

SYNTHESIS AND CHARACTERIZATION OF ZNO THIN FILMS DEPOSITED BY CHEMICAL BATH TECHNIQUE

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Abstract

ZnO thin films have been deposited on silica glass substrate using the chemical bath deposition technique. The precursors used were zinc chloride and aqueous ammonia. The solution was stirred continuously with the help of a magnetic stirrer at a bath temperature of 70 °C and a deposition time of 70 minutes. The elemental composition and the surface morphology were studied using energy dispersive and scanning electron microscopy. The band gap was 2.72, 2.66, 2.60 eV for as-deposited, annealed at 200 °C and 300 °C respectively. There was a red shift in the band gap energy as the annealing temperature was increased. This might be due to an improvement in the crystallinity of the ZnO thin films.

Index Terms: Zinc oxide, chemical bath, band gap, annealing

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1. INTRODUCTION

Zinc oxide (ZnO) is a wide band gap semiconductor material (Raidou et al, 2010) and it is a versatile and an important technological material. ZnO has many applications that include transparent electrodes [Teng et al, 2006, Young-Sung et al, 2005], piezoelectric [Ajayan et al, 2010], light emitting diode [Jae-Hong et al, 2006], photovoltaic devices [Singh et al, 2011], gas sensors [Suchea et al, 2006], solar cells [Shen et al, 2010; Lupan et al, 2009; Park et al, 2012] and dye-sensitized solar cells [Thitima et al, 2009], ultraviolet sensor [Panda and Jacob, 2012].

Many methods have been used to deposit ZnO for various applications. They include ac magnetron sputtering [Bernède et al, 2008], dc magnetron sputtering [Abdjev et al, 2008; Sutthana et al, 2010], ion implantation [Xu et al, 2012], molecular beam epitaxy [Heo et al, 2006], metal organic chemical vapor deposition [Tan et al, 2005], sol-gel method [Tahar, 2005], spray pyrolysis [El Hichou, 2004] and chemical bath method [Chu et al, 2009]. The chemical bath method has an advantage over other methods since it is very simple, it does not require sophisticated equipment, it uses low temperature and has low cost of deposition [Annuar et al, 2010; Nwodo et al, 2010].

In this paper, thin films of ZnO have been deposited on silica glass substrate using chemical bath method. The elemental composition and the morphology of the film have been studied. The band gap and the effect of annealing temperature on band gap have also been investigated.

2. MATERIALS AND METHODS

The reagents used in this experiment were zinc chloride (from BDH Poole England 98.00 % purity), aqueous ammonia. 0.1 M of zinc chloride was prepared and small drops of ammonia were added and stirred continuously using a magnetic stirrer to obtain optimum pH of 9.4 for this deposition. 70 ml solution of zinc chloride and aqueous ammonia were put in 100 ml beaker and the substrates whose surface had been prepared under standard conditions were vertically suspended in the beaker and the solution was constantly stirred using magnetic stirrer in a water bath of constant temperature of 70 °C. The deposition time was 70 minutes. After 70 minutes the substrate with deposited thin films were removed, rinsed with distilled water and left to dry. The as-deposited ZnO thin films were also annealed at 200 °C and 300 °C in a furnace.

The films deposited were characterized using energy dispersive X-ray analysis (EDAX) equipment (EDS Genesis

4000). The surface morphology of the films was observed using scanning an electron microscope (ESEM Quanta 400 FEG, FEI). The absorbance of the film was also measured using UV mini Schmadzu UV-VIS spectrophotometer in the wavelength range 300-1100 nm.

RESULTS AND DISCUSSIONS

Figure 1 shows the elemental composition of the as-deposited ZnO thin film. The EDAX spectrum is consistent with the formation of ZnO on silica glass substrate. Other elements such as Si, Au etc. emanate from the substrate. The scanning electron microscopy (SEM) image of the surface morphology of the as-deposited ZnO thin film is shown in Figure 2. The image shows nanorods of the ZnO thin films. The band gap can be determined from the Stern (1963) relation

$$Ah\nu = k(h\nu - E_g)^{\frac{1}{2}} \quad (1)$$

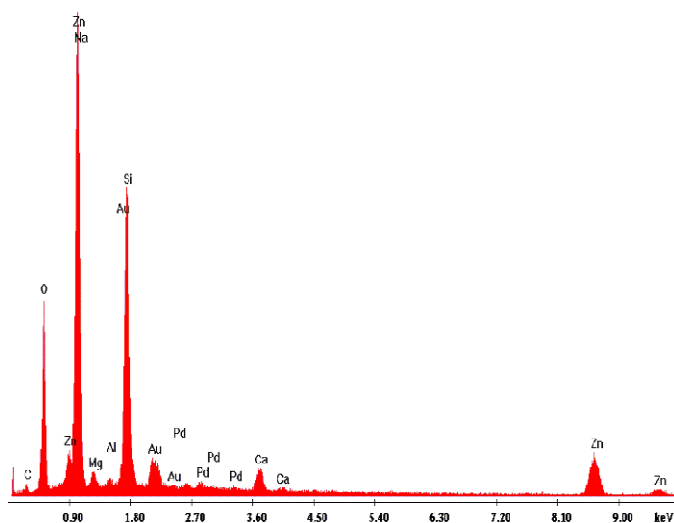


Figure 1: Energy dispersive X-ray analysis (EDAX) analysis of the as-deposited ZnO

where, A= Absorbance
 h = Planck's constant
 ν = frequency
 E_g = Band gap
 n = the type of transition ($n=1$ for direct transition)
 k = A constant

A plot of $(Ah\nu)^2$ against the photon energy $h\nu$ gives a curve as shown in Figure 3 and extrapolation of the linear portion of the curve to the $h\nu$ axis gives the band gap E_g . The band

gaps E_g for as-deposited, annealed at 200 °C and 300 °C are respectively 2.72, 2.66 and 2.60 eV. The band gap value of 2.72 for as-deposited thin film is comparable to the band gap value obtained by Eya *et al* (2005). There is a red shift in the band gap values of the as-deposited 2.72 eV, annealed at 200 °C of 2.66 eV and 300 °C of 2.60 eV. This is also in agreement with the works of Elilarassi and Chandrasekaran (2010) and Lv et al, 2011] who also observed a reduction in band gap of ZnO as the annealing temperature was increased. This might be due to an improvement in the crystallinity of the ZnO thin films.

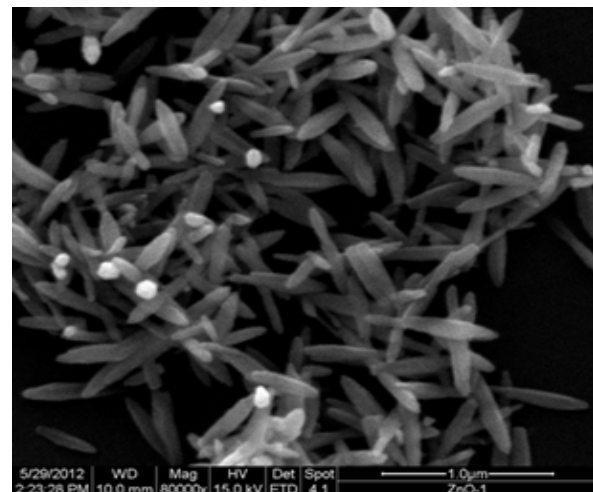


Figure 2: SEM image surface morphology of as-deposited ZnO thin film

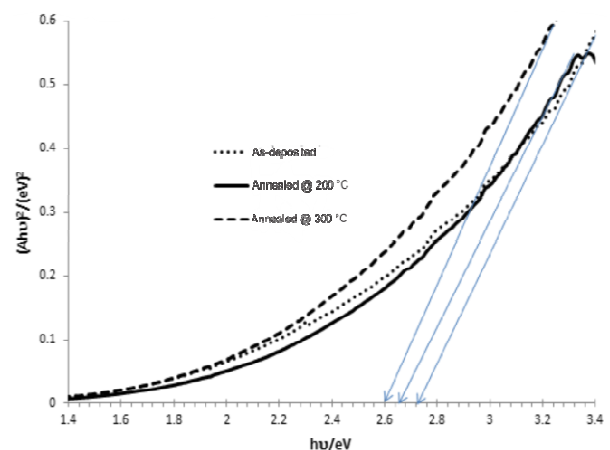


Figure 3: A graph of $(Ah\nu)^2$ versus $h\nu$ of ZnO thin film for as-deposited, annealed at 200° and 300 °C

CONCLUSION

ZnO thin films have been successfully deposited on silica glass substrate using chemical bath deposition technique. The elemental composition of the films was studied using energy dispersive X-ray diffraction. The surface morphology of the films was also investigated. The nanorod

of the as-deposited ZnO thin film was observed using the scanning electron microscopy. The optical band gap for the as-deposited, annealed at 200 °C and 300 °C were respectively 2.72, 2.66 and 2.60 eV. There was a red shift in the band gap energy as the annealing temperature was increased. This might be due to an improvement in the crystallinity of the ZnO thin films.

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