Materials Chemistry and Physics 162 (2015) 628e639

A study on the sensing of NO_2 and O_2 utilizing ZnO films grown by aerosol spray pyrolysis

G.H. Mhlongo [a, *], D.E. Motaung [a], I. Kortidis [b], N.R. Mathe [a], O.M. Ntwaeaborwa [c], H.C. Swart [c], B.W. Mwakikunga [a], S.S. Ray [a], G. Kiriakidis [b, **]

[a] DST/CSIR National Centre for Nanostructured Materials, Council for Scientific and Industrial Research, Pretoria 0001, South Africa
[b] Transparent Conductive Materials Lab, Institute of Electronic Structure and Laser, Foundation for Research and Technology Hellas, 100N. Plastira str.,Vassilika Vouton, 70013 Heraklion, Crete, Greece
[c] Department of Physics, University of the Free State, Bloemfontein ZA9300, South Africa

Abstract

The present paper addresses the preparation and characterization of ZnO nanostructured thin films obtained using aerosol spray pyrolysis method at different deposition periods. Aiming at understanding the chemical composition, structural and morphological properties of the samples, characterization was performed using X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD), atomic force microscopy (AFM) and focused ion beam scanning electron microscopy (FIB-SEM), respectively. Defect structures were characterized by photoluminescence (PL), Raman, and electron paramagnetic resonance (EPR) techniques. The purity and crystallinity of the deposited films with increasing growth time were confirmed from XRD studies supported by Raman studies. AFM and SEM revealed morphology transition from uniform small particles to rod-like structures fused together growing perpendicular to the surface with prolonged deposition time. Optical absorption analyses revealed the decrease in the optical band-gap energy from 3.38 to 3.27 eV with prolonged growth time. The dominant emission at 2.80 eV (445 nm) in the PL spectra signifies the presence of Zn(subi) in the Zn(subO) nanostructures which is shown to slightly decrease with an increase in growth time. EPR analyses revealed higher ferromagnetic (FM) signal for ZnO films grown for 20 min. Improved sensitivity to both NO(sub2) and O(sub2) was observed for ZnO nanostructured film grown for 20 min owing to higher Zn(subi) and V(subO) as compared to its counterpart. Film grown for longer periods showed a decrease on the FM and sensitivity due to reduced Zn(subi) and V(subO) defects induced by larger grain sizes.