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ORIGINAL ARTICLE

Investigation Of Role Of Wo_3 Additive On Drift Mobility And The Dc Electrical Resistivity Of Nicuzn Spinel Ferrite

Datta Kakde, C.M.Kale ,A. A. Pandit C.M.Kale

Department of Physics, Yeshwantrao Chavan College, Sillod, Dist. Aurangabad,(M.S.),India

ABSTRACT:

The DC electrical resistivity was studied for $Ni_{0.3}Cu_{0.2}Zn_{0.5}Fe_2O_4$ + x WO_3 samples (x= 0.00 wt. % to 1.00 wt. % in the steps of 0.25wt. % WO_3) prepared by using conventional ceramic technique. The DC electrical resistivity ρ, Curie temperature Tc and activation energies for electric conduction in ferromagnetic (Ef) and paramagnetic (Fp) region. The variation of logarithm of resistivity with reciprocal of temperature shows a definite kink near Curie temperature. The plot of resistivity obeys the Arrhenius relation. It has been found that the resistivity decreases with WO_3 additives significantly. The activation energy in paramagnetic region and ferrimagnetic region has been calculated from resistivity plot. It is observed that the activation energy in paramagnetic region is greater than in ferrimagnetic region. Drift mobility of all the samples has been calculated and it was observed that the samples having higher resistivity have low mobility. And also mobility decreases as Curie temperature decreases.

KEYWORDS:

Spinel ferrite, ceramic method, resistivity, activation energy, drift mobility.

INTRODUCTION

Polycrystalline soft ferrites are well known magnetic materials and widely used in many technological applications such as transformer core, microwave, high quality filters, antenna rods, radio frequency circuits and also used in sensors[1-5].Many researchers have investigated the effect of introducing various ions in NiCuZn ferrites. The electrical behavior is one of the most important properties of ferrites, which depends on the preparation technique, chemical composition, sintering temperature and addition of additives [6-7]. In order to study the structural, electrical and magnetic properties,to change the sintering temperature,microstructure of NiCuZnferrites with the addition of WO3.In the present work NiCuZn ferrites with the addition of WO3 by wt. % selected for detailed investigations of structural,electrical as well asmagnetic properties by considering the variations of these properties are also discussed.

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EXPERIMENTAL TECHNIQUE:

The NiCuZn ferrites with the compositions of $Ni_{0.3}Cu_{0.2}Zn_{0.5}Fe_2O_4$ were synthesized from A.R. grade NiO, ZnO, CuO, and Fe_2O_4 by solid state reaction method. The materials were calcined at 930oC for 12 hrs to obtain spinel phase and then mixed with WO_3 in the steps of 0.25 wt. % from 0.25 to 1.00 wt. % of WO_3. The samples were grounded for two hours and then the powder calcined at 1100oC for 12 hrs to obtain final product. The characterization of the prepared samples was done by measuring lattice constant, particle size, and X-ray density etc. from XRD data.

The DC resistivity measurements were carried out by using conventional two-probe method and were investigated in the temperature range 300oK to 8000K.

RESULTS AND DISCUSSIONS

The typical X-ray diffractogram for the composition$Ni_{0.3}Cu_{0.2}Zn_{0.5}Fe_2O_4$ doped with 0.25, 0.75 wt. % and 1.00 Wt. % WO_3 shown in Fig1. The sample show mainly spinel phase formation. The intensity of peaks belonging to WO_3 increases as the content increases by wt. % and slight shifting in the position of peaks belong to ferrite towards lower d-spacing values was found. The detailed lattice constant of substituted NiCuZn ferrites listed in Table 1. The lattice constant obtained from X-ray diffraction data slightly decreases with the increasing WO_3 content,[8] because of the small ionic radius(0.62 A.U.) of W6+ ions than the radius (0.64 A.U.) Fe^{3+} ion. The d. c. electrical resistivity measurement was carried out using two probe techniques in the temperature range 300oK to 800oK. The effect of temperature on the d.c. electrical resistivity 'ρ' for the sample x = 0.00, 0.25, 0.50, 0.75, and 1.00 wt. % illustrated in Fig 2. The electrical resistivity 'ρ' decreases as temperature't' increases.

The resistivity increases is attributed to increasing in drift mobility of electric charge carrier which thermally attributed on increasing the temperature. In fact, these decreasing in 'ρ' as temperature increase are the normal behavior for the semiconductor, which is controlled by the following Arheneous relation

$$\rho_{dc} = \rho_0 \exp\left(\frac{-\Delta E}{kT}\right) \qquad (1)$$

Where, the symbols have their usual meaning.

The graph exhibit two region namely paramagnetic and ferromagnetic region, these two region were separated at a point called Curie temperature. The Curie temperature is the temperature above which ferromagnetic material transform to paramagnetic material. It was reported that, on passing through Curie point a change in slope or gradient of line must takes place. These effects in gradient or slope depend on the exchange interactions which determine the Curie temperature 'Tc' [9].

The activation energy of paramagnetic region 'EP' and ferromagnetic region 'EF' calculated from the slope of broken line on both sides of Curie temperature, which also determine the function of WO3 content 'x'. The values of activation energy [10] in paramagnetic region 'EP', ferromagnetic region 'EF' and change in activation energy 'E' were listed in Table 2.

The variation of resistivity with temperature is similar to all compositions. Kink is observed in all the resistivity plots which divide the curve in two regions namely ferrimagnetic and paramagnetic region. The behavior of resistivity is similar to other well-known ferrites [11]. All these resistivity plots are used to determine the activation energy of each sample.

Drift mobility of all the samples has been calculated using the following relation

(2)

Where 'e' is the charge on electron, 'ρ' the resistivity and 'n' is the concentration of charge carriers, which can be calculated from the following relation [ ].

(3)

Where 'M' is the molecular weight, 'Na' the Avogadro's number, 'ρa' the density of the sample and 'p' is the number of iron atoms in the chemical formula of the oxide.

The variation of mobility with respect to resistivity is shown in Fig. 3. It can be seen that the samples having higher resistivity have low mobility [12]. it can also be seen that mobility decreases as Curie temperature decreases.

Figure 4 (a graph between mobility (μd) and 1000/T(k)) show temperature dependence of mobility, it can be seen that by increasing temperature, mobility increases.

Table 1.Variation of Drift Mobility at Curie temperature of $Ni_{0.3}Cu_{0.2}Zn_{0.5}Fe_2O_4 + x\ WO_3$ ferrite

WO3 wt.%	Curie temperature 'T_c' (K)	D.C. Resistivity ρ (Ω-cm)	Drift Mobility μd (cm^2/V-s)
0.25	472	1.514×10^{3}	1.914×10^{-28}
0.50	478	2.074×10^{3}	1.790×10^{-28}
0.75	490	2.846×10^{3}	1.598×10^{-28}
1.00	496	3.711×10^{3}	1.361×10^{-28}

Table 2.Variation of activation energy in ferrimagnetic and paramagnetic region of $Ni_{0.3}Cu_{0.2}Zn_{0.5}Fe_2O_4 + x\ WO_3$ ferrite

WO_3 wt.%	Activation energy (eV)		ΔE
	E_F	E_P	(eV)
0.00	0.40	0.56	0.26
0.25	0.27	0.45	0.18
0.50	0.27	0.38	0.11
0.75	0.23	0.33	0.10
1.00	0.18	0.29	0.11
1.25	0.13	0.25	0.12

Table 3 Variation of Drift Mobility at Curie temperature of $Ni_{0.3}Cu_{0.2}Zn_{0.5}$ Fe_2O_4 + x WO_3 ferrite

WO3 wt.%	Curie temperature ‘T_c’ (K)	D.C. Resistivity ρ (Ω-cm)	Drift Mobility μd (cm^2/V-s)
0.25	472	1.514×10^3	1.914×10^{-28}
0.50	478	2.074×10^3	1.790×10^{-28}
0.75	490	2.846×10^3	1.598×10^{-28}
1.00	496	3.711×10^3	1.361×10^{-28}
1.25	499	4.821×10^3	1.096×10^{-28}

Table 4 Curie temperatureby A.C. Susceptibility, D.C. Resistivity and Loriea technique of $Ni_{0.3}Cu_{0.2}Zn_{0.5}$ Fe_2O_4 + x WO_3 ferrite

.WO_3 wt.%	Curie temperature ‘T_c’ (K)		
	A.C. Susceptibility	**D.C. Resistivity**	**Loriea technique**
0.00	468	469	485
0.25	472	471	493
0.50	478	476	503
0.75	490	497	520
1.00	496	515	527
1.25	499	535	534

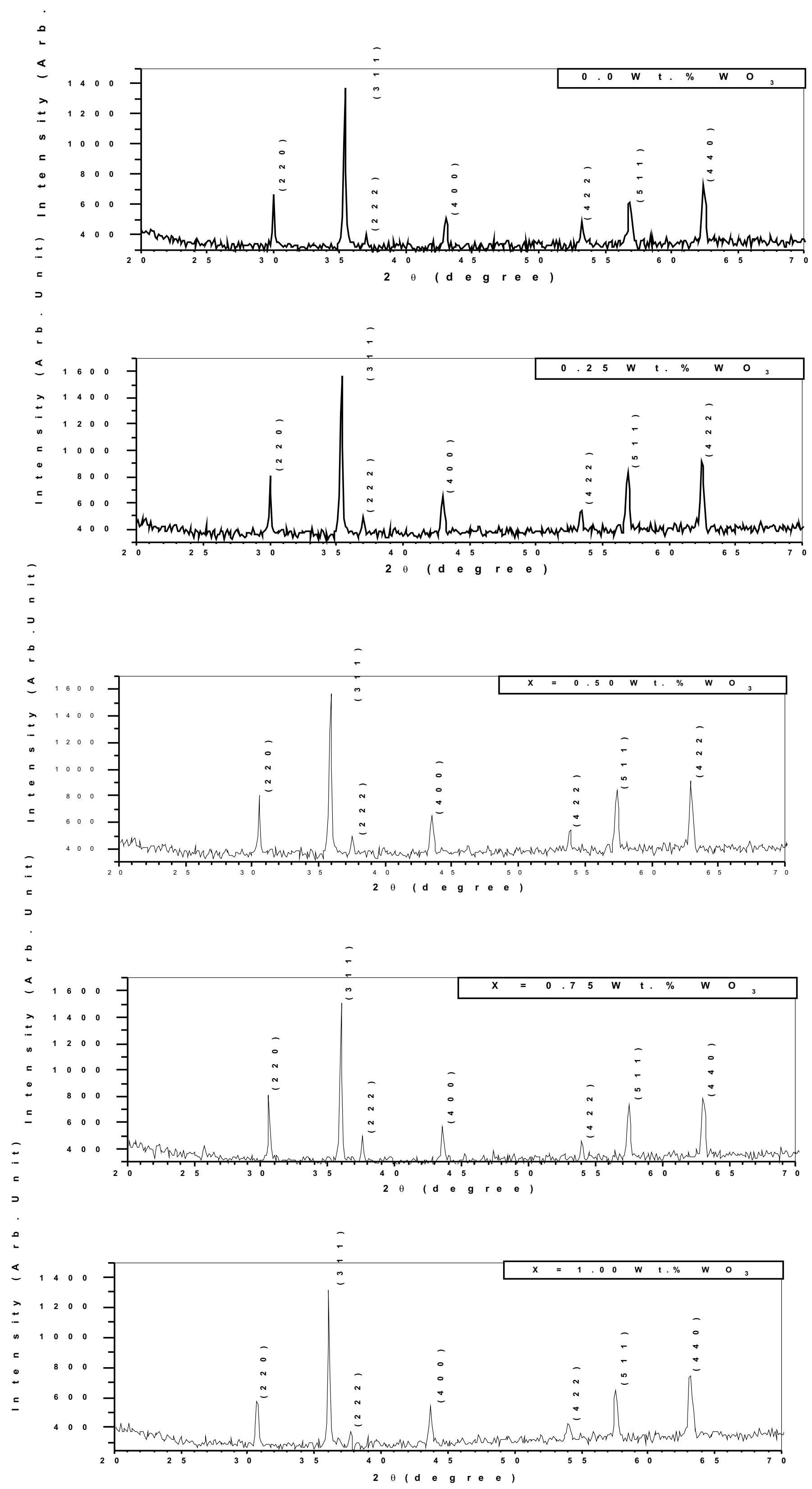

Fig. 1. X-ray diffraction pattern of $Ni_{0.3}Cu_{0.2}Zn_{0.5}$ Fe_2O_4 + x WO_3 ferrite

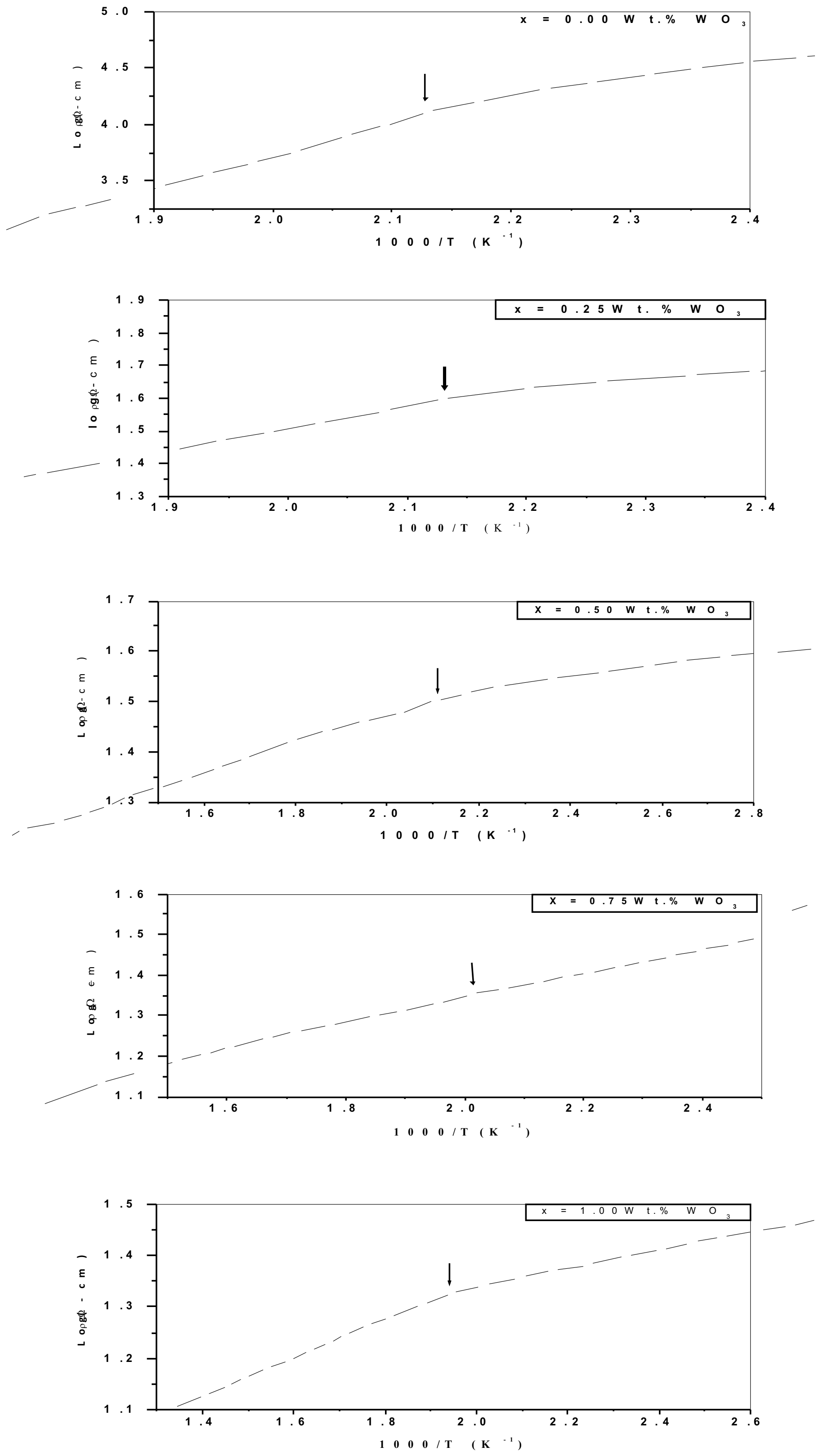

Fig.2. Variation of log Vs 1000/ T for the system x = 0.00 to 1.00 of $Ni_{0.3}Cu_{0.2}Zn_{0.5}$ Fe_2O_4 + x WO_3 ferrite

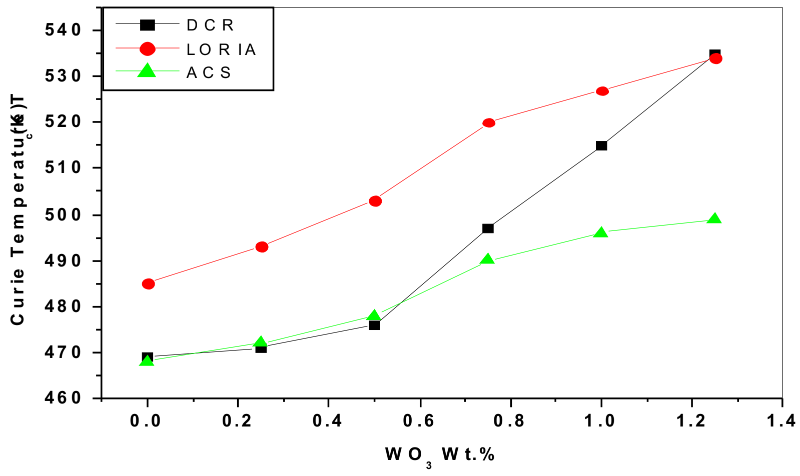

Figure 3: Variation of Curie temperature Tc (K) WO3 wt. % for $Ni_{0.3}Cu_{0.2}Zn_{0.5}$ Fe_2O_4 + x WO_3 ferrite

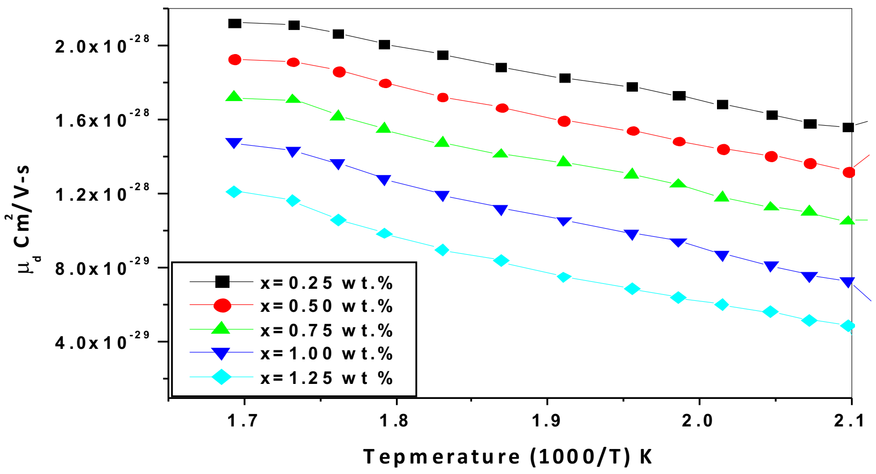

Figure 4: variation of drift mobility with the function temperature K

CONCLUSION:

The prepared NiCuZn spinel ferrite using WO_3 additives show single phase cubic spinel structure from the calculated structural parameter.

The samples have semiconductor behavior, where d.c. electrical resistivity 'ρ' decreases on increseasing the temperature.

Curie temperature (Tc) was found to increase as WO3 content 'x' increases.

Drift mobility of all the samples show temperature dependence nature.

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