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Synthesis and Characterizations of Cadmium Sulphide (CdS) Thin Films by Chemical Spray Deposition Technique

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ABSTRACT: Cadmium Sulphide is an n-type semiconductor and it is perfectly suitable for a window layer in thin films based solar cells due to its desirable structural and optical properties. CdS thin films have been coated on microscopic glasssubstrate around 300^0 C by spray pyrolysis technique. Cadmium acetate and Thiourea in different concentrations were used as precursors. The fabricated films are characterized for various properties. Their structural properties were studied by X-ray diffraction,morphological properties are studied by SEM with EDX, and optical studies determined by UV-VIS spectrometry. The band gap value of the CdS thin films varied from 2.1eV to 2.4eV.

Keywords: CdS, Spray pyrolysis, XRD, SEM-EDX , UV-VIS, Band gap.

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I. INTRODUCTION

The semiconducting materials attract a considerable attention due to their electrical and optical properties. Cadmium sulphides(CdS) have been widely studied for extensive optoelectronic applications including: solar cells, smart windows, light emitting diodes, optical communications, flat panel displays[1], photo-transistors[2]. CdS is II-VI semiconductors have n- type semiconducting properties with an electrical resistivity of 10^{-2}-10^{-4} Ωcm and a band gap is 2.42eV [3]at room temperature.Cadmium sulphides have been considered as one of the promising material for solar cell application due to its low resistivity and high electrical conductivity and high transmittance in the visible range of solar spectrum [4].

CdS thin films have been synthesized using various physical and chemical deposition techniques including: chemical bath deposition(CBD)[5], activated reactive evaporation, spray pyrolysis[6], rf-sputtering, dc-sputtering[7],chemicalvapour deposition[8],reactive magnetron sputtering, metal oxide chemical vapour deposition (MOCVD)[9], pulsed laser deposition (PLD) and sol gel. Spray pyrolysis is one of the thin film deposition techniques that has produced considerably large area and uniform films in variety of different materials and provides economical and efficient usage of evaporent[10].

The aim of this study is to carry out experimental studies of the structural, optical and morphological properties of the film of cadmium sulphides deposited by spray pyrolysis technique.The film properties depend on the precursor preparation, spray rate, the substrate temperatureand the cooling and flowrate.

II. EXPERIMENTAL DETAILS:

Preparation of thin films

For the thin film preparation, different precursor concentrations0.05M,0.1M,0.15M,and 0.2M of cadmium acetate$Cd(CH_3COO)_2$ with 0.1M concentration of thiourea$CS(NH_2)_2$ were dissolved in distilled water. The slides were washed in a detergent solution rinsed with de-ionised water and cleaned with acetone then dried in air for clean glass substrate. The nozzle to substrate distance was 30cm and the flow rate of the solution was 3ml/min. The substrate temperature was maintained at 300^0 C.When compressed air with the precursor solution was passed through the nozzle at constant pressure,the film was deposited on the heated substrate (300^0 C)for producing CdS thin films.Optical absorption and transmission data were obtained with an UV-VIS spectrometer in the range of 300nm-900nm.The crystalline structure of the thin films was analysed using X-ray diffractometre with CuKα radiation of $1.5418A^0$.Scanning electron microscopes and Energy dispersive X-ray analysis are used to study the surface morphology and true composition of the sample being analysed and percentage of materials involved in the CdS thin films.

III. RESULTS AND DISCUSSION

3.1. Structural analysis

X-ray diffraction analysis

X-ray diffraction patterns of CdS thin films exhibits three distinct peaks at 2θ values of 26.20^0 ,32.57^0 and 66.01^0 angles.The presence of these peaks indicates that the crystalline size of the particles are very small and semi crystalline in nature. High crystallinity was observed from the high intensity of the diffraction peaks 26.20^0 ,32.57^0 . No other peaks were identified in the XRD results, because of the various concentrations of precursors.Peak width (FWHM) varies inversely with crystallite size and peak intensity weakest at larger angles of 2θ, which verifies that 66.01^0 angle has high peak width and low intensity.32.57^0 , 26.20^0 angles has high intensity with smaller peak width. The average grain size of CdS deposited over a glass was 3nm, determined from Debye-Scherrer formula.

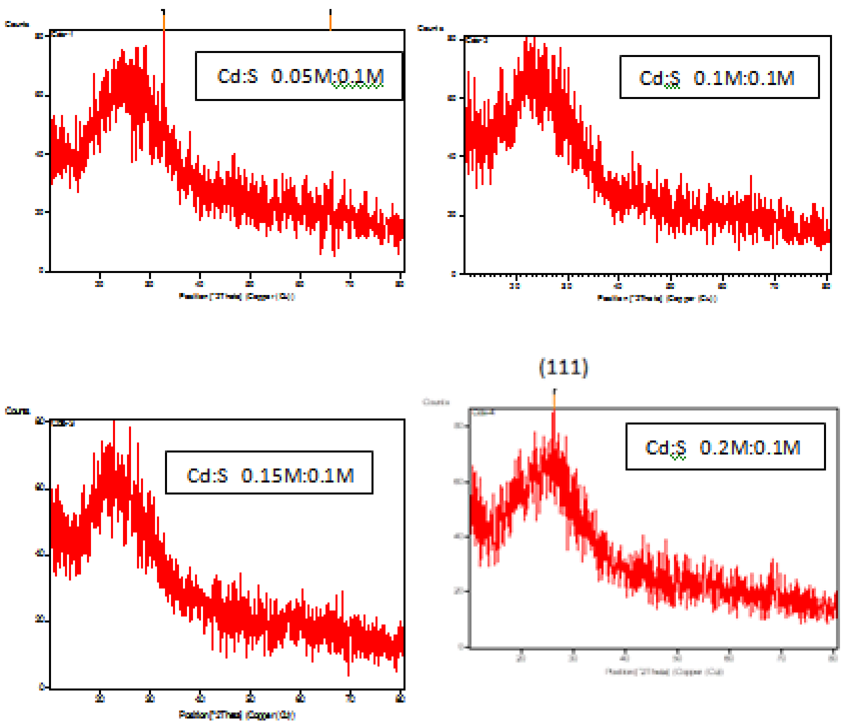
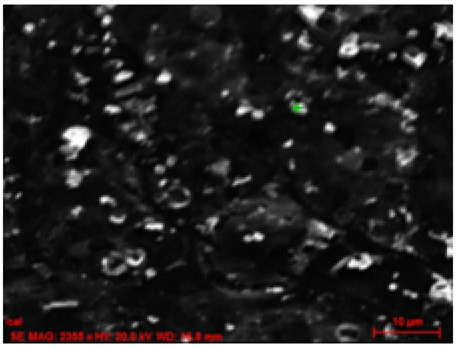


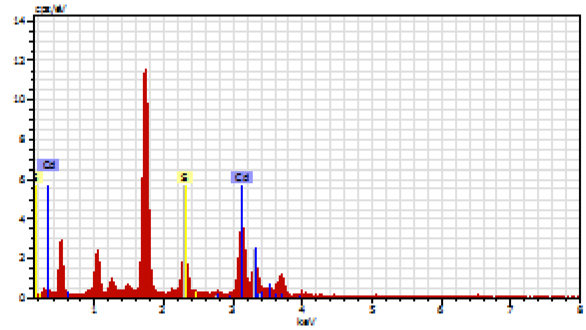
Fig1:XRD patterns of CdS thin films

3.2. Morphology Studies

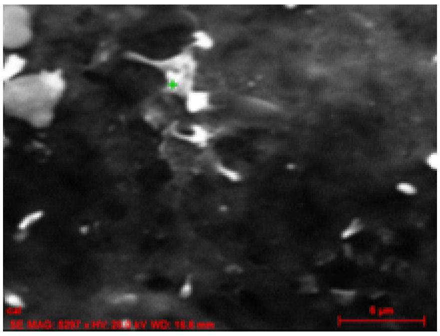
The surface morphology and grain size of the particles were determined by scanning electron microscopy.Fig.2. Shows the magnified image of the CdS samples. And the result was different for each concentration. The images of the samples 1 & 4 (Cd 0.05M & 0.2M) showed that the CdS thin films had uniform morphology, polycrystalline nature and almost spherical in shape. From the samples 2 & 3 (Cd 0.1M & 0.15M)it can be seen that there is a collection of irregular particles, which were agglomerated randomly.

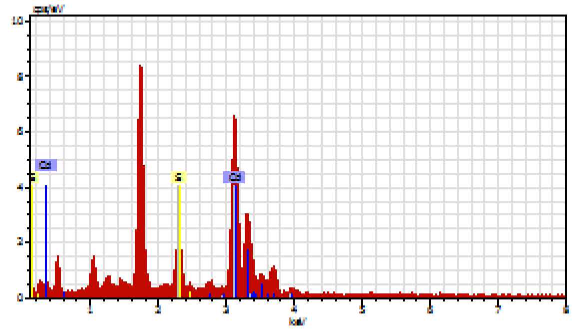
Fig.3 shows the EDX spectrum of CdSnanoparticles. The atomic percentages of Cd & S were recorded considerably and the result confirms the presence of cadmium sulphide nanoparticles. In this study the domination of cadmium ions were increased because of the absence of complexing agent which is used to decompose thiourea and produce sulphur. While compared with others early works [13] the deductable changes were occurred in the chemical composition of Cd & S .The obtained Cd values are so high, and S islow. The average stoichiometric composition of Cd is 75% and S is 25%.



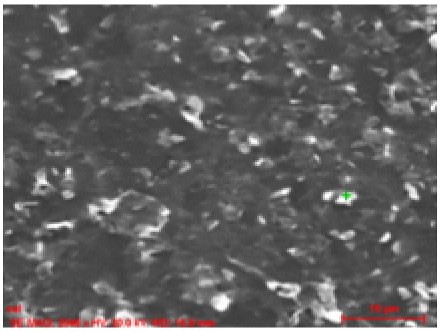


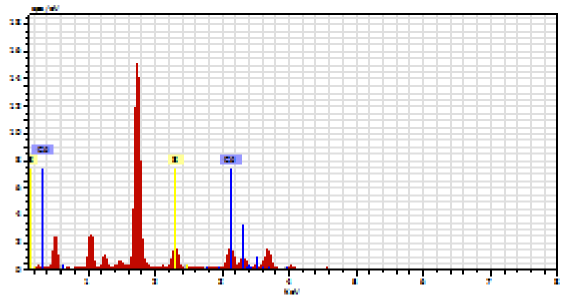
Sample 1: Cd:S 0.05M:0.1M



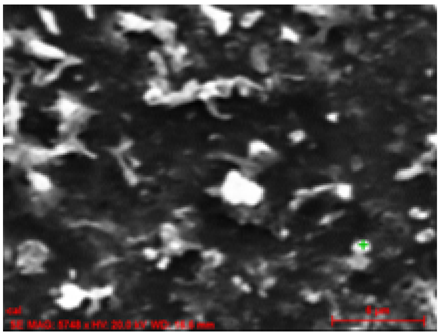


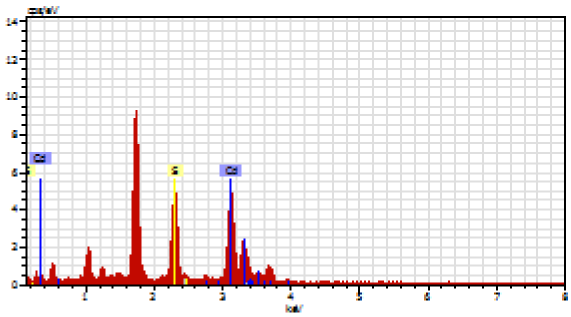
Sample 2: Cd:S 0.1M:0.1M





Sample 3: Cd:S 0.15M:0.1M





Sample 4: Cd:S 0.2M:0.1M

Fig.2. SEM images of CdS thin film Fig.3. EDX graph of CdS thin film

3.3. Optical studies

UV-VIS Spectroscopy

The optical characterization of the CdS thin films were done by UV-spectrometer. And the spectrum observed in the wavelength of 300 – 900 nm.In fig.4.The percentage of transmission takes very low in the wavelength region of λ<500nm, which is the spectral region of absorption. All the films have a high range of transmission in the range of above 500nm. The percentage of transmission was about 40-70% at visible to infrared region. i.e The film present lower transmission 70%in the visible region.

From the UV analysis the absorption of CdS in fig.5 has been obtained below 500nm, for four different concentrations. It's clearly showed that the CdS nanoparticles were strongly adoptable for opto electronic applications.

The absorption co-efficient α is calculated from Lambertz law [14]

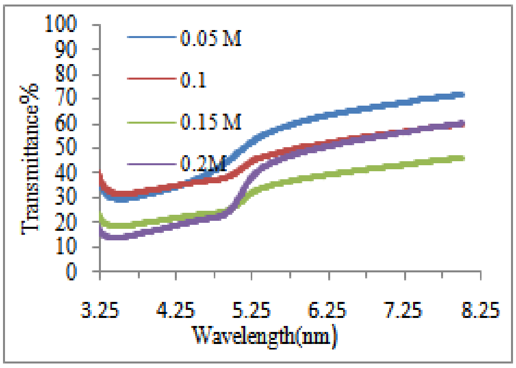
α=2.303A/t ------------------------------ (4)

Where A is the optical absorption and t is the film thickness.

The absorption co-efficient (α) and the incident photon energy ($h\upsilon$) are related by[15] the equation

$(\alpha h\upsilon)^{1/n}$= A ($h\upsilon$-E_g) -------------- (5)

The optical band gap energy of the CdS thin films are determined by plotting $(\alpha h\upsilon)^2$ vs$h\upsilon$(Fig6). The intercept on the $h\upsilon$ axis determines the band gap of the CdS thin film. In this study it has been observed that depending on the different concentrations of the films, the direct band gap values were obtained as 2.1eV, 2.15eV, 2.3eV, 2.4eV respectively. These values are very much related to the original band gap value of CdS 2.42eV. The band gap of the CdS reduces with reduced concentration of Cd that results that increased conductivity of the material.



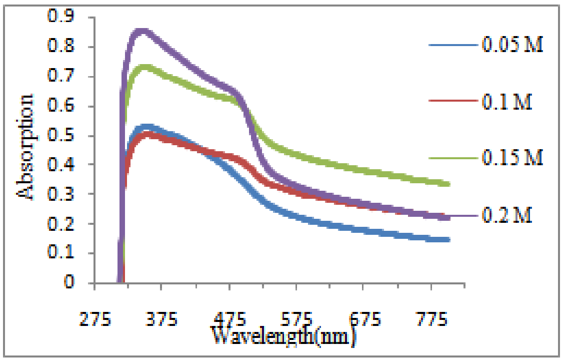


Fig4: Optical transmission spectrum of CdS Fig5: Optical absorption spectrum of CdS

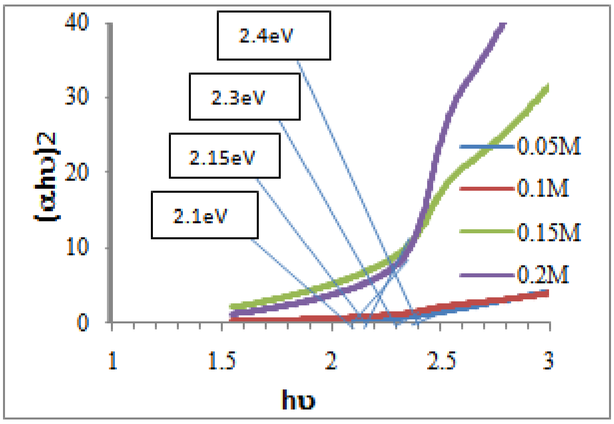


Fig6: Band gap determination of CdS thin films

IV. CONCLUSION

CdS thin films was deposited on glass substrate at 300 degree using spray pyrolysis technique which is simple, economic and easy method. Four different concentrations of precursors were used. XRD patterns showed that some films are polycrystalline and some are amorphous .The SEM images showed that the formation of CdS thin films , And the EDX confirms the presence Cd& S particles in the samples. And optical studies determined the band gap lies in the range from 2.1eV to 2.4eV . These optimized conditions are suitable for solar cell applications.

REFERENCES

[1]. S.Schmitt-Rink,D.S.Chemla,D.A.B.Miller, Linear,nonlinear optical properties of semiconductor quantum wells.Adv.phys 38(1989),89-188.

[2]. T.K.Subramanyam,S.Uthannaand B.SrinivasuluNaidu,Mater.lett.35(1998),214

[3]. M.Ortega,G.Santana,A.MoralesAcevedo,Solid State Electron,44(2000)1765.

[4]. A.P.Alivisator,,perspectives on the physics chemistry of semiconductors nanocrystals.J.Phys.chem.100(31)(1996)13226-13239.

[5]. B.R.Lanning and J.H.Armstrong Behaviour for solution grown CdS for thin film solar cell technologies. Int .J.Solar energy 12(1992),247-255.

[6]. H.H.Afifty,I.K.El Zawawi and I.K.Battisha,J.matter Sci-Mater El 10(1999),497

[7]. P.K.Ghosh,U.Maiti,N.Chattopadhyay,Structural and Optical characterization of CdS nano fibers synthesized by DC-sputtering technique. Mater.lett. 60(2006),2881-2885.

[8]. P.J.Sebastian,J.NarvaezandA,Sanchez,J.phy. D:Appl.phy29(1996).1356

[9]. S.J.C.Irvine,V.Banioz,D. lamb,etal MOCVD of thin photovoltaic solar cells-nextgeneration production technology.cryst,Growth 310(23)(2008) 5198-5203.

[10]. Ikhmayies,J.Shadia,Production & Characterization of CdS/CdTe thin film photovoltaic solar cells of potential industrial use.Ph.D thesis university of Jordan , Ammam, Jordan.(2002).

[11]. Y.Yusoff,P.Chelvanathan,Q.Huda,M.Akhtaruzza,M.M.Alam,ZA.AlOthman,N.Amin,High Quality CdS thin film growth by avoiding anomalies in chemical bath deposition for large area thin film solar cell applications,Journal of Nanoscience and Nanotechnology Vol15,(2015)(9240-9245).

[12]. B.D.Cullity,Elements of X-ray Diffraction Addition – Wesley Reading, M.A.P 102(1972).

[13]. S.Yilmaz,Y.Atasoy,M.Tomakin,E,Bacaksiz, Comparitive study of CdS,CdS:Al,CdS:Na and CdS:(Al-Na)thin films prapared by spray pyrolysis,Super lattices and microstructures (2015)1-9.

[14]. N. Ghobadi,Int.Nani lett. 1, 3 (2013)

[15]. J.Singh ,I.K.Oh and S.O. Kasap,Optical absorption, photo excitation and excitons in solids, in photoexcited processes,Diagnostics and Applications, edited by A.Peled.K.Luwer Academic Publishers, Dordrecht,Netherland(2003) P.P.25-55.

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