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Investigation on the surface texture and optical properties of CdZnS thin films on ITO coated glass substrates for optical applications

M.S.Revathy[1], T.Mugesh[2], T.Prem kumar[3] and T.Chitravel[4]

[1]Department of Physics, KLN College of Engineering, Sivagangai.

[2]Nadar Sarasvathi College of Engineering and Technology, Theni-625531

[3]Gwangju Institute of Science and Technology, Republic of Korea, Gwangju-500712.

[4]Anna University: Chennai, Madurai Region, Madurai - 625 002.

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ABSTRACT

Cadmium zinc sulfide (CdZnS) thin film was deposited on transparent conduction Indium tin oxide (ITO) coated glass substrate by a cost effective chemical bath deposition (CBD) method. Commercially purchased ITO coated glass substrate with sheet resistance 8 Ω/cm^2 was utilized for the deposition of CdZnS thin film under optimized chemical bath conditions. Surface texture of the fabricated CdZnS thin film was analyzed by atomic force microscopy (AFM) and scanning electron microscopy (SEM) analysis. The optical absorption and transmittance properties of the fabricated CdZnS thin film was investigated by UV-Vis spectroscopy in the wavelength range of 300 to 1100 nm. The investigated surface and optical properties of the fabricated CdZnS thin film towards optical applications are presented and discussed.

Introduction

One can alter the band gap energy of chemical bath deposited CdZnS thin films from 2.27 eV to 3.25 eV [1]. CdZnS thin films were widely used as a wide-band-gap window material in hetero-junction solar cells, low-voltage cathode luminescence, high-density optical recording and blue, and ultraviolet laser diodes [2-3]. In fact, CdZnS chalcogenide semiconductor has variable bandgap energy of 2.4 eV to 3.7 eV, mainly dependent on a relative the Zn and Cd ratios[4-7].

CdZnS thin films were widely used as a wide band-gap buffer and window material in hetero-junction solar cells and in photoconductive devices. In high efficiency solar cells, where very thin CdS films have been demonstrated to be effective buffer layer, the replacement of CdS thin film by the higher band gap CdZnS has led to increase the short circuit current and decrease the window absorption losses. In recent years there has been considerable interest in the field of thin film semiconductor solar cell devices.

The ternary CdZnS films have become the subject of considerable interest due to the possibility of using these films as a buffer layer in solar cells [8-15]. CdZnS thin films were prepared by many techniques such as evaporation, spray pyrolysis,Chemical bath deposition (CBD), dip technique, electrodeposition, etc. Among various deposition methods, CBD method is a cost effective method and it provides the stable, uniform, adherent on hard films with relatively good reproducibility. In the present work CdZnS thin films were deposited on ITO coated glass substrates by a cost effective CBD method and its surface texture and optical properties are presented and discussed.

Experimental

The following table (1) illustrates the optimized procedure for the deposition of CdZnS thin films.

Table 1

S.No	$CdCl_2$	$ZnCl_2$	$CS(NH_2)_2$	NH_4Cl	H_2O	Bath Temperature
1.	0.2 M	0.1 M	0.4 M	0.2 M	100 ml	80° C
2.	0.2 M	0.15 M	0.4 M	0.2 M	100 ml	80° C
3.	0.2 M	0.2 M	0.4 M	0.2M	100 ml	80° C

The ITO substrates were cleaned by isopropanol, methanol, acetone and then deionized water for each 3 minutes prior to the deposition. We have obtained the CdZnS thin film having high adherence and good optical quality at the optimized concentration of cadmium chloride ($CdCl_2$: 0.2 M), zinc chloride ($ZnCl_2$: 0.2 M), thiourea ($CS(NH_2)_2$: 0.4 M), ammonium chloride (NH_4Cl: 0.2 M), water (H_2O: 100 ml) and the chemical bath temperature at 80° C. The surface and optical properties of the CdZnS thin film deposited on ITO substrate at this optimized concentration was examined.

Results and discussion

The surface and optical properties of the CdZnS thin film deposited on ITO substrate at this optimized concentration were investigated by AFM and UV-Vis-NIR spectroscopy at room temperature. Atomic force microscopes (AFM) are well suited for visualizing the surface features of the CBD deposited CdZnS thin film, especially when the surface feature sizes are less than one micron. Figure 1 shows the AFM image of the deposited CdZnS thin film under optimized concentration.

The observed surface feature of the CdZnS thin film shows the granules-like morphology with very less porous nature. This smooth surface morphology with pinhole free, closely packed and spherical granules will be very useful for making the homo junction between p-type and n-type material in hetero-junction devices. The surface morphology of the deposited CdZnS film was further investigated by SEM analysis.

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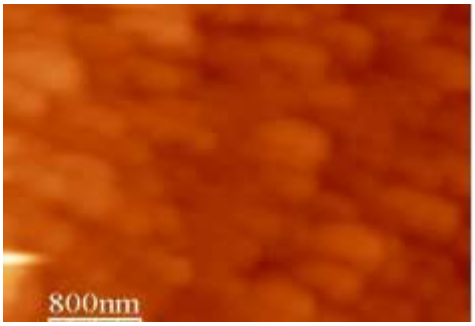

Figure 1 The AFM image of the deposited CdZnS thin film under optimized concentration.

Figure 2 shows the SEM image of the CdZnS thin film.

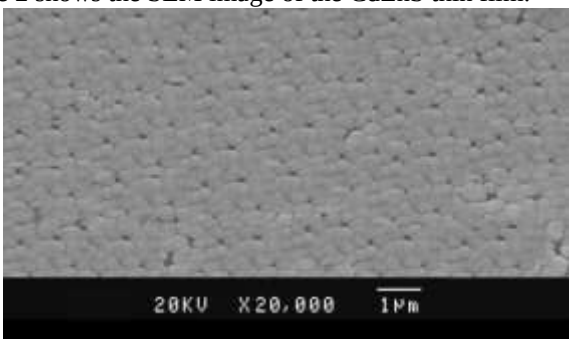

Figure 2 The SEM image of CdZnS thin film at optimized concentration

The SEM image also exhibits the deposited CdZnS thin film having granules-like morphology with smooth surface. The similar sized spherical granules packed smoothly in the observed SEM image which reflects the better surface quality of the deposited CdZnS thin film under optimized conditions. Both AFM and SEM analysis shows similar surface characteristics. Optical absorption property of the deposited CdZnS thin film under optimized concentration was investigated by UV-Vis-NIR spectrophotometer in the wavelength range of 300 to 1000 nm and was shown in the figure 3.

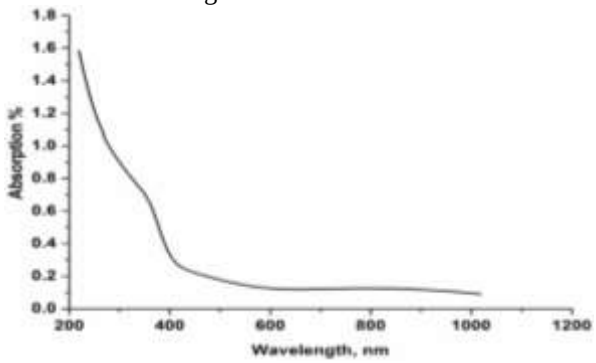

Figure 2 The optical absorption spectrum of the deposited CdZnS thin film under optimized concentration.

The calculated band gap energy from the absorption edge was nearly 3 eV which results the suitability of the deposited CdZnS thin films for window layer application in optoelectronic devices.

Conclusion

CdZnS thin films are deposited by a cost effective chemical bath deposition method. The surface morphology and its optical properties were analyzed by AFM, SEM and UV-Vis spectroscopy. Both the observed AFM and SEM images show the densely packed, pinhole free, smooth and granules-like morphology. The optical band gap energy was calculated by using the wavelength of optical absorption edge and was nearly 3 eV. The observed results show the possibilities of utilizing the deposited CdZnS thin films towards optical device applications. Further research on CdZnS thin films are also in progress.

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