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Characterization of cadmium sulfide thin film grown by chemical bath deposition technique with SEM, XRD, EDAX and AFM analysis

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ABSTRACT

In Chemical bath deposition technique, the cadmium chloride and thiourea solutions were taken in a basic medium (pH ~ 11.8) at 90°C for 4 hours. The Cds thin film was prepared on glass substrate. The structural and morphological properties of films obtained by CBD were investigated using X-ray diffraction (XRD), Scanning Electron Microscope (SEM), Energy Dispersive X- ray Spectroscopy (EDAX) and Atomic Force Microscope (AFM). X - ray pattern showed that the CdS thin film deposited without any complex agent was grown on an amorphous phase. SEM image showed that the CdS thin film deposited homogeneous, uniform grain size and good adhesion to the substrate.

Keywords: CdS thin film, XRD, SEM, EDAX and AFM

INTRODUCTION

Cadmium sulfide (CdS) is an important semiconductor material. It is used extensively in photo sensors, transducers, optical detectors, and other devices. In the last five decades, CdS has been one of the most investigated thin film semiconductors for photovoltaic. Today CdS is considered as the best-suited window material for both CdTe and CuIn (Ga) Se_2 solar cells [1-3]. The most important parameter for transparent thin films used for optical window applications is the band gap energy. There are several deposition techniques used for the deposition of thin film CdS including sputtering [3,4], chemical bath deposition [5], thermal evaporation [6] chemical vapour deposition [7], close space sublimation [8], molecular beam epitaxy [9], spray pyrolysis (10)screen printing and electrolysis. Each deposition process produces different structural, electrical and optical properties of the CdS thin films. Among the different technique Chemical bath deposition 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. Cds thin films can be achieved by chemical bath deposition in an alkaline aqueous solution consisting of thiourea, cadmium salts and ammonia. In CBD method ammonia is mainly used as a complexing agent for the cadmium ions in the reaction solution and the bath temperature was maintained at around 90°C and the deposition time was 4 hours. Many researchers investigated the optical properties of CdS thin films, but few have studied the relation between band gap energy and film thickness and the tailing in the forbidden band gap [11, 12, 13].

In this work the Cds thin films can be prepared by chemical bath deposition method and Characterization with SEM, XRD, EDAX and AFM analysis.

MATERIALS AND METHODS

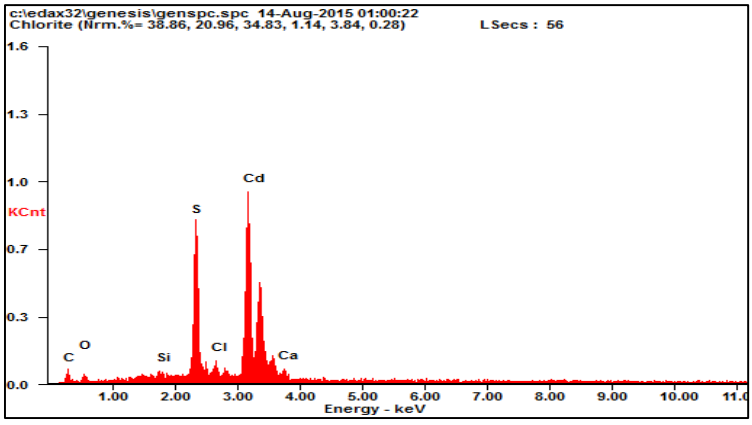
The glass substrate (35 X 25 X 1) mm used in the present study is first rinsed with distilled water. Then they are treated with NaOH solution. this alkaline agent dissolves fatty material by saponification and renders then wet. After a rinse with disstilled water, the substrates are kept in ultrasonic agitator for 30 minutes to remove organic impurities. Finally substraes are clened with isopropyl alcohol vapours and hence enhance the removal of surface contaminates. The substrates are then heated in an oven for about 45 minutes at a temperature 100^{o}C. Drying and dust removal finally makes them ready for the coating process. Any slight marks found on the substrates mean that the whole process must be repeated [14,15]. The chemical bath deposition (CBD) method is employed to deposit CdS thin films on to glass substrates using thiourea as sulphide ion source and cadmium chloride as cadmium ion source in ammonia bath. The molar solutions of $CdCl_2$(0.05M) and thiourea (0.2M) potassium hydroxide (0.02M) were prepared using doubly disstilled water. NH_4NO_3 solution (0.1M) is then added to the $CdCl_2$ the pH of solution is maintained at 11.8 with the pH meter for the film deposition. The substrate were immersed in solution containd in glass beaker placed in side a water bath.The bath temperature was maintained at around 90^{o}C and the depositon time was 4 hours. From theses condition uniform film deposition on glass substrates was achieved. The coated film was processed by X- ray diffraction, SEM, EDAX and AFM Analysis.

RESULTS AND DISCUSSION

3.1. Energy Dispersive X-Ray Spectroscopy (EDAX)

The surface morphology and elemental composition analysis of CdS thin flims by chemical bath deposition technique using aqueous cadmium chloride and thiourea solutions in a basic medium a pH ~ 11.8 at 90^{o}C for 4 hours. The deposited Cds thin film taken to study the macrostructure of thin film, chemical composition of materials such as the presence of cadmium, sulphur and oxygen. The crystalline grains, surface roughness, particle size can be calculated.

Fig.1. EDAX Spectrum of Cds Thin Film (5:3:1:2)



EDAX results which are consistent with the formation of thin flms of CdS deposited on silica glass substrates.it is widely known that CBD processees are associated with films which possess a relatively high concentration of impurities

The energy dispersive X-ray spectra shows that the expected elements detected in the thin film. the small percentage of Si, Ca, Cl, C and O elements are presnet in the thin films. It is evident that these elements may probably result from chloride used as substrate.

3.2. X-Ray Diffraction (XRD)

XRD analysis is carried out on CdS films and typical diffraction patterns of as grown CdS thin films prepared by CBD technique on glass substrates with different thickness. The spectra are obtained by scanning 2θ in the range 10 - 80^{o}. The XRD pattern to confirm and presented the CdS thin film on glass substrate.

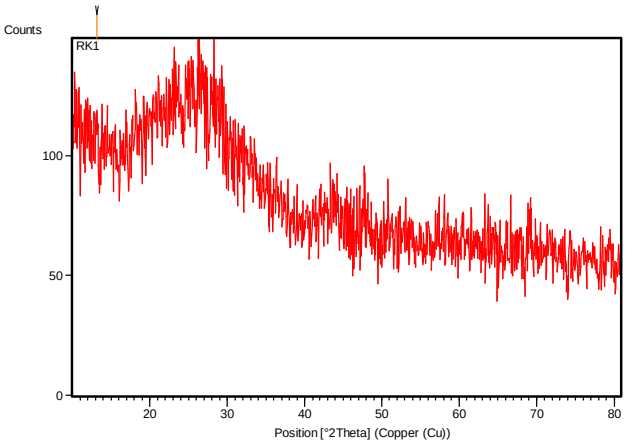


Fig.2. X-Ray Diffraction pattern of CBD - CdS Thin Film (5:3:1:2)

The others smaller peaks were observed (24, 27, 28 and 47) corresponding to the (100, 002, 101 and 210) planes respectively. It is clear from the high intensity peaks which indicate a significant increase in crystallite size with the cubic modification [16, 17]. The crystallite size of the CdS thin film was calculated using the Debye - Scherrer formula [18].

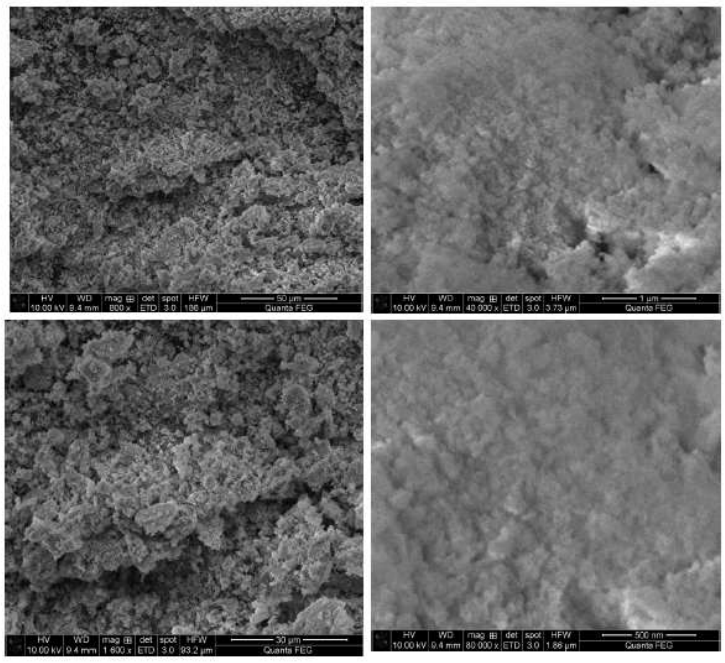


Fig.3. SEM of CdS thin film at different magnitudes

3.3. Scanning Electron Microscopy (SEM)

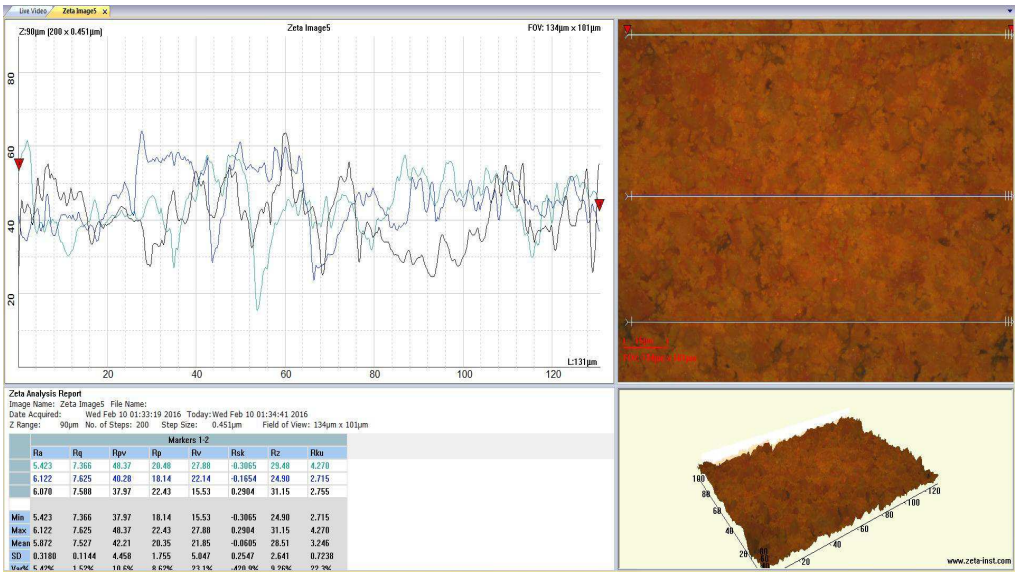
The scanning electron microscopy is a convenient technique to study the microstructure of thin films. It shows that most homogeneous film was obtained in the bath with (5:3:1:2) solution for 4 hours. In this case the slow deposition rate led to small uniform grain size and shape and the good adhesion to the substrate. But not uniformly covered the

substrate on the films. We estimated the grain sizes from different grains within the films and found to be about 10 to 500nm.

The SEM micrograph shows a cubical morphology and an irregular pattern without any void, pinhole or cracks and those they cover the entire substrate. It is clearly observed that the glassy nature along with amorphous phase of CdS thin films [19]. The grains are found to be thickly packed and also indicate that the grains are dense, smooth and without any visible pores.

3.4. Atomic force Microscope (AFM)

The AFM images expose well defined particle like features with granular morphology and indicate the presence of small crystalline grains. The scanning is done over an area of 134 µm X 101 µm. The AFM images expose well defined particle like features with granular morphology and indicate the presence of small crystalline grains. The root mean square surface roughness of the film is 42.21nm. The image also reveals that the film is without crack and is continuous with very well connected grains.



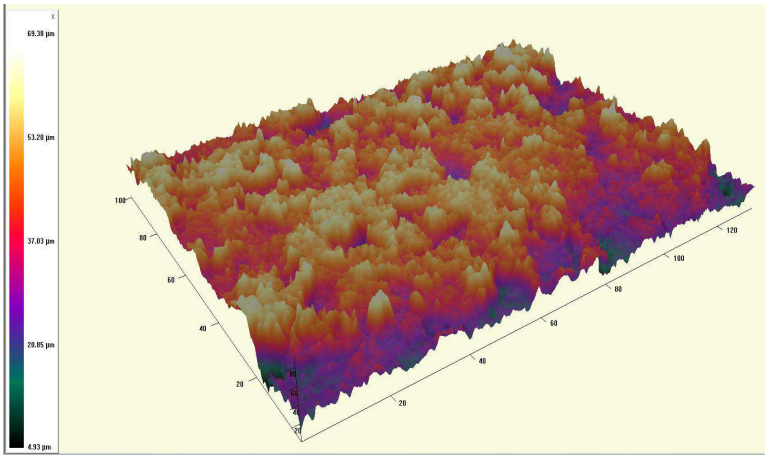


Fig.5. 2D & 3D AFM micrographs of CdS thin film

Morphlogy analysis of CdS thin film grown on glass substrate display uniform and compact surfaces with no pinholes and absorbed colloidal particles. the film on glass substrate display a rougher surface features with cluster

structures, hills with various heights and lateral extensions. It is mainly caused by the bigger roughness of the surface of CdS film increases with the increasing roughness of the substrate [20].

CONCLUSION

1. Cds thin film was obtained using the simple chemical bath depoition method. Which is simples, least expenses to produce unifrom, adherent and reproducible large area thin film for solar related applications.
2. Experimental findings clearly indicated that deposition time responsible for thickness.
3. The particle structure and size was determined using XRD. X-ray pattern showed that the CdS thin film deposited without any complexing agent was grown on an amorphous phase.
4. The average crystallite size 'D' was determined (86.66nm)
5. SEM image showed that the CdS thin film deposited homogeneous, uniform grain size and good adhesion to the substrate. The band energy gap value calculated from analysis of Photoluminescence spectra was found as 2.61 eV.
6. The surface of CdS film increases with the increasing roughness of the substrate.

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