Efficiency of Perovskite-Perovskite Tandem Solar Cells

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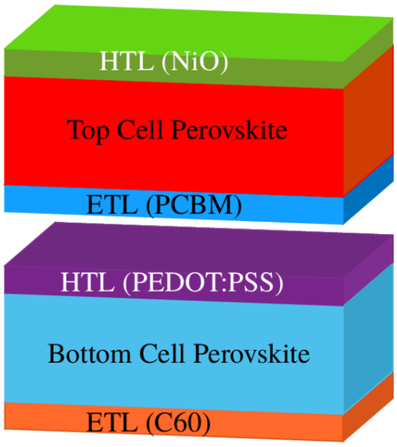
In recent years, perovskite solar cells have emerged as a very solar cell technology due to potential high power-conversion efficiency, bandgap tunability and cost-effective fabrication process. Halide organic-inorganic (HOPs) perovskites based solar cells have exceeded power conversion efficiency of 23% [1]. Single junction solar cells have theoretical efficiency limit of about (31%) [2]. To surpass this theoretical limit and to fully utilize the available solar spectrum, it is highly desired to adopt multijunction and tandem solar cells technologies. To achieve high efficiencies and simultaneously reducing the cost per kWh, thin film based tandem solar cell technologies must be adopted.

HOPs offer wide range of bandgaps making them a suitable candidate for tandem solar cells [3]. In a tandem solar cell subcells can be connected in different configurations such as two-terminal (2T) configuration, four terminal configuration (4T). Final tandem cell performance is determined by the combination is used. Intermediate layer connecting two cells plays an important role. Ion migration is another issue in perovskite solar cells, limiting their performance by introducing hysteresis effects [4], though the exact reason behind the hysteresis is still under debate [5].



To understand charge carrier generation, transport and recombination in individual cells as well in combined tandem structure is important to make best use of the tandem architecture. Drift-diffusion is a powerful tool to analyse charge carrier behaviour in such devices, including effect of contact metal work function, doping and traps present there in various layers. Theoretical simulations based on finite element drift diffusion methods, have been successfully used to explore various phenomenon in single junction devices. So, objective of the thesis would be:

1) Implementing Drift-diffusion simulation model to analyse all perovskite tandem solar cells, in different configurations.

2) To study role of grains and ion migration, in the tandem solar cell performance.

Student is expected to have background in Physics/Electrical/Computer Science and to have good programming skills.

References

[1] NREL Efficiency chart, 2018. URL:https://www.nrel.gov/pv/assets/images/efficiency-chart-20180716.jpg.
[2] Rühle, Sven. "Tabulated values of the Shockley–Queisser limit for single junction solar cells." Solar Energy 130 (2016): 139-147.
[3] Rajagopal, Adharsh, et al. "Highly efficient perovskite–perovskite tandem solar cells reaching 80% of the theoretical limit in photovoltage." Advanced Materials 29.34 (2017): 1702140.
[4] Azpiroz, Jon M., et al. "Defect migration in methylammonium lead iodide and its role in perovskite solar cell operation." Energy & Environmental Science 8.7 (2015): 2118-2127.
[5] Ansari, M.I.H., et al. "Frontiers, opportunities, and challenges in perovskite solar cells: A critical review." Journal of Photochemistry and Photobiology C: Photochemistry Reviews 35 (2018): 1-24.