

Copper Ferrite: - Electrical Properties For Cadmium Substituted Copper Ferrite

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ABSTRACT

Spinel ferrites with general formula $Cu_{1-x}Cd_xFe_2O_4$ ($x = 0.0$ to 0.6) were prepared by solid state ceramic technique. Electrical properties of the present spinel system were studied by means d.c. resistivity measurements. The temperature dependence of d.c. resistivity plots of all samples was studied by two -probe method. Each sample show break in resistivity plot, this point is known as Curie temperature. The resistivity decreases with increase in temperature.

Key words: Copper ferrite, Electrical Properties.

INTRODUCTION

Ferrites have wide range of applications due to their interesting electrical properties. The electrical properties of ferrites depend upon chemical composition, Methods of preparation and sintering temperature [1, 2]. The electrical conductivity in ferrites can be explained on the basis of Verway mechanism [3]. The study of dielectric properties of ferrites produces valuable information on the behavior of electronic charge carriers leading to greater understanding of the mechanism of dielectric polarization. It is reported that incorporation of Cd in $CuFe_2O_4$ necessitates adjustment of both Cu^{2+} and Fe^{3+} ions [4]. The present work reports effect of Cd substitution on d.c. resistivity of Copper ferrite.

METHODOLOGY

The $\text{Cu}_{1-x}\text{Cd}_x\text{Fe}_2\text{O}_4$ (for $x = 0.0-0.6$) composition were prepared by solid state ceramic technique. Powders of Copper oxide (CuO) from Reidel (99.9%), cadmium oxide (CdO) from Loba Chemicals (99%) and ferric oxide (Fe_2O_3) from Reidel Chemical (99%) were used as raw materials. The ferrite system were prepared by the double sintering ceramic method. The XRD patterns of all the samples were recorded using $\text{CuK}\alpha$ radiation on a Pw710 diffractometer.

The electrical resistivity as a function of Cd concentration was measured using a two probe method for all samples in the form of pellets. The temperature dependence of d. c. resistivity of all the samples was studied by two-probe method. For good electrical ohmic contact the pellets were polished and a silver paste was applied on both the surfaces. Another electrode at other side is attached to ceramic beads and is spring loaded to keep the pellet intact in between the electrodes.

The resistance of each pellet has been measured for falling temperature at the step of 10°C , during each measurement sufficient time was allowed for the sample to attain the equilibrium temperature. The resistivity measurements were carried out from room temperature to beyond Curie temperature. The resistivity ρ was calculated from dimensions and resistance of the pellet by using the relation,

$$\rho_{dc} = \left[\frac{\pi r^2}{t} \right] R\Omega - cm$$

Where r is radius of the pellet, t is thickness of the pellet; R is resistance of the pellet.

RESULTS AND DISCUSSIONS

XRD ANALYSIS:

The diffraction pattern were recorded in the 2θ range 20° to 80° with scanning rate of 2° per minute using $\text{CuK}\alpha$ radiation of wavelength 1.5418 \AA . The unit cell dimensions are determined from the d-spacing of a line by making use of the cubic formula for inter planer spacing $a = d (h^2 + k^2 + l^2)^{1/2}$ where, a is the lattice

constant, d is inter-planer spacing and $(h k l)$ is the miller indices.

The X-ray density (d_x) was calculated using the following relation [5] $d_x = \frac{ZM}{NV}$ where Z is number of molecules per unit cell. For cubic ferrite $Z = 8$, M is molecular weight, N is Avogadro's No. (6.022×10^{23}), V is the volume of unit cell (a^3). Scherrer [6], shows that the mean diameter d of the crystalline composing a powder is related to the X-ray diffraction broadening (B) by the equation

$$D = \frac{0.9\lambda}{B \cos \theta}$$

Where, λ is the wavelength of incident radiation. B is the full width of half maxima. θ is glancing angle for (311) peak.

Analysis of the XRD patterns revealed that all the samples have a single phase cubic structure.

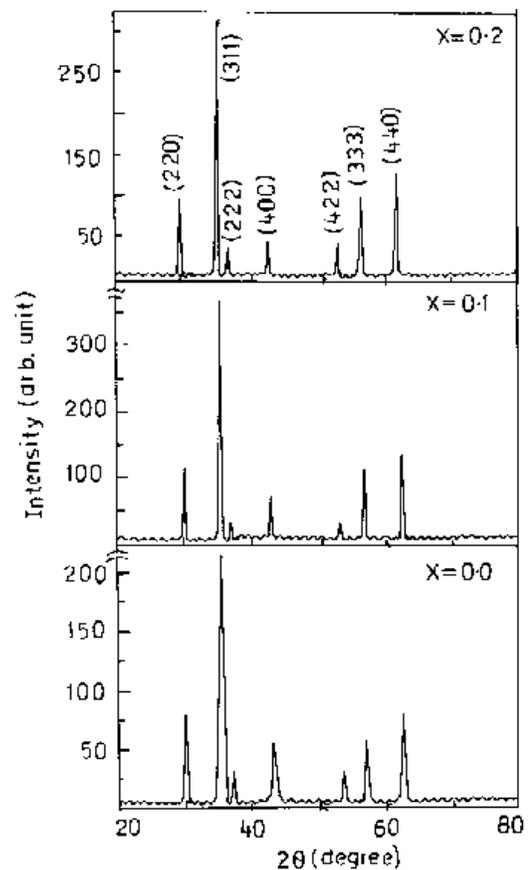


Table 1: Transition temperature T_c (K), Activation energy (ΔE) for $\text{Cu}_{1-x}\text{Cd}_x\text{Fe}_2\text{O}_4$ ($x = 0.0 - 0.6$)

Comp. (x)	Transition temperature (D.C.R.) T_c (K)	Activation energy ' ΔE ' (eV)		
		E_p	E_f	ΔE
0.0	720	0.477	0.24	0.23
0.1	700	0.391	0.24	0.14
0.2	680	0.465	0.28	0.17
0.3	664	0.636	0.23	0.39
0.4	646	0.556	0.35	0.19
0.5	622	0.431	0.09	0.33
0.6	600	0.556	0.19	0.35

DC RESISTIVITY

Variation of logarithmic of resistivity versus reciprocal of temperature is shown in **Fig. 2** for all the samples. All these resistivity plots are similar in nature and obey the

Arrhenius relation. $\rho = \rho_0 \exp [E_g / K_B T]$

where E_g = Activation energy in eV

K_B = Boltzmann constant, T = Absolute temperature.

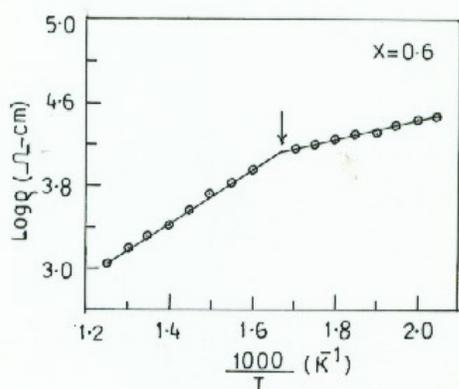


Fig 2 Variation of $\log \rho$ versus $1000/T$ for the series $\text{Cu}_{1-x}\text{Cd}_x\text{Fe}_2\text{O}_4$

The resistivity decreases with increase in temperature. Each sample shows a break in resistivity plot at a particular temperature. At this point the plot divides into two regions namely ferrimagnetic region and paramagnetic region. This temperature may correspond to Curie temperature of the sample. Using these resistivity plots and Arrhenius relation given in equation (4.18). The activation energy of all the samples was calculated and the values of activation energy are given in Table 1.

The electrical conductivity in ferrites can be explained on the basis of Verwey-de-Boer mechanism [7], i.e. exchange of electrons between ions of same elements that are present in more than one valence state distributed randomly over equivalent crystallographic lattice sites ($\text{Fe}^{3+} \leftrightarrow \text{Fe}^{2+}$). The addition of Cd^{3+} ions reduces Fe^{3+} ions on the B sites.

CONCLUSION

- 1) Decrease in dc resistivity of Cd content is due to electron - hole compensation.
- 2) Decrease in dc resistivity for Cd is due to hopping mechanism between Cu^{2+} and Cd^{3+} ions.

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