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ORIGINAL PAPER

Study of Undoped and Indium Doped ZnO Thin Films Deposited by Sol Gel Method

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Abstract

In this paper, we report the effects of Indium doping concentrations (from 0 to 10wt%) on the structural, morphological, and optical properties of deposited In doped ZnO (IZO) thin films prepared by the sol–gel method through the dip coating technique. X-ray diffraction (XRD) analysis indicates that all ZnO thin films have a polycrystalline nature with a hexagonal wurtzite phase with (002) as a preferential orientation. XRD results demonstrate that the particle size of ZnO decreased with the increase in Indium concentrations. Raman scattering spectra confirmed the wurtzite phase and the presence of intrinsic defects in our samples. Energy dispersive spectroscopy (EDS) and the X-ray photoelectron spectroscopy (XPS) measurements, confirmed the presence of zinc, oxygen and indium elements which is in agreement with XPS results. The photoluminescence (PL) spectra of the films exhibit defects-related visible emission peaks, with intensities differing owing to different concentrations of zinc vacancies. UV–Vis spectrometer measurements show that all the films are highly transparent in the visible wavelength region (≥70%) and presented two different absorption edges at about 3.21 eV and 3.7 eV, these may be correspond to the band gap of zinc oxide and indium oxide respectively.

Keywords IZO thin films · Raman · Phonon · Transmittance · Photoluminescence

1 Introduction

Transparent Conducting Oxides (TCOs) are extensively used in microelectronic devices, light emitting diodes, thin films, anti-reflection coatings for transparent electrodes in solar cells [1, 2], gas sensors in surface acoustic wave devices [3], varistors, spintronic devices, and lasers [4]. They perform in a very interesting way in optical, mechanical and electrical applications [5].

Among TCOs, ZnO has advantages of low cost and non-toxicity, so it has been acknowledged as a promising alternative to indium tin oxide and tin oxide [6]. ZnO easily crystallizes in the wurtzite structure with n-type electrical conductivity. It is a binary II-VI semiconductor compound, with a bulk direct band gap of 3.37eV at room temperature and a large exciton binding energy of 60meV. This could be increased to over 100meV in super lattices [7]. As a result of its high electrochemical stability and absence of toxicity, it is typically used in a variety of optical and electrical applications [8].

In spite of its excellent conductivity, as it contains high concentrations of native defects (oxygen vacancies or zinc interstitials), ZnO is not stable chemically and electrically at high temperature. However, its physical properties can be deeply modified and improved by n-type impurity doping, the doped ZnO thin films having low resistivity and suitable good optical gap energy at low temperature and being transparent in the visible region. ZnO nanostructures can doped with a variety of elements, like Al, Ga, Mg, Li, P, N, Ni, In, and Co [9–11]. IZO thin films have been selected as the object of this study because they exhibit high mobility, good optical transparency, and lower material cost.

Thin films can be developed by some physical methods, such as thermal evaporation [12], pulsed laser deposition (PLD) [13] and sputtering [14], or chemical techniques,

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