Integr. Res. Adv. 2014, 1(1), 5-7 Article

Integrated
Research Advances

Integrated Science

Study of magnetic properties of mixed Cobalt-Zinc Ferrites synthesized by solid state reaction technique

Leena Jaswal,[1] Brijesh Singh[2]

[1]*Department of Physics, Dravidian University, AP.* [2]*Department of Physics, RKMV Shimla, HP.*

Received Date: 12-June-2014

ABSTRACT

Cobalt and Zinc ferrites CoxZnyFe2O4,(x=0.7,0.3,0.4,0.2 and y=0.3,0.7,0.6,0.8) were prepared by solid state reaction technique. The crystalline structure of the sample was investigated by X-ray diffraction(XRD). All samples show cubic spinel structure. The lattice parameter decreases with increasing cobalt content. Magnetic properties shows that the prepared sample exhibit ferromagnetic behaviour at room temperature. The saturation magnetization increases with increasing cobalt content. Curie temperature of various samples were calculated. The Curie temperature increases with increasing content of Cobalt ions. The variation of initial permeability and magnetic loss with frequency are explained with the help of established models.

Keywords: Cobalt – Zinc ferrite, XRD, Magnetic Properties, Values of Saturation Magnetization, Curie Temperature.

INTRODUCTION

Magnetism, the phenomenon by which material assert an attractive or repulsive force on or influence on other material has been known for thousands of years. Many of our modern technological devices rely on magnetism and magnetic material. These material are used in electrical power generator, transformer, electric motors, radios, television, telephone, computers, component of sound and videos reproduction system. Ferrites, combining insulating and ferrimagnatic properties, have long been used in technology. The study of mixed Co-Zn ferrities is attractive because of their importance in ferro-fluids, magnetic drug delivery, hyperthermia for cancer treatment etc.[1]. Research on the application of ferrites for protecting the natural environment is currently being actively investigated . Research is also in progress for the purpose of using ferrites as a carrier for intensifying X-rays in the human system. This will be a magnetic intensifier and interestingly, can be remotely controlled. Strong, high frequency magnetic fields were recently reported to have a strong effect on cancer. The objective of the present work is to prepare the sample of mixed Co-Zn ferrites by solid state reaction technique and investigate the magnetic properties of these samples. The results of properties like saturation magnetization, Curie temperature, initial permeability and magnetic loss factor are reported in this paper. The variation in these properties are explained with the help of established models and theories.

Leena Jaswal
kz hema & rup bhawan near sub judge residence sunder nagar HP 175018
Tel:09418074754
Email: leenathakur26@gmail.com

Cite as: *Integr. Res. Adv., 2014, 1(1), 5-7.*

EXPERIMENTAL TECHNIQUES

The spinel ferrites of composite formula $Co_xZn_yFe_2O_4$ (x=0.7,0.3,0.4,0.2 and y= 0.3,0.7,0.6,0.8) were fabricated by solid state reaction technique. The crystalline structure of the sample were investigated by X-Ray diffraction. All samples show cubic spinel structure. The magnetization was measured at room temperature in a magnetizing field, using a vibrating sample, magnetometer. The lattice parameter were calculated for all the composition. The measurements of magnetization with the help of Hysteresis loop technique, at room temperature were done for all the prepared sample. The saturation magnetization of each sample was carried out using high field Hysteresis loop technique[2].The Curie temperature was measured for all the samples. The initial permeability was determined by measuring the inductance of toroidal sample by the method, given by Heck[3]. The Toroid having ratio of outer diameter to innerdiameter equal to 1.5 and thickness 20mm used for this purpose. About 55 turn of 30 swg enameled copper wire were wound on these toroid was measured at room temperature at various frequencies using an LCR meter bridge. The initial permeability is expressed as the ratio of inductance L of the sample Lo inductance with air core,

$$\mu_i = L/Lo$$

The magnetic loss factor, tanδ is defined as the ratio of core-loss resistance to reactance, and consist of three components; namely Hysteresis loss, eddy current loss and residual loss and is expressed by the following formula:

$$\tan\delta = Rm/\omega L$$

Rm → core loss resistance, ω → 2∏f and L is inductance of test coil with core. The variation of magnetic loss factor with frequency is reported in this paper.

RESULT AND DISCUSSION

Typical X-Ray diffraction pattern for the samples of $Co_xZn_yFe_2O_4$ (x=0.7,0.3,0.4, 0.2 and y= 0.3,0.7,0.6,0.8) are shown in fig.1.

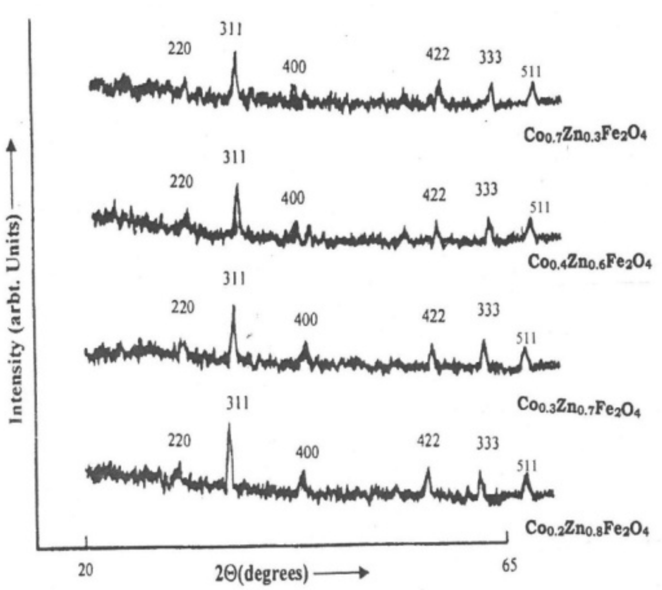

Figure 1..XRD Patterns of Co-Zn ferrites.

All samples show cubic spinel structure. The lattice parameters were calculated for each sample. It is observed that the lattice parameter (a) decreases with increasing cobalt content. The reason for this decrease of lattice parameter values may be due to the smaller ionic radii of Co^{2+}(83.8 pm) as compared to Zn^{2+}(88pm).The saturation magnetization of the annealed samples of $Co_xZn_yFe_2O_4$ ferrite system were calculated and are in good agreement with the reported values. In cubic system of ferromagnetic spinels, the magnetic order is mainly due to a super exchange interaction mechanism occurring between the metal ion in the A and B sub lattices. The substitution of nonmagnetic ion such as Zinc, which has a preferentially A site occupancy results in the reduction of the exchange between A and B sites. According to Neel's two sub lattice model of ferrimagnetism , the magnetic moment per formula unit in μB is expressed as

$$\mu_B N(x) = M_B(x) - M_A(x)$$

Where M_B and M_A are the B and A sub lattice magnetic moment in μ_B respectively. The values of saturation magnetization for samples are listed in table 1. The value of saturation magnetization in 125.5 emu/g for $Co_{0.7}Zn_{0.3}Fe_2O_4$ and $Co_{0.2}Zn_{0.8}Fe_2O_4$ for 30.2 emu/g.

Table 1. Values of Saturation Magnetization Ms (emu/g)

S.No.	Concentration. (x)	Saturation Magnetization Ms (emu/g)
1	$Co_{0.7}Zn_{0.3}Fe_2O_4$	125.5
2	$Co_{0.4}Zn_{0.6}Fe_2O_4$	70.3
3	$Co_{0.3}Zn_{0.7}Fe_2O_4$	50.4
4	$Co_{0.2}Zn_{0.8}Fe_2O_4$	30.2

Co^{2+} ion preferentially occupy B-site[4] and the variation of saturation magnetization with increasing substitution of Co^{2+} ion is attributed to the high exchange interaction energy and relatively higher orbital contribution of Co^{2+} ions for magnetic moment[5].The Curie temperature of samples was measured and values are given in table 2.

Table 2. Values of Curie Temp. T_c

S.No.	Concentration. (x)	Curie Temp. T_c
1	$Co_{0.7}Zn_{0.3}Fe_2O_4$	520
2	$Co_{0.4}Zn_{0.6}Fe_2O_4$	490
3	$Co_{0.3}Zn_{0.7}Fe_2O_4$	480
4	$Co_{0.2}Zn_{0.8}Fe_2O_4$	470

In the present work substitution of Cobalt ion has been successfully used to increase Curie temperature. Physically, at Curie temperature, the thermal agitation is so violent that it reduces, on average, the alignment of the magnetic moment along a given axis to zero. It follows that a ferromagnetic material above its Curie temperature is paramagnetic. The variation of initial permeability, μ_i, with frequency is shown in Figure 2.

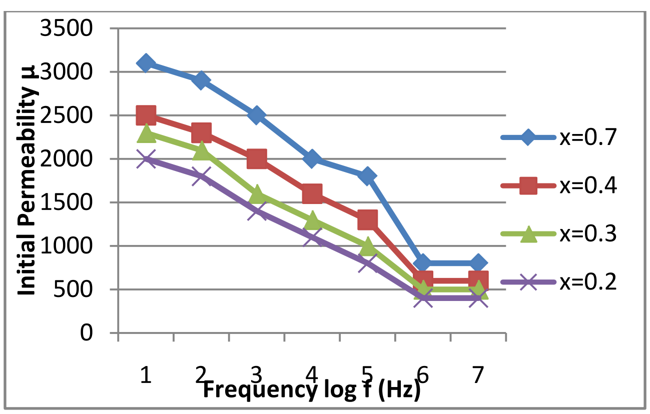

Figure 2. Variation of Initial Permeability with Frequency of $Co_xZn_{1-x}Fe_2O_4$ Ferrites.

The values of initial permeability remains constant for all samples. This can be explained on the basis of Globus model. According to this model the relaxation character is ,

$$(\mu_i - 1)^2 . f_r = \text{constant}.$$

The initial permeability in ferrite is due to domain wall displacement and remains constant with frequency as long as there is no phase lag between the applied field and domain wall displacement[6]. The magnetic loss is shown in fig.3.

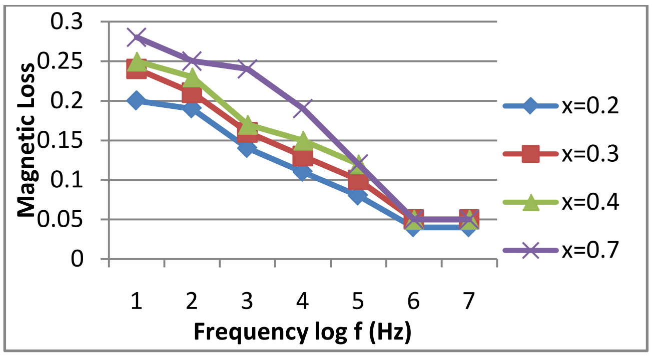

Figure 3. Variation of Magnetic Loss with Frequency of $Co_xZn_yFe_2O_4$

The value of magnetic loss factor (tanδ) is high at low frequency and decreases continuously below 1MHz. The tanδ remains almost constant above frequency of 1MHz. The loss is in agreement to that reported for ferrites by other worker.[7,8]

CONCLUSION

1. All the samples under investigation have a spinel structure with single phase in X-Ray diffraction analysis.
2. The values of M_S increases with increase in Cobalt content.
3. Curie temperature increases with increase in Cobalt content.
4. μ_i decreases with increasing substitution of Cobalt content ions.

REFERENCES AND NOTES

1. K. Raj, R. Moskowitz, R. Casciari. Advances in ferrofluid technology. *J. Magn. Magn. Mater.* **1995**, 149, 174-180.
2. C.R. Murthy, S.D. Likhite, S.P.Sastri. Philosophical Magzine. **1971**, 23, 503.
3. C. Heck. Magnetic Materials, their application. Butter Worths: London. **1974**.
4. E. Rezlescu, L. Sachelarie, P.D. Popa, N.Rezlesecu. Effect of substitution of divalent ions on the electrical and magnetic properties of Ni-Zn-Me ferrites. *IEEE trans on magn.* **2000**, 36, 3961.
5. B.S. Chauhan, R. Kumar, K.M. Jadhav, M.Singh. Magnetic study of substituted Mg-Mn ferrites. synthesized by citrate precursor method. *J.Magn.Magn. Mater.* **2004**, 283, 75.
6. A.K. Singh, T.C. Goel, R.G. Mendiratta, O.P. Thakur, C. Prakash. Magnetic properties of Mn-substituted NiZn ferrites. *J. Appl. Phys.* **2002**, 92, 3872.
7. S.H. Kang, H.I. Yoo. The effect of nonstoichiometry (delta) on the magnetic properties of $(Mg_{0.22}Mn_{0.07}Fe_{0.71})(3\text{-delta})O_4$ ferrite. *J.Appl.Phys.* **2000**, 88, 4754.
8. O.F. Caltm, L. Spinu. Magnetic Properties of High Frequency Ni-Zn Ferrites Doped with CuO. *IEEE trans .Magn.***2001**, 37, 2353.