Magnetic Properties of Zn-Ti Substituted BaFe12O19

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Abstract

Barium hexaferrite BaFe12O19, is a ferrimagnetic substance. Its magnetic properties are mainly due to the particular site distribution of Fe ions in it. The Fe3+ ions in BaFe12O19, were partially substituted by Zn2+ and Ti4+ ions. This paper reports the study of the magnetic properties of the compound BaFe10ZnTiO19 synthesized using the solid state diffusion method. X-Ray diffraction (XRD) study confirmed the magnetoplumbite (M) structure for the sample and was found to have a single crystalline phase. Magnetic properties are studied with the help of Vibrating Sample Magnetometer (VSM). Magnetization (M) is plotted against applied magnetic field (H) at room temperature which shows decrease in saturation magnetization (Ms), Coercivity (Hc) and remnant Magnetization (Mr) in the doped sample.

Keywords- Magnetoplumbite, Magnetic Properties, Vibrating Sample Magnetometer, Coercivity

I. INTRODUCTION

Barium hexaferrite ($BaFe_{12}O_{19}$) or BaM is a well-known hexagonal M- type ferrimagnetic material with large saturation magnetization, chemical stability and corrosion resistivity. It is widely used in the manufacture of permanent magnets, magnetic recording media, electrical and electronic devices, transformers, etc. [1-5]. The structural and magnetic properties of the substituted hexaferrites strongly depend on the methods of synthesis, electronic configuration of the substituted cations, their site preferences and the concentration of the substituents

Many research groups have studied the effect of doping with different cations to investigate the physical properties of many hexaferrites. Such as Paul [6] examined the interparticle interactions, magnetic and structural properties of the M-type barium ferrite composite powders $BaFe_8(Ti_{0.5}Mn_{0.5})_4O_{19}$ and $BaFe_{8.5}(Ti_{0.5}Mn_{0.5})_{3.5}O_{19}$ with packing densities ~75%, embedded in synthetic rubber. Tyagi [7] developed nickel and zinc substituted strontium hexaferrite, $SrFe_{11}Zn_{0.5}Ni_{0.5}O_{19}$ ($SrFe_{12}O_{19}/NiFe_2O_4/ZnFe_2O_4$) nanoparticles. The maximum reflection loss of the composite reaches ~ 29.62 dB (99% power attenuation) at 10.21 GHz which suits its application in RADAR absorbing materials. 'The impedance analysis has been widely used to study the dielectric behaviour of the crystalline and polycrystalline ceramic materials.

Fe^{3+} ions in M type ferrite occupy five sublattices 2a, 2b, 12k with spins parallel to overall magnetization and another two sublattices $4f_1$ and $4f_2$ with antiparallel spins. So much work has been done to modify magnetic properties through the substitution Fe^{3+} ions. Teh et al. [8] have studied the substitution of Co (III) ion into $BaFe_{12}O_{19}$, which is mainly acting as a control specimen in comparison of magnetic properties with Co (II) substituted specimens. Zhang et al. [9] have doped MnO_2 in $BaFe_{12}O_{19}$ and found that Mn ions are distributed homogeneously in the grains and in the grain boundaries. The saturation magnetization and magnetocrystalline anisotropy constants both reach the highest values at a particular concentration.

Present work has been done to study effect of partial substitution of Fe^{3+} ions by combination of divalent Zn ions and tetravalent Ti ions so as to maintain proper stoichiometry.

II. MATERIALS AND METHODS

Polycrystalline hexaferrite with composition $BaFe_{10}ZnTiO_{19}$ was synthesized by the conventional ceramic technique using highly pure Fe_2O_3 (Sigma – Aldrich), ZnO, BaO and TiO_2 (all Merck). The powders were taken in proper proportion and presintered to remove traces of moisture. Then by proper grinding the mixture is heated at 1300° C for a long time to get the desired compound.

III. RESULTS AND DISCUSSION

A. Magnetic Properties

The change in Magnetization (M) (emu/g) with applied field (H) (Oe) at room temperature for undoped Barium hexaferrite and doped sample are shown in Fig.1 and Fig. 2 respectively. For undoped sample, M_s is 49.08 emu/g and H_c is 1.005 kOe which are low values as compared to the reported results indicating improvement of crystalline formation. The coercieve field also increases with increase in calcination temperature upto 1000 ^oC but after that it decreases.' The value of saturation (M_s) and coercivity (H_c) decrease with increase in the concentration of Zn^{2+} and Ti^{4+} ions and no hysteresis is observed in the doped sample. The net magnetization in the samples is due to the spins of Fe^{3+} ions. As Zn and Ti both are non-magnetic ions, when Zn^{2+} and Ti^{4+} ions

are substituted to $BaFe_{12}O_{19}$, they cannot add to the magnetization of the sample and hence the net magnetism is decreasing. It may be predicted that if concentration of Zn and Ti ions increase further then magnetic parameters may decrease further.

If change in magnetization is studied with variation in temperature, above room temperature for the sample, it may be observed that with increase in temperature Magnetic Moment and hence magnetization decreases and may become zero at a particular temperature called Curie temperature (T_c) after which substance becomes paramagnetic in nature.

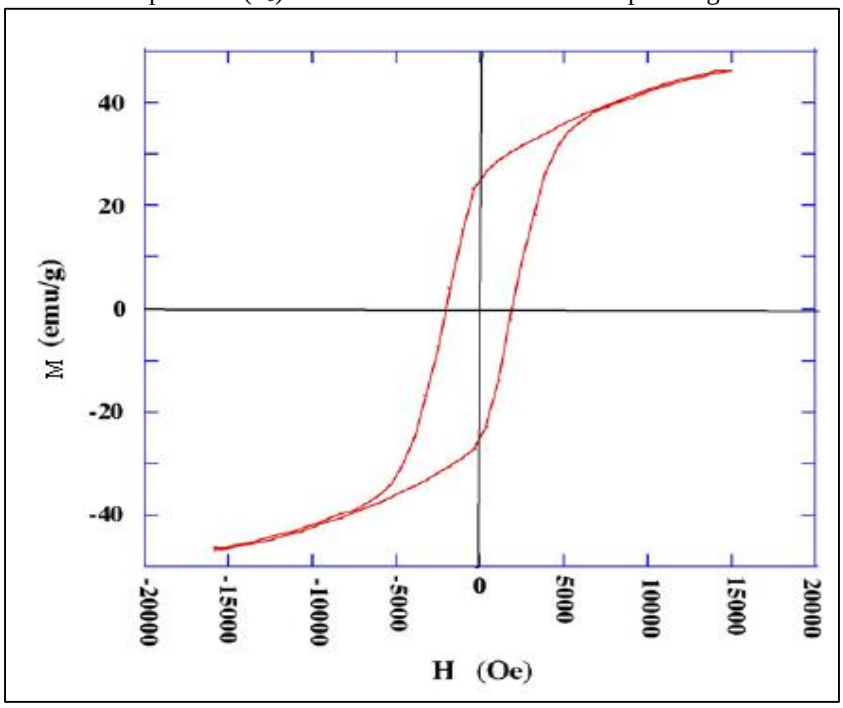

Fig. 1: M vs H curve for undoped sample

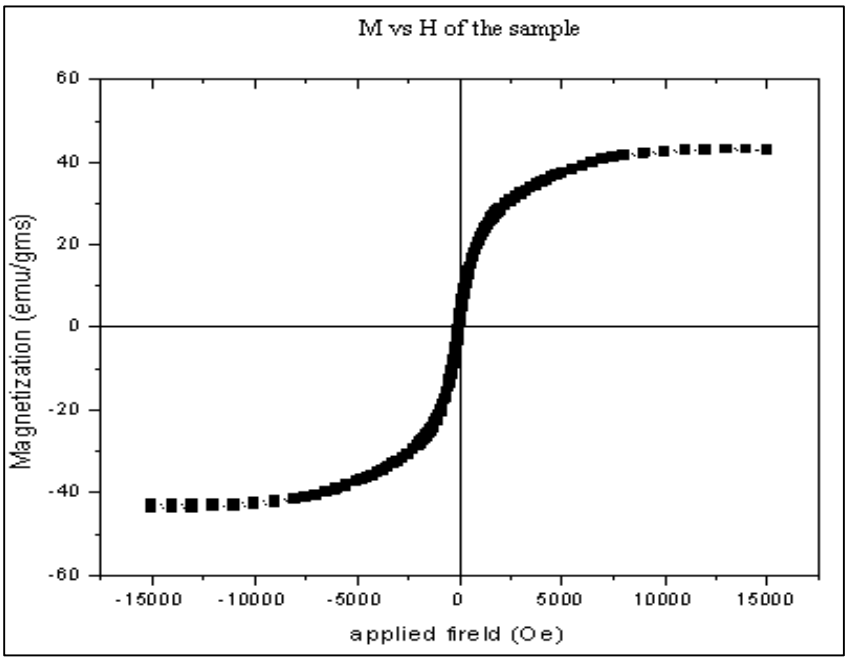

Fig. 2: M vs H curve for doped sample

IV. CONCLUSIONS

The sample $BaFe_{10}ZnTiO_{19}$ is synthesized by conventional ceramic method, and found to possess hexagonal magnetoplumbite structure with single phase.

Magnetization versus applied field curves show hysteresis for undoped sample shows hysteresis while in doped sample hysteresis is lost showing that with substitution the magnetic properties are decreased.

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