

**MULA EDUCATION
SOCIETY'S**

SONAI COLLEGE,



A PROJECTS REPORTS

ON

“CHARACTERISATION OF CDS THIN FILM BY CBD METHOD”

SUBMITTED TO



SAVITRIBAI PHULE PUNE UNIVERSITY

BY

Name of Student

Kakde pradeep ambadas

Prof. Sadekar h.k

Department of Physics,
ACS COLLEGE SONAI YEAR

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M.E. SOCIETY

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SONAI

(AFFILIATED TO SPPU)

CERTIFICATE

This is certify that project work entitled “ has been carried out successfully by **Mr. KAKDE PRADEEP AMBADAS** during the academic year 2020-21in partial fulfillment for their course study for post-graduation in physics as per syllabus prescribed by Savitribai Phule Pune University.

Prof. Sadekar.h.k

(Project guide)

Dr. Sadekar hk

(Head, Dept. of Physics)

Examiner

1) Bhaskar C.H.

2)

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Pradip k
Name of Student

Mr pradeep

ambadas kakde.

A C S college,

Sonai

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Chapter 1

1.1 Introduction

Nanotechnology is one of the most active research areas which has wide applications in almost all fields. Nanotechnology forms bridge that links single elements with single crystal bulk structure. Nanotechnology is part of science

and technology about the manipulation matter on atomic and molecular size. Nano is just a prefix of small-scale size in which 1 nanometer = 10^{-9} m. Technology is the application of science for practical purpose. Nano is a very small in which it is the size as virus and DNA.

The ideas and concept behind nanoscience and nanotechnology started with the talk entitled “There’s plenty of Room at the Bottom” by physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology, on December 29, 1959, long before the nanotechnology word was used. Nanoscience and nanotechnology involve the ability to see and to control individual atoms and molecules. Everything on the Earth is made up of atoms- the food we eat, clothes we wear, the buildings and the houses we live in and our own body. Nanotechnology is also being applied to or developed for applications to a variety of industrial and purification processes. Purification and environmental clean-up applications include the desalination of water, water filtration, wastewater treatment, groundwater treatment and other Nano remediation. In industry, applications may include construction materials, military goods and nano-machining of nano-wires, nano-rods, few layers of graphene, etc.

Current research on semiconductors is focused on the properties of quantum dots which have a large band gap due to the quantum size effect and exhibit strong size-dependent optical and electrical properties. Cadmium sulfide (CdS) is an important semiconductor material. Cadmium Sulfide (CdS) is one of the important wide energy gap semiconductors mainly because of its applications in piezoelectric transducers, laser materials and photovoltaic cells. CdS is n-type of semiconducting material with direct optical bandgap 2.42 eV at room temperature. It has very large scope due to its semiconductor nature and its band gap. Cadmium sulfide (CdS) films deposited by chemical of that heterojunction are not fully understood yet and in bath deposition (CBD) have been used for the fabrication particular it is not clear which role play the intrinsic of high efficiency

CdTe and CuIn, Ga, Se, thin films solar properties of CdS, i.e. band gap, band line up with CIS cells technique has proved its excellence for larger area for thin film

1.2 Why cadmium Sulphide?

cadmium sulfate is an inorganic compound with the formula cds. It finds limited use in electronic devices. CdS, also known as galen

a, is the principal ore and most important compound of lead.

Molecular formula:	cds.	Appearance	Yellow-orange to brown solid
Density	4.826 g/cm ³ , solid	Molar mass:	144.48 g·mol ⁻¹
Melting point:	1,750°C (3,180 °F;2,020 K)		10 Mpa
Boiling point:	980 °C (1,800 °F;250 K)		(sublimation)
Solubility in water	insoluble		
Solubility	soluble in acid		
Refractive index	2.529		
Crystal structure:	hexagonal.		

1.3 Applications of cadmium Sulphide

CdS is one of the oldest and most common detection element materials in various infrared detectors. As an infrared detector, cds functions as a photon detector, responding directly to the photons of radiation, as opposed to thermal detectors, which respond to a change in detector element temperature caused by the radiation. applications

- 1) For solar cells applications.
- 2) Used in the deposition of CdS semiconductor thin films since the 1960s.
- 3) CdS. used as a window material in high efficiency thin film solar cells based on CdTe
- 4) and Cu(In, Ga)Se₂ (CIGS) .
- 5) It has also been used in other applications including electronic and optoelectronic devices.
- 6) Although other techniques have been used in the deposition of CdS, chemical bath deposition is known to enhance the performance of cadmium sulfide window used in solar cell.
- 7) CdS films also need to have a suitable conductivity, and adequate thickness to allow high transmission (50–100 nm) and good uniformity to avoid short circuit effects.

Chapter 2

Synthesis and Characterizations Technique:

2.1.1 Electro deposition

Electro deposition is widely used in making metallic coatings. Electrodeposition can be understood as a special electrolysis resulting in the deposition of solid material on an electrode. This process involves i) oriented diffusion of charged growth species (typically positively charged ions) through a solution when an external electric field is applied and ii) reduction of the charged growth species at the growth or deposition surface which also serves as an electrode. Electrodeposition is only applicable to electrically conductive substrates. The process is also known as electroplating. When deposition is confined inside the pores of template membranes, if the template membrane is removed, nanorods or nanowires are prepared.

2.1.2 Electroless deposition

In the electroless deposition films of metals may be deposited directly without any electrode potentials being involved, by the use of suitable compound in solutions. Such deposition is known as electroless deposition or chemical reduction plating. In electroless deposition films can be grown on substrate by dipping them in appropriate solutions of metal salt and reducing agent without the application of any electric field. Deposition may occur by homogeneous chemical reactions usually reduction of metal ions in solution by a reducing agent. There are three type of reaction takes place, i) Noncatalytic reaction where any type of substrate used, ii) Catalytic reaction where the film formation takes place on metallic substrate and iii) Catalytic reaction using activators where deposition takes place with the help of activators to activate non-catalytic surface.

2.1.3 Spray pyrolysis

This is thermally stimulated reaction between the clusters of liquid / vapour atoms of different spraying solutions of the desired compound onto the substrate maintained at elevated temperature. The sprayed droplets on reaching the hot substrate undergo pyrolytic decomposition and form a single crystal or cluster of a crystallite product. The other volatile byproducts and excess solvents escape in the crystallite of the product. The other volatile byproduct and excess solvents escape in the vapour phase. The thermal energy for decomposition, subsequent

combination of the species, sintering and recrystallization of crystallites is provided by hot substrates.

2.1.4 Sol-gel method-

Sol-gel method is commonly useful in formation of metal oxide. Sol-gel process is low temperature process. Sols are solid particles in liquid. Gels are nothing but a continuous network of particles with pores filled with liquid. A sol-gel process involves formation of sols in liquid and then connecting the sol particles to form porous network. By drying the liquid, it is possible to obtain powders, thin films.

2.1.5 Successive ionic layer adsorption and reaction (SILAR)

In SILAR method thin films are obtained by immersing substrate into separately placed cationic and anionic precursors and rinsing between every immersion with ion-exchanged water. The rinsing time in ion exchange water is critical for ionic layer formation. Basic mechanism of SILAR involves three most important steps: (i) specific adsorption of the most strongly adsorbed ions of the compound to be grown, by the substrate immersion in a solution of one of its cationic precursors, (ii) water rinsing of the excess solution still adhering to the substrate, and (iii) chemical reaction between the most strongly specific adsorbed cations and the less strongly adsorbed anions by the subsequent substrate immersion in the solution.

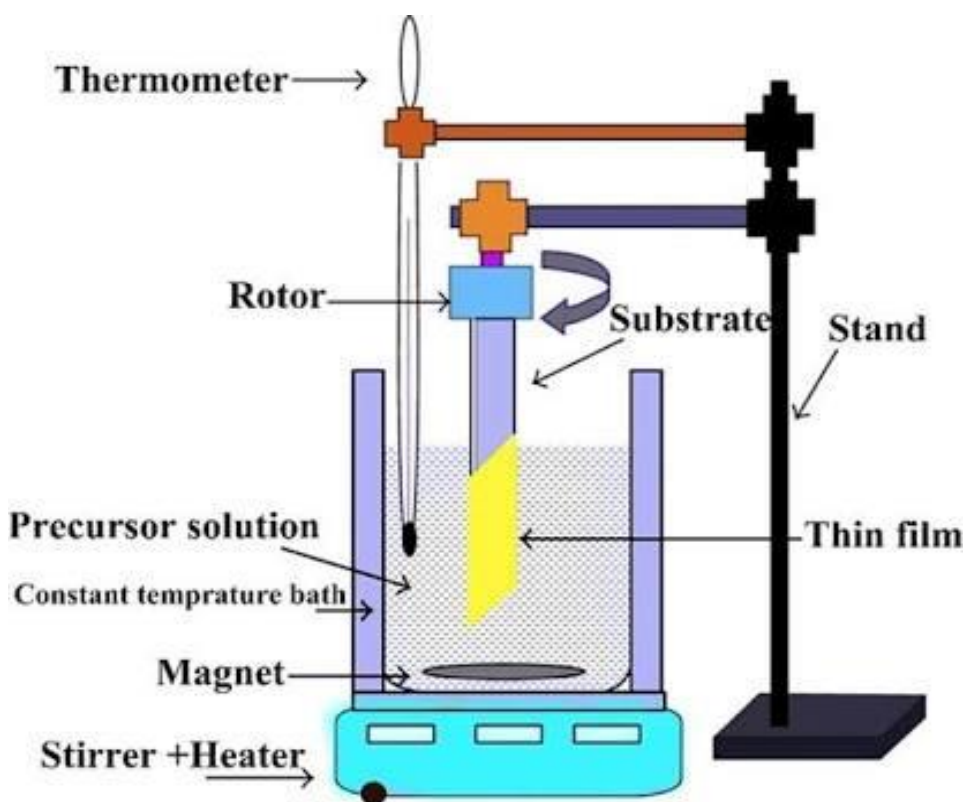
2.1.6 Chemical Bath Deposition (CBD) :

Chemical bath deposition (CBD), or chemical solution deposition (CSD), is a method to deposit thin films and nanomaterials, first described in 1869. Chemical bath deposition (CBD) is the simplest, inexpensive and convenient method for large area deposition at room temperature. It is also known as chemical solution deposition (CSD) or chemical deposition (CD). This technique was first used for the deposition of silver on the silver mirror by Liebig. The deposition technique was first described in 1869. For the deposition of films this technique requires a vessel to contain the aqueous solution of common chemicals and the substrate on which deposition is to be carried out. In addition to this condition like, deposition conditions such as mechanism for stirring and a thermostat bath to maintain a specific and constant temperature should be optimised. The general review on chemical bath deposition techniques were published by many researchers. Chemical deposition is the deposition of films on a solid substrate from a reaction occurring in a solution

using the prototypical metal sulphide as, a metallic salt in solution can be converted to metal sulphide by adding sulphide ions, metal sulphide immediately precipitates unless the solution is very dilute a few milli molar or less in which case metal sulphide forms as a colloidal solution. The rate can be controlled by formation of the sulphide slowly in the solution. The rate of formation of sulphide, and therefore reaction, can be controlled by parameters, such as the concentration of sulphide forming precursor, temperature and pH of solution. However, depending on the deposition condition like pH, of the solution, temperature, stirring, time of deposition the quality as well as the stoichiometry of the film differs and hence their structural and optical properties. Many scientists have reported that chemical bath deposition can be carried out in acidic as well as alkaline solutions, most of the CBD reactions have been carried out in alkaline solutions.

Experimental set-up :

The experimental set up used for the thin film deposition by chemical bath deposition (CBD) method is shown in fig. . It consists of container, usually a glass beaker, magnetic stirrer, substrate holder and thermometer etc.



Experimental set up for chemical bath deposition (CBD) method

The water bath is kept on the magnetic stirrer-heater set up in order to maintain the constant temperature. The substrates are dipped in to the glass beaker containing precursor solution. The glass beaker serves two purposes as chemically inertness and visibility inside the bath

Advantages:

- 1) The method does not require sophisticated instrumentation.
- 2) It is applicable for large area deposition.
- 3) Electrical conductivity of the substrate materials is not an important criterion.
- 4) The deposition is easy even at low temperature and avoids the oxidation or corrosion of the metallic substrate.
- 5) An intimate contact between reacting solution and substrate gives pinhole free and uniform deposition.
- 6) Stoichiometry of the deposit can be easily maintained.
- 7) The process is slow that facilitates better orientation of crystallites with improved grain structure.
- 8) The method can be used to deposit a large number of metal chalcogenides.
- 9) As very dilute solutions are used in the process, the method offers minimum toxicity and occupational hazards

Disadvantages:

- 1) Wastage of solution after every deposition.
- 2) Proper substrate cleaning is very important factor in obtaining good adherent film

2.2 Characterization Techniques

2.2.1 X-Ray Diffraction (XRD)

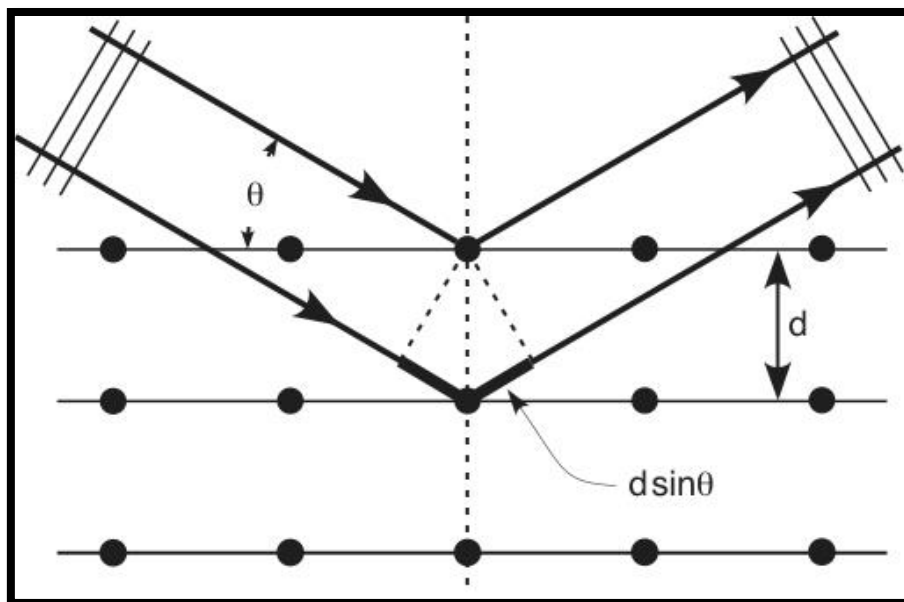
X-ray diffraction (XRD) is well known technique to obtain the information of composition, phase and crystallite orientations of the material. Structure identification, determination of lattice parameters and grain size are based on the X-ray diffraction pattern. Improved detection methods for X-ray, the availability of commercial mono-chromators and intense micro focus X-ray sources have made X-ray diffraction method applicable to film as thin as 100Å. The several workers have described X-ray diffraction arrangement, suited to study of thin films. This technique employs a chromate to provide a diffracted beam, which is further diffracted from the film surface oscillating about the mean diffraction position. The X-ray diffraction technique based on monochromatic radiation is more important because the spacing of the planes can be deduced from the observed diffraction angles. The phenomenon of X-ray diffraction can be considered as reflection of X-rays from the crystallographic planes of the material and is governed by the Bragg's equation;

$$2d \sin\theta = n \lambda$$

Where, d is lattice spacing, λ is the wavelength of the monochromatic X-ray, n is the order is diffraction and θ is diffraction angle. The 'd' values are calculated using above relation for known values of θ , λ and n. the X-ray diffraction data thus obtained is compared with American Standards for Testing of material (ASTM) powder diffraction data to identify the unknown material. The sample used may be powder, single crystal or thin film.

The crystallite size (D) of the deposits is estimated from the full width at half maximum (FWHM) of the most intense diffraction line by Scherer's equation as follows.

Where, D is crystallite size, λ is wavelength of X-rays used (Cu K α 1.0542 Å), β is full width of half maxima of the peak (FWHM) in radians, θ is Bragg's angle and K is constant. Value of K varies from 0.89 to 1.39, but for most cases it is closer to 1. Though this technique is applicable for determination of crystal structure, lattice parameters, particle size etc, it is not useful for identification of individuals of multilayer or percentage of doping material.



Bragg's diffraction by using X-ray and XRD graph with intensity variation

2.2.2 UV-Vis spectroscopy

It involves the spectroscopy of photons & spectrophotometer. It uses light in the visible & adjacent near ultraviolet & near infrared ranges. In this region of energy molecules of space undergo electrons transitions. UV/Visible spectroscopy is routinely used in the quantitative determination of solution in the transition metal ions & highly conjugated organic compounds.

- 1) Solution of transition metal ions can be colored (i.e. absorb visible light) with d-electrons within the metal atoms can be excited from one electronic state to another. The colors of metal ions solution in strongly affected by the other species such certain anions or legends.
- 2) Organic compounds also absorb light in the UV or visible regions of the electromagnetic spectrum solvents for these determinations are often water for water soluble compounds or ethanol for organic soluble compounds.
- 3) While charge transfer complexes also give rise to color so the color are often too intense to be used for quantitative measurement.

The Beer-Lambert law states that the absorbance of a solution is directly proportional to the concentration of the absorbing species in the solution and the path length. Thus, for a fixed path

length, UV/VIS spectroscopy can be used to determine the concentration of the absorber in a solution.

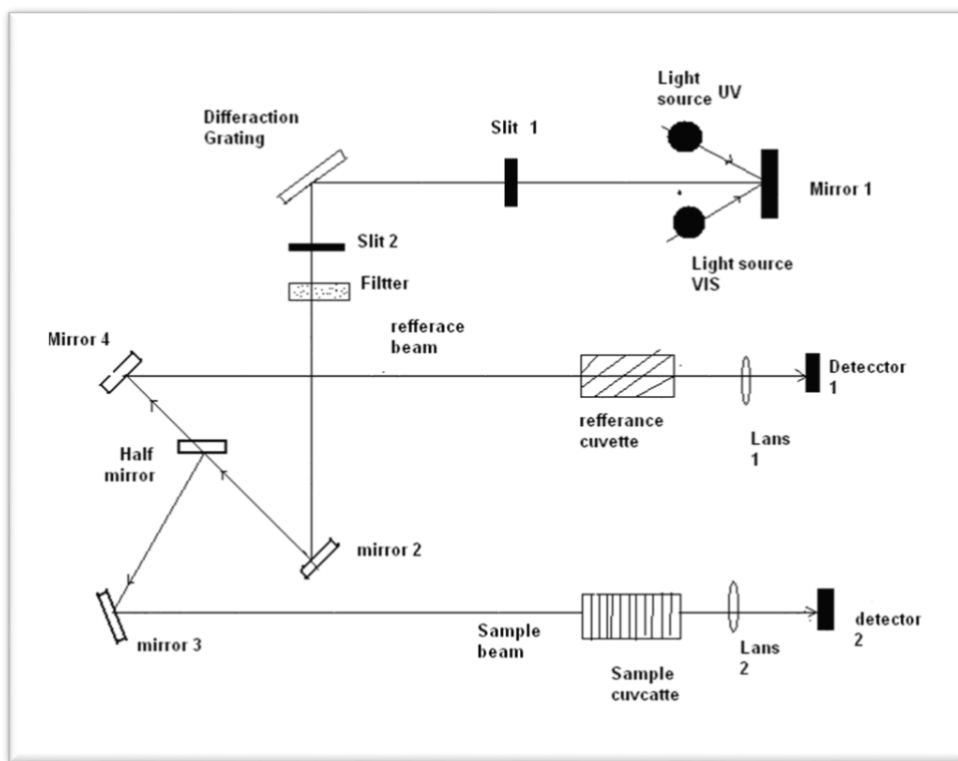
The method is most often used in a quantitative way to determine concentrations of an absorbing species in solution, using the Beer-Lambert law:

–

where A is the measured absorbance, I₀ is the intensity of the incident light at a given wavelength, I is the transmitted intensity, L the path length through the sample, and c the concentration of the absorbing species. For each species and wavelength, ε is a constant known as the molar absorptivity or extinction coefficient.

The instrument used in ultraviolet-visible spectroscopy is called a UV-Vis spectrophotometer. It measures the intensity of light passing through a sample (I), and compares it to the intensity of light before it passes through the sample (I₀). The ratio I / I₀ is called the transmittance, and is usually expressed as a percentage (%T). The absorbance, A, is based on the transmittance:

$$A = - \log (\%T / 100\%) \quad (3.3)$$



Block diagram of UV-Vis spectrophotometer

The spectrophotometer consists of a light source (an incandescent bulb for visible wavelength or a deuterium arc lamp in UV), a sample holder, diffraction grating or monochromator to separate the different wavelength of light & a detector. The detector is typically photodiode or a CCD. Photodiodes are used with monochromator which filter the light so that only light of single wavelength reaches the sample. Diffraction gratings are used with CCDs which collect light of different wavelength on different pixels.

Study of the optical properties of the films is necessary for applications of the films in opto-electronic devices. The considerable theoretical and experimental investigations on the optical behavior of thin films deal primarily with reflection, transmission and absorption properties and their relation to the optical constants of the film. The equilibrium situation semiconductor can be distributed by generation of carriers due to optical absorption. Optical photon incident on any material may be reflected, transmitted or adsorbed. The phenomenon of radiation absorption in a material is altogether considered to be due to (i) inner shell, (ii) valence band electron, (iii) free carriers including holes as well as electrons, and (iv) electron bound to localized impurity centre or defects of some type. In study of fundamental property of the semiconductors, absorption by the second type of electron is of great importance. In an ideal semiconductor, at absolute zero temperature the valence band would be completely full of electrons, so that electron could not be excited to higher energy state from the valence band. Absorption of quanta of sufficient energy tends to transfer of electrons from valence band to conduction band.

For crystalline materials, the transition of electrons from valence band to conduction band can be grouped into direct and indirect process. In direct inter band optical transition the value of wave vector K for electrons remains unchanged in $E-K$ space and momentum also does not change, while in indirect inter band transition the wave vector K for electrons changes in the $E-K$. It is possible to differentiate the nature of optical transition as direct allowed or direct forbidden by classical relation

Chapter 3

Experimental works

3.1 Substrate Cleaning:

The commercial glass micro slides (Blue star) of the dimensions of 75 X 25 X 1.35 mm were used as substrate. Substrate cleaning plays a vital role in the deposition of thin films. The properly cleaned substrates are required for the deposition. The contaminated substrate surface provides nucleation sites facilitating the growth, which results non-uniform film growth. The cleaning technique depends on the nature of the substrate, the nature of the contaminants and the degree of the cleanness required. The contaminants include those from manufacturing procedures, human contact, airborne dust, and grease and oil particles. To avoid the contamination the surface of substrate must be made clean enough that contaminant particles do not interfere with the adherence of a deposited film. Cleaning involves the washing the substrate and contaminants without damaging the substrate surface itself by surfactants, chromic acid and distilled water. The following procedure has been adopted for cleaning of the micro slide glass substrate deposition

- 1) First the micro slides were washed with double distilled water,
- 2) The substrate is then washed with surfactant,
- 3) Then boiled with concentrated nitric acid solution for 1 day,
- 4) The substrate were washed with double distilled water,
- 5) Finally, the substrates were degreased in AR grade acetone, air dried and were used for deposition.

3.2 Preparation of precursor solution:

All the chemicals used for the deposition were of AR grade. The solutions were prepared in double distilled water. The chemicals used were

- 1) Cadmium sulphate octahydrate, Loba (India) Ltd.
- 2) Thiourea, Loba (India) Ltd.
- 3) Aqueous ammonia Loba (India) Ltd.
- 4) Acetone Loba (India) Ltd.

All the solutions were prepared in double distilled water by weighing the chemicals on analytical balance

Molecular weight (Analytical grade)

Chemical	Molecular formula	Molecular weight
Cadmium sulphate	CdSO ₄	208.47 g/mol
Thiourea	CS(NH ₂) ₂	76.12 g/mol

The stock-solutions of high purity cadmium sulphate (CdSO₄), thiourea [CS(NH₂)₂] and ammonium hydroxide (NH₄OH) in aqueous medium were prepared using distilled water. CdSO₄ is the source of Cd²⁺ ions, CS(NH₂)₂ is the source of S²⁻ ions and NH₄OH is a complexing agent. High purity AR grade Loba chemicals were used. 1M CdSO₄ solution was prepared by dissolving 2.0847 g of CdSO₄ in 10 mL of distilled water. 1M CS(NH₂)₂ was prepared by dissolving 7.612 g of thiourea in 10 mL of distilled water. 10 M (25%) NH₄OH was used. The molarity (M) is given by

$$M = \frac{\text{number of moles of solute}}{\text{Volume of solution (l)}}$$

3.3 Deposition of the nanocrystalline CdS thin films:

The Semiconducting cadmium sulphide thin films were deposited by using Loba analytical reagent grade cadmium sulphate (CdSO₄), thiourea (CH₄N₂S) and aqueous ammonia (NH₃). The CdS thin films were prepared from alkaline bath using cadmium sulphate, thiourea and ammonia as Cd²⁺, S²⁻ ion sources and ligand respectively. The preparative parameters such as ion concentration, deposition time, pH of solution, were optimized. For the deposition of CdS thin films, 10 ml 1M cadmium sulphate solution and 2 ml. aqueous ammonia was taken in 50 ml glass beaker. To this solution, 10 ml 1 M thiourea solution was added with constant stirring. The pH of



the solution was adjusted to 12. The cleaned glass substrate was clamped vertically with the holder and the holder is properly fixed in beaker containing the precursor solution. During the deposition the mixture of solution was continuously stirred at room temperature (300 K). The substrate coated with CdS thin film were taken out from the precursor mixture after 2-hour time interval, washed with distilled water and dried in open air. CdS thin films prepared by this method were homogeneous uniform, well substrate covered and yellowish in color.

3.4 Reaction mechanism and growth of CdS thin films:

Nanocrystalline CdS film can be prepared by hydrolysis of thiourea in an alkaline medium containing a Cd^{2+} salt and a suitable complexing agent which allows for obtaining a soluble species, Cd^{2+} in this medium. The decomposition of CdS occurs when ionic product of Cd^{2+} and S^{2-} exceeds the solubility product of CdS [$K_{sp}(\text{CdS}) = 10^{-28}$]. In presence of ammonia, cadmium complex formation of $\text{Cd}[(\text{NH}_3)_4]^{2+}$ takes place at $\text{pH} \sim 10$. This complex is soluble in an alkaline

medium. The general chemical equation for the formation of CdS thin film can be written as follows

Thiourea (CH₄N₂S) hydrolyses in solution to give S²⁻ ions according to:



Similarly, ammonia hydrolyses in water to give OH⁻ ions according to the equation,



When ammonia solution is added to Cd²⁺ salt solution, Cd (OH)₂ starts precipitating when solubility product (SP) of Cd (OH)₂ is exceeded, i.e.



The Cd (OH)₂ precipitate dissolves in excess ammonia solution to form the complex cadmium tetra- amine ions [Cd (NH₃)₄]²⁺,



Finally, the CdS thin film formation takes place,



3.5 Instruments

Magnetic heater and stirrer:

Magnetic stirrers use a rotating magnetic field to move a stir bar around in liquid samples. The movement of this stir bar mixes the sample thoroughly with rapid movement and agitation. The speed of the magnetic field is controlled by the user, so it can be customized to the specific sample that's being stirred. These stirrers should be used with glass or other non-metal beakers to prevent interference with the magnetic field.

Depending on the application, you can configure your magnetic stirrer with hot plates to heat your samples as they're stirred. With the use of heating plates, you can mix a wide variety of samples for different applications.

This is use for heating and stirring of solution which work on magnetic field. The temperature is can be set as we required and rpm can be adjusted



Fig. Magnetic stirrer

Analytical balance:

Analytical balance (lab balance) is a class of balance designed to measure small mass in the sub-milligram range. The measuring pan of an analytical balance is a transparent enclosure with doors so that dust does not collect and so any air currents in the room do not affect the balance's operation.

The Analytical balance is use to weight a chemical substance. Its least count is 0.0001g. The balance is capable to weighing up to 0.001 to 0.0001g



Fig. Analytical Balance

X-ray Diffractometer:

There are different types of X-ray diffractometers for crystal structure analysis. Some can be used for Nano-materials analysis. The most commonly used diffractometers are known as Powder diffractometers or Debye-Scherrer Diffractometers after their inventors.

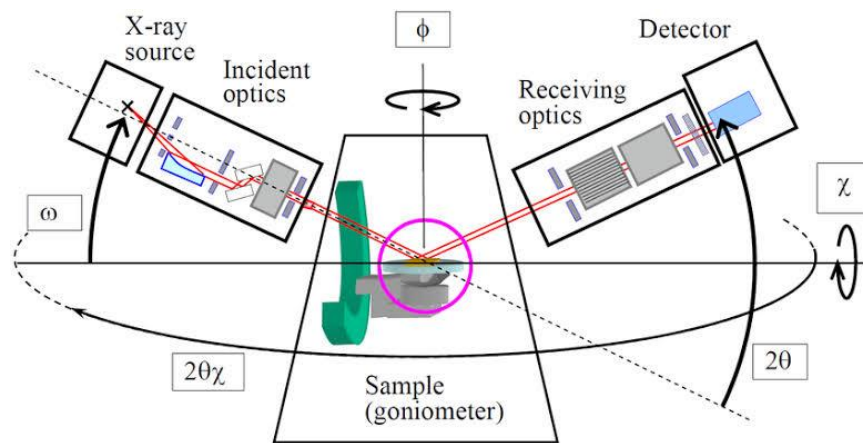


Fig. X-ray Diffractometer

This diffractometer is conceptually simple and allows quite an accurate determination of crystal structure of polycrystalline samples, thin films and nanoparticle. As illustrated in above figure it consists of a monochromatic source of x-rays, sample holder and an X-ray detector. Both sample and the detector move around an axis passing through sample center and normal to the plane of the paper. The diffracted rays make angle 2θ at the detector with respect to incident beam direction. A plot of intensity (counts), as a function of angle 2θ (usually 20 to 160), is diffraction pattern ready for analysis. Detector is a suitable photon counter like Geiger Muller tube, proportional counter scintillation counter etc. Usually, due to finite size of X-ray beam 1-2 mm², smaller angles ($<20^\circ$) are not accessible using these diffractometers. However, for some detailed analysis of thin films or nanoparticles, where additional information is needed as small as $0.1-0.2^\circ$, modifications of Debye Scherrer Diffractometer or other diffractometers are needed.

Chapter 4

Result and Discussion

4.1.1 Analysis of XRD

2θ	θ	θ in rad	$\sin\theta$	$\sin^2\theta$	$\sin^2\theta/\sin^2\theta_{\min}$	$3*(\sin^2\theta/\sin^2\theta_{\min})$	$h^2+k^2+l^2$	(h,k,l)	$d=\lambda/2\sin\theta$	$a=d*(h^2+k^2+l^2)^{0.5}$
23.2736	11.6368	0.203094	0.201701	0.040683	1	3	3	111	3.8190159	6.614729605
24.8728	12.4364	0.21705	0.21535	0.046375	1.139911	3.419732855	3	111	3.5769758	6.195503874
26.4614	13.2307	0.230912	0.228866	0.05238	1.287494	3.862481832	4	200	3.3657269	6.731453759
28.1476	14.0738	0.245627	0.243164	0.059129	1.453394	4.360181789	4	200	3.1678149	335629805 6.
30.0549	15.02745	0.262271	0.259274	0.067223	1.65235	4.957050918	5	210	2.9709846	6.643323607
31.3465	15.67325	0.273542	0.270143	0.072977	1.793788	5.381364989	5	420	2.8514507	6.376037661
43.6763	21.83815	0.381136	0.371976	0.138366	2.983603	8.950808112	9	300	2.0708351	6.212505185
47.8875	23.94375	0.417885	0.405828	0.164697	3.14429	9.432870757	9	300	1.8980933	5.694279903
51.6233	25.81165	0.450485	0.435402	0.189575	3.206129	9.618387655	10	310	1.7691689	5.594603164
									Average=	6.26645184

Table: Calculation to determine lattice parameter and particle size determination

Xrd pattern follows

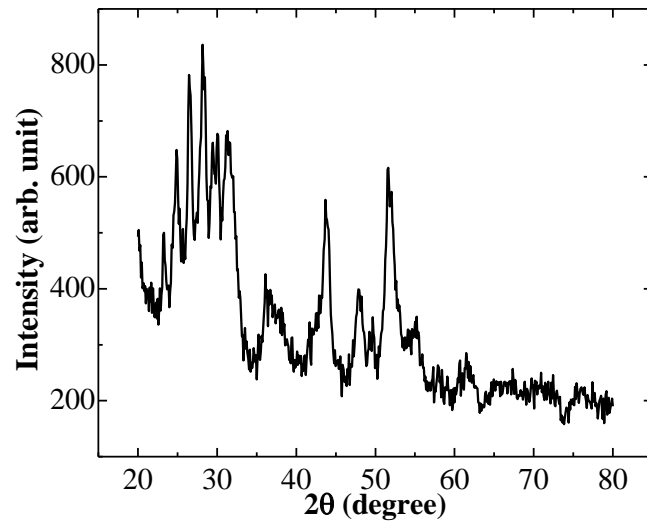
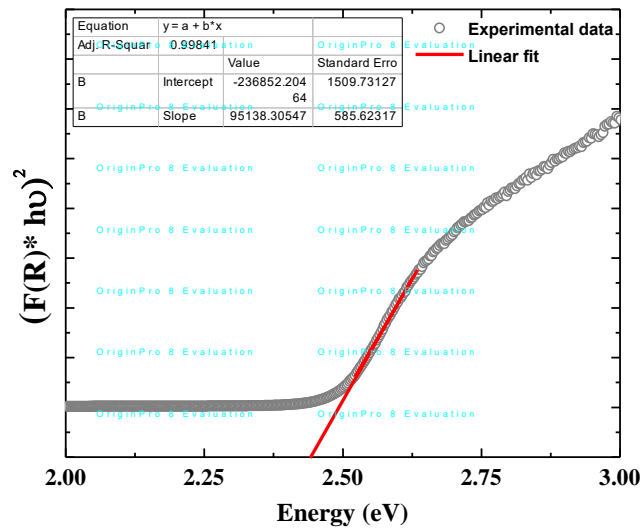
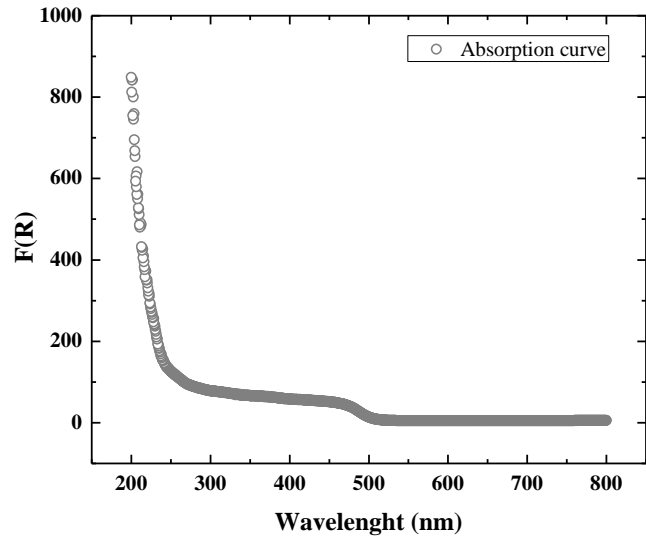


Fig. Xrd of cds thin film

From the X-ray diffraction data, we get the plot as above which tells us the information about its structure and particle size. The XRD shows that the structure cds is hexagonal

DRA analysis



The nature of the transition was determined using the Tau's relation,

$$[(h\nu\alpha)]^{1/n} = A (h\nu - E_g)$$

where 'hv' is the photon energy, and A, n are constants. The exponent n depends upon the type of transition and has values of 1/2, 2 and 3/2 for direct, indirect and direct forbidden transitions, respective

The optical band gap of material is found by following formulation,

$$E_g = \frac{\text{intercept value}}{\text{slope value}} = \frac{236852.204}{95138.305} = 2.48 \text{ eV}$$

Structure visulaization

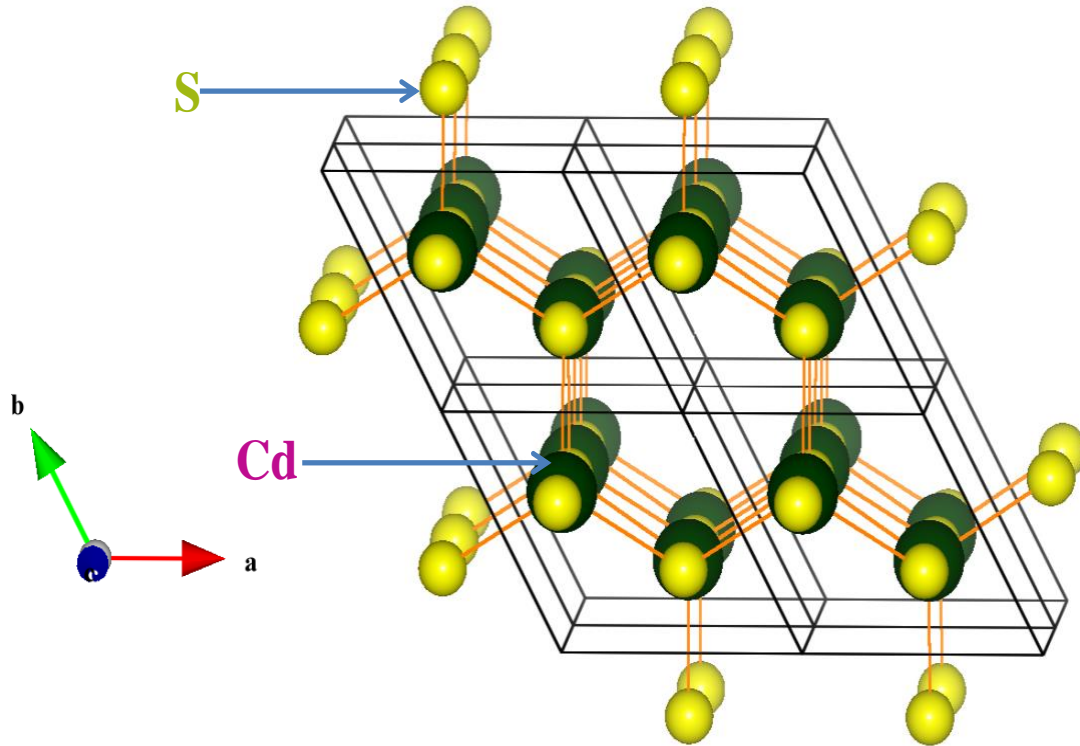


Figure: Representative hexagonal crystal structure of synthesized CdS nano particles
This structure gives exact pictorial idea of atomic positions. The crystal structure is hexagonal
Wurzite structure. This crystal structure is found in the mineral Greenockite.

Chapter 5

Conclusion and Future Scope

- CdS thin film successfully deposited by chemical bath deposition method.
- XRD confirms the formation of hexagonal wurzite structure of CdS.
- Optical absorption spectra show the CdS material absorption starts in the IR range. The band-gap values were calculated from Tau's plot are 2.48 eV for as-deposited CdS thin films.

To enhance properties of CdS thin films, future work will be directed towards acquiring doping and annealing of CdS thin films.

Chapter 6

References

- 1) X ray diffraction: A practical approach c-suryanarayan M. grant Norton
- 2) Research paper and journal articles
- 3) Origin manual
- 4) VESTA manual