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Topic: Synthesis and characterization of Spinel Compounds

Abstract

Nano-crystalline spinels have many applications in magnetism and technological point of view. Spinels have a lot of applications in high frequency devices, memory cores and magnetic recording media. In case of magnetic nano-particles, finite size effects and both inter and interparticle interactions give rise to this unusual magnetic behaviour. The exchange bonds are broken due to the absence of oxygen ions from the surface which induces surface spin disorder. Magnesium ferrite Spinel is a well known soft magnetic material with very low cubic magneto-crystalline anisotropy, low corecitivity and moderate saturation magnetization. It is thus a promising material for various technological applications in the microwave region.

The main objective of present work is the synthesis of nano-particles of transition metal doped spinel compounds and to investigate the effect of doping on their structural, electrical, optical and magnetic properties over middle range of dopant concentration, temperature and frequency. In the present thesis, the synthesis and characterization of nano-structured system having composition Mg2-xTi1-xM2xO4, (M = Ni & Zn) has been carried out. The synthesis has been done by normal and modified solution combustion techniques. The so- prepared materials were investigated broadly for structural analysis, AC and DC electrical transport properties, dielectric studies and magnetic properties respectively. In brief, the main points are summarized below:

Chapter 1 gives a brief account of the introduction, occurrence, structures and theory of magnetism aspects involved in the present work.

Chapter 2 describes various experimental techniques used for the preparation and characterization of samples. These include sample preparation techniques: sol-gel method and solution auto-combustion method. We have also described different techniques used for sample

characterization such as X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), FTIR, magnetic and electrical analysis as well.

Chapter 3 is devoted to the study of the structural, morphological, optical and magnetic properties of $Mg_{2-x}Ti_{1-x}M_{2x}O_4$, where M = Ni, Zn and x = 0.0, 0.5 and 1.0. We synthesized these samples using sol-gel auto combustion method and characterized them for their phase purity by x-ray diffraction (XRD) technique; these are found to be single phase. A detailed study has been made on how the structure and lattice constant of the unit cell of MTO change on doping with Ni and Zn using x-ray diffraction data. The morphological analysis has been carried out nano-particle of different sizes and FTIR analysis has been carried out to check the presence of different functional groups. The magnetization loop observed at room temperature clearly shows that a transition from diamagnetic domain to paramagnetic domain takes place when we doped with nickel, while the magnetic behaviour remains unchanged when doped with Zinc.

Chapter 4 describes the preparation and results of the DC conductivity on $Mg_{2-x}Ti_{1-x}M_{2x}O_4$ (M = Ni and Zn, x = 0.0, 0.5 and 1.0) These measurements were performed using two probe set-ups in the temperature range 77-347 K. Mott's variable range hopping (VRH) model has been used to analyze these samples. Activation energy and Mott's parameters have also been calculated.

Chapter 5 explains the preparation and results of the AC resistivity measurements on $Mg_{2-x}Ti_{1-x}M_{2x}O_4$ (M = Ni and Zn, x = 0.0, 0.5 and 1.0) The electrical resistivity measurements were performed using four-probe technique in the temperature range 81-347 K. All the samples show insulating behaviour. We estimated the dielectric loss, dielectric constant as a function of temperature and frequency.

Chapter 6 describes the summary of our work results of our study on $Mg_{2-x}Ti_{1-x}M_{2x}O_4$ (M = Ni and Zn, x = 0.0, 0.5 and 1.0) samples. We have grown a series of samples of various thicknesses (16, 65 and 70 nm) by sol-gel combustion method. We also described a summary of the characterized work that has been carried out on these samples. In addition to this, we discussed our future plan of work in this very promising area.