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Studying the Optical Properties of CdS Thin Films Prepared by Thermal Vacuum Evaporation Technique with a Different Thickness

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ABSTRACT

CdS thin films with a different thickness have been prepared on glass substrates by using the thermal vacuum evaporation technique at substrate temperature of 150oC. The optical characteristics of the prepared thin films have been investigated by UV-VIS spectrophotometer in the wavelength range (300-1100 nm) . The films have a direct allow electronic transitions and the optical absorption are shifted to the low energies by increasing the thickness . Also the optical energy gap (Eg) has decreased from 2.47 eV to 2.22 eV by increasing the thickness value. The extinction coefficient (k) , refractive index (n) and the real and imaginary dielectric constants ($\varepsilon 1$, $\varepsilon 2$) are investigated. All of these constants increased with the increases in thickness and shifted to the low energies.

Introduction:

Metal chalcogenides (sulfides, tellurides and selenides) are of great importance for researchers because they are potential candidates for optoelectronic application such as photo detectors, solar cells, thin film transistors etc.[1-3].Among the wide band gap II-VI semiconductors cadmium sulfide (CdS) with its direct band gap of 2.42eV at room temperature is a promising material for above applications[4-6]. There are several methods for depositing CdS thin films, such as; vacuum evaporation(VE)[7], chemical bath deposition (CBD) [8,9,10], spray pyrolysis(SP)[11,12], etc. However, the(EV) is a simple technique by which enables to get uniform and homogeneous thin films. This paper deals with the optical properties of CdS thin films prepared by the thermal vacuum evaporation technique in a different thickness.

Experimental:

Cadmium sulfide (**CdS**) thin films prepared by the thermal vacuum evaporation technique on to glass substrate. Micro glass slide substrates were first cleaned with detergent water, degreased with acetone and rinsed with deionized water in an ultrasonic cleaner for(**15min**), then immediately dried by blowing air and wiped with soft paper. **CdS** powder with high purity (**99.999%**) was used in the films preparation. Thin films were prepared under a vacuum **~10^{-5}** torr using (**EDWARED coating unit -model 306A**). A molybdenum boat with a cover was used as the evaporation source and the substrate was (plate) held at **150^{o}C** of temperature , which were placed directly above the source at distance of **17cm**. Films thickness was measured by using the weight method which is the most approximate method and the quantity of material is needed to achieve that films thickness is given by[19]:

$$m = 2\pi\rho D^2 t \quad \ldots\ldots\ldots\ldots\ldots 1$$

where : **m** is the mass of material.

D is the distance between the source and the sample holder.

ρ is density of material.

t is the thickness of the film.

The **UV-VIS** spectrophotometer type **Jenway 6405 UV/VIS** was used to measure the absorptance and transmittance in the wavelength range **300-1100nm**, and from these measurements, the optical parameters were calculated.

Results and Discussion:

The absorption coefficient (α) is related with the absorbance (A) through the following relation: [13]

$$\alpha = 2.303\frac{A}{t} \quad \ldots\ldots\ldots\ldots\ldots 2$$

Where t is the thin film thickness .

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The optical absorption coefficient (**α**) for CdS thin films was calculated from Eq.(2) . The value of (**α**) for all thin films is found to be greater than 10^4 cm^{-1} in the UV- visible region , which indicates that the films have a direct optical energy gap [14] .This relatively high absorption coefficient is very important because the spectral dependence of(**α**) can drastically affect the solar conversion efficiency , so that the value of (**r**) in the imperial following equation is equal to 1/2 [14] .

$$(\alpha h\upsilon) = c(h\upsilon - E_g^{opt})^r \ldots\ldots\ldots\ldots 3$$

Where c is constant .

Fig.(1) shows the optical absorption coefficient (**α**) as a function of photon energy (**hυ**) for the thin films with a different thickness. From this figure, (**α**) has been increased with increasing the thickness and all the prepared films have low absorbtance in the visible/near infrared region ~500nm to1100nm.However, absorbance is high in the ultraviolet region.

A direct optical energy gap (**E_g**) can be obtained from Fig.(2) for different thicknesses .It can be seen that(**E_g**) decreases with increasing the films thickness, as shown in table(**1**) . Here, the lower value of E_g is attributed to the creation of localized states in the band gap during film preparation, while the higher value of **E_g** is accounted to the very small grain size of the film[15].

The values of the extinction coefficient are calculated using the following relation [16]

$$k = \frac{\alpha\lambda}{4\pi} \ldots\ldots\ldots\ldots\ldots 4$$

Where λ is the wavelength of the light .

Variations of the extinction coefficient as a function of photon energy are shown in Fig.(**3**) which shows that **k** increased with increasing films thickness. The rise and fall in the extinction coefficient is directly related to the absorption of light, in the case of polycrystalline films, extra absorption of light occurs at the grain boundaries. This leads to non-zero of **k** for photon energies smaller than the fundamental absorption edge[**14**].

The refractive index (**n**) was calculated using relation (5) [16].

$$n = \frac{1+R}{1-R} + \left[\frac{4R}{(1-R)^2} - K^2\right]^{\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots 5$$

Where R is the reflectivity

The values of **n** vs. **hυ** were shown in Fig. (4). From this figure the value of **n** in general increased with increasing film thickness and with increasing **hυ** . The peak values of the refractive index for the films with different thicknesses vary in the rang from **2.24** to **2.4**. Fig.(4) shows that for the films with thickness = **0.2, 0.5 µm**, there are two well-defined maxima and two minima, and for the film with thickness = **0.7, 1.0 µm**, there are one well-defined maximum and one minimum. These behaviors are accounted to the particular structure of films and their thickness [17] .

The real and imaginary parts of dielectric constants were determined using the following equations [18].

$$\varepsilon_1 = n^2 - k^2 \ldots\ldots\ldots\ldots 6$$

$$\varepsilon_2 = 2nk \ldots\ldots\ldots\ldots\ldots 7$$

The plots of real (ε_1) and imaginary (ε_2) dielectric constants of thin films with (**hυ**) as a function of the film thickness variation are illustrated in figures (5 and 6) respectively .

Fig. (5) showed that the (**ε_1**) values were increased with increasing photon energy. Also it increased with the increasing of the film thickness and it has a shift toward the low energies. The values of the real dielectric constant for the films of different thickness vary in the range from **5.0** to **5.7**.

Fig. (6) shows the behavior of ε_2 with hυ as a function of the film thickness. It shows the same behavior of k

Good quality, adherent, and uniform CdS films with different thickness are obtained by the thermal vacuum evaporation technique. The effect of the film thickness on optical absorption properties was investigated. The observed band gap energy is inversely dependent on film thickness. Also the optical constants(n,k,ε1,ε2) for all films have been investigated.

Table 1. decreasing the band gap with increasing films thickness.

sample	Thickness(µm)	Band
1	0.2	2.47
2	0.5	2.42
3	0.7	2.39
4	1.0	2.22

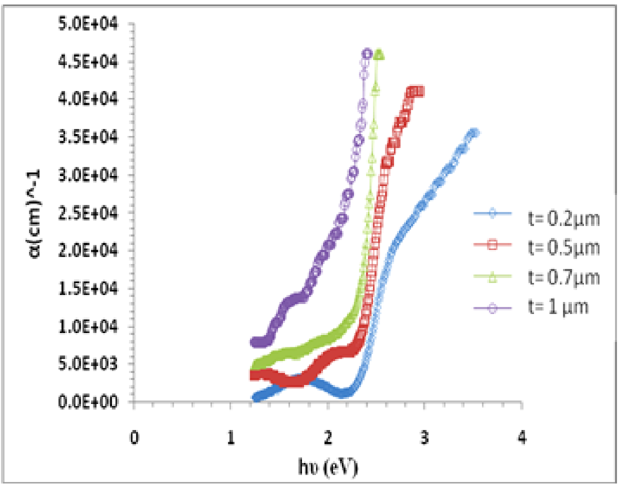

Fig.(1) (α) vs. (hυ) for CdS thin films prepared with different thickness.

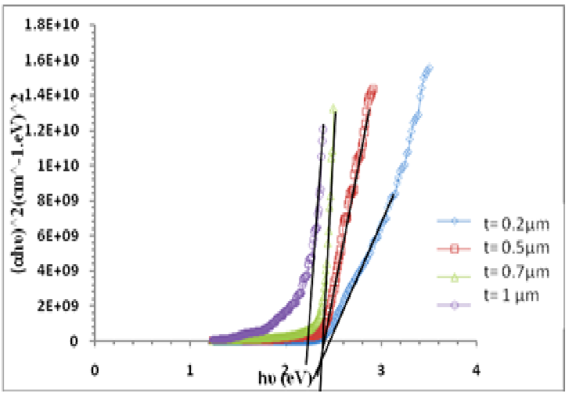

Fig.(2) The optical energy band gap(E_g) for CdS thin films prepared with a different thickness.

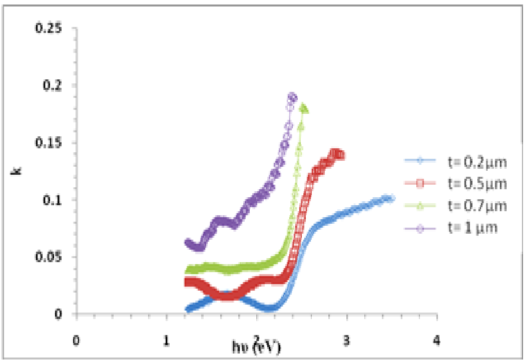

Fig.(3) The extinction coefficients(k) vs. (hυ) for CdS thin films prepared with a different thickness.

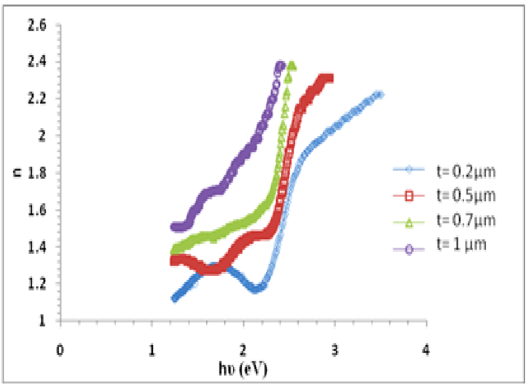

Fig.(4) The refractive index(n) vs. (hυ) for CdS thin films prepared with a different thickness.

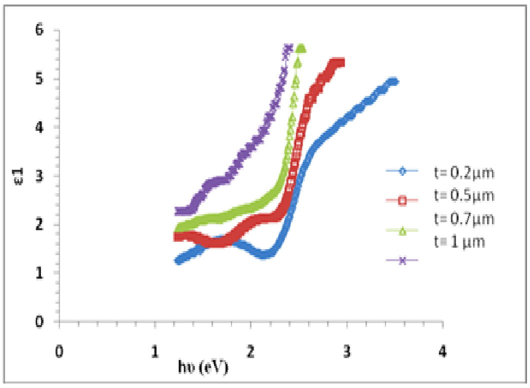

Fig.(5) The real dielectric constant(ε_1) vs. (hυ) for CdS thin films prepared with a different thickness.

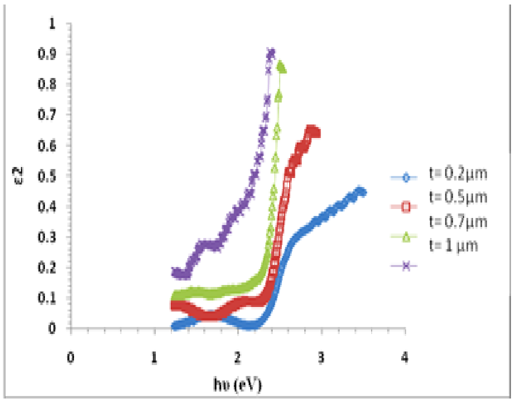

Fig.(6) The imaginary dielectric constant(ε_2) vs. (hυ) for CdS thin films prepared with a different

References:

1- M. Thambidurai, N. Muthukumarasamy, Dhayalan Velauthapillai, S. Agilan, R. Balasundaraprabhu," Impedance spectroscopy and dielectric properties of cobalt doped CdS nanoparticles" *Powder Technology* 217 (2012) 1–6

2- *M. Ueno, H. Minoura, T. Nishikawa, and Tsuiki, J. Electrochem. Soc. 130, 43(1983).*

3- *J. Touskova, D. Kindl, and J. Tousek, phys. Stat. sol. (a)124, 539 (1994).*

4- *J. Britt, C. Ferekids, Appl. Phys. Lett. , 62, 285 (1993).*

5- D. Saikia, P. K. Gogoi , P. K. Saikia, *Chalcogenide Letters* vol. 7, No.5, (2010)331-333.

6- Y. Kashiwaba, H. Kirita, H. Abe, T. Ikeda, *Jap. J. Appl. Phys*. , 29(9),1733(1990).

7- Lepek M., and B. Dogil, *Thin Solid Films*, 109:L103-L107, (1983).

8- Ariza-Calderon, H., R. Lozada-Morales, O. Zelaya-Angel, G.J. Mendoza-Alvarez ND L. Banos, *J. Vac. Sci. Technol*. A, 14 (4):2480-2482 (1996).

9- Melo de, O., L. Hernandez, O. Zelaya-Angel, R. Lozada-Morales, M. Becerril and E. Vasco, *Appl. Phys. Lett*. 65(10):1278-1280 (1994).

10- Vigil, O., I. Riech, M. Garcia-Rocha and O. J. Zelaya-Angle, *Vac. Sci. Technol*. A 15 (4):2282-2286 (1997).
11- Ikhmayies. J. Shadia., Production and Characterization of CdS/CdTe thin film photovoltaic solar cells of potential industrial use., Ph.D. Thesis. University of Jordan, Amman, Jordan (2002).
12- Salwh G. G. , Z. W. Manookian and S. A. W. Abdoul Ghafor, *Iraqi Sic. Pys. and Math.* , *J. Math. Phys*. 12(1):91-98 (1991).
13- J. I. Pankove, Optical processes in Semiconductors, Prentice- Hall, Englewood Cliffs, NJ, (1971)
14- P. P. Sahay, R. K. Nath, and S. Tewari, *Cryst. Res. Technol*. 42, No.3, 275-280 (2007).
15- V. Popescu, E. M. Pica, I. Pop, and R. Grecu, *Thin Solid Films* 349, 67 (1999).
16- J. C. Manifacier, J. Gasiot and J. P. Fillard, *J.Phys. E*. : Scientific Instruments, 9 (1989).
17- F. Tepehan and N. Ozer, *Sol. En. Mater. Sol. Cells* 30, 353 (1993).
18- J. E. Bertie," Introduction The Theory and practice of Vibrational Spectroscopy" (2001).
19- K. Chopra, "Thin Film Phenomena", McGraw-Hill, New York, (1969).

دراسة الخصائص البصرية لأغشية CdS الرقيقة المحضرة بتقنية التبخير الحراري في الفراغ وبسمك مختلف

ماهر نوري ثميل

الخلاصة

حضرت أغشية CdS الرقيقة على شرائح زجاجيه باستخدام تقنية التبخير الفراغي الحراري عند درجات حرارة الأساس 150 oC . تم دراسة الخصائص البصرية للأغشية المحضرة باستخدام مطياف (UV-VIS) ضمن مدى الأطوال الموجية (300-1100nm) .ولقد وجدت إن هذه الأغشية ذات انتقالات إلكترونيه مسموحه وان الامتصاصية تزداد بزيادة السمك مع إزاحة نحو الطاقات الواطئة وكذلك تقل فجوة الطاقة من 2.47eV إلى 2.22 eV مع زيادة سمك الأغشية المحضرة. كما تم دراسة معامل الخمود (k) ومعامل الانكسار (n) وثابتي العزل الكهربائي الحقيقي(ε1) والخيالي (ε2) وجميعها أبدت زيادة مع زيادة السمك وإزاحة نحو الطاقات الواطئة .