Device Engineering of Perovskite Solar Cells to Achieve Near-Ideal Efficiency (PV-4)

A joint India-U.S. research consortium funded under the *Joint Clean Energy Research & Development Center (JCERDC)*

Scientific Achievement:

Despite the exciting recent research on perovskite-based solar cells, the design space for further optimization and the practical limits of efficiency are not well known in the community. To address the above, here we 1) identify the detailed balance performance limits, 2) identify the physical mechanisms that contribute to sub-optimal performance of current perovskite-based solar cells, and 3) suggest schemes to further improve the performance (see Fig. 1).

Significance and Impact:

This work provides a comprehensive modeling framework to understand and optimize the performance of perovskite-based solar cells. Further, we show that it is possible to achieve efficiencies and fill factors greater than 25% and 85%, respectively, for an optimally designed perovskite-based solar cell—which could be of immense interest to the community.

Research Details:

Self-consistent numerical simulation involves:

- Poisson and carrier continuity equations.
- Trap-assisted recombination, radiative recombination, and Auger recombination mechanisms.
- Theoretical calculations on detailed balance limit efficiency.

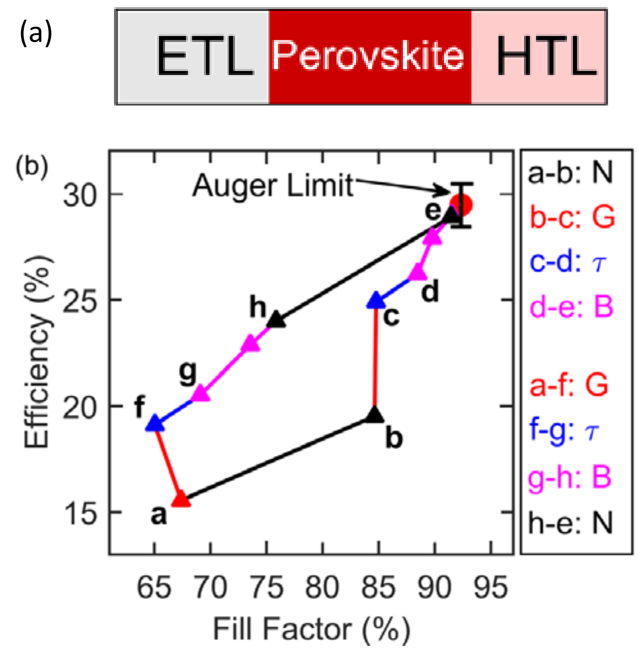

Figure 1. Device engineering to improve the efficiency of perovskite solar cells. (a) Schematic of a perovskite solar cell. (b) Efficiency trends with respect to variation contact layer doping (N), non-radiative lifetime τ and radiative recombination rate *B*, and carrier generation rate, *G*. Point **a** corresponds to simulations calibrated with the experimental results reported by Liu et al., *Nature* 2013. Each curve represents the performance trend due to the variation of a single parameter, as listed in the right panel.

Publication: S. Agarwal and P. R. Nair, Device engineering of perovskite solar cells to achieve near ideal efficiency, *Applied Physics Letters* **107**, 123901 (2015).
DOI: dx.doi.org/10.1063/1.4931130

Contact: Pradeep Nair (*prnair@ee.iitb.ac.in*)