Dielectric and Magnetic Studies of Nano-sized CoNiZn Ferrite Prepared from Combustion Synthesis

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Abstract

Synthesis of CoNiZn ferrite by combustion method was carried out using Maleic acid as a novel fuel. Thermal decomposition temperature for combustion synthesis was fixed using TG-DTA studies. Characterization of synthesized compound was done by X-ray Diffraction studies. Average crystallite size was found out using Scherrer formula. Dielectric constant was measured as a function of applied frequency in the range from 20 Hz to 1 MHz at varying temperature. Temperature dependent magnetization studies as ZFC-FC measurements were carried out at different applied fields.

Introduction

Thermally and chemically stable nanoparticles of spinel ferrites possess great potentials for application in catalysis, gas sensors, high quality ceramics, Ferrofluid technology, magneto caloric refrigeration, medical diagnostics, magnetic resonance imaging, high-density information storage system and as superparamagnetic materials. The properties of these materials mainly depend on their shape, size, content and structure, which are strongly determined by the synthetic processes [1, 2]. Here we report synthesis of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$ ferrite by combustion method and its study of dielectric and magnetic properties**.**

Experimental: Synthesis and Characterization

Nanoparticles of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$ were synthesized by combustion method using maleic acid as a novel fuel and metal nitrates, [$Ni(NO_3)_3.6H_2O$, $Zn(NO_3)_3.6H_2O$, $Co(NO_3)_3.6H_2O$ and $Fe(NO_3)_3.9H_2O$] as oxidisers. Oxidising and reducing valencies of oxidizer and fuel were used to fix their stoichiometry [3]. Once mixed, the slurry was subjected to preheated furnace at 400˚C followed by calcination at 500˚C. This 'as prepared' sample was characterized by XRD using Rigaku Miniflex X-ray Diffractometer. Its magnetic studies were carried out using Quantum design, USA make cryogen free VersaLab VSM while the dielectric study was carried out using WayneKerr 6500P LCR meter.

Results and discussion

TG-DTA studies

The TG-DTA plot of the solid mixture obtained after drying the homogenized melt of oxidiser and fuel is shown in Fig. 1. The NETZSCH STA 409

PC(Luxx) analyser was used for the studies. As can be seen from Fig. 1 the complete decomposition of melt occurs above just 300˚C hence temperature for combustion synthesis was chosen as 400˚C.

X-ray Diffraction studies

The XRD powder pattern of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$

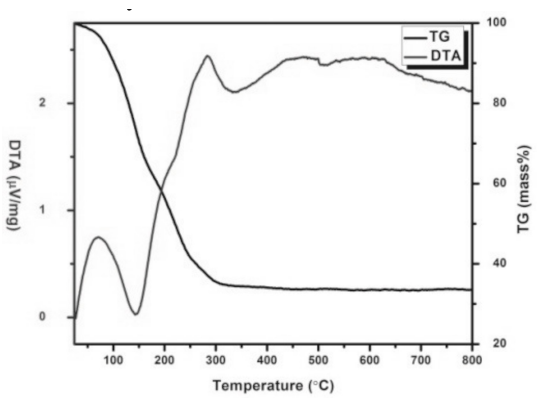

Fig. 1. TG-DTA plot of homogenised mix of Oxidiser and fuel melt

is shown in Fig. 2 which indicates formation of single phase cubic spinel structure. The average crystallite size found out using Scherrer Method was 23.79 nm while its lattice parameterwas 8.3944 A˚. The Porosity (P) was found to be41.22%.

Dielectric studies

Fig. 3 shows the change in dielectric constant with increase in frequency from 20Hz- 1MHz of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$. Dielectric constant is seen to decrease with increase in frequency which is in accordance with Maxwell-Wagner model [4]. Fig. 4 illustrates change in dielectric constant with temperature of sample at 20Hz and 1 MHz. A normal dielectric behaviour is observed wherein dielectric constant increases with temperature after 550K.

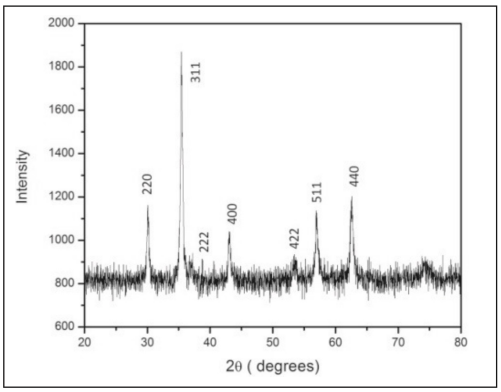

Fig.2. XRD powder pattern of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$

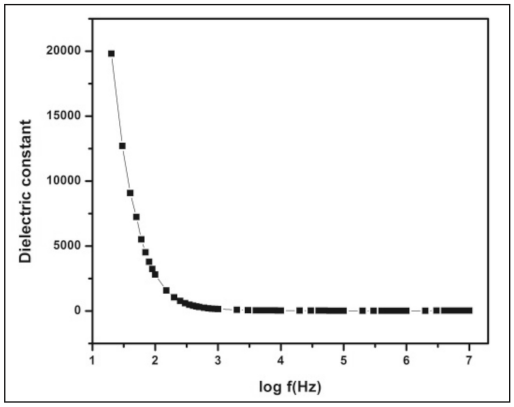

Fig. 3. Plot of dielectric constant vs. Log Frequency of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$.

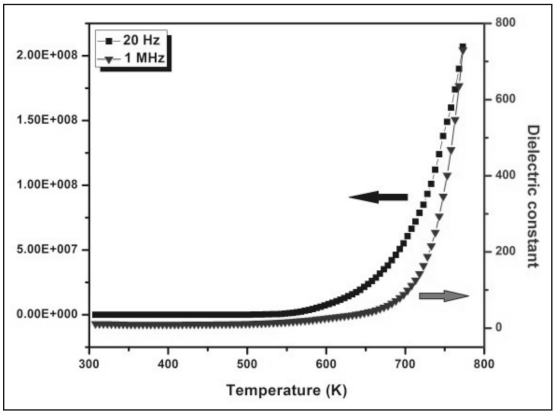

Fig. 4. Dielectric constant vs. temperature of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$.

Magnetization Studies

Magnetic field dependent magnetization studies of the sample have been carried out at 300K and 50K. The Ms, Mr and Hc values obtained are given in Table 1. It has been observed that the thermal energy reaches to minimal at lower temperature (50K) making it easy for magnetic moment to get aligned with magneticfield direction leading to increase in magnetization[5]. Fig. 5 shows temperature dependent magnetization studies as ZFC and FC measurements in the range of 50K- 400K at applied field of 250Oe, 500Oe and 1000Oe. It can be seen that Blocking temperature (T_B) goes on decreasing with increase in applied field [6].

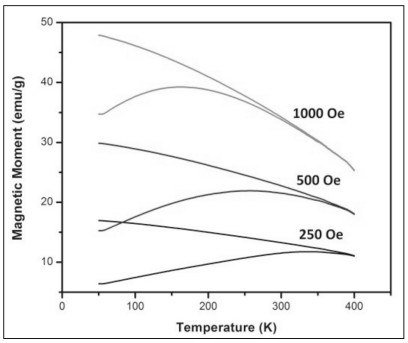

Fig. 5. *Temperature dependent magnetic studies ZFC-FC measurements in the range of 50K- 400K at three different applied fields of 250 Oe, 500 Oe and 1000 Oe.*

Table 1. Saturation Magnetization (Ms), Remenance (Mr) and Coercivity (Hc) of $Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$ at 50K and 300K.

Temperature (K)	Ms (emu/g)	Mr (emu/g)	Hc (emu/g)
50K	101.30	18.04	365.48
300K	61.17	5.48	55.27

Conclusion

$Co_{0.1}Ni_{0.4}Zn_{0.5}Fe_2O_4$nanoparticles were successfully synthesized by Combustion Method using Maleic acid as a novel fuel. Using XRD data average crystallite size was found to be 23.79 nm. Dielectric constant is found to decrease with increasing frequency and increase with increasing temperature. Magnetizationstudies showed higher magnetization values at 50K compared to 300K. Also ZFC-FC curve indicated decrease in blocking temperature with increase in applied field.

References

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