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Performance investigation of Perovskite/CIGS tandem solar cell using numerical modelling and simulation

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In the modern world, multi-billion projects are going on researching photovoltaic (PV) devices. Considering the global energy demand the contribution of solar power is still negligible. Therefore, researchers are working on finding new solutions to enhance the performances of these PV devices. With the approach of the multi junctional PV devices, researchers identified a clear path to reach Shockley & Queisser's detailed balanced limit. This research was focused on modelling a tandem cell structure with perovskite and CIGS materials to obtain the best efficient device with enhanced performance. Therefore, a two-terminal tandem structure was modelled computationally. The SCAPS-1D (one-dimensional solar cell capacitance simulator) software was used for the modelling and simulations. The top cell configuration was modelled with SnO2, PCBM, CH3NH3PbI3 and PEDOT: PSS materials and the bottom cell with ZnO, CdS and CIGS materials. The higher energy bandgap materials were used in the top cell to absorb the high energies from the AM1.5G spectrum. The energies penetrating through the top cell are absorbed by the bottom cell. Therefore, low energy bandgap materials were used for the bottom cell absorber. In the simulation procedure, a SCAPS script was used to analyze partial absorptions of the top cell. Additionally, a homojunction was created at the bottom cell CdS/CIGS interface according to previous studies. This process created an SDL (surface defect layer). The defect densities of the two interfaces; CdS/SDL and SDL/CIGS were altered to analyze the possible outcomes. According to the results, 30.946% efficiency was observed for the tandem device with 1.816 V open-circuit voltage and 20.863 mA/cm2 short circuit current. According to the defect density alteration of the interfaces, the defects at the SDL/CIGS interface showed high influence compared to CdS/SDL. With the results of JV characteristic curves and quantum efficiency curves, the current matching condition and the peak efficiency have appeared at the same condition. Therefore, the results adhere to the basic operation of the tandem configuration. By concerning the interface defect densities, it can be concluded that the changing defect densities at SDL/CIGS interface change the direction of the carriers, which causes the efficiency decrement. In numerical modelling, many assumptions were used, and the fabrication of the model is recommended to observe the practical situation.

Keywords: CIGS, Optimization, Perovskite, SDL, SCAPS, Tandem

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