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REVIEW OF RESEARCH

ELECTRICAL PROPERTIES OF EUROPIUM SUBSTITUTED YTTRIUM IRON GARNET

Shesherao S. Jawale
Department of Electronics, Yeshwantrao Chavan Mahavidyalaya, Tuljapur,
Dist-Osmanabad- 413 601, Maharashtra, INDIA.
Corresponding author: drssjawalepatil@gmail.com

ABSTRACT:

Samples of $Y_{3-X}Eu_XFe_5O_{12}$ (x= 0.0 to 0.5) were prepared by using high purity Y_2O_3, Eu_2O_3, Fe_2O_3 and using ceramic technique. The Curie temperature of all the samples was determined using a. c. susceptibility measurements. The measurements of a. c. susceptibility were carried out in the temperature range 300-800K using double coil set up. The Curie temperature decreases with increase with increase in Eu substitution.

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

INTRODUCTION:

Yttrium Iron Garnet (YIG) and substituted YIG have been investigated extensively because of their technical importance and the ease with which properties can be tailor made to suit various applications [1-4]. Number of ions can be substituted in YIG which occupy the lattice site determined primarily by their ionic radii.

It is found that certain ions occupy strictly a particular lattice sites while some others can occupy both tetrahedral (d) and octahedral [a] sites present in YIG structure [5, 6]. Substituted rare earth iron garnets show wide variety of interesting magnetic properties [1, 5]. Theoretical models, one based on Neel's model [7], another suggested by de-Geenes [8] based on Yafet-Kittel models [9], and one suggested by Gilleo [10] have been used to explain the magnetic behaviour of YIG. A large number of cations can be substituted at yttrium sites or at iron (Fe^{3+}) sites enabling a wide variation in the properties of garnets. The magnetic properties of gallium and aluminum [10, 11] substituted yttrium iron garnet have been reported in the literature [11]. Similarly, the structural, electrical and magnetic properties of non-magnetic Si and Ge substituted YIG, have also been reported in the literature [12, 13]. In the literature, studies on the properties of pure yttrium iron garnet [14], and pure europium iron garnet [15] have been reported in the literature on the structural, electrical, magnetic properties of europium substituted yttrium iron garnet. In the present work, the electrical properties of europium substituted Yttrium Iron Garnet were studied.

EXPERIMENTAL:

Samples of $Y_{3-X}Eu_XFe_5O_{12}$ (x= 0.0 to 0.5) were prepared by using high purity Y_2O_3, Eu_2O_3, Fe_2O_3 and using ceramic technique. The oxides were mixed thoroughly in stoichiometric proportions to yield the desired composition and wet ground. The mixture was dried and presintered at 1050^0C for 24 hours in air and cooled to room temperature. The powder was reground and pelletized using hydraulic press. The cylindrical pellets were finally sintered at 1350^{0}C for 24 hours and slowly cooled to room temperature at the rate of 2^{0}C per minute to obtain garnet phase.

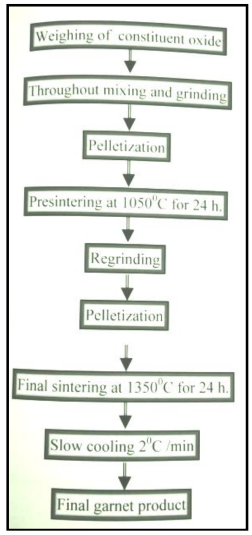

Fig. 4.1. Flow chart of stages involved in preparation of Garnet by ceramic method.

The Curie temperature of each sample was determined from the low field a. c. susceptibility data. The measurements of a. c. susceptibility were carried out in the temperature range 300-800 K. From the plots of X_T / X_{RT} versus temperature, Cuie temperature of the sample is obtained. The Curie temperature setup comprises of

1. A. C. susceptibility unit,
2. Solenoid and pickup coil assembly,
3. Platinum furnace,
4. Furnace power supply,
5. Thermocouple and temperature indicator.

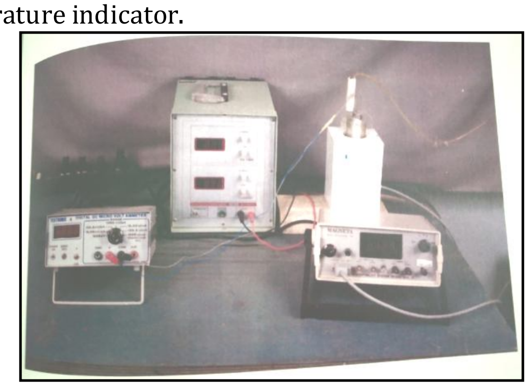

Fig. 4.2 Experimental setup for thermal variation of a. c. susceptibility.

Fig. 4.3 Experimental setup for a. c./d. c resistivity

1. A. C. susceptibility unit : Model ACS 2A:

The schematic of this unit is given in Fig. 4.4 IT consists of function generator, balancing circuit and signal processing circuit based on lock-in amplifier principle.

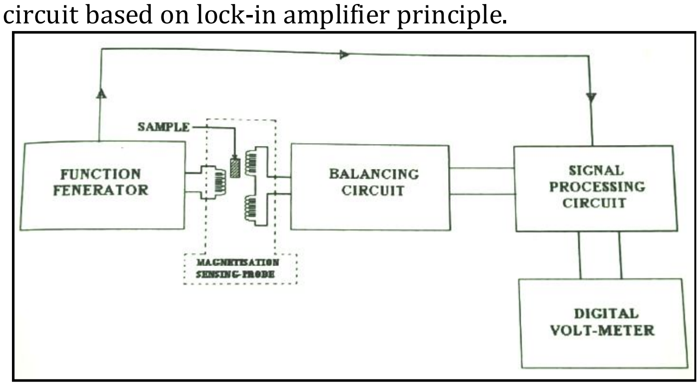

Fig. 4.4 Schematic of a. c. susceptibility system

2. Solenoid and pickup coil assembly:

The pickup coil is wound in two sections comprising three windings. The main two windings are identical and wound in opposition. The sample under test is placed in the vicinity of one of the windings producing a differential voltage proportional to the magnetization of the sample.

3. Platinum furnace:

The sketch of the furnace is shown in Fig. 4.5 The platinum wire is wound on a quartz tube of diameter 18 mm and wrapped with a fiber glass ribbon and pushed tightly in another quartz tube. The furnace is introduced in a double wall jacket which can take water for cooling the region of the furnace. The whole assembly is put into the solenoid and then held in plastic container.

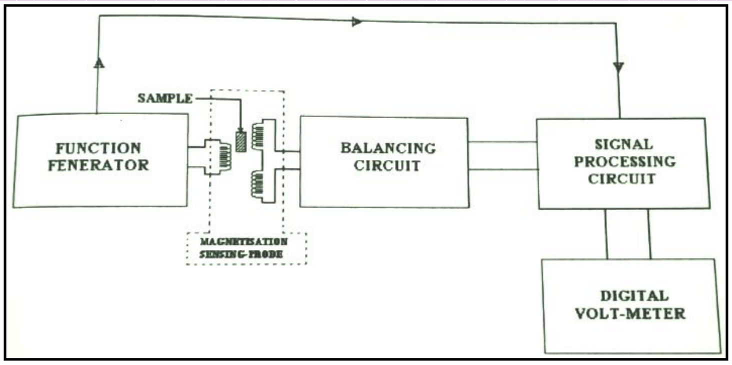

Fig. 4.5 Furnace assembly

4. Furnace power supply:

It is a regulated d. c. power supply whose voltage and current can be varied continuously in the range 0-300 volts, 0-5 amperes.

5. Thermocouple and temperature indicator:

The thermocouple is platinum- platinum-Rhodium (13%). Junction which is terminated into one channel of Data Acquisition Unit. When the thermocouple is in good contact with the samples, the temperature indicator directly reads the temperature of the sample.

RESULTS AND DISCUSSION:

A. C. susceptibility measurement:

The thermal variation of all the sample have been studied for all the samples in the temperature range 300-800k using double coil set up.

Table 4.1: Curie temperature for $Y_{3-x}Eu_x Fe_5O_{12}$ system (x = 0.0 to 0.5)

Com 'x'	σ_s (emu/g)	Magneton number n_s (μ_B)		Magneton number n_s (μ_B) normalized		Curie Temp. $T_{c\,k}$
		Obs.	Cal.	Obs.	Cal.	
0.0	33.67	4.448	5.000	1.000	1.000	550
0.1	27.19	3.624	4.778	0.816	0.956	530
0.2	21.76	2.923	4.556	0.657	0.911	520
0.3	18.65	2.527	4.334	0.568	0.867	510
0.4	16.58	2.265	4.112	0509	0.822	500
0.5	15.54	2.141	3.900	0.481	0.780	485

The plots of a. c. susceptibility (x_T/x_{RT}) (RT is room temperature) against temperature (T) for all the samples are shown in Fig. 4.7 and Fig. 4.8.

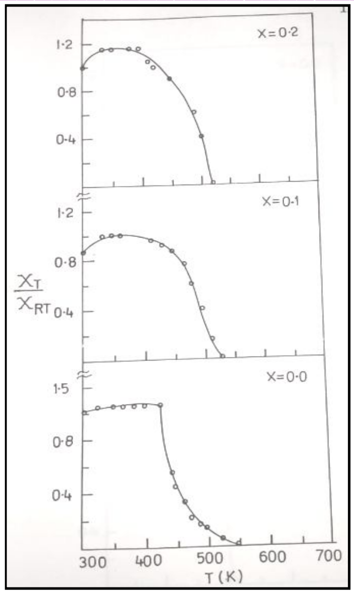

Fig. 4.7. Variation of a. c. susceptibility with temperature for $Y_{3-x}Eu_xFe_5O_{12}$ system (x = 0.0, 0.1 and 0.2)

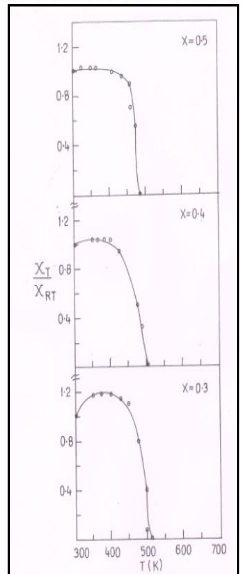

Fig. 4.8. Variation of a.c. susceptibility with temperature for $Y_{3-x}Eu_xFe_5O_{12}$ system (x = 0.3, 0.4 and 0.5)

The plots exhibit normal ferromagnetic behaviour, which decreases with the addition of Eu substitution. These plots are used to determine Curie temperature of the samples. The Curie temperature obtained from a. c. susceptibility data is given in Table 4.1 for all the sample.
The dependence of Curie temperature with composition 'x' is depicted in Fig. 4.9.

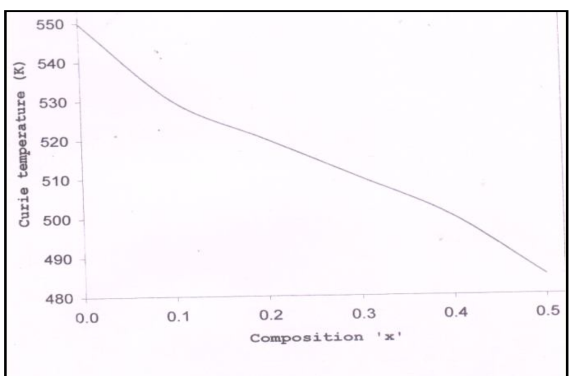

Fig. 4.9 Variation of Curie temperature with concentration 'x' for the system $Y_{3-x}Eu_xFe_5O_{12}$

It is observed from Fig. 4.9 that T_c decrease slowly with the increase in Eu substitution. The decrease in Curie temperature is attributed to decrease in magnetic linkages.

CONCLUSION:

The curie temperature decreases with increase with increase in Eu substitution. The Curie temperature of pure YIG (x = 0.0) is in good agreement with those reported by others.

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