CdS THIN FILMS ACT AS LOW ENERGY PASS OPTICAL FILTERS IN SOLAR CELLS

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ABSTRACT

Cadmium Sulphide (CdS) thin films deposited on glass substrates by chemical bath deposition (CBD) technique. The chemical bath deposition offers, temperature uniformity throughout the solution, and the control over CdS film thickness. The CdS films are grown on glass substrates (sized, 1×3 inch) by varying four parameters, viz., temperature, pH of the solution bath, dipping time of substrates and molar ratio concentration of cadmium chloride ($CdCl_2$) and Thiourea (CH_4N_2S) solutions. Further, the CdS depositied films are characterized for optical transmission and absorption measurements by means of UV-VIS spectrophotometer (chemito) in the rangte of 200 nm to 1000 nm. The obtained optical transmission / absorption spectra of CdS films corresponds to the nature of low energy pass optical filters used in oslar cells having energy band gap value is 2.38 eV.
Keywords *: CdS, thin film, CBD technique, optical filters.*

INTRODUCTION

The cadminum sulphide (CdS) thin films[1] find number of applications in the areas of opto-electronic devices[6], multilayer LED's , optical IC's and optical filters[2,7,8,9,10]. The energy band gap of CdS thin films is 2.41 eV[5], which makes it is an ideal material to be as a low energy pass optical filters in solar cells.

The deposition of cadmium sulphide (CdS) thin films can be prepared by number of deposition techniques – such as, i) RF sputtering deposition technique, ii) Thermal evaporation deposition technique, iii) Chemical deposition technique, iv) Chemical vapour deposition (CVD) technique, v) Spray-Pyrolysis deposition technique, vi) vaccum deposition technique, vii) Chemical bath deposition[3,4] (CBD) technique.

Among these various deposition techniques, the chemical bath deposition (CBD) technique is more advantages than other deposition techniques. Because, it is inexpensive, easy to available everywhere, it does not requires sophisticated instrumentation and by using this technique, it is easy to deposit CdS sample over a larger area. Moreover, it consumes less electric power & time period. The deposition of cadminum sulphide (CdS) thin films on a glass substrates depends upon the various parameters – such as, i) Temperature, ii) pH-Value of the solution, iii) Molar ratio proportion of of $CdCl_2$ and CH_4N_2S, and iv) Dipping time of substrates. By varying these parameters, we have prepared cadmium sulphide (CdS) thin films. These CdS deposited thin films are characterized by UV-VIS spectrophotometer (Chemito) in the range of 200 nm to 10000 nm.

From the obtained CdS spectra, we studied the optical transmission and absorption phenomenon of the CdS thin films. This study suggests that the nature of spectra so obtained is in agreement with the theoretical nature of low energy pass optical filter used in solar cells. Also, we found that the energy band gap value of CdS thin films by using formula, $Eg=hc/\lambda_g$, where,h is plank's constant$=6.63\times10^{-34}$ J-s and C be the velocity of light = 3×10^8 m/sec. and λ_g is the observed wavelength of CdS from absorption spectra.

EXPERIMENTAL :

The cadmium sulphide (CdS) thin films are deposited on glass substrate (sized,1×3 inch). The glass substrates to be used are pre-cleaned chemically in acetone and dried by oven. While deposing, the subtracts were placed in vertical position in the solution bath. The solution used in chemical bath for deposition of CdS thin films consist of Cdmium Chloride ($CdCl_2$), Thiourea (Ch_4N_2S), Triethynolamine and liquid ammonia (purity 99.9%). Initially, the acquous solution of 50ml of 1M cadmium chloride and 50ml of 1M thiourea is mixed into a beaker of 250ml capacity. Then 4-5 ml of triethynolamine is added as a reacting medium for deposition purpose. The pH of the whole solution is controlled by adding 8-10 ml liquid ammonia. The beaker of solution is kept on the static magnetic stirrer for stirrering the solution of various constant temperatures and dipping times, to obtain no. of substrates.

Secondly, in the separate experimentation, the CdS thin film deposition is carried out at various temperatures i.e. at room termperatuer (30^0C), 40^0C, ... 120^0C and various dipping times of the substrates i.e. 20′, 30′, ... 120′ (minute) along with four different molarity proportions of cadmium chloride and thiourea as 1:05, 1:1, 1:15 and 1:2 . This deposition process is carried out at different pH values of the bath solutions i.e. 8pH , 8.5pH, ...12pH. After deposition, the substrates taken out from the beaker and washed with the double distilled water. These parameters affect the thickness and quality of surface uniformity of deposited CdS thin films. Further, these CBD grown CdS thin films are characterized for optical transmission and absorption by using UV-VIS spectro photometer (Chemito) in the range of 200 nm to 1000 nm. The observed transmission spectra is compared with the nature of low energy pass optical filters used in solar cells.

RESULTS & DISCUSSION :

The Cdmium sulphide (CdS) thin films were prepared by suing chemical bath deposition (CBD) technique with various molar concentrations of cadmium and sulpher compounds. The films prepared in bath containing equimolar concentration of cadmium chloride ($CdCl_2$) and Thiourea (CH_4N_2S) were fond to have good surface uniformity, adhesion characteristics and optical filtering characteristics. The results obtaining after carrying out the no. of experiments reveals that the optical filtering characteristics, the transmission and absorption properties of CdS thin films vary along with the variations in one of the parameters – i.e. temperature, dipping time of glass substrates in the solution, pH-value of the solution and the molar ratio proportions of $CdCl_2$ & CH_4N_2S.

The above parameters are discussed in details as follows:

i) Temperature :

This parameters affect the surface uniformity, thickness, molecular structure of CdS thin film. Also, it modifies the optical filtering characteristics, transmission and absorption properties of the CdS films. While preparing no. of CdS films at various temperatures i.e. at 30^0C (room temp.) 40^0C, 50^0C, ...120^0C , it is found that , at lower temperatures (say at room temp.) the film surface becomes more rough but as the temperature goes on increasing (i.e. at 80^0C), the film surface is more uniform and transmissive than that of low temperatures. But if the temperature is increased beyond 80^0C, the surface of CdS thin films becomes more denser. Also, it is found that the temperature decreases or increased from 80^0C, it affects the optical filtering characteristics, as well as, the transmission / absorption characteristics of CdS thin films.

ii) Dipping time of substrates :

We prepared several films with increasing dipping times i.e. at 20, 30, ... 110 & 120 minutes & found that the thickness of the film is a function of dipping time. i.e. more the dipping time, more the film thickness with dense surface. And less the dipping time, less the film thickness with non-uniform surface, but the film prepared at 60′, shown the more uniform thickness with good quality. Whereas, the dipping time of 120 minutes gives thick films having rough surface with large porosity. Therefore, we observed that, the dipping time parameter affects the surface uniformity, thickness and the optical filtering transmission and absorption properties of CdS thin films.

iii) pH-value of solution :

We prepared no. of CdS thin films by CBD technique with various pH values i.e. at 8 pH, 8.5pH, ... & 12 pH and found that the variations in the pH values affect the optical properties of thin films, such that, the film prepared at lower pH value (i.e. at 8pH) is found to be more thick and rough surface, whereas ,at higher pH value (i.e. at 12pH) , the film is found to be more thick, denser, with large porosity and uniform surface. But the CdS film prepared at the bath solution having pH range from 10.2 pH to 10.5 pH gives uniform thickness and compact films with good surface quality. From the observed results, it is seen that, the pH value of solution either increased or decreased from 10.5 pH value, it is found that the affects on the film thickness, surface uniformity, optical filtering properties and optical transmission / absorption properties.

iv) Molar ratio concentrations :

While preparing CdS thin films, first we kept the molar concentration of Cadmium chloride ($CdCl_2$) constant at one mole (1M) and varied the molar concentration of thiourea (CH_4N_2S) from 0.5M to 2.5M in the step of 0.5M. Secondly, we kept the molar concentration of thiourea constant at one mole (1M) and varied the molar concentration of cadmium chloride ($CdCl_2$) from 0.5M to 2.5M. in the step of 0.5M. Then by using their varied molar ratio proportions of $CdCl_2$ and CH_4N_2S we prepared the CdS thin films. And we studied the effect of molar ratio proportion on thickness, surface uniformity, optical and structural properties of films. When the molar ratio proportions of $CdCl_2$ and CH_4N_2S is kept at 1M:0.5M or 0.5M:1M, the CdS thin films are found to be transparent (with less adhesion) where as, at higher molar ratio proportions i.e. at 1M:2M or 2M:1M, the thickness of the films is found to be more thick, denser with rough surface. Whereas, the molar ratio proportions when kept at 1M:1M, it yields uniform thickness with good surface quality of CdS thin films and therefore, it affects on the optical filtering and structural properties.

v) CdS thin film act as an optical filter:

It is well known that the filters can alter the transmission characteristics of the optical systems and their optical phenomenon. Some filtes are discrete optical components which derive their filtering characteristics from the nature of the bulk material, but many are actually filtering coatings applied to plain transmissive optical substrates. The filters can be classified by the physical mechanisms of their operations or by their functions and the another type is the spectral filtering mechanism. The typical spectral filters selectively transmit and reflect certain wavelengths to separate them. The spectral filters are classified in to number of filters depending on their functions and characteristics.

The theoretical (typical) spectral nature of low energy pass optical filters used in solar cell is shown in fig.1 below. The spectral nature of optical filter shows a low energy pass optical filter because, it transmit wavelengths longer than a certain value and reject the shorter wavelength in solar cells.

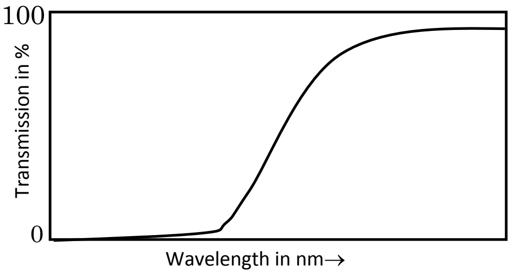

Fig.1 *Theoritical Spectra of Low energy pass Optical filter in Solar cell.*

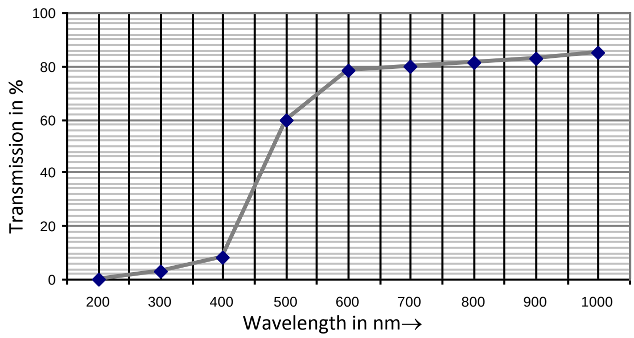

Fig.2 *: Experimental Transmission Spectra of CdS thin film deposited at 80^{0}C,60′,10.5pH & 1M:1M molar proportion of $CdCl_2$ & CH_4N_2S.*

The experimental nature of optical transmission / absorption spectra of CdS thin films prepared by four different parameters i.e. at 80^{0}C,60′,10.5pH and 1M:1M molar ratio proportions of $CdCl_2$ and CH_4N_2S is shown in fig.2 as above.

The optical transmission wavelength of CdS films is charactericsed by using UV-VIS spectrophotometer (Chemito) in the range of 200 nm to 1000 nm. From this UV-VIS spectra of CdS thin film, we measured that the CdS film absorb the wavelength upto 300nm. The optical transmission wavelength of CdS film goes on increasing within the range of 300nm to 600nm. Above the 600nm wavelength the CdS film has maximum transmission (i.e. in the region fo visible to near infrared region and its transmission is 86%) as shown in fig.2. in this region the CdS thin film act as an low energy pass optical filters in solar cells.

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So, the experimental nature of optical transmission spectra of CdS thin film (shown in fig.2) is in agreement with the theoretical spectral nature of low energy pass optical filter as shown in fig.1.

Whereas, the optical absorption wavelength of CdS thin films is measured by using the Uv–Vis spectrophotometer (Chemito) in the range of 280 nm to 550 nm, as shown in above figure 3 (B).

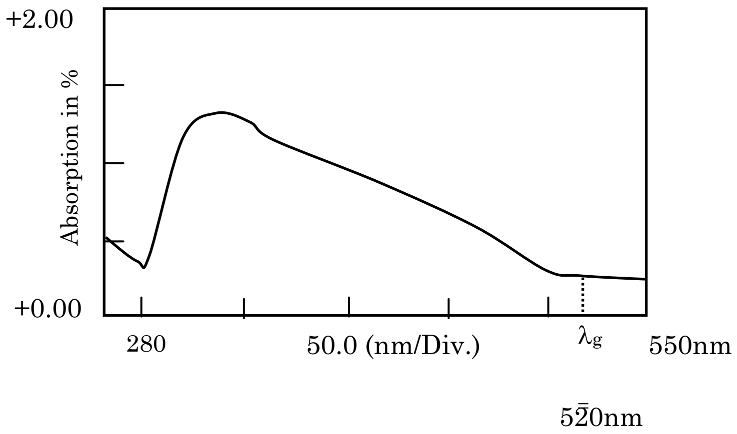

Fig.3: Optical absorption Spectra of CdS thin film prepared at at 80^0C,60′,10.5pH &1M:1M molar proportion of $CdCl_2$ & CH_4N_2S.

From the typical absorption spectra of CdS films, we concluded that the CdS thin film absorb the wavelength up to 520 nm and above the 520nm wavelength the CdS thin film has minimum absorption. From this spectra we study the band gap energy for the prepared CdS thin film is calculated by using formula i.e. $Eg = h.c./\lambda g$, where 'h' and 'c' are the plank's constant and velocity of light respectively and λg is absorbed wavelength of CdS film taken from the graph. The band gap energy is found to be 2.38 eV. and is in agreement with the West R.C.[(5)] value of 2.41 eV.

CONCLUSION :

The cadmium sulphide (CdS) thin film quality depends critically on various parameters i.e. the CdS films grown at 80^0C temperature, 60′ dipping time, 10.5 pH value and 1M:1M molar ratio proportions of cadmium chloride ($CdCl_2$) and thiourea (CH_4N_2S) are found to have thickness uniformity with less porosity and good adhesion to the surface. The band gap energy is found to be 2.38 eV. The experimental transmission spectra of CdS thin film shows good agreement with the theoretical spectral nature of low energy pass optical filters in solar cells.

Hence from the observed results we concluded that, the CdS thin films prepared at 80^0C, 60′, 10.5pH value and 1M:1M molar proportion of $CdCl_2$ and CH_4N_2S gives good quality films and it is act as an low energy pass optical filters in solar cells having energy band gap is 2.38 eV. and shows good agreement with the reported values obtained by West R.C.[(5)] Eg = 2.41 eV.

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