PSC and CIGSSe Solar Cells: Merging Two Technologies in a Forward-Looking Testing Ground

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Abstract

New industrial and technological solutions for green energy and optoelectronics are needed to bypass the state of the art in methodology and performances, demanding an extra-effort from researchers in the field of material science for the synthesis, characterization, and prototyping of more performant materials and device solutions. In this framework, we show how two well-established thin-film photovoltaic technologies, perovskites and $Cu(In_{1-x}Ga_x)$ $(S_ySe_{1-y})_2$ (CIGSSe) solar cells, can be combined to valorize their key features on the way to enhance devices conversion efficiency. Perovskite solar cells (PSCs) stand out for their ability to absorb visible light, high efficiency comparable to commercial silicon-based solar cells exceeding 25%, flexibility, semi-transparency, and lightweight properties, making them up-and-coming for various applications. Similarly, CIGSSe solar cells exhibit higher efficiency than amorphous silicon photovoltaic devices, lower toxicity, and are lighter and less rigid, making them suitable for tandem modules alongside other solar cell technologies. The CIGSSe absorber layer is a p-type material, renowned as an efficient absorber ($\alpha > 10^5$) with a tunable optical bandgap that can be adjusted within a range of 1.01 eV ($CuInSe_2$) to 2.5 eV ($CuGaS_2$) by varying the cationic (In/Ga) and anionic (S/Se) ratio of the solid solution, allowing for optimization to best match the solar spectrum, a crucial advantage in photovoltaic applications. Here we present a roadmap and the first results of our three pathways: i) Introduction of CIGSSe into PSCs: exploring the integration of CIGSSe into semi-transparent perovskite solar cells to improve their efficiency and stability; ii) CIGSSe utilization as hole transport material (HTM): investigating the potential of CIGSSe as an HTM in perovskite solar cells to enhance their performance for large-scale application; iii Tandem device CIGSSe/PSC: developing novel tandem solar cells by combining CIGSSe and PSC technologies to achieve higher overall efficiency.

Keywords

Perovskite Solar Cell, Hole Transporting Layer, CIGSSe Solar Cells, Tandem CIGSSe/PSC