©2016 Published in 4th International Symposium on Innovative Technologies in Engineering and Science 3-5November 2016 (ISITES2016 Alanya/Antalya - Turkey)

Influence of pH deposition potential on ZnO films obtained by lectrodeposition

[1*], Barış Altıokka [2]Ayça Kıyak Yıldırım

[1*]*Bilecik Vocational School of Higher Education, Bilecik Şeyh Edebali University, Bilecik 11210 Turkey*
[2]*Bilecik Vocational School of Higher Education, Bilecik Şeyh Edebali University, Bilecik 11210 Turkey*

Abstract

Polycrystal ZnO thin films have been deposited on ITO coated glass substrate by the electrodeposition process which is called chronoamperometry, using 0.01 M Zinc nitrate ($Zn(NO_3)_2.6H_2O$) at 68 ± 2 ^OC deposition temperature. Applied cathodic potential was selected as to be -1,05 V and aqueous solutions were saturated by oxygen for 30 minutes in all experiments. The influence of different pH values which reaching from 5 to 8 on the morphological and crystal structural ZnO thin films was determined. Thus the optimum deposition conditions have been appointed. The crystal structures were realized by X-ray diffraction (XRD) and consequence demostrate that all the films have a hexagonal grain structure. It was acquired by XRD that the crystallite sizes of the films are between 40nm and 54 nm. The optical properties of the films were analyzed from the absorbance measurements. The energy band gaps of the films ranging between 3.33 eV and 3.62 eV. A scanning electron microscope was used to view the morphological characterization of the obtained films. The results showed that the shape of films is hexagonal pillar form. The another surface was covered very dense rods.

Key words: ZnO, Zinc Nitrate, Energy Band Gap, Rods

1. Introduction

ZnO (Zinc Oxide) is a very significant II–VI semiconductor material with a direct bandgap of 3.37 eV at room temperature. ZnO is widely used such as optoelectronic devices, thin films lightemitting diodes, antireflection coatings transparent electrodes in solar cells, varistors, spintronic devices, surface acoustic wave devices, gas sensors, and lasers [1] Different morphologies of ZnO nanostructures such as notubes, nanorods and nanoparticles have been deposited by different processes. These processes require sophisticated instruments with high temperature and high vacuum and thus high cost. Therefore, there is a growing interest in cost effective wet chemical techniques like chemical bath deposition (CBD), sol–gel, spray pyrolysis, successive ionic layer adsorption and reaction (SILAR) and electrodeposition. In the last 10 decades the nanostructured oxides, electrodeposition is an excellent method to deposit nostructured zinc oxide. In addition, there are several obvious advantages, such as simple, a low cost process and a good quality thin film [2].

2. Materials and Method

In this study, The electrodeposition procedure carried out with three-electrode which were saturated calomel electrode, a platinum wire as a counter electrode and working electrode. The deposition carried out in 0.01 M Zincnitrate (Zn(NO3)2.6H2O) and at 68 ± 2 ^OC of deposition

*Corresponding author: Address: Faculty of Engineering, Department of Civil Engineering Sakarya University, 54187, Sakarya TURKEY. E-mail address: caglar@sakarya.edu.tr, Phone: +902642955752

temperature. -1.05 V was used as to be cathodic potential and aqueous solutions were saturated with oxygen for 30 minutes before the depositions. The pHs of the final solutions were adjusted to the 5, 6, 7 and 8.

The structural properties were analyzed by using a a PANalytical Empyrean XRD. The optical properties of the ZnO films were analyzed by using absorbance measurements with JASCO V–530 UV-vis. The surface morphology of the ZnO films was investigated by a Zeiss SUPRA 40VP SEM.

3. Results and Discussion

3.1 X ray diffraction analysis

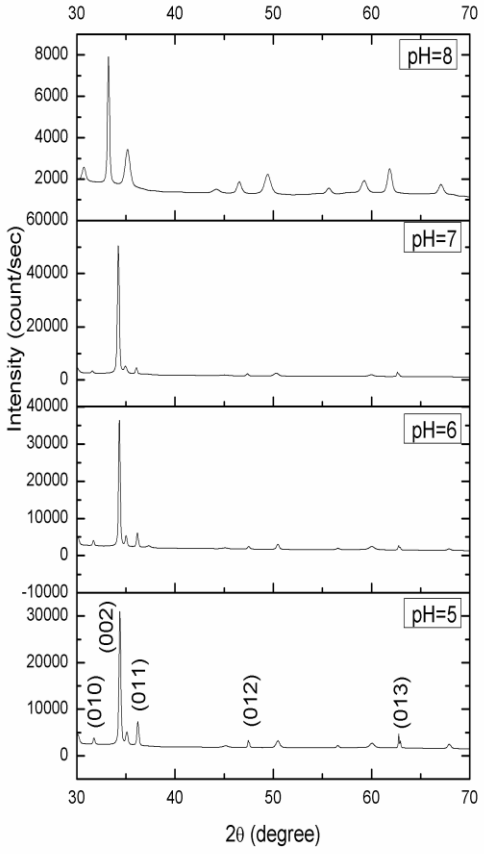

Figure 1 XRD patterns of the ZnO films

Figure 1 shows the XRD patterns of the obtained ZnO films. It is shown from the Fig. 1 that all films have strong (002) peak intensities. This peak related to the hexagonal structure.The peak intensities of the films obtained at pH 6 and 7 are relatively high. It is concluded that this situation related to the film thickness and good crystallization.

The crystallite sizes of the films were calculated Debye Scherrer equation which is given in Eq. 1.

$$cs\,(crystallit\,r\ size) = \frac{0{,}089 \cdot 180 \cdot \lambda}{3{,}14 \cdot B \cdot \cos\theta}(nm) \quad . (1)$$

where 2θ is the position of peak center, λ is the wavelength of X-ray radiation (1.54056 Å), B is the full width at the half maximum of peak height (in degrees) [3]. The calculated crystallite sizes of the films are given in Table 1. It is shown from the Table 1 that the crystallite size of the film obtained at pH=5 is relatively lower than that of the other films.

The film thickness of the films were calculated by gravimetric method and given in Table 1. The thickness of the film obtained at pH=5 relatively low.

Table 1 Calculated crystallite sizes and film thicknesses of the ZnO films

pH	5	6	7	8
Crystallite size(nm)	35	46	43	45
Film thickness (nm)	432	653	684	598

3.2 Optical Properties

The absorbance measurements of the films are given in Fig. 2. The absorbance of the film obtained at pH=5 shifted low wavelength values like as 340nm.

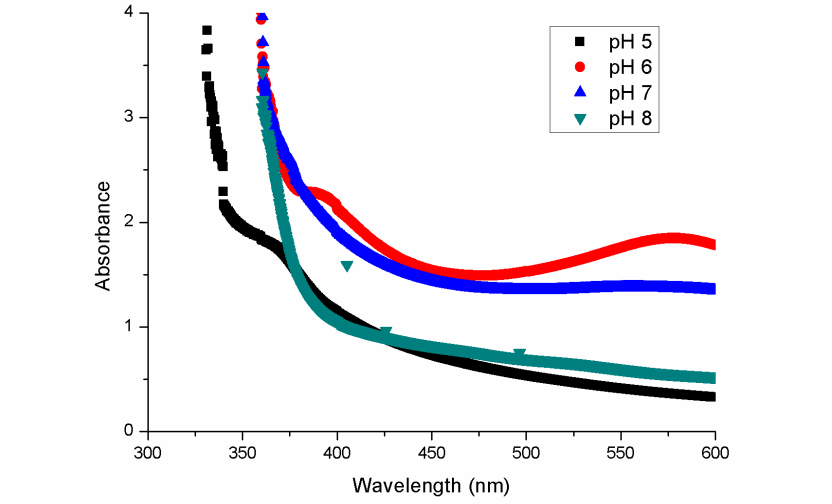

Figure 2 Absorbance versus wavelength graphs

The band gabs of the films were estimated from the $(\alpha h\nu)^2$ versus hν graphs which are given in Fig.3. The band gaps of the films obtained at pH 6, 7 and 8 were varied between 3.30 and 3.36

eV. These values well match values of the literature. On the other hand band gap of the film obtained at pH 5 is 3.62 eV. This value is relatively high.

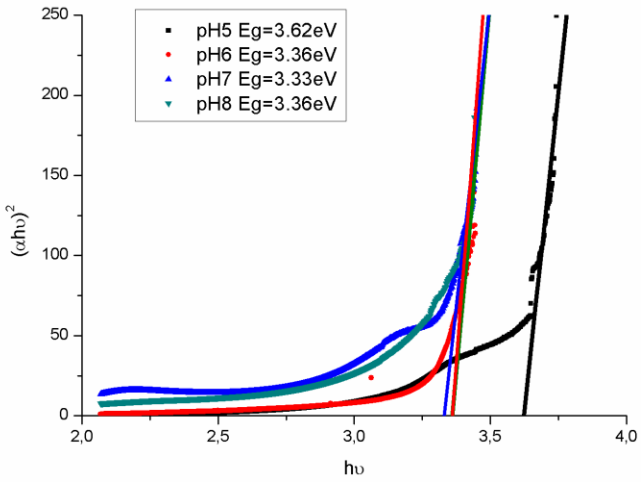

Figure 3 $(\alpha h\nu)^2$ versus $h\nu$ graphs of the films

3.3 Surface Morphologies of the Films

The 50000 times magnified SEM images of the films are shown in Fig. 4. When Fig. 4a was analyzed, it is shown that ZnO was grown cauliflower like structure. The surface of the films obtained at pH 6 and 7 shown in Fig. 4b and 4c respectively were covered ZnO rod form. The sizes of these rods are average 100nm and 300nm for Fig. 4b and 4c respectively. It is also shown in Fig. 4d that ZnO was grown rod like structure but end of the rods is sawed-off form.

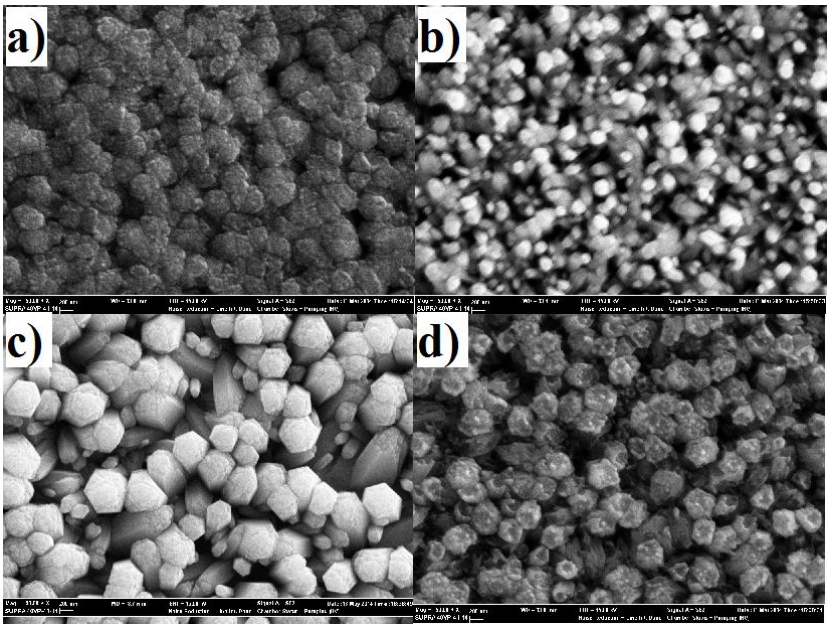

Figure 4 50000 times magnified SEM images of the films obtained at pH a) 5, b) 6, c) 7, d) 8

Conclusion

In this work, ZnO films were produced by potentiostatic technique of electrodeposition. In the literature, band gap of the ZnO films is average 3.37eV however the film having 3.62eV can be produced. The surface of this film was formed cauliflower like structure. This may be cause increasing surface area. Therefore the film may be suitable for gas sensors.

References

[1] Arfaj E. A., Subahi A., The influence of external magnetic field on the structural and optical properties of nanocrystalline ZnO thin films prepared by dip coating method, Superlattices and Microstructures 2015 86 508–517

[2] Atourki L., Ihalane E. H.,. Kirou H, Bouabid K., Elfanaoui A.,. Laanab L,. Portier X, Ihlal A., Characterization of nanostructured ZnO grown by linear sweep voltammetry, Solar Energy Materials & Solar Cells 2016 148 20–24

[3] Bhowmik R.N., Nrisimha Murty M., Sekhar Srinadhu E., Magnetic modulation in mechanical alloyed Cr1.4Fe0.6O3 oxide, PMC Physics B 2008, doi:10.1186/1754-0429-1-20