Research Paper Physics

The Effect of Gamma Radiation on Optical Properties and Hall Effect of Thin Zns Film

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ABSTRACT

In this search prepared Zinc sulfide (ZnS) thin film by using the thermal method of evaporation in vacuum under pressure 5x10-5 mbar of thickness 300nm on glass substrate at room temperature.
Also the search had included studying some of the structure and optical and electrical properties of ZnS thin film before and after irradiation from Co-60 with ray dose (10) Mrad. The results of X-ray examination showed that the granular size become less after irradiation because the intensity of the non irradiation film is larger than that of irradiation. This means that crystallization become less because the granular size become less.
The measurement of the absorption and transmittance spectra within the range of wavelength of (200-600) nm. The absorption seems to be higher in the radiation than the irradiation films. The increase of the absorption occur when the photon energy is equal to the value of the energy gap then the electronic transfers between the valance and the conduction band will began, this is useful in applications of photovoltaic, sensors and solar cell. The transmittances decreased with radiation by gamma in the wavelength larger than 400nm. Absorption coefficient of ZnS thin films has the same value and the same behavior of A, and it increased with increasing wavelength to value 300 nm then it will be almost constant. This because of the increased value of the absorbance.
Direct band gap energy of ZnS thin films was estimated to be 2.4 eV for non irradiative thin film and 2.1 eV for irradiative thin film. The decrease in the values of optical energy gap after exposure to radiation and the reason for this is due to formation of localized levels within the optical energy gap which leads to decrease the values of energy gap.
Refractive index of ZnS thin films at 500 nm wavelength for non irradiative film 1.9 and for the film after irradiation is 2.3.
Extinction coefficient value for the film before irradiation 0.29 and 0.31 after irradiation at 500 nm.
The entire sample P-type, with irradiation the conductivity decrease two order of magnitude, and also the kereru of concentration decreases one order of magnitude.
The mobility increase six times by irradiation.

KEYWORDS

Introduction

Thin films represent a prominent place in the applied research of solid state physics, where it is possible to know the physical and chemical characteristics that can not be studied in some bulk cases [1].

The sulfide zinc ZnS white powder transparent in two phases (α wurtize) and (β zinc-blend) changes to α phase at a temperature 1293K and normal atmospheric pressure and do not dissolve in acid and dissolves in the water as he was little toxicity and zinc sulpfide in semiconductor materials with optical band gap (3.5±0.02) at room temperature and the boiling point 1665°C and a melting point 150°C, its molecular weight 97.43, the refractive index within the range of wavelength 1060 μm is 2.29.

The thin films have mechanical, electrical, magnetic and optical properties which may differ from those of the bulk material and are used commonly in the form of a deposit on a suitable substrate for integrated circuits, resistors, capacitors, transistors and superconductors [2].

In recent year it is interest to study the effect of high-energy irradiation such as gamma rays, light and heavy particles such as electron and neutrons on solid materials used in electronic and mechanical devices, ZnS thin films is an important semiconductor material and it have been found useful in various devices [3-5], such as applications:

- Antireflection coating for the solar cell [6]
- Environmental friendly buffer layer as compared to copper indium selenide layer in CIS based thin film solar cell [7].
- Wide band gap material for electroluminescent and opto-electronic devices [8].
- Photosynthetic coatings [9].
- Blue light emitting laser diodes [10].
- As α - particle detector [11].

There are many techniques that have been used to prepare thin films. Among the various thin film deposition techniques. Previously, ZnS thin film have been deposited by thermal evaporation [12], electron beam evaporation [13], chemical vapor deposition [14], chemical bath deposition [15], pulsed laser deposition [16], molecular beam epitaxial [17] and close-space sublimation [18].

In the present study we have prepared ZnS thin films by thermal evaporation. This method is one of the older method used in the deposition of thin films to get pure thin film. The basis of the work of this technique is the deposition of vaporized material from the boat (melting degree is greater than the melting point of the substance to be evaporated) on the substrate surface.

There are several factors that affect the formation of thin films, substrate temperature, rate of deposition, residual gas pressure, distance between the boat and substrate.[19]

Experimental work

High purity (99.99%) zinc sulfide powder was used as a source for deposition of ZnS films on soda lime glass substrates 2.6x2.6 cm^2 using thermal evaporated method (Edwards E306) at high vacuum coating unit. The glass substrate were first treated with detergent and washed in running water and alcohol respectively. The substrates then dried with a fine tissue paper and cleaned with isopropyl alcohol (IPA) in an ultrasonic cleaner. The source to substrate distance is 15-18 cm. Thickness of film was 300 nm. The method

were used for thickness measurement is the "Weighting method". The time of deposition is 4 min. The molybdenum boat was used as source for ZnS powder. A vacuum of $5x10^{-5}$ mbar was maintained in the chamber during deposition. The substrate temperature during deposition was at room temperature. The structure of the prepared thin films was obtained using the X-ray diffraction techniques using radiation from CuKα radiation target in the range of 2θ between 10°–100°. The optical transmission spectra of the deposited thin films were measured by UV-VIS spectrophotometer, the optical properties was calculated as a function of the photon energy at the wavelength in the range 200-800 nm. The gamma source is Co-60 ray doses (10) Mrad.

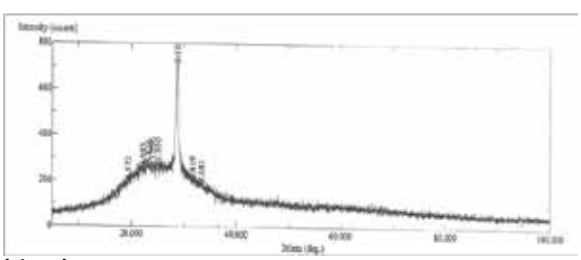
Hall effect measurements has been done by Van der Pauw (Ecopia HMS-3000) Hall Measurement Systems. Measurements required four ohmic contacts on the sample, it has been pleased in four point into this device.

Results and discussion

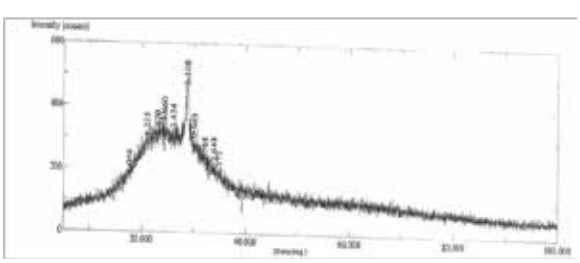
Structural test:

The structure of ZnS thin films were analyzed by X-ray diffraction pattern. Fig 1 and 2 show the (XRD) spectra for non irradiated and irradiated ZnS thin film respectively. We found the d-values by calculating the value of θ from the peaks of the X-ray spectrum using Bragg's relation $2d\sin\theta = n\lambda$ (n=1 in present study, λ= 1.54045 nm for Cu target). The d values were compared with the standard ASTM data. The grain size (G) of the deposited films can be determined from half maximum intensity by using Scherer equation(1), where K is approximately equal 0.9, λ = 1.54045°A,θ is the diffraction angle and B is the width of diffraction line at half maximum intensity, to confirm the structure of ZnS as listed in Table (1) for non irradiated and irradiated ZnS thin films.

$$G = \frac{K'\lambda}{B\cos\theta} \qquad (1)$$



(Fig. 1)



(Fig. 2)

(Fig. 1 and 2) shows XRD pattern for non and irradiated thin film respectively

Table (1)

The comparison of lattice constants value from X-ray pattern and ASTM for peak of ZnS before and after irradiation film

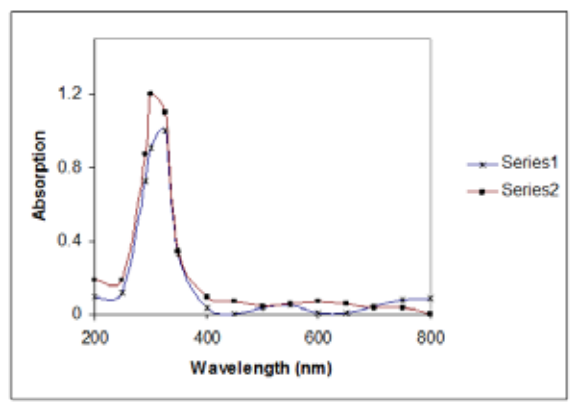
	2θ	d	hkl	I	I/I_0	G
Before irradiation	26	3.1016	0010	713	100	13.5822
After irradiation	25.9	3.1079	0010	469	100	10.18464

These spectrums were obtained by scanning 2θ in the range from 10 to 100 and reveal the crystalline nature of the films. The film showed in figure 1 a single peak at

2θ = 28.760° for non irradiated and irradiative film figure 2 2θ = 2.28.7° ,the intensity of the non irradiation film is larger than that of the irradiation film. The granular size become less after irradiation because the intensity of the non irradiation film is larger than that of irradiation. This means that crystallization become less because the granular size become less. These results are in good quantitative with the recent work of Subbaiah et al.[20]

Optical Properties of ZnS Films

Figures 3 showed the absorbance change of films with wavelength before and after irradiation.

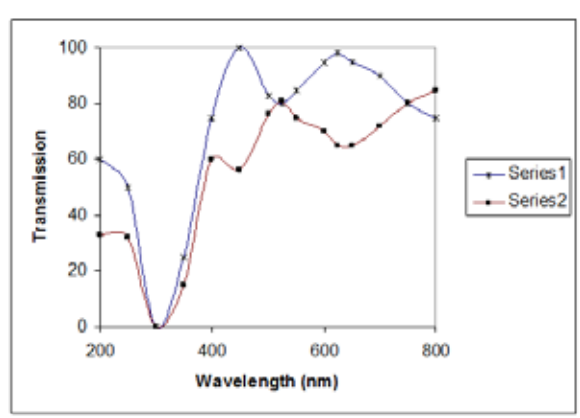


(Fig. 3) The absorption spectra of ZnS thin films as a function to the wavelength before and after irradiation

ZnS films have good absorption at short wavelength region, the absorption increase with increasing of the wavelength. The absorption seems to be higher in the radiation than the irradiation films.

The increase of the absorption occur when the photon energy is equal to the value of the energy gap then the electronic transfers between the valance and the conduction band will began, this is useful in applications of photovoltaic, sensors and solar cell.

The transmittances decreased with radiation by gamma in the wavelength larger than 400nm as in Figure 4. Also we see the appearance of many peaks in the two films so that mean the thin films are uniform.



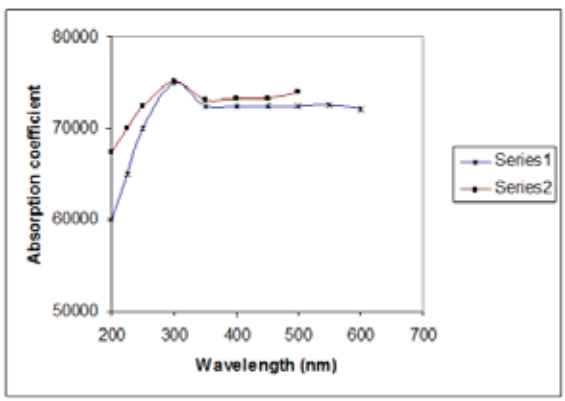
(Fig. 4) The transmission spectra of ZnS thin films as a function to the wavelength before irradiation

The absorption coefficient depends on the properties of the semiconductor in terms of forbidden energy gap of electronic transitions that occur between energy packets.

The absorption coefficient was calculated for thin films prepared in terms of absorbance spectrum using the relationship (3):

$$\alpha = 2.3\frac{A}{t} \qquad (3)$$

Figure 5 showed the absorbance coefficient change with photon energy for ZnS films before and after irradiation



(Fig. 5) The absorption coefficient of ZnS thin film as a function to wavelength before and after irradiation

Absorption coefficient of ZnS thin films has the same value and the same behavior of A, and it increased with increasing wavelength to value 300 nm then it will be almost constant.

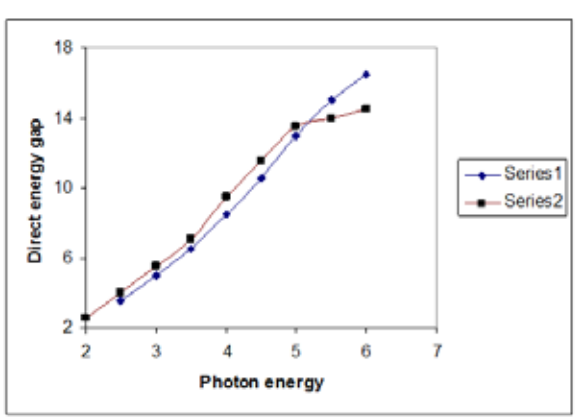
The optical energy gap for the direct allowed transition between valence bands and

conduction bands of ZnS thin films was calculated from equation (4):

$$(\alpha h\upsilon) = \beta(h\upsilon - Eg)^{r} \qquad (4)$$

using r =2.The values of the band gap of ZnS thin film for the direct transition can be determined by extrapolating the straight line portion of the $(ahν)^2$ versus hν , as shown in Figure 6.

The relationship between $(\alpha h\nu)^r$ and photon energy (Eg), point along a straight line tangent to the curve with the absorption axis of the photon energy

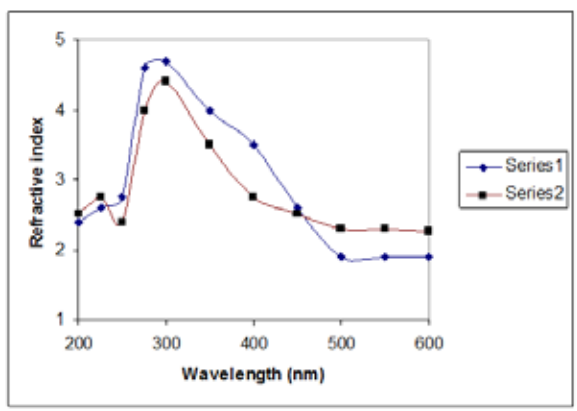


(Fig 6) The optical energy gap for the direct allow transition of ZnS thin
film before and after irradiation

Direct band gap energy of ZnS thin films was estimated to be 2.4 eV for non irradiative thin film and 2.1 eV for irradiative thin film.The value of the optical energy gap for the irradiation ZnS thin film is less than the non irradiation thin film in the direct energy gap. The decrease in the values of optical energy gap after exposure to radiation and the reason for this is due to formation of localized levels within the optical energy gap which leads to decrease the values of energy gap [20].

The Refractive index (n) can be determined from the transmission spectrum using equation (6):

$$n = \left[\left(\frac{4R}{(R-1)^2}\right) - K^2\right]^{1/2} - \frac{(R+1)}{(R-1)} \qquad (6)$$



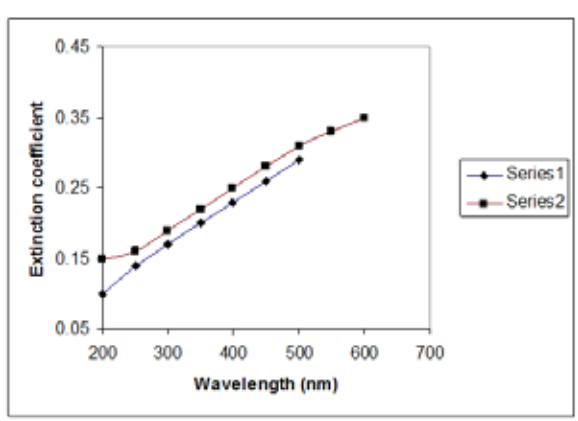
(Fig.7) Refractive index of ZnS thin films before and after irradiation.

The value of refractive index at 500 nm wavelength for non irradiative film is 1.9 and for the film after irradiation is 2.3 as in Figure 7. The heist value of refractive index for the two films are in the same wavelength of 300nm.

The extinction coefficient k can be determined from a transmittance spectrum as a

function of the wavelength it can be determined from the relation (7):

$$K_0 = \alpha\lambda / 4\pi \qquad (7)$$



(Fig.8) The extinction coefficient as a function to the wavelength of ZnS thin film before and after irradiation.

Extinction coefficient k versus wavelength spectra is shown in Figure 8, The value of K for the film before irradiation 0.29 and 0.31 after irradiation at 500 nm. film because it depends on the value of the absorption coefficient. The two films have

the same behavior it increase with increasing wavelength.The increasing of the extinction coefficient values rapidly when the values of the energies near edge of optical absorption, which confirms for direct electronic transitions at these energies [21].

The real and imaginary parts of dielectric constant (ε_r, ε_i) shown in table 2, were calculated by using equation (8):

$$\varepsilon_r = n^2 - K^2$$
$$\varepsilon_i = 2nK \qquad (8)$$

Table (2)
The value of the real dielectric constant and the imaginary dielectric constant at wavelength 500 nm

	Before irradiation film at λ=500 nm	After irradiation film at λ=500 nm
Real dielectric constant	2	5.7
Imaginary dielectric constant	1.1	1.35

The real dielectric and imaginary constant for the film before irradiation is greater than for the film after irradiation. The real part depend on the refractive index, the imaginary part depend on extinction coefficient.

Table (3) Hall effect measurement
Values of (σ, n_h, μ) before and after irradiation

	σ (Ohm.cm)$^{-1}$	n_h (1/cm^3)	μ (cm^2/V.s)
Before irradiation	$1.692*10^7$	$5.692*10^{11}$	$6.482*10^1$
After irradiation	$1.872*10^5$	$7.44*10^{10}$	$4.48*10^2$

From the measurement of Hall effect. The entire sample P-type, with irradiation the conductivity decrease two order of magnitude, and also the kereru of concentration decreases one order of magnitude. The mobility increase six times by irradiation as shown in table 3.

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