A study of gamma radiation effect on the magnetic properties of Ni Zn ferrite

Shaikh Asif Karim[1], Sayyed Mujeeb Hadi[2]

[1]Department of Physics and Electronics, Sir Sayyed College, Aurangabad

[2]Department of Physics and Electronics, Sir Sayyed College, Aurangabad

asifkarim93@gmail.com

Abstract:

A system of ferrite, namely Ni1_xZnxFe2O4 with x = (0.0, 0.2, 0.4, 0.6, 0.8, 1.0), have been prepared by the standard ceramic method to investigate the effect of gamma rays irradiations using Co^{60} source on the magnetic properties. The unirradiated and irradiated samples were then subjected to characterization techniques of magnetization. The results of this characterization for irradiated from that of the unirradiated samples is proposed.

Introduction

The polycrystalline spinel ferrite are well-known magnetic materials and are very useful in microwave applications(Krupanicha, 1976), high quality filters, antenna rod, transformer cores etc.(Pileni, 2001). Nickel and substituted nickel ferrite are the important class of spinel ferrite(P. Didukh, 2002). According to crystal structure nickel ferrite is an inverse spinel ferrite and possesses high electrical resistivity and low eddy current losses(Sinha, 1963). The substitution of zinc in nickel ferrite modifies the properties of nickel ferrite which are useful in many device applications(RadhaKrishnamurthy, 1986). The properties like structural, electrical and magnetic are known to be sensitive to the chemical composition, microstructure, type and amount of dopant .

Material and Methods

Experimental Techniques

Polycrystalline samples of spinel ferrite having the generic formula $Ni_{1-x}Zn_xFe_2O_4$ with x = (0.0, 0.2, 0.4, 0.6, 0.8, 1.0) 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.

Result and Discussion

Magnetization

The saturation magnetization σ_s and magneton number n_B for all the samples were calculated using hysteresis loop technique(R.D.Shenon, 1976). The values of σ_s and n_B are given in table 1 for irradiated and unirradiated samples. 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 in figure 1.

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	$53^0 42'$	$54^0 50'$
0.6	1.07	1.23	6.87	7.02	105	121	$69^0 8'$	$69^0 31'$
0.8	0.69	0.79	8.50	8.51	68	78	$79^0 58'$	$79^0 23'$
1.0	0.13	0.15	10.00	10.00	14	16	$89^0 15'$	$89^0 8'$

Table 1:*Magneton number (n_B), saturation magnetization (•$_s$) and Yafet Kittle angle (•$_{yk}$) of before and after γ-irradiation of $Ni_{1-x}Zn_xFe_2O_4$*

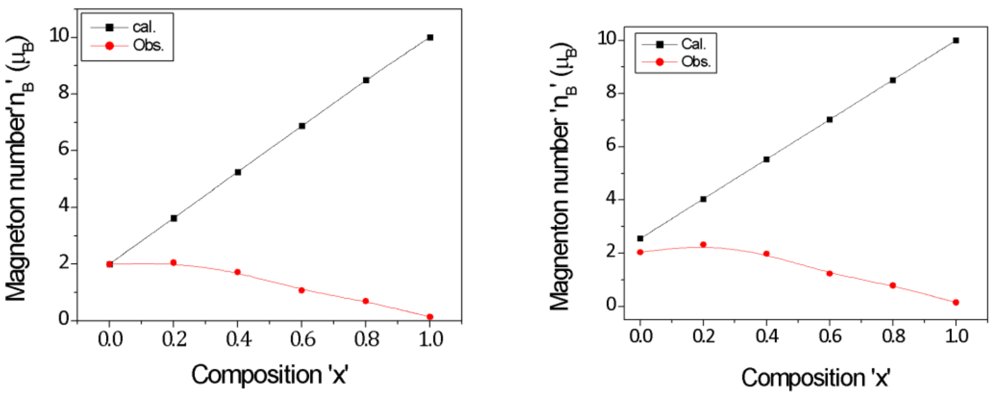

Fig. 1: *Variation of observed and calculated magneton number before and after irradiation with composition for $Ni_{1-x}Zn_xFe_2O_4$*

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 ferrimagnetisms Neel's magnetic movement n_B^N is given by

$$n_B^N = M_B(x)-M_A(x)$$

where, M_B and M_A are the B and A sub-lattice magnetic moments in •$_B$.

Taking ionic magnetic moments of Fe^{3+}, Zn^{2+}, Ni^{2+} as $5\mu_B$, $0\mu_B$ of and $2\mu_B$ respectively and using above equation, 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 behavior of present investigated sample, a three sub lattice model given byYafet and Kittle is applied . According to (Y. Yafet and C. Kittel, 1952) model the magneton number can be given by

$n_B = M_B\cos\cdot_{YK} - M_A$

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.

Conclusions

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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