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Preparation and Characterization of Chemical Bath Deposited CdS Thin Film for Solar Cell

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Abstract: The objective of this work was the investigation of CdS grown by CBD on commercial glass and glass covered by Indium Tin oxide (ITO) substrates. Both ITO and CdS are window layers influencing the photovoltaic response of the cell. CBD technology offers the deposition of a thin uniform film with a minimal thickness on the rough substrate surface. CdS thin films have been grown by chemical bath deposition (CBD) using cadmium chloride and thiourea as the Cd and *S* ion sources CBD growth of CdS using uncoated glass substrates enabled optimization of deposition parameters, e.g. concentrations of $CdCl_2$, NH3 and thiourea SC(NH& bath temperature and deposition time. Successively glass plates coated with ITO layers were used as substrates. Both as-grown and air-annealed samples were studied. Investigation of optical transmission in the range 350 - 2200 nm, using Perkin - Elmer Lambda 19 spectrophotometer

Key words: Chemical Bath Deposition · Cadmium Chloride · Thiourea

INTRODUCTION

Cadmium sulfide (CdS) films deposited by chemical bath deposition (CBD) have been used for the fabrication of high efficiency CdTe and Culn, Ga, Se, thin films solar cells. In a typical CIGS-based solar cell a very thin CDs buffer layer is usually deposited between the ITO window layer and the ClGS absorber layer in order to achieve high conversion efficiency. Among various buffer layer materials such as CdS, (Cd,Zn) S, ZnS, ZnO, ZnSe, Sn (S,O)2, Zn Se deposited by CBD, ALE, MOCVD, or other deposition processes, the best performance ClGS solar cell with a total-area conversion efficiency of 18.8% and other high-efficiency (> 17%) ClGS solar cells were obtained using the CdS buffer layer deposited by the CBD method.

Thin film solar cells based on CuInSez or CuInSz (CIS) as well as CuIn,Gal.Sez (CIGS) absorbers need buffer layer to form photovoltaic heterojunction. One of the best buffer materials for this purpose is a thin (about 30 nm) CdS layer. Cadmium sulphide is a wide band gap semiconductor (Eg = 2.4 eV) and in a form of thin film is mostly obtained by vacuum methods. However, the highest efficiencies for n-CdS/ p-CIS photovoltaic heterojunction are obtained with CdS manufactured by chemical bath deposition (CBD) method. The properties of that heterojunction are not fully understood yet and in particular it is not clear which role play the intrinsic properties of CdS, i.e. band gap, band line up with CIS layer, lattice mismatch etc. It is also not clear which properties of CBD process (good step coverage, low temperature deposition, chemical passivation and lack of bombarding energetic species) influence the properties of the interface. Chemical bath deposition (CBD) is now widely used for the elaboration of low cost polycrystalline thin film solar cells, because it offers the advantages of economy, convenience and the capability of large area deposition [1].

In this paper, we focus on the properties of chemically deposited CdS thin films The effect of annealing in air at 100 - 300°C for different durations on structure, composition, optical and electrical properties will be presented [2].

Experimental

Substrate Cleaning: The CdS thin films were deposited on glass substrate. Deposition on commercial conducting glass (SnO_2/glass) was also made in order to study the

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substrate influence. Ultrasonic cleaning of substrates using detergent solution, distilled water and acetone. Finally Vapour degreasing of substrates by using isopropyl alcohol for 20 min.

Chemical Bath Deposition: This method allows the deposition of very thin films, of the order of a few nanometers and it is an easy and inexpensive solution growth technique. The physical properties of the chemical deposition of CdS films are dependent upon the growth parameters such as the bath temperature, the relative concentrations of the various reactants in the solution the pH value and the type of substrate. Precursors used for CdS solution preparation are cadmium chloride ($CdCl_2$) {cadmium source}, thiourea (sulphur source), sodium citrate (catalyst), liquid ammonia (pH variation), distilled water used as the medium of solution preparation.

In our case, $CdCl_2$ (.02M), CH_4N_2S (.05M), $C_6H_7Na_3$ (.02M) the CdS solution were prepared with the precursors for 60 ml of solvent medium (distilled water) with the help of magnetic stirrer. The pH was determined with a pH-meter and controlled to obtain pH =11.5. For the film deposition, the substrates were immersed in solution contained in glass beaker placed inside a water bath. The bath temperature was maintained at around 85°C and the deposition time was 10, 20 and 30 min for different thickness and the bath temperature was maintained at around 85°C. From these conditions uniform film deposition on all substrates was achieved. Then the coated films were proceeding for characterization studies such as optical studies, X-ray diffraction, EDAX and SEM analysis [3].

RESULT AND DISCUSSION

Optical Properties: From the optical transmission and reflectivity spectra, measured at room temperature, for the CdS films grown by the CBD techniques, The transmittance characteristics of the deposited CdS films have been studied in the wavelength range 190 to 2500 nm. The transmittance spectra of CdS film is shown in Figure 1a and 1b. Generally, transmittance of window layer should be more than 85% here; the results show that the transmittance of coated films varies from 65 to 75% for different annealed films. Thickness of films near to Micrometer level so that the coated films get the lowest results. From these results we came to know that for reducing the film thickness, the deposition time should be optimized (or) reduced and band gap of coated film is 300 - 400 nm and annealed films get growth in transmittance [4].

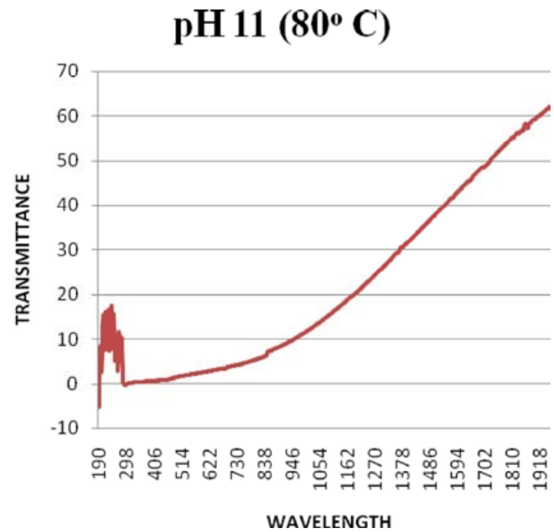

Fig. 1(a): Graph plotted for optical properties (transmittance Vs Wavelength)

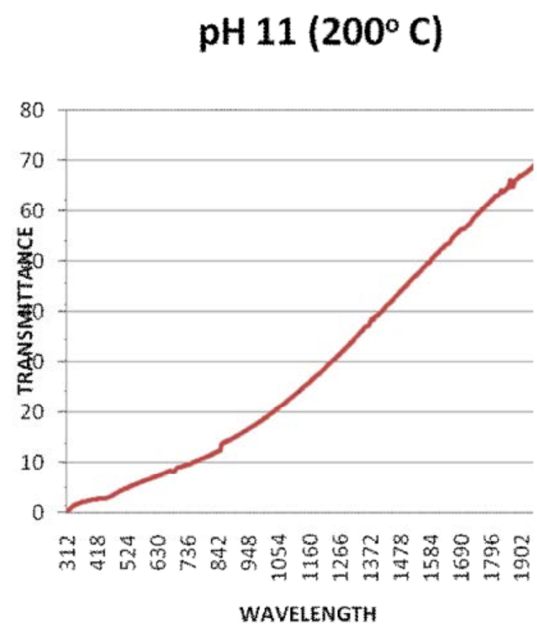

Fig. 1(b): Graph plotted for optical properties (transmittance Vs Wavelength)

XRD Studies: Figure 2 display the XRD patterns of the samples grown on glass. As can be seen, the films present hexagonal Wurzite (Greenockite) structure with preferential growth in the [002] direction. There is a tendency to a more prominent orientation in the [002] direction when the thickness of the film increases, independently of the type of substmte and deposition method. When the thickness decreases the preferential [002] orientation decreases depending upon the layer

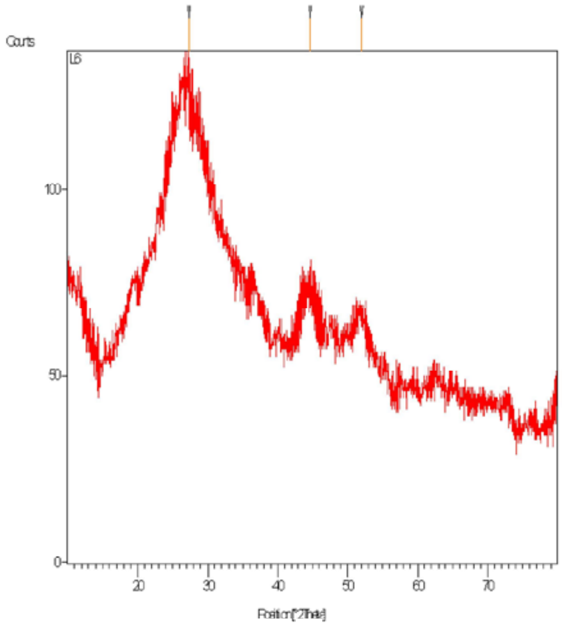

Fig. 2: X-ray diffraction pattern of CdS thin films grown on glass

thickness, for each deposition method.. Whereas in graph the corresponding peak regions for the structure are 24°, 29° and 44°. the solution-grown CdS thin films present an amorphous phase when the samples are grown on glass. In our experimental wnditions, the penetration of the X-ray beam for the (002) peak is about 8000 nm and therefore the influence of the amorphous glass subshate in the XRD pattern can be present in samples with small thickness.Energy dispersive x-ray analysis has been carried out to determine the composition of the deposited CdS films. [5] The results indicate that the deposited CdS film has a near stoichiometric composition of Cd : 51.65 atomic% and S : 48.35 atomic%.

CONCLUSION

In the present work CdS films have been deposited on to molybdenum coated glass substrates and indium tin oxide substrates by electron beam deposition method. Energy dispersive x-ray analysis has been carried out to determine the composition of the deposited CdS films. The results indicate that the deposited CdS film has a near stoichiometric composition of Cd : 51.65 atomic% and S : 48.35 atomic%. The x-ray diffraction pattern of the CdS film is shown in figure 2. The deposited CdS film is observed to be hexagonal Wurzite (Greenockite) structure.

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