Synthesis of zinc oxide thin films by spray pyrolysis technique

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The economic spray pyrolysis process were used to prepare Zinc oxide thin films. Ahigh - quality thin film is obtained by optimizing factors that include concentration, flow rate, nozzle to substrate distance. The temperature is differed between 350˚C to 450˚C. The structural and optical qualities were studied through physical investigation. According to XRD, the films have a hexagonal crystal structure. A scanning electron microscope reveals the material's uniform deposition &adhesion across a glass substrate. A direct band gap of about 2.4 to 2.6 eV was obtained for different temperatures.

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1.Introduction

Zinc Oxide is a II-VI semiconducting substance used in many fields of semiconductor industry with energy gap of 3.37 eV [1]. The optical, electrical and structural characteristics Zinc oxide are distinct. ZnO is considered to be an alternate to GaN for device applications with large excitation energy at room temperature [2].These thin films have many applications that includes gas sensing [3], LED [4], solar cells [5], field emitters [6], Piezo electric generators [7], etc. Like other oxide thin films such as MnO [8,9,10], ZdO can be prepared by spray pyrolysis technique [11], magnetron sputtering [12], RF sputtering [13], Sol gel [14], pulsed laser deposition [15], SILAR [16] and electrodeposition [17].

2.Experimental

By applying the spray pyrolysis approach and changing the temperature from 350˚C to 450˚C.On the glass substrate thin layer of Zinc oxide were created. Zinc chloride, along with water, is used as a starting solution. The molar concentration of 0.2 M of Zinc Chloride mixed with 50 ml of water is taken as a precursor solution. To get a homogeneous mixture, the solution was agitated for one hour and the finished product was kept in a burette. Compressed air, the carrier gas, was permitted to pass through the spray head's. The films were evenly coated on the substrate by allowing the spray head to move manually. A chrome-alumel thermocouple was used to monitor and regulate the substrate temperature with an accuracy of ± 5˚C. The substrate underwent three rounds of ultrasonic cleaning: trichloroethylene, acetone, and methyl alcohol, followed by a rinse in distilled water. Other deposition parameters were held constant including

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solution flow rate, carrier gas (air) 0.2 kg/ cm^2, nozzle to substrate distance and volume of the solution. UV, XRD and SEM were used to characterize the produced films.

3. Result and discussion

Zinc oxide thin films with a white surface produced at temperature ranging from 350˚ to 450˚C were examined using UV-VIS –NIR spectrophotometer. Fig.1 shows the optical transmittance curve of sprayed ZnO films that were obtained in the spectral range 400-1000 nm.

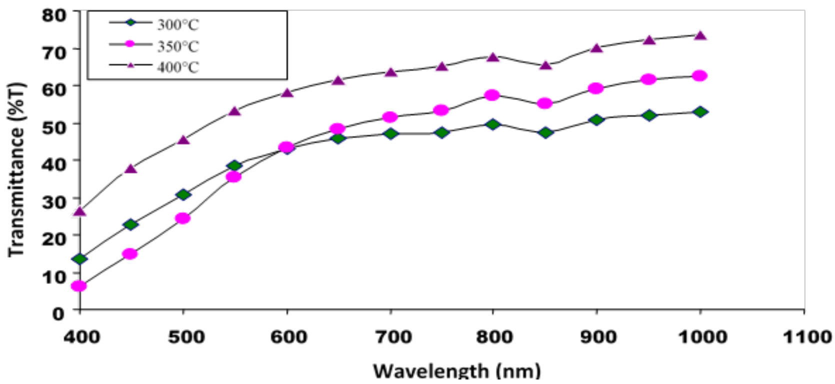

Fig.1. Optical transmittance spectra at different temperature for ZnO thin fims,

The film prepared at lower temperature has less transmittance (350˚C with 53%) than the films prepared at higher temperature (450˚C with 75%). These films have maximum transparency and less absorption in the near IR region (Fig.2). The film obtained at 350˚C and 400˚C had interfered in the 600nm range, which shows the homogeneity of the films with uniform thickness.

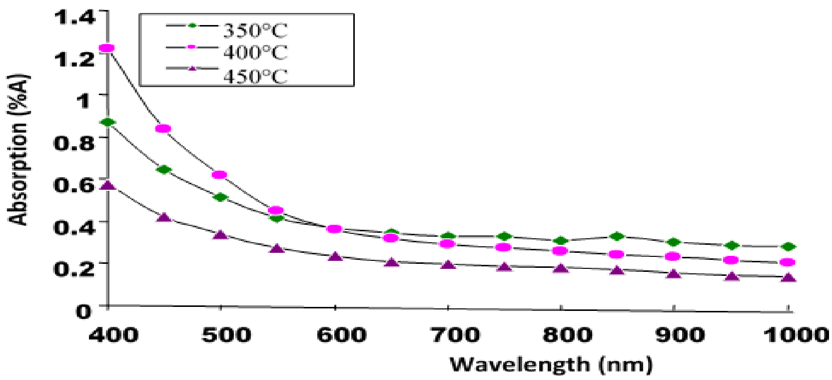

Fig.2.ZnO thin fims, absorption spectra at different temperature.

Reflection (R) of the film is computed using the formula R= [1-(A+T)] based on the optical transmittance and absorption

The reflection values of the film vary in the range of 0.15 to 0.23 for the temperature 350˚C and 400˚C. The film obtained at 450˚C shows gradual increase of reflection. As the reflection of these films is very less, it is used for antireflection coating. The absorption co efficient of the film is calculated using the relation $\alpha= (2.303 \log (1/T))/t$, this expression shows that the absorption coefficient depends on thickness of the film here, film thickness reduces as the temperature rises and hence absorption co efficient increases (Fig.3).

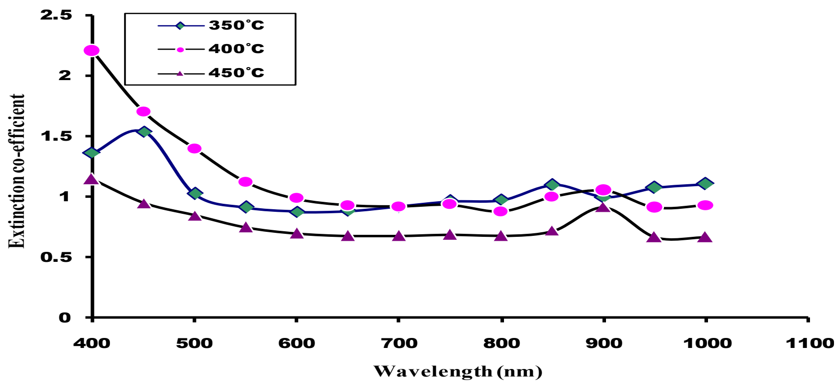

Fig.3.Variation of extension co-efficient with wave length.

From optical reflectance data of the film, refractive index (n) is calculated using the expression

$$n = (1+R)^{1/2}/(1-R)^{1/2}$$

Fig.4. depicts the refractive index's changes with wave length. Maximum refractive index of about 3.05 is obtained at a temperature of 450˚C refractive index decreases gradually and then increases. Fig.5. shows $(\alpha h\nu)^2$ versus hν for ZnO thin film. Band gap energy for different temperature is 450˚C – 2.62 eV, 400˚C – 2.51 eV and at 350˚C – 2.45 eV.

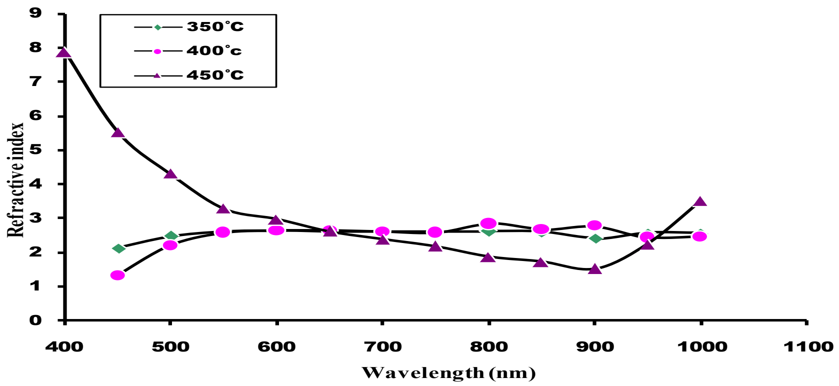

Fig.4.Variation of refractive index with wave length.

The optical band gap shrinks as the film's thickness and temperature rises. Structural study clearly shows that this drop in energy band gap with thickness is caused by particle size, decrease in strain and a dislocation density

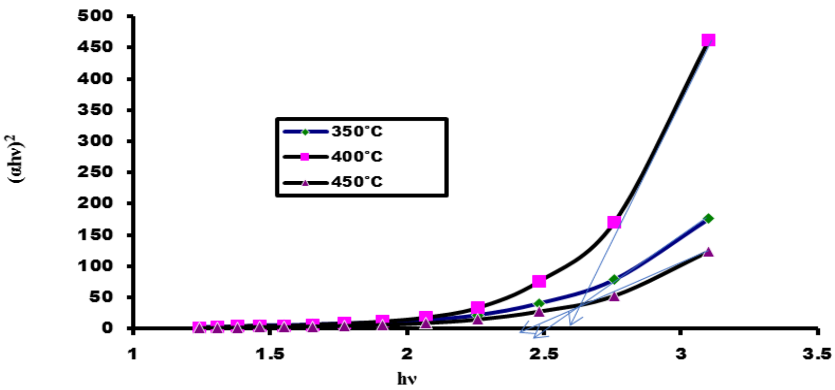

Fig.5. Band gap of ZnO films prepared at different temperature.

3.1. Structural analysis

The films prepared at 450˚C shows intense peak at 36.18˚ corresponding to (101) plane, microstrain and dislocation density of the film is calculated as 0.183210 and 0.0578. This film shows that films have hexagonal crystal structure. Fig.7. shows SEM analysis of film at 450˚C, it is seen that the films have nano rod structure with maximum size of 278.57nm.

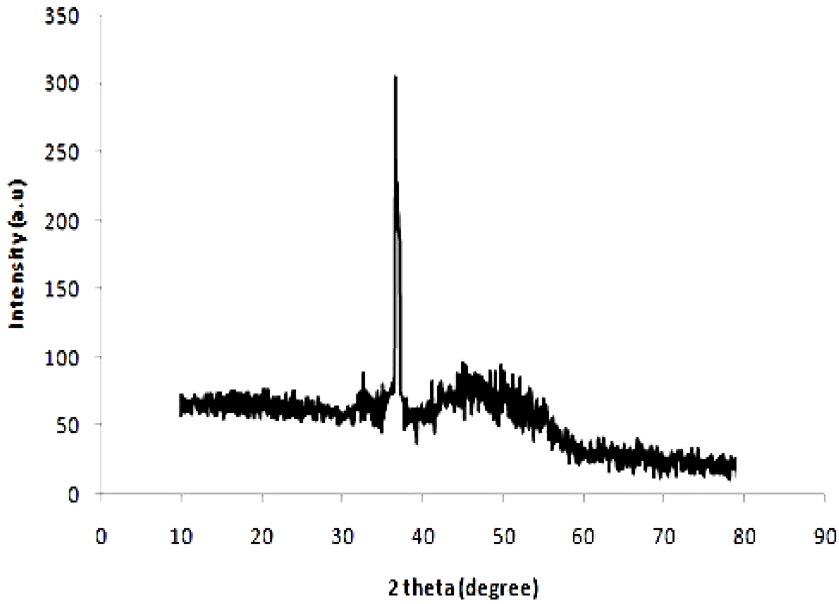

Fig.6. X –Ray diffraction of ZnO thin films at 450°C.

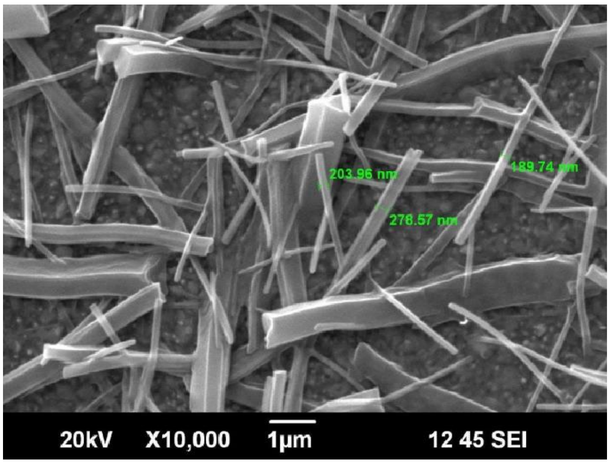

Fig.7.SEM analysis of ZnO films prepared at 450°C.

5. Conclusion

Spray pyrolysis process were used to created Zinc Oxide thin films at various temperature on a glass substrate. Analysis was conducted on the optical characteristics of ZnO materials including transmittance, absorption, refractive index and the band gap energy of the film. Thin films thickness is a key factor in transmittance. These findings indicates that ZnO is suitable for solar cell applications, like batteries that can be recharged

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