Simulation-Based Optimization of Perovskite and CIGS-based Solar Cells

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Tandem solar cells are one of the most efficient ways to overcome the limits of power conversion efficiency (PCE) of single junction solar cells and today reach PCEs higher than 30% [1]. Perovskite solar cells (PSCs) have been successfully combined with silicon bottom-subcell in tandem configurations, reaching the efficiencies exceeding 32% for two-terminal (2T) configuration [1]. Despite the promising future of this technology, the research community is also searching for alternatives, which can potentially go along with mainstream silicon-based photovoltaics to help propel the transition towards renewable sources of energy. One of them are CuIn(Ga)Se_2 (CI(G)S) materials. They offer the advantages of compositional tunable bandgap in the range 1.03 – 1.68 eV combined with a high absorption coefficient, allowing for an all thin-film tandem technology [3,4,5]. Indeed, perovskite/CI(G)S 2T tandems have been demonstrated with efficiencies as high as 24.2% [6]. Although they still lag behind those of PVK/Si tandems, they have a theoretical potential to reach efficiencies higher than 40% [2]. Reaching this goal will require a dedicated optimization of the device layout with respect to its electrical and optical properties.

In this work we show the potential of the transfer matrix method (TMM) to simulate and optimize monolithic tandem solar cells based on CI(G)S and perovskite absorbers. Providing that simulation models fits well experimental data, we were able to perform a detailed optical loss analysis. This allowed us to determine sources of parasitic absorption and decreased sub-band gap transmittance, and further to find better substitute materials to improve light absorption and conversion efficiency in the tandem. Our results set guidelines for the 2T perovskite/CI(G)S tandem solar cells development, predicting achievable efficiency of 30%, for the current direction of the perovskite/CI(G)S tandem development.

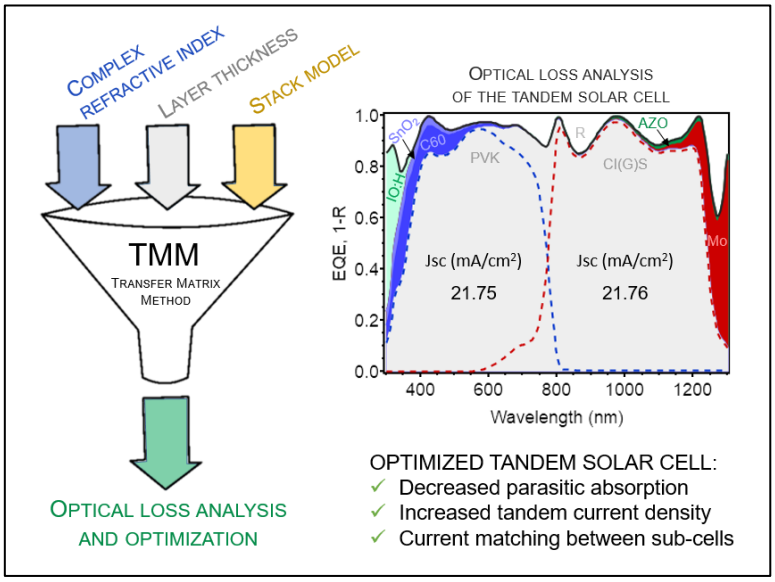

FIG. 1. Simulation scheme and optical loss analysis of the real tandem solar cell.

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