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ELECTRICAL PROPERTIES OF $Y_{2.8}Eu_{0.2}Fe_{5-X}Al_xO_{12}$ GARNET SYSTEM

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ABSTRACT:

The sample of the series $Y_{2.8}Eu_{0.2}Fe_{5-x}Al_xO_{12}$ were prepared by using high purity oxides of Y_2O_3, Eu_2O_3, Fe_2O_3 and Al_2O_3. The thermal variation for a. c. susceptibility measurements were carried out in the temperature range 300K-800K using double coil set up operating at 263 Hz. A. C. susceptibility data suggest that the samples X = 0.0, 0.2 and 0.4 shows ferromagnetic behaviour while samples paramagnetic behaviour while samples with x = 0.6, 0.8 and 1.0 show paramagnetic behavior.

KEYWORDS: Curie temperature, A. C. susceptibility measurement, Yttrium iron garnet

INTRODUCTION:

Yttrium iron garnet (YIG) exhibits ferrimagnetism with low hysteresis loss and high resistivity at room temperature. Because of this, it is of technical importance and finds use in radio-electronics and UHF technology (Krupichka 1976). Hence the study of magnetic and electrical properties is important and useful. The magnetic properties of YIG have been investigated by many workers (Epstein and Frackiewicz 1959; Wurlitzer and Richter 1970; Wurlitzer 1987; Bush 1988; Chukalkin et al 1989). There are some reports on studies on electrical conductivity (Elwell and Dixon 1968; Fontana and Epstein 1971; Metselaar and Larsen 1974; Lal et al 1982; Petrov et al 1986). There are only a few reports on dielectric properties. Hirakata et al (1991) reported the dielectric behaviour at liquid nitrogen tem- peratures but the dielectric constant was not clearly indicated. Hofmeister and Campbell (1992) determined low- and high-frequency dielectric constants from infrared reflectivity measurements and indicated that the data by direct measurement is not available for a pure YIG single crystal [1-8].

To our knowledge very few reports of the structural, electrical and magnetic properties of substituted yttrium iron garnet are available in the literature [9-15].

In the present work, the electrical properties of $Y_{2.8}Eu_{0.2}Fe_{5-X}Al_xO_{12}$ garnet system were studied.

EXPERIMENTAL:

The samples of $Y_{2.8}Eu_{0.2}Fe_{5-x}Al_xO_{12}$ were prepared by using high purity oxides of Y_2O_3, Eu_2O_3, Fe_2O_3 and Al_2O_3. Appropriate quantities of the constituents were mixed thoroughly in agate pestle mortar for 4 hours. The resulting powders were ground for 2 hours. The powder were ground and preheated at 1100^0C at 24 hours. Then it was further mixed and ground cylindrical pellets and fired at 1400^0C for 24 hours. Finally, the pellets were cooled to room temperature at the rate of 2^0C per minute. The thermal variation for a. c. susceptibility measurements were carried out in the temperature range 300K-800K using double coil set up operating at 263 Hz.

RESULTS AND DISCUSSION:

A. C. susceptibility measurement:

The plots of a. c. susceptibility $^{x_T}/_{x_{RT}}$ (RT is room temperature) against temperature (T) for the samples with $X = 0.0, 0.2$ *and* 0.4 are shown in fig. 5.7, which exhibit normal ferromagnetic behaviour. The plots of $^{x_T}/_{x_{RT}}$ are used to determine the Curie temperature obtained from $^{x_T}/_{x_{RT}}$ plots are given in table 5.1. The samples with X = 0.6, 0.8 and 1.0 do not show any thermal variation of a. c. susceptibility and hence no curie temperature was obtained for these samples.

Table 5.1: Curie temperature for $Y_{2.8}Eu_{0.2}Fe_{5-x}Al_xO_{12}$ system ($x = 0.0$ to 1.0)

Com. 'x'	σ_S (emu/g)	Magneton number n_B (μ_B)		Magneton number $n_B(\mu_B)$ normalized		Curie Temp. T_C (K)
0.0	31.080	4.17	4.556	1.000	1.000	556
0.2	27.1995	3.62	4.356	0.868	0.956	550
0.4	24.346	3.22	4.156	0.772	0.912	416
0.6	20.720	2.72	3.956	0.652	0.868	-
0.8	16.576	2.15	3.756	0.516	0.824	-
10	11.655	1.50	3.556	0.360	0.781	-

Thus, the samples with $0 \leq X \leq 0.4$ show ferromagnetic behaviour, whereas samples with $0.6 \leq X \leq 1.0$ exhibit paramagnetic behaviour. Usually when non-magnetic ions like Al^{3+} ions substituted in a ferromagnetic lattice T_C decreases. During this substitution ferromagnetic curie temperature declines are mostly linearly.

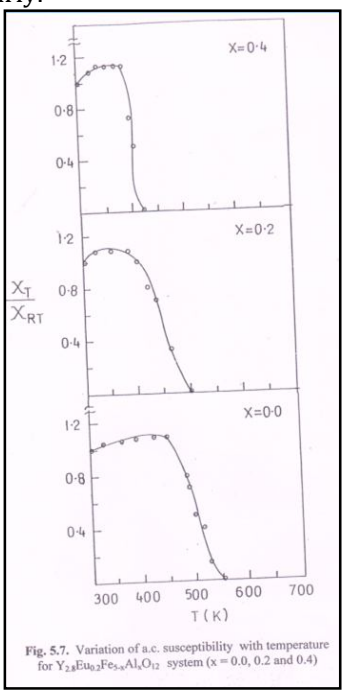

Fig. 5.7. Variation of a.c. susceptibility with temperature for $Y_{2.8}Eu_{0.2}Fe_{5-x}Al_xO_{12}$ system (x = 0.0, 0.2 and 0.4)

The removal of magnetic ions from magnetic sub-lattice weakens the network of the super-exchange interactions, which tends to align the neighboring magnetic dipole anti-parallel. The transition between the ordered ferromagnetic states to disorder paramagnetic state is designated by the ferromagnetic curie temperature. The values of Curie temperature obtained from a. c. susceptibility (x_T/x_{RT}) plots are given in table 5.1.

CONCLUSION:

1. A. C. susceptibility data suggest that the samples x = 0.0, 0.2 and 0.4 shows ferromagnetic behaviour while samples paramagnetic behaviour while samples with x = 0.6, 0.8 and 1.0 show paramagnetic behaviour.
2. Curie temperature obtained from x_T/x_{RT} plots decreases with Al substitution for $x \leq 0.4$.

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