Unravelling Optical and Electrical Degradation of Perovskite Solar Cells and Impact on Perovskite/Silicon Monolithic Tandem Modules

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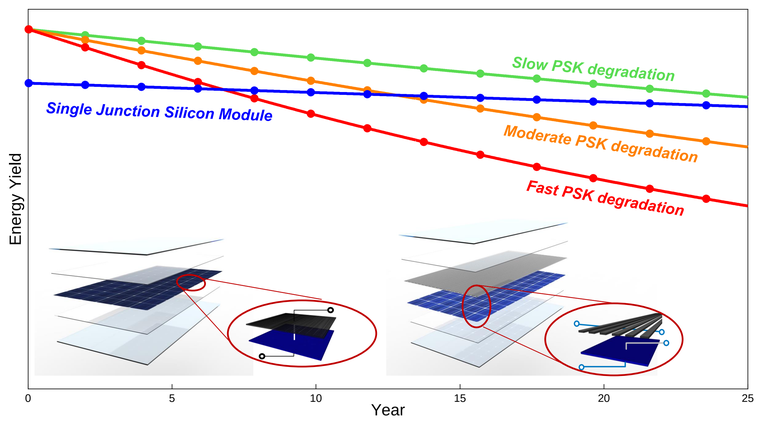
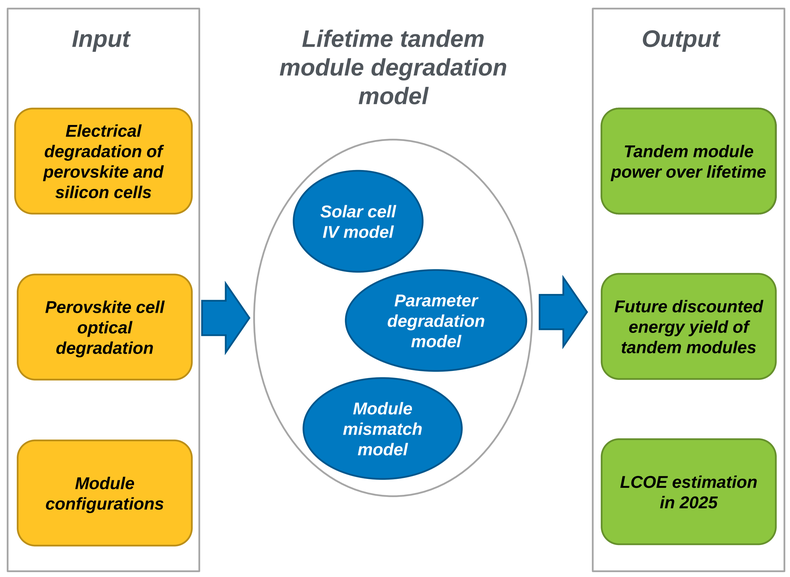
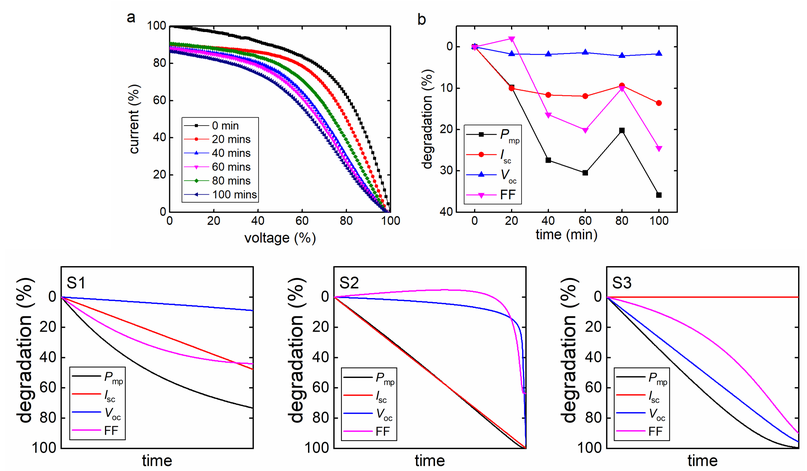
Tandem module power rating and degradation



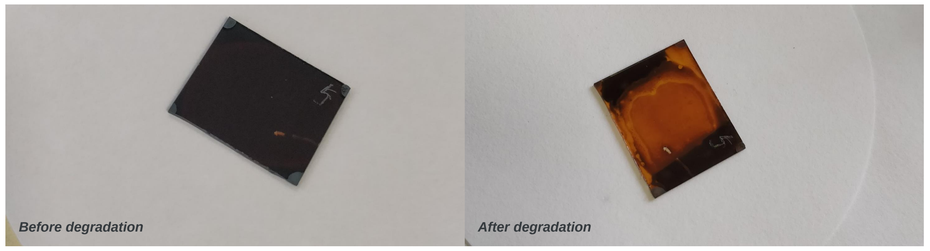
Silicon based perovskite tandem cells have great potential to further improve the current single junction silicon module efficiency. However the uncertainty of perovskite solar cells' long term stability leads to uncertainty of economic competitivity against conventional silicon modules.

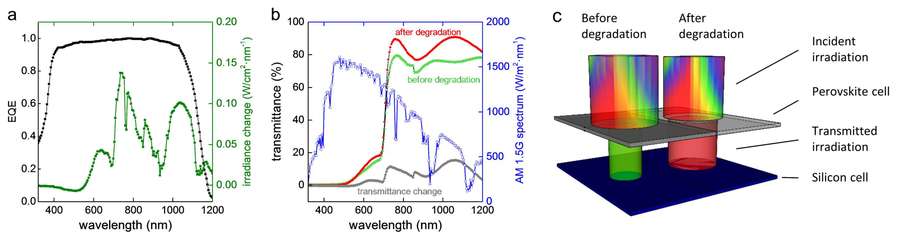


Electrical degradation example and three potential degradation modes



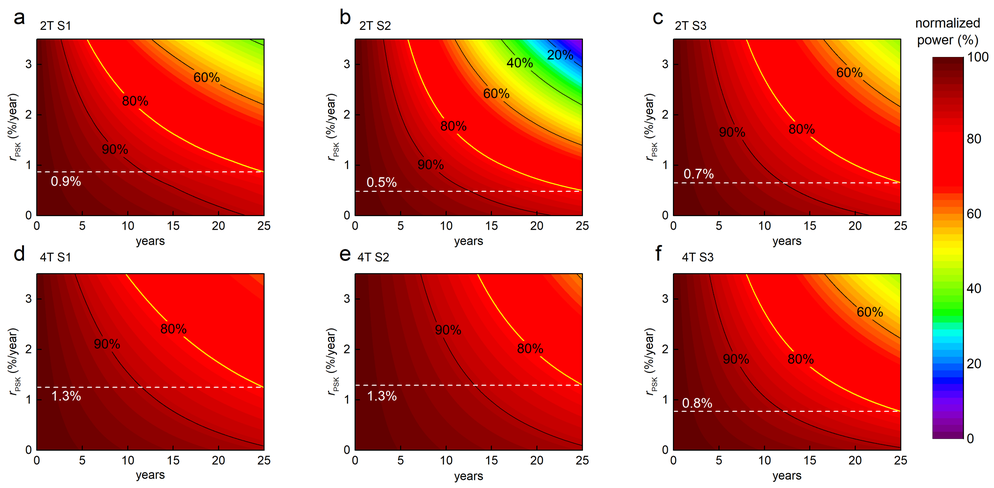
Perovskite cell bleaches as degrades





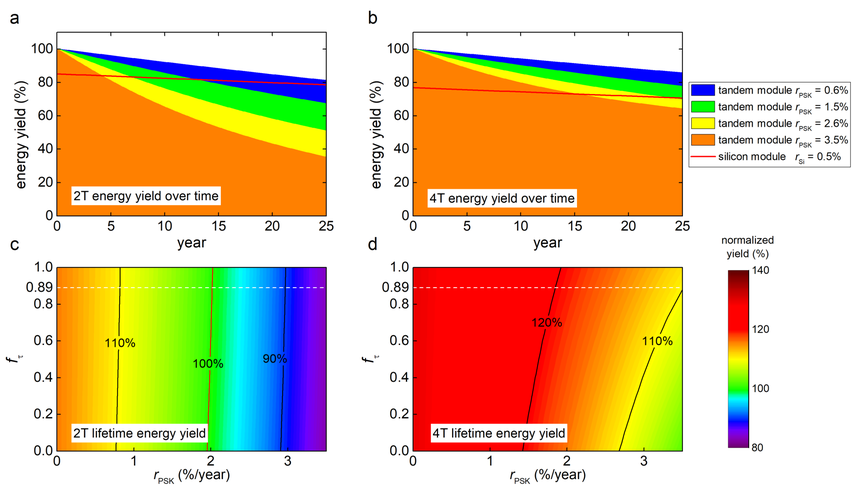
The optical degradation of the perovskite top cell will translate into I_{sc} increase at the silicon bottom cell. Based on our in-house fabricated cell, we obtained a ratio of 0.89 between the I_{sc} loss at the top cell and the I_{sc} gain at the bottom cell.

2T and 4T Module power degrades at different rates with varied perovskite stability



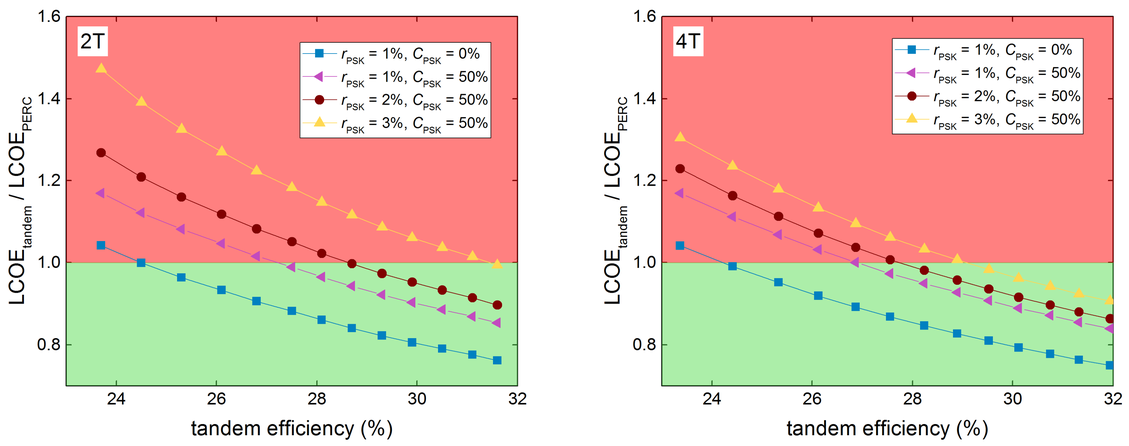
The module power is simulated for both 2T and 4T tandem modules considering electrical mismatch and optical compensation effect. While silicon cell degradation rate is based on field data, the perovskite cell degradation rate is varied between 0% to 3.5%.

Initial Power Rating vs Degradation Rate



Using unstable perovskite top cells, even featuring a high initial power rating, a tandem module could still have a lower lifetime energy yield than only using the same silicon bottom cells.

Economical Viability of Tandem Module in 2025



By estimating the cost of the module, BOS and O&M, the projected LCOEs of 2T and 4T perovskite/silicon tandem modules are compared to the projected LCOE of mono c-Si PERC modules in 2025. Simulations are conducted for different tandem cell efficiencies, perovskite cell degradation rates and additional cost for tandem technologies.

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