Structural, EPR and optical properties of Zn0.75TM0.25O (TM = Mn, Fe, Co, Ni) aerogel nanoparticles

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Abstract

ZnO nanopowders with different 3d transition metal (TM) doping (TM = Mn, Fe, Co, Ni) were synthesized by a new protocol based on slow hydrolyse of zinc acetate dissolved in methanol and super-critical drying in ethyl alcohol. The prepared Zn1-xTMxO (x = 0.25) nanoparticles were characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM), differential scanning calorimetry (DSC), optical absorption and electron paramagnetic resonance spectroscopy (EPR). The results demonstrated that the TM dopant significantly affects the structural and magnetic properties of the samples. From the XRD spectra, the lattice parameters, average crystallite size and microstrain values were obtained. All ZnTMO nanoparticles show an expansion of the lattice parameters compared those of the bulk samples. Unit cell volume was minimized with Fe doping and increased as the atomic number of the dopant moved away from Fe. The XRD pattern indicates the formation of hexagonal wurtzite phase of ZnO for all the TM dopants. Electron microscopy characterization showed that the size of the Zn1-xTMxO particles is about 25 nm did not change significantly for the different dopants. Optical absorption measurements show that band gap energies of the TM-doped ZnO nanoparticles are around 3.2 eV. The Urbach energy of the ZnTMO nanopowders varies with the TM dopant. From magnetic measurements we observed the presence of room temperature ferromagnetic order in our TM-doped ZnO samples. EPR spectra confirm that TM ions were mainly incorporated as TM2+, occupying the Zn2+ sites in the wurtzite structure of ZnO. Room temperature ferromagnetic order was observed only in Ni- and Co-doped ZnO samples, whereas Mn- and Fe-doped powders showed only antiferromagnetic and paramagnetic interactions, respectively. The correlation between the structural and magnetic properties as a function of the TM dopant is discussed.

Keywords

KeyWords Plus: DOPED ZNO NANOPARTICLES; DILUTED MAGNETIC SEMICONDUCTORS; ROOM-TEMPERATURE FERROMAGNETISM; DOPING CONCENTRATION; COPRECIPITATION METHOD; RAMAN-SCATTERING; ZN1-XMNXO; RESONANCE; DESIGN; FE3O4

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