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Studying the optical properties of ZnxCd1 – x S thin films prepared by chemical bath deposition (CBD) and the effect of annealing temperature.

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ABSTRACT

The Zn_xCd_{1-x} S (x=0.2,0.5,0.7) thin films have been deposited by chemical both deposition method on glass substrates from aqueous solution containing cadmium acetate , zinc acetate and thiourea at 80 ±5 ℃ and after annealed at 150-200 ℃. optical method was used to determine the band gap of films between 3.95 to 4.1 eV. The UV-VIS spectra of films have been studied and the result are discussed.

Introduction

Cadmium Zinc sulfide thin films have been widely used as a wide band-gap window material in hetro-junction solar cells and photconductive devices .In solar cell systems, where Cds films have been demonstrated to be effective, the replacement of Cds with the higher band gap ternary CdZns has led to a decrease in window absorption losses, and has resulted in an increase in the short circuit current in the solar cell [1] . $Cd_{1-x}Zn_x$ s ternary compounds are promising materials for a veriety of optoelectronic device applications, such as electroluminescent, photoluminscent and photoconductor devices [2,5] . $Cd_{1-x}Zn_x$ s in bulk form has a band gap tunability from 2.4 – 3.7ev and hence can emit at different wavelength by varying the Cd content [6] . In this work, an attempt has been made to study the preparation and characterization of $Cd_{1-x}Zn_x$ S thin film along with optical properties . The effects annealing temperature on optical properties of Cd_1 – xZn_x S thin films were studied and the results are reported [7] .

Experimental

Chemical bath deposition technique was adopted for the preparation of $Zn_x\ Cd_{1-x}$ S thin films .Cadmium acetate , Zinc acetate , thiourea , ammonia , used for preparation .$Zn_x\ Cd_{1-x}$ S thin films were produced on glass substrates by the chemical bath deposition technique . 0.1 M cadmium acetate , 0.1 M zinc acetate and 0.1 M thiourea were dissolved in 100 ml of de-ionized water and stirred for 10 minutes using a magnetic stirrer . NH_3 was added slowl was added slowl from a burette held vertycally to the cadmium acetate solution .

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Initially the solution becomes milk white and on further addition of NH_3 it becomes clear solution . Thiourea solution was slowly added with cadmium acetate solution under gentle stirring condition . NH_3 was again added till the PH value reaches 11 . Under gentle stirring zinc acetate solution was added with Cd + S solution and again PH was adjusted to 11 by adding NH_3 .The prepared solution was placed on a hot plate and ultrasonically cleaned glass substrates were placed vertically in the solution . Temperature was maintained at 80 + 5 C^0 with a PID controlled temperature monitor for 2 hours . After 2 hours the films were taken out of the solution, rinsed in de-ionized water to remove the loosely bounZn_xCd_{1-x} S powder , and dried in air at room temperature for 3 hrs to remove moisture from the solution prior to annealing .These films deposited on glass substrates were annealed at 150C^0 and 200C^0 .During annealing the color of the film changed from yellow to orange . Films prepared by this method were uniform smooth and reflecting and are well adherent with the substrate . Solutions used for production of $Zn_x\ Cd_{1-x}$ S samples are shown in Table 1 . Aqueous solutions of Cadmium acetate , Zinc acetate and thiourea were used sources of Cd , Zn and S respectively .The UV –VIS spectrophotometer type Jenway 6405 UV / VIS was used to measure the absorptance and transmittance in the wave length range 300 – 1100nm, and from these measurements, the optical parameters were calculated.

Table 1. Aqueous solutions of Cadmium acetate , Zinc acetate and thiourea were used sources of Cd , Zn and S respectively

Zn	Cd	S	X
4ml	16ml	20ml	0.2
10ml	10ml	20ml	0.5
14ml	6ml	20ml	0.7

Results and discussion

The value of absorption coefficient α at various wave lengths have been calculated and found to be dependent on both radiation energy and composition of thin films.This behavior can be attributed to the existence of defects when the films devated from the stoichiometric composition x [8].

The absorption coefficient (α) is related with the absorbance (A) through the relation

$\alpha = 2.303\frac{A}{t}$ ……………(1) where (t) is the sample thickness.

The value of (α) for all $Zn_xCd_{1-x}s$ thin films are fond to be greater than $10^4 cm^{-1}$ in the visible region as shown in fig.(1). which means that the films have a direct energy gap [9].$(\alpha h\nu)^{\frac{1}{m}} = c(h\nu - E_g)$ … … … … … … … ….(2)

,where E_g the optical band gap (c) is the constant and $m = \frac{1}{2}$ for an allowed direct energy gap and **m=** $\frac{3}{2}$ for aforbbiden direct energy gap [10].

In order to determine the optical band gap of $zn_xcd_{1-x}s$ thin film, taking $m = \frac{1}{2}$, $(\alpha h\upsilon)^2$ was ploted versus $h\upsilon$ using the data obtained from the optical absorption spectra , the direct band gap of the $zn_xcd_{1-x}s$ thin films was optained by extaploting the linear part of the zero of the ordinate. Atypical plot of$(\alpha h\upsilon)^2$ *versus* $h\upsilon$ for $Zn_xCd_{1-x}S$ thin films is shown in fig(2,7,8,9) .the band gap $zn_xcd_{1-x}s$ of the thin films was estimated to be (4.1)eV . The value of extinction coefficient are calculated using the following relation(3).

$k = \frac{\alpha\lambda}{4\pi}$ …………(3)

Where λ is the wavelength of the light

The k values are ploted vs hv for $Cd_{1-x}Zn_x$ S thin films at different annealing temperature as shown fig (3)which shows that k increased with increased hv . the refractive index (n) was calculated using relation (4)

$n = \frac{1+R}{1-R} + [\frac{4R}{(1-R)^2} - k^2]^{\frac{1}{2}}$ …..(4)

fig(4) shown that increases as wavelength increases. Real and imaginary parts of dielectric constant were determined using the following equations[11]

$\varepsilon_{1=n^2-k^2}$…….(5)

$\varepsilon_2 = 2ink$…….(6)

Where ε_1 and ε_2 is the real and imaginary dielectric constant .the plots of real (ε_1)and imaginary (ε_2) dielectric constant of thin films are illusitrated in fig.(5,6)

The complex optical conductivity ($\sigma^* = \sigma_1(\lambda) + i\sigma_2(\lambda)$) is related to the complex dielectric constant ($\varepsilon^* = \varepsilon_1(\lambda) + i\varepsilon_2(\lambda)$) by the relation[12].

$\sigma_1 = \omega\, \varepsilon_2\, \varepsilon_o$ (7)

$\sigma_2 = \omega\, \varepsilon_1\, \varepsilon_o$ (8)

where ε_o is the free space dielectric constant and ω is the incident light frequency. The real σ_1 and imaginary σ_2 parts of the optical conductivity as a function of the wavelength are shown in Figs. (10,11) . From these figures, it is seen that the optical conductivity increases with increasing wavelength. This suggests that the increase in optical conductivity is due to electrons excited by photon energy.

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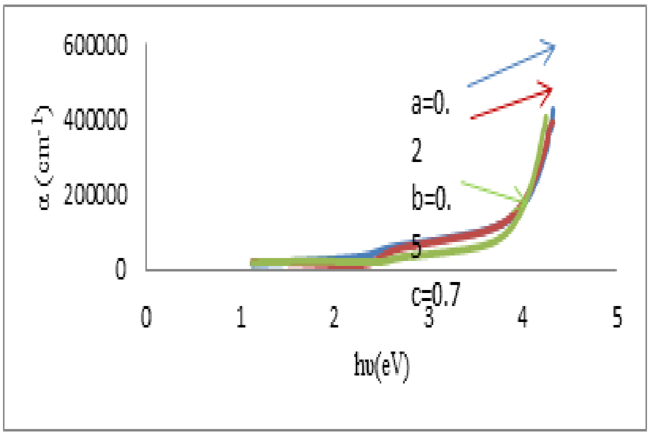


Fig (1) the variation of absorption coefficient (α) with (hυ) for thin films at a=0.2, b=0.5,c= 0.7.

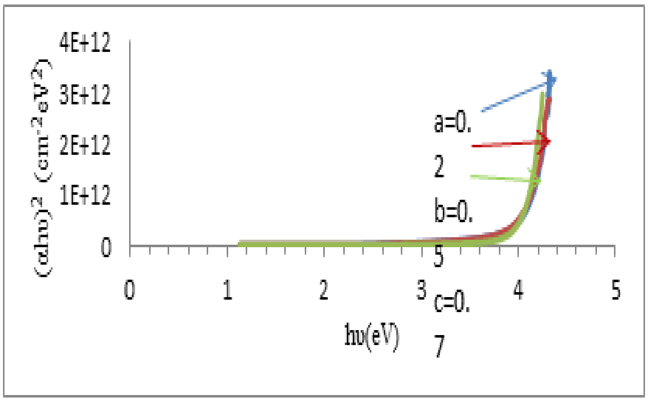


Fig (2) the optical energy gap (Eg) value of films at a=0.2, b=0.5,c= 0.7

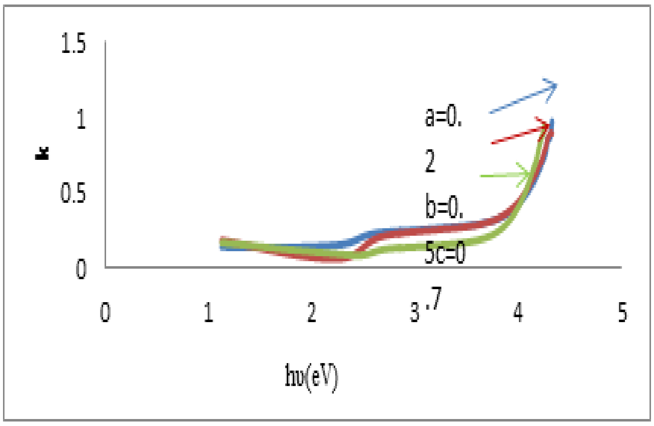
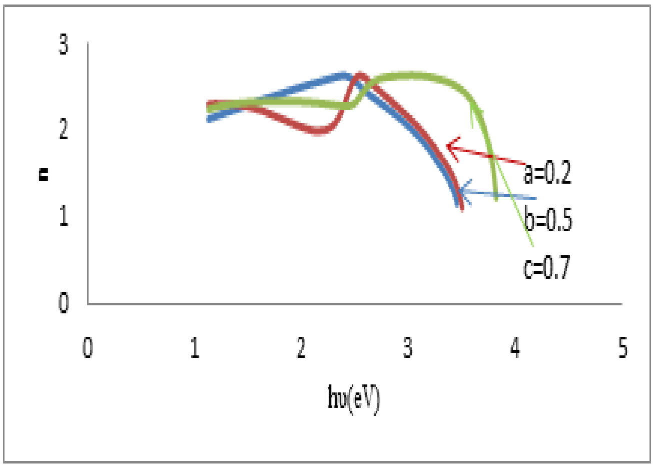
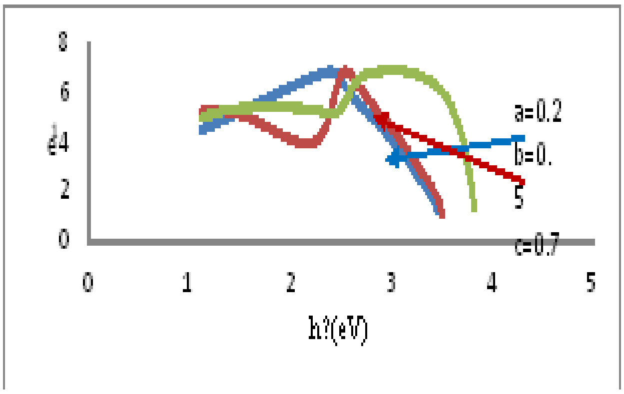


Fig (3) the extinction coefficient (k) with (hυ) at a=0.2, b=0.5,c= 0.7 .



Fig(4) the refractive index (n) with (hυ) at a=0.2, b=0.5,c= 0.7 .



Fig(5) the real part of dielectric constant ε_1 with (hυ) at a=0.2, b=0.5,c= 0.7 .

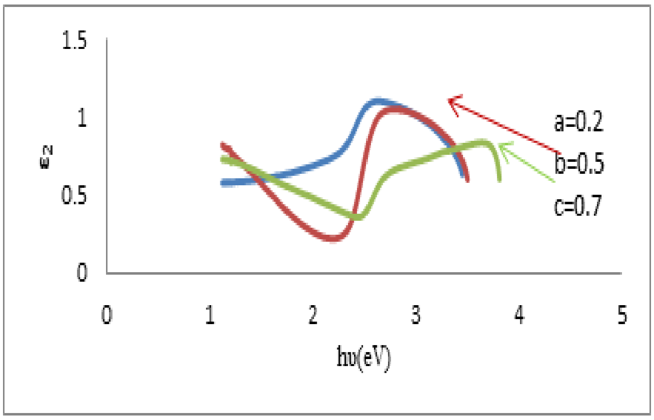


Fig (6) the imaginary part of dielectric constant ε_2 with (hυ) at a=0.2, b=0.5,c= 0.7 .

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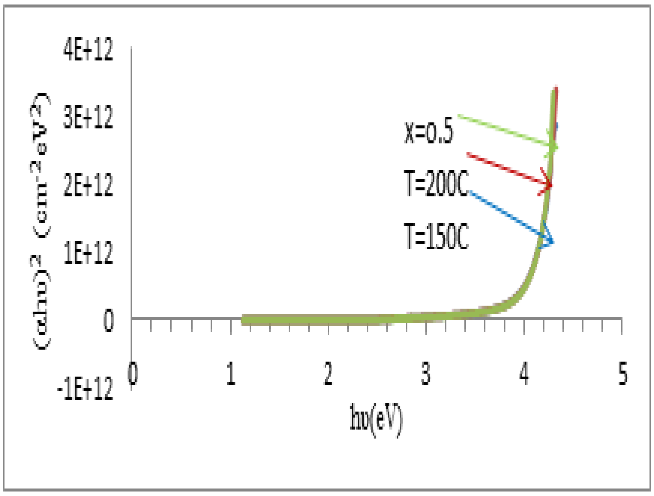

Fig (7) the optical energy gap (Eg) value of films at x=o.5 ,T=200C ,T=150C.

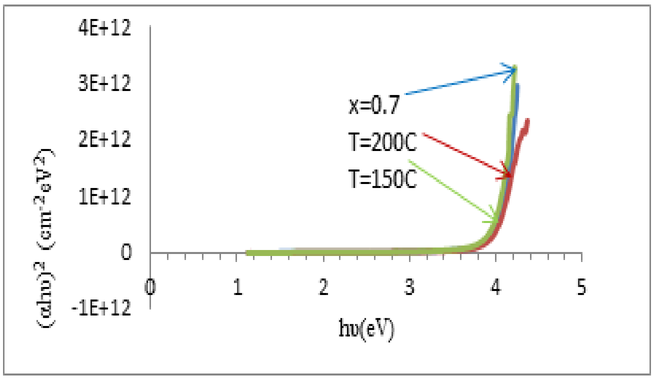

Fig (8) the optical energy gap (Eg) value of films at x=0.7 ,T=200C ,T=150C.

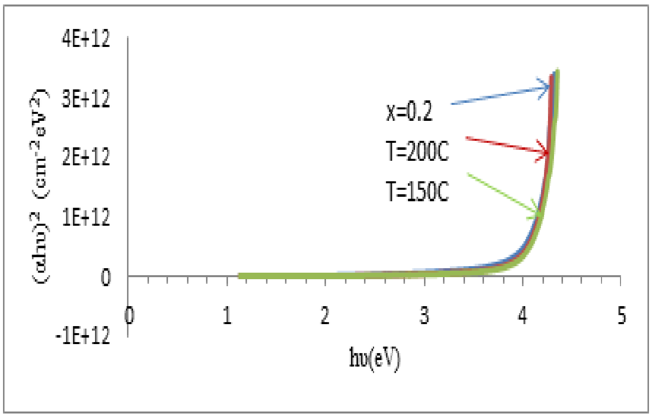

Fig (9) the optical energy gap (Eg) value of films at x=0.2 ,T=200C ,T=150C.

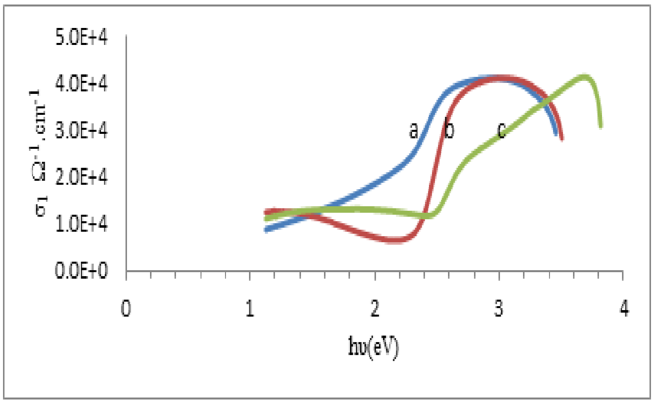

Fig. (10) real optical conductivity vs. photon energy at a=0.2, b=0.5,c= 0.7

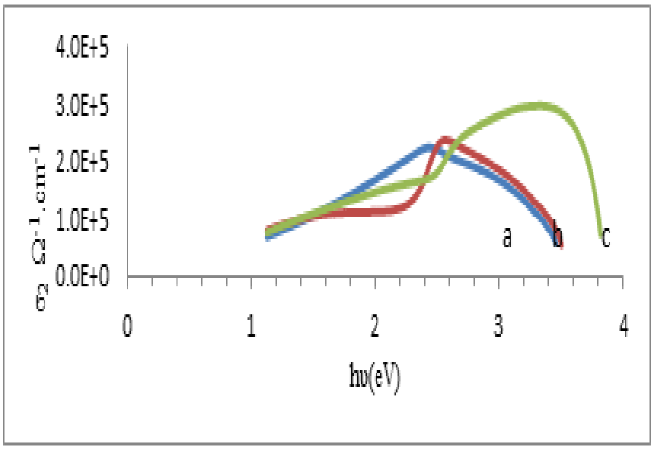

Fig. (11) imaginary optical conductivity vs. photon energy at a=0.2, b=0.5,c= 0.7

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الخصائص البصرية للاغشيه الرقيقه Znx Cd1 – x S المحضره بطريقة الترسيب الكيمياوي

ابراهيم جاسم عبدالله

الخلاصة

الاغشيه الرقيقه Znx Cd1 – x S تم ترسيبها على قواعد زجاجيه بتقنية الترسيب الكيميائي عند درجة حرارة 80°C سيليزيه باستخدام كل من كلوريد الكادميوم و كلوريد الخارصين و الثاريوريا مع استخدام محلول الامونيا للحصول على محلول قاعدي وتم تلدين هذه الاغشيه عند درجه حراره ١٥٠و ٢٠٠ درجه سليزيه وتم دراسه كل الثوابت البصريه مثل معامل الامتصاص ، معامل الانكسار ، معامل الخمود و ثابت العزل الكهربائي ضمن مدى الاطوال الموجيه ٢٠٠-١١٠٠ نانومتر وتبين بأن فجوة الطاقة البصريه للاغشيه المحضره تتناقص من ٤,١ الى ٣,٩٥ الكترون فولت مع زيادة درجة حرارة التلدين .