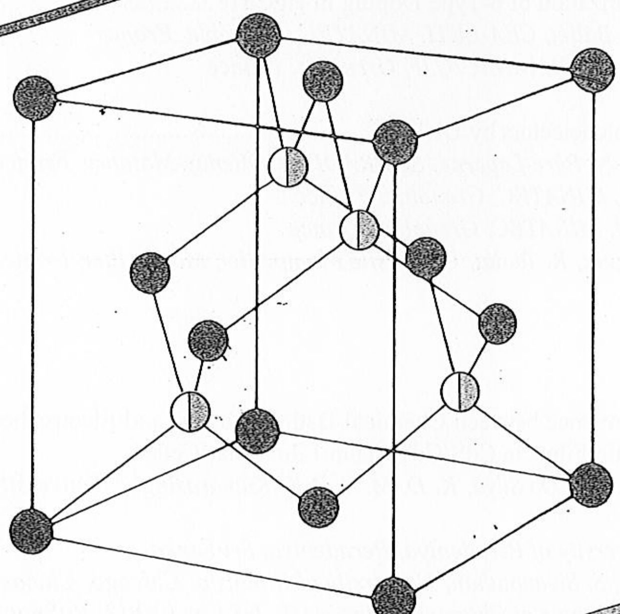
EXTENDED ABSTRACTS

THE 2013 U.S. WORKSHOP on the PHYSICS and CHEMISTRY of II-VI MATERIALS



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Session 4: Materials I

Poster Session

A STUDY ON SOLUTION GROWN CdZnS AS A WINDOW LAYER FOR SOLAR APPLICATIONS

B.S. Dassanayake[1], D.S.M. De Silva[2], K.A.S. Pathiratne[2], E. Colegrove[3], X. Zheng[3,4], R. Dhere[3,5], S. Sivananthan[3]

[1]*Department of Physics, University of Peradeniya, Peradeniya, Sri Lanka*

[2]*Department of Chemistry, University of Kelaniya, Kelaniya, Sri Lanka*

[3]*Microphysics Laboratory, Department of Physics, University of Illinois at Chicago, IL, 60607, USA*

[4]*Northwestern Polytechnical University, China*

[5]*Episolar Inc., Bolingbrook, IL, 60440, USA*

Introduction

With the realization of the importance of the innovative renewable energy sources to meet the ever increasing energy demand, II-VI thin film solar cells such as CdS/CdTe have received a considerable attention lately. CdS is easily vacancy doped (V_s) n-type on the order of 10^{17} in addition to the good conduction band alignment of CdS and CdTe.

After successfully producing CdS/CdTe cells with efficiencies over 14%, there are clear pathways for further improvements. As the band gaps of CdTe and CdS are 1.5 and 2.4 eV, respectively, primarily photons with energies within this range are absorbed in the CdTe and contribute to the cell's photocurrent. One of the possible ways to improve the performance is by increasing the band gap of the window material. The ternary compound cadmium zinc sulphide ($Cd_xZn_{1-x}S$) have been extensively investigated as vital candidate for wide band gap material to improve the cell performance[1]. The replacement of CdS with the higher energy gap ternary $Cd_xZn_{1-x}S$ leads to a decrease in window absorption loss and hence increase the efficiency of the cell[2].

In the present work Chemical Bath Deposition (CBD) and Close Space Sublimation (CSS) methods were used to grow the window and the absorber layers respectively of CdZnS/CdS and CdS/CdTe solar cell structures. The CBD growth of CdS was carried using cadmium acetate, thiourea, ammonium acetate, and ammonium hydroxide on a commercially available TEC 15 glass with no high resistivity buffer layer. For CdZnS cadmium acetate was replaced with a mixture of cadmium acetate and zinc acetate in 10:1 proportion. CdTe was deposited using the CSS method at ~10 Torr in the presence of He and O_2 at a substrate temperature of 550℃ and a source temperature of 600℃.

Results & Discussion

CdZnS was successfully deposited on TEC 15 glass and compared with the CdS window layer thin film. The deposition of CdZnS was confirmed by the XRD measurements (results not shown). In order to investigate bad gap shifting of the deposited thin films, optical absorbance measurements were conducted for both CdS and CdZnS films. The absorbance measurements revealed an expected blue shifted band gap for CdZnS compared to CdS as shown in the Fig. 1. It can be observed that the band gap of CdZnS (2.41 eV) is higher than CdS (2.38 eV) from the results. Even though the obtained value of CdS band gap is slightly smaller than the standard value (2.42 eV), the deviation of the band gap going from pure CdS to CdZnS is apparent from the steeper slop of CdZnS in comparison to CdS. This variation of band gap is comparable with a similar work elsewhere[3]. Surface roughness measurements of both CdS and CdZnS samples were analyzed using an AFM. The results are shown in the Fig. 2. As it can be seen, higher surface roughness of the CdZnS was noted compared to CdS exemplifying distinguishable differences between the two. The thickness of the CdZnS layer was about 2 times thicker than the compared CdS layer. So a comparative evaluation of the transmitted light through the two thin films is not shown here. In the case of similar thicknesses a blue shift is expected when the Cd^{+} concentration is decreased by the addition of Zn^{+}.

J-V characteristics were taken using a Newport Solar Simulator with an AM1.5G filter to extract V_{oc}, J_{sc}, FF and efficiency. The obtained V_{oc}, J_{sc}, FF and efficiencies are given in the Fig. 3. All of V_{oc}, J_{sc}, FF and Efficiency values of CdZnS was found to be slightly lower than that of CdS. An appreciable average efficiency of 12.1% was observed for the solar cells fabricated using the CdZnS window layer in comparison to the ones with CdS, which yielded 13.8%. The values look to be promising for a preliminary work and cell optimization is planned with thinner window layer and also by varying the Cd:Zn ratio of the thin film.

Conclusion

CdS/CdTe and CdZnS/CdTe solar cells using CBD and CSS methods were successfully fabricated. The results look promising with a considerable alteration of band gap of CdZnS window layer in comparison to CdS. A cell efficiency of 13.8% was observed for the fabricated CdS/CdTe cell whereas it was greater than 12.1% for the CdZnS/CdTe. Further investigations into the improvisation of the cell are planned in the future.

References

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Illustrations

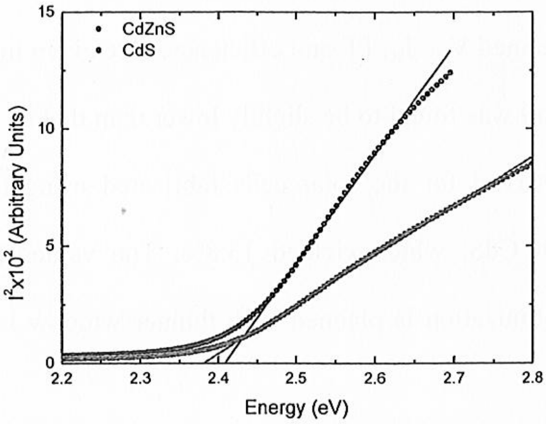

Fig. 1: Intensity^2 vs. Energy for CdZnS and CdS thin films

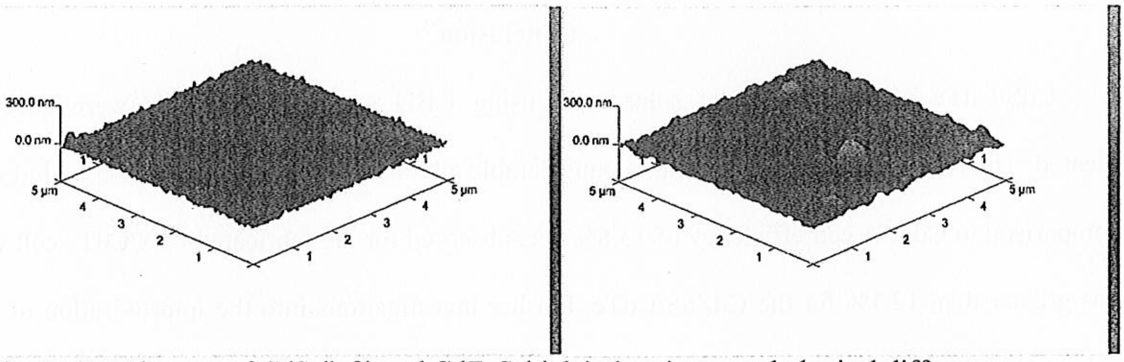

Fig. 2: AFM images of CdS (left) and CdZnS (right) showing morphological differences

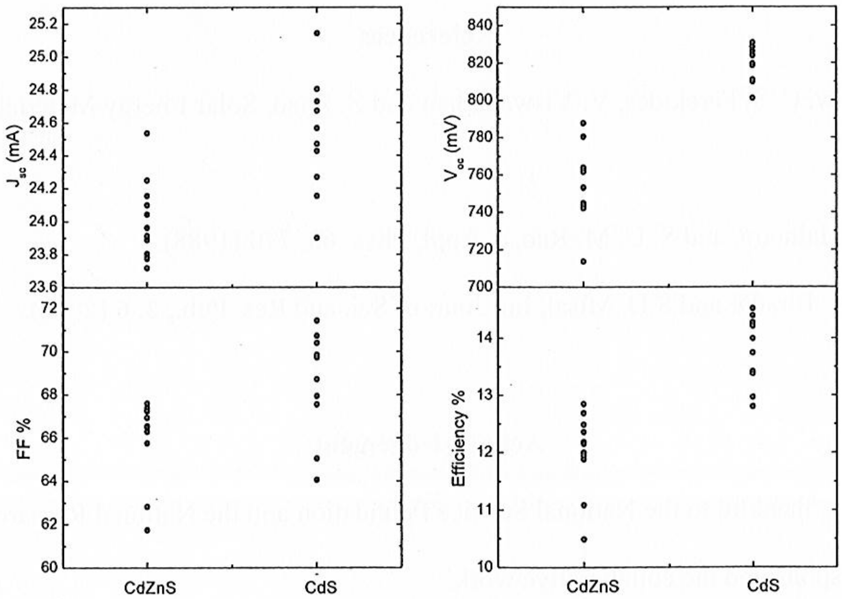

Fig. 3: Voc, Jsc, FF and Efficiency for CdZnS/CdTe and CdS/CdTe devices. Each dot represents a fabricated device.