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Research Article

STRUCTURAL AND OPTICAL PROPERTIES OF ZINC OXIDE THIN FILMS PREPARED BY THE CHEMICAL SPRAY PYROLYSIS METHOD

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ABSTRACT
Nanostructured zinc oxide thin films have been deposited by using spray pyrolysis technique onto the glass substrates at 573K under optimized conditions. The as deposited zinc oxide thin films were characterized for their structure through X-ray diffractometry (XRD). Optical absorption studies of the thin films have been made through Lambda 25 UV-VIS spectrophotometer (PerkinElmer) in the spectral range 300 -1100 nm. The structural study revealed that ZnO thin films are nanocrystalline in nature with hexagonal wurtzite structure. The optical characterization shows that the band gap of the spray deposited ZnO thin film is of the order of 3.34eV.

Keywords: *Thin Films, Nanostructures, Spray Pyrolysis, Optical Properties*

INTRODUCTION
Zinc oxide (ZnO) is one of the most prominent metal oxide semiconductors. It is an n-type semiconductor of hexagonal (wurtzite) structure with a direct energy wide band gap of about 3.37 eV at room temperature (Chen *et al.*, 1998; Ozgur *et al.*, 2005). It is a versatile material with good electrical, optical, thermal properties and chemical stability is abundant in nature, low-cost and non-toxic. Transparent conducting zinc oxide thin films, have found extensive applications in optoelectronic devices (Dower and Joshi, 1984) such as solar cells (Ronovich *et al.*, 1980), liquid crystal displays, heat mirrors and multiplayer photothermal conversion system (Chopra *et al.*, 1983). ZnO thin films have been deposited by various techniques, such as thermal evaporation (Ma *et al.*, 1999; Aly *et al.*, 2001), sputtering (Minami *et al.*, 2007), chemical vapor deposition (Lu *et al.*, 2007), sol-gel (Musat *et al.*, 2006), pulsed laser deposition (Liu and Lian, 2007) and electrochemical deposition (Fathy and Ichimura, 2006). In addition to these techniques, spray pyrolysis has received a little bit of extra attention because of its simplicity and cost-effectiveness.
In the present work, chemical spray pyrolysis method was utilized for the deposition of nanocrystalline ZnO thin films onto glass substrates. The structural characterizations were carried out using X-ray diffraction (XRD). The composition dependent optical properties were studied by using Lambda 25 UV-VIS spectrophotometer (PerkinElmer).

MATERIALS AND METHODS
Spray pyrolysis technique (SPT) is one of the simple, cost effective and important technique to deposit a wide variety of thin film using different materials. Spray pyrolysis is a process in which thin films are deposited by spraying a solution on a heated surface. Droplets impact on the substrate surface, spread into a disk shaped structure, undergoes thermal decomposition, where the constituents react to form a chemical compound.
Chemical spray deposition processes can be classified according to the type of reaction taking place during the formation of compound. In process, the droplet resides on the surface as the solvent evaporates, leaving behind a solid that may further react in the dry state. The solvent evaporates before the droplet reaches the surface, the dry solid impinges on the surface, where decomposition occurs and the solvent vaporizes as the droplet approaches the substrate; the solid then melts, vaporizes, the vapor diffuses to the substrate, there to undergo a heterogeneous reaction. For obtaining good quality thin films, the necessary optimum conditions required are substrate temperature, pressure, spray rate, concentration

of the solution, the distance between spray nozzle and substrate etc.,. The improvement in the quality of the thin films can be achieved with automization techniques such as microprocessor based controller spray pyrolysis

The average thickness of the as deposited ZnO film was measured by the gravimetric method. The structural studies were carried out using Philips PW 1710 diffractometer with Cu-Kα radiation of wavelength 1.5405 A°. The optical characteristics were studied using Lambda 25 UV-VIS spectrophotometer (PerkinElmer) to find band gap energy of ZnO thin films.

RESULTS AND DISCUSSION

Structural Analysis

The XRD pattern for zinc oxide thin films deposited at 573K substrate temperature is shown in figure 1. There are six orientation peaks that could be observed in the film, identified as (100), (002), (101), (102), (103) and (201) orientation peaks at diffraction angle are 31.742, 34.513, 36.360, 47.561, 62.902 and 69.251 respectively. The analysis of diffraction peaks has revealed the hexagonal wurtzite structure of zinc oxide.

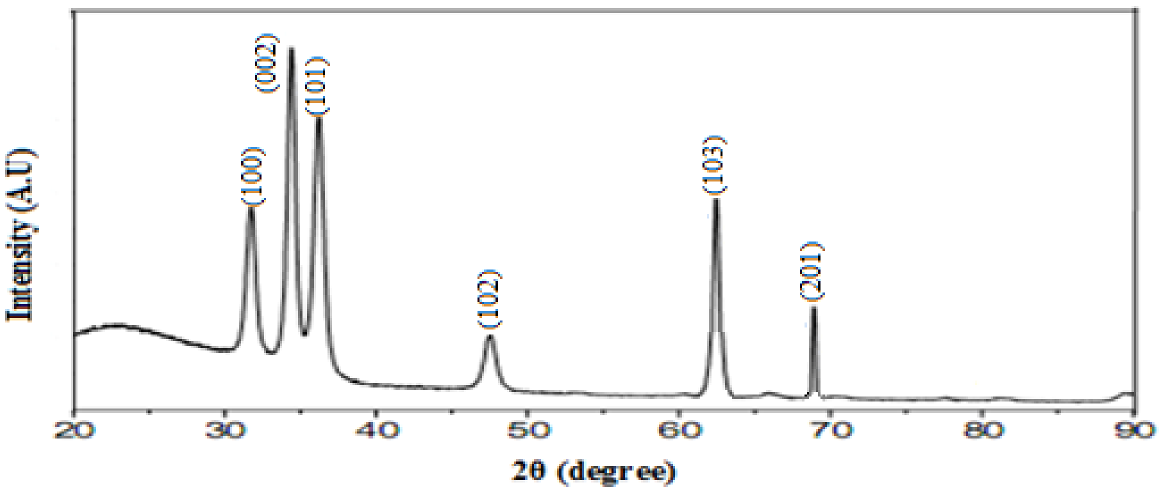

Figure 1: XRD Pattern for Zinc Oxide Thin Films

Table 1: Comparison of Observed and Standard XRD Data of ZnO Thin Films (JCPDS Card 36-1451)

Film	Observed Data		Standard Data		hkl	Phase
	2θ(Degree)	**d (A^0)**	**2θ(Degree)**	**d (A^0)**		
ZnO	31.742	2.801	31.770	2.814	1 0 0	ZnO
	34.513	2.589	34.422	2.603	0 0 2	ZnO
	36.360	2.332	36.253	2.475	1 0 1	ZnO
	47.561	1.890	47.539	1.911	1 0 2	ZnO
	62.902	1.441	62.864	1.477	1 0 3	ZnO
	69.251	1.333	69.100	1.358	2 0 1	ZnO

Optical Analysis

The optical absorption studies were carried out for the wavelength range 300 to 1100 nm (figure 2) and the absorption spectra is analyzed to find band gap energy of zinc oxide thin films. The nature of transition is determined by using the relation,

$$\alpha = \frac{A(h\upsilon - Eg)^n}{h\nu} (1)$$

where, hυ is the photon energy, Eg is the band gap energy, A and n are constants. For allowed direct transitions n = 1/2 for allowed indirect transitions n = 2.

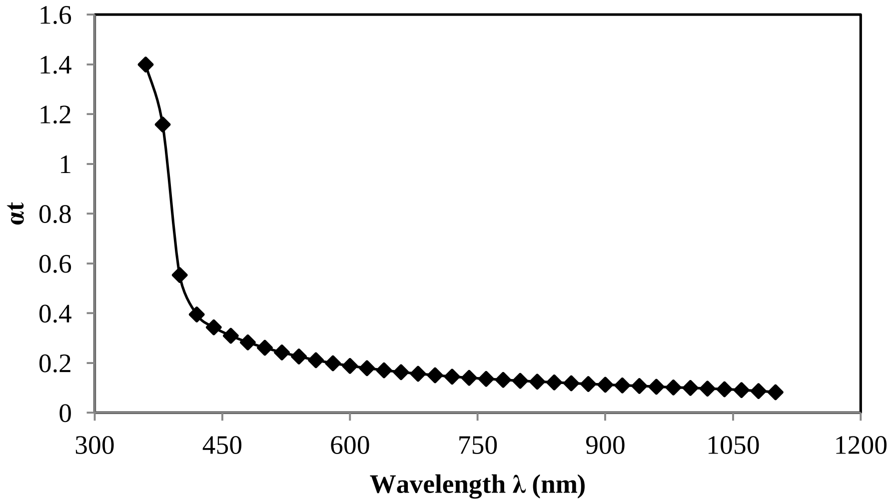

Figure 2: Variation of Optical Absorption vs. Wavelength for Zinc Oxide Thin Film

The width of the energy gap is a characteristic value for each material. The plots of $(\alpha h\upsilon)^2$ versus "hυ" are shown in Figure 3. The nature of plots indicates the existence of direct transition in zinc oxide thin films. The optical characterization shows that the band gap of the spray deposited zinc oxide thin film is of the order of 3.34eV.

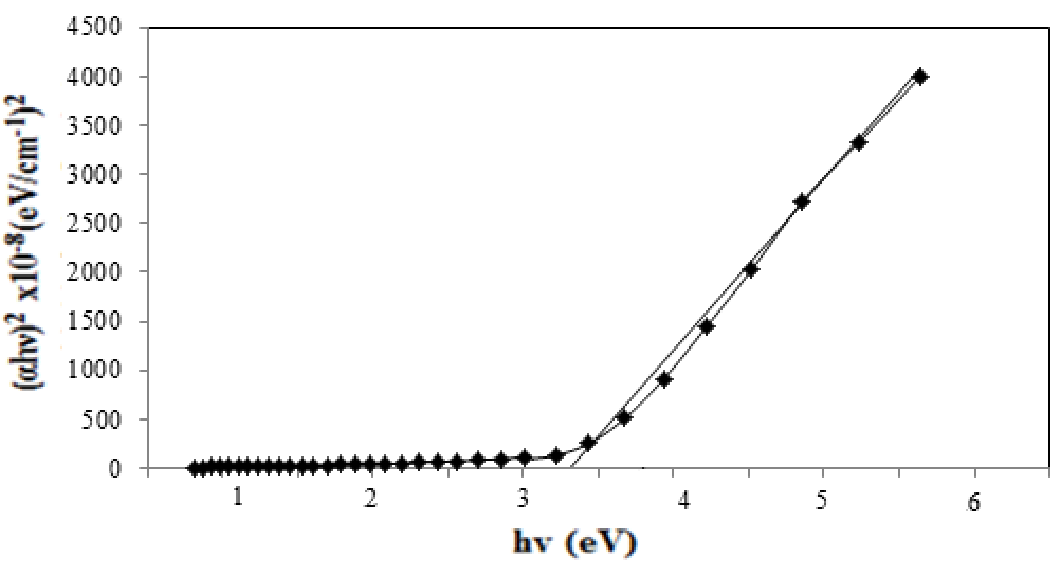

Figure 3: Plot of $(\alpha h\upsilon)^2$ Versus hυ for Zinc Oxide Thin Film

Conclusion

The structural and optical properties of zinc oxide thin films prepared by the chemical spray pyrolysis were studied. The structural analysis revealed that zinc oxide thin films are nanocrystalline in nature with hexagonal wurtzite structure. The optical characterization shows that the band gap of the spray deposited zinc oxide thin film is of the order of 3.34eV.

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