Biohouse, Volume 2: Issue 3, May-June 2016

Biohouse Journal of Research in Science

ISSN 2379-1527

Investigation of Thermo emf of MgCuZn Ferrites

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Abstract: *The series of samples of MgCuZn ferrites are investigated for thermo emf in the temperature range of 40^0C to 400^0C at an interval of 5^0C with 10^0C temperature gradient across the sample. From these measurements Seebeck coefficient α and corresponding Fermi energies are calculated for all the samples throughout the investigated temperature region. The compositional variation of Seebeck coefficient at room temperature showed a maximum at x = 0.1 copper concentration. All the samples studied have attained a maximum Seebeck coefficient at certain temperature. All the samples studied have exhibited negative Seebeck coefficient in the entire temperature region of investigation suggesting that these MgCuZn ferrites come under n– type semiconductors.*

I. Introduction

While electrical conduction is a vital property in itself type of conducting carrier also plays a crucial role in designing the material for the required application. In the case of low–mobility semiconductors such as ferrites, study of thermoelectric power is the only alternative. Studies on thermoelectric power help in identifying the type of carrier apart from understanding the conduction mechanism in ferrites. These properties depend on many factors such as chemical composition, method of preparation, cation distribution in tetrahedral (A-) and octahedral (B-) sites, sintering temperatures etc[1]. Furthermore a thermoelectric power study of ferrites – oxide materials is important firstly due to the conversion of thermal energy to electrical energy. Secondly oxides are comparatively stable, abundant in nature, reliable and renewable energy sources than tellurides such as PbTeand GeTe [2]. MgCuZn ferrites are competent as core materials for high frequency applications due to their equally good electrical and magnetic properties as those of NiZn and NiCuZn ferrites with an added advantage of cost effectiveness and environmental friendly [3]. Many reported the thermoelectric power on Mg based ferrite systems such as ZnMgNd, NiMgCuZn, NiMgZnCo, MgZn, MgTi and Mg-Fe-O [3–8]. Thermoelectric property of this particular MgCuZn ferrite system is not yet reported. In view to understand the type of carriers, conduction mechanism in these MgCuZn ferrites the composition and temperature dependence of thermoelectric power is studied in the present work.

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II. Experimental Technique

$Mg_{0.5-x}Cu_xZn_{0.5}Fe_2O_4$ where x = 0.05, 0.1, 0.15, 0.2, 0.25 and 0.3 ferrite samples are synthesized from analytical grade MgO, ZnO, CuO and Fe_2O_3 by conventional double sintering method. All the samples are finally sintered temperature of 1250oC in Zn atmosphere. Pellets of diameter 1cm and thickness of 0.2cm are first characterized by X-Ray diffraction studies (PM 1730, Germany using Cu Kα radiation) for phase confirmations. The surfaces of the sample pellet are coated with silver paste (Du Pont) for good ohmic contacts. The pellet is placed in the sample holder and then the entire cell is kept into a tubular furnace for the measurement of thermoelectric power. A temperature difference of 10oC across the pellet is maintained using a small independent micro-furnace fitted with the sample holder assembly. The thermo–emf across the pellet is measured with a dc micro voltmeter (Philips). The thermo–emf measurements were made after the attainment of thermal equilibrium. The temperatures have been measured using calibrated chromel–alumel thermocouple. The measurements were made in the temperature range of 40 to 400oC at intervals of 5oC. Seebeck voltage Vs is determined by using the relation Vs = α (T2-T1) where the constant of proportionality (α) is known as the thermoelectric power and has the dimensions of volt per degree. It is also referred to as Seebeck coefficient.

III. Results and Discussions

The typical X-ray diffraction (XRD) patterns of the investigated ferrite series with x = 0.10 and 0.25, exhibit single phase spinel structure of the ferrite samples is observed. As the copper concentration increased the densities of the present ferrite series increased with a slope change at x= 0.1 concentration. The increase in density may be due to increased compactness in the ferrites during liquid phase sintering. Copper oxide at elevated temperature gets decomposed to Cu_2O which has low melting point [9]. It is expected that at temperatures even less than the melting point of Cu_2O a eutectic copper rich region facilitate liquid phase sintering of the ferrite. A similar behaviour was reported in previous study [10] in iron deficient MgCuZn ferrite series sintered in conventional and microwave furnaces. The concentration x = 0.1 seems to be critical concentration of copper at which an abrupt change in the properties of MgCuZn ferrites are already reported [11,12]. The slope change in density and the peak value of thermoelectric power studies (values in Table 1) at x = 0.1 once again confirms the critical limit of copper concentration in MgCuZn ferrites. At low concentrations of copper it appears that there is an abrupt change in the population of Fe^{3+} and Cu^{2+} ions. And hence the Seebeck coefficient showed a large negative value. At this composition Rezlescu et al [13] also have reported high resistivity behaviour

IV. CONCLUSIONS

MgCuZn ferrite series of stoichiometric proportion Mg0.5-xCuxZn0.5Fe2O4 (x = 0.05 – 0.3) are synthesized by usual ceramic double sintering method. Measured Seebeck coefficient increases with increase in Cu till x=0.1 and then decreases. This is attributed to the critical concentration limit of copper. N-type carrier hopping is observed from Seebeck coefficient throughout the temperature range investigated. The Seebeck coefficient transition temperature Ts do not match with magnetic Curie transition temperature but signifies the initiation of hole conduction from Ts.

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