Journal of Engineering and Applied Sciences 13 (18): 7537-7540, 2018
ISSN: 1816-949X

Characterization of a Zinc Oxidethin Film Used Simple Chemical Method

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Abstract: This manuscript describes synthesizeof Zinc Oxide (ZnO) thin film by simple chemical method. The structural, topographical and th optical properties of the synthesized thin film were studied by using X-Ray Diffraction (XRD), Atomic Force Microscopy (AFM), Fourier-Transform Infrared Spectroscopy (FTIR), UV-Vis absorption and Optical microscope (OP) image. The XRD pattern of ZnO thin film deposited on a substrate of glass shows polycrystalline structure, the wurtzite structure with average crystallite size 36.207 nm was appeared. While 3D AFM image show 42.35 nm average grain size with 2.69 and 3.19 nm for each roughness average and root mean square, respectively. PL spectra of ZnO thin film revealse that the emission wavelength of ZnO thin film equal to 400 nm and emission energy of the film (3.1 eV).

Key words: Manuscript, ZnO, topographical, synthesized, XRD, AFM

INTRODUCTION

Among the various functionalities, metal oxide thin films are very attractive for different applications because of their amazingoptical and electrical properties (Yung *et al*., 2009). Today, Zinc Oxide (ZnO) has attracted a lot of interest from the researchers as one of the most promising semiconductors for its versatile applications in ultraviolet and blue light emitter, chemical and gas sensors, varistors, spintronic devices, surface acoustic devices, piezoelectric transducers and optoelectronic devices (Liu *et al*., 2005; Rusop, 2012; Wacogne *et al*., 1995; Shan *et al*., 2004). An inorganic compound Zinc Oxide (ZnO) is generally used as an chemical addition in many materials and products which including rubbers, plastic, ceramics, glass, cement and lubricants (Battez *et al*., 2008). ZnO nanoparticles have received wide attention due to their outstanding performance in photonics, optics and electronics. Since, the 1960's preparationthin films of ZnO has been an dynamic field because of their applications as photodetectors, catalysts and transducers (Wang, 2004). Zinc oxide is a white powder with 3.37 eV energy band gap at room temperature that is unsolvable in water. ZnO crystallizes have two main forms, hexagonal wurtzite and cubic zincblendeas illustrates in Fig. 1 (Niederberger, 2007; Hassan *et al*., 2016). This study describes the preparation of ZnO thin film by chemical metod using Zinc chloride dissolved in ethanol to obtain Zinc oxide.

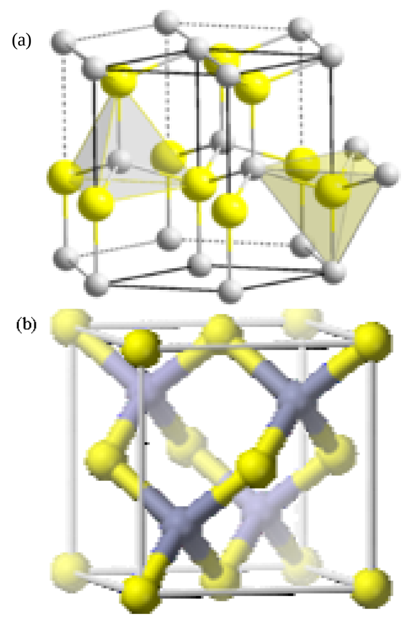

Fig. 1: Two main forms of crystalline ZnO: a) Hexagonal wurtzite and b) Cubic zincblende

MATERIALS AND METHODS

Zinc Chloride ($ZnCl_2$) was first dissolved in 99.99% purity ethanol which was used as a solvent. The molar ratio of ethanol to zinc chloride was maintained to 1M and zinc chloride concentration was 0.80 mol/L. The resulting solution was stirred at 60°C/h to give a clear and

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Table 1: Summary of X-ray characterization

2θ (deg)	D (nm)	δ*10^{14}, lin.m^{-2}	η*10^{-4}, lin^{-2}.m^{-4}
31.6590	32.75350	0.932148	10.599630
34.3620	28.56412	1.225627	12.154230
36.1691	30.51800	1.073712	11.376070
45.4200	59.22944	0.285052	5.861528
56.4956	28.11908	1.264730	12.346600
62.7523	30.16400	1.099062	11.509580
67.8102	44.10269	0.514126	7.871968

homogeneous solution ready for deposit. Precipitation was performed using a fresh solution. The films were prepared on ultrasonic glass cleaner substrates using a drop casting method. Then the films entered the air at 500°C for one hour. Zone thin layer phases were determined by X-Ray Diffraction XRD, atomic force microscopy AFM and infrared spectroscopy Fourier transform FTIR, UV-Vis absorption and optical microscope image Table 1.

RESULTS AND DISCUSSION

Figure 2 illustratethe pattern of XRD diffraction of thin film of Zinc oxide. The peaks are indexed as 31.6° (100), 34.34° (002), 36.16° (101), 45.42° and 47.7° (102), 56.4° (110), 62.7° (103) and 67.8° (112), respectively. All diffraction peaks of the prepared thin film exhibit hexagonal wurtzite structure and there is no impurities in the structure of the ZnO thin film, this proves that pure Zinc oxide thin film were as synthesized. The strain value (η) and average crystallites size (D) was determined from Debye-Scherrer equation (Mahaiu *et al*., 2011). The dislocation density (δ)were determined from Eq. 3:

$$D = 0.9\lambda / \beta \cos\theta \quad (1)$$

$$\eta = \frac{\beta \cos\theta}{4} \quad (2)$$

$$\delta = \frac{1}{D^2} \quad (3)$$

Figure 3 show 3D AFM image of ZnO thin films. The surface of the thin film has good disposition and the grains are homogenous and aligned vertically. The structural and topographical properties of the surface were improved for thin Zinc oxide thin film after annealing at 500°C, making them widely used in optical instruments and granular size measurements, giving the impression that the thin layer is readily available in nanostructures. RMS is estimated as the mean root of the surface roughness and average grain size and is listed in Table 2.

Table 2: Average grainsize, roughness surface and RMS of ZnO thin films

Variables	(nm)
Average grain size	42.35
Roughness average	2.690
Root mean square	3.190

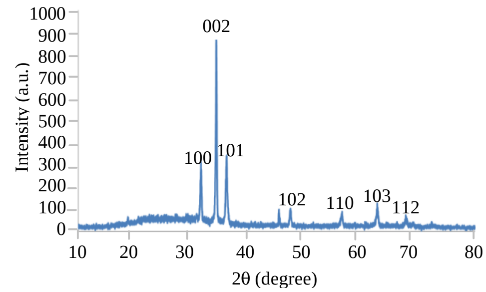

Fig. 2: XRD pattern of thin film of zinc oxide

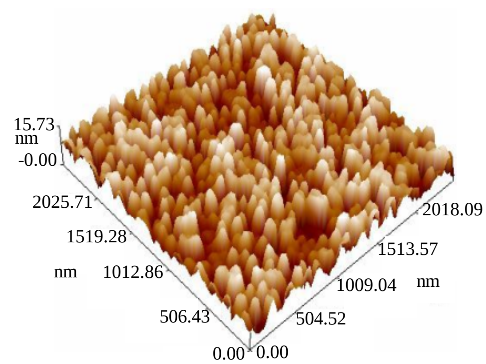

Fig. 3: 3D AFM for ZnO thin films

Figure 4 shows the FT-IR spectra of the prepared thin film. The bands correspond to (Zn-O) appeared at 620.93 cm^{-1} are caused by inter-atomic vibrations. The 1018, 1119.15 and 3552.30 cm^{-1} was observed, possibly due to O-H expansion and deformation, respectively which was allocated to absorb water on the metal surface. Harish Kumar and Renu Rani stated that similar FT-IR spectra were observed in ZnO's high-profile film (Kumar and Rani, 2013).

Figure 5a shows the transmittance spectrum of ZnO thin film as a wavelength function. It reveals that the ZnO gives good transparency propertiesat the spectral range 200-850 nm. The change in permeability as a function of the length of the ZnO nanoparticles and the increase in UV-VIs at 295-900 nm indicate the possibility of using ZnO nanoparticlessuspension in the manufacture of reagents and solar cells (Wang *et al*., 2002). Figure 5b shows the band gap of ZnO thin film plotting the graph of square ($\alpha h\nu$) versus photon energy ($h\nu$). The value of the band gap for ZnO thin film is found to be around 4.6 eV.

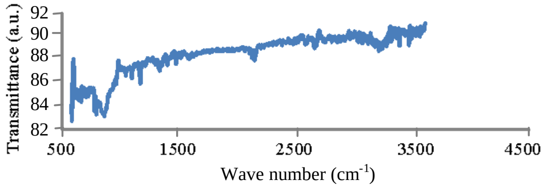

Fig. 4: Observe from the data FTIR spectrum of the pure ZnO

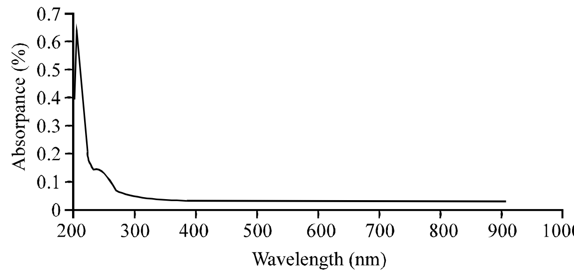

Fig. 6: UV-Vis spectra of ZnO thin film

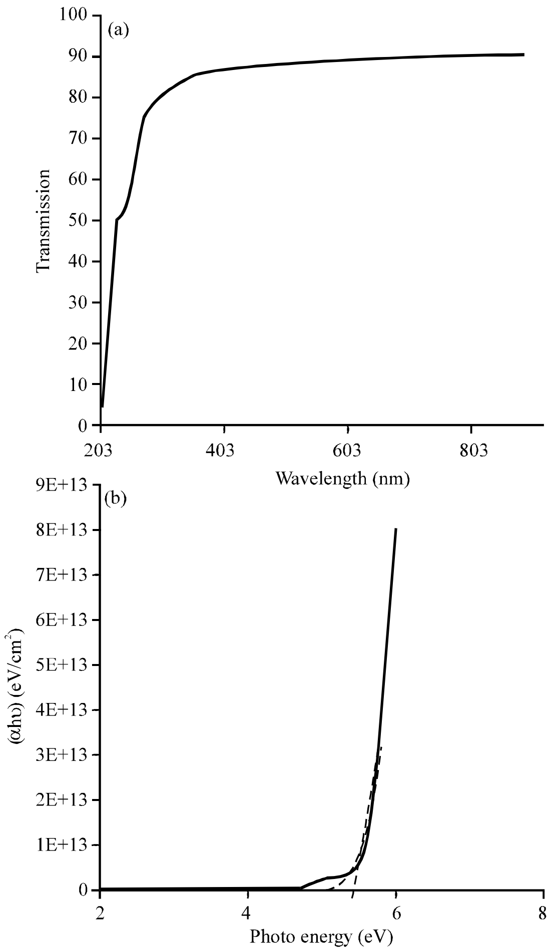

Fig. 5: a) The transmittance spectrum of (ZnO) thin film and b) The band gap of ZnO

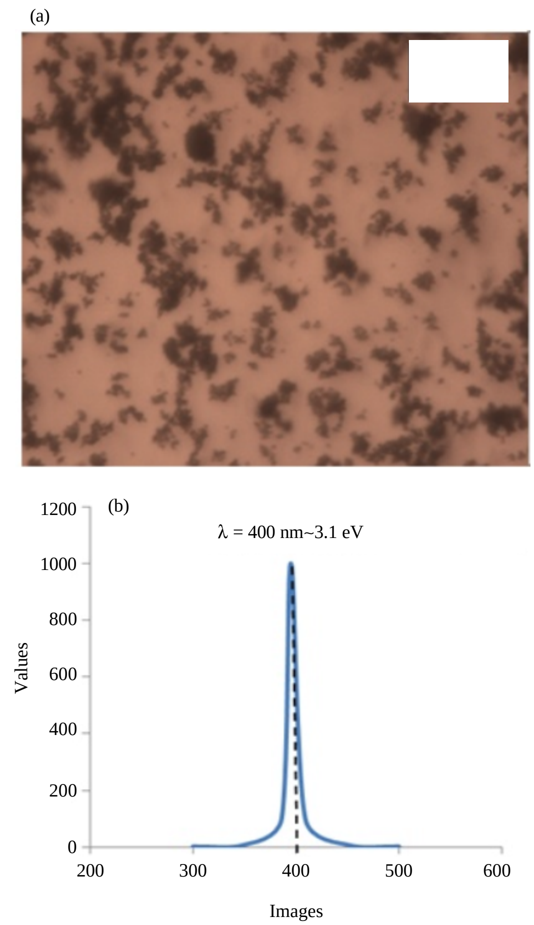

Fig. 7: a) The optical microscope images of ZnO thin films and b) The PL spectra of SnO thin film

Figure 6 shows UV-Vis spectroscopy of the ZnO thin film which explains the high atomic absorption at about 207 nm as a result of electron transmission between the ranges from the deep level of the valence range.

Figure 7a exhibits the optical microscope images of ZnO thin films were deposited on glassand annealing at temperature (500°C) which illustrate the configuration of nanoparticles on the surface of glass substrate homogeneously. Figure 7b showthe PL emission (λ_{ex} = 400 nm) of prepared thin film of ZnO. The PL emission wavelength (350 nm) and emission energy of the film (3.1 eV). Emission wavelength located in the Vis-region of the electromagnetic spectrum. Visible light emissions from the ZnO thin film arose from intrinsic defects such as oxygen vacancy, interstitial oxygen, Zinc vacancy, Zinc interstitial and antisite oxygen in ZnO crystal. The blue tape may appear at 400 nm due to oxygen-related hair defects and zinc functions or interstitial ads (Hu *et al.*, 2001). The spectral analysis of room temperature indicates a large amount of surface conditions related to oxygen vacancy in the sample.

CONCLUSION

The XRD pattern of ZnO nanoparticles deposited on glass clearly seen that the ZnO thin film has polycrystalline in nature the case of the wurtzite structure. The transmittance spectrum of (ZnO) thin film are corrected for glass transmission in UV region. The PL emission wavelength was 400 nm and emission energy of the film (3.1eV). Emission wavelength located in the visible region of the electromagnetic spectrum and this good impression to use ZnO thin film in a solar cell.

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