UGC Minor Research Project

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TITLE OF THE PROJECT:

"Study of Magnetic and Electrical properties of ultrafine $Ni_x Zn_{(1-x)} Fe_2O_4$ powder prepared using wet chemical method".

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SUMMARY OF THE FINDINGS

Under this project nano particle Ni_x Zn $_{(1-x)}$ Fe_2O_4 powder (X=0.50 and 0.70) was successfully synthesized using wet chemical method. The characterization using standard techniques such as XRD, TEM, IR and AFM showed that obtained particles are of nano size. Analysis of XRD spectrum show single phase cubic spinel structure. The observed lattice constant values of 8.3977 (Å) and 8.3952 (Å) for Ni=0.50 and Ni=0.70 respectively are comparable with reported literature. The IR absorption spectrum of samples show two absorption bands ν_1 is between wave number 600–550 cm^{-1} whereas lower band ν_2 between 450–385 cm^{-1}which is a common feature of all the ferrites indicating single phase spinel structure having two sub-lattices. The TEM image of the sample with Ni=0.50 show particle sizes varying in the range of 15 nm to 64 nm. The AFM image show that particle sizes vary in the large range of 20 nm to 80 nm. The SEM results show that particles are with uniform size for Ni=0.50 whereas agglomeration is noticed in case of sample with Ni=0.70. The saturation magnetization was found to be 68 emu/g and 72.5 emu/g for Ni=0.50 and Ni=0.70 respectively. The close hysteresis loop observed at room temperature indicates SPM nature of nano particles. The sintered samples showed increase in saturation magnetization are attributed increase in grain size due to sintering. The room temperature Mössbauer spectrum recorded to monitor the local environment around Fe cations in sample Ni=0.50 showed three magnetic sextets which are arising due to Zeeman splitting. The two major sextets are corresponding to Fe ions residing at the A site (inner sextet) and B site (outer sextet) of the lattices indicates ferrimagnetic behavior of the sample. The presence of superparamagnetic (SPM) particles in the sample was confirmed using central doublet in Mossbauer spectra of the sample. The results of the isomer shift vary in the range of 0.311 mm/s to 0.490 mm/s. This shows that, Fe ions are in the trivalent state. The normalized susceptibility variation indicates that all the samples exhibit typical ferrimagnetic behavior. The ferrimagnetic ordering is seen to increase with increase in Ni content, which is also supported by Mossbauer analysis. The Curie temperature of the main phase of sample was found to be 225^0C and 280^0C for Ni=0.50 and Ni=0.70 respectively. It can be seen that, $\mathbf{T_c}$ increases with increasing Ni content in the sample. This is attributed to strengthening of A-B interaction.

The DC resistivity decreases with increasing temperature showing typical semiconductor like behavior. The room temperature resistivity of nano samples is of the order of 10^7 ohm-cm. It is seen that room temperature resistivity increases Ni=0.70 is more compared to Ni=0.50. This increase in resistivity with increase in Ni content can be explained on the basis of site occupation of different ions. The sintered samples showed similar trend having lower resistivity compared to nano samples. This decrease in resistivity can be attributed to increase in grain size due to sintering. The dielectric constant decreases with the increase in frequency and ultimately attains a constant value at higher frequency for all the compositions. In present work, the maximum ε of 65 (at 50 Hz) was obtained for sample with Ni=0.70 sintered at 1000^{o}C, whereas, the minimum ε of 33 (at 50 Hz) was obtained for Ni=0.5 0 sintered at 900^{o}C. The increase in sintering temperature brings an increase in grain size as well as increase in Fe^{2+} concentration and which resulted into increase in dielectric constant of sintered samples. In present investigation the low dielectric loss were observed with lowest value of 0.22 (at 3 MHz) for sample with Ni=0.50 (sintered at 900^{o}C).

SIGNATURE OF

PRINCIPAL INVESTIGATOR

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