Abstract

Zinc-ferrite nanoparticles dispersed in a silica matrix were prepared by sol-gel process using metallic nitrates as precursors of ferrite and tetraethylorthosilicate (TEOS) as a precursor of silica. Zn:Fe molar ratio was controlled at 1:2. The weight ratios of Zinc-ferrite nanocomposites were $x(ZnFe_2O_4)/(100-x)SiO_2$ (where x= 40, 60, 80 wt. %), and heat treated at 700, 800 and 900 ^oC, for 2 hours. The obtained phase of zinc-ferrite nanocomposites were confirmed using X- ray diffraction (XRD), thermo gravimetric analysis (TGA) and scanning electron microscope (SEM).

The temperature dependence of electrical conductivity for all the investigated samples has been studied between 50 and 200 ^oC. The results show an activation process of the electrical conductivity with temperature combined with two different conduction mechanisms. The first occurred at relatively low temperature range which the most predominant mechanism of conduction is due to the hopping of electrons between filled and empty states (Fe^{2+} and Fe^{3+}). The second occurred at relatively high temperature range at which the conduction is mainly due to a small polarons.

Current-voltage characteristics were studied for all the investigated samples at room temperature. It is noticed that, two regions in I-V characteristics curve are observed, the first one is the ohmic region and the second is space charge region. The drift mobility (μ) and the concentration of charge carriers (n) are calculated and discussed for all samples. The results show that, the experimental values of concentration

of charge carriers decrease by increasing $ZnFe_2O_4$ content and increase of annealing temperature.

The ac conductivity (σ_{ac}), dielectric constant (ε') and dielectric loss (ε") have been studied between (100-300 ^oC), in the frequency range (5-100 kHz). All these parameters increased with increasing temperature. According to koops model, there is parallel relation between conduction mechanism and polarization mechanism.

The frequency dependence of the ac conductivity show, in general, σ_{ac} increases with increasing frequency for all investigated samples. The frequency dependence of σ_{ac} should be explained on the basis of hopping of electrons between filled and empty states (Fe^{2+} and Fe^{3+}).

The frequency dependence of the dielectric constant, ε', and dielectric loss, ε" show, in general, ε' and ε" decrease with increasing frequency for all investigated samples. The frequency dependence of ε' and ε" should be explained on the basis of the arising from electronic, ionic and dipolar polarization.

Compositional variation of the ac conductivity, σ_{ac}, dielectric constant, ε', and dielectric loss, ε", has been studied. It is seen that all these parameters decrease with increasing Zn-ferrite content. The decrease of these parameters is attributed to increase of particle size which increases with increasing both of Zn-ferrite content and annealing temperature. Increasing of particle size implies an increase of the insulating surface on the grain boundaries, which normally accounts for high electrical resistance of the nanocrystalline material.

The magnetic susceptibility, χ, was carried out using the conventional Gouy's method at room temperature. It is clear that χ depends largely on the particle size distributions. Magnetic susceptibility increases with increasing both of Zn-ferrite content and annealing temperature. These may be due to the interaction between Zn-ferrite nanoparticles with silica enhanced (silica provides homogeneous and isolated particles).