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Preparation ZnO Thin Film by using Sol-gel-processed and determination of thickness and study optical properties

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Abstract

In this paper, we synthesis (ZnO) by using the sol-gel method. Polycrystalline technique and a 200-rpm coating speed. The sample put on hot plat at 60 ^{o}C for (60 mint), then, the films annealing treatment up to (650^{o}C). Optical properties such as Absorption, transmittance, Absorption coefficient α, and the films thickness (d) were calculated from interference of transmittance spectra. The energy band gap, and the thickness of the films were evaluated as (3.04 eV and 207.5 nm) respectively**.**

Key words: Synthesis, (Zno), sol-gel, annealing treatment, Absorption, transmittance spectra.

Introduction

Zinc oxide (ZnO) is a wide-band semiconductor, with a variety of applications in photonic, photovoltaic, and electronic devices, such as blue light emitting diodes (LEDs), lasers, UV detectors, transistors, and solar cells as cheap [1-4] ZnO, one of the most attractive semiconductor materials, has notable advantages, including good carrier mobility, a wide direct band gap energy (3.27 eV) [5].In addition, Among other major uses of ZnO, particularly in powder form, are pigments[6,7], photo catalysts [8,9], and UV absorbers. Excellent UV absorption of ZnO can be also utilized in cosmetics, paints, varnishes, and plastics [10,11]. Performance of ZnO in the UV absorption applications is determined primarily by such properties of the ZnO powders as particle size, morphology, agglomeration level, defect structure, and chemical composition (purity, dopants).. At the same time, they should possess high UV absorption, which is determined by the crystallographic and chemical properties.

The deposition of high quality Zno thin films is reported using a wide variety of techniques, such as reactive evaporation [12], sputtering [13], chemical vapor deposition [14], spray pyrolysis [15], sol-gel [16], and electrochemical deposition [17].

The sol- gel chemical deposition technique is very attractive as it can be implanted easily in laboratory for the deposition of semi-conducting thin films [18]. In addition, the efficiency of deposition technique and the non-alkoxide route make the sol-gel ZnO thin films very interesting in the semi-conductor oxide thin films filed [19].

In this work, ZnO was prepared by using sol- gel method, and deposited on glass substrates by spin coating technique. Then, heated in a furnace at a temperature of 650 °C.

Experimental procedure

ZnO thin films were deposited on glass substrates by using the sol-gel method according to reference (20). Zinc acetate $(Zn(C_2H3O_2)_2$, Aldrich−99.99%) was added in a mixture of isopropanol ($(CH_3)_2CHOH$, and ethanolamine (H_2NCH_2CH2OH, Aldrich−99%, MEA)]. The molar ratio of MEA to zinc-acetate was maintained at 1, where the amount of zinc acetate was adjusted to 1.0 mole. The mixture was stirred at 60 °C for 1 hr and then aged at room temperature (RT) for 24 hrs to yield a homogeneous solution. ZnO thin films were prepared by spin coating the stored solution on a glass substrate at rotation speeds ranging from 2000 rpm for 30 sec. The ZnO thin films were then dried on a hotplate at 60 °C for 30 min. The sample was heated in a furnace at a temperature of 650 °C for 1 hr at a heating rate of 50 °C / min [20]. The transmittance (T) and reflectance (R) were measured by a (CE-7200) spectrophotometer in the wavelength range of 350 to 900nm.

Optical absorption measurements is a standard technique for investigating band structure and it is therefore of interest to study absorption in thin films. In the present contribution we measure the absorption, transmission, and investigate reflectance of ZnO: films and determine the optical band gap.

Results and Discussion

The absorption (A) and transmission (T) measurements were performed at room temperature as function of wavelength (300 -900 nm).

The absorption spectrum of the ZnO film on the glass (ZnO/Glass) substratum is shown in Fig. 1. which gives a Maximum of the absorbance was at wavelength 390 nm. Fig. (2) shows UV–visible transmittance spectra of the ZnO thin films that grew at room temperature. From the figure, a change of optical transmittance can be seen in the range of 400–900 nm with increasing and a low value of transmittance (11-23 %).

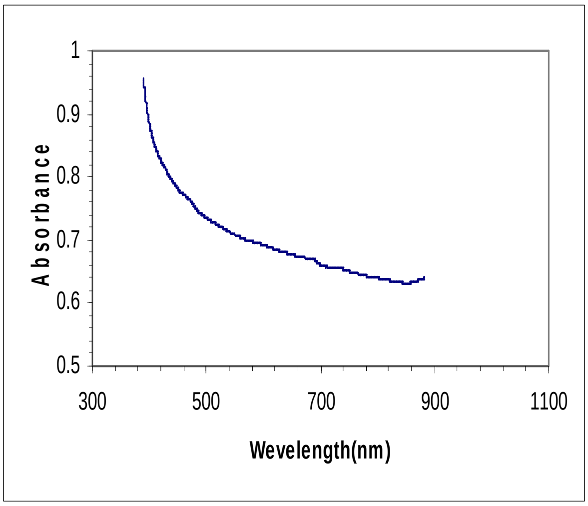


Fig.(1). Absorption spectra of the ZnO film coated on the glass

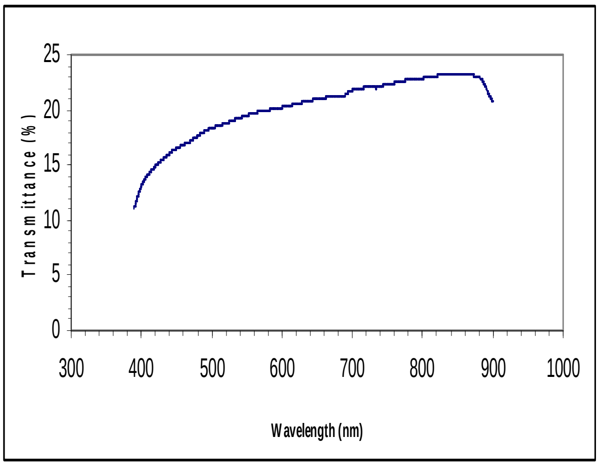


Fig.(2) transmission of the investigated films

The reflectance (R) was calculated using the following relation (1) [21]:

$$R = 1- [T / e^{-A}]^{0.5} \quad ……… \quad (1)$$

where R is the reflectance, T is the transmittance and A is the absorbance.

The refractive index corresponding to T_{max} and T_{min} for same wavelengths are calculated from equation (2) [22]. The variation of refractive index with wavelength λ of incident radiation (hν) for ZnO thin film is shown in Figure (3). Refractive index found to decrease with increasing wavelength λ:

$$n = [1+ (R)^{0.5} / 1- (R)^{0.5}] \quad …… \quad (2)$$

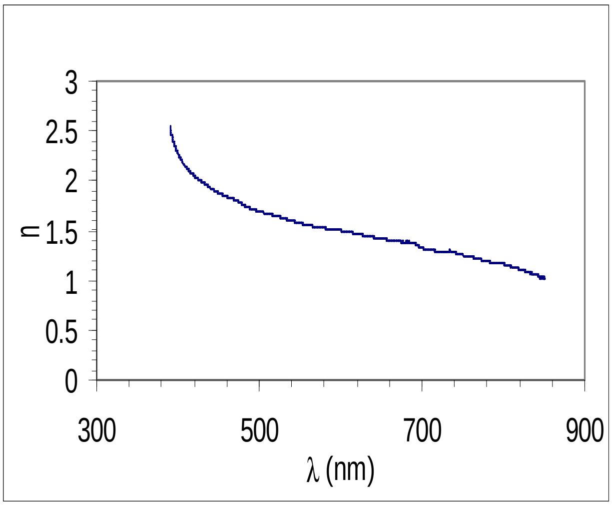


Fig.(3): Variation of Refractive index with λ for ZnO thin films

The thickness of the thin film can be calculated by equation (3) [24]:

$$\mathbf{d = [\ \{\lambda_1 \lambda_2\}/\ \{(n_{\lambda 1}\lambda_2) - (n_{\lambda 2}\lambda_1)\}]\ \ldots \qquad (3)}$$

where λ_1 λ_2 are the wavelengths at which two successive maxima or minima occur and $n_{\lambda 1}$ $n_{\lambda 2}$ are the corresponding refractive indices.

The Absorption coefficient can be defined after correcting according to the relation: [23]:

$$\alpha = \mathbf{[2.33/d]\ [A'-A'']} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \mathbf{(4)}$$

where (d = 207.5 nm) is the thickness of the film obtained by using equation (4). A′ is the Absorption and A″ is the reflection correction. the Correction is carried out on absorptions spectra by drawing straight line from tail curve at long wave length (transplant region) towards the short wave length, then minuses from absorption value (A″) at straight line from absorptions to wavelength (A′). Figure (4) showsthe relationship between absorption coefficient and photon energy. The value of absorption coefficient plays an important role to the limitation of the type of transition. From the same figures appears the value of the (α) up than (10^{4} cm^{-1}) so that the transition was direct electron transmission [25].

For direct transition, the absorption coefficient α is given by the following relation obtained by Mott and Davis [26]:

$$(\alpha h\nu)^2 = B\,(h\nu - E^{opt}_{g}) \quad \ldots\ldots\ldots\ldots \quad (3)$$

where B is substance parameter, which depends on electronic transition probability, (hv) is the photon energy and E_g^{opt} is the so-called Tauc gap [27].

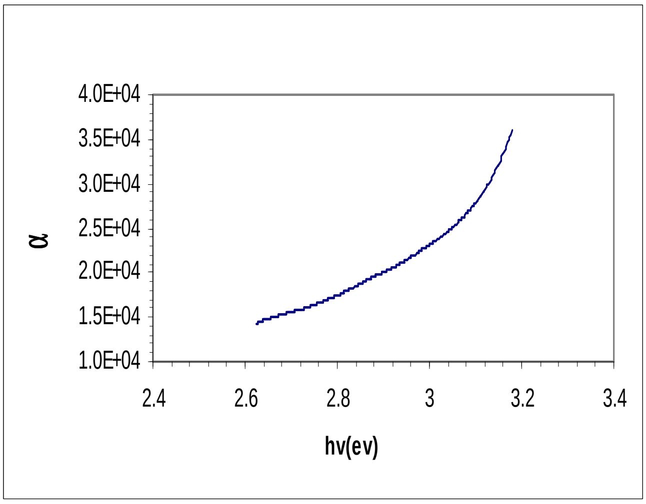
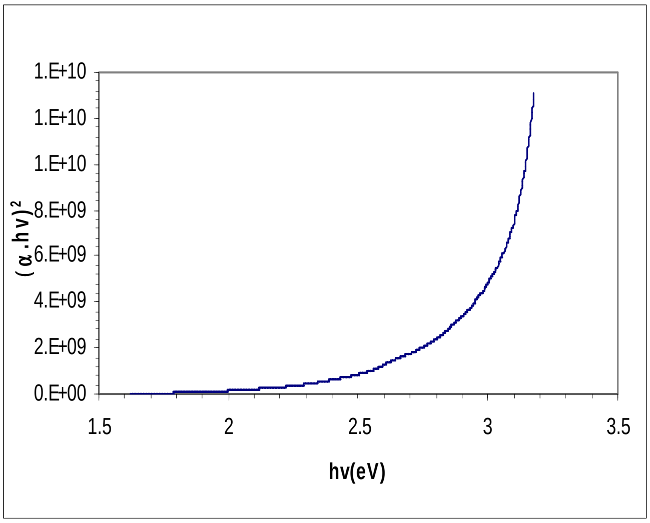


Fig. (4): The absorption coefficient vs. photon energy.

The spectral variation of absorption coefficient plotted as $(\alpha\ hv)^2$ versus the photon energy (hv) is shown in Fig.(5).

The optical energy gap, E^{opt}_{g}, for direct allowed transitions, can be obtained by extrapolating the linear portions of the curves to α hv = 0. The allowed direct transition optical gap is found abut (3.04 e V) of (ZnO).



Fig(5): Plot of $(\alpha\ hv)^2$ vs photon energy hv near the absorption edge for ZnO.

Conclusion

Pure ZnO thin films were prepared on glass substrate by using sol-gel technique in order to study optical properties. Zinc acetate, isopropanol, and monoethanolamine were used as the precursors. We found that the thickness equal to (207.5 nm) and the ZnO thin film depended on the coating speed of the spin coater and on the viscosity of the sol. the optimized ZnO film had luminescence band, which corresponded to UV band at 390nm. We highly expect our results to be applicable to next generation flexibleelectronic devices and high sub-systems that require low temperature preparation process.

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