Tandem perovskite-silicon solar cell optimized by improving silicon solar cell efficiency using carbon-based photon conversion layer.

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Abstract:

Monolithic perovskite/silicon tandem solar cells have emerged as a promising technology in the field of photovoltaics, offering the potential to significantly enhance the efficiency of solar energy conversion [1]. They have a theorical maximum efficiency of up to 45%, when the band gap maximum is 1.5 eV [2]. For the perovskite-silicon tandem with a power conversion efficiency (PCE) of ca. 28%, the contribution of the silicon cell is typically low (ca. 6%) due to weak incident flux, whereas that of the top perovskite cells is ca. 22% [3]. In this work, we have carried out a computational optimization of the performance of perovskite-silicon tandem solar cells using SCAPS-1D software. A tandem architecture of ITO/HTL/perovskite/ETL (top cell) -Si (bottom cell) was selected, using ZnO as ETL (electron transport layer), perovskite ($MAPbI_3$) as absorber layer and Spiro-Ometad as HTL (hole transport layer) in the top cell. We investigated the impact of the thickness of the perovskite in the whole tandem device using transfer matrix method (with python), which showed the best optimal results at 700 nm thickness and additionally investigated the other key operating parameters of the cell such as series and shunt resistances. Then we further investigated the effect of carbon-based photonic conversion layer to the absorption properties of the bottom cell. The obtained results have shown that under satisfactory simulation conditions, the current density (Jsc), open circuit voltage (Voc) and fill factor (FF) of the tandem perovskite- silicon solar cell can be improved, with a remarkable increase in the power conversion efficiency (PCE) of ca. 8%. These results from simulations are currently used to build a very optimized tandem perovskite/silicon solar cell.

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