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Variation of band gap in chemically deposited $Pb_xCd_{1-x}S$ thin films

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ABSTRACT

In this paper, $Pb_xCd_{1-x}S$ ($0.0 \leq x \leq 1.0$) thin films were successfully deposited on suitably cleaned glass substrate at constant temperature 75 ^{0}C, using the chemical bath deposition technique. The effect of Pb incorporation on the CdS films was investigated by using optical properties. The optical properties such as absorption and band gap energies of the films were carried out by UV-Vis transmission in the range 350-800 nm using UV spectrophotometer. The band gap of the films ($0.0 \leq x \leq 1.0$) was found in the range 2.34-1.2 eV. The film thickness was found to vary from 407 nm to 687 nm as composition parameter 'x' increased from 0 to 1 in $Pb_xCd_{1-x}S$ thin films deposited on glass slides by using chemical bath deposition technique.

Keywords: Chemical Synthesis, $Pb_xCd_{1-x}S$ Thin Films, Thickness variation, Optical Properties, Band Gap variation.

INTRODUCTION

In past decades, a study of CdS and PbS mixed thin films are used for technical importance [1]. Lead Sulphide (PbS) is the most typical IV- VI semiconductor compounds with band gap 0.41 eV. A lead sulphide material has various types of applications such as photography [2], sensors [3], solar absorber [4], and optical switch [5], infra-red detectors [6-7] among others.

Cadmium Sulphide (CdS) is II-VI semiconductors compounds having direct band gap (2.42 eV) so has been used in many applications. It is has various type of applications such as piezoelectric and optoelectronic devices [2], visible light emitting diode and laser [8-9].

These materials can be deposited by using various techniques, such as, electro-deposition [10-12], spray pyrolysis [13], vacuum deposition [14] and chemical bath deposition [15-21], CVD [22], successive ionic layer and reaction (SILAR) [23], sol-gel methods [24].

The major factor for growing thin film depending upon deposition conditions such as bath temperature, stirring rate, pH, solution concentration etc. the film growth can take place by ion-by-ion condensation of materials or by adhesion of colloidal particles from the solution on the substrate, impurity level and post-deposition processing. The use of CBD technique has received much attraction due to its great potential application to fabricate high quality films. It is a preparative method for large area fabrication of film, which is simple and low cost technique.

In this study, $Pb_xCd_{1-x}S$ thin films were deposited onto glass substrates by using Chemical Bath deposition technique and the optical properties was reported.

MATERIALS AND METHODS

1. SUBSTRATE CLEANING

Glass micro slide having 75mm long x 25mm wide x 1.35mm thick were substrate dipped in a chromic acid for 1-2 hours at room temperature, washed by using laboline, rinsed in acetone and then ultrasonically cleaned by using distilled water.

2. SYNTHESIS OF $Pb_xCd_{1-x}S$ THIN FILMS

For the synthesis of $Pb_xCd_{1-x}S$ thin films AR grade chemicals used such as lead acetate, cadmium acetate, thiourea and liquor ammonia.

$Pb_xCd_{1-x}S$ thin films were grown on glass substrates by the Chemical Bath deposition technique at temperature 75°C.The bath solution was prepared by mixing the appropriate volumes of 0.1M lead acetate $[Pb(CH_3COO)_2.2H_2O]$, 0.1M cadmium acetate $[Cd\ (CH_3COO)_2.2H_2O]$, 6M ammonia (NH_3), 1M Thiourea $[(NH_2)_2.CS]$.

Take depositing solution of 0.1M lead acetate, 0.1M cadmium acetate, 6M ammonia in glass beaker. Then place this beaker in chemical bath and set temperature 75°C.When temperature reaches to 50°C place glass substrate vertically in solution and add 20ml of 1M Thiourea drop by drop in a beaker until temperature increases from 50°C to 75°C. After deposition cool it to room temperature and rinsed with distilled water and dried in air. All $Pb_xCd_{1-x}S$ films exhibited yellowish to deep black color.

3. SAMPLE CHARACTERIZATION

In order to study optical properties of $Pb_xCd_{1-x}S$ thin films, Optical absorbance spectra was studied in wavelength range 350 – 800 nm with a UV-2450 spectrophotometer.

RESULTS AND DISCUSSION

1. THICKNESS VARIATION

Figure1. Shows the thickness of the $Pb_xCd_{1-x}S$ thin films obtained at temperature 75°C. Thickness of film is important factor in the study of film properties. The film thickness was measured by a surface profilometer method. The method chosen should be convenient, reliable and simple.

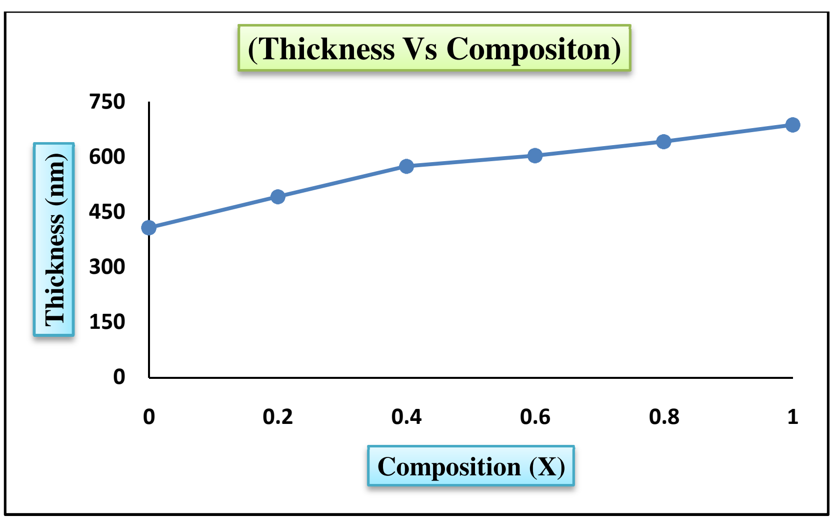


Figure.1.Shows the variation in Thickness with Composition (x)

The film thickness was found to vary from 407 nm to 687 nm as composition parameter 'x' increased from 0 to 1, as shown in Figure 1. The Calculated thickness of film with varying composition 'x' is listed in Table 1.

Table 1. Shows Composition (x) with thickness of $Pb_xCd_{1-x}S$ ($0 \le x \le 1$) thin films

Composition (X)	Thickness (nm)
0	407
0.2	492
0.4	575
0.6	603
0.8	642
1	687

2. OPTICALABSORPTION STUDIES

The optical absorbance spectra of different $Pb_xCd_{1-x}S$ thin films deposited on amorphous glass substrates prepared at temperature75°C are shown in Figure 2. Optical absorbance spectra for the films were recorded by a UV-2450 spectrophotometer.

During scanning process, a blank glass slide was placed in one of the beam direction and another glass with the deposited film was in the other beam's direction. Thus, the absorption spectra displayed by the spectrophotometer were as a result of the films deposited on the glass slides.

The spectrum is a plot of absorbance against wavelength obtained at temperature 75°C. The spectrum shows that the deposited $Pb_xCd_{1-x}S$ thin film starts absorbing at wavelength of 350 nm which then increases until it reaches a maximum at 800 nm before it starts to decrease. The absorption edge lies in the UV-Visible region.

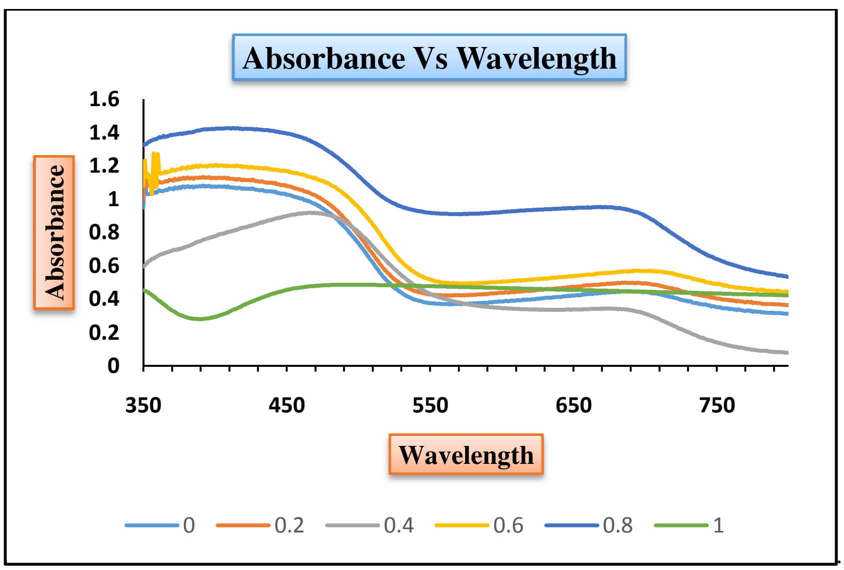


Figure.2. Absorbance spectra for the $Pb_xCd_{1-x}S$ thin films

The energy gap (Eg) of synthesized films was determined by using Tauc formula [25], as shown in equation (1).

$$\alpha h\nu = A\,(h\nu - Eg)^m \qquad \text{....(1)}$$

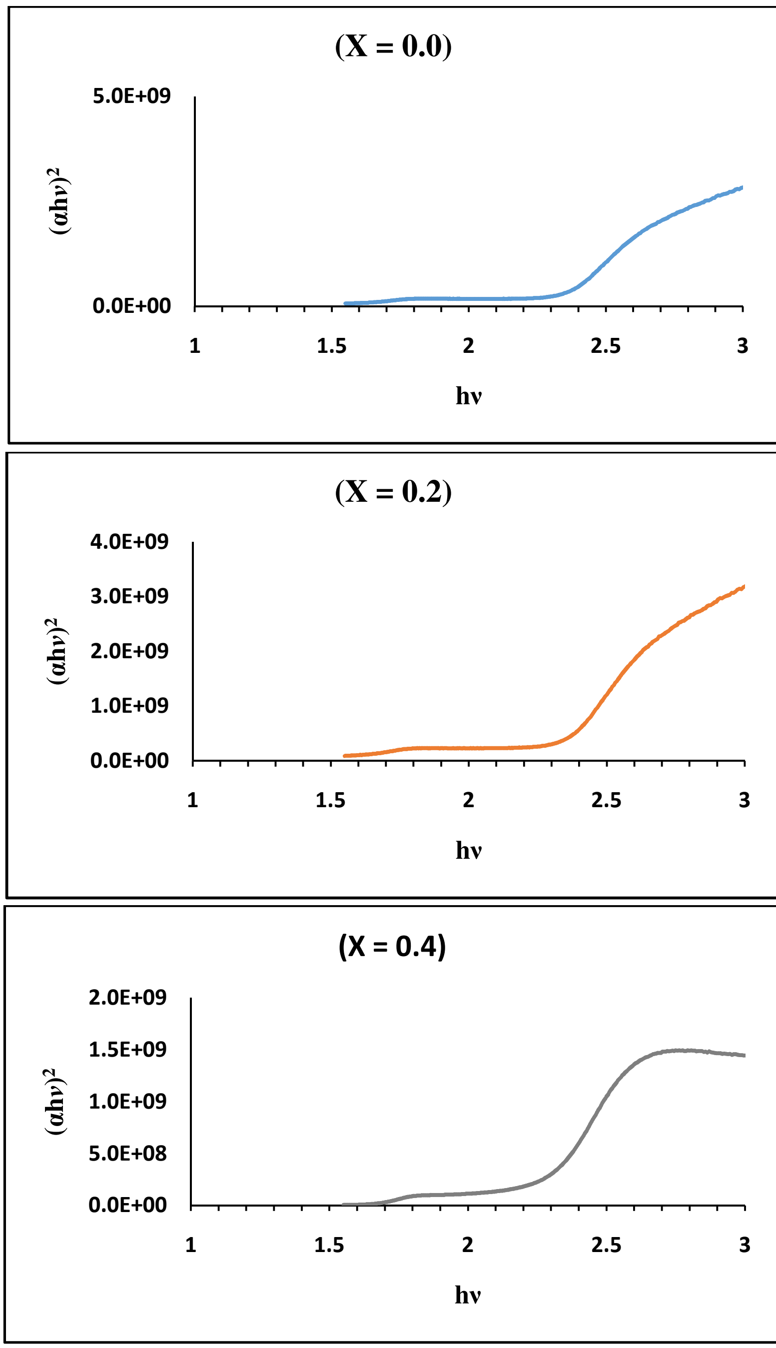
Where,
α = Absorption coefficient
hν = Photon energy
Eg = Optical band gap
A = Constant which related to effective masses associated with valance band and conduction band.

m = Assume value of 1/2, 2, 3/2 and 3 for allowed direct , allowed indirect, forbidden direct and forbidden indirect transition, respectively.

For allowed direct type of transition following equation (2) is used.

$\alpha h\nu = A\,(h\nu - Eg)^{1/2}$ ….(2)

Graphs between $(\alpha h\nu)^2$ vs h*ν* is plotted for composition ($0.0 \le x \le 1.0$)is shown in figure. 3 and the intercept of extra plotted straight line at $(\alpha h\nu)^2 = 0$ axis gives the value of Eg of material. The value of Eg so obtained vary from 2.34 to 1.1 indicating decrease in band gap with increase in composition "x".



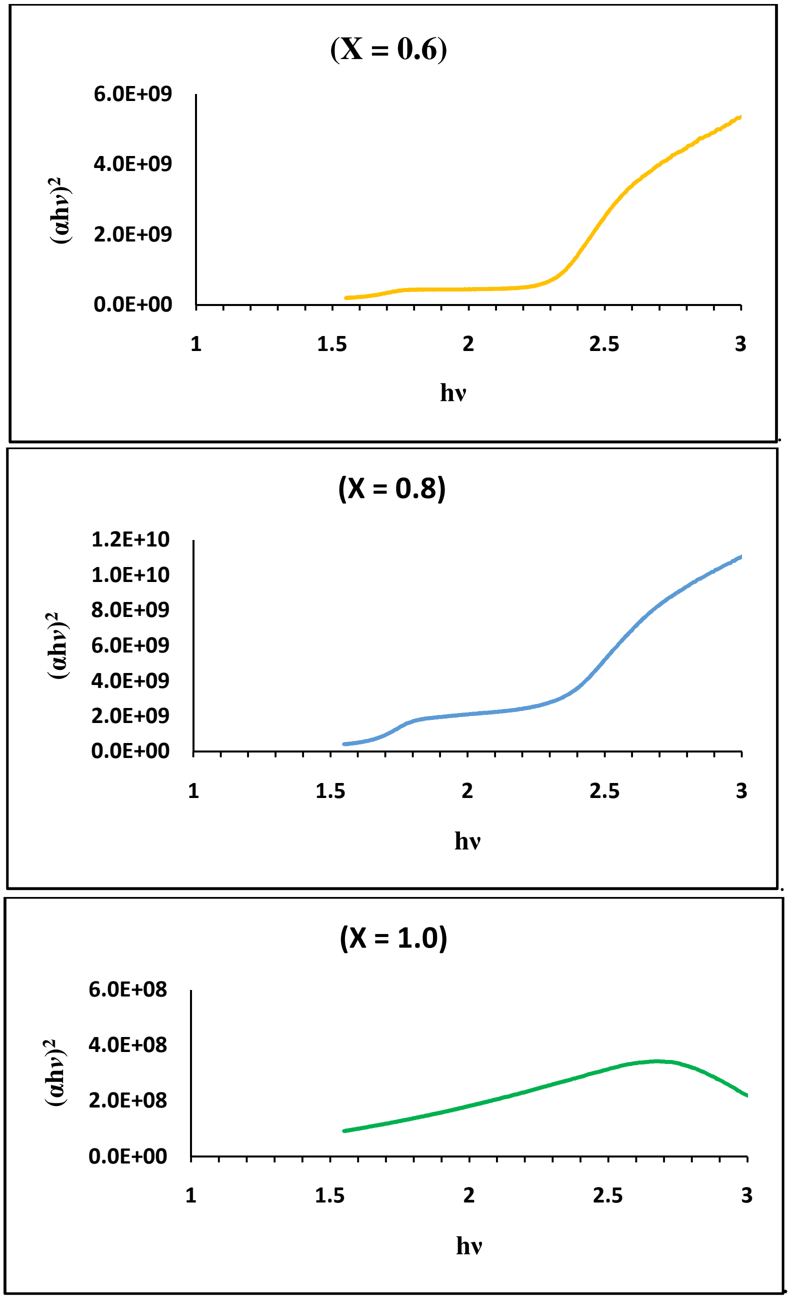


Figure.3. $(\alpha h\nu)^2$ vs$h\nu$ for the $Pb_xCd_{1-x}S$ thin films ($0.0 \leq x \leq 1.0$)

3. BAND GAP VARIATION

The band gap of deposited $Pb_xCd_{1-x}S$ thin films are shown in Table 2. The band gap of deposited films was found to be in the range of 2.34 -1.2 eV which very high as compared to the bulk PbS (0.41eV). Also it is observed that, the band gap of the films reduce with increasing Pb doping content in CdS. This decrease of band gap is consistent with dependence on crystallite size. As the CdS and PbS are highly sensitive to light and in view of their practical application, a study of their mixed thin films structure as electrochemical converters is of technical importance are discussed[26].

It is detected that variation of Eg with film composition is not linear, shown in Figure. 4, such type of variation in band gap reported for $Cd_{1-x}Pb_xS$ [27].

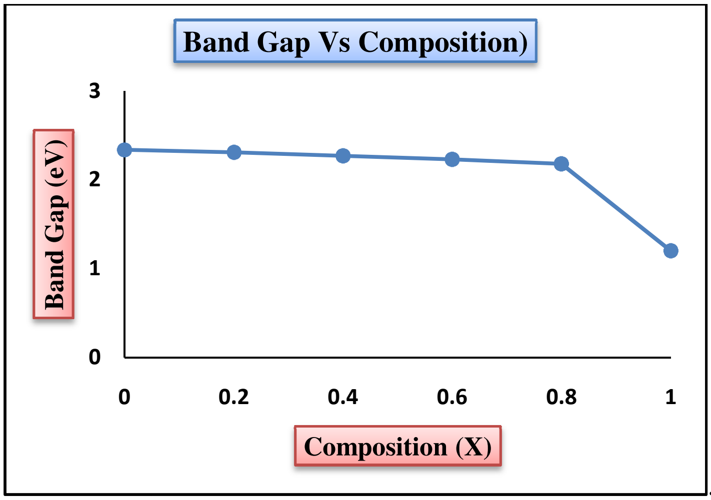


Figure.4. The Variation in Band gap with Composition (X)

Table 2. Shows Composition (X) with Band gap (eV) of $Pb_xCd_{1-x}S$ thin films ($0 \le x \le 1$)

Composition (X)	Band Gap (eV)
0	2.34
0.2	2.31
0.4	2.27
0.6	2.23
0.8	2.18
1	1.2

CONCLUSION

In this work, $Pb_xCd_{1-x}S$ thin films were deposited on cleaned glass substrate by chemical bath deposition technique. The experimental characterization indicates that Pb doping play an important role in optical properties of the films. UV-Visible analysis shows that the $Pb_xCd_{1-x}S$ thin films have its absorption edges at UV-Visible region. The optical properties show a significant change in band gap value with doping. The optical absorption measurement indicates that band gap is decreases with increasing composition "X" in films.

The band gaps of the films lie in the visible range, so these films can be used in solar cell and optoelectronics applications. These results indicate that there is a strong relation between the doping concentration and optical properties of the films.

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REFERENCES

[1] Schoolar, Richard B, *U.S.Patent*, **1979**.
[2] P. K. Nair, O. Gomezdaza and M. T. S. Nair, *Adv. Mater. Opt. Electr.*, **1992**, (1):139.
[3] H. Hirata and K. Higashiyama, *Chem. Soc. Jpn.*, **1971**, (44):2420.
[4] T. K. Chaudhuri and S. Chatterjee, *Proc.Int. Conf. Thermo electronic, (Arlington, USA)*, **1992**, (11):40.
[5] R. S. Kane, R. E. Cohen and R. Silbey, *J. Phys. Chem.,* **1996**, (100):7928.
[6] H. Kanazawa and S. Adachi, *J. Appl. Phys.,* **1998**, (83):5997-6001.
[7] R. K. Joshi, A. Kanjilal and H. K. Sehgal, *Appl. Surf. Sci.,* **2004**, (43):221.
[8] A. Pan, H. Yang, R. Yu and B. Zou, *Nanotechnology*, **2006,** (17):1083.

[9] Y. Gu, E. S. Kwak, J. L. Lensch, J. E. Aller, T. W. Odom and L. J. Lauhon,*Appl. Phys. Lett*., **2005, (**87): 43111.
[10] P. K. Nair, M. Ocampo, A. Fernandez, M. T. S. Nair, *Sol. Energy Mater*. **1990**, (20):283.
[11] H. Elabd, A. J. Steckl, *J. Appl. Phys*. **1980**, 51(1):726.
[12] N. Chaudhari, B.K. Sharma, *Ind. J. Pure Appl. Phy.***2008**, (46):261.
[13] T. Elango, S. Subramanian, K. R. Murali, *Surf. Coat. Technol*. **2003**, (8):123.
[14] V.D. Das, K.S. Bhat, *J. Mater.Sci*. **1990**, (7):169.
[15] E. U. Masumdar, L. P. Deshmukh, *Turk. J. Phys*. **2003**, (27):271.
[16] E. U. Masumdar, S. H. Mane, V. P. Pujari, L.P. Deshmukh, *Ind. Jour. Pure App. Phy*., **2002**, (40):624.
[17] E. U. Masumdar, S. H. Mane, V. S. Karande, V. B. Pujari, P.N. Bholsale, L.P. Deshmukh, *J. Mat. Sci. Mater. Elect*; **2003**, (14):43.
[18] E. U. Masumdar, V. B. Gaikwad, V. B. Pujari, P. D. More, L. P. Deshmukh, *Mat. Chem. Phys*. **2003**, (77):669.
[19] I. Pop, C. Nascu, V. Lonescu, E. Indvea, I. Bratu, *Thin Solid Films*, **1997**, (307):240.
[20] N. Chaudhary, B. K. Sharma, *Bull. Mater. Sci.***2009**, (32):43.
[21]Modaffer. A. Mohammed, Ali M. Mousa, and J. P. Ponpon, *J. SemiconductorTechnology and science*, **2009**, 9(2):117-122.
[22] D.H. Frigo, O.F.Z.Khan, P.Obrien, *J.Crtystal Growth*,**1989**, (6):989.
[23]Y.F.Nicolou and M.Dupuy, *J.Electrochemicalsoc*.,**1990**,(137):2915.
[24] S.C. Ray, M.K. Karanjai, and D. Dashupta, *Thin Solid Films*, **1998**, (322):117.
[25]A.S.Obaid, M.A.Mahdi,Z.Hassan and M.Bououdina,*Superlattice and Microstructure*, **2012**,52: 816-823.
[26] K. L. Chopra, S. Major, D. K. Panday,*Thin Solid Films*, **1983**, 1:102.
[27]M. A. Barote, A. A. Yadav, E. U. Masumdar, *Chalcogenide Letters*,**2011**,8:129 – 138.