



MAGNETIC CHARACTERIZATION OF Sr_2 -W TYPE FERRITE SYNTHESIZED BY CO-PRECIPITATION METHOD

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ABSTRACT

A series of $CaSr_2 (MnZn)_{x/2}Fe_{16-x}O_{27}$ ($x=0.0,0.2,0.4,0.6,0.8,1.0$) W-type hexagonal ferrites were prepared by chemical co-precipitation method. The saturation magnetization (M_s), retentivity (M_r) and coercivity (H_c) were measured from MH-loops taken VSM. It was observed that the all M_s , M_r and H_c initially decreases with substitution upto $x=0.4$ and increases for higher substitution ($x>0.4$). This magnetic behavior is explained on the basis the site occupancy by substituent.

Keywords: Co-precipitation, VSM, Anisotropy, Coercivity, Relative permeability.

INTRODUCTION

Ferrites are magnetic materials, basically iron oxides, that show interesting magnetic properties. The advantage of ferrites is that they are more efficient and have low cost than other magnetic materials. Due to their better chemical stability, mechanical hardness, excellent corrosion and wear resistance and level of media noise, they are also suitable for rigid disk media without protective and lubricant layers[1]. Due to large magneto-crystalline anisotropy and strong dependence of the orientation of easy axis on the microstructure, they have the best potential for application in both perpendicular and longitudinal magnetic recording media. The magnetic properties of ferrites can be controlled by substitution of divalent or trivalent ions[2]. W-type hexaferrites are of special interest because of their wide applications. Mostly W-type barium hexaferrite are used as

electromagnetic wave absorbers[1,3], permanent magnets and recording media[4].

In the present work, the effect of Mn-Zn substitution on magnetic properties of Sr_2 -W type ferrite is studied.

EXPERIMENTAL

$CaSr_2(MnZn)_{x/2}Fe_{16-x}O_{27}$ ($x = 0.0, 0.2, 0.4, 0.6, 0.8, 1.0$) hexaferrites particles were prepared by chemical co-precipitation method[5-8]. A.R. Grade Calcium nitrate ($Ca(NO_3)_2$), Strontium nitrate ($Sr(NO_3)_2$), Manganese nitrate ($Mn(NO_3)_4$), Zinc nitrate ($Zn(NO_3)_2$) and Ferric nitrate ($Fe(NO_3)_3 \cdot 9H_2O$) were used as starting materials. Stoichiometric amounts of Calcium nitrate, Strontium nitrate, Manganese nitrate, Zinc nitrate and Ferric nitrate were dissolved one by one in 100 ml of distilled water. Ammonia solution (25%) was added slowly to adjust pH of 7. The mixed solution was stirred for two hours by using magnetic stirrer and was kept for 24 hours for ageing. The Calcium-Strontium hexaferrite precipitate was separated in a centrifuge machine. The precipitate was washed in 1:1 mixture of methanol and acetone followed by 100% de-ionized water to remove impurity. The precipitate was dried at 100° C for about 24 hours and crushed and calcinated at 1000°C for 4 hours. Finally crushed for 5 hours to obtained $CaSr_2 (MnZn)_{x/2}Fe_{16-x}O_{27}$ hexaferrite particles.

RESULTS AND DISCUSSION

Fig 1 shows M-H loops for as synthesized samples. The magnetic parameter as obtained from the M-H loops are tabulated in Table 1.

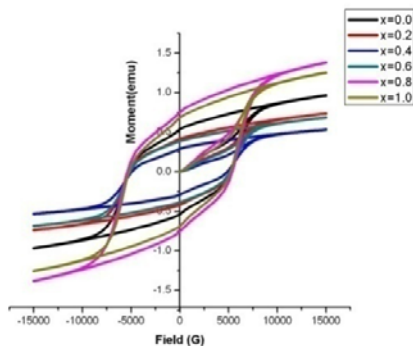


Figure 1: MH- Loops

Table 1: Magnetic Parameters

MnZn Conc. (x)	Coercivity Hci Gauss	Sturation Magnetization Ms emu/g	Retentivity Mr emu/g	Magnetic moment	Squareness	Relative permeability
0.0	5217.3	28.41	15.77	7.84	0.55	55.87
0.2	5179.1	21.66	12.29	5.98	0.57	44.18
0.4	4918.8	13.97	7.64	3.86	0.55	28.99
0.6	5124.1	20.77	11.69	5.74	0.56	44.31
0.8	5385.8	36.35	19.79	10.05	0.54	80.00
1.0	5210.1	40.45	22.14	11.19	0.55	83.15

The magnetic parameters of the samples are studied by using Vibrating Sample Magnetometer (VSM). The M-H loops for all the six samples of this series are shown in figures 5.34 to 5.39. The graphs are showing the variation of magnetic moment as a function of magnetizing field upto 15 KGauss. The corresponding magnetic parameters such as Hc, Mr, Ms, magnetic moment (μ), squareness and relative permeability are tabulated in table 1. The magnetic moment in terms of Bohr magneton is calculated by using the relation [3],

$$\text{Magnetic moment} = \frac{M \times M_s}{5585}$$

Where M is the molecular weight of the sample

The relative permeability is determined from the expression,

$$\text{Relative Permeability} = \frac{M_s \times d}{H_{max}}$$

Where d is the bulk density and H_{max} is the maximum applied field.

The magnetic properties of hexagonal ferrites are affected strongly by substitution of non(dia and para) magnetic cations[1,9-11]. The magnetic properties are affected by the occupancy of interstitial sites by the substituents. In W-Type hexagonal ferrites, Fe^{3+} ions are situated in five sublattices – 12k, 4f₁, 4f₂, 2a, 2b. Of which 12k, 4f₂ and 2a sites are octahedral, 4f₁ site is tetrahedral and 2b site is bipyramidal. Sites 12k, 2a and 2b have spin up configuration and contribute positively to magnetization. 4f₁ and 4f₂ sites have spin down configuration[1,12].

It is reported that Zn^{2+} has marked preference for tetrahedral site. Whereas Mn^{4+} may occupy tetrahedral or octahedral site. Replacement of Fe^{3+} at tetrahedral site 4f₁, which has spin down configuration, increases the net magnetic moment. The paramagnetic Mn^{4+} ions may occupy the spin up or spin down octahedral sublattices vacated by Fe^{3+} ions. This

replacement of Mn^{4+} ions into the octahedral site is responsible for the variation of net magnetization of the material[1].

The values of M_s and M_r found to decrease upto $x = 0.4$, thereafter they are showing increasing trend. The decrease in M_s initially may be attributed to occupancy of Mn in octahedral site with spin up($12k$) configuration. It is reported that Zn has strong preference to tetrahedral site[13]. Thus the occupancy of non magnetic Zn at tetrahedral site results in weakening of super exchange interaction between tetrahedral($4f_1$) and octahedral ($12k$) sites. This may be cause of reduction in M_s [14]. The decrease in M_s may be due to low magnetic moment of Mn and Zn than Fe[15]. Fe^{3+} ions in spin down state causes reduction in magnetization. Replacement of Fe^{3+} ions in spin down state increases M_s . Therefore the increase in M_s may be due to occupancy of Mn in tetrahedral spin down($4f_1$) sites[15].

The collinear arrangement of magnetic moments is determined by the super exchange interaction between Fe^{3+} ions in ferrites[14,16]. The substitution of much Zn weakens the super exchange interaction between tetrahedral & octahedral sites which results in a deviation of the collinear arrangement of magnetic moment and a destruction of magnetic structure. This may be the reason of decrease in M_r [14]. At higher concentration, the replacement of Fe^{3+} by Mn in spin down state may be the cause of increase in M_r .

High values of H_c is due to strong uniaxial magneto crystalline anisotropy in hexagonal ferrites. The contribution of $4f_2$ and $2b$ sites to anisotropy field is large. Thus initial decrease in H_c may be due to replacement of Fe^{3+} ions at both $4f_2$ and $2b$ sites. Another cause may be increase in grain size with substitution. In the present investigation, the porosity is found to decrease with Mn-Zn substitution upto $x=0.4$ and increases for higher concentration(published earlier)[17]. Pores offer hindrance to the flow of applied field across the grains. The grain size increment with substitution reduces inter granular pores. Therefore ferrites can be demagnetized at low applied field which decreases H_c . The increase in H_c at higher concentrations($x=0.8,1.0$) may be simply due to increase in porosity[15,18].

CONCLUSION :

The high values of H_c is due to strong uniaxial magneto crystalline anisotropy in hexagonal ferrites. There is not much change in H_c with substitution. Large values of H_c suggest that the material belongs to the category of hard ferrite. High values of resistivity and H_c suggests that the present samples are useful for high frequency applications. The M_s magnetization and M_r decreases initially with substitution and increases at higher substitutions.

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