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Microstructural and photoluminescence properties of sol–gel derived Tb3+ doped ZnO nanocrystals

Guy L. Kabongo [a,b,c], Gugu H. Mhlongo [b,⇑], Thomas Malwela [b], Bakang M. Mothudi [a], Kenneth T. Hillie [b,d], Mokhotjwa S. Dhlamini [a,b,⇑]

a Department of Physics, University of South Africa, UNISA 0003, PO Box 392, Pretoria, South Africa
b National Centre for Nano-structured Materials, CSIR, PO Box 395, Pretoria ZA 0001, South Africa
c Département de Physique, Université Pédagogique Nationale, Kinshasa/Ngaliema 8815, Congo
d Department of Physics, University of Free State, Bloemfontein ZA 9300, South Africa

Abstract

Un-doped and Tb(Sup3+) doped ZnO nanocrystals with different concentrations of Tb(Sup3+) were synthesized by a sol–gel method and their photoluminescence (PL) properties were investigated. The successful incorporation of Tb(sup3+) ions with different concentration (0.15, 0.5 and 1 mol %) in ZnO was realized and confirmed through different characterization. High crystalline ZnO products were produced without the need of a post-heat treatment. Elemental mapping conducted on the as prepared samples using Scanning electron microscope (SEM) equipped with energy dispersive X-ray spectrometer (EDX) revealed homogeneous distribution of Zn, O, and Tb ions. The high resolution transmission electron microscope (HR-TEM) analyses indicated that the un-doped and Tb(sup3+) doped samples were composed of homogeneously dispersed particles of high crystallinity with an average size ranging from 3 to 6 nm in diameter, which was in agreement with X-ray diffraction (XRD) analyses. Raman spectroscopy was used to further elucidate the wurtzitic structure of the prepared samples. PL study revealed that among different Tb(sup3+) concentrations, 0.5 mol% Tb(sup3+) doped ZnO nanoparticles showed clear emission from the dopant originating from the 4f–4f intra-ionic transitions of Tb(sup3+) while the broad defects emission was dominating in the 0.15 and 1 mol% Tb(sup3+) doped ZnO. Optical band gap was extrapolated from the Ultraviolet Visible spectroscopy (UV–Vis) absorption analysis using TAUC's method and the widening of the optical band gap for the 0.15 and 0.5 mol% Tb(sup3+) doped samples and the reduction of the optical band gap for the 1 mol% Tb(sup3+) doped sample as compared to the un-doped sample was observed. Energy transfer mechanism between Tb(sup3+) and ZnO is discussed in detail.