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RESEARCH ARTICLE

STRUCTURAL ANALYSIS OF ZINC OXIDE THIN FILMS PREPARED BY THERMAL EVAPORATION TECHNIQUE

Balaganesh, A.S. and B. Chandar Shekar*
Department of Physics, Kongunadu Arts and Science College, Coimbatore-641029, Tamil Nadu, India.

ABSTRACT

Zinc oxide thin films of 800nm were successfully prepared by thermal evaporation technique. XRD analysis revealed polycrystalline nature of the as prepared ZnO films. The structural parameters such as crystallite size, dislocation density and micro strain were evaluated and discussed.

Keywords: Structural analysis, Zinc oxide thin film, thermal evaporation technique.

1. INTRODUCTION

Thin film technology is stretching its hands in all directions and the thin be defined as any solid or liquid object with one of the dimension is very much less than that of the other two (1). Faraday obtained first evaporated thin films using metal wires in an inert atmosphere in the year 1857(2). After 30 years Warhol in 1887 discovered thin metal film using a pure heating a platinum wire in presence of vacuum. Thin films can be considered to possess two dimensions. Thickness of thin film is usually discussed in terms of Angstrom (Å) and is of the same order of magnitude as the dimension of single atom depending on the properties to be investigated and technological application of the film thickness can be arranged from a few angstrom(Å) to 1000 Å. Thin film properties are strongly dependent on the method of deposition and the background pressure. Specific applications in modern technology demand film properties such a high optical reflection, non porosity, high inertness towards corrosive environment, stability with respect to temperature, stoichiometry and orientation in single film crystal films.

Deposition of thin films increases the contact area of the cell components, resulting in high fraction of reactants. Since its thickness is limited than the bulk material, thin films result in higher current density and cell efficiencies because the transport of ions is easier and faster. All films whether prepared by vacuum deposition or by other techniques are invariably associated with some growth defects or imperfections such as lattice defects , stacking faults , twining, disorders in atomic arrangement, dislocations, grain boundaries , foreign atom inclusion, etc. Thin films science and technology plays an important role in the high tech industries. Thin film technology has been developed primarily for the need of the integrated circuit industry. The demand for development of smaller and smaller devises with higher speed especially in new generation of integrated circuits requires advanced materials and new processing techniques suitable for future Giga Scale Integration (GSI) technology. In this regard, physics and technology of thin film can play an important role to achieve this goal. The production of thin films for device purposes has been developed over the past 45 years. Thin film as a two dimensional system are of great importance to many real -world problems. Their material cost is very small as compared to the corresponding bulk material and they perform the same function when it comes to surface processes. Thus, knowledge and determination of the nature, function and new properties of thin films can be used for the development of new technologies for future applications (3- 5).

Thin film technology is based on three foundations: fabrication, characterization and application. Some of the important applications of thin films are microelectronics, communication, optical electronics, and catalysis, coating of all kinds, and energy generation and conservation strategies. Transparent and highly conducting oxide thin films have attracted many research due to their wide range of applications in industry as well in research. Transparent and conducting layers of some metallic oxides such as CdO, SnO, In_2O_3 has known for long time.

Zinc oxide is an inorganic compound with the formula ZnO. ZnO is a white powder that is insoluble in water, which is widely used as an additive in numerous materials. It occurs naturally as the mineral zincite but most zinc oxide is produced synthetically. In materials science, ZnO is a wide-bandgap semiconductor of the II-VI semiconductor group. This semiconductor has

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*Correspondence: Dr. B. Chandar Shekar, Assistant Professor, Department of Physics, Nanotechnology Research Lab, Kongunadu Arts and Science College, Coimabatore-641029, Tamil Nadu, India. E-mail: chandar.bellan@gmail.com

several favorable properties, including good transparency, high electron mobility, wide bandgap, and strong room-temperature luminescence. Those properties are used in emerging applications for transparent electrodes in liquid crystal displays, in energy-saving or heat-protecting windows, and in electronics as thin-film transistors and light-emitting diodes.

Electrical properties of ZnO has a relatively large direct band gap of ~3.3 eV at room temperature. Advantages associated with a large band gap include higher breakdown voltages, ability to sustain large electric fields, lower electronic noise, and high-temperature and high-power operation. The bandgap of ZnO can further be tuned to 3 - 4 eV by its alloying with magnesium oxide or cadmium oxide.

2. MATERIALS AND METHODS

2.1 Preparation of ZnO thin film

In this present work ZnO thin films were deposited using vacuum evaporation method Hind Hivac coating unit. The source material (ZnO (Aldrich 99.9%) is taken in the Mo boat of 200 Amps. Initially, the boat was heated using 10A till the material reach its melting point and a seed layer is allowed to form on the substrate which is placed on the substrate holder 17.5 cm above the source material. After that the amps get increased to get the thin film of the material with sufficient thickness. The thickness of the film can be monitored using digital thickness monitor, attach to the system. The rate of deposition of the film was kept constant at 0.2 Å/sec to get the uniform thickness of the film.

2.2. Structural Characterization

The structural characterization is very important in explaining optical and electrical properties of ZnO thin films. The X-ray diffraction patterns were recorded from 20^0 to 80^0 for ZnO thin film of thickness 800nm prepared by thermal evaporation of ZnO powder at a pressure of 3×10^{-6} torr.

3. RESULTS AND DISCUSSION

The as deposited films are dark brown, rich in zinc and present a low transmittance; their microstructure was studied using XRD (Fig. 1).

The XRD results show that the prepared film is polycrystalline in nature at randomly oriented. All the peaks in the diffraction pattern correspond to the hexagonal structure of ZnO and are indexed on the basis of JCPDS data card no. 5-664. The prominent peaks around 2θ = 37.4 and 44^0 are respectively corresponding to (101) and (203) crystal orientation. The preferential orientation was along (101) crystal plane. The strongest peak along (101) is observed and the other peaks are so weak; this suggests that the films will have the best structure along this orientation (6).

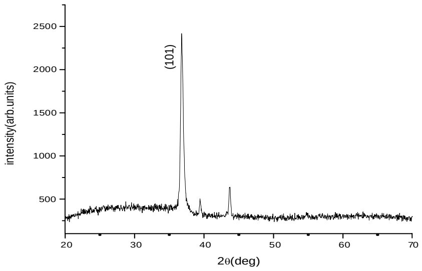

Fig. 1. X-ray diffraction pattern of ZnO thin film.

2.3. Determination of Structural Parameters:

From the XRD profiles, the crystalline size (D) was calculated using the Debye Scherer's formula from the full width at half maximum [FWHM],

$$D = \frac{k\lambda}{\beta\cos\theta} \quad \ldots \quad (1)$$

Where the constant K is the shape factor = 0.94, λ is the wavelength of the X-rays [1.5406 Å for CuK_α], θ is the Bragg's angle and β is the FWHM.

The dislocation density (δ) can be evaluated from the crystalline size (D) by the| following relation,

$$\delta = \frac{1}{D^2} \quad \ldots \quad (2)$$

The origin of the micro strain is related to the lattice misfit, which in turn depends upon the deposition conditions. The micro strain (ε) can be calculated from the following relation,

$$\varepsilon = \left[\frac{\beta\cos\theta}{4} \right] \quad \ldots \quad (3)$$

The structural parameters evaluated by using the above equations from the XRD pattern are given in the Table 1.

Table 1. Structural parameters of ZnO thin film.

Plane	D(Å)	FWHM (β°)	2θ	D(nm)	δ×10^{-3} (nm^{-2})	ε× 10^{-2}
101	2.4847	0.43323	36.77	18	3.08	0.17

4. CONCLUSION

Thin film of ZnO of 800 nm thickness was successfully prepared by thermal evaporation technique. The as prepared ZnO film is polycrystalline in nature. The crystallite size was evaluated to be 18nm. The structural parameters like dislocation density (δ) and micro strain (ε) are evaluated to be 3.08×10^{-3} nm^{-2} and 0.17×10^{-2} respectively.

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