Influence of doping concentration on the zinc doped nickel oxide nanostructures: morphological, structural, and optical properties

ABSTRACT

The zinc doped nickel oxide (Zn:NiO) nanostructures with 0 at.% (UD), 1 at.% (1ZNO), and 2 at.% (2ZNO) of Zn concentrations were successfully deposited on the NiO seed-coated glass substrates. The films were successfully produced from two synthesis techniques: the sol-gel spin coating for NiO seed-coated and the solution immersion for the Zn:NiO nanostructures. The films were then pre-baked at 150 °C and subsequently annealed at 500 °C. The Zn doping concentrations affecting NiO in terms of morphological, structural, and optical properties were investigated. The surface morphologies and cross-sectional images of the Zn:NiO nanostructures were observed by field emission scanning microscopy. The observation showed that the groups of nanoflower (NF), which were grown above the nanosheet (NS) array were gradually decreased with the increasing percentage of the Zn doping. The thickness of the NS also drastically decreases as the Zn dopant is increased. The thicknesses measured are 910 nm, 410 nm, and 100 nm for UD, 1ZNO, and 2ZNO, respectively. The X-ray diffraction analysis showed the Zn:NiO peak intensities were affected and decreased as the Zn doping is increased. Take into account the significant differences in the (200) plane, the crystal parameters were calculated. The dislocation density, interplanar spacing, lattice parameter, and unit cell volume increased as the Zn doping increased. Meanwhile, the average crystallite size reduces when the percentage of Zn doping is increased. This condition makes the Zn:NiO nanostructures are promising for sensing applications due to enhanced surface area. The strain and stress values of the Zn:NiO showed the tensile strain and compressive stress, respectively. The transmittance spectra showed the transparencies in the visible region within 400 to 800 nm wavelength increases when the percentage of Zn doping is increased. The average transmittance percentages are 32.1 %, 62.8 %, and 67.0 % for UD, 1ZNO, and 2ZNO, respectively. The optical bandgap increases sharply as the Zn doping increased from 3.55 to 4.75 eV.