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Structural and optical properties of Cd(1-x) ZnxS(x=0)/CdS thin film using chemical bath deposition technique

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ABSTRACT

Cd(1-x)ZnxS (x=0)/ CdS thin films were deposited by the chemical bath deposition technique. Depositions were done on cleaned glass substrates. The compositions, structural properties of deposited thin films were studied using X-ray diffraction technique. XRD studies reveal that the films are crystalline with hexagonal structure. Calculated lattice parameter shows good agreement of jcpds data card. It is observed that grain size of CdS thin film is 18 nm. The band gap of the CdS thin films 3.50 eV as composition x = 0

Keywords: CdS, Thin films, CBD technique, Optical Properties, Structure Properties

INTRODUCTION

II-VI compound semiconductor deposition from aqueous solution has gained attention due to the economical advantages and capability of large-area deposition [1 -2]. Cadmium sulfide (CdS) is the most studied chalcogenide with a bandgap of 2.4 eV (in bulk) [3], additionally, it was studied as the semiconductor active layer during the early development of Thin Film Transistors (TFTs) [4]. The application of CdS films as window layers in high-efficiency solar cells based on cadmium telluride (CdTe) and copper indium gallium selenide Cu (In, Ga)Se2 (CIGS) has recently increased the interest and studies on this material [5].

Group II-VI semiconductor thin films have attracted considerable attention from the research community because of their wide use in the fabrication of solar cells and other optoelectronic devices [6-8]. Thin films of CdS can be grown by chemical and physical methods such as chemical bath deposition CBD [9], spray pyrolysis [10], electrodeposition [11], solution growth [12], Sol-Gel [13], successive ionic layer of adsorption and reaction (SILAR) [14], vacuum deposition [15], sputtering [16], sintering [15], sublimation [16], molecular beam epitaxy [17] Among these techniques, chemical bath deposition (CBD) is the most good-looking because of its useful features over other deposition techniques because it is simple, gives high quality films at low temperatures, requires slow evaporation temperatures and easily coats very large surfaces[18].

In this paper, we reported the structural and optical characterization of CdS thin film using chemical bath deposition technique. And reveal the various others observation.

METHODOLOGY

$Cd_{(1-x)}Zn_xS$ (x = 0)/ CdS thin films were deposited by the chemical bath deposition technique. Here x represents the Zn parameters in the bath solution as also in the films. Aqueous solutions used as sources for Cd^{2+}, Zn^{2+} and S^{2-}, as $Cd(CH_3COO)_2$ $2H_2O$, $Zn(CH_3COO)_2$ $2H_2O$ and $CS(NH_2)_2$ are used respectively. The entire chemical used in the present study and reagent used was of analytical reagent grade. Substrate cleaning plays an important role in the deposition of thin films. Substrate cleaning and preparation of $Cd_{(1-x)}Zn_xS$ thin films. One of the film preparing (x=0) which is CdS we prepare (10ml) $CdSo_4$ + (4ml)TEA(tri eithil ammain) in a glass beaker and sterred well for 2min. And (10ml) Thioria+(10ml) NH_3 + (4ml)NAOH all solution mixed in a beaker and add the deionized water to fill the beaker up to 150ml. Therefore, the glass slides were washed with detergent and again rinsed in acetone before the deposition of the films. The cleaned substrate was kept dipped in deionized water before use. The well-cleaned glass substrates were slowly introduced into the bath vertically after obtaining the homogeneous solution. The desired pH value, 9 to 11 was achieved by the addition of aqueous ammonia solution proportionally into the mixture in the chemical bath. The temperature of the mixed solution was maintained at 75^0C using a constant temperature under continuous stirring. The films were prepared under continuous stirring for 1 h. The deposited films were cleaned several times with de-ionized water. After that film was drying in sun and air.

On adding NH_4OH to the aqueous bath containing $CdSO_4$ the chemical reaction results in the formation of a white precipitate of $Cd(OH)_2$:[19]

$$CdSO_4 + 2NH_4OH \leftrightarrow Cd(OH)_2 + (NH_4)_2SO_4$$

On adding excess of NH_4OH the white precipitate of $Cd(OH)_2$ gets dissolved and forms tetra-amine-cadmium (II) ($[Cd(NH_3)_4]^{2+}$) and hydroxyl ion (OH):

$$Cd(OH)_2 + 4NH_4OH \leftrightarrow [Cd(NH_3)_4] + 2OH^- + 4H_2O$$

On adding thiourea solution, reaction with OH^- results in the formation of $CN_2H_2$and SH:

$$CS(NH_2)_2 + OH^- \leftrightarrow CN_2H_2 + SH^- + H_2O$$

SH^- combines with $[Cd(NH_3)_4]^{2+}$ to form CdS with the liberation of ammonia gas:

$$[Cd(NH_3)_4]^{2+} + SH^- \leftrightarrow CdS + NH^+{}_4\ 3NH_3\uparrow$$

The CdS deposition occurs on the $Cd(OH)_2$ film formed initially.

RESULTS AND DISCUSSIONS

XRD Measurements

XRD study reveals that the film is crystalline with hexagonal structure. It is observed that grain size of CdS thin film is 20nm. Cadmium sulfide exists in sphalerite, cubic and hexagonal forms. However, some authors have observed hexagonal structure for CdS films and the others observed cubic or hexagonal structure [1-8].

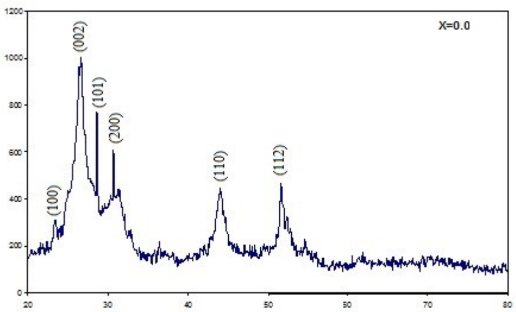

Fig (a) XRD Pattern of CdS thin film

Our thin film $Cd_{(1-x)}Zn_xS(x=0)$/ CdS thin films were deposited by the chemical bath deposition technique. The XRD patterns of films deposited on glass are shown in Fig. a). The films show an intense diffraction peak centered at 26.72 corresponding to the (002) lattice plane and its corresponding 'd' value is 3.33 (Joint Committee on Powder Diffraction Standard, JCPDS Card No. 80-0006. The XRD data deals the good agreement with the used jcpds card. diffraction peak in the plane (h k l), it is just possible to roughly estimate the nanoparticle size from the Debye–Scherrer formula [20].

$$D = \frac{0.94\lambda}{\beta \cos\theta} \quad \text{……………………. (4)}$$

where D is the mean particle size, λ is the wavelength of the target used in XRD instrument and is 0.15406 nm for the CuKα target, β is the FWHM of the peak of (h k l) plane and θ is the diffraction angle (2θ). The Debye-Scherrer formula is used to determine the grain size.

Thin film $Cd_{(1-x)}Zn_xS$ (x = 0)/ CdS thin films were deposited by the chemical bath deposition technique. Grain size *D* can be estimated from the slope of the straight line and the intercept on the *β* cos *θ/λ* axis, respectively. The estimated value for the grain size is 20 nm. Peak (100), (002), (101), (200), (102), (110) and (112) plane of x=0.0 (CdS) material show hexagonal structure. As shown in Fig (.a). The standard crystallographic data for CdS were taken from JCPDS card no. 80-0006 which is a good agreement.

The lattice parameters a and c for hexagonal (Eq. (5)) calculating using the following equation [12-14,18]. Lattice parameter calculated for CdS is (a= 4.20, c= 6.30).

$$\frac{1}{d^2} = \frac{4}{3}\left(\frac{h^2 + hk + k^2}{a^2}\right) + \frac{l^2}{c^2} \quad \text{………….. (5)}$$

Where d is interplanar distance, a and c are lattice constants, and h, k, and l are the Miller indices of the plane.

Optical Analysis

$Cd_{(1-x)}Zn_xS(x=0)$/ CdS thin films were deposited by the chemical bath deposition technique. The optical analysis of CdS thin films is linear at the absorption edge, which confirms that CdS is a direct band gap semiconductor.

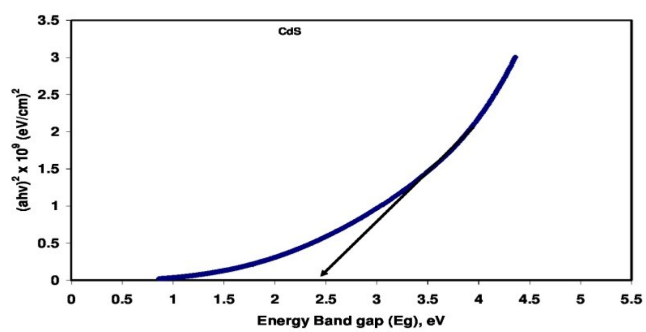

Fig. (C) Energy band gap of semiconductor CdS thin film

Table (a) : Various structural parameters of CdS thin films

	2θ Obs	Intensity Obs	CdS (H)	CdS (C)	(d) value	Lattice constant	D (mn)
X=0.0	23.4	310		(100)	3.8031	a = 4.20	20
	26.72	100	(002)	--	3.3372	c = 6.30	
	28.60	100	(101)	--	3.1223		
	30.75	60.5		(200)	2.9090		
	36.46	21.6	(102)	--	2.4645		
	44.00	44.5	(110)	--	2.0579		
	51.94	46.8	(112)		1.7604		

Extrapolating the straight-line part of the $(ahv)^2$ versus hυ scheme. The probable band gap values are programmed. As shown in fig .c). Energy band gap was observed that 2.45 eV.

CONCLUSION

In this work, we prepared $Cd_{(1-x)}Zn_xS$ (x = 0)/ CdS thin films by the chemical bath deposition technique. The deposited ZnS thin film is crystalline in nature. Debye-Scherrer formula is used to settle on the grain size 20 nm. We also studied the Influence of preparative parameters on the CdS film growth rate. The XRD pattern shows that the deposited CdS film is Hexagonal in nature. The band gap (Eg) value of the deposited film is about 2.45 eV. The film was tack good accord with the listed jcpds data card.

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