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Gama Radiation Effect on Behavior of Nickel Zinc Spinal Ferrite System with Variation in Zinc Content.

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Introduction

The polycrystalline spinel ferrite are well-known magnetic materials which are very useful in microwave applications, transformer cores etc.[1-3]. Because of their low eddy current losses and dielectric losses they are considered as well known dielectric material. The property of magnetic conductor and electrical insulator made them useful in variety of application. The magnetic properties are known to be sensitive to the chemical composition, type and amount of dopant [4, 5, 6] etc. According to crystal structure nickel ferrite is an inverse spinel ferrite and possesses high electrical resistivity and low eddy current losses. The substitution of zinc in nickel ferrite modifies the properties of nickel ferrite which are useful in many device applications.

Recently irradiation by gamma rays, laser beam etc. has become a field of interest for the scientists [7, 8, 9, 10]. Irradiation effect provides several unique aspects in understanding of damaged structure and thereby modifying the properties of ferrite materials. Effect of γ radiation of $Co_{0.6}Zn_{0.4}Mn_xFe_{2-x}O_4$ on the structural properties has been reported by Hamada [11]. It has been reported that the physical properties of Ni, Zn, Cu spinel ferrite are also affected by irradiation. The structural, electrical and magnetic properties of Ni-Zn spinel ferrites have been reported in the literature [12, 13, 14]. However, to our knowledge no reports are available in the literature on the effect of γ radiation on the properties of Ni-Zn spinel ferrite prepared by ceramic technique.

In the present work we report a systematic investigation of structural, electrical, magnetic properties of Ni-Zn ferrite before and after gamma irradiation.

Experimental Technique of preparation

Polycrystalline samples of spinel ferrite having the generic formula $Ni_{1-x}Zn_xFe_2O_4$ with x = (0.0, 0.2, 0.4) were prepared using the standard ceramic technique. The pure oxides (NiO, ZnO and Fe_2O_3) of 99.9% purity supplied by MERCK were used. The powders were mixed in stoichiometric proportion and ground in an agate mortar pestle to obtain a very fine powder. The powder was then sintered at 900°C for 12 hrs. The sintered powder is again ground and palletized. These pellets are finely sintered to 1100^0C for 24 hrs and then cooled to room temperature for 24 hrs. Finally the samples were polished to obtain disc with two uniform parallel surfaces.

The powder X-ray diffractograms were obtained by using Phillips X-ray diffractometer model 3710 in the 2θ range of 20^0 to 80^0 at room temperature. The magnetic properties like saturation magnetization, magneton number are studied by hysteresis loop technique. The data was collected at room temperature. A.C. susceptibility measurements on powder samples were carried out in the temperature range 300 to 800 K using double coil set up.

The samples of Ni-Zn ferrite were irradiated with gamma rays using Co^{60} source. The source used in the present study is a commercially available laboratory source provided by Nucleonix systems (P) Ltd. Hyderabad. All the magnetic properties were investigated before and after gamma radiation.

Magnetization Study, Results and discussion:

The saturation magnetization σ_s and magneton number n_B for all the samples were calculated using hysteresis loop technique [15]. The values of σ_s and n_B are given in table 1 for irradiated and unirradiated samples.

Table 1

Magneton number (n_B), saturation magnetization (σ_s) and Yafet Kittle angle (θ_{yk}) of before and after γ-irradiation of $Ni_{1-x}Zn_xFe_2O_4$

Comp. 'x'	**'n_B' (μ_B)**				**'σ_s' (emu/gm)**		**'θ_{yk}'**	
	Obs.		**Cal**		**Before**	**After**	**Before**	**After**
	Before	**After**	**Before**	**After**				
0.0	1.99	2.03	2.00	2.55	175	178	0	$10^0 55'$
0.2	2.05	2.33	3.62	4.04	181	206	$35^0 13'$	$38^0 38'$
0.4	1.72	1.98	5.25	5.53	152	175	$53^0 42'$	$54^0 50'$

It is observed from table that both σ_s and n_B decreases with Zn composition x. The behavior of magneton number with zinc composition is depicted for irradiated and unirradiated sample.

Neel's two sub lattice model is applied to understand the magnetic behavior of the samples. According to Neel's two sub lattice model of ferrimagnetism Neel's magnetic movement n_B^N is given by

$$n_B^N = M_B(x) - M_A(x) \quad \text{.........(1)}$$

where,

M_B and M_A are the B and A sub-lattice magnetic moments in μ_B.

Taking ionic magnetic moments of Fe^{3+}, Zn^{2+}, Ni^{2+} as $5\mu_B$, $0\mu_B$ and $2\mu_B$ respectively and using above equation (1), Neel's magnetic moment has been calculated. The observed & calculated values of magneton numbers are listed in table 1. It is evident from table that there is a discrepancy in the observed & calculated values of magneton number.

This suggests that the structure is non collinear. To explain the observed magnetic behaviour of present investigated sample, a three sub lattice model given by Yafet and Kittle is applied [16]. According to Yafet and Kittle model the magneton number can be given by

$$n_B = M_B \cos_{\theta YK} - M_A \qquad \ldots\ldots\ldots\ldots(2)$$

The values of Y-K angle determined using above equation are given in table 1. It is seen from the table that Y-K angle increases with zinc substitution.

Conclusion

A comparative study of saturation magnetization from magneton number and Y-K angle for the irradiated and unirradiated sample clearly indicates that there is no much effect on the magnetic properties after irradiation of samples by gamma rays

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