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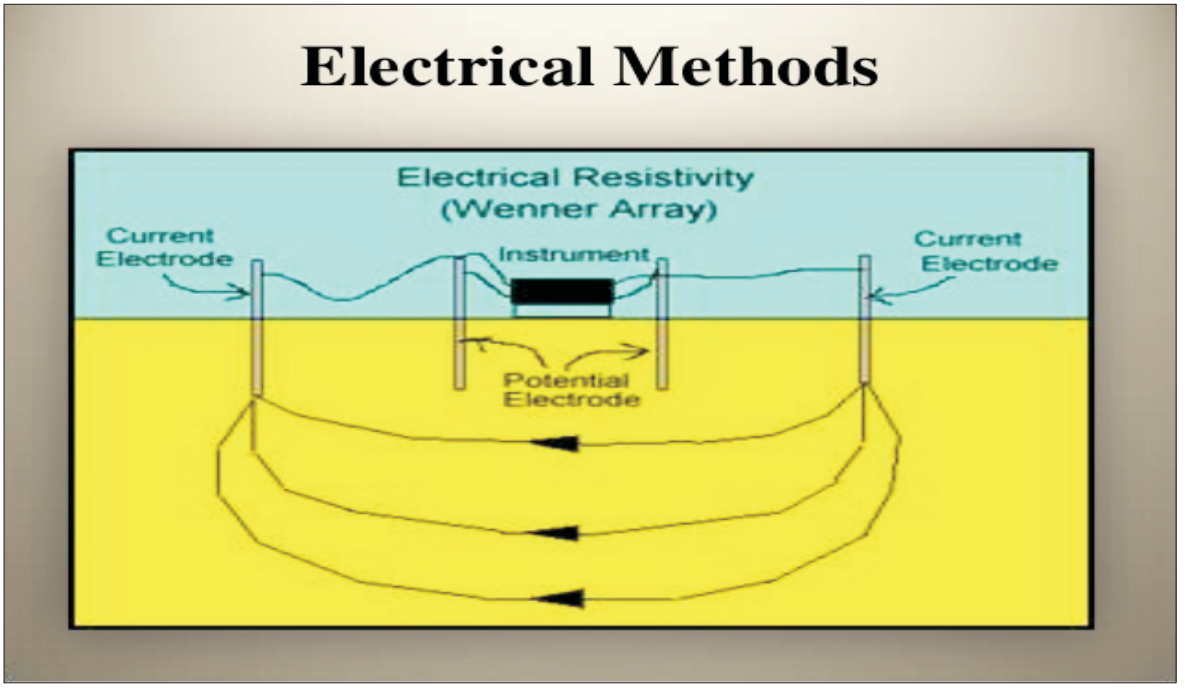
ELECTRICAL RESISTIVITY OF THE MIXED SPINEL $Co_{1.5-y}Zn_ySi_{0.5}Fe_{1.0}O_4$



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ABSTRACT:

Polycrystalline ferrites (y=0.1,0.2,0.3,0.4,0.5) have been prepared in the pellet form and studied by means of X-ray diffraction and electrical resistivity measurements. X-ray analysis shows that they are single phase cubic spinels. The lattice parameter obtained from X-ray data increases with increase in Zn concentration. The dc resistivity of these samples is studied as a function of Zn content and temperature. The activation energy of each sample is calculated from the plots of $Log\rho_{dc}$ against $10^3/T$. The activation energy in paramagnetic region is found to be larger than that in the ferromagnetic region.

KEY WORDS: Resistivity, Activation energy, paramagnetic.

INTRODUCTION:

Ferrites are used for several applications in electronic industry and therefore , it is required to monitor the electrical and dielectric properties so as to suit the desired application by introducing dopants in the spinel lattice. The cobalt ferrite possesses an inverse spinel structure and degree of inversion depends upon the heat treatment[1]. We have studied the effect of Si4+ substitution in cobalt ferrite on electrical and magnetic properties of the system[2.3]. Here, with a view to study the conduction mechanism in the mixed spinel $Co_{1.5-y}Zn_ySi_{0.5}Fe_{1.0}O_4$ system, the dc resistivity as a function of Zn composition and temperature has been investigated and the result of such a study are presented in this communication.

LITERATURE SURVEY

Some workers have concentrated on the study of the electrical and magnetic properties of tetravalent Ti^{4+} and Ge^{4+} substituted Cobalt ferrite system [4,5]. Recently to increase the resistivity and to develop the desired microstructure tetravalent ions like Ti, Sn, and Si are substituted in mixed ferrites. It is observed that the resistivity increases with increase in Si4+ in Ni-Cd ferrite [6]. The addition of tetravalent ions like Tn and Si in Co-Cd mixed ferrite have been studied to understand the role of these ions on physical properties of ferrites. Cation distribution in Si4+ substituted Cu ferrite have been studied by some workers[7].

In view of the above considerations , in the present study, an attempt has been made to understand the effect of non-magnetic Zn substitution in Si substituted Co ferrite on the electrical properties.

MATERIALS AND METHODS

Samples with the composition $Co_{1.5-y}Zn_ySi_{0.5}Fe_{1.0}O_4$ (y=0.1 to 0.5) were prepared by standard ceramic technique using AR grade Fe_2O_3,CoO,ZnO, and SiO_2. These oxides were mixed in the proper proportion to yield the desired composition and presintered at 900^0C for 24 hours in air. The pellets of 1 cm diameter were made from the presintered powder. They were finally sintered at 1050^0C for 24 hours and slowly cooled to room temperature at the rate of 2^0C per minute in air. The X-ray diffraction patterns for all the samples were obtained using FeKα radiation on a Philips x-ray diffractometer. The dc resistivity as a function of temperature was measured using a two probe method using spring loaded brass electrode for all the samples. The electrical contacts were made using dried silver epoxy. The activation energy was calculated from the variation in resistivity with temperature using the formula-

$$\rho_{dc} = \rho_0 \exp[\rho E/Kt].$$

RESULTS AND DISCUSSION

Analysis of XRD patterns revealed that all the samples have a single phase cubic structure. The values of lattice constant 'a' determined from XRD data with an accuracy ± 0.002A^0 for y = 0.0 to 0.4 are shown in table. The lattice parameter 'a' gradually increases with increasing the concentration y of Zn. The increase in 'a' is due to the replacement of smaller ionic radius of Fe (0.64A^0) by larger Zn (0.74A^0) ion.

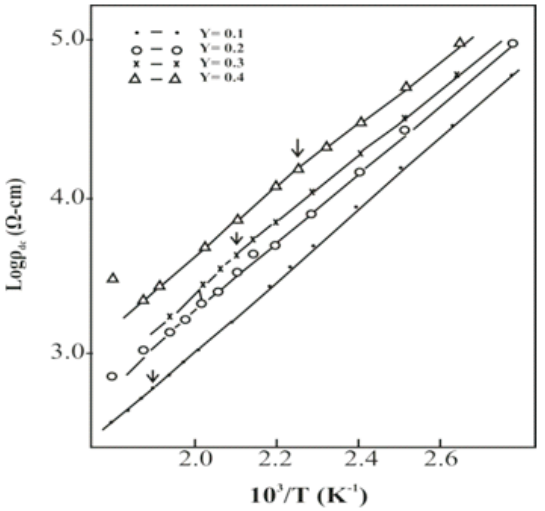

Fig: Logρ_{dc} versus 10^3/T plots for the $Co_{1.5}$-y$Zn_ySi_{0.5}Fe_{1.0}O_4$ System

DC electrical resistivity measurement were performed from room temperature (300 K) to 600K. The plots of Logρdc against 103/T shown in figure suggest the variation of resistivity follows Arehenious relationship

$$\rho_{dc} = \rho_0 \exp[\rho E/KT]. \text{ ---------- (1)}$$

where ρ_0 is the temperature independent constant, ρE is activation energy and k Boltzmann constant. The variation of ρdc with temperature is almost linear upto the the transition temperature known as Curie temperature at which ferromagnetic material changes over to paramagnetic state due to the influence of magnetic ordering upon the conductivity process in ferrites. It is evident from the figure that the slope of ρ_{dc} against 103/T curve changes at Curie temperature (T_c) and the T_c values determined from resistivity plots listed in the Table are in good agreement with those obtained from A.C. susceptibility data. It is observed from the Table that the values of Curie temperature decrease with Zn concentration. This is attributed to decrease in AB interaction with increasing Zn content.

The electrical conduction in these samples is attributed to Verwey [8] mechanism explained on the basis of hopping of electrons between ions of the same element but of different valencies placed on equivalent crystallographic sites. In this case the conduction can be possibly due to the exchange of electronics between Fe^{2+} and Fe^{3-}; Co^{2-} and Co^{3+}.

Values of activation energy in para and ferri magnetic regions calculated using the relation (Eq.1) are tabulated in the table. It is clear that the activation energy in the paramagnetic region is greater than that the activation energy in the ferrimagnetic region. This behavior is similar in all the ferrite samples. According to the theory of magnetic semiconductor one expects a reduction in the activation energy as the system undergoes the transition from paramagnetic state to ferrimagnretic state. A similar behavior is observed in the values of activation energies for the present system.

Table: Lattice constant, Curie Temp. and Activation energy of $Co_{1.5-y}ZnySi_{0.5}Fe_{1.0}O_4$

Sample y	Lattice const 'a' A^0	Curie Temp ^0K		Activation energy eV	
		Resi.	Suscept.	Para	Ferri.
0.0	8.378	550	570	0.590	0.480
0.1	8.375	538	545	0.554	0.464
0.2	8.376	515	520	0.509	0.437
0.3	8.379	495	490	0.512	0.442
0.4	8.387	465	460	0.495	0.396

CONSULSIONS

Values of Curie temperature obtained from resistivity plots are in agreement with those obtained from susceptibility data. Curie temperature is found to decrease with increase in Zn content. Activation energy in the Paramagnetic region is greater than the activation energy in the ferromagnetic region.

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