Characterization of Zno Thin Films Prepared By Sol Gel Spin Coating Method

Rajesh Kumar, Jyoti Sheoran

School of Chemical Engineering & Physical Sciences, Lovely Professional University,

Phagwara (Punjab), India-144411

Abstract

It is a known fact that the ZnO thin films find use in various fields, particularly in optoelectronic devices. But the factors that are responsible for the shape, size, crystalline behaviour, uniformity and stoichiometry of these thin films are still not fully understood. In this article an attempt has been made to prepare the thin films of ZnO of various molar concentrations by sol gel spin coating technique and determine their characteristics with the help of UV-Vis spectroscopy and x-diffraction studies.

Key Words: ZnO, spin coating, UV, XRD

1. Introduction

ZnO is an excellent II-VI compound semiconductor with a large exciton binding energy of 60meV. Zinc oxide finds use in a variety of applications that include piezoelectricity, laser diodes, light emitting diodes and spintronics. ZnO has a band gap of 3.37 eV. ZnO is a wonderful material with important optical, structural and electrical properties [1,11-13]. ZnO thin films can also be used in Flat panel displays, OLED displays, Thin film transistors (TFTs) and the transparent electrode window layer of thin film solar cells. The UV radiation from the excited ZnO thin films is detected, which makes it possible to manufacture ultraviolet laser devices. This kind of short wave laser device may act as replacement of the infrared laser memories. Additionally, various light emitting devices such as blue light, green light and purple light can be emitted by ZnO thin films [15-17]. ZnO thin films have been prepared by various techniques such as pulse laser deposition, thermal evaporation, electro deposition, chemical bath deposition, magnetron sputtering, ultrasonic spray and sputtering [2-6]. Some factors that effect the thin film growth during sol gel spin coating process are quality of precursor solutions, their concentrations, p^H values, complexing agents and individual rinsing and immersion time periods. The factors that control the shape, size and crystallinity of ZnO thin films are still not properly understood. The understanding of these factors needs further research investigations. Sol gel spin coating technique is a comparatively simple and cost effective technique of thin films growth. This technique does not require costly vacuum systems. Moreover the shape, size, crystallinity, uniformity and stoichiometry of the thin films can be controlled effectively in this method of thin film preparation [7-8]. The proper selection of substrates is very important for the growth of the thin films because the matching in the lattice parameters and crystal structure between the film and the substrate strongly effects the crystal growth behaviour of the thin films[14]. ZnO is a material used for various functions such as high stability towards different chemicals as well as light, good electrochemical coupling coefficient, paramagnetic nature etc.[9,10]. The fact The optical properties of these thin films were determined by UV-Vis spectroscopy while the structural properties were studied by x-ray diffraction (XRD).

2. Experimental Details

The sol gel was prepared by dissolving Zinc acetate dehydrate as a precursor, ethyl alcohol as a solvent and mono ethanolamine as stabilizing agent in appropriate quantities. The resultant solutions were transferred to a suitable furnace maintained at an appropriate temperature and for a certain period of time for the sol gel formation to take place.

A few drops of this viscous liquid were poured on to the glass slides which were placed on the slide holder in the spin coater. The speed of the spin coater kept in the range of 2000-3000 rpm for 10 seconds so that a sufficient amount of deposit is present on the substrates. It should be noted that before deposition of thin films, the glass substrates were cleaned thoroughly with hydrochloric acid, soap and acetone to remove any type of organic and inorganic impurities present on the surface of the glass slides.

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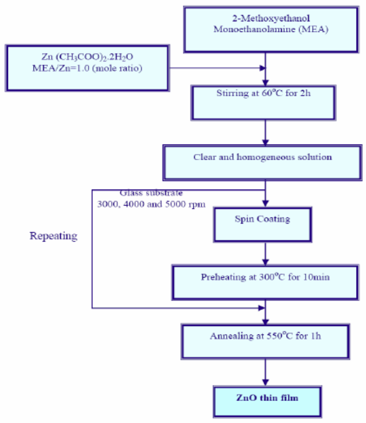

Fig. 1 The above diagram represents the flow chart of deposition of ZnO thin films

3. Results and discussion

(a) Thickness measurement: Thickness measurement is of utmost importantance for the thin films growth. There are various ways to determine the thickness of thin films namely:

Microbalance technique, quartz crystal oscillator method, photometric method, ellipsometry, interferometery, absorption spectroscopy, stylus method and weight difference method.

If W_1 and W_2 are the weights of the substrate before and after thin film deposition in grams, A is the area of thin film deposition in cm^2 and 'ρ' is the theoretical density of ZnO , then the film thickness can be calculated as

$$t = \frac{w_2 - w_1}{A\rho} \times 10^4 \, \mu m$$

The thicknesses of the thin films were found to be 0.22µm or 212 nm. The relationship between thickness and spin speed of disk and is given by

$$t \propto 1/\sqrt{\omega}$$

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(b) Optical Characterization

The energy gap of films was determined from graph between (hν) and $(Ah\nu)^2$ as shown in fig. 2. Where ν is the frequency of the visible light and A is the optical absorption coefficient. The band gap comes out to be approximately 3.9eV. The percent variation in the band gap values is about 15%.

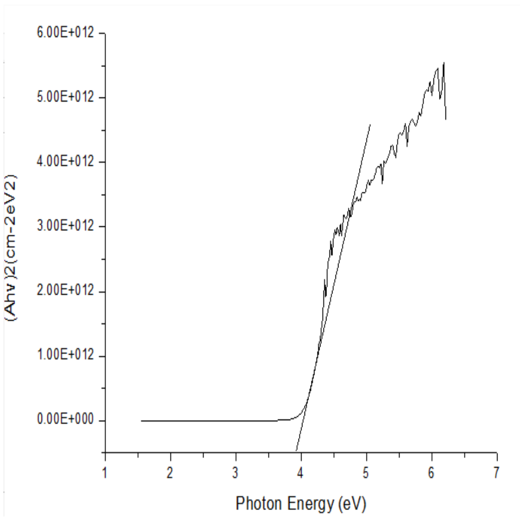

Fig. 2 The above diagram shows the plot between the photon energy (eV) and $(Ah\nu)^2$

(c) **Structural properties**

From the XRD, the grain size and diffracting planes can be determined and

$$\text{Grain size, } D = 0.9\,\lambda / (\beta \cos\theta)$$

θ is angle of scanning that varies from 10^0 to 80^o with a scanning rate of 1^o per minute.

D = grain size

λ = wavelength used (1.54Å).

β = FWHM

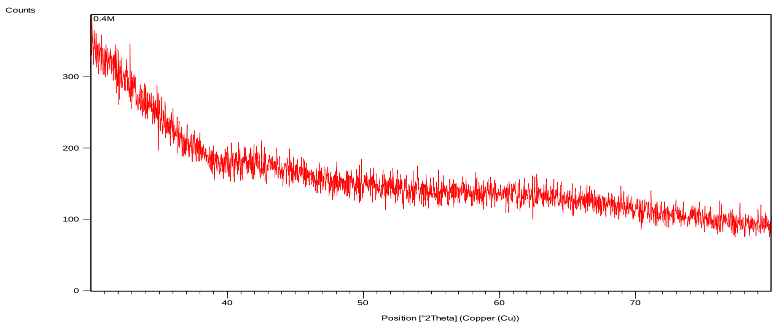

Fig. 3 The above diagram illustrates the x-ray diffractograph of ZnO thin films prepared by 0.4 M solution

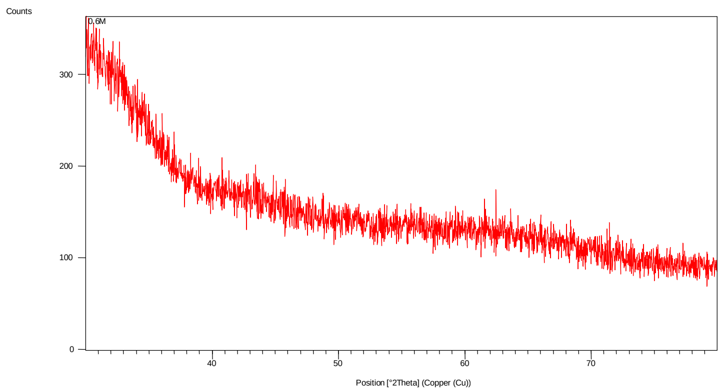

Fig. 4 The above diagram illustrates the x-ray diffractograph of ZnO thin films prepared by 0.6 M solution

From the above diagrams, there is no noticeable peak is observed. This clearly amorphous nature of the films.

4. Conclusion: From the above results, it is concluded that the band gap computed from these studies is little different from the band gap reported in the literature. This difference can be due to preparation technique and conditions. The thin films prepared do not have crystalline structure but rather amorphous in nature. This is confirmed by non-appearance of any notable peak in the x-ray diffractographs.

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