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RESEARCH ARTICLE

Opto-electronic properties of spray deposited in doped ZnO Thin Films

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ABSTRACT

In doped ZnO thin films with different In content were deposited on glass substrates at 400 °C by spray pyrolysis technique. The effect of Indium doping on the electrical and optical properties of ZnO films was investigated. The optical transmission spectra recorded in the wavelength range from 300 to 900 nm. The dark electrical resistivity of these samples was measured in the temperature range 300 to 550 K. the electrical resistance was found to be decreased to 6.3 x 10^{-3} (Ω-cm) for 3% In doping.

Keywords: Zinc oxide, Thin films, Chemical spray, optical properties, electrical properties.

INTRODUCTION

Zinc oxide (ZnO) is the subject of increasing interest in the last few years owing to its potential applications in ultraviolet (UV) optoelectronic devices [1-2], transparent conducting oxide (TCO) thin films [3-4] and spintronics [5-7]. In addition, ZnO offers noticeably high chemical, mechanical and thermal stabilities [4]. Due to the these properties, ZnO is a promising material for several technological applications such as ultraviolet (UV)/blue emission devices [5-6], solar cells [7–9], piezoelectric devices [10], acousto-optical devices [11], acoustic resonators [12], chemical sensors [13–16],

Several approaches have been proposed and developed for the preparation of In doped ZnO thin films such as magnetron sputtering [17], spray pyrolysis [18], metal-organic chemical vapour deposition (MOCVD) [19], pulsed laser deposition (PLD) [20], arc plasma evaporation[21], dip-coating [22] and ion plating [23]. Among these, spray pyrolysis is one of the most used methods.

METHODOLOGY

In-ZnO thin films were deposited on the pre-heated glass substrates by simple and cost effective spray pyrolysis technique at 450 ^{0}C, Spray rate 2.5 ml/min, substrate to nozzle distance 30 cm and molar concentration was 0.5 M. The precursor used was Zinc acetate dehydrated ($Zn(C_2H_3O_2)_2.2H_2O$). The Indium chloride was the doping source. The In percentage in the solution was varied from 1 at% to 4 at% in the starting solution. The prepared solution is then sprayed on the heated glass substrates which transforms the solution (mixture) to a stream formed with uniform and fine droplets. Characterization techniques used, were UV vis spectrometer and electrical conductivity.

RESULTS

Optical properties

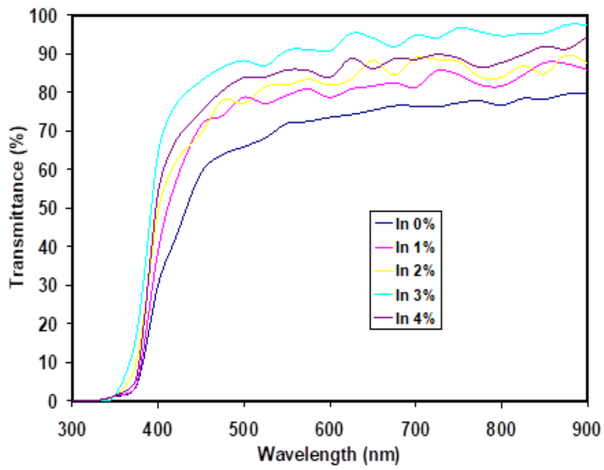

Figure 1: Transmission spectra of In-doped ZnO thin films.

Fig. 1 shows the optical transmission spectra recorded in the wavelength range from 300 to 900 nm. From this figure it is observed that, all transmittance spectra show sharp absorption edge in the wavelength range between 380 to 425 nm. The average optical transmittance in the visible range for all In-doped thin films was about 70% to 95%. This indicates that the films prepared with these conditions are smooth and uniform [24]. The optical band gaps were estimated from the optical transmission spectra by plotting $(\alpha hv)^2$ versus photon energy (hv) and extrapolating the straight line portion of this plot to the photon axis as in Fig. 2.

The optical band gap varied from 3.25 eV to 3.31 eV as In varied from 1 to 4%.

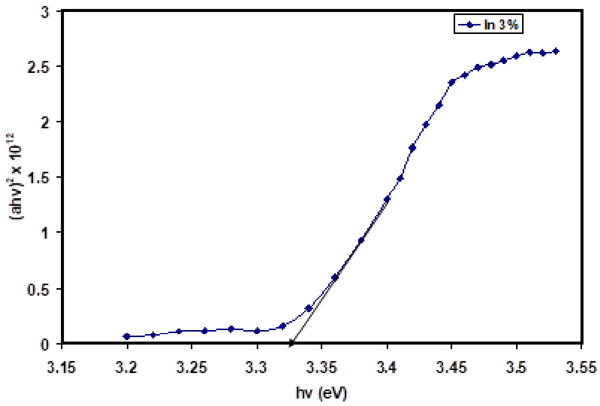

Figure 2: The plot of $(\alpha hv)^2$ vs photon energy of In-doped ZnO (3%) thin films.

Electrical characterization

The dark electrical resistivity of these samples was measured in the temperature range 300 to 500 K. The plot of log resistivity versus 1000/T is shown in Fig. 3. It is observed that the electrical resistivity is decreased as the indium doping concentration is increased from 0 to 3 at% and when exceeding 3 at% the resistivity increases. This may be due to the addition of indium in the ZnO lattice, In^{3+} acts as a substitution donor in the host lattice which explains the observed decrease in electrical resistivity with In-doping concentration.

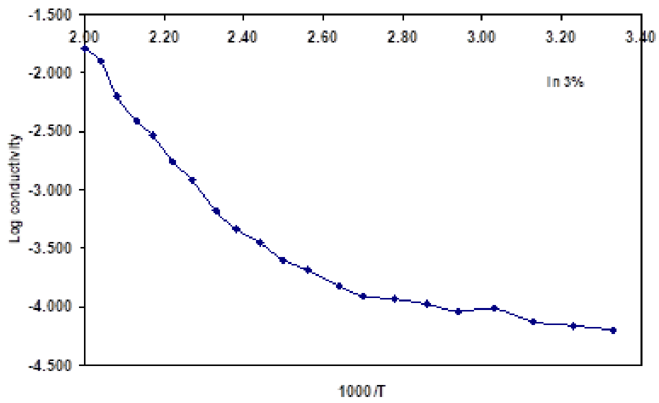

Figure 3: Conductivity as a function of In-doping concentration

CONCLUSION

In-doped ZnO (IZO) films were deposited on amorphous glass substrates at 400 ^{o}C by spray pyrolysis. The physical properties of these films have been studied in detail as a function of increasing In doping (from 1 to 4 %) concentration. The optical analysis showed that the transmittance spectra have sharp absorption edge in the wavelength range between 380 to 425 nm. The optical band gap varied from 3.25 eV to 3.31 eV as In varied from 1 to 4%. The electrical resistivity is decreased as the indium doping concentration is increased from 0 to 3 at%.

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