Microstructural and optical properties of Sol-Gel Co-doped ZnO thin films

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Abstract

Undoped and Co-doped ZnO thin films with different amounts of Co have been deposited onto glass substrates by sol–gel spin coating method. Zinc acetate dihydrate, cobalt acetate tetrahydrate, Isopropanol and monoethanolamine (MEA) were used as a precursor, doping source, solvent and stabilizer respectively. The molar ratio of MEA to metal ions was maintained at 1.0 and a concentration of metal ions is 0.6 mol.L^{-1}.The Co dopant level was defined by the Co/(Co+Zn) ratio it varied from 0 to 7% mol. The structure, morphology and optical properties of the thin films thus obtained were characterized by XRD, EDX, SEM, UV-Vis, Photoluminescence and Raman. The XRD results showed that all films crystallized under hexagonal wurtzite structure and presented a preferential orientation along the c-axis with the maximum crystallite size was found is 23.5 nm for undoped film. The results of SEM indicate that the undoped ZnO thin film has smooth and uniform surface with small ZnO grains, and the doped ZnO films shows irregular fiber-like stripes and wrinkle network structure. The average transmittance of all films is about 72–97% in the visible range and the band gap energy decreased from 3.24eV to 3.01 eV with increase of Co concentration. DRX, EDX and optical transmission confirm the substitution of Co^{+2} for Zn^{+2} at the tetrahedral sites of ZnO. In addition to the vibrational modes from ZnO, the Raman spectra show prominent mode representative of $Zn_yCo_{3-y}O_4$ secondary phase at larger values of Co concentration . Photoluminescence of the films showed a ultraviolet (UV) and defect related visible emissions like violet , blue and green , and indicated that cobalt doping decreased the UV and visible emissions intensity.

Keywords: Sol-Gel; ZnO thin film; Cobalt doping ; Microstructure; optical properties