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MAGNETIZATION STUDY Of $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ ARE PREPARED BY USING SOL-GEL AUTO COMBUSTION METHOD

S. T. Alone[1]*, R. H. Kadam[2], A. G. Patil[3], S. E. Shirsath[3]

[1*]Department of Physics, Rajarshi Shahu A.S.C. College, Pathri, Aurangabad (MS) India

[2]Materials Research Laboratory, Srikrishna Mahavidyalaya Gunjoti, Osmanabad(MS), India

[3]Department of Physics, Vivekanand College, Aurangabad (MS), India.

[*]**Corresponding Author**: drsureshtalone@gmail.com

ABSTRACT:

$Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ (x = 0.0, 0.25, 0.50, 0.75, 1.0) nano particles have been synthesis by the sol–gel auto combustion method, using nitrates of the respective metal ions, and citric acid as the starting materials. The process takes only a few minutes to obtain as-received Cr-substituted Ni-Cu-Zn ferrite powders. Saturation Magnetization (Ms), Remnant magnetization (Mr), Coercivity, and Remnance ratio, molecular weight and magneton number measured at 300 K using high field hysteresis loop technique decreases with increasing *x*, suggesting decrease in ferrimagnetic behaviour.

KEYWORDS: Sol-Gel method; Nano ferrite, magnetization

1. INTRODUCTION

The magnetic, piezomagnetic and magneto-mechanical properties of the nickel-rich ferrites were investigatedin the last 70 years [1-7]. Ni-Cu-Zn ferrites are excellent soft magnetic materials in high frequency devices due to their low cost, high resistivity and low eddy current losses, which have been studied extensively for multiplayer chip inductor applications. But up to now Ni-Cu-Zn ferrites for RF integrated inductors have been reported scarcely. $Ni_{0.4}Cu_{0.2}Zn_{0.4}Fe_2O_4$ thin films were fabricated by sol-gel method and RTA process. Magnetic nanoparticles of spinel ferrites are of great interest in fundamental science, especially for addressing the fundamental relationships between magnetic properties and their crystal chemistry and structure. Super paramagnetism is a unique feature of magnetic nano-particles and is crucially related to many modern technologies including ferro fluid technology [8], magneto electric refrigeration, contrast enhancement in magnetic resonance imaging (MRI) [9], and magnetically guided drug delivery. Super-paramagnetic properties have been extensively studied in the pure metal nano-particles, such as Fe, Co, and Ni with the size confined within only a few nanometers, whose applications are limited by the poor chemical stability. Recently, more attention has been focused on the preparation and characterization of super-paramagnetic metal oxide nano-particles such as spinel ferrites, MFe_2O_4 (M = Co, Mg, Mn, Zn, etc.).

Ni-Cu-Zn ferrites are well-established soft magnetic materials for multilayer chip inductor (MLCI) applications because of their high electrical resistivity, hard mechanical properties, high Curie temperature, and environmental stability. Recently, studies have been carried out on the Ni-Cu-Zn ferrite nano-particles though no studies of Al^{3+}substitution in the Ni-Cu-Zn ferrite are reported. The present work is focused on the Al^{3+}substitution in the Ni-Cu-Zn ferrite to check their modified properties for MLCI application. The aim of this paper is synthesis and to study the magnetic properties of the samples of the series $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ (x = 00.0, 0.25, 0.50, 0.75, 1.0) are prepared by using Sol-Gel auto combustion method.

2. EXPERIMENTAL:

The samples of the series $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ (x = 00.0, 0.25, 0.50, 0.75, 1.0) are prepared by using Sol-Gel auto combustion method. The starting samples were taken in the form of Nitrates as, Nikel Nitrate, Copper Nitrate, Zinc Nitrate, and Ferric Nitrate. The obtained powder was then subjected to further heating treatment into a muffle furnace at 600^0C for six hours. The final product is then grinded and subjected to further study. The magnetic properties were measured using pulse field technique.

3. RESULTS AND DISCUSSION:

Plots of magnetization versus applied magnetic field (M-H loops) for all the samples except for x=1.0 are given in Figure 1. Saturation Magnetization (**Ms**), Remnant magnetization (**Mr**), Coercivity, and Remnance ratio, molecular weight and magneton number for $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ are given in Table 1. It can be seen from table 1 that coercivity and remanance ratio both decreases with Al^{3+} concentration x. The large values of coercivity indicate nano-size nature of the prepared samples. The values of coercivity are in the reported range to that of other nano size spinel ferrite. The saturation magnetization M_S founds to decreases with Al^{3+} content x. The decrease in magnetization is explained by the A-B interaction. In the present case, Al^{3+} ions of low magnetic moment values ($3\mu_B$) replace Fe^{3+} ions of high magnetic moment ($5\mu_B$). The magnetic moment in ferrite is mainly due to the uncompensated electron spin of the individual ions and the spin alignments in the two sub-lattices, which are arranged in an anti-parallel fashion. In a spinel ferrite, each ion at the A site has 12 B-site ions as nearest neighbours.

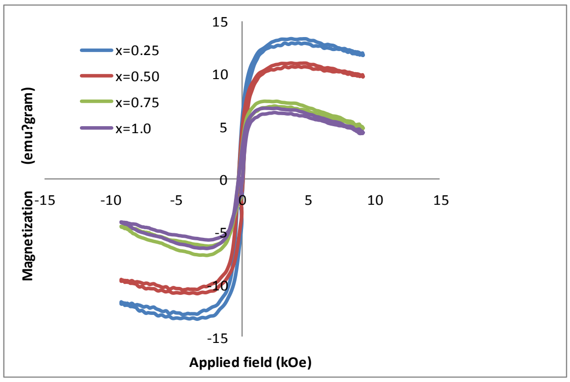

Fig. 1 *Variation of Magnetization with applied field of samples for the system* $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ (x = 0.25, 0.50, 0.75, 1.0)

Using M_S values, the magneton number n_B has been calculated using the relation,

$$n_B = \frac{Molecular\,Weight \times M_s}{5585} \qquad (1)$$

The values of magneton number are also given in Table 1. It can be seen from values of magneton number that magneton number decreases with Al^{3+} content x. The decrease in magneton number may be due to the substitution of Al^{3+} ions of low magnetic moment in place of Fe^{3+} ions of high magnetic moment.

The main contribution of magnetic property carries from presence of Fe^{3+} ions on octahedral [B] site of spinel lattice. In the present work Fe^{3+} ions at octahedral B-sites are decreasing due to the substitution of Al^{3+} ions at B-site. This also causes the decreases in A-B interaction and hence the magnetization of the system $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ decreases with Al^{3+} concentration x. To understand the magnetic behaviour of the present samples, Neel's model has been applied. According to Neel's two sub-lattice model of ferrimagnetism, the Neel's magnetic moment is given by,

$$n_B = M_B - M_A \qquad (2)$$

where, M_B is magnetic moment of B-site, M_A is magnetic moment of A-site. The values of calculated magneton number are given in Table 1. The observed magneton number and calculated magneton number are compared and it is found that there is a difference in their values. This clearly suggests that there exists a canting at octahedral [B] site and structure is non-collinear. The difference in observed and calculated values of magneton number is due to the canting effect resulted from substitution of Al^{3+} ions in place of Fe^{3+}ions.

Table. 1 Saturation Magnetization (**Ms**), Remnant magnetization(**Mr**), Coercivity, and Remnance ratio, molecular weight and magneton number for $Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$

x	Ms	Mr	Coer civity	Remnant Ratio	Molecular Weight	nB
0.25	12.05	5.76	304.76	0.48	230.63	0.50
0.50	9.87	4.72	288.54	0.48	223.41	0.39
0.75	4.81	3.19	262.87	0.66	216.19	0.19
1.00	4.29	2.90	248.63	0.68	208.98	0.16

4. CONCLUSION:

$Ni_{0.4}Cu_{0.3}Zn_{0.3}Al_xFe_{2-x}O_4$ (x = 00.0, 0.25, 0.50, 0.75, 1.0) nano particles have been synthesis by the sol–gel auto combustion method. The decrease of saturation magnetization with increasing Al^{3+}content occurs because the replacement of Fe^{3+} by Al^{3+} ions weakens the sublattice interaction and lowers the magnetic moments of unit cells. Saturation Magnetization (Ms), Remnant magnetization (Mr), Coercivity, and Remnance ratio, molecular weight and magneton number measured at 300 K using high field hysteresis loop technique decreases with increasing *x*, suggesting decrease in ferrimagnetic behaviour.

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