Synthesis of Cadmium Sulfide (CdS) Nanoparticles using Participation Method

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Abstract:

CdS powder was successfully prepared using participation method. CdS powder was prepared by the chemical precipitation technique using Cd, HCl and H_2S and preparing the screen printed sintered films of CdS, on the glass substrate with the help of cadmium chloride and ethylene glycol. The XRD measurements showed that the obtained grain size is around 3.25nm.

Keywords*: Cadmium Sulfide (CdS) - Nanoparticles - participation method*

1. Introduction

Interest has been devoted to the development of II-VI group binary inorganic low dimensional materials via simple and inexpensive chemical route. This kind of material is highly desired for various potential applications in the field of advanced electronic and optoelectronic devices. CdS is one of important candidates of II-VI group binary inorganic semiconductors for optoelectronic applications. It has direct band gap of 2.42 eV at room temperature and high photosensitive properties [*Amalnerkar, (1999), Joseph (2007), Sanap, (2010), Khallaf (2008), Okhrawi (2005)*]. CdS nanoparticles and nanocrystalline thin films have recently received much attention because of their unique physical, chemical and mechanical properties as compared to the bulk counterpart [*Khan (2018)]*. They are extensively used in optoelectronic devices because they tune emission in the visible region of the electromagnetic spectrum by the change in particle size. CdS thin films are also useful in the fabrication of thin film transistors, light detectors, solar cells [1mm]. Absorber layers based on (CIS), Cu(In,Ga)Se2 (CIGS) and CdTe compound semiconductors are important for terrestrial applications because of their high efficiency, long-term stable performance and potential for low-cost production. Highest record efficiencies of 19.5% for CIGS1 and 16.5% for CdTe[2]and CuInSe2 have been achieved [*Joseph (2007),*]. It's ideal band gap, high optical absorption, and relative ease of deposition have made CdS especial attractive for the preparation of thin film solar cells. CdS is current used as a window layer in thin film solar cells [*Joseph (2007), Okhrawi (2005)*], because of its large band gap and high transparency. CdS thin films are are widely used as optical window material in photovoltaic solar cells [*Naseem (1996)]* and have been regarded as a prime candidate [*Romeo (2004)*] for Solar fabrication. polycrystalline thin films in the solar cell industry has become an attractive alternative to the conventional silicon solar cell process due to its low production. Absorber layers based on (CIS), Cu(In,Ga)Se2 (CIGS) and CdTe compound semiconductors are important for terrestrial applications because of their high efficiency, long-term stable performance and potential for low-cost production. Highest record efficiencies of 19.5% for CIGS1 and 16.5% for CdTe[2]and CuInSe2 have been achieved **[***Abd-Lefdil (1998)***].** CdS is photoconductive material used for different applications **[***Jefferyl(1992) Nikhil .(2004) H.M. (2008) Albor-Aguilera, (2009) Adawiya (2008) Singh (2011) Ezeme (2010)* **].**

2. Material and Methods

2.1 Chemical Material :

Cadmium(Cd), hydrochloric acid (HCL), and Hydrogen Sulphide (H_2S), cadmium chloride($CdCl_2$), , distilled water, and filter paper.

Preparation of CdSNPs.

CdS powder was prepared by the chemical precipitation technique using Cd, HCl, $CdCl_2$,and H_2S.: Cadmium metal (1 g) was completely dissolved in HCl (5 ml) solution. Then H2S Sulpihde was passed through the solution. The reaction of precipitation for this process is given below

$Cd + 2HCl \longleftrightarrow CdCl_2 + H_2$ (1)
$CdCl_2 + H_2S \longleftrightarrow CdS + 2\,HCl.$ (2) [*Nikhil .(2004)*]

The yellow precipitate obtained in the above process was filtered. This composite was then dried in an oven at 50°C for 30 min. When the precipitate was completely dried, it was then crushed to fine powder by grinding process as shown figure**(1).**

2.2 X-ray Diffraction (XRD):

X-ray diffraction method was used for studying and analyzing structures of CdS crystalline samples of powder, XRD using X pert high score plus software program(No.9430040601). The analysis were taken for 2θ ranging from 10^o to 60^0 using Kα line of wavelength 0.175087 ^{0}A.

2.3 UV-VISB Spectrophotometer

In this study the optical absorbance and transmittance of the sample in the range 200 nm to 1100 nm and intensity of light at 40kv, UV spectrophotometer type SED-SPE-48,UVmini, 1240 company shimadzu, p/N 206 -54000-92 , p/N 206 -55659 -38 had been used for analysis of samples for optical properties were obtained, light source of 20W halogen lamp (Long-life-2ooo hour), deuterium lamp (socke type), automatic light source mechanism has been employed. Absorption and transmission spectra were obtained directly through the Computer using Origin lap for analyzing and acquirement of data .

3. **Results and Discussions :** This part divided into two section, firs section deals with XRD spectrum of prepared CdSNP while second section deals with UV-Visb. absorbance & transmission spectrum of CdSNP. Fig-1: shows the photograph of prepared CdS powder.

3.1 (XRD) of the cadmium sulphide powder :

The X-ray diffraction pattern of CdS powders is shown in Figure (2). The pattern for the prepared powder indicates all the peaks corresponding to hexagonal Wurzite (Greenockite) of CdS observed, with a lattice constant of a = 4.1500 Å, C=6.7370Å. The structure has been assigned a PDF for (ICSD data card no 00-041- 1049). The peaks (010), (002), (011), (012), (110), (013), (020), (112), (021), (004), (022) and (120) seen in the diffraction pattern correspond to the hexagonal phase of CdS. The diffraction peaks at 2θ (degrees) are indexed as the planes

Fig(1) powder CdS

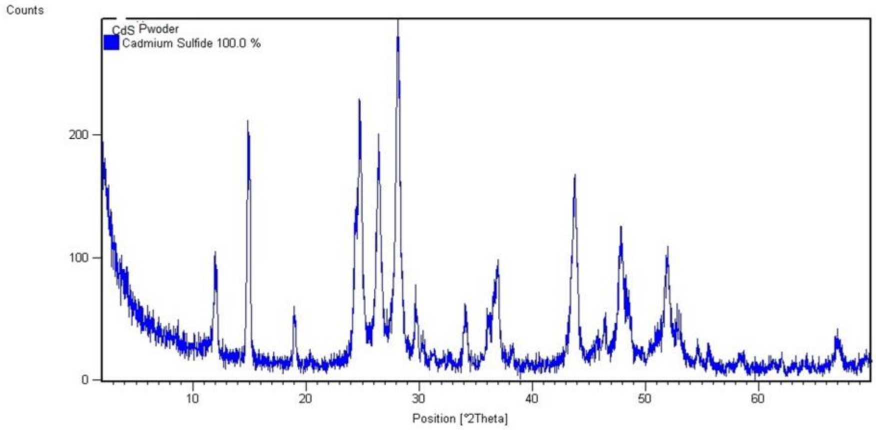

Figure (2)XRD pattern of Cadmium Sulphide Powder

Table(1) XRD data of CdS Powder

No.	Pos. [2Θ^0]	d-spacing [^{0}A]	Rel. Int. [%]	FWHM [[2Θ^0].]
1	12.0081	7.37039	26.33	0.2755
2	15.0597	5.88311	57.82	0.3149
3	18.9555	4.68185	14.87	0.2755
4	24.7447	3.59808	74.48	0.2755
5	26.5262	3.36033	62.1	0.3542
6	28.1	3.1756	100	0.3149
7	29.7696	3.0012	14.04	0.2362
8	34.1269	2.62733	14.94	0.3936
9	37.0321	2.42761	28.32	0.2362
10	38.2559	2.35272	4.44	0.4723
11	43.811	2.06643	52.67	0.3936
12	46.4238	1.95603	9.39	0.3149
13	47.8462	1.90115	35.56	0.2755
14	51.9732	1.75948	28.5	0.4723
15	55.6096	1.65274	4.71	0.2362
16	58.5182	1.57733	3.57	0.4723
17	62.0546	1.49567	3.57	0.3149

Table -2: Important calculated factors from XRD spectrum

No	2θ (degree)	FWHM (β)	d(Å) (011)	Lattice Parameters (Å)	Dislocation density (ð) × 10^{17}(m^{-2})	Crystallite size (D) (nm)	**Micro-strain(ε) × 10^{-3}**
1	**28.1**	**0. 3149**	**3.1756**	**4.1370**	**0.95**	**3.25**	**1.212**

of CdS as shown in table (1). All the diffraction peaks in the pattern correspond to the hexagonal phase of CdS (space group: *P*63*mc*). The lattice parameters which have been calculated are in good agreement with the reported standard values (ICSD data card no 00-041- 1049). This powder was used as source material for the deposition of thin films on glass substrates by the screen printed technique.

The average nanocrystalline size is calculated from (FWHM) of broadening of the diffraction peaks using Debye–Scherrer's formula (3).

$$D = \frac{k\,\lambda}{(\beta \cos\theta)} \ldots\ldots (3)$$

Where D is the average crystallite size, k a fixed number of 0.9 (Scherrer's constant), λ the X-ray wavelength (λ=0.175Å), θ the Bragg's angle in radians, and β (FWHM) the full width at half maximum of the peak in radians. The detailed variation of the peak position (2θ), full width at half-maximum (FWHM, β) value, d value, a value, average crystallite size (D), The dislocation density (δ) value and micro-strain (ε) along the (011) plane of CDS are presented in Table 2. These results are calculated according to the following relations:

$\varepsilon = \beta \cos\theta / 4$ (4)

$\delta = 1/D^2$ (5)

3.2 Optical properties of CdS

The absorption spectra of CdS powder have been recorded over wavelength range 200 nm-1100nm using a spectrophotometer at the room temperature as shown in figure . In this spectrophotometer, absorption and transmission spectra are obtained directly through the Computer using Origins software.

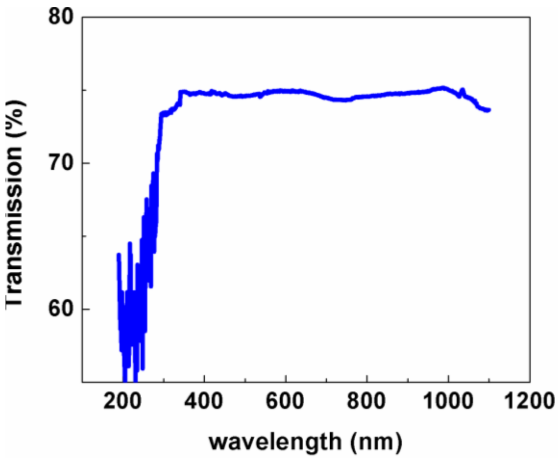

Fig-(3) : Transmission spectrum for CdS

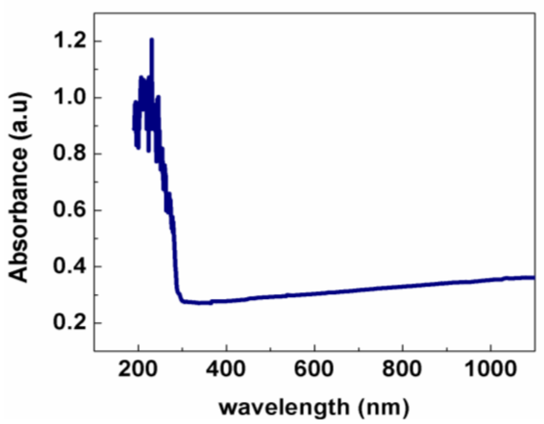

Fig-(3-b) : Absorbance spectrum for CdS

4. Conclusions:

CdS nanoparticles was successfully synthesized by the chemical precipitation technique using Cd, HCl and H_2S with the help of cadmium chloride and ethylene glycol. The obtained nanoparticles has a value grain size around 3.25nm. An optical properties of CdS nanoparticles has been recorded over wavelength range 200 nm-1100 nm using a UV-VISB spectrophotometer. (*Amalnerkar, (1999), Joseph (2007), Sanap, (2010), Khallaf (2008), Okhrawi (2005*)

5. References:

[1] Amalnerkar D.P.. (1999), Photoconducting and allied properties of CdS thick films. Vo. 60 , pp 1-21.

[2] Joseph D. Beach and Brian E. Mc Candless. (2007) Material Challenges for CdTe and CulnSe2 Photovoltaics . V 32, pp 1-5.

[3] Sanap V.B., Pawar B. and Growth H., (2009) Characterization of Nanostructured CdS Thin Films by Chemical bath deposition Technique Vol. 6, No. 8, , p. 415 – 419.

[4] Khallaf, H. Isaiah O. Oladeji, G . Chai, Lee Chow (2008) Characterization of CdS thin films grown by chemical bath deposition using four different cadmium sources. 516 , 7306–7312.

[5] Okhrawi M J. (2005) Photovoltaic Solar Cell From Low-Cost Thin- Films Technology. No, 185, 2005, 703-706.

[6] Naseem, S. Nazir, D. Mumtaz, R. and Hussain K. (1996) Evaporation Thin Films of CdS and CdTe Optimization for Photovoltaics Applications. Vol. 12, p 89-94.

[7] Romeo, A. Terheggen, M. Abou-Ras, D. Ba tzner, D. L. Haug, F.J. lin, M. Ka Rudmann D.and Tiwari. A. N. (2004) Development of Thin-Films Cu(In, Ga) Se_2 and CdTe Solar Cells. pp 93-111.

[8] Abd-Lefdil, M. Mesaoudi, C. Bihri, H. Abd- Lefdil S. and Sayah. D. (1998.) Thin Films for CIS Solar Cells. V. 1, No. 1,

[9] Jefferyl, G. Schwartz, R. Richard j and Lee, Y (1992). Development of a Computer Model for Polycrystalline Thin-Film CuInSe2 and CdTe Solar Cells. Paper 313.

[10] Rania M A I . (2008.) Enhancement of Photoelectrochemical Characteristics of CdS Thin Film ElectrodesPrepared by Chemical Bath Deposition: Effect of Annealing and Rate of Cooling Professor Hikmat S. Hilal, Ph. D.Dr. Amer Hamouz, Ph. D.

[11] Nikhil K. K .(2004) Solid State, Transparent, Cadmium Sulfide-Polymer Nan- composited ..

[12]H.M. (2008) Optical Properties of Zinc Oxide Thin Films for MSc..

[13] Albor-Aguilera, M.L. González-Trujillo, M.A. Cruz-Orea, A. Tufiño-Velázquez. M. (2009) Thermal and optical properties of polycrystalline CdS thin films deposited by the gradient recrystallization and growth (GREG) technique using photoacoustic methods. 517 pp 2335–2339 .

[14] Adawiya Jet al. (2008) Annealing Effect on Structural, Electrical and Optical Properties of CdS Films Prepared by CBD Method. School of Applied Sciences, University of Technology, Baghdad, IRAQ, pp 1-129

[15] Singh, V. Sharma, P.K. Chauhan, P. (2011) Synthesis of CdS nanoparticleswith enhanced optical properties . 62, , pp43-52.

[18] Ezeme, F. I. et al (2010) . Roul of Thermal Annealing on the Optical and Solid State Properties of Chemically Depodited Cadmium Sulphide Nanocrystalline Thin Film Growth in Polymer Matrix. Vol. 1, No 1, p. 45 – 50.

[19] Khan, Z R et al (2018) Sol-gel derived CdS nanocrystaline thin films: optical and photoconduction properties , Material Science – Poland 36(2) 235-241