Preparation, Electric and Magnetic Properties of Ni-Co/Ni-Zn Ferrites

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Abstract
The two ferrite systems $Ni_{0.2}$ $Co_{0.8}$ Fe_2O_4 and $Ni_{0.5}$ $Zn_{0.5}$ Fe_2O_4 were prepared by conventional ceramic method. The formations of cubic spinal structure of the ferrites were confirmed from XRD measurements. The surface morphology and average grain size was studied with the SEM measurements. A DC conductivity measurement reveals semiconducting nature of ferrites. The variation of dielectric constant and loss tangent with frequency at room temperature was studied. The dielectric dispersion is observed at lower frequency region and it remains constant at higher frequency region. The monotonic increase in AC conductivity with frequency shows small polaron type conduction. The magnetic hysteresis of ferrites was studied. At room temperature ferrites exhibit magnetic behaviour indicating the presence of ordered magnetic system.

Keywords: XRD; SEM; Conductivity; Magnetic hysteresis

1. Introduction:

In the recent technology ferrites find vide applications in the field of electronic industry, which is a mixture of Fe_2O_3 and the oxides of other materials represented by general formula MFe_2O_4, where M is usually a divalent metal ion. During 1933-1945 Snoek and his associates at the Philips Research Laboratory in Holland developed the ferrites for commercial uses. In 1948 Nëel has given theoretical explanation for ferrites and later he named it as "ferrimagnetism"and at the same time Gorter has given the history for the development of the ferrites. Ferrites play important role in modern technologies like electrical engineering, nuclear power engineering, computer systems and other electronic applications. Ferrites have created considerable interest among the researchers who are in search of new ferrites with improved properties. The physical parameters such as magnetization, coercivity, conductivity, porosity, grain size and microstructure play an important role in deciding the suitability of a ferrite for a particular application [1].

2. Experimental:

The $Ni_{0.2}$ $Co_{0.8}$ Fe_2O_4 and $Ni_{0.5}$ $Zn_{0.5}$ Fe_2O_4 are selected as the ferrite phases, prepared through solid state reaction method by using analytical reagent (AR) grade Ni, Co, Zn and Fe oxides in molar proportions and mixed thoroughly in acetone medium in agate mortar for 2-3 hrs. The ferrite phases are presintered at 800 °C for 10 hrs by slowly increasing the temperature of the furnace at the rate of 100 °C /hr and then slowly cooled to room temperature.

The X-ray diffraction patterns of the samples were recorded by using PW-1710 X-ray diffractometer with CuK_α radiations. The SEM micrographs of the samples are obtained by using SEM model JEOL-JSM 6360. The DC electrical resistivity of the samples is measured by two probe method. The dielectric properties were measured by two probe method using LCR meter bridge (Model HP 4284 A). The magnetization measurements are made by using a high field hysteresis loop tracer.

3. Results and Discussion:

XRD patterns for the systems $Ni_{0.2}Co_{0.8}$ Fe_2O_4 and $Ni_{0.5}$ $Zn_{0.5}$ Fe_2O_4 (fig 1) show well defined peaks (without impurity phase) with specific indices and the appearance of more intense (311) line in both the systems confirms the formation of cubic spinel structure. The difference in lattice parameter of the ferrites is due the larger ionic radii of Co than Zn. The SEM micrographs of ferrite systems show fine grains with varying porosity and smaller grain size. The resistivity decreases linearly with temperature showing semiconducting nature of ferrites. The estimated activation of para region is greater than 0.2 eV shows small polaron type of conduction mechanism[2]. The dielectric constant and loss tangent decreases with increase in test frequency indicating dispersion in certain frequency region and then reaches a constant value. The high values of dielectric constant at lower frequency region and low values at higher frequency region indicate large dispersion due to Maxwell-Wagner type of interfacial polarization in accordance with Koop's theory. The monotonic increase in AC conductivity with increase in frequency suggests small polron type of conduction mechanism. The magnetic hysteresis loops (M-H) of the two ferrite systems at room temperature exhibits magnetic behaviour indicating the magnetic ordered structure. The large saturation magnetization is observed for the Ni-Zn ferrite is due the large grains of Zn ions increase the magnetization[3].

TABLE 1. Lattice parameter, average grain size, porosity, activation energy and saturation magnetization.

Parameters	Ni-Co ferrite	Ni-Zn ferrite
a (Å)	8.372	8.342
d (μ m)	1.63	1.77
Porosity (%)	16.5	15.4
Activation Energy (Para) in eV	0.34	0.35
Saturation magnetization (emu/gr)	43.55	51.32

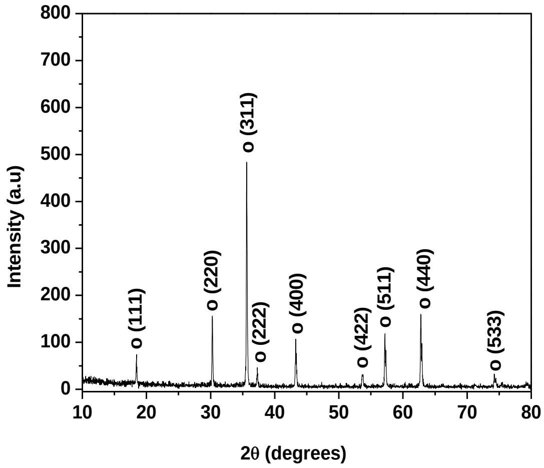

Fig. 1: XRD pattern of $Ni_{0.2}Co_{0.8}Fe_2O_4$ ferrite phase

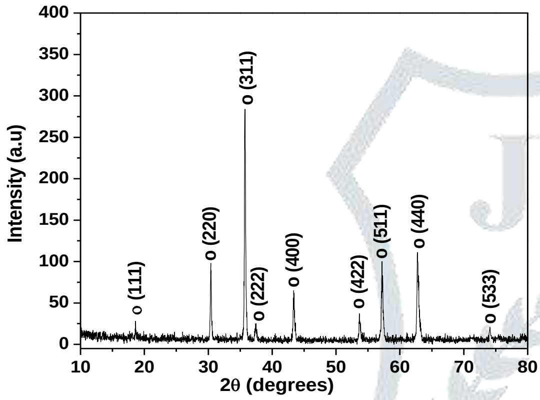

Fig. 1: XRD pattern of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ ferrite phase

4. Conclusion:

In the present study ferrite phases $Ni_{0.2}Co_{0.8}Fe_2O_4$ and $Ni_{0.5}Zn_{0.5}Fe_2O_4$ were synthesized by the standard double sintering ceramic method. The XRD patterns of both the systems confirm the formation of cubic spinel structure. The scanning electron micrographs of ferrites show fine grains with varying porosity and smaller grain size. The estimated activation energies for the ferrites in the higher and lower temperature regions suggest the temperature dependence of the mobility of charge carriers and the activation energy of paraelectric region greater than 0.2 eV (above Tc), reveals polaron hoping in ferrites. The variation of dielectric constant and loss tangent with frequency at room temperature shows the decrease in dielectric constant with increase in test frequency and indicates dispersion at certain frequency region and then becomes almost constant. The saturation magnetization of Ni-Zn ferrite is larger than Ni-Co ferrite due the large grains of Zn ions.

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