Theoretical investigation of Dye on Perovskite Tandem Solar Cells

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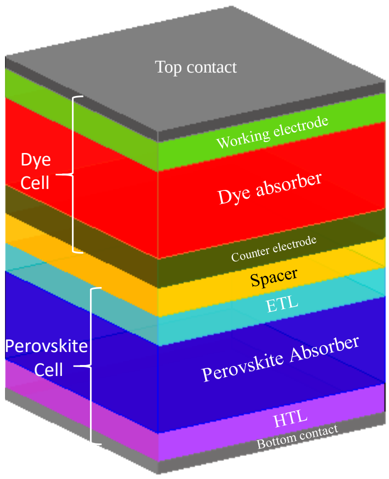
In recent years, perovskite solar cells have emerged as a very solar cell technology due to potential high power-conversion efficiency, bandgap tunability and cost-effective fabrication process. Halide organic-inorganic (HOPs) perovskites based solar cells have exceeded power conversion efficiency of 24% [1]. On the other hand, dye-sensitized solar cells (DSCs) are another potential class of hybrid cell. DSCs offer transparency, flexibility, and high conversion efficiencies even at dim light conditions [2]. Single junction solar cells have theoretical efficiency limit of about (31%) [3]. 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.

HOPs offer wide range of bandgaps making them a suitable candidate for tandem solar cells [4]. Integration of dye and perovskite solar cells can lead to achieve higher efficiency to bring down solar cell price significantly. In a tandem solar cell, subcells can be connected [5] in two different configurations: two-terminal (2T) and four terminal configuration (4T). Final tandem cell performance is determined by the performance of individual subcells, and the configuration they are connected with. Intermediate layer (spacer) connecting two cells plays an important role. The spacer can lead to electronic losses by recombining charge carriers, and the optical losses by light absorption.



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. On the other hand, optics management in a tandem configuration is crucial. Drift-diffusion (DD) is a powerful tool to analyse charge carrier behaviour in such devices, including the effect of contact metal work function, doping and traps present there in various layers. Also, combining optical models with the DD can help investigating full optoelectronics of a tandem cell. So, objectives of the proposed thesis would be:

1) Electronic simulations using DD model to analyse charge transport in dye-perovskite tandem solar cells, in different configurations.

2) Combining optical models with DD for complete optoelectronic simulation of the tandem cell.

Student is expected to have background in Physics/Electrical/Computer Science, and to have good programming skills with MATLAB (or any other language).

References

[1] https://www.nrel.gov/pv/assets/pdfs/best-research-cell-efficiencies.20200406.pdf.
[2] Nam, Sang-Hun, et al. "Review of the Development of Dyes for Dye-Sensitized Solar Cells." *Applied Science and Convergence Technology* 28, no. 6 (2019): 194-206.
[3] Rühle, Sven. "Tabulated values of the Shockley-Queisser limit for single junction solar cells." Solar Energy 130 (2016): 139-147.
[4] 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.
[5] Yun, Sining, et al. "New-generation integrated devices based on dye-sensitized and perovskite solar cells." *Energy & Environmental Science* 11, no. 3 (2018): 476-526.