Dera Natung Government College Research Journal ISSN: 2456-8228
Volume 5 Issue 1, pp. 68-71 January-December 2020

Short communication

Magnetic properties of composite (1-x)$BiFeO_3$-x$Ba_5PrTi_3V_7O_{30}$

Hage Doley[a,*]

Department of Physics, Dera Natung Government College, Itanagar-791113, Arunachal Pradesh.

***Abstract*:** Ceramic composite of (1-x)$BiFeO_3$-x$Ba_5PrTi_3V_7O_{30}$ with different x values are prepared by using high-temperature solid-state reaction technique. Magnetic measurement is done at low temperature by PPMS Vibrating Sample Magnetometer which shows that the magnetization is maximum for x=0.3.

Keywords: Multiferroic, Ferroelectrics, Hysteresis, VSM.

I. Introduction

Multiferroic materials are material that shows various ferroic orders (Spaldin et al., 2010). Among such types of materials, Bismuth Ferrite ($BiFeO_3$) is one of such kind which shows both ferroelectricity and ferromagnetic order simultaneously (Kumar et al., 2000). However, due to the semiconducting nature of $BiFeO_3$ (because of the presence of Fe in the compounds) it has a very low value of ferroelectricity, which severely restricts its use as Ferroelectric materials. But it was found that when $BiFeO_3$ is mixed with other pure Ferroelectric materials such as $Ba_5TbTi_3V_7O_{30}$ (Doley et al., 2019) there is a clear enhancement in the magnitude of ferroelectric polarization in $BiFeO_3$ (Doley et al., 2019, 2020). Furthermore, it was also found that there is also an improvement in the magnetization of $BiFeO_3$ when mixed with $Ba_5TbTi_3V_7O_{30}$ (Doley et al., 2020). Our aim is to see if there is any improvement in the magnetic properties when there is a change in the Rare Earth element i.e. when Tb is replaced by Pr.

II. Objectives of the Study

In our present work we are studying the magnetic properties of the composite (1-x)$BiFeO_3$-x$Ba_5PrTi_3V_7O_{30}$ (x = 1, 0.7, 0.3).

III. Materials and Methods

**Corresponding Author: hagedoley@gmail.com*
Received on: 30.05.2020, Revised on: 19.10.2020, Accepted on: 21.10.2020
Cite as: ***Doley H. 2020. Magnetic properties of composite (1-x)BiFeO3-xBa5PrTi3V7O30, Dera Natung Government College Research Journal, 5, 68-71.***
DOI: https://doi.org/10.56405/dngcrj.2020.05.01.09

$(1-x)BiFeO_3-xBa_5PrTi_3V_7O_{30}$ (x = 1, 0.7, 0.3) ceramics are developed by using solid state reaction technique. The starting precursor materials are stoichiometrically mixed and then calcined at 1023 K for 12 h at a rate of $1^{o}C$/min . The calcined powders are mixed with a small amount of PVB (polyvinyl butyral) as a binder and the powders are pressed as a disk in a stainless steel die under a pressure of 7 tons to make pellets of 1-2 mm of thickness and 12-13 mm in diameter. Finally, pellets are sintered at 1073K for 6 h followed by cooling at 2 ℃/min. Magnetic properties are analyzed using Physical Property Measurement System (PPMS: Quantum Design, San Diago, USA) Vibrating Sample Magnetometer (VSM). Hysteresis (M-H) loops are reported at room temperature 300 K.

IV. Results and Discussion

M-H hysteresis loops for the composite $(1-x)BiFeO_3$ - $xBa_5PrTi_3V_7O_{30}$ (for x = 0.3,0.7 and 1) at 300 K are shown in Figure 1. When $BiFeO_3$ is introduced to $Ba_5PrTi_3V_7O_{30}$, there is an advent of the spontaneous magnetic moment in the composite. It can be seen that even at the application of a very high external magnetic field, there is no saturation of magnetization, indicating the typical antiferromagnetic nature of the composite. The narrow loop of the hysteresis curve suggests that magnetization is induced one and has canted antiferromagnetic order spins. From Table 1 it can be seen that x = 0.3, has maximum magnetic Coercivity field i.e. H_c ~ -1620 Oe and x = 0.7 has maximum remanent magnetic field i.e. B_r ~ 123 X 10^{-4} emu/g having around 3 order more than x =0.3. However, as x increases i.e., $Ba_5PrTi_3V_7O_{30}$ in the system, there is a decrease in the area of the loop indicating the system goes into the paramagnetic state with a lower spontaneous moment. And for x = 1 ($Ba_5PrTi_3V_7O_{30}$) sample is pure paramagnetic in nature.

Table 1: The Magnetic properties are analyzed at room temperature (300 K).

Sample	H_c (Oe)	B_r (10^{-4} emu/g)
$Ba_5PrTi_3V_7O_{30}$	0	0
$0.7BiFeO_3$ -$0.3Ba_5PrTi_3V_7O_{30}$	-1620	0.179
$0.3BiFeO_3$ -$0.7Ba_5PrTi_3V_7O_{30}$	-1013	123

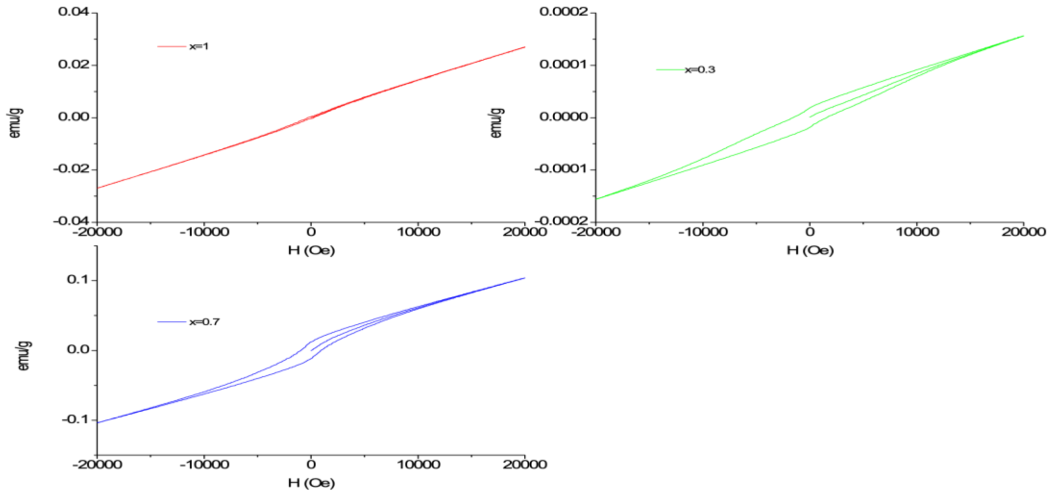

Fig. 1: M-H hysteresis loops for (1-x)$BiFeO_3$ - $xBa_5PrTi_3V_7O_{30}$ at 300K.

V. Conclusion and Recommendations

Magnetic measurement shows that the remnant magnetization is maximum for x = 0.3 i.e., 0.7$BiFeO_3$ – 0.3$Ba_5PrTi_3V_7O_{30}$ and the magnetic Coercivity field is maximum for x = 0.7 i.e., 0.3$BiFeO_3$ – 0.7$Ba_5PrTi_3V_7O_{30}$ and x = 1 (pure $Ba_5PrTi_3V_7O_{30}$) is paramagnetic in nature. Thus, it can be concluded that for x = 0.3 i.e., 0.7$BiFeO_3$ – 0.3$Ba_5PrTi_3V_7O_{30}$, the composite has most effective magnetic property having high magnetic Coercivity field and very high remnant magnetization. So, the composite material 0.7$BiFeO_3$ – 0.3$Ba_5PrTi_3V_7O_{30}$ could be considered as a very good multiferroic which can be used for construction of the non-volatile magnetic storage memory devices exploring the ferromagnetic properties.

References :

Spaldin, N. A., Cheong, S. W. and Ramesh, R. (2010). *Multiferroics: Past, present, and future.* Physics Today, 63(10), 38.

Kumar, M. M., Palkar, V. R., Srinivas, K. and Suryanarayana, S. V. (2000), *Ferroelectricity in a pure $BiFeO_3$ ceramic.* App. Phys. Lett., 76(19), 2764.

Doley H., Swain, P. K., Panigrahi, A. and Tado, G. T. (2019). *Study of structural and ferroelectric properties of the composite $Ba_5RTi_3V_7O_{30}$ (R=Pr, Tb).* Bull. Pur. & App. Sci., 38(2), 65.

Doley, H., Swain, P. K., Panigrahi, A. and Tado, G. T. (2020). *Structural and ferroelectric properties in the solid solution $(Ba_5RTi_3V_7O_{30})_x(BiFeO_3)_{1-x}$*. Ferroelectrics, 568, 104.

Doley, H., Panigrahi, A. and Chakraborty, P. (2019). *Study of electrical and magnetic properties of* *multiferroic composite* $(BiFeO_3)_x(Ba_5RTi_3V_7O_{30})_{1-x}$,. Adv. Ints. Sys. Comp., 862 451.

Doley, H., Swain, P. K. and Panigrahi, A. (2020). *Modulating the magnetic properties of* $BiFeO_3$ *by addition of* $Ba_5TbTi_3V_7O_{30}$, Proc. and App. of Ceram., 14(4), 277.