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Transparent ZNO Thin Films Grown by Spin Coating Methods for OPTO-Electronic applications

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Abstract:
Zinc Oxide (ZnO) thin films are deposited by spin coating method at three different spinning speeds of 3000rpm, 4000rpm and 5000rpm. The polycrystalline nature of the films are conformed from X-ray diffraction analysis. The optical bandgaps of the films are 3.2, 3.18 and 3.16 eV respectively. Films also shows very good transparency of more than 80% wavelength more than 480nms. The transparency in visible range of spectrum and low temperature deposition of ZnO thin films makes them appropriate for devices such as Thin Film Transistors, Sensors, and Light Emitting Diodes etc.

Keywords: *Spin coating, X-ray Diffraction, Band gap, Thin films*

1. Introduction

The explosion in science and technology in the area of micro electronic devices especially transparent displays, thin film transistors and sensors causes a boom in thin film technology. Now a days the researchers are concentrating on flat panel displays, opto-electronic devices, solar cells etc. Transparent Conducting Oxides (TCOs) plays a vital role in this. Due to some extra ordinary features ZnO is considered as a promising material for TCOs. [1]- [3]. Large band gap, good optical stability, excellent piezo electric properties make ZnO to be used in Thin Film varistors, sensors, acoustic wave devices, Light Emitting Diodes, Transistors etc. [4]-[5].

ZnO thin films can be deposited using different techniques and they are RF magnetron sputtering, pulsed laser deposition, electron-beam evaporation, sol–gel Spin coating process and spray pyrolysis method [6]- [10]. Spin coating is preferred as it can operate in low temperature, large area deposition is possible, ease of compositional modification also it provides better quality of films etc.[11]. The work discusses about thin film ZnO preparation and its physical and optical properties on different chunck rotation rates.

2. Experimental Details

ZnO thin films are deposited on a glass substrate by Spin coating method. The substrates are washed using acetone and then isopropanol in ultrasonic bath for 20 minutes each. After ultrasonic bath, the substrates are rinsed using deionized water and dried. For spin coating the solution is prepared using Zinc acetate dehydrate, 2 methoxethanol (MEA) and mono ethanol amine.

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The molar ratio of zinc acetate dehydrate to MEA is kept at 0.5M. The coating solution is poured on the surface of substrate and are rotated at three different rotation rates such as 3000rpm, 4000rpm and 5000rpm for 30 seconds and preheated at 250ºC for 5 minutes. The films are then annealed at 400ºC for 2hrs.

The structural analysis of the films are observed from X-ray Diffraction (XRD) technique. Scanning Electron Microscopy (SEM) is used for the surface analysis of thin films. The optical properties are analyzed from UV-Vis Spectrometer.

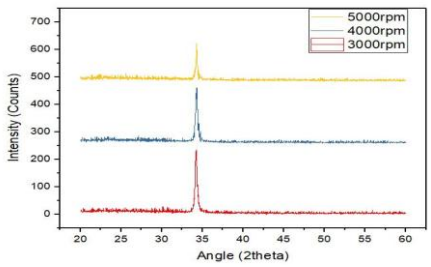
3. Results and Discussions

XRD spectra of ZnO thin films prepared at different spinning speeds 3000rpm,4000rpm and 5000rpm are shown in Figure 1. It indicates that the films are oriented along (002) plane along the c-axis. From the spectra it is analyzed that the peak is increased with RF power also the films obtained are polycrystalline. Scherrer's formulae is used for the calculation of crystal size [12]

$$D = \frac{k\lambda}{\beta_{2\theta} Cos\theta}$$

Where k is a constant and is equal to 0.94, λ is the wave length of X-ray used, β2θ is the Full width Half Maximum (FWHM) of the X-ray peak obtained. 2θ is the Bragg's angle.

Figure 1 X-ray Diffraction spectra of ZnO thin films



The variation in FWHM of ZnO thin Films for varying RF powers were presented in Table1 Strain along the c-axis can be calculated using the equation [13]

$$\epsilon = \frac{(d_{film} - d_{powder})}{d_{powder}} \times 100$$

Whered_{film} is the d spacing of ZnO thin film, and d_{power} is the d spacing of ZnO which is obtained from [JCPDS No. 36-1451]. Strain and d_{film} values are calculated and presented in Table 1. It is observed that the d spacing of ZnO powder is less than that of d spacing of ZnO thin films. The stress of thin films are calculated using the equation [14]

$$\sigma = \frac{233(c - c_0)}{c_0} (GPa)$$

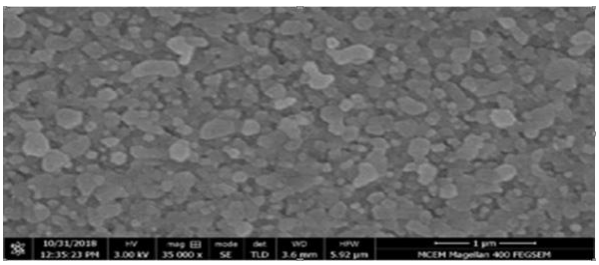
Where c and c0 are the lattice parameters of ZnO thin film and ZnO powder respectively.

	FWHM	d(Å)	c(Å)	D (nm)	ε(%)	σ(G Pa)
3000rpm	0.1680	2.6127	5.2254	39.86	0.334101	3.395694
4000rpm	0. 1440	2.61295	5.2259	35.32	0.343702	3.418314
5000rpm	0.2880	2.61869	5.23738	30.17	0.564132	4.951318

Table1.Lattice parameters, grain size, strain and stress of ZnO films prepared at different RF powers.

Figure 2 shows the surface micrograph of ZnO thin films obtained from Scanning Electron Micrograph(SEM). The figure give as an idea that the thin films developed are uniform and continuous. A decrement in grain size is also observed as the chunk rotation rate increases which intern causes the deterioration in crystallinity.

Figure 2 SEM images of ZnO thin films atchunk rotation rates of 3000rpm, 4000rpm and 5000rpm



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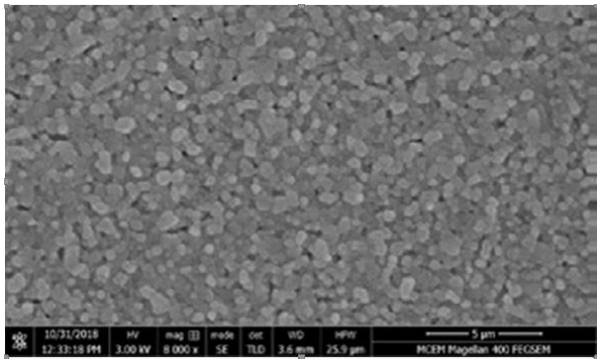
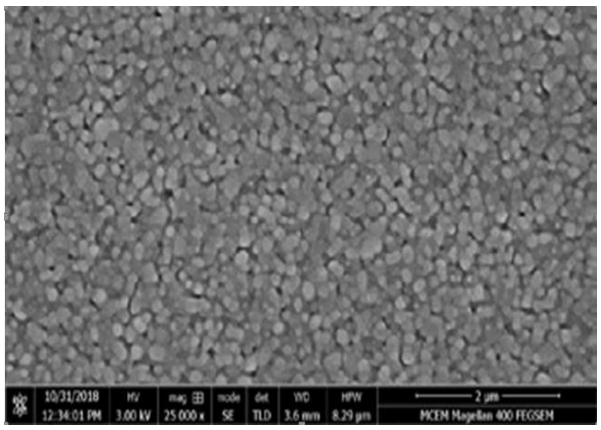


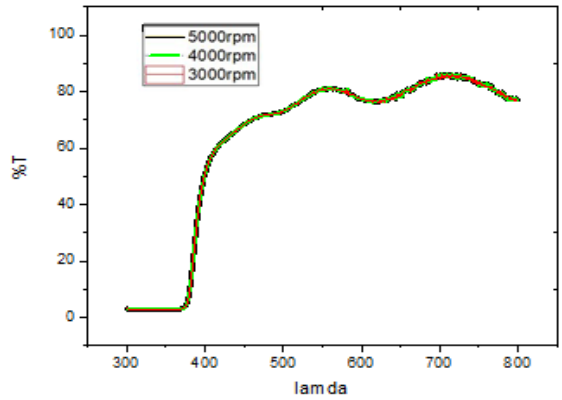


Transmittance spectra of ZnO thin films are shown in Figure 3. The transmittance are found to be more than 80% in the optical transmittance spectrum of 480-800 nm. The absorption coefficient of the films are estimated using the relation [15]

$$\alpha h\nu = A(h\nu - E_g)^{1/2}$$

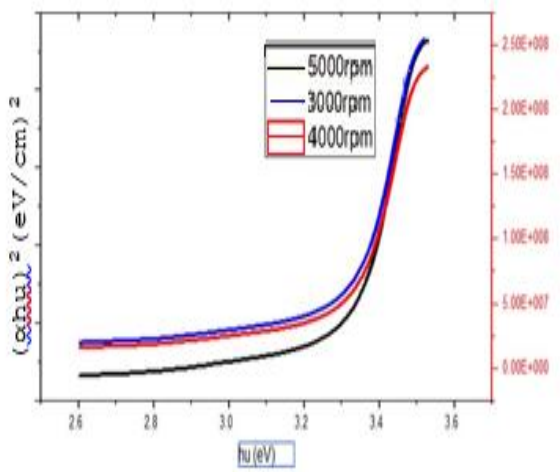
Where hυ is the photon energy, αis the absorption coefficient, Eg is the band gap and A is a constant.

Figure 3.Transmittance spectra of ZnO films



At 370 nm a sharp absorption edge is observed which shows ZnO is a direct band gap semiconductor material. Tauc plot is used to find out the energy band gap of ZnO thin films and is shown in Figure 4. The band gap values are obtained as 3.26 eV, 3.26 eV and 3.22 eV for films deposited at 3000rpm, 4000rpm and 5000rpmrespectively and are presented in Table 2. A plot of energy band gap and position of UV peak for different rotation rates are shown in Figure 5.

Figure 4.The plot of (αhv)2 vs. hv of ZnO films deposited at different RF powers



Sample	Eg(eV)	Position of UV peak emission
ZnO at 3000rpm	3.26	3
ZnO at 4000rpm	3.26	3.12
ZnO at 5000rpm	3.22	2.9

Table2.Energy band gap (Eg) and position of UV emission peak at three RF powers

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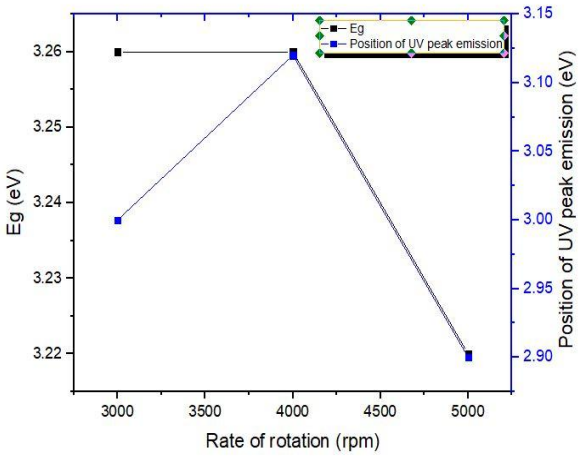

Figure 5.Energy band gap (Eg) and position of UV emission peak as a function of the chunk rotation speeds

4. Conclusion

Structural, morphological and optical properties of ZnO thin films are shown obtained for three different chunk rotation speeds. The results indicates that the thin films obtained are poly crystalline and are oriented in c-axis. Also, as the spinning speed increases, crystallite size decreases while tensile stress increases. The optical band gap of films are found to be decreased with increasing chunk rotation speed.

The obtained films were well efficient to be used as channel layers for the opto- electronic devices such as transparent thin film transistors, solar cells etc.

References

1. H. Hosono, Thin Solid Films, 515, 6000–6014, (2007).
2. Y. Liu, Y. Li, and H. Zeng, J. Nanomater., 2013, 9, (2013).
3. A. Facchetti and T. J. Marks,Transparent Electronics: From Synthesis to Applications, wiley, USA, (2010).
4. A. Kurhekar, P. R. Apte, and S. Duttagupta, Braz J Phys, 44, 665–672, (2014).
5. K. Al-rashdi, M. Farooqui, M. Mohsin, and G. Rabbani, J. Adv. Sci. Res., 7, 1, 1–8, (2016).
6. VirAtul, Chandra Sudhir, Srivastava A K, Chakroborty B R, Sehgal G, Dalai M K, Bose, G, Appl. Surf. Sci.,257, 22,9568–9573, (2011).
7. C. Gümü, O. M. Ozkendir, H. Kavak, and Y. Ufuktepe, J. Optoelectron. Adv. Mater., 8, 1,299–303, (2006).
8. Scott Robin C, Leedy Kevin D, Bayraktaroglu Burhan Look, David C, Zhang Yong-hang., Appl. Phys. Lett., 072113,2010, pp. 1–4, (2012).
9. T. Peng, Q. M. Fu, and C. Liu, J. Korean Phys. Soc.,52, 100–103, (2008.)
10. M. Saleem, L. Fang, A. Wakeel, M. Rashad, and C. Y. Kong, World J. Condens. Matter Phys.,2012, 10–15, (2012).
11. A. Liu, J. Zhang, and Q. Wang, “STRUCTURAL AND OPTICAL PROPERTIES OF ZNO THIN FILMS PREPARED BY DIFFERENT SOL-GEL PROCESSES,” Chem. Eng. Commun., vol. 198, no. 4, pp. 494–503, 2010.
12. Z. R. Khan, M. Zulfequar, and M. S. Khan, Mater. Sci. Eng. B Solid-State Mater. Adv. Technol.,174, 1–3, 145–149, (2010).
13. I. Özen, M. A. Gülgün, and M. Özcan, Key Eng. Mater.,268,1225–1228, (2004).
14. G. P. Daniel, V. B. Justinvictor, P. B. Nair, K. Joy, P. Koshy, and P. V Thomas, Phys. B Phys. Condens. Matter, 405,7, 1782–1786, (2010).
15. M. S. K. Ziaul Raza Khan, Mohd Shoeb Khan, Mohammad Zulfequar, Mater. Sci. Appl., 2, 340–345, (2011).