Investigating the recombination junction in perovskite-silicon tandem solar cells

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Fabricating low-cost and high-efficiency tandem solar cells presents the opportunity to significantly reduce the levelized cost of electricity for solar photovoltaic systems. Perovskite-silicon tandems can potentially achieve power conversion efficiencies of up to 44% according to the detailed-balance limit assuming a top-cell bandgap of approximately 1.7 eV [1]. Organometal-halide perovskite materials in a single single-junction architecture have been reported in the literature with efficiencies of around 25% [2], and one of the main features of these materials is the facile integration with existing Si manufacturing as an additive technology. Perovskite-silicon tandem solar cells have been reported in the literature with efficiencies of >29% [3], and usually employ complex stacks with numerous deposition steps which are rather unattractive from an industrial perspective. We therefore fabricated a simplified tandem structure consisting of a perovskite n-i-p stack on a silicon heterojunction (SHJ) structure, and have obtained efficiencies of ~18% without anti-reflection coating with a V_{OC} of >1.7 V. The optimization of the recombination junction between the top and bottom cells is expected to provide further performance improvement. In this study, we have investigated the influence of various interlayers and annealing conditions on the recombination junction between a thin-film silicon layer used in the SHJ bottom cell and an SnO_2 electron transport layer used in the perovskite top cell.

[1] T. Leijtens, K. A. Bush, R. Prasanna, and M. D. McGehee, “Opportunities and challenges for tandem solar cells using metal halide perovskite semiconductors,” *Nat. Energy*, vol. 3, no. 10, pp. 828–838, Oct. 2018, doi: 10.1038/s41560-018-0190-4.

[2] M. Jeong *et al.*, “Stable perovskite solar cells with efficiency exceeding 24.8% and 0.3-V voltage loss,” *Science*, vol. 369, no. 6511, pp. 1615–1620, 2020, doi: 10.1126/science.abb7167.

[3] A. Al-Ashouri *et al.*, “Monolithic perovskite/silicon tandem solar cell with >29% efficiency by enhanced hole extraction,” *Science*, vol. 370, no. 6522, pp. 1300–1309, Dec. 2020, doi: 10.1126/science.abd4016.

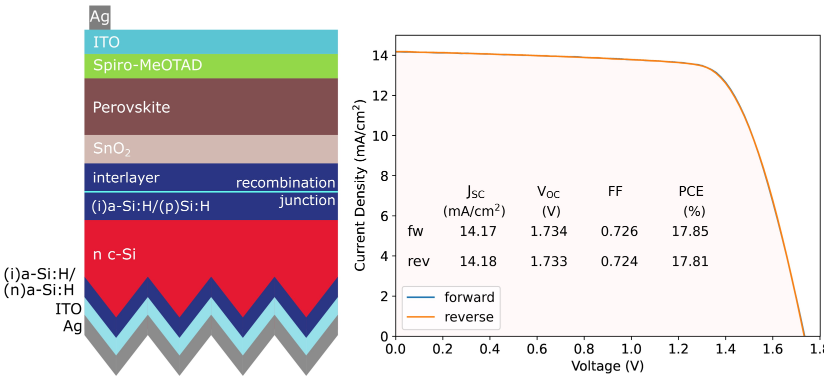

Figure 1. Tandem device structure (left) and the typical cell performance (right).