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STRUCTURAL, MAGNETIC AND INITIAL PERMEABILITY PROPERTIES OF $Ni_{0.33}Zn_{0.63}Fe_2O_4$ SPINEL FERRITE

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Abstract: *Spinel ferrite having composition $Ni_{0.33}Zn_{0.63}Fe_2O_4$ was prepared by ceramic method and characterized by X-ray diffraction technique. The magnetic and initial permeability properties were investigated by standard method. X-ray diffraction pattern analysis confirms the formation of single phase cubic spinel structure. The saturation magnetization, coercivity and remenance magnetization properties obtained in the present work are suitable for multilayer chip inductors applications (MLCI). Temperature dependence of initial permeability show decreasing trend.*

Keywords: *Ni-Zn ferrite, Initial permeability, magnetic properties.*

1 Introduction

Polycrystalline ferrite consisting of iron oxide and metal oxide has a wide range of applications in the field of electronics, computer, and telecommunications. Ferrites are commercially important class of magnetic materials due to their combined electrical and magnetic properties. These properties of ferrite changes with respect to type and amount of dopant, synthesis methods, sintering time and temperature, synthesis parameters and distribution of cations over the available sites [1-4]. However, the properties of the ferrite materials prepared by ceramic techniques are exhibits good electrical and magnetic properties which are useful in many industrial and biomedical applications [5].

In the family of ferrites, spinel ferrites are important from research and academic point of view. Spinel ferrites are recognized by the formula AB_2O_4, where A stands for divalent cation such as Ni, Zn, Cd, Cu, Co, Mn etc and B stands for trivalent Fe ions. The structure of spinel ferrite is cubic and consists of two interstitial sites namely tetrahedral (A) and octahedral [B] site. Cations of different size and values can accommodate in these interstitial sites depending upon their site preference energy and bring variation in electrical and magnetic properties. The magnetic properties are mostly dependent on occupancy of cations at tetrahedral A site and octahedral B site.

In the literature, nickel ferrite and substituted nickel ferrite have been studied by number of researchers [6-8]. The properties of Ni-Zn ferrite materials are further modified by substituting cations like copper ions. Substitution of copper ions in this ferrite is known to useful to reduce the sintering temperature drastically. The structural, magnetic, electric and dielectric properties of copper substituted nickel - zinc ferrite have been studied to know the effect on observed modification. The magnetic properties like saturation magnetization, coercivity and initial permeability are of prime interest from the point of view of their applications.

2. Experimental

2.1 Preparation of $Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrite

The $Ni_{0.33}Zn_{0.63}Fe_2O_4$ powder sample was synthesized by using conventional ceramic method using starting material NiO, ZnO and Fe_2O_3 were of highly chemically pure A.R. grade (99.99 %). Stoichiometric proportions of these starting materials (Oxides) were accurately weigh and mixed thoroughly. Then first pre-sintering of powder was carried out at 1225 K for 12 h. The sintered powder is again reground and sintered at 1375 K for 12 h. The mixture was ground using agate mortar pestle in order to obtain very fine homogeneous powder. The powders pressed under hydraulic press by applying pressure 6 ton/cm^2 for 15 min to form disc shaped pellets (10 mm diameter in dimensions) and toroid-shaped pellets (20 mm outer diameter and 10 mm inner diameter in dimensions). The prepared pellets of $Ni_{0.33}Zn_{0.63}Fe_2O_4$ sample was compacted using polyvinyl-alcohol (PVA) as a binder. The disc-shaped pellets and toroidal-shaped pellets were sintered at 1323 K for 24 h. and then slowly cooled.

2.2 Characterizations

The X-ray diffraction (XRD) pattern were recorded at room temperature in the angle 2θ range 20^0 to 80^0 by using X-ray diffractometer (Philips X-ray diffractometer Model PW 3710) using Cu-Kα as a target having wavelength λ = 1.5406 Å. The magnetic properties such as saturation magnetization (Ms), remanence magnetization (Mr) and coercivity (Hc) were studied by pulse field hysteresis loop tracer (Magneta Company) technique at room temperature. The initial permeability was measured on a toroid samples using LCR-Q meter (APLAB, India) as a function of temperature at a fixed frequency of 1 KHz.

3. Results and discussion

3.1 X-ray diffraction

The room temperature X-ray diffraction (XRD) pattern of prepared $Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrite sample under investigation is represented in Fig. 1. The X-ray diffractions pattern showed intense, clear, and sharp peaks which are indexed using Bragg's law. The Miller indices (220), (311), (222), (400), (422), (511), (440) and (533) belong to spinel ferrite was observed in the X-ray diffraction pattern, in which (311) is the high intensity plane. All the observed planes seen in the XRD pattern belongs to spinel structure with cubic symmetry. Our X-ray diffraction pattern is analogous to that reported for other spinel ferrites [10, 11]. The analysis of XRD pattern reveals the formation of single phase cubic spinel structure.

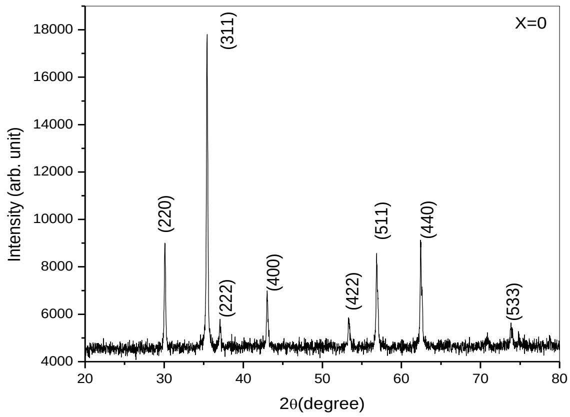

Fig. 1 XRD pattern of $Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrite

3.2 Magnetic properties

The magnetic properties of the present sample of $Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrites were studied by using pulse field hysteresis loop technique at room temperature. The variation of magnetization with applied field (M-H plot) is shown in Fig. 2. As a normal behaviour the magnetization increases with increasing applied magnetic field and reaches to the its saturation value at high fields. Using the M-H plots, the value of saturation magnetization (M_S), coercivity (H_C) and remanence magnetization (Mr) are obtained and are given in inset of fig. 2.

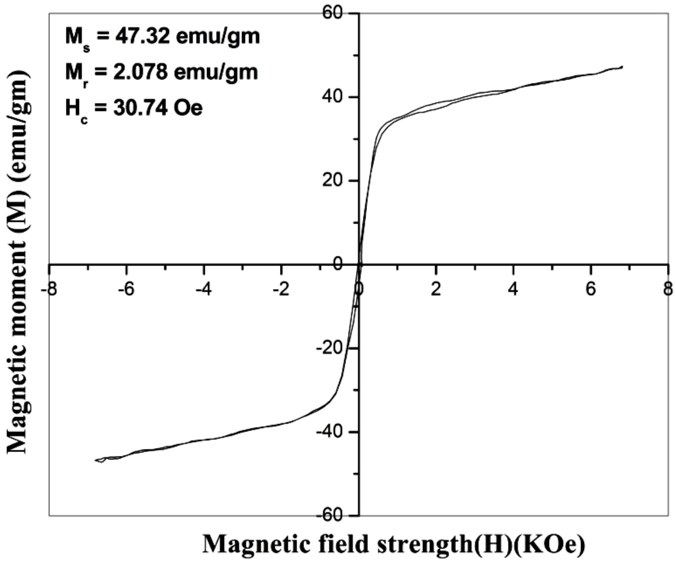

Fig. 2 M-H plot of $Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrite

In present study, thermal variation of initial permeability determinations have been carried out using LCR-Q meter in the range from room temperature to 550 K at fixed frequency 1 KHz by low field inductance measurement of coils with toroidal cores. The thermal variation of initial permeability for present sample (Fig. 3) indicates that, the permeability slightly decreases with increase in temperature. At a certain temperature, the permeability suddenly decreases near to a Curie temperature of the samples and then falls down to a minimum value of permeability.

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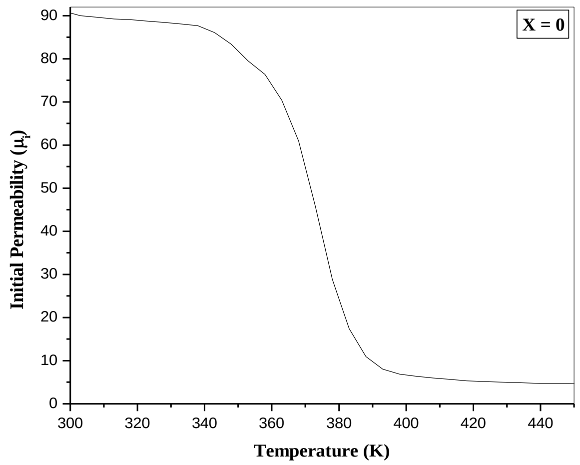

Fig. 3 Initial permeability of $Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrite

Conclusions

$Ni_{0.33}Zn_{0.63}Fe_2O_4$ spinel ferrite was prepared successfully using ceramic method. XRD pattern confirms the formation of single phase cubic spinel structure. The initial permeability decreases with increasing temperature.

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