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THERMOELECTRIC POWER OF Mg Zn-FERRITES

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Abstract: Zinc substituted ferrites with general formula $Mg_{(1-x)} Zn_x Fe_2O_4$ (where X=0.0,0.25,0.5,0.75,1.0) were prepared by ceramic technique. The thermo-electric power was measured by differential methods in the temperature range 30-200°C. It was observed that both n and p-type carriers were responsible for conduction in these materials. Sample for which X=0.0 shows p-type behavior and that with X=0.25 shows an n-type behavior throughout the temperature range mentioned above. The samples with X=0.5,0.75,1.0 show n- to p-type behavior. It was observed that all the samples are degenerate type semi-conductors.

Keywords: Ceramic technique, conduction, ferrites, thermoelectric power.

INTRODUCTION

Magnesium ferrites have been used in high frequency applications. Due to their enormous resistivity they can withstand high frequency electromagnetic fields. Due to a combination of high specific resistance and remarkable magnetic properties, these materials become one of the best choices for microwave applications.

This is the reason that we opted to study the electrical behavior of magnesium ferrites. Ferrites are not band type semiconductors and the conduction takes place due to hopping of electrons or holes in these materials. Due to this, the measurement of Hall current becomes difficult. However, thermopower measurements have been carried out in ferrites [Hanaish *et al*. 1991, Patil *et al*. 1994, Mazen *et al*. 1995, Bhise *et al*. 1996, Atif 1999, Islam *et al*. 2001, 2002]. The conduction is either through n- to p-type carriers [Boyanov 1994] or through p- to n-type carriers. But occasionally p- to n-type behavior has been observed [Patil *et al*. 1994]. Most of the materials under consideration were found to be degenerate semiconductors.

In this communication, we have reported the results of measurement of thermopower in $Mg_{(1-x)} Zn_x Fe_2O_4$ ferrites. X-ray diffraction has been employed for the verification of appropriate phase of the material. Results are discussed.

MATERIALS AND METHODS

The $Mg_{(1-x)} Zn_x Fe_2O_4$ ferrites were prepared by ceramic method. The samples were finally sintered at about 1250°C and the phase was confirmed by X-ray diffractometer model XD-5A equipped with CuK_α radiation. The other details of the sample preparation are reported elsewhere [Islam *et al.* 2001].

Thermopower was measured by differential methods. For thermoelectric power measurement, the sample was sandwiched between the probes of the sample holder. A temperature difference of 20K was maintained across the sample with the help of a heater fitted with each electrode. Temperature of the both surfaces of the sample was measured with the help of two identical chromel-alumel thermocouples. The Seebeck coefficient (α) was determined by the relation:

$$\alpha = \lim_{\Delta t \to 0} \Delta V / \Delta T \qquad (1)$$

Where ΔV is the thermo electromotive force (e.m.f.) (in mV) developed across the sample due to a temperature difference ΔT.

Table 1: Values of diffraction angle 2θ, inter-planer spacing d, hkl and lattice constant a, for $Mg_{(1-x)}Zn_x Fe_2O_4$ sintered at 1250 °C.

Sr. No.	Mole Fractions (X)	2 θ	d (Å)	hkl	a (Å)
1.	0.00	30.17	2.959	220	8.370
		35.54	2.523	311	
		43.09	2.092	400	
		57.12	1.610	333	
2.	0.25	30.02	2.973	220	8.403
		35.36	2.535	311	
		42.97	2.102	400	
		56.88	1.617	333	
3.	0.50	30.01	2.974	220	8.414
		35.34	2.536	311	
		42.95	2.103	400	
		56.79	1.619	333	
4.	0.75	29.97	2.978	220	8.424
		35.23	2.540	311	
		42.90	2.106	400	
		56.72	1.621	333	
5.	1.00	30.00	2.975	220	8.428
		35.36	2.535	311	
		42.80	2.110	400	
		56.70	1.622	333	

RESULTS AND DISCUSSION

The X-ray diffraction patterns for $Mg_{(1-x)} Zn_x Fe_2O_4$ system are shown in Fig.1. The X-ray diffraction parameters are listed in Table 1. The d-values and hkls reveal that the phase developed in each sample is F.C.C., thereby confirming the spinel structure.

Fig. 2 shows the plot of Seebeck coefficient (α) vs. temperature for all $Mg_{(1-x)}Zn_xFe_2O_4$ samples in the temperature range 293-453K. It is clear that all the samples are degenerate type semiconductors. Degenerate samples obey the general equation for the temperature dependence i.e.

$$\alpha = A + B / T \qquad (2)$$

where A and B are constants.

It can be seen from Fig.2 that the Seebeck coefficient for the sample (X=0.0) is positive throughout the temperature range and shows p-type behavior. For X=0.25 the Seebeck coefficient remains negative and hence indicates n-type conduction mechanism. For samples X=0.5, 0.75, 1.0 the Seebeck coefficient varies from negative to positive and exhibits n- to p- type conduction. Hence both type of carriers are taking part in the conduction process.

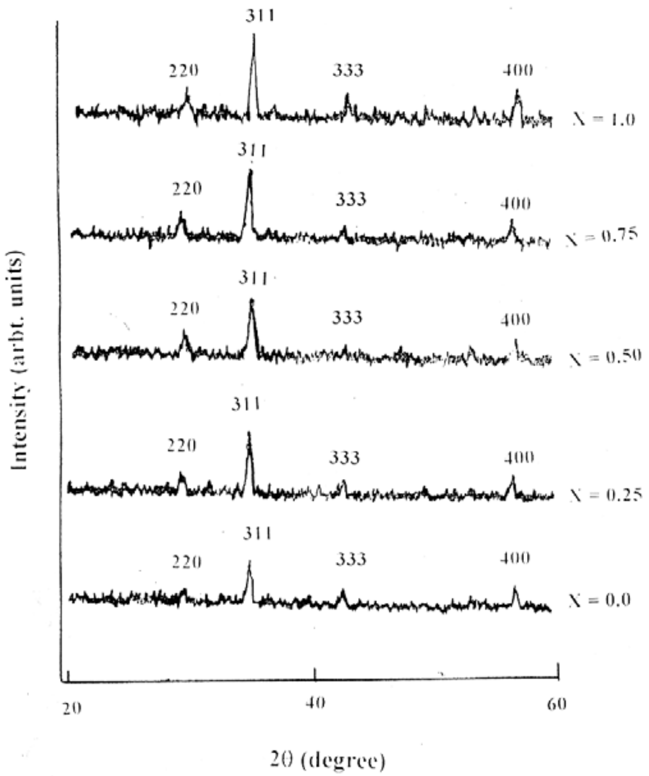

Fig. 1: X-ray diffraction patterns for various $Mg_{(1-x)} Zn_x Fe_2O_4$ ferrites.

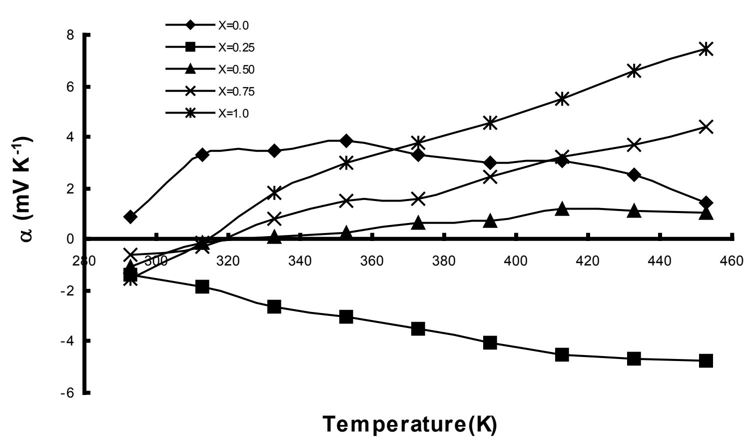

Fig. 2: Plot of thermoelectric power (α) vs. temperature (K).

Table 2: X-ray density D_x and Porosity P for $Mg_{(1-x)}Zn_x Fe_2O_4$ ferrites.

Sr. No.	Concentration "X"	X-ray density "D_x" (gm cm^{-3})	Porosity "P"
1.	0.00	4.53	0.36
2.	0.25	4.71	0.36
3.	0.50	4.92	0.35
4.	0.75	5.13	0.32
5.	1.00	5.35	0.33

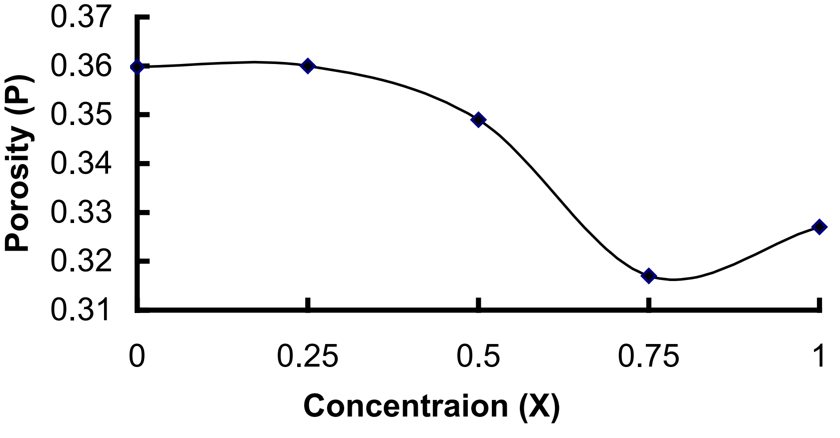

Fig. 3: Plot of porosity (P) vs. Zn-concentration (X).

X-ray density (D_x) and porosity (P) for various concentrations of Zn are listed in Table 2. The graph between porosity (P) and Zn concentration (X) is shown in Fig. 3. It is obvious that porosity decreases from 0.35-0.312 for X=0.0 to X=0.75 due to increased number of oxygen vacancies in the sample. The increase in porosity above X=0.75 may be due to the presence of more cation vacancies due to the loss of Zinc [Uitert 1953]. These results of porosity agree with the results of thermopower and room temperature resistivity reported by Islam [2001] i.e. more porous sample have high resistivity and vice versa.

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