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Chemical Papers 68 (2) 217–222 (2014)
DOI: 10.2478/s11696-013-0442-5

ORIGINAL PAPER

Synthesis, characterization and photoluminescence properties of Ce^{3+}-doped ZnO-nanophosphors

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Received 19 October 2012; Revised 31 March 2013; Accepted 15 May 2013

The present study involves the synthesis of Ce^{3+} doped ZnO nanophosphors by the zinc nitrate and cerium nitrate co-precipitation method. The synthesized nanophosphors were characterized with respect to their crystal structure, crystal morphology, particle size and photoluminescence (PL) properties using X-ray diffraction (XRD), scanning electron microscopy (SEM)/energy dispersive X-ray (EDX), transmission electron microscopy (TEM)/ Energy-dispersive X-ray spectroscopy (EDS) and PL-spectroscopy respectively. XRD results revealed that ZnO nanophosphors are single phase and cubic type structures. Further, PL spectra of ZnO:Ce^{3+} nanophosphors showed green emission because of the charge transfer at single occupied oxygen vacancies with ZnO holes and red emission due to the cerium ion transitions. Intensity and fine structure of the Ce^{3+} luminescence and its temperature dependence are strongly influenced by the doping conditions. The formation of ZnO:Ce^{3+} nanophosphors was confirmed by Fourier transform infrared (FTIR) and XRD spectra.

Keywords: nanophosphors, doping, co-precipitation, FTIR, photoluminescence

Introduction

Due to their unique and fascinating properties, nanostructured materials have triggered tremendous motivation among scientists to explore their applications. Alkaline earth oxides gathered a lot of attention in past decades because they are considered to be excellent host materials. Nanoparticles are a new group of advanced materials having different properties than bulk materials. These properties include unique mechanical, chemical, physical, electrical, optical and surface area, which in turn define them as nanostructures. The most important characteristics of the materials in the nano-size regime are their ability to change their physical properties. During 1980s, a considerable progress was achieved in the field of material science to understand the size related properties in materials. When the size of the semiconductor nanoparticles decreases, the energy gap (band gap) increases and the optical spectrum is shifted towards the short wavelength region (Murray et al., 1993; Kumar et al., 2010). Luminescent materials, i.e. nanophosphors, emit radiation when stimulated with fast electrons, X-rays, ultraviolet photons or some other form of radiation. In recent years, research has been boosted by opto-electronic applications such as solid state lighting, lasers, displays and optical storage media and medical diagnostic applications like biological assays. Various types of materials can be used for nanophosphor production. They have bixbyte type oxide hosts with a cubic structure containing low symmetry sites suitable for the incorporation of activators (rare earth or transition metal ions) providing suitable emission in the visible and near-infrared region.

Zinc oxide (ZnO), particularly, exhibits attractive properties such as a wide direct band gap (3.37 eV) (Hauschild et al., 2006; Klingshirn, 2007a; Jattaukul et al., 2011), large excitation binding energy (60 meV), low refractive index (1.9), resistance to high-energy irradiation, stability to intense ultraviolet (UV) illumination and low toxicity (Cruz-Vázquez et al., 2005; Klingshirn, 2007b; Manam et al., 2009; Maciel et al.,

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