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Large area efficient interface layer free monolithic perovskite/homo-junction-silicon tandem solar cell

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Monolithic perovskite/silicon tandem solar cells show great promise for further efficiency enhancement for current silicon photovoltaic technology [1]. In general, an interface (tunnelling or recombination) layer is usually required for electrical contact between the top and the bottom cells, which incurs higher fabrication cost and parasitic absorption. Most of the monolithic perovskite/Si tandem cells demonstrated use a hetero-junction silicon (Si) solar cell as the bottom cell and on small areas only. For commercialization, demonstrations on large area are essential. To date, there is only one monolithic perovskite/silicon tandem device larger than 10 cm^2 which uses a hetero-junction Si cell as the bottom cell and a nano-crystalline Si interface layer to provide sufficient vertical conductivity between the top and the bottom cells. The champion device had a PCE of 18.0% on 12.96 cm^2 [2].
Recently, we reported a simpler approach for integrating a perovskite solar cell monolithically onto a Si solar cell on 4 and 16 cm^2 (show in Figure 1) [3]. The first advantage of this approach is that it does not require the additional fabrication of an addition interface layer between the perovskite and Si cell. Instead, it utilises the SnO_2 electron transport layer of the perovskite top cell to also serve as a recombination contact with the silicon bottom cell. The second advantage of this approach is that it is compatible with a homo-junction p-n Si solar cell, which is a common Si solar cell structure for commercial cells. The third advantage is that the entire sequence for the planar perovskite cell fabrication is done at low temperatures minimising damage to the bottom Si solar cell. Finally, this monolithic tandem approach does not rely on the SnO_2 for lateral conduction, which is managed by the p++ emitter, making up scaling to large area relatively straightforward. The low lateral conductivity in SnO_2 localises the effects of shunting having a, similar advantage as the nano-scyrstalline Si interface layer used in previous work [2]. Recent optimizations have improved cells' performance from 20.5% (4 cm^2) to 21.8% (>10 cm^2).

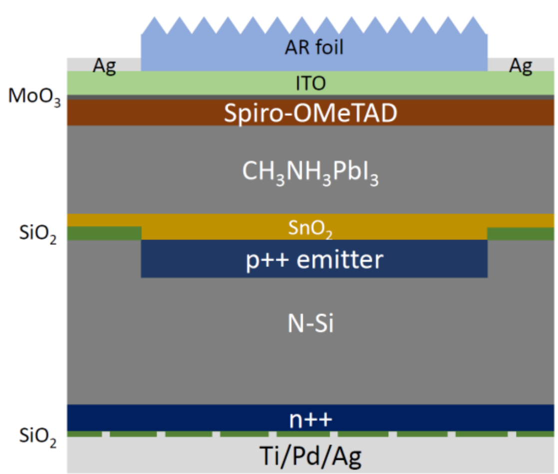

Figure 1. Schematic device design of interface-layer-free perovskite/silicon-homojunction solar cell (not to scale).

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