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Short Communication

Investigation of Absorber Layer Thickness Effect on CIGS Solar Cell in Different Cases of Buffer Layers

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This study investigates the interplay between the absorber layer of $Cu(In,Ga)Se_2$ solar cells and the buffer layer of these devices. $Cu(In,Ga)Se_2$ devices with absorbers of different thicknesses and different buffer layers are simulated. We found that the reduction in thickness of the CIGS cell leads to decrease short-circuit current, it is the main cause of degradation photovoltaic conversion efficiency. It has been found that substitution of the CdS buffer layer by other materials such as ZnS can limit this performance degradation.

Keywords: Solar cell, CIGS, Buffer layer, Efficiency, AMPS-1D

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1. INTRODUCTION

The second-generation thin film solar cells are increasingly promising for their cheaper production and better efficiency. Cells based on (i) CdTe, (ii) (CIGS) and (iii) Si (a-Si:H) absorbers are the three most potential photoconductors for thin film solar cells because of their excellent efficiency[1]. Thin film (CIGS)-based solar cells have attracted much attention in recent years. Several alternative buffer layers have been investigated, including Zn(OH,S), ZnSe, Zn(Se,OH) [2, 3], Zinc sul-fide (ZnS) , 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 (J_{sc}) in CIGS solar cells, this improvement can be achieved by replacing the CdS buffer layer with a ZnS or ZnSe buffer layer.

In our work it has been interesting to study the effect of the thickness of the absorber layer (the thickest layer) on the photovoltaic efficiency of the CIGS cell for different buffer layers and to make a comparison between the studied cases.

The simulated CIGS thin film solar cell consists of a ZnO Window/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 [4]. The solar AM 1.5 radiation was adopted as the illuminating source with a power density of 100 mW/cm^2.

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2. RESULTS

In this work tow materials used as buffer layer were simulated considered a higher electron affinity and energy gap compared to the CdS. In particular a 3.5 eV energy gap for ZnS and 2.8 eV for ZnSe was used and 50 nm thick buffer layers (see Fig. 1).

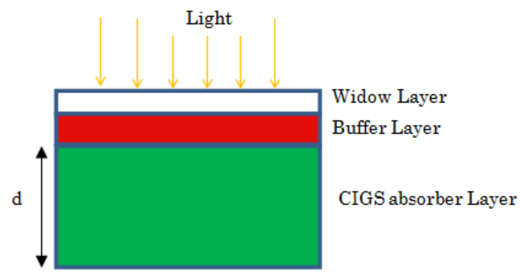

Fig. 1 – CIGS solar cell with different buffer layers

The resulted spectral response curves obtained from simulations are reported in Fig. 2. From this figure it is seen that photo-response from the shorter wavelength region was obtained as expected.

As shown in the simulations results the most promising Cd-free buffer is the ZnS, having the highest spectral response. A comparison among the simulated solar cells performances using different buffer layers and the reference cell with CdS is presented in table 1.

As reported in Table 1 using ZnS and ZnSe as buffer layer enhances the short circuit current and consequently the efficiency. On the contrary the open circuit voltage and the fill factor are just slightly influenced by the change of the buffer layer.

The conversion efficiency (η) curves of the ZnS-based cell, ZnSe-based cell and the CdS-based as a function of CIGS cell thickness (≈ Absrber layer thickness) are shown in Fig. 3. We observed that ZnSe/CIGS cell performance decreased with cell thickness compared to the standard CdS and ZnS -based cell. The substitution of the CdS buffer layer by ZnS can limit the efficiency degradation by diminution of absorber layer thickness.

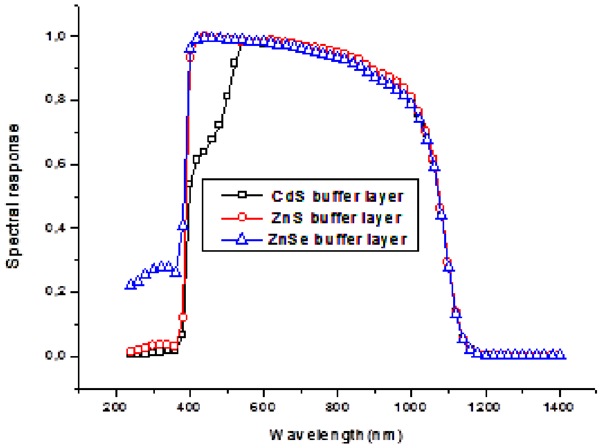

Fig. 2 – Spectral response of CIGS solar with different buffer layers

Table 1 – Comparison of the performance of CIGS solar cell with ZnS, ZnSe,and CdS buffer

Buffer layer used in the simulation	Photovoltaic characteristics			
	V_{CO} (mV)	J_{SC} (mA/cm²)	FF (%)	η (%)
CdS	0.64	36.68	79.41	18.69
ZnS	0.64	39.83	79.85	20.47
ZnSe	0.64	38.85	73.72	18.44

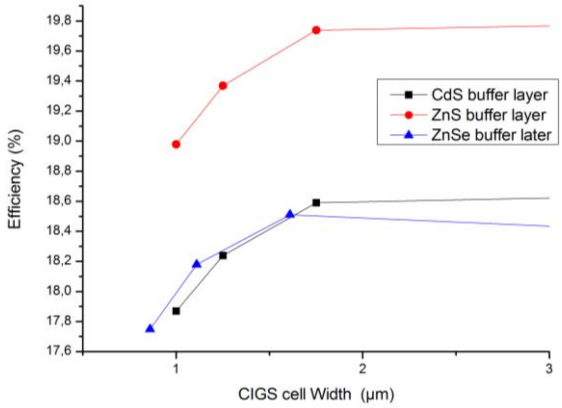

Fig. 3 – Conversion efficiency of CIGS solar cell vs of devices thickness with different buffer layers

3. CONCLUSION

CIGS solar cell performance with ZnS, ZnSe buffers layers has been investigated. It was possible to obtain photo-response from the shorter wavelength region using the ZnS or ZnSe buffer layer. We observed that cell performance increased compared to the standard CdS-based cell. It has been found that substitution of the CdS buffer layer by other materials such as ZnS can limit this performance degradation by diminution of absorber layer thickness.

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