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Study of Properties of Cadmium Sulfide Prepared by Chemical Spray Pyrolysis Method

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Abstract: In this paper, we prepare thin films of CdS using the method of spray pyrolysis with thicknesses (150,200,250) nm. The optical, electrical and structural properties have been investigated for those films ready on glass substrates. Cadmium sulfide membrane has a polycrystalline structure of the hexagonal type. An increase in thickness did not affect the crystalline nature of the material as the material remained polycrystalline. Optical properties included the calculation of energy band gaps of the allowed direct electronic transitions. The energy band gap for CdS in the range (2.2-2.7)eV . The calculations also included some optical constants, such as transmittance also absorption coefficient. The increase in thickness led to an increase in the absorbance and absorption coefficient as well a decrease in the transmittance. The electrical properties include D. C. electric conductivity Hall effect. It was showing that the type of CdS films were (p-type).

keywords: CdS films, structure, optical, electrical properties.

1 Introduction

The spray pyrolysis technique is a simple technology in which an ionic solution–containing the constituent elements of a compound in the form of soluble salts is sprayed over heated substrates using a stream of clean dry air [1]. The CdS thin films were prepared by spraying an aqueous solution of cadmium chloride (CdCl2) and thiourea [(NH2)2CS] on glass substrate kept at 200, 300 and 400◦C [2].

Cadmium sulfide is a semiconductor material of Collection II - VI (II-VI) elements in the periodic Table [1]. The crystal structure of matter is the cube (Zinc blende) and hex (hex) as shown in Figure ((A & B) 1.1) [2]. The unit cell is of the central faceted type (f.c.c.) and the lines connecting sulfur ions and cadmium ions are covalent bonds resulting from sharing two electrons between the cadmium atom and sulfur [3].

Cadmium sulfide (CdS) has a direct energy gap and high optical storage. The CdS crystal has a yellow-orange color. The CdS crystal has a yellow-orange color [4]. The type of delivery of CdS is (p-type) and can be (n-type) based on the preparation process [5] or by adding some impurities such as (In, Cl, Br) [6].

The structure of Cadmium Sulfide (CdS) is solid hexagonal or cubic crystal. Thin films of CdS can be used as window material of CdS/CdTe solar cells and other optical devices because of their high band gap. • Cadmium sulfide CdS cadmium sulfide material possesses direct energy band gap and high optical conductivity [7]. The energy gap width is 2.4eV at 300o K [8]. Thus, its cut-off wavelength is at 2.4eV, at a wavelength of 0.52µm, in the green region of the visible spectrum. Accordingly, the membrane is absorbent at the green and blue wavelengths, while the long wavelengths (yellow and red) are permeable.

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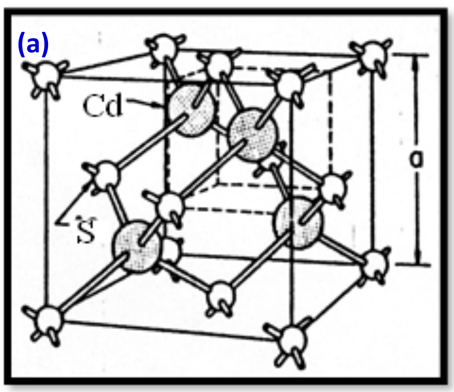
CdS thin films have recently received considerable attention because of their numerous excellent properties in optoelectronic fields. CdS thin film has a broad range of applications in technical fields, such as heterojunction solar cells, light emitting diodes, large screen liquid crystal devices, gas sensors and field effect transistors [9].

CdS indicates some magnetic properties. Magnetic thin films also have potential applications in memory and microwave devices. Second and third order perturbed Heisenberg Hamiltonian was used to describe the Magnetic properties of ferromagnetic and ferrite films [10, 11].



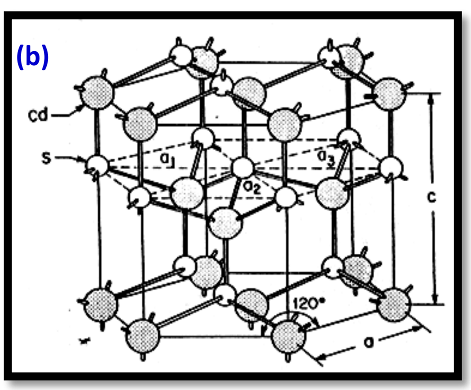


Fig. 1: Crystal structure: (a) the composition of the cube (b) Composition of hexagonal [1, 2].

This paper is important because it demonstrates the effect of thickness on CdS film properties and thus helps in determining the effect of film thickness in applications.

The aim of the current paper to produce CdS thin films by spray pyrolysis technique then investigate their structural, electrical and optical properties. In this paper, cadmium sulfide films were prepared by Chemical Spray Pyrolysis Method using cadmium chloride whose chemical formula is [CdCl2.H2O], and thiourea at a temperature of 400C° and with different thickness to detect the effect of thickness on the structural and optical properties of cadmium sulfide films.

The organization of this paper is, as follows: Section (1) It includes the introduction, research materials, methods of preparation, characteristics, objectives and importance. Section (2) It deals with the practical method for preparing cadmium sulfide films .It includes the following

1- Using cadmium chloride and thiourea.
2- molar concentration 0.1M
3-The solution is mixed with a magnetic stirrer for 15 min.
4- The solution is sprayed on heated bases at 400C°.
5- Chemical reactions continue to produce film CdS.

Section (3) is devoted to results and discussion, and provides a discussion of the structural properties of X-ray diffraction, optical properties, absorbance, transmittance, optical power bandwidth, and electrical properties. Section (4) is devoted to conclusion.

2 Experimental Details

For the preparation of CdS films, cadmium chloride, its chemical formula [CdCl2.H2O], and thiourea NH2SCNH2:

Prepare the decomposition solution at room temperature and at 0.1 M concentration by dissolving cadmium chloride in 25 ml of distilled water with NH2SCNH2 dissolved in the same amount of water above.

To obtain the weight to be melted within the previous standard, we use the following formula

$$M = (Wt / MWt).(1000/V) \quad (1)$$

M: Molecular concentration (mol / l).
Wt: The weight to be damaged (g).
Mwt: Molar weight of the matter (g / mol).
V: The size of the instillation water in which the

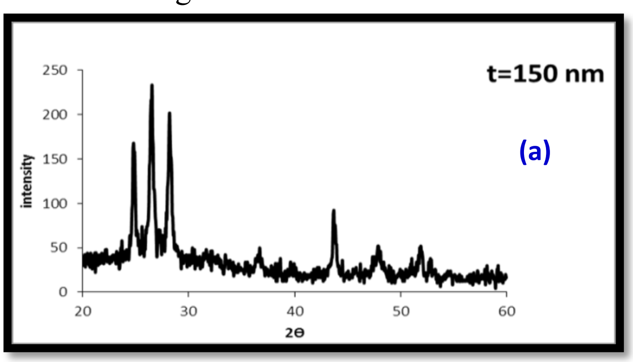
solubility has been dissolved.

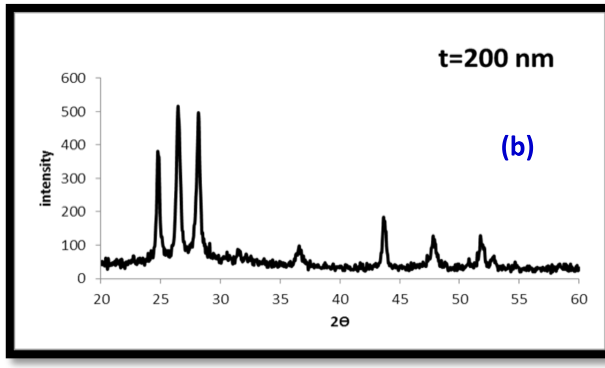
The solution is mixed with a magnetic stirrer for 15 min. to complete the solubility process. The solution is then left for an hour to obtain a homogeneous solution. The solution is then placed in the spray tank. The solution is sprayed on heated bases at 400C°. In the form of batches within specified time intervals (the duration of the solution is 5 seconds and then stops for 55 seconds). When the droplets of the solution reach the surface of the hot base, the solid compound resulting from evaporation of the water of the solution droplets reacts with the effect of the heat to become CdS. Chemical reactions continue to produce film CdS.

3 Results and Discussions

3.1 Structural Properties

The results of the X-ray diffraction spectrum, as shown in Fig.2, clarify that CdS films have a polycrystalline and Hexagonal structure, which is consistent with previous studies [12, 13, and 14]. The results showed that most of the peaks of the X-ray spectrum for films deposited at 400C° are in accordance with ASTM Tables. In Fig.2, which shows the X-ray spectrum of CdS films, a remarkable change is observed in the intensity of the diffraction peaks for some levels. This shows that some levels were preferred for the growth of crystals where the intensity of the film increases with increasing thickness.





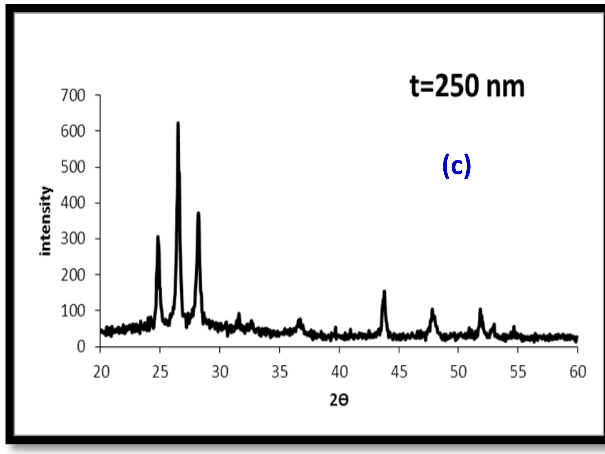


Fig. 2: x-ray diffraction results for CdS thin films

Table 1: Results obtained from XRD for CdS films

Thickness (nm)	2θ (deg.)	d_{hkl} std.(Å)	d_{hkl} exp.(Å)	G.S (nm)	FWHM (deg.)	hkl
150	24.854	3.58	3.57	264.89	0.307	100
	26.530	3.35	3.35	209.55	0.389	002
	28.240	3.16	3.15	215.29	0.380	101
200	24.822	3.58	3.58	252.44	0.31470	100
	26.504	3.35	3.36	207.04	0.38370	002
	28.179	3.16	3.16	220.85	0.35970	101
250	24.859	3.58	3.57	303.10	0.26210	100
	26.554	3.35	3.35	260.12	0.30540	002
	28.216	3.16	3.16	273.18	0.29080	101

3.2 Optical Characterization

The transmittance and absorption spectrum were measured as a function of the wavelength in region (300-1100) nm as shown in Fig.3 and Fig.4. Fig. 3, shows transmittance spectrum for CdS films as It shows an increase in

transmittance with increasing wavelength as the CdS film at (250)nm thickness showed less transmittance than CdS films at thickness (150) nm and (200) nm, which indicates an increase in absorbance. The permeability spectrum depends on the chemical composition of the material and thickness of the membrane as well as the topography and reflectivity of the surface.

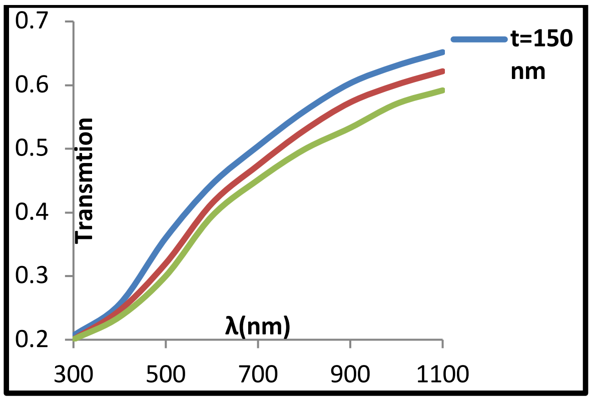


Fig.3: Transmission spectrum of CdS films

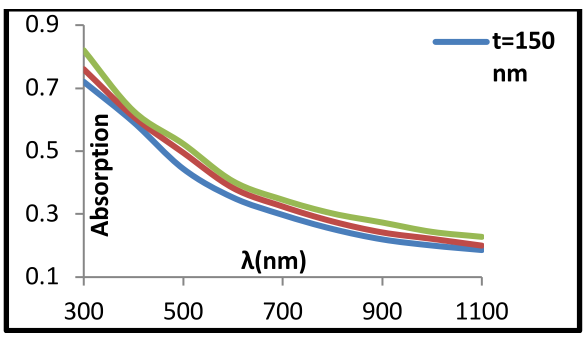


Fig.4: Absorption spectrum of CdS films

The absorption coefficient (α) plays an important role in detector design calculations because it varies for different semiconducting materials, and is a function of the wavelength of the incident light and affects the amount of light absorbed by the films.. The absorption coefficient of the CdS film was calculated based on the absorbance spectrum as a function of the wavelength according to the relationship [14-15]

$$\alpha = 2.303\left(A'/t\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The energy gap of the CdS films was calculated by drawing a relationship between $(\alpha h\upsilon)^2$ and $(h\upsilon)$ as in Fig.6 and by extending the straight line from the curve and its intersection with the x-axis to the energy gap value of the films as the results of the drawing showed that the nature of the transitions of these films direct transmission permissible depend on high absorption coefficient values. The value of the energy gap for a CdS film with a thickness of (150) nm was obtained at (2.2) eV, (2.5) eV and (2.7) eV at the thickness of (200) and (250) nm.

this result shows that the energy gap increases with increasing thickness, and these values are close to what the researcher found [10], so this result shows that the absorption coefficient is proportional to $(h\upsilon\text{-}Eg)^2/h\upsilon)$ for a material with direct permissible transport [16]

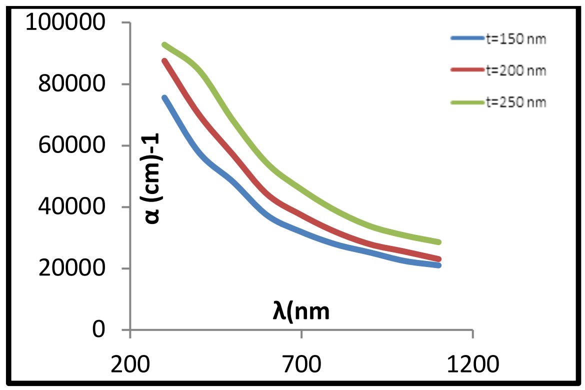


Fig. 5: Absorption coefficient of CdS films

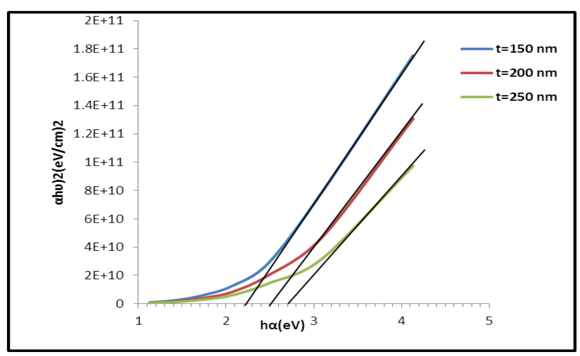


Fig. 6: Energy gap spectrum of CdS films

3.3 Electrical properties

Electrical properties of CdS thin films with a thickness of (200) nm.

Figure 7. It is shown that the conductivity of CdS

thin films increases when the temperature is increased. We notice that two separate regions exist during heating: The first at a low temperature and the second at a higher temperature.

The first activation energy (Ea_1) is (1.25) eV and second activation energy (Ea_2) is (2.9) eV.

The results of the Hall Effect study showed that the electrical conductivity of CdS films is of the positive (p-type) type according to the relationship between the generated Hall voltage and the electric current passing through the sample, as shown in Fig. 7.

From the Hall effect measurement, the value of the Hall modulus RH of CdS films 1183(cm^3/C) and the concentration of charge carriers $5.003*10^{15}$(cm^{-3}). As for the mobility of the CdS film 6.805(cm^2/Vs), it is noted that the results obtained are close to what other researchers have reached for the same preparation method. More applications, such as thermal stability and crystallization kinetics of the semiconducting,… etc., can be made using the present technique [14-27]. Moreover, using the applied treatments need some extensions on different subjects, such as a novel technique for numerical approximation of two dimensional non-linear coupled Burgers' equations using uniform algebraic hyperbolic tension. B-Spline-based differential quadrature method [28] can be used to best understand the electrical properties of CdS thin films when the thickness reduces dramatically. More insights on the hyperfine interactions can be understood using more complicated numerical treatments [29-33].

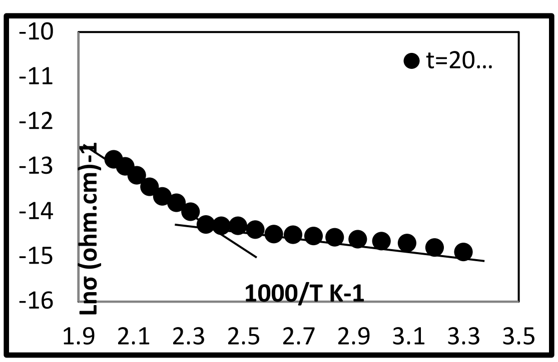


Fig. 7: Lnσ versus 1000/T for CdS thin films

4 Conclusions

In this paper, we presented a scheme to prepare thin films of CdS using the method of spray pyrolysis with thicknesses (150,200,250) nm. We discussed the optical, electrical and structural properties for those films. It was shown that Cadmium sulfide membrane has a polycrystalline structure of the hexagonal type. Furthermore, an increase in thickness did not affect the crystalline nature of the material as the material remained polycrystalline.

We witnessed rising (normalized) negativity of the cadmium sulfide membrane, which has a polycrystalline structure of the hexagonal type. Furthermore, the increase in thickness did not affect the crystalline nature of the material as the material remained polycrystalline. In addition, increasing the thickness led to an increase in the absorbance and absorption coefficient and a decrease in the transmittance (for all the prepared films within the wavelength range (300-1100 nm), as well as an increase in the values of the forbidden energy gap. Finally, the electrical measurements indicated the existence of the p-type cds films.[34].

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Conflict of Interest:

The authors declare that there is no conflict of interest regarding the publication of this paper.

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