Some Characterization of Chemical Bath Co-Deposited CdS-ZnS Thin Films

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ABSTRACT

Cd_{1-x}Zn_S thin films have been co-deposited on glass slide substrates by the chemical bath deposition technique at 80 °C for 60 min. X-ray diffraction studies suggest that for the as-deposited thin films with zinc atomic fraction x ≤ 0.7 is belong to zincblende structure. For x > 0.7, the films appear to have an amorphous character, as no distinguishable peaks can be seen in XRD diffractogram. Energy gap value (E_g) of the films was deduced from optical transmission spectra showing the presence of two energy gap values situated in low and high energy region. This can be interpreted in terms of the presence of mixed phases i.e. the pure CdS and CdZnS phases. The sheet resistance linearly increases from 5.0 x 10^9 to 2.1 x 10^{11} Ω/sq for x = 0 to x = 0.9. However the sheet resistance value was decreased several order of magnitude under illumination with an ELH halogen lamp. Photoluminescence (PL) spectra of Cd_{1-x}ZnS films exhibit red and green emission bands with peak positions around 550 and 640 nm. The red emission band could be attributed to surfaces states occurring mostly in CdS phase. The green one was believed to the overlapping of Cd-interstitial and S-vacancy occurring mostly in CdZnS phase.

1. Introduction

Cd_{1-x}Zn_S alloy compounds have attracted technological interest because the energy gap can be tuned and the lattice parameters can be varied. In recent years the replacement of CdS with its ternary alloy Cd_{1-x}ZnS has been attempted for improvement of the (Cd,Zn)S/Cu(In,Ga)Se_2 solar cell performance; this has resulted in a higher efficiency of 16.9 %. Moreover, the replacements of CdS with the higher energy gap ternary Cd_{1-x}ZnS has also led to a decrease in window absorption loss, and has resulted in an increase in the short circuit current in the solar cell. In this study, we prepared Cd_{1-x}ZnS thin films by a modified chemical bath deposition technique. The optical and electrical properties performed in the absence and under illumination measurements with an ELH halogen lamp have been investigated in order to better understand the growth conditions that give rise to films for optimum device performance.

2. Experimental Details

The deposition took place, at 80 °C for 60 min, on slide glass substrates cleaned with trichloroethylene, acetone, ethanol and distilled water in an ultrasonic cleaner. The aqueous solution used for CdS-ZnS co-deposition contained

0.01 M [CdSO_4+ZnSO_4], 0.05 M SC(NH_2)_2, 1.5 M NH_3 and 3.0 M Na_2H_4·H_2O in deionized water with total volume 150 ml[1]. The crystal structure of these films was checked by X-ray diffraction (XRD) measurements in the grazing incidence mode with 3 ° of beam inclination were performed, using a monochromatic CuKα radiation with a slit of 1.0 mm. Surface morphology were examined by JEOL model JSM - 6400 scanning electron microscope. The optical transmission spectra were carried out at about 10 K by using a Keithley 614 electrometer. Photoluminescence (PL) spectra were carried out at about 10 K by using a 365 nm wavelength from a clear mercury lamp as an excitation source.

3. Results and Discussion

The films obtained by this method, after ultrasonic cleaning, were smooth, uniform, adherent, bright yellow orange in color and the yellowness increases with increasing zinc content. Cd_{1-x}ZnS films deposited on slide glass substrates show only one diffraction peak located around 2θ = 28° (Fig.1). The peak could be probably associated with (111) reflection of the zincblende structure. Increasing Zn content gives rise to rapidly decrease in the peak intensity and it was disappeared when the Zn atomic ratio (x) > 0.7. From SEM micrograph, grain size decreases rapidly as Zn atomic ratio (x) increases (Fig. 2). Fig. 3 shows the optical transmission spectra of the as-deposited Cd_{1-x}ZnS films. The shift of absorption edge toward shorter wavelength indicates that increasing Zn atomic ratio gives rise to increase in energy gap (E_g). Energy gap of the films was determined by using the plot of absorption coefficient (α) versus photon energy (hv) showing the presence of two energy gap values situated in low and high energy region. This can be interpreted in terms of the presence of mixed phases i.e. the pure CdS and CdZnS phases. By extrapolating the linear portion of the plot of (αhv)^2 vs hv to the abscissa of the graph, we can be accurately obtain two energy gap values of the as-deposited films. It presents Energy gap of pure CdS phase, about 2.4 eV, seems to be independent of the Zn atomic ratio (x). Conversely, CdZnS phase presents the variation of energy gap from 3.1 to 3.9 eV when the Zn atomic ratio increases from 0.2 to 0.9. Fig. 4 shows the variation of E_g1 and E_g2 of the as-deposited films. Our results are in agreement with the ones previous reported [1].
The sheet resistance linearly increases from $5.0 \times 10^9$ to $2.1 \times 10^{11} \ \Omega/\text{sq}$ for $x = 0$ to $x = 0.9$. However, the sheet resistance value was decreased several orders of magnitude under illumination with an ELH halogen lamp. Photoluminescence (PL) spectra of pure CdS films, around 10 K, appear three broad emission bands peaking at 640, 580 and 550 nm, called red (R), yellow (Y) and green (G) bands respectively (Fig. 5). R band could be attributed to surface states [2]. Y band is associated with Cd-interstitial and G band is related to S-vacancy [3]. PL spectra of Cd$_{1-x}$Zn$_x$S films exhibit two emission bands, called R and G bands. R band is related to surface states occurring mostly in CdS phase. G band was believed to be the overlapping of Cd-interstitial and S-vacancy occurring mostly in CdZnS phase.

**4. Conclusions**

The chemical bath deposition is a simple and suitable method for obtaining smooth, uniform, high reflecting and strong adherent CdS-ZnS thin films. Moreover, this method has allowed to deposit CdS-ZnS thin films with Zn atomic ratio $x_{\text{film}}$ controllable by adjusting the $x_{\text{solution}}$ in the deposition bath. The present work constitutes an intermediate step towards the development of low cost and low Cd content CdZnS/CuInGaSe$_2$ thin film solar cells.

**REFERENCES**

