

Fourier transform infrared spectroscopy (ftir) study of cadmium sulfide (cds) thin film prepared by chemical rute

Addisalem Haile

Abstract

Cadmium Sulfide thin films were prepared by chemical bath deposition (CBD) technique. The bath solution was a mixture of cadmium acetate and thiourea as source of cadmium and sulfur respectively, ammonia hydroxide was used as complexing agent. In order to investigate the effect of deposition time; films were prepared with four deposition times 45,60,75 and 90min the X-ray diffraction, UV visible spectrophotometry and Fourier transform infrared techniques were used to investigate CdS thin films and the different steps of reactions leading to CdS product. Cubic CdS thin films were obtained with (111) plan preferred orientation. Estimated crystallite size was found in the range 5.91-7.9 nm. The Band gap energy was 2.4, 2.2, 2 and 1.98 eV for four deposition time respectively. The functional group of CdS thin films were proposed based on FTIR results. The FTIR spectroscopy studies were conducted by bruker tensor 27FTIR spectrometer using a standard ATR cell. The samples were scanned from 450 cm^{-1} to 4000 cm^{-1} . We obtained Cd-S stretching functional group around $647\text{-}653\text{ cm}^{-1}$ and other related functional group blow 1000 cm^{-1} . The SEM micrographs showed that the film surface was composed of spherically shaped grains over the entire glass substrate and the elemental analyses of the films confirmed that the atomic percentage of Cd: S is nearly 1:1, indicating that the synthesized thin films were in the desired stoichiometric ratio.

Key words: Chemical bath deposition, Cadmium Sulfide, Thin film, FTIR, XRD, SEM

INTRODUCTION

Materials are the key innovative trigger in the development of many new products and technologies. They have been ingrained in human culture since the beginning of history. Materials are exceptionally diverse. Metals, polymers, ceramics, semiconductors, and composite materials constitute the main classes of materials. Based on their specific properties they constitute the foundation of technology, whether the technology pertains to structural, electronic, optical, thermal, electrochemical, environmental, biomedical, or other applications. Materials may be grouped into six different categories: mechanical, electrical, thermal, magnetic, optical, and deteriorative. Materials structures, properties, processing and performance are important components of material science [1]. Materials science and technology is a multidisciplinary approach to science that involves designing, choosing, and using three major classes

of materials such as: metals, ceramics, and polymers (plastics). Wood also could be used.

Nano science and nanotechnology deal with the study of extremely small things in the nanometer range from 1 nm to 100 nm and their possible applications. In the nanotechnology,

nanomaterial's are prepared, characterized and utilized for different purposes. Historical evidences show that nanomaterial's were synthesized and used from the ancient days [2]. An ancient person used colloidal gold for the treatment of arthritis, dipsomania, etc. In 19th century systematic experimental work was conducted on nanomaterial's, particularly on gold collides. After 20 years, people finally obtained the ability of the manipulation of atoms and molecules by using precise tools and new era of Nano science and nanotechnology began [3, 4].

Nanotechnology is a very important technology because it develops new instruments and modifies as well as replaces existing instruments; it also promises new advancement in technologies. Due to the novel properties of nanomaterial, it extended extensively to the other fields of science and engineering. Nanomaterial's has potential applications in Nano electronics, Nano photonics, sensors, resonators, LEDs, LCD displays, etc. The

Ms. Addisalem Haile is currently Lecturer of Jinka University, Ethiopia and pursuing masters degree program in Material Science in Hawasa University and , Ethiopia, PH-0945009672 . E-mail: ms.Addisalemhaile@gmail.com

properties of nanomaterial are significantly different from the bulk materials. Such significant changes in the properties of materials are due to the Nano sized materials. Nano sized materials exhibit some properties like, large fraction of surface atoms, high surface energy, and spatial confinement and reduced imperfections over corresponding bulk materials. Development of laser and light emitting diodes (LEDs) are most promising in the future developments of optoelectronics. Now we can get highly intense, efficient and long lifetime white light source. In recent years, the development of nanostructured

1 Experimental Procedures

1.1 Materials Used for preparation CdS Thin Film

In order to deposit cadmium selenide thin film by chemical bath deposition method, some materials were used. Such materials were spoon, beakers, cylinders, magneto-stirrer, heater, thermometer, water bath, chemical bath, micro-beam balance and the equipment that used to measure PH values and glass slide. So without those materials we cannot prepare CdSe thin film in the chemical bath deposition method.

1.2 Reagents or Chemicals Used for synthesis CdS Thin Films

In the present work cadmium acetate ($\text{Cd}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$), thiourea and ammonium hydroxide (NH_4OH) have been used as; cadmium sources, Sulphur sources, a complexing agents, and for adjusting pH value a solution respectively.

1.3 Preparation of 0.12M ($\text{Cd}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$) (cadmium acetate)

7.835 g of ($\text{Cd}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$) (cadmium acetate) was weighted into a beaker. The salt was dissolved in small amount of distilled water and then transferred into 250ml volumetric flask using funnel. The solution was then topped up to the 250ml mark with distilled water and thoroughly shaken to dissolve the salt completely. The resulting solution had a concentration of 0.12M.

1.4 Preparation of 0.2M thiourea ($\text{CS}(\text{NH}_2)_2$)

3.729 g of thiourea ($\text{CS}(\text{NH}_2)_2$) was weighted into a beaker. The salt was dissolved in small amount of distilled water and then transferred into 250ml

materials in the form of thin films occupy a prominent place in basic research and solid state technology due to their expanding range of potential applications in the diverse field such as photovoltaic cells, electronic components, fabrication of large area photodiode arrays, photoconductors, sensors, antireflection coatings, optical filters, solar selective coatings and solar cells etc. The nanostructured material has high surface area to volume ratio and hence shows different structural, optical, electrical, magnetic and dielectric properties than bulk [2-3, 9].

volumetric flask using funnel. The solution was then topped up to the 250ml mark with distilled water and thoroughly shaken to dissolve the salt completely. The resulting solution had a concentration of 0.2M.

1.5 Substrate Cleaning Procedure

The most important in the deposition of thin films is cleaning substrate. In principle, most clean surfaces can be used as substrates, although the degree of adhesion can vary greatly from one material to another. Glass is one of the most commonly used substrates in CBD. In spite of the fact that glass is a relatively inert material, the surface of glass can be very reactive towards species in solution. In this work, ordinary commercially available of glass slides were used as substrates for the deposition of CdS. Before deposition the microscope glass slides were degreased in nitric acid overnight and subsequently kept in ethanol for about an hour, after that, ultrasonically cleaned with distilled water and dried under ambient conditions.

1.6 Deposition of Cadmium Sulfide Thin films

The preparation conditions of CdS thin films were optimized by adjusting concentration of dissolved chemicals, bath temperature, and bath solution pH as well as deposition time to obtain homogeneous films with good adherence to the substrate. The chemical bath contained cadmium acetate [$\text{Cd}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}$] of 99 % purity and thiourea ($\text{CS}(\text{NH}_2)_2$) of 98% purity, which provided cadmium ions and Sulfurions respectively, while ammonium hydroxide (NH_4OH) was used as a complexing agent. All the solutions were prepared using deionized water and all the chemicals used

were analytical graded without further purification. The complexing agent in the chemical bath deposition technique prevents spontaneous precipitation and reduces the concentration of free metal ions. The following procedures were used for the deposition of cadmium sulfide thin films: 10 ml of cadmium acetate $[\text{Cd}(\text{CH}_3\text{COO})_2 \cdot 2\text{H}_2\text{O}]$ was poured into a 100 ml beaker then 18ml distilled water added and complexed with 15ml ammonium hydroxide (NH_4OH) solution was added slowly to adjust the pH of the bath around 12.4. The 10ml thiourea $(\text{CS}(\text{NH}_2)_2)$ and 10ml distilled water added, the total volume is 63. Finally the temperature kept at 65°C for (45, 60, 75 and 90) min deposition time, during which the colour of the solution changed from light yellow to deepyellow

Figure 4.6.

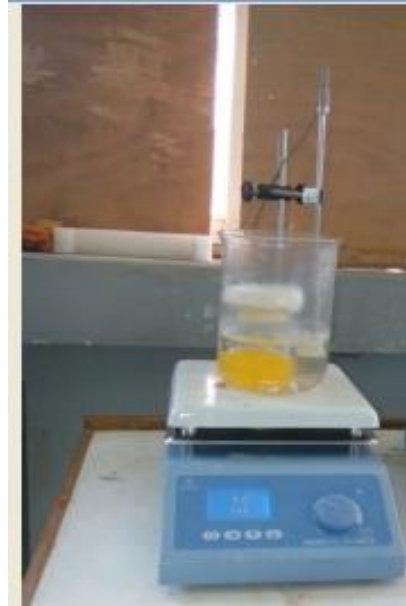


Figure 4.6: Color change of CdS chemical bath during CdS thin film deposition.

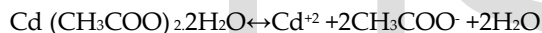
After deposition, the CdS films were removed from the bath and washed with distilled water to remove the loosely adhered CdS particles on the film and finally dried in air. The obtained films are homogeneous, densely packed and smooth well adherent to the glass substrate. All the films used in the present investigation were deposited simultaneously from the same bath deposited using the same chemical solution at different deposition time with a fix temperature. Figure 4.7 shows the color of CdS thin film after deposition.



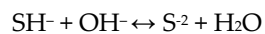
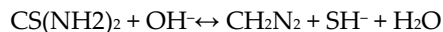
Figure 4.7: The Color of CdS thin film after deposition at t= 45, 60, 75,90min respectively.

1.7 The reaction mechanism of CdS Thin film deposition

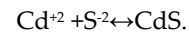
In the chemical bath deposition of CdS thin film semiconductor can be obtained by direct reaction between $[Cd^{2+}]$ and $[S^{2-}]$ precursor species in solution. The cadmium ion is complexed by ammonia to control the slow release of Cd^{+} to avoid sudden precipitation of CdS. The cadmium acetate decomposed as follow:



In the anionic precursor solution, thiourea hydrolysis occurs and gives S^{2-} ions according to:



Finally the cadmium ion (Cd^{2+}) is released from cadmium acetate and sulfide ion (S^{2-}) is released from thiourea. The direct interaction of the Cd^{2+} and S^{2-} by ion by ion mechanism:



When the ionic product exceeds the solubility product of CdS, i.e. $[Cd^{2+}][S^{2-}] \geq K_{sp}$ CdS precipitated as a thin film on the substrate.

2 RESULT ANALYSIS AND DISCUSSION

2.1 Characterization Techniques of CdS Thin Films

2.1.1 FTIR analysis

The FTIR spectroscopy studies were effectively used to identify the functional groups present in the synthesized compound and to determine the molecular structure. In order to analyze qualitatively the presence of the functional groups, "The FTIR spectroscopy studies were conducted by bruker tensor 27 FTIR spectrometer using a standard ATR cell. The samples were scanned from 450 cm^{-1} to 4000 cm^{-1} ." The band positions and numbers of absorption peaks are depending on deposition time, crystalline structure, thickness of thin film and chemical composition, also on morphology [5]. The characteristic vibrational frequencies of the functional groups have been presented in Figure 5.1-5.4. The CdS bond formation our thin film samples increase with the deposition time at 65°C temperature. The efficiency may increase due to the effect of increase of CdS bond formation and improvement of particle size with the deposition time.

A. At t=45minutes

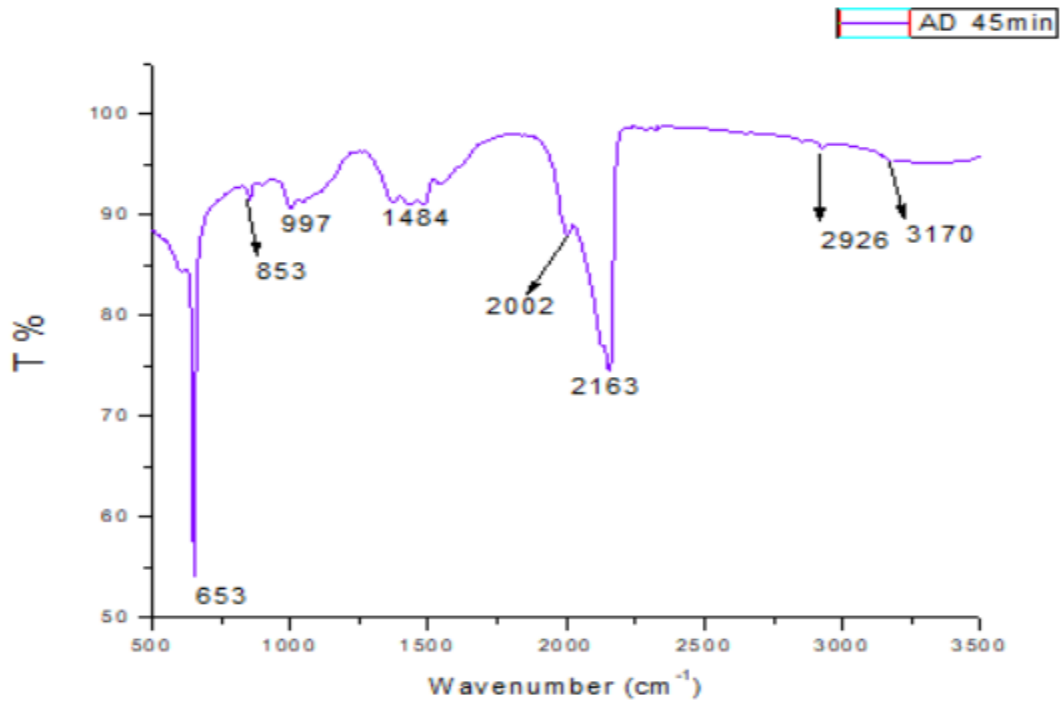


Figure 5.1: FTIR Spectra for CdS thin film at 45 min

Table 5.1: The wave number and chemical bond related to absorption peak in the spectrum at 45min

Wavenumber (cm ⁻¹)	Chemical bond
3170	Hydrogen bond O-H stretching
1484	C-H bending of CH ₃ (acetone)
997	C-O stretching
653	Cd-S stretching
853	SO ₄ ⁻

2002- 2926	C-H Stretching vibration
------------	--------------------------

The absorption bands at 3170cm⁻¹ very strong hydrogen bond O-H stretch and often overlap the C-H absorbance [6]. Sharp or broad C-H bending of CH₃ (acetone) papered at 1484cm⁻¹. CdS particles showed two stretching bands of C-O at 997 cm⁻¹, 653cm⁻¹Cd-S stretch [7]. Trace amount of SO₄⁻as impurity is seen at absorption peak 853cm⁻¹ [8]. The absorption assign to C-H Stretching vibration at 2002-2926cm⁻¹[9].

B. At t=60minutes

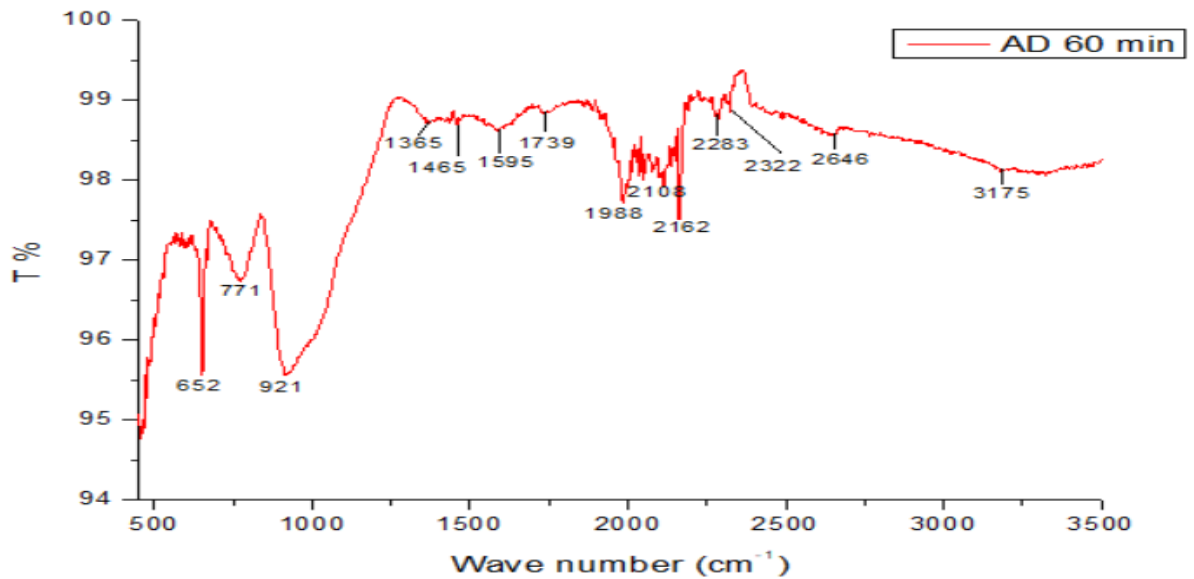


Figure 5.2: FTIR Spectra for CdS thin film at 60 min

Table 5.2: The wave number and chemical bond related to absorption peak in the spectrum at 60min

Wave number (cm-1)	Chemical bond
3175	hydrogen bond O-H stretch
771	C-S stretching
2108-2646	C-H stretching
921	C-C
1988	C=C
652	Cd-S

1365	C-N Stretch (NO ₂)
1465	N-C-N Vibration
1595	C=N
1739	C=O

In the fig. 5.2 shows, the absorption band at 3175cm⁻¹ shows the presence of very strong hydrogen bond O-H stretch and often overlaps the C-H absorbance, the symmetric and asymmetric C-S stretching vibrations in thiourea at 771cm⁻¹[6], [8-10]. The frequency at 2108-2646cm⁻¹,921cm⁻¹,1988cm⁻¹and 652cm⁻¹ due toC-H,C-C, C=C and Cd-S stretch respectively [11-13,9].

C. At t=75minutes

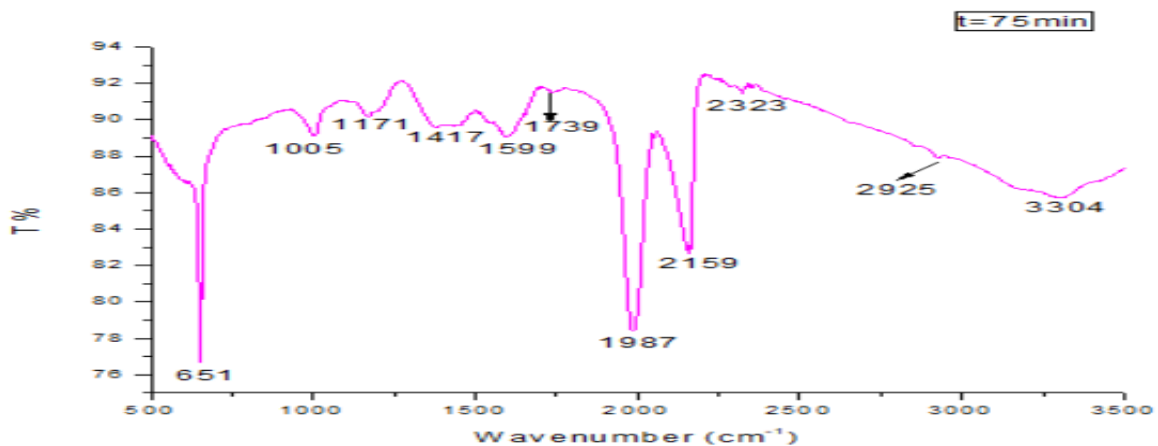


Figure5.3: FTIR Spectra for CdS thin film at 75 min

Wavenumber (cm ⁻¹)	Chemical bond
3304	hydrogen bond O-H (N-H)
1987	C=C
1599	C=N
1171	C-N
959	C-C stretching
1005	C-O stretching
651	Cd-S Stretching
1417	C-O-H bend
2323-2925	C-H Stretching

Table 5.3: The wave number and chemical bond related to absorption peak in the spectrum at t=75min

In the fig. 5.3 shows, the absorption bands at 3304cm⁻¹ shows the presence of very strong hydrogen bond O-H stretch and often overlap the C-H absorbance and N-H Stretching due to the presence of thiourea [14]. C=C absorption band 1987cm⁻¹, C-H stretch assign to 2323-2925cm⁻¹[6, 7-10] ,the bending vibration of C=N at 1599cm⁻¹[15].The presence of thiourea in the sample is identified at 1171cm⁻¹ assign to C-N and C-C stretch at 959cm⁻¹.Small and weak Cd-S (CdS nanoparticle) 651cm⁻¹[16,9].

D. At t=90minutes

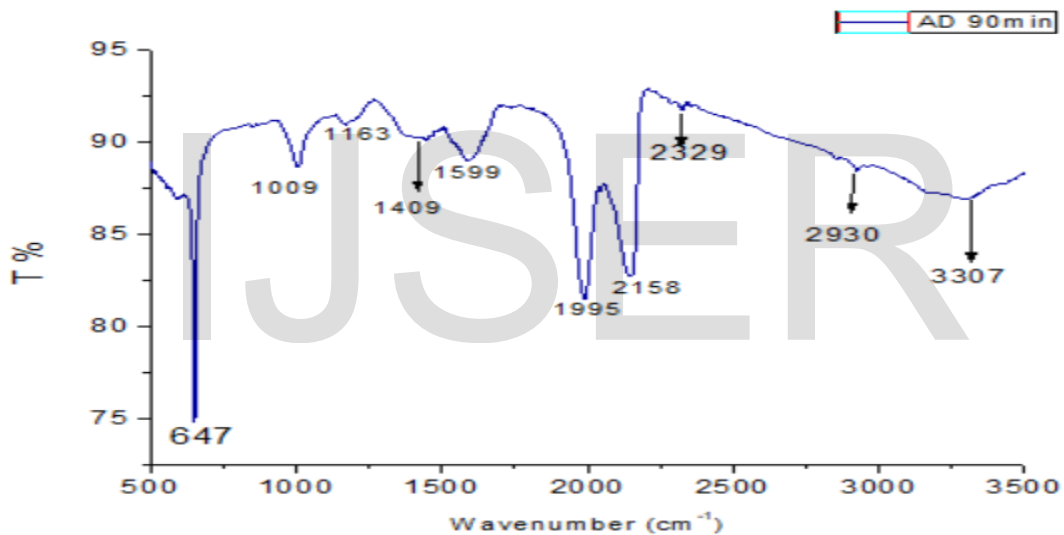


Figure 5.4: FTIR Spectra for CdS thin film at 90 min

Wavenumber (cm ⁻¹)	Chemical bond
3307	Hydrogen O-H bond
2930	C-H stretching
1009-1163	C-N or S-O (acetone or Sulphate)
647	Cd-S stretching
1599	C=N stretching
2158	C-C stretching
1995 -1409	C-O stretching
2329	S-H bond (free H ₂ S)

As shows Figure 5.4, the absorption band 3307cm⁻¹ assign to broad hydrogen bond O-H stretch, small and weak S-H bond (free H₂S) at 2329cm⁻¹, 2930cm⁻¹ to strong C-H stretch. The C-N stretching vibrations at 1009 cm⁻¹ in thiourea are shifted to the higher frequency of 11638cm⁻¹. The increase in frequency may be attributed to a strong double bond character of the carbon to nitrogen bond on complex formation and the single bond character of the carbon to sulfur bond [7]. The peak at 647cm⁻¹ is for CdS stretch. The peak at 1599cm⁻¹, 2158cm⁻¹, 1409-1989cm⁻¹, are respond to the strong bending vibration of C=N, C-C stretching, medium C-O stretching [7-10, 9]. Thesis experimental result shows that, frequency and wave number are directly related but inversely related with wave length. Therefore, when the wave length increases with deposition time we get more molecules of film. When the deposition time varies we obtain more absorption band (peaks) and difference chemical bonds of CdS thin film at different place. Most of CdS bonds and other related bonds are found at blow 1000cm⁻¹ wave number.

2.1.2 UV-Analysis

Optical parameters, like absorbance and band gap are very important parameters to be considered while studying the optical properties of

Table 5.4: The wave number and chemical bond related to absorption peak in the spectrum at 90min.

materials. During this investigation the optical absorption measurement was carried out in the wavelength range from 400 nm to 1000 nm by using a SHIMADUZ UV-3600 Plus spectrophotometer at room temperature. The optical data was then analyzed using the Stern equation for near-edge absorption:

$$A = \frac{K(h\nu - E_g)^{\frac{n}{2}}}{h\nu} \quad (5.1)$$

Where K is constant, E_g is the energy separation between the valence and conduction band that called band gap, A is absorbance, ν is the frequency of the radiation, h is the Planck's constant and n carries the value of either 1 or 4. The value of n is 1 for the direct transition and 4 for indirect transition; respectively is a pure number. Since most of compound semiconductors including CdS have a direct band gap, the value of n was taken to be 1. The band gap energy (E_g) can be obtained by taking the linear portion of the curve towards zero absorption ($(A h\nu)^2 = 0$) [17]. As shown in the Figure 5.5, the estimated band gap values of the films deposited at (45, 60, 75 and 90) min respectively, similarly ref [18] reported. The fundamental absorption, which corresponds to electron excitation from the valence band to the conduction band, can be used to determine the nature and value of the optical band gap.

The band gap of CdS thin films was determined for each film by plotting $(\alpha h\nu)^2$ versus $h\nu$ and then extrapolating the straight line portion to the energy axis [5]. The Tauc plot is used to find the band gap of CdS thin films. As shown in Figure 5.5, the energy gap of the film is continuously decreased from 2.4, 2.2, 2 and 1.98eV as deposition time increases from 45 to 90min respectively. As deposition time increase the thickness of CdS thin film increase but the band gap energy decrease, Because the band gap energy thin film depend on the particle size (thickness). As shown Figure 5.5, the obtained experimental results conclude that an increase in deposition time allows more materials to be deposited onto substrate and thicker films to be formed. For example, the thickness of CdS films was varied as the deposition time was increased. However, the band gap decreases with increase of

film thickness. The band gap values obtained are 2.4, 2.2, 2 and 1.98 eV for the CdS films deposited for 45, 60, 75 and 90 min, respectively [7-10, 19]

have reported a similar trend for the chemical bath deposited Cu₂S films

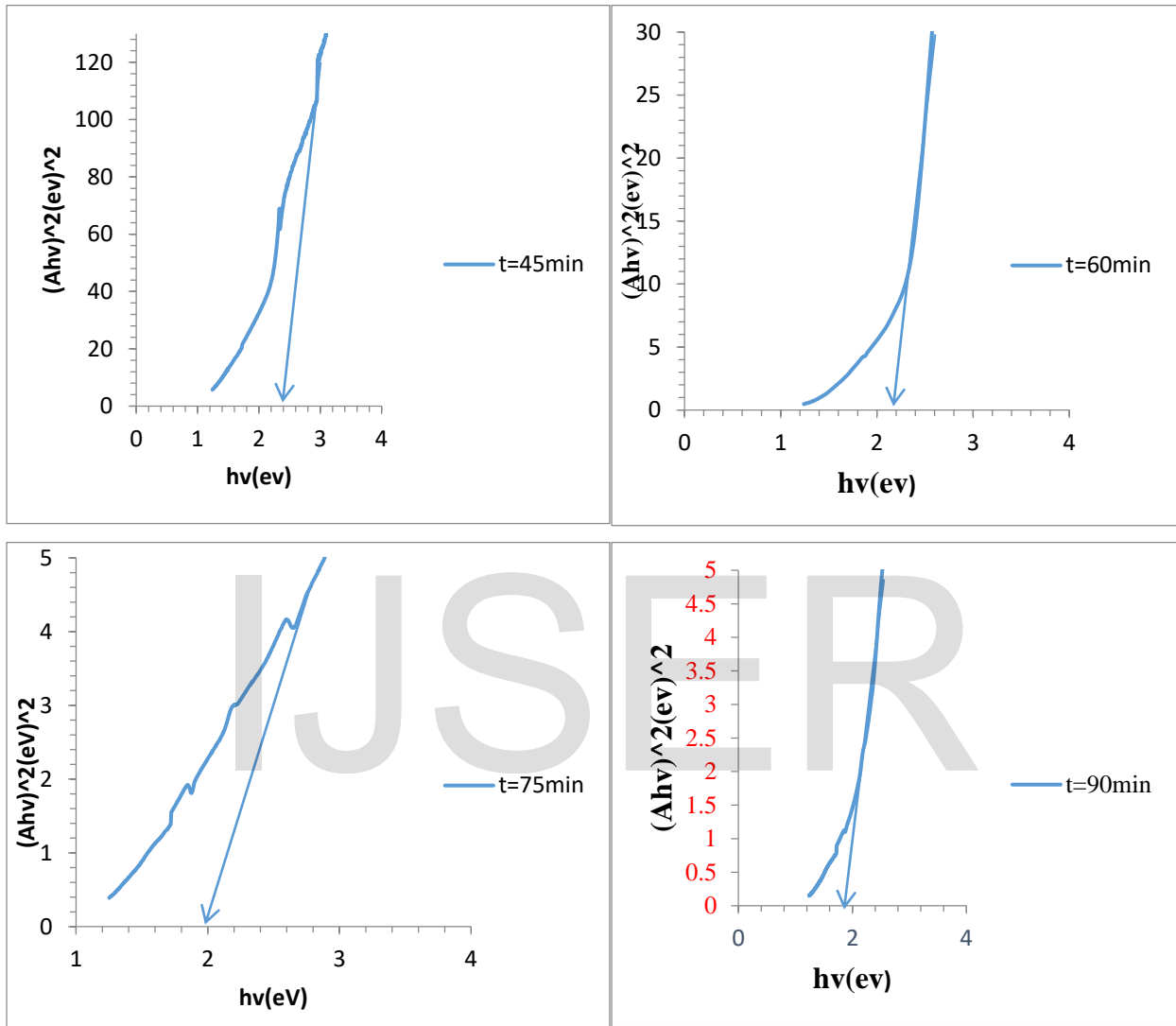


Figure 5.5: A Graph of energy square $(Ah\nu)^2$ vs. photon energy $(h\nu)$ for different deposition time at 65°C.

Table 5.5: Optical band gap with difference deposition time at fixed temperature (65°C)

Deposition time (min)	Band gap (eV)
45	2.4
60	2.2
75	2
90	1.98

2.1.3 Elemental Analysis and Morphological Studies

Elemental analysis for the as-deposited CdS thin film was carried out using Energy-Dispersive X-ray (EDX) attached to the SEM. Oxford X-Max^N energy dispersive X-ray analysis (EDX) attached with a Tescan VEGA3 scanning electron microscope (SEM) is used to study the elemental composition and surface morphology of the samples.

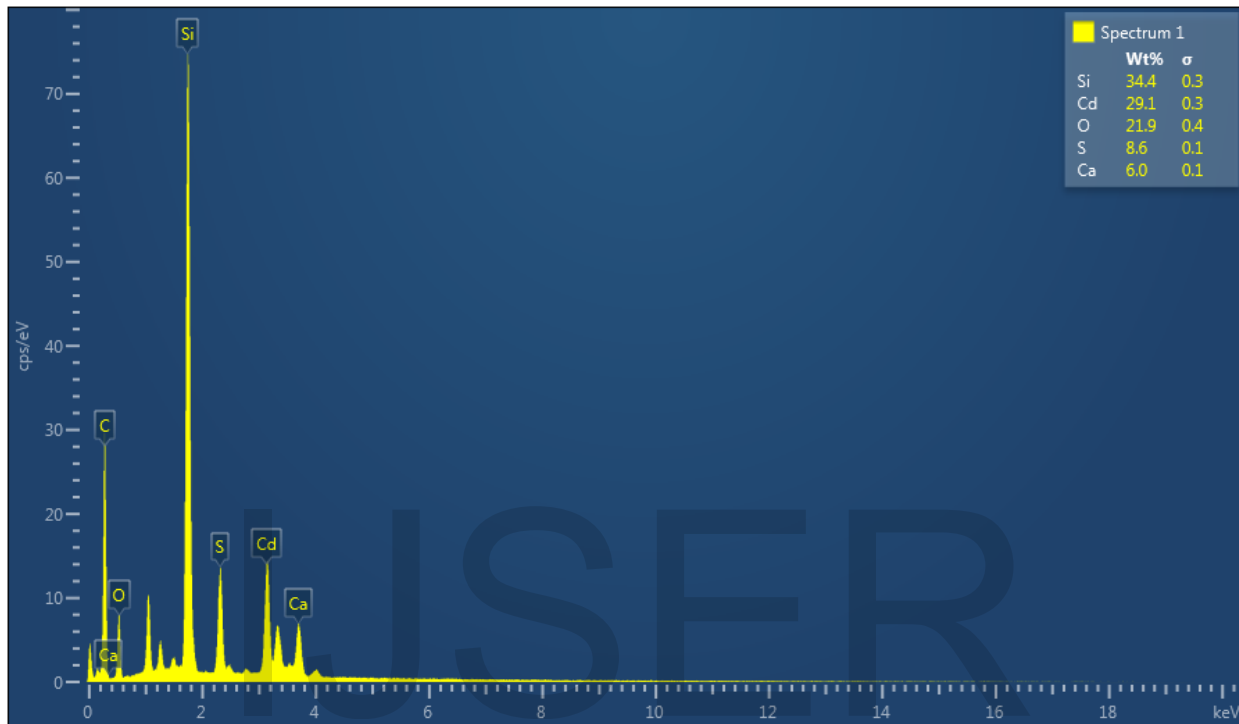


Figure 5.6: Energy-Dispersive X-ray spectrum of the as-deposited CdS thin film at 75min

Figure 5.6 shows the EDX spectrum of the as-deposited CdS thin film, which is consistent with the formation of the binary compound. The atomic percentage of Cd: S is 49.9:50.1, which is nearly 1:1 indicating that the thin film had the desired stoichiometric ratio. This is comparable to results reported by ref [20]. Other peaks such as oxygen, silicon, carbon and calcium are observed. The carbon peak is related to the carbon coating of the films before SEM and EDX analysis. The presence of other peaks may be related to the glass substrate. Figures 5.7, 5.8 and 5.9 show the SEM micrographs

of the as-deposited CdS thin films taken at different magnifications at 75 min within the micrometric range. The surface morphology is composed of largely spherically shaped grains with different grain sizes and uniformly distributed over a smooth homogenous background without visible defects such as cracks, peeling or pinholes. Some of the micrographs also show the presence of pockets of clusters of spherically shaped grains. This is comparable to results reported by ref. [20, 21].

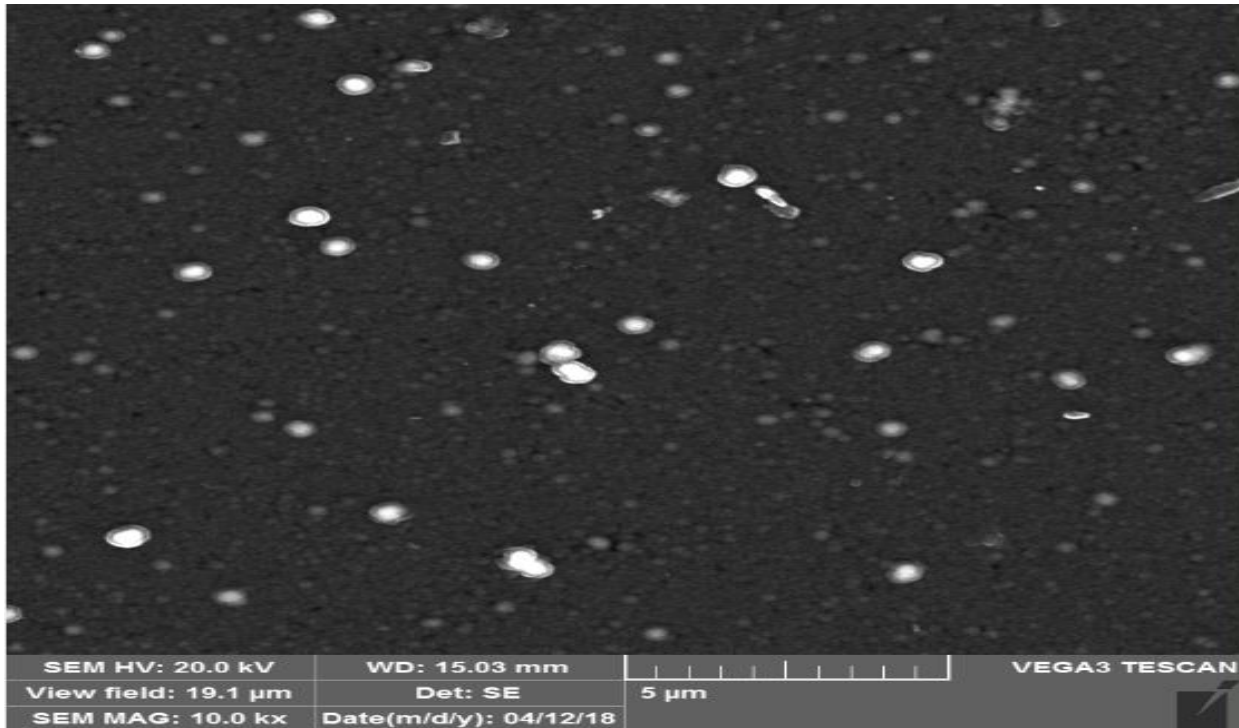


Figure 5.7: The SEM micrograph of as-deposited CdS thin film (magnification 10 KX)

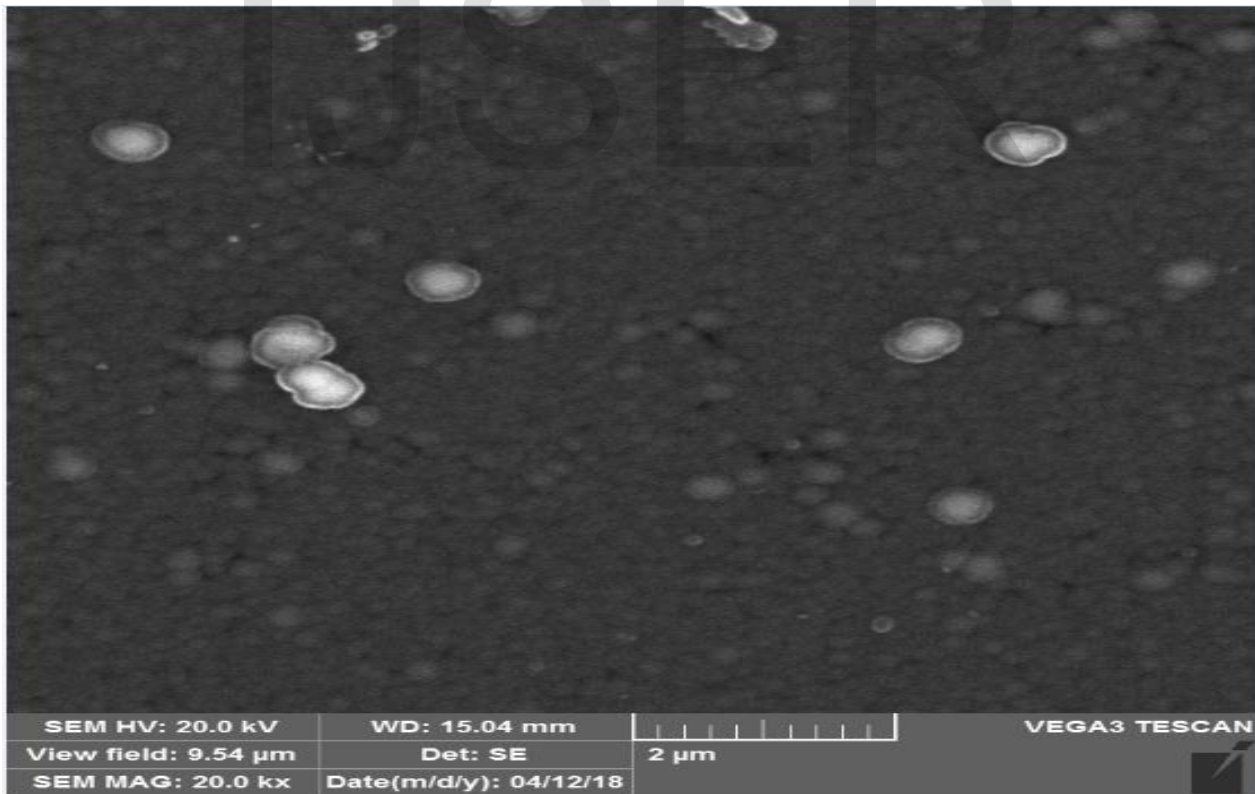


Figure 5.8: The SEM micrograph of as-deposited CdS thin film (magnification 20 KX)

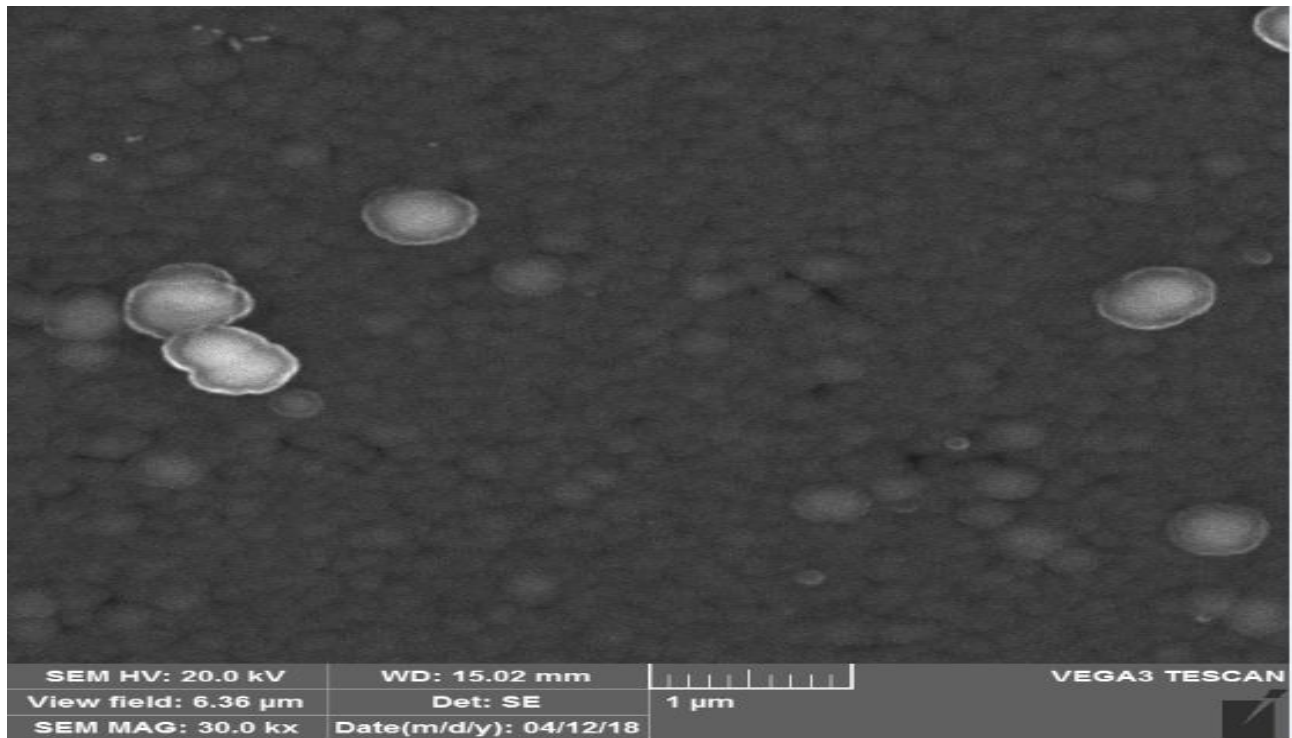


Figure 5.9: The SEM micrograph of as-deposited CdS thin film (magnification 30 KX)

2.1.4 Structural Analysis

Structural characterization has been studied by XRD-7000S. Structural properties of CdS thin films were carried out using X-ray diffractometer, with Cu K ($\lambda = 1.54060 \text{ \AA}$) and energy incidence 40kv, 30 mA.

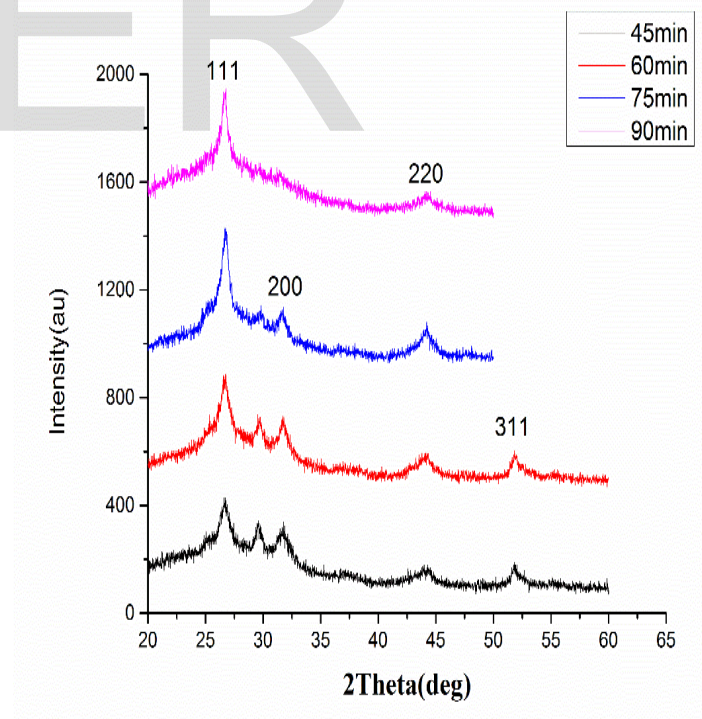


Figure 5.10: XRD patterns of CdS thin films deposited at 45, 60, 75 and 90 min at 65°C

Structural properties of CdS thin films were carried out using X-ray diffractometer, with Cu K ($\lambda = 1.54060 \text{ \AA}$) and energy incidence 40kv, 30 mA. Figure 5.10 shows X-ray diffraction patterns of CdS thin films, deposited with 45, 60, 75 and 90 min. As can be seen all films diffraction patterns exhibit peaks at 26.68° , assigned to the (111) of CdS cubic structure and much well with spatial group F-43m, Space group number (216) having Joint Committee Powder Diffraction System card (JCPDS No:00-010-0454). Two peaks appear at 26.68° and corresponding to plans (111) and (220) respectively in the case of 90min whereas diffraction peak intensity increases with deposition time and the diffraction peak disappeared as deposition time increase from 45-90min; this is a consequence of thickness increasing which leads to better crystallinity of CdS thin films. However, for solar cell applications, Crystal system cubic is preferred due to its thermodynamic stability. The inter-planar spacing d_{hkl} can be calculated from the X-ray diffraction profiles using the Bragg condition equation (4.1). From Figure 5.5, the XRD pattern shows four peaks at 2θ position around $26.68, 31.12, 42.330$ and 52.162 which can be indexed as reflections from the (111), (200), (220) and (311)

planes respectively. The peaks are in good agreement with the standard JCPDS data file reference code: 00-010-0454 and 01-089-0440 of the cubic (Hawleyite) structure. The intensity of the peak at position 26.680 indicates that the grains have a preferred orientation along the (111) plane. The XRD analysis agreed well with earlier reports (20-22). The lattice parameters for cubic phase structure (hkl) are given by equation:

$$a_{hkl} = d_{hkl} \sqrt{h^2 + k^2 + l^2} \quad (5.2)$$

The lattice constant (a) of CdS thin film can be calculated from the preferred orientation of the crystal along (111) plane at $2\theta = 26.68$. The value of $a = 5.77 \text{ \AA}$ obtain from bras law. The crystalline size (D) was obtained from the X-ray diffraction pattern using the scherre (1918) formula which is given:

$$D = \frac{K\lambda}{\beta \cos \theta} \quad (5.3)$$

The CdS thin film at the bath temperature of 65°C with crystalline size $5.91 \text{ nm}, 6.388 \text{ nm}, 7.3 \text{ nm}$ and 7.9 nm , increase as deposition time increase from 45, 60, 75 and 90 min respectively.

Table 5.6: (a) some standard and observed structural parameters of CdS

Standard (JCPDS files cod: 00-010-0454)				Observed values at 45min				Observed values at 60 min			
$2\theta(\text{deg})$	d (nm)	hkl	Lattice parameter (a)	$2\theta(\text{deg})$	d(nm)	hkl	Lattice parameter(a)	$2\theta(\text{deg})$	d(nm)	Hkl	Lattice parameter (a)
26.547	3.355	111	5.811	26.6881	3.337	111	5.779	26.68	3.338	111	5.78
30.748	2.9055	200		31.7262	2.818	200		31.74	2.816	200	
44.04	2.0545	220		42.55	2.122	220		44.00	2.1012	221	
52.16	1.752	311		51.88	1.76	311		51.91	1.759	311	

Table 5.7: (b) some standard and observed structural parameters of CdS

Standard (JCPDS files cod: 00-010-0454)				Observed values at 75min				Observed values at 90 min			
2θ(deg)	d (nm)	hkl	Lattice parameter (a)	2θ(deg)	d(nm)	hkl	Lattice parameter(a)	2θ(deg)	d(nm)	Hkl	Lattice parameter (a)
26.547	3.355	111	5.811	26.6956	3.337	111	5.779	26.68	3.343	111	5.78
44.04	2.0545	220		42.97	2.103	220		44.00	2.138	221	

Conclusion

A well adherent cadmium sulfide thin film has been successfully deposited on glass substrate by using chemical bath deposition technique and the FTIR property successfully studied. The thin films were deposited from chemical bath contains cadmium acetate, thiourea and ammonia hydroxide at deposition time 45, 60, 75 and 90min. The FTIR analyses revealed that the functional group of CdS thin film depend on the deposition time, when the deposition time increase the transmittance of peak increase and the functional group of CdS thin film also increase. Additionally, the peaks are shifted to another wave length due to deposition time and film thickness increase. We obtained Cd-S stretching functional group around $643-652\text{cm}^{-1}$ and other related functional group blow 1000cm^{-1} . The average crystallite size of CdS thin film was obtained using the Debye-Scherrer equation and found to be 5.91nm, 6.388nm, 7.3nm and 7.9nm, increase as deposition time increase from 45, 60, 75 and 90min respectively. The SEM micrographs show the surface morphology is composed of spherically shaped grains. Energy dispersive X-ray spectroscopy confirmed that the as-deposited thin films had the desired stoichiometric ratio. The optical band gap determined from optical absorption spectroscopy, was found in the range of 1.98 eV to 2.4 eV.

Therefore, the functional group of CdS thin film depend on the deposition time, when the deposition time increase the transmittance decrease, number of peaks increase and the position of absorption band slightly changed. Also

the band gap and crystal size were decrease and increase respectively.

ACKNOWLEDGMENT

I am using this opportunity to express my gratitude to my Advisor Dr Fekadu Gashaw from Hawasa and Mr Tekalign Regasa from Jimma University who supported me throughout the course of this research project.

I am thankful for their aspiring guidance, invaluable constructive criticism and friendly advice during the project work. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to the project.

References

1. Abshiro (2015) Synthesis and characterization of cadmium zinc sulphide ($\text{Cd}_{1-x}\text{Zn}_x\text{S}$) Thin films from modified acidic chemical baths for photovoltaic application, Kwame Nkrumah University of Science and Technology
2. Mohite. (2015) studies of doped and undoped nanostructured zinc oxide thin films for solar Cell application, Solapur University, Solapur
3. Pacific Northwest national Laboratory (2008) Materials Science and Technology, Richland, Washington, U.S. Department of Energy, 1-10
4. A .U. Ubale , K. S. Chipade, M.V. Bhute , P. P. Raut, G. P. Malpe (2012). Structural, Optical and Electrical Properties of Nanostructured CdS: CuS Composite Thin Films Grown by CBD Method

- International Journal of Materials and Chemistry 2(4), 165-172
5. M. Muthusamy, S. Muthukumar, M. Ashokkumar, (2014), Composition dependent Optical, structural and photoluminescence behavior of CdS: Al thin films by chemical bath Deposition method, *Ceramics International* 40, 10657–10666
 6. David Halliday, Robert Resnick, & Walker, J. (2011). *Fundamentals of physics*.-9th ed. John Wiley & Sons, Inc United States of America, ISBN 978-0-470-46911-8, 234-251
 7. R. Sathishkumar, E. Devakirubai, A. Dduke John David¹, S. Tamilselvan, and S. Nithyanantham, (2016) Structural and Optical Studies of Cadmium Sulfide (CdS) Thin Film by Chemical Bath Deposition (CBD), *India, Materials Focus*. 5, 1–6, 2016
 8. S. S. Kawar, B. H. Pawar (2009). Synthesis and characterization of CdS n-type of Semiconductor Thin films having nanometer grain size, *Chalcogenide Letters*, 6, 219 – 225
 9. Cao, G., Yan, Y., Zou, X.M., Zhu, R.S. and Ouyang, F. (2018). Applications of Infrared Spectroscopy in Analysis of Organic Aerosols, *Spectral Analysis Reviews*, 6, 12-32
 10. S. C. Ezugwu, F. I. Ezema, R. U. Osuji, P. U. Asogwa, A. B. C. Ekwealor, B. A. Ezekoye, (2009). Effect of deposition time on the band-gap and optical properties of chemical bath deposited CdNiS thin films, optoelectronics and advanced materials – rapid Communications, *Journal of optoelectronics and Advanced Materials*, 3 (2), 141 – 144
 11. S.M. Ho (2015). Chalcogenide Thin Films Prepared using Chemical Bath Deposition Method: Review, *Research Journal of Applied Sciences, Engineering and Technology* 11(10): 1058-1065
 12. Mohite. (2015) studies of doped and undoped nanostructured zinc oxide thin films for solar Cell application, Solapur University, Solapur
 13. Beggas, B. Benhaoua, A. Attaf, M.S. Aida. (2016). Growth study of CdS thin films Deposited by chemical bath, *Optik* 127, 8423–8430
 14. Ashutosh Mishra et al [2014]. X-Ray diffraction and Fourier transformation infrared Spectroscopy studies of copper (II) thiourea chloro and Sulphate complexes, *J. Phys.: Conf. Ser.* 534 012014
 15. Tiwari, Sandip, (1955). *Compound semiconductor device physics*, ISBN 0-12-691740, 675-683
 16. Kariper, E. Güneri, F. Göde, C. Gümüş (2012). Effect of pH on the physical properties Of CdS thin films deposited by CBD, 9(1) 27
 17. SaeidehEbrahimiasl , Wan Md. Zin Wan Yunus AnuarKassim and ZulkarnainZainal (2011), Synthesis of Nanocrystalline SnO_x (x = 1–2) Thin Film Using a Chemical Bath Deposition Method with Improved Deposition Time, Temperature and pH, *Sensors*, 11, 9207-9216; doi:10.3390/s111009207
 18. Selma M. H. Al-Jawad, Ali M. Mousa, WessalAeadTaha (2008) Investigation of optical Properties of cadmium sulfide (CdS) thin films by chemical bath deposition. *Um-Salama Science Journal*, 6(1)
 19. S.M. Ho (2015). Chalcogenide Thin Films Prepared using Chemical Bath Deposition Method: Review Research *Journal of Applied Sciences, Engineering and Technology* 11(10): 1058-1065
 20. Smt. SwapnaSamanta, M. S. Shinde and R. S. Patil, (2015) Studies on Characterization of Cadmium Sulphide Thin Films Deposited by Chemical Bath Deposition (CBD) and Successive Ionic Layer Adsorption and Reaction (SILAR) Method; *Int. J. Thin Fil.Sci Tec.* 4 (2) 97-101
 21. Fekadu Gashaw Hone, Francis Kofi Ampong, TizazuAbza, Isaac Nkrumah, Robert Kwame Nkum and Francis Boakye (2015). Synthesis and Characterization of CdSe Nanocrystalline Thin Film by Chemical Bath Deposition Technique, Kwame Nkrumah University of Science and Technology, *Int. J. Thin. Fil. Sci. Tec.* 4(2), 69-74

22. Rita Anionye Daniel-Umeri (2015). Effect of pH on the Optical Properties of CadmiumSulphide (CdS) Thin Film

Deposited Using Chemical Bath Method. International Journal of Materials Science and Applications, 4 (2), 138-142.

IJSER