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Effect of substrate temperature on structural and morphological studies by spray pyrolysed ZnO thin films

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Abstract

Present research work has been focused on the synthesis, growth mechanisms and physical properties of ZnO thin films prepared by cost effective spray pyrolysis technique. ZnO thin films have been grown using spray pyrolysis technique at different substrate temperature (250, 300, 350, 400, and 450°C). Structural and morphological analysis were done by X-ray Diffraction and Scanning electron microscope. X-ray diffraction result shows that the prepared ZnO films were polycrystalline and observed grain size increases with substrate temperature. The Fourier transform infrared (FTIR) spectroscopy confirmed the formation of ZnO with Zn–O stretching vibrations. SEM analysis confirmed the increase of grain size and change of grain shapes with substrate temperature. The study thus confirmed the pivotal role of substrate temperature in deciding the structural and morphology properties of the ZnO thin films.

Introduction

An improved interest in ZnO as an optoelectronic material has been triggered by reports on p-type conductivity [1], diluted ferromagnetic properties [2], thin film oxide field effect transistors [3], and considerable progress in nanostructure fabrication. Zinc oxide, a member in the II–VI family with a wide band gap (3.3 eV) and a large exciton binding energy (60 meV) and naturally shows n-type conductivity due to a large number of native defects, such as oxygen vacancies, zinc interstitials and ionized hydrogen (H^+) [4,5]. It owns a unique position among materials owing to its superior and diverse properties such as transparent conductors [6], light emitting devices [1,7], piezoelectricity [6], chemical stability, biocompatibility, optical transparency in the visible region [8], high voltage-current nonlinearity, transparent or high temperature electronics, etc. ZnO Thin films have been prepared using different techniques like plasma-assisted molecular dip coating [9,10], chemical vapor deposition [11,12], sol–gel process [13,14], electrostatic spray deposition [15,16], pulsed laser deposition [17,18], spin coating method [19,20], vacuum arc deposition [21,22] and spray pyrolysis [23,24]. Among these techniques chemical pyrolysis technique is the best technique to acquire good quality thin films. The primary objective of this

study is to determine the structural and morphological properties of the prepared ZnO samples. The cubic lattice type and also the crystalline nature of the films can be understood from XRD studies, identification of ZnO phase formation through FTIR and surface morphology through SEM.

Section snippets

Experimental part

The ZnO films were deposited by spray pyrolysis onto glass substrates at different deposition temperature. Zinc acetate dehydrate [Zn $(CH3COO)_2{\cdot}H_2O$] was used as a starting precursor diluted in 50% ethanol and 50% distilled water. Few drops of HCl was added to the precursor solution to get clear and homogeneous solution. The molar ratio of zinc acetate dehydrate was maintained at 0.2M. Fig. 1 shows the procedure for preparing ZnO thin films and optimized spray parameters.

After successful…

Structural studies

X-ray diffraction patterns detailed in the range 20–80° of ZnO thin films deposited at different substrate temperatures 250, 300, 350, 400 and 450°C by spray pyrolysis technique are shown in Fig. 2.

It is evident that all the films reveal polycrystalline nature with hexagonal wurtzite structure (Fig. 2). The observed d values matches well with standard values (COD No 96-900-4180). For low temperatures the growth is mainly along (0 0 2) plane and the diffraction peaks become sharper with much…

Conclusion

ZnO thin films were prepared by spray pyrolysis technique at different substrate temperatures. The effects of substrate temperature on the structural and morphology of the deposited films were investigated. The structural and morphology properties of the ZnO thin films have been found dependence to substrate temperature. XRD study revealed the wurtzite hexagonal structure and their crystallite sizes were gradually improved on increasing substrate temperature. FTIR spectra confirmed the metal…

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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