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Studies on Growth and Characterization of CdS Thin Films Deposited by Chemical Bath Deposition Technique

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ABSTRACT:

Chemical Bath Deposition (CBD) technique was used to deposit CdS thin films on amorphous glass substrate with different pH values changing from 8 to 10. The effect of pH on the structural and optical properties of CdS thin films was investigated. The X-ray diffraction data (XRD) and ultraviolet-visible absorption spectroscopy were used to characterize the thin films. X-ray diffraction reveals growth of the cubic phase with preferential orientation along (002) direction and are polycrystalline. The band gap of the film increased from 3.753eV to 3.900 eV with increasing pH values. After investigation it was concluded that the pH value of 9.5 is suitable for producing CdS thin films by chemical bath deposition technique. The formed films were uniform and with good adherence to the substrate. Optical study shows that the film has a band gap of 3.900 eV.

Keywords: Chemical Bath Deposition Technique, Thin Films, XRD, UV Spectroscopy**.**

I. INTRODUCTION:

Thin film has received tremendous attention in the recent years especially after the world war because of numerous application of film in diverse fields such as in electronics, defense, medical, in astrophysics, numerous applications of films leads to intense studies of them especially to develop and prepare better films with specialized properties from newer compounds or composite materials. Thin film science now covers a wide span of disciplines such as solid state physics, surface science, crystallography, crystal growth process, optics, electronics and material science etc. The II – VI group semiconductor compounds (CdSe,CdS, CdTe, ZnSe etc) are of great importance because of their applications in optoelectronics, solar cells, integrated and electro-optic devices. CdS thin films can be deposited by several techniques such as spay pyrolysis [1-2], sol gel coating [3-4], chemical vapour deposition[5], chemical bath deposition [6-16, 23-25], pulse laser deposition[17-19], ionic layer adsorption and reaction (SILAR)[20], sputtering[21], Spin Coating Technique[22] etc. have been maintaining in the laboratories of many universities and colleges. Chemical bath decomposition technique appears to be a relatively simple, inexpensive, convenient, easy method to prepare a homogeneous film with controlled composition however depending on the deposition conditions such as pH of the solution, temperature, stirring and time of deposition. By chemical bath deposition technique many binary semiconductors thin film has been prepared such as CdS, PbS, CdSe, PbSe, ZnSe and CdTe by spray pyrolysis technique [26-28].

In the present work the CdS thin films will be prepared by chemical bath deposition (CBD) technique using desired equimolar aqueous solutions of cadmium sulphate and thiourea in appropriate volumes on to glass substrates with different pH values using ammonia water. The effect of pH on its structural and optical properties are investigated in this paper.

II. EXPERIMENTAL DETAILS

CdS thin film was deposited on a amorphous glass substrate (supplied by blue star of dimensions 75 mm X 11 mm X 1mm). The substrate was cleaned with detergent solution 'labolene', distilled water and finally ultrasonically. The stock-solutions of Cadmium Sulphate $CdSo_4$: A.R.Grade supplied by s.d. fine chemical Ltd. Mumbai, Thiourea ($Cs(NH_2)_2$): A.R.Grade supplied by s.d. fine chemical Ltd. Mumbai and Ammonia (NH_4OH) (32% NH_4OH): A.R.Grade supplied by s.d. fine chemical Ltd. Mumbai. Were prepared using double distilled water.

The CdS thin films were deposited in aqueous solution containing 0.1 M cadmium sulphate, 0.1 M Thiourea and ammonia as complexing agent. Add this weighed $CdSO_4$ and ammonia in 75 ml double distilled water in the glass beaker and stir the solution continuously for several minutes to become homogeneous solution at moderate rate. Ammonia was added drop by drop in solution to maintain the pH value of the solution is 9.5 at temperature 70ºC. When the temperature of solution reaches 70ºC then adds the thiourea. The bath was placed over a heater cum magnetic stirrer. The cleaned glass substrate was immersed in bath and solution was no stirred during the deposition process. CdS thin film was deposited for 15 minutes then samples were washed with distilled water and dried in air. The experimental setup used in this present investigation is shown in Fig. 1 below.

Fig. 1 Experimental Setup

The adherent yellow colored CdS thin films were shown in Fig. 2.

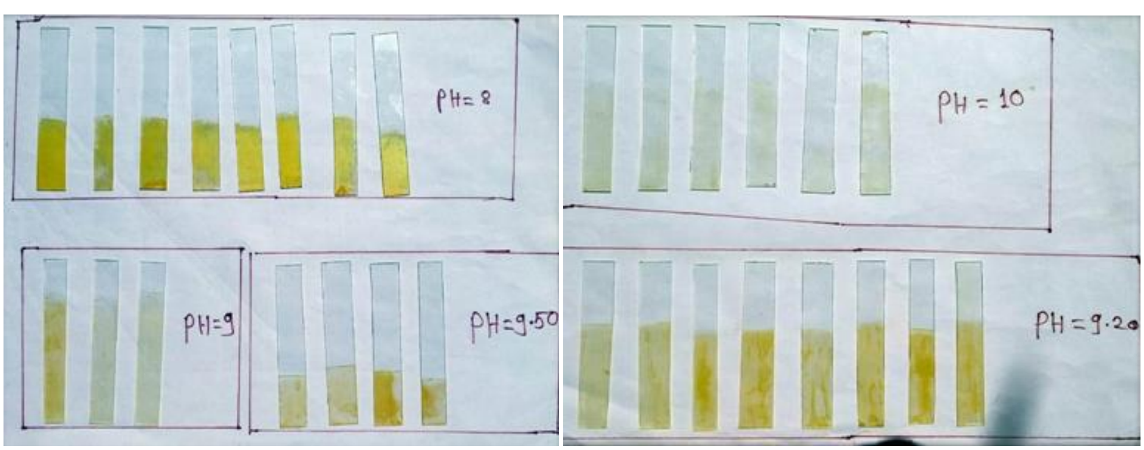

Fig. 2: Deposited CdS thin films at different pH.

In order to find optimized condition for deposition of CdS thin films, initially the deposition was carried out by varying one of the parameter as pH of the solution and keeping the others at fixed value and for optimization of pH of the solution, deposition was carried out by varying pH of solution and keeping others at fixed value.

$$CdSO_4 + 4NH_4Cl \rightarrow Cd(NH_3)_4^{2+} + Cl^- + 4H_2O$$
$$H_2O \rightarrow H^+ + OH^-$$
$$CS(NH_2)_2 + (OH)^- \rightarrow H_2N(COH)NH + SH^-$$
$$Cd(NH_3)_4^{2+} + SH^- \rightarrow CdS + NH_4^+ + 3NH_3$$

The CdS thin film was characterized by using XRD and UV visible spectroscopy.

III. RESULTS AND DISCUSSION

X – Ray Diffraction (XRD)

The structural characterization of CdS thin films was carried out by analsizing the X – ray diffraction patterns obtained using Philips X-Diffractometer Model PW-1710 (λ = 1.05406 Å for Cu-Kα Radiation). The as-grown CdS thin films deposited at various pH of solution were characterized by the XRD technique with Cu-Kα radiation with the help of Ni filter. The XRD patterns obtained for the films grown on bare micro slides glass plates were studied in 2θ range of 20–80º. The XRD patterns (figure 3) show that the films are polycrystalline [12]. It was seen that the plane (111) of CdS appears with higher peak intensity in the diffractogram with pH 9.5. Besides it, the planes (200), (220), (311), (400) were also observed in the same diffractogram. The intensity of CdS plane peaks is comparatively higher for the pH 9.5. A matching of the observed and the standard'd' values confirm that the deposited films are of CdS having cubic crystal structure [13]. The calculated value of lattice constant 5.8200Å agrees well with the standard values for single crystal CdS [14].

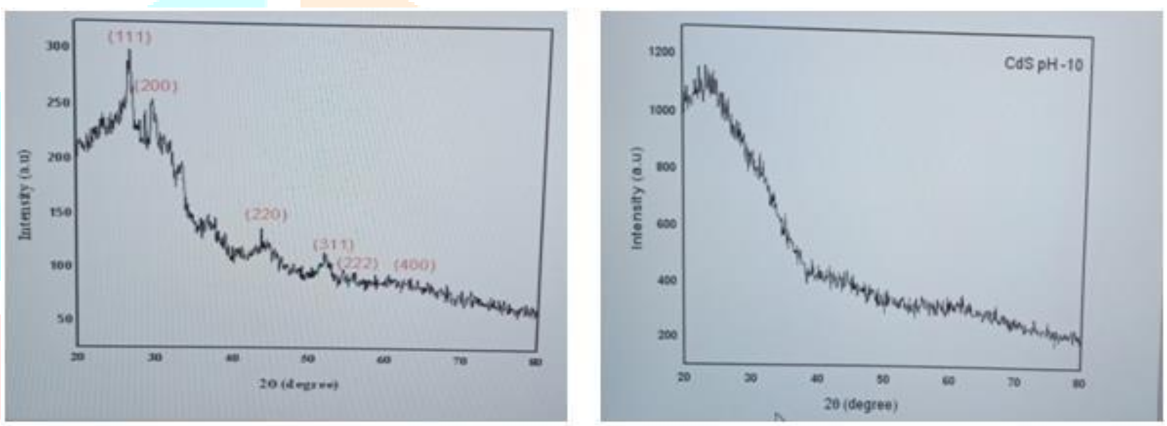

Fig. 3a) At pH 9.5

Fig. 3b) At pH 10

Fig. 3: X-Ray diffraction patterns for CdS thin films deposited at various pH.

UV- Visible Spectroscopy

Optical absorption studies of CdS thin films deposited on the glass substrates were carried out in the wavelength (λ) range 200–550 nm at room temperature. The variation of absorbance (A) with the wavelength (λ) is shown in Fig. 3. It is seen that the optical absorbance coefficient is a function of photon energy. It also shows higher absorption on the shorter wavelength side and the presence of an absorption edge. The band gap of the films increased from 3.752 to 3.900 eV with increasing pH values. After all investigation, it was concluded that the pH value of 9.5 is suitable for producing CdS thin films by chemical bath deposition technique. The formed film was uniform and with good adherence to the glass substrate[15]

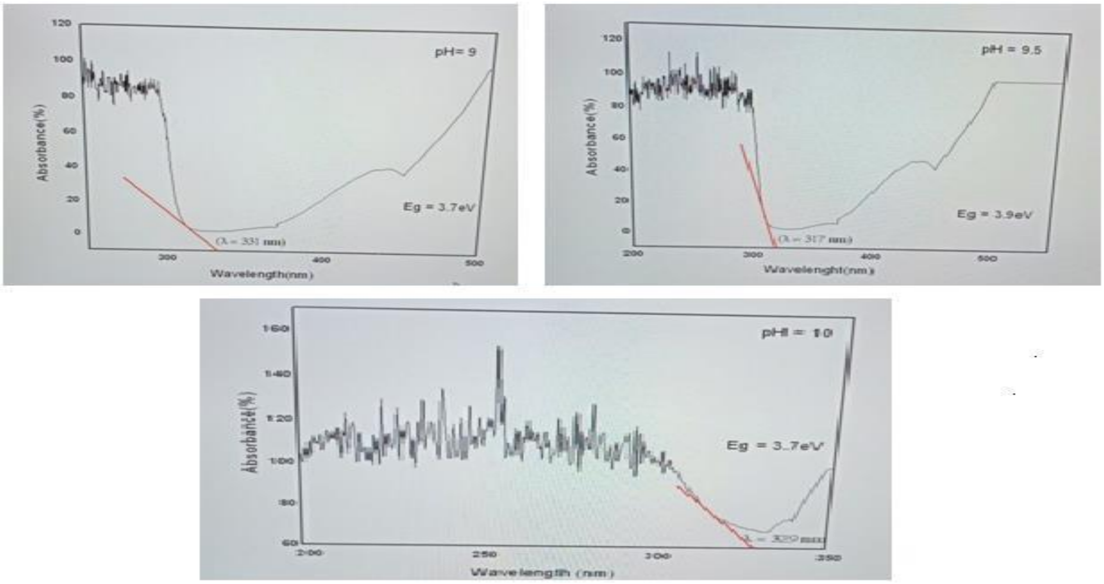

Fig 4: Plot of optical absorbance of CdS thin films at various pH

The band gap of the films increased from 3.753eV to 3.900eV with increasing pH values from 9 to 10. After all investigations, it was concluded that the pH value of 9.5 is suitable for producing CdS thin films by chemical bath deposition technique. The study shows that the prepared film has a band gap of 3.900eV.

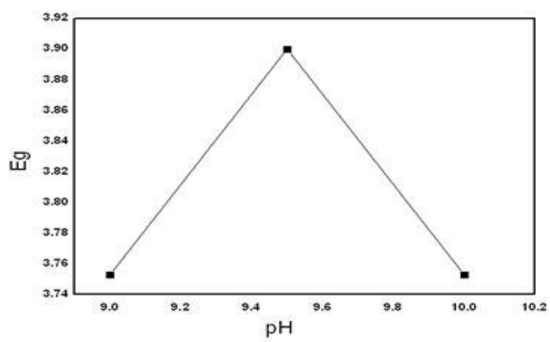

Fig 5 Variation Band gap energy with pH of solution

IV. CONCLUSIONS:

The CdS thin films were successfully deposited on the glass substrates using Chemical Bath Deposition (CBD) technique. The CBD method is simplest, least expensive to produce uniform, adherent and reproducible large area thin film for solar cell applications. The CdS thin film was yellow in colour. The XRD studies reveal that the films were polycrystalline with cubic structure. The optical absorbance study shows that the prepared thin film has band gap of 3.900 eV. The band gap of the CdS thin films increased from 3.753 eV to 3.900 eV with increasing pH values of the chemical bath from 8 to 10. This result indicates that the thin films of CdS obtained at pH 9.5 with wide band gap are good candidates to be applied in different optoelectronic devices.

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