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Optical Study of Cadmium Sulphide Thin Film Prepared by Chemical Bath Deposition

B. S. BHADORIA, RAMA SHANKER YADAV and AKANKSHA SRIVASTAVA

Department of Physics, Bundelkhand University, Jhansi, (U.P.)-284128 India.
email: ramaphysics09@gmail.com

ABSTRACT

The Cadmium Sulphide is window material for solar cells. The thin films of CdS were deposited on glass substrate by chemical bath deposition techniques. The results from X-ray diffraction and optical absorption coefficient are used to characterize the thin film. This study represent that the growth of CdS-CBD thin film is controlled by pH, temperature, time of dipping and concentration of material. The dependence of energy band gap on the film thickness is also represented. This study will provide the future aspects for the solar energy storage using different doping materials in order to remove the toxicity.

Keywords-: Chemical bath deposition, XRD, Energy band gap.

1. INTRODUCTION

Thin Cadmium Sulphide (CdS) films have been used in industries predominantly in solar cells. The best solar cells based on $Cu(InGa)Se_2$ (CIGS) absorbers are achieved by using a very thin (50 nm) CdS buffer layer deposited by chemical bath deposition (CBD). The CBD technique has been used for the preparation of CdS/CdTe in high conversion efficiency (16%) in solar cell[8]. Among various techniques that can be used for the preparation of thin CdS films (thermal evaporation, chemical spray, electro deposition and sputtering), CBD is a simple which is also used to deposited the semiconductor on photovoltaic device.

The CBD method appears suitable for large area industrial process because it is the least expensive and a low temperature method. Another advantage of the CBD technique is its ability to deposit very thin films (50 nm) in a conformal manner on a rough substrate surface. The rate of growth in CBD is controllable by pH, temperature, time of dipping and the relative concentrations of the reactants in the bath solution. The alkaline bath solution *(*pH > 9*)* normally consists of a cadmium salt, thiourea $[SC(NH_2)_2]$, NH_4OH and a complexing agent such as NH_4Cl and TEA[7].

The CdS thin film has a high visible transmittance and near IR reflectance[4]. The mechanics and growth kinetics of CdS thin film, from alkaline bath containing the Cd

salts and thiourea, have been studied in order to obtain good quality, used in manufacturing solar cell, optoelectronic devices and photo conducting sensors etc. The optoelectrical properties of thin film are influenced by the film microstructure which depends on the preparation parameters and post deposition conditions as annealing, cleaning etc. The effect of the solution composition and temperature on the optical absorption coefficient, resistively and energy band gap is considerable[8]. Thermal annealing in different atmospheres reduces the energy band gap. The electrical resistively that can vary over several orders of magnitude, depends not only on the doping level, but also on the film microstructure and thickness.

2. EXPERIMENTAL DETAILS

Chemical bath deposition is a useful method for obtaining a very thin CdS films as a buffer layer in a window of a thin film solar cell because it is inherently a low temperature process which does not damage the surface of the thin film as an absorber during deposition and can be applied to be rough one.

CdS films were deposited from a particular bath and their structure, optical and optoelectrical characteristics were measured with the aim of finding the correlation between the optoelectrical and the microstructure parameters. The deposition of CDS thin film is carried in two ways. First, the films were grown on soda-lime glass substrates, in the temperature range 70–90°C. The alkaline solution (pH ≈ 11) consists of $CdCl_2$ (2mM), thiourea (3mM), NH_4OH (640mM) and NH_4Cl (≈15mM) Second, Solution of 0.2M Cd $(CH3COO)_2$ and 0.5M H_2NSCNH_2 in deionized water were prepared separately. These solutions were heated to a temperature between 60-90°C, and then ammonia water was added to the cadmium acetate solution to maintain the pH value in the range between7-10. Before mixing the thiourea solution into the cadmium acetate solution to start the growth of CdS film, a sodalime glass substrate was dipped into the cadmium acetate solution. The film was deposited in 0.5 to 20 minute and then the substrate was pulled out from the solution and was dried after cleaning ultrasonically in deionized water. The pH value and the temperature of the solution were monitored using a pH meter and mercury thermometer.

2(a) - Effect of pH

The variation of pH during the growth is important in the structural film quality and was observed experimentally. It was found that, for low pH the Cd^{++} ion concentration in solution is more due to less complexation of Cd^{++} ions and the homogeneous process takes place at slow rate resulting in a lower thickness. At high pH the Cd^{++} ion concentration is less due to higher complexation but S^{--} ion concentration is more that gives higher deposition rate[5].

2(b) - Effect of Temperature

During the deposition of CdS film on glass substrate using CBD, the temperature is varied from 70-90°C which result the film deposition of various thickness. The optimum temperature for the better thin film deposition is 75°C[5].

2(c) - Band Gap Calculation

The optical spectrum of a semiconductor generally exhibits a sharp rise a certain values of incident photon energy for the calculation of band gap, the transmittance of the deposited CdS thin film is calculated for different wavelength of incident radiation. This may be done with the help of spectrophotometer. The absorption of the film is calculated using the 20% reflection. The value of absorption per unit thickness is calculated for the given reflection and transmittance. The photon energy for direct band gap material is given by the following equation.

The graph is plotted between energy and square of the product of absorption & energy for the direct band gap material and the intercept of the slope with energy axis provide the band gap of the material.

2(d) - Thickness Calculation

The band gap of the thin film is calculated with UV-1800 spectrophotometer and it is compared with bulk material. The difference provide the confinement applied on material so the thickness of thin film is determined by following formula-

Where μ is the translational mass of CdS material and L is the thickness of CdS thin film.

3. RESULT & DISCUSSION

The optical properties of chemical bath deposited CdS thin films were investigated using the spectrophotometer UV-1800. The transmittance was observed for the thin film for various temperature, different pH and time of dipping of the substrate in the solution. The transmittance and absorption of CdS thin film for the different temperature at constant time of dipping is shown in figure 1(a, b) and 2(a, b) respectively.

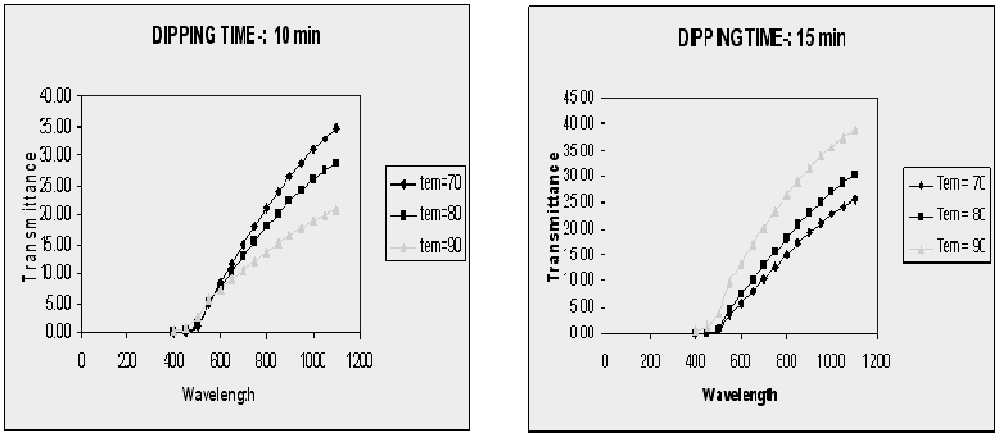

Figure 1(a, b):- Transmittance - Wavelength graph for CdS thin film at diff. dipping time.

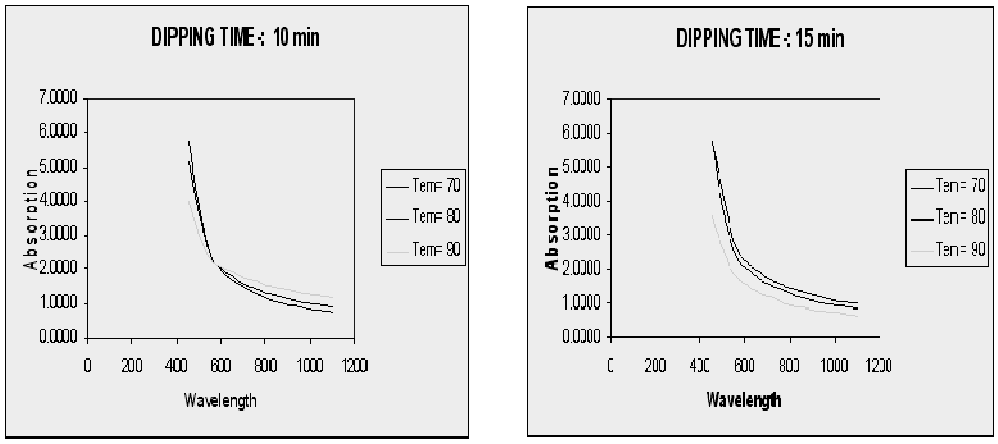

Figure 2(a, b):- Absorption - Wavelength graph for CdS thin film at diff. dipping time.

The variation of band gap for CdS thin film at pH=8 and dipping time 10 min for different temperature (70°C, 80°C, 90°C) is shown in figure 3. The nature of graph is nearly exponential and band gap at 80°C is found to be approximate 2.3eV. It can be seen that this graph is the strong function of temperature at higher range.

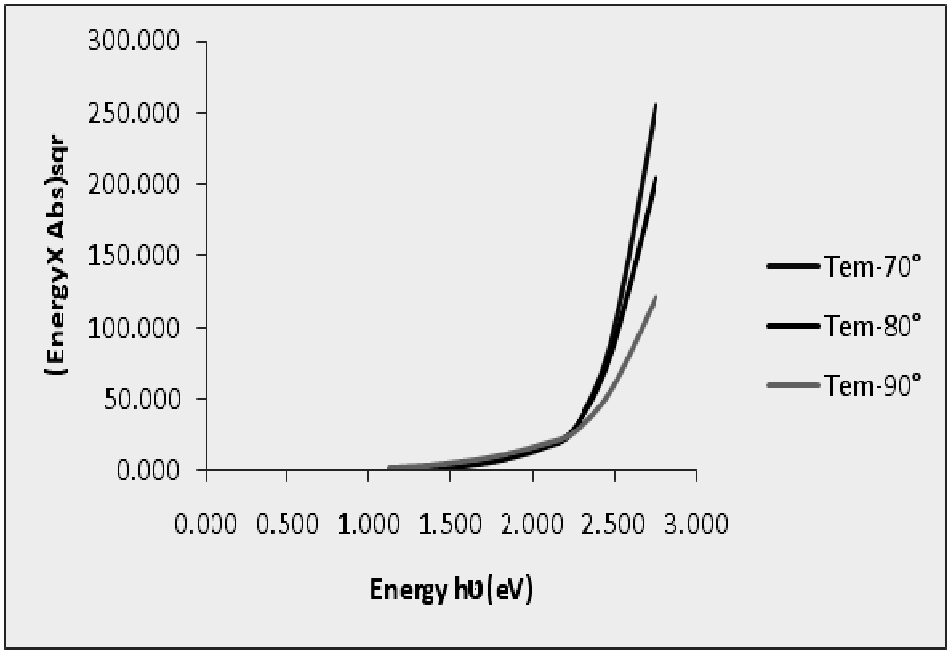

Figure 3:- Band gap variation for CdS thin film at different temperature.

The XRDs are taken for the study of the structure of material deposited on the material (Tem= 80°C, pH=8 & deposition time 10min). The first peak in XRD is mainly due to noise hence it can be ignored and the calculation form second and third peaks sows that the material is nearly cubic structure with plane (111) and (220). The lattice constant for the plane (111) is 5.77A° and for the plane (220) is 5.82A°.

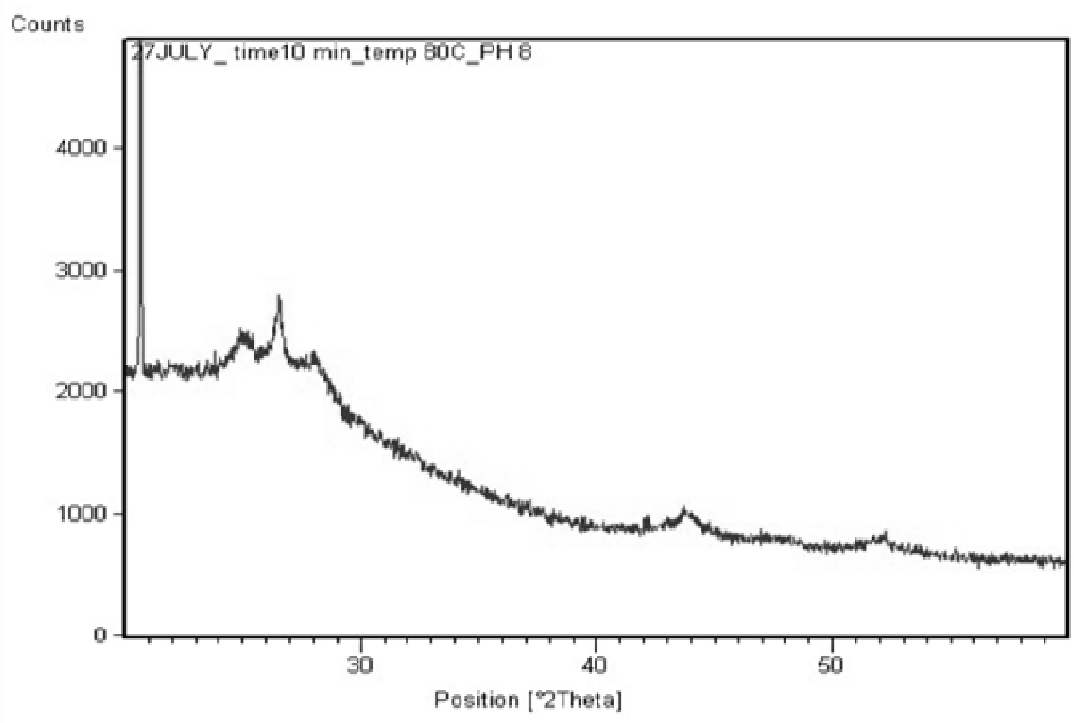

Figure 4:- XRD of CdS thin film

4. CONCLUSION

We have successfully deposited the good quality thin films of CdS by CBD technique on commercial glass substrate. The preparation parameters as temperature, pH, time of deposition and concentration play important role in the process of deposition of thin films and it affects the deposition rate. The observed band gap of the CdS is 2.4 - 2.5eV approximately for all time of deposition. The thin film is characterized by the XRD and photo spectrometer techniques. The XRD data shows the cubic structure of CdS thin film. The obtained results can be useful for the starting point for the synthesis and processing of multilayer films solar cells applications.

5. ACNOWLEDGEMENT

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