Role of chromium on structure, optical and magnetism of Cr doped ZnO nanoparticles

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The role of Cr incorporation into the ZnO were probed through investigations into the structural, optical and magnetic properties. Diluted magnetic semiconductors (DMSs), ZnO and $Zn_{1-x}Cr_xO$ ($x = 0.03$ and 0.05), were prepared by solution combustion method with glycine as fuel. Powder x-ray diffraction (XRD) results indicate that both the ZnO and $Zn_{1-x}Cr_xO$ ($x = 0.03$ and 0.05) have single hexagonal wurtzite structures, indicating that Cr ions substituted the Zn ions without influencing the structure. This is in agreement with previous theoretical and experimental results suggest that only Cr^{3+} ions substituted into Zn^{2+} sites without altering the structure [1, 2]. Following the Willamson-Hall approach [3], the crystallite size and microstrain of the samples were calculated and found to be be 42±2 nm for ZnO and it reduces to 33±4 nm in $Zn_{0.97}Cr_{0.03}O$, while lattice strain increased from 0.039±0.005% to 0.048±0.008%, respectively. Rietveld refinement analysis reveals that lattice parameters a and c of ZnO are well matched with standard data (PDF# 36-1451). The value of both a and c increases slightly for $Zn_{0.97}Cr_{0.03}O$ while a decrease was observed for $Zn_{0.95}Cr_{0.05}O$. Transmission electron microscopy (TEM) reveals that particle size of ZnO is 47±2 nm and for $Zn_{1-x}Cr_xO$ (x = 0.03 and 0.05) samples, particles are agglomerated. The optical bandgap obtained using diffuse reflectance spectroscopy was found to be 3.305±0.003 eV and 3.290±0.003 eV for ZnO and $Zn_{0.97}Cr_{0.03}O$, respectively. The field-dependent magnetization (M - μ_oH) measurements were carried out using a vibrating sample magnetometer (VSM) at 300 K. All the samples exhibits ferromagnetic behavior. In ZnO ferromagnetism at 300 K is due to different observed defects (oxygen and zinc vacancies). The $Zn_{0.97}Cr_{0.03}O$ showed the highest saturation magnetization and remnant magnetization are 0.664±0.01 emu.g^{-1} and 0.126±0.002 emu.g^{-1}, respectively, while $Zn_{0.95}Cr_{0.05}O$ sample exhibit a higher coercive field (23.7 mT) than that observed for $Zn_{0.97}Cr_{0.03}O$ sample (19.5 mT). The study of XRD and high resolution TEM (HR-TEM) confirms, all the samples are in wurtzite structure and the cause of magnetism is explained on the basis of complex interplay between the defects and Cr substitution at Zn sites [4].

References:

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