Investigating Injection vs Extraction Properties in Perovskite Solar Mini-Modules Using Luminescence Imaging Techniques

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Abstract:

Perovskite solar cells (PSCs) have made remarkable advancements in recent years, yet several challenges continue to hinder their full potential. Notable issues include optical voltage losses, non-reversible carrier properties, and metastability in opto-electronic parameters, all of which affect device performance and stability[1]. This work aims to tackle these critical challenges by integrating advanced experimental techniques into scalable devices.
We will investigate optical voltage losses and non-reciprocal charge injection/extraction phenomena through wide-field hyperspectral luminescence imaging (HI)[2]. Electroluminescence (EL) and photoluminescence (PL) measurements under various operating conditions (open or short circuit OC SC, several bias V_{OC} V_{MPP}) will be used to study the reciprocity and efficiency between charge injection or collection.
Our study will focus on module-scale samples. We will assess the impact of deposition inhomogeneity on many optoelectronic parameters such as optical voltage losses, Quasi-Fermi Level Splitting (QFLS), Urbach energy tail (Eu) and their evolution with degradation mechanisms.
The primary objectives of this research are the study of charge transport non-reversibility, quantifying the effects of deposition inhomogeneity and overall effect during device degradation. Our combined approach aims to enhance the reproducibility, stability, and performance of PSCs by addressing key bottlenecks related to metastability, ion dynamics, and voltage losses.

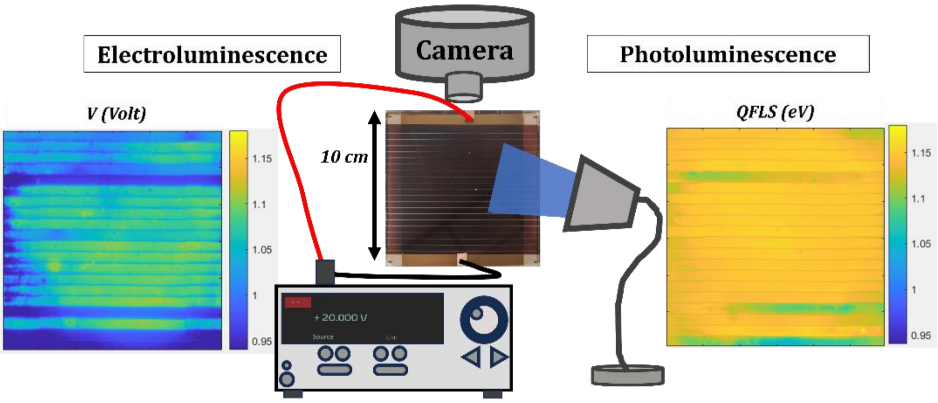

Figure – Hyperspectral luminescence imaging technique (EL and PL) on a 10x10 cm² module of 20 cells. Mapping of potential and QFLS from fitting the spectra

Keywords: perovskite solar cells, optical voltage losses, ion migration, metastability, hyperspectral imaging, degradation mechanisms, charge transport modeling.

References

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2. Cacovich, S. *et al.* Imaging and quantifying non-radiative losses at 23% efficient inverted perovskite solar cells interfaces. *Nat. Commun.* **13**, 2868 (2022).