Highly homogeneous copper ferrite nanoparticles production

SUMMARY AND CONCLUSION

A simple and economical route has been prepared for producing three series of highly homogeneous copper ferrite nanoparticles. The ferrite sample was prepared by conventional oxide ceramic method. The ferrite system formed is$CuFe_{2-2y}Al_{2y}O_4$ (where y= 0. 0, 0. 05, 0. 15 & 0. 25). The effect of aluminum content on structural, electrical and magnetic properties was studied. The microstructural properties of the prepared samples are investigated using X-ray diffraction, Scanning Electron Microscope, and Infra red absorption spectroscopy. The X-ray diffraction patterns reveal inverse spinel tetragonal structure for all the synthesized samples. The average crystal sizes were calculated using Scheerer formula. The crystal size calculated in the present study is found in the nano range 50nm to 100 nm.

For all the synthesized samples, the X- ray density and physical density is found to decrease with increase in Al concentration.

The Curie temperature was determined from the susceptibility measurements. It show the phase transition of ferromagnetic or ferrimagnetic to paramagnetic substance. The changing Curie temperature values give us the information about the strength of the *A-B* exchange interactions and the thermal stability of the ferromagnetic characteristics. Below the Curie temperature; the magnetic material shows continuous magnetization. Above the Curie temperature; the magnetic material does not show any magnetization. The Curie temperature is affected by the A-B distance. The Curie temperature decreases with increase in the distance A-B. In the ferromagnetic class Fe^{3+} ion is having the highest magnetic moment and thus it plays an important role in deciding properties. Therefore Curie temperature is directly linked with $Fe3^{+}$ ion participating in A-B interaction. The value of Curie temperature is found to be decrease with decrease in Fe^{3+} ion concenteration. The magnetic susceptibility of the ferrimagnetic materials increase with increase in temperature. At a certain temperature; called Curie temperature (Tc) the material lose its ferrimagnetic nature and become paramagnetic. Sudden drop in magnetic susceptibility is observed at Tc.

The electrical properties of ferrites are usually based on the band structure and carrier hoping model. Ferrites have higher resistance than metals by several times. They are also regarded as very structure sensitive material. This created considerable interest in many research workers for the development and potential application of ferrites in the electronic industry. The conductivity of ferrite is greatly influenced by porosity, grain size and microstructure of the sample. It is observed that DC electrical resistivity increases with increasing concentration of Al^{3+} ions. The activation energies in both ferrimagnetic and paramagnetic region of the composition are determined from the slope of respective lines. Activation energies in ferromagnetic region are found very less than that of a paramagnetic region. These investigated results are in good agreement with reported in literature. For ferromagnetic material , the activation energy lies in between 0. 1 eV to 0. 3 eV and for ferromagnetic it is in between 0. 3 eV to 0. 5 eV.

In ionic crystal the dielectric constant decreases rapidly with increasing frequency and then reaches a constant value. It is seen that the value of the dielectric constant is very high at low frequencies and decreases with increasing frequency, then at higher frequency they become almost constant. The electron exchange between Fe^{+2} and Fe^{+3} ions cannot follow the change of the external field beyond certain frequency. Due to this fact the dielectric constant dectreases with increase in frequency. The dielectric constant ε’ and dielectric loss tangent tanδ decreases with increasing frequency for all $CuFe_{2-2y}Al_{2y}O_4$ compositions. It is seen that the value of dielectric constant ε’ and dielectric loss tangent tanδ increases with addition of $Al3^{+}$ ions. The decrease in the electrical resistivity at low temperature is attributed to the impurities, which reside at the grain boundaries. The decrease in resistivity with increasing temperature could be attributed to negative temperature coefficient of resistance of $CuFe_{2-2y}Al_{2y}O_4$. Therefore it is concluded that aluminum content influences electrical conductivity and microstructure of copper ferrite.

The variation of AC resistivity is nearly frequency independent at low frequencies. It is also seen that, the resistivity varies with aluminum content. As the aluminum content increases, the ac resistivity decreases. The behaviour of data indicates that, hoping of charge carrier among localized is more predominant. It is also found that small polarons play a role in the conduction process. The conduction mechanism and dielectric behaviour are found to be strongly colrelated for all the prepared samples.

Conclusions:

An attempt is made to meet the challenges for the advancements in the new ferrite technology. The variation in the structural, electrical and magneticproperties of spinel copper ferrites introduced by the substitution of aluminum. The obtained results are summarized with following important concluding remarks:

• XRD analysis revealed that all the samples have single phase cubic spinel structure.

• Crystallite size lied within 50 nm to 100 nm.

• All the samples are slightly porous evident from SEM analysis

• X-Ray density decreases with increase in Al^{+3} content.

• Physical density decreases with increase in Al^{+3} content.

• Porosity increases with increase in Al^{+3} content.

• Particle size increases with increase in Al^{+3} content.

• Ionic radii R_A (Tetrahedral side) increases with increase in Al^{+3} content.

• Ionic radii R_B (Octahedral side) increases with increase in Al^{+3} content.

• Ionic bond length A-O decreases with increase in Al^{+3} content.

• Ionic bond length B-O increases with increase in Al^{+3} content.

• Ionic bond length A-O decreases with increase in Al^{+3} content.

• Lattice constant ‘ a’ increases with increase in Al^{+3} content.

• Lattice constant ‘ c’ decreases with increase in Al $^{+3}$ content.

• Dielectric constant ε’decreases with increase in frequency.

• Dielectric loss factor ε’’ decreases with increase in frequency.

• Loss tangent also decreases with increase in frequency.

• A. C. resistivity remains approximately uniform over a wide range of frequency.

• D. C. resistivity increases with increase in temperature.

• Curie temperature decreases with Al $^{+3}$ content.

• Saturation magnetisation decreases with Al $^{+3}$ content.

• Magnetic moment decreases with Al $^{+3}$ content.

• Retentivity decreases with Al $^{+3}$ content.

• Coercivity decreases with Al $^{+3}$ content.

• The dielectric constant and dielectric loss decreases with the increase in frequencyin all the samples of the four series investigated.

• The synthesized nanomaterials possess high saturation magnetization, lowcoercivity and improved room temperature resistivity together with low dielectricloss.

• Data obtained demonstrate the ability to tune properties of doped copper-ferrite tomatch intended applications.