size of the particle, dislocation density and lattice strain are calculated.The VSM studies a calculation of magnetic properties concluded that the saturation magnetization of the value of 0.9859 emu/g and the remenent magnetization of the value of 0.3359 emu/g.

REFERENCE

[1] Farzana Majid, Saira Riaz and Shahzad Nazism, "Ferromagnetic and Dielectric Behavior of Bismuth Iron Oxide Nanoparticles under As-synthesized conditions," ACEM 14, PP 24-28, [2014].
[2] K. Karthikeyan, A. Thirumoorthi, "Synthesis, Characterization and Photoluminescence behavior of Bismuth Ferrites," IJAASR, Vol 2, 1, [2017].
[3] Inas Kamal Battisha, Ibrahim Sayed Ahmed Farag, Mostafa Kamal, Mohamed Ali Ahmed, EmadGirgis, Hesham Azmi El Meleegi and Fawzi El Desouki, "Dielectric and Magnetic Properties of Nano-Structure $BiFeO_3$ Doped with Different Concentrations of Co Ions Prepared by Sol-Gel Method," New Journal of Glass and Ceramics, Vol 5, PP 59-73, [2015].
[4] Aseya Akbar, Saira Riaz and Shahzad Naseem, "Preparation and Characterization of $BiFeO_3$ Thin Films by Sol-Gel Route," ACEM' 12, PP 26-30, [2012].
[5] Pradeep Reddy Vanga, R.V. Mangalaraja, M. Ashok, "Structural, Magnetic and Photocatalytic Properties of La and Alkaline Co-doped $BiFeO_3$ Nanoparticles," Material Science in Semiconductor Processing (ELSEVIER), Vol 40, PP 796-802, [2015].
[6] R.R. Sinha, S.K. Sinha, M. Mursaleen, SwapanBera, JaidevMahta, AshokKumar, "Synthesis of Bismuth Ferrite nano particles by sol-gel method and their Characterization," IOSR-JAP, Vol 7, PP 44-47, Feb, 2015.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY