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Numerical simulation of CIGS solar cell with ZnS buffer layer

Benslimane Hassane , Gani Abdennour, Dennai Benmoussa and Benslimane Abdelkader

Abstract— **To increase the performance of CIGS photovoltaic conversion of solar cell we simulate numerically this cell when we change the buffer layer CdS by ZnS. The effects of two different buffer layers, CdS and ZnS, are compared. The ZnS-based devices have higher values in the short-circuit current (Jsc). Using the ZnS buffer layer, higher performance was obtained compared to the CdS buffer layer-based cell. The buffer layer ZnS may be promising for improving the performance of CIGS solar cells.**

Keywords— Buffer layer; ZnS; CIGS ; Solar cell; AMPS-1D

I. Introduction

Electrical and optical numerical simulations of thin film solar cells are becoming a common practice. Thin film (CIGS)-based solar cells have attracted much attention in recent years.

Buffer layer absorption represents one of the major losses in today's CIGS and CdTe thin-film solar cells [1]. Thinning of the CdS or replacing it with a higher band-gap material are possible alternatives. New materials are necessary for several reasons: (a) minimization of current losses by window and buffer absorption (replace CdS).

(b) establishment of favorable band-offsets for wider-band-gap CIGS. (c) use as transparent front and back contacts in tandem devices.

Several alternative buffer layers have been investigated, including Zn(OH,S), ZnSe, Zn(Se,OH) [2,3], Zinc sulfide (ZnS) [4] , a possible replacement for II–VI semiconductor materials, is a direct wide band gap compound with a band gap energy of~3.8 eV which implies that further improvements in the short-circuit currents (Jsc) in CIGS solar cells can be achieved by replacing the CdS buffer layer with a ZnS buffer layer .

In this present work, a one dimensional simulation program called analysis of microelectronic and photonic structures (AMPS-1D) [5] is used to simulate the CIGS solar cell with ZnS buffer layer. We compared this structure with conventional cell with CdS buffer layer.

- *Benslimane Hassane is with Laboratory of semiconductors devices physics, Materials science department, T.M University, Bechar, Algeria E-mail: hassane_ben@Yahoo.fr*
- *Gani Abdennour is with Laboratory of Magnetic Materials, Djillali liabes University, Sidi Bel Abbes, Algeria Email: abouaminea@gmail.com*
- *Dennai Benmoussa is with Laboratory of semiconductors devices physics, Materials science department, T.M University, Bechar, Algeria Email: deennai_benmoussa@yahoo.com*
- *Benslimane Abdelkader is with Electrical Engineering department, T.M University, Bechar, Algeria E-mail: slimane_kada@Yahoo.fr*

II. Model

The simulated ZnS/CIGS thin film solar cell consists of a ZnO Window/ Zn Buffer layer /CIGS absorber/. A schematic of this structure is shown in Fig. 1. Light enters the cell through the Window, and passes through the entire of solar cell.

In a one-dimensional semiconductor device, the device physics operation can be described by solving Poisson's equation, and the electron and hole continuity equations at each position throughout the device. AMPS-1D simulates device operation by solving these coupled differential equations [5]. The solar AM 1.5 radiation was adopted as the illuminating source with a power density of 100 mW/cm^2

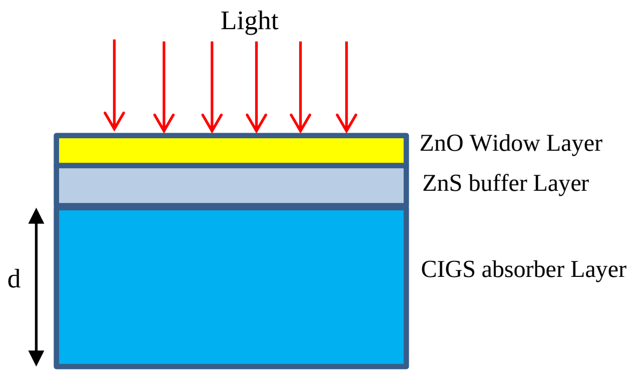

Fig.1. CIGS solar cell with ZnS buffer layer

III. Results

The spectral response curve of the ZnS-based cell and the CdS-based cell are shown in Fig. 2. From this figure It was possible to obtain photo-response from the shorter wavelength region using the ZnS buffer layer.

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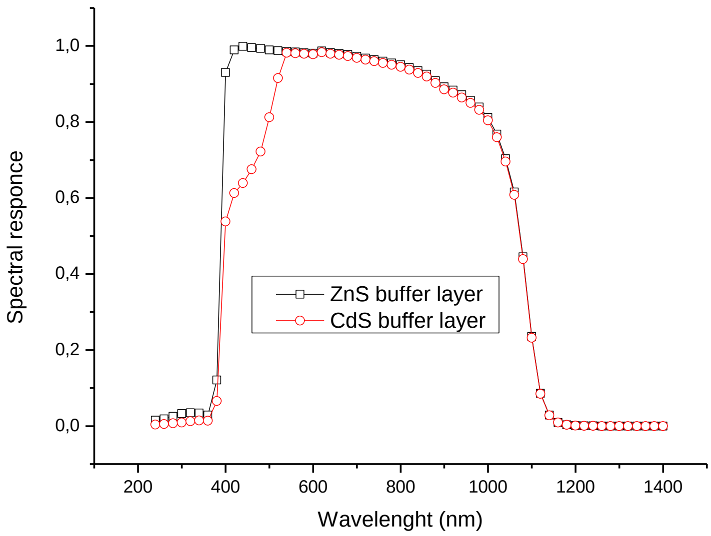

Fig.2. Spectral response of CIGS solar cell with ZnS and with CdS buffer layer

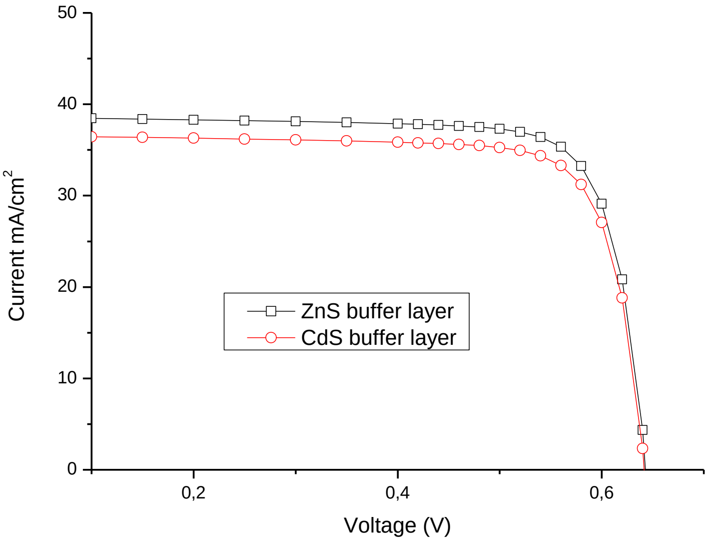

Fig 3. Characteristics of CIGS solar cell using the ZnS buffer layer and standard CdS buffer layer simulated under AM1.5 illumination

Table I shows the results of the CIGS thin film solar cells using the ZnS buffer layer. The CIGS solar cell with a ZnO/ZnSCIGS (d=3μm)) structure yielded an efficiency of 19.78% with J_{sc} =38.60mA/cm^2, V_{oc}=0.64V, and FF=79.73%. The reference CdS/CIGS solar cell yielded an efficiency of 18.64% with J_{sc} =36.59mA/cm^2, V_{oc}=0,64 V, and FF=79.24%. table I, shows a good agreement between our simulate results and experiment.

Photovoltaic caracteristics	ZnS buffer layer	CdS buffer layer	Experimental results [4]
Jcc (mA/cm^2)	38.60	36.59	34.9
Voc(V)	0.64	0.64	0.671
FF	79.73	79.24	76.6
η (%)	19.78	18.64	18.1

Table I. Comparison of the performance of CIGS solar cell with ZnS, CdS buffer layer two cases and experimental results.

We confirmed that the ZnS/CIGS solar cell increased the short current density because it is a wider band gap buffer layer material relative to the CdS/CIGS solar cell. However, the fill factor FF of the ZnS/CIGS solar cell (in the case of d=3μm) was slightly decreased compared to the reference CdS/CIGS solar cell.

The I–V characteristics of ZnS/CIGS and the reference cell with CdS buffer layer, are shown in Fig. 3. It is seen from the figure, in case of the ZnS/CIGS structure, the performance is better than the standard structure of CdS/CIGS.

IV. Conclusion

CIGS solar cell performance with ZnS buffer layer has been investigated..The photon with the wavelength less than 520nm (corresponds to the band gap of standard buffer layer CdS) cannot be transmitted to the absorber layer (CIGS), it may be possible to improve the cell performance by replacing CdS with another appropriate wider gap buffer material, the ZnS-based buffer layer has become more successful to realize high-efficiency CIGS solar cell.
We observed that ZnS/CIGS cell performance increased compared to the standard CdS-based cell.

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