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Synthesis and Characteristics of Pure ZnO Thin Films Prepared by Chemical Bath Deposition Method

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Abstract: ZnO thin films have been deposited onto the glass substrates by the chemical bath deposition method. In this work we have studied the structural and morphological properties of ZnO thin films prepared by chemical bath deposition method. Zinc acetate dihydrate was used as the precursor material. The structural and morphological properties of the films have been investigated by X-ray diffraction and atomic force microscopy characterization methods. Scherrer's formula was used to calculate particle size. The thin films have (002) as the preferred orientation. The root mean square roughness of the films was calculated.

Keywords: Zinc oxide film, chemical bath deposition, Particle size, AFM.

I. INTRODUCTION

This The Zinc oxide (ZnO) due to its wide direct band gap 3.3 eV, large exciton binding energy 60 meV, transparency in the visible range, non-toxicity, abundancy in nature, is an excellent versatile II–VI compound semiconductor [1–3]. ZnO nanostructures, as a II–IV binary semiconductor, have attracted considerable attention because of their good optical, electrical and easily tunable morphological properties and their potential applications in solar cells, solar energy-hydrogen conversion devices, photo-electrochemical hydrogen generation applications and sensors [4–7]. Studies on the application of ZnO thin film to the Surface Acoustic Wave(SAW) device and Film Bulk Acoustic Resonator(FBAR) filter are being made, because of its excellent piezoelectric properties[8–11]. It has an advantage as a transparent electrode material in photovoltaic cells because of its good material properties as compared with indium tin oxide[12,13]. In the last decade, Molecular Beam Epitaxy (MBE), magnetron sputtering, Pulsed-Laser Deposition (PLD), sol–gel process and Metal–Organic Chemical Vapor Deposition (MOCVD) are some of methods used to prepare ZnO thin fi lms on various substrates [14–19]. By CBD method, various nanostructures can be obtained simply by changing precursor chemicals, concentration of solution, growth temperature and growth time [20–22].In addition, the solution growth technology is suitable to obtain stoichiometrical ZnO films because of its oxygen-rich deposition environment [17-23].Many investigations are still carried out to improve the characteristics of ZnO materials. In the present proposed work, thin films of zinc oxides in pure form will be prepared using chemical bath deposition method and to study the structural and morphological properties of ZnO thin films along with micro structural quantities.

II. EXPERIMENTAL

An ZnO thin films were prepared on glass substrates (76×26×1.5mm) by chemical bath deposition method. The glass substrates were cleaned with soap solution followed by acetone. Then it was degreased in acetone and ethanol 1:1 for final cleaning. The deposition solutions were formed by first dissolving weighed amounts of zinc acetate (0.0188 M), and ethylenediamine (0.0340425 M) was used for all the films. In this case temperature was 50°C. The microscopic slide of borosil glass(9100P01) was used as a substrate.

The color of the deposited ZnO thin films was milky white. In the present work the deposition time was 1hours.The structural properties of the prepared films were studied by X-ray diffraction measurements (Bruker D8 Advanced Diffractometer (λ= 1.54059 Å)).The surface morphology was investigated using atomic force microscope (AFM,PARK XE-7).

III. STRUCTRUAL PROPERTIES

The crystallographic structure of the ZnO films was examined by powder X-ray diffraction technique. Pure ZnO thin films have been deposited onto the glass substrates at 50°C substrate temperature. X-ray diffraction spectra of the undoped ZnO thin films are shown in Fig. 1. X-ray diffraction spectra of all the films were taken at room temperature. The peaks with the Miller indices given belong to the ZnO [24]. The presence of sharp structural peaks in these X-ray

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diffraction patterns confirmed the polycrystalline nature of the films. As shown in Fig. 1, all the thin film has (0 0 2) as the preferred orientation. This(0 0 2) preferred orientation is due to the minimal surface energy which the hexagonal structure, *c*-plane to the ZnO crystallites, corresponds to the densest packed plane. This result is in good agreement with literature data [25,26–28]. The starting solution was mixed thoroughly and final solution was sprayed. The nozzle–substrate separation used was of 30 cm. During the spraying process, the substrates were heated by electrically heating the copper plate.

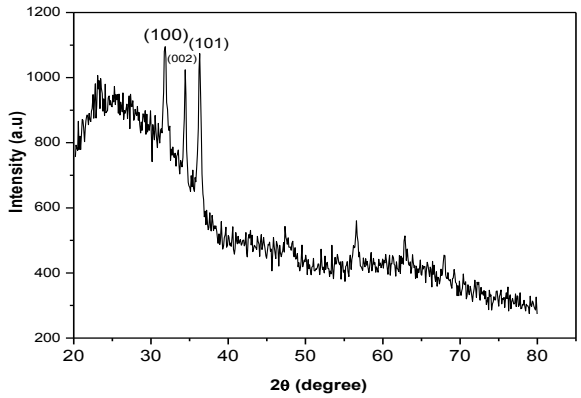

Fig. 1 XRD pattern of ZnO thin film deposited at 50^0C

The particle size for the samples was calculated from the X-ray diffraction data by using Scherer's formula.

$$D = \frac{0.9\lambda}{\beta\cos\theta}$$

where,

λ = wavelength of the X- rays (1.5406Å),
β= FWHM of the peak with highest intensity
θ = diffraction angle

From equations the particle size, dislocation density, micro strain and lattice constant of ZnO thin films deposited at 50^0 C were calculated as reported in the Table 1.

2θ	Particle size(nm) D	Dislocation density(δ)line^2/m^2 x10^{15}	Micro strain(ε) x10^{-3}
31.7557	41.09603	0.000592	0.000843
34.4195	38.34595	0.00068	0.000904
36.3099	36.88103	0.000735	0.00094

IV. MORPHOLOGICAL PROPERTIES

The AFM analysis allowed us to study the morphology of the films produced, to infer the size of the grains formed, and to analyze possible defects existing between grains (see Fig.2). The data achieved reveal films with different surface morphologies and grain sizes. The surface images obtained by AFM, showing CBD films with a high surface roughness and high grain sizes. The AFM image of the film shows porous structure consisting of grains with different sizes separated by empty spaces. Atomic force microscopy (AFM) was used to examine surface roughness of the films over a cross-sectional area of 5 µm x5 µm as shown in Fig.2.

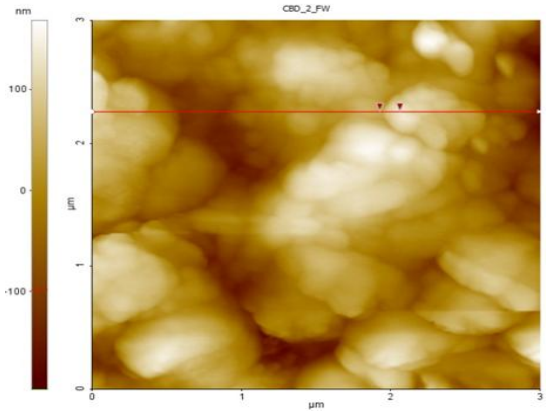

Fig. 2 The AFM image of the film of ZnO thin film deposited at 50^0C

V. CONCLUSION

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Zinc oxide thin films have been successfully deposited on glass substrates by the chemical bath deposition deposition technique. From the X-ray diffraction analysis all the films show hexagonal structure along with c-axis oriented (002) plane and average particle size is nearly equal to 40 nm. Morphology of the ZnO thin film is strongly influenced by the substrates of the film. The root mean square roughness (Rq) of the ZnO thin film is nearly equal to 73 nm.

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