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Chemical Bath Deposited Cadmium Sulphide Thin Film Structural Analysis

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Abstract— Chemical Bath Deposition was used to deposit a thin coating of Cadmium Sulphide. Deposition of thin films using the Chemical Bath Deposition Approach is the simplest, most straightforward, and most cost-effective method available. The Cd+2 ions came from Cadmium Sulphate, whereas the S-2 ions came from Thiourea. The pH of the reaction mixture was maintained with aqueous ammonia, and the complexing agent triethylamine was added. A 484 nm thick yellowish-orange CdS film was deposited. The deposited thin film's X-ray diffraction pattern exhibited a hexagonal/cubic crystal structure combination. The observed d values and the conventional d values coincided quite well.

Keywords-Chemical bath deposition, Cadmium sulphide, Thiourea, X-ray diffraction.

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I. Introduction

CdS are the chemical formula for the inorganic compound cadmium sulphide. It has a yellow hue and functions as an electrical semiconductor. Light-dependent resistors and solar cells both use CdS. Piezoelectric transducers made from thin films of Cadmium Sulfide may operate at frequencies in the GHz range. [1] Cadmium sulphide might be employed in thin-film solar cells in the future. Future electrical and photonic devices may benefit from semiconducting nanostructures. Optoelectronic devices may be built using their distinct physical and chemical features. [2,3,4,5].

Semiconducting materials may be deposited using a variety of physical and chemical methods. Material to be deposited, substrate type and thickness, application, and so on all play a role in determining which method to utilise. Physical and chemical methods are both employed in the deposition of semiconducting materials. In comparison to physical approaches, chemical ones are less expensive and simpler.

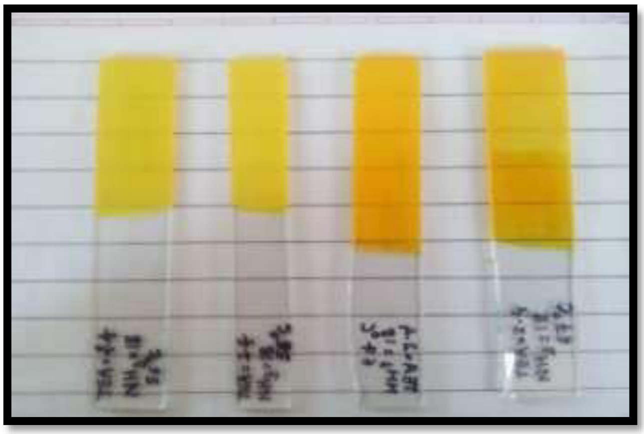
To deposit thin films of composite materials, the chemical bath deposition (CBD) procedure is employed as a solution growth process. The precipitation of chalcogenide from a metal complex aqueous solution happens under particular conditions when combined with a chalcogen-bearing compound aqueous solution. Controlling the precipitation ensures that the chemical is deposited on the container wall and the substrate surface. Binary and ternary deposits using the CBD approach have been successful. semiconductors. The deposition process is controlled by factors such as temperature, pH, ion concentration, the nature of the substrate, and the nature of the complexing agents and salts utilised. The CBD method is easy and inexpensive. In the CBD technique, aqueous solution thin films are either deposition by passing a current or deposition by chemical reaction under proper circumstances are applied to the substrate. Simple processes generate stable, adherent, thin coatings with high repeatability. Several factors influence the thickness of thin films, including deposition time, solution composition and temperature, as well as substrate topography and chemical composition.

II. Experimental Method

CdS were deposited on a thin glass slide as a substrate. The glass slides were cleaned in a solution of Chromium trioxide by boiling for 1-2 hours. Double-distilled water and acetone were used to wash the boiling substrates, which were subsequently dried. CdSO4 was utilised as a source of Cd+2 ions, Thiourea as a source of S-2 ions, TEA as a complexing agent, and liquid Ammonia to keep the reaction mixture's pH at 10.5. It is common practice to use a complexing agent to regulate the reaction rate to achieve the required thin film growth. Double-distilled water was used to create 10 ml of a 1M CdSO4 solution. Then, 10 ml of 1M Thiourea solution in double-distilled water was made. A reaction mixture was formed by mixing 10 ml of 1M CdSO4 solution with 10 ml of 1M Thiourea solution with steady stirring. To this, a 2.4 ml solution of triethylamine (TEA) was gradually added while swirling constantly. To keep the pH level at 10.5, 18 ml of Ammonia solution was slowly added to the reaction mixture.

A paraffin oil bath was used to keep the reaction mixture at a consistent temperature. The reaction mixture was agitated at a rate of 70 rpm by a rotator for a deposition duration of 90 minutes while the glass substrates were placed on the substrate holder, as illustrated in Fig. 1. A thin, homogeneous, and adhering yellowish-orange film formed on the glass substrates after 90 minutes, as illustrated in Figure 2.

Fig. 1. Experimental Setup for CBD deposition of CdS thin film.



To get a precise measurement of the Cadmium sulphide substrate's weight per unit area (mg/cm2), a computerised weight scale was used. By employing an X-ray diffractometer (XRD) (Rigaku D/max 2550Vb+18 kw with CuK 1=1.54056) in the region of diffraction angle 2 from 20o to 80o, the internal structure of Cadmium Sulphide thin films was examined..

III. RESULTS AND DISCUSSIONS

A. Chemical Reaction

$[Cd(NH3)_4]_2 + Cd^{+2} + 4NH_3$
(dissociation of complex to free Cd^{+2} ions)-----(1)

$(NH_2)_2CS + 2OH\text{-}\ S^{-2} + CN_2H_2 + 2H_2O$
(formation of sulphide ions) ------------------ (2)

$Cd^{+2} + S^{-2}$ - CdS
(CdS fromation by ionic reaction)-------------- (3)

The simple cluster (hydroxide) mechanism:

$nCd^{+2} + 2nOH\ [Cd(OH)_2]n$
(formation of a Cd(OH)2 cluster)-------------(4)

$[Cd(OH)_2]n + nS^{-2}nCdS + 2nOH$
(exchange reaction) ------------ (5)The complex decomposition ion - by - ion mechanism:

$(NH_2)_2CS + Cd^{+2}\ [(NH_2)_2CS\text{-}Cd]^{+2}$-------- (6)

$[(NH_2)2CS\text{-}Cd]^2+ + 2OH\text{-}\ CdS + CN2H_2 + 2H_2O$ ---------- (7)

The complex decomposition cluster mechanism:

$[Cd(OH)_2]n + (NH_2)2CS\ [Cd(OH)_2](n\text{-}1)(OH)_2Cd$------S-----$C(NH_2)_2$------------------------(8)

$[Cd(OH)_2](n\text{-}1)(OH)_2Cd$----S---$C(NH_2)_2[Cd(OH)_2](n\text{-}1) + CdS + CN2H_2 + 2H_2$ ----(9)

B. Structural Analysis

The XRD diffractogram of a 484 nm thick CdS thin film, formed at a substrate temperature of 560 C, is shown in the graph of intensity against 2. As shown in this image of CdS thin film, it is polycrystalline with a mixture of hexagonal and cubic crystal formations. Table.1 presents the diffraction data in tabular form.

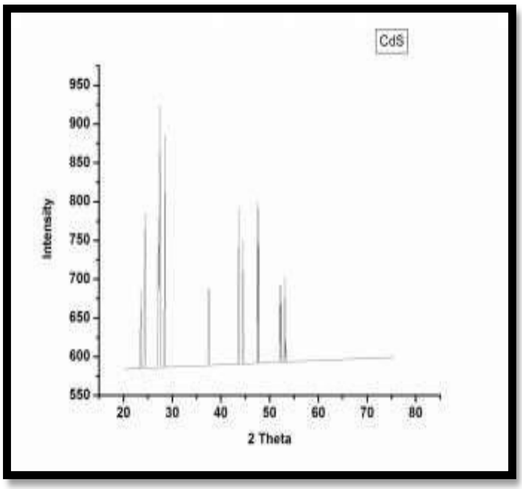


Fig.3.XRD pattern of Cobalt sulphide thin film

	2θ Obs. Deg.	2θ Std. Deg.	d (^{0}A) obs.	d (^{0}A) std.	I/I_{ma} Obs.	I/I_{ma} Std.	Phase CdS	Phase β-CdS
	24.5	**24.363**	**1.68**	**1.68**	**780**	**10**	**------**	**222**
	27	**26.336**	**2.603**	**2.414**	**125**	**10**	**104**	**-----**
	28.193	**28.193**	**4.528**	**4.528**	**880**	**999**	**101**	**-----**
	44	**43.048**	**3.536**	**3.533**	**790**	**414**	**------**	**220**
	48	**48.117**	**1.007**	**1.007**	**800**	**406**	**10**	**-----**

Table.1.Structural parameters of CdS thin films

Figure 3 depicts the XRD pattern of a 484 nm CdS thin film deposited at 560C. A tight match exists between the measured d values and what is expected. CDs' thin film is polycrystalline and a combination of cubic and hexagonal crystal structures is abundantly seen in the diffraction pattern. When comparing the observed data to the standard, we find that it is quite close to PDF# 020454 (222) and PDF#020544 (104) as well as PDF#892944 (101) and PDF#750581 (220) as well as PDF#800006 (103), and PDF#751546 (311) accordingly. The Scherrer's relation was used to compute the average crystallite size from 101 planes,

$$D = \frac{k\lambda}{Q\cos\theta}$$

When is θ the diffraction angle, λ is the entire width at half the maximum of the diffraction line, and D is the average crystallite size, the resulting equation is as follows: Estimated dimensions of the crystallite were 45 nm in diameter. Many electrical and optoelectronic devices rely on nanocrystalline thin films [7, 8] for their fabrication.

IV. Conclusion

Chemical bath deposition was used to produce thin coatings of cadmium sulphide. The deposited thin layer has a thickness of 484 nm. There are mixed phases of hexagonal and cubic structures in the polycrystalline films from the XRD examination. Cadmium sulphide thin film might be prepared using the chemical bath deposition method. An orange-yellow Cadmium sulphide thin coating was formed on the substrate.

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