Large-scale solution process of self-assembled monolayers as passivation layers for inverted perovskite solar cells.

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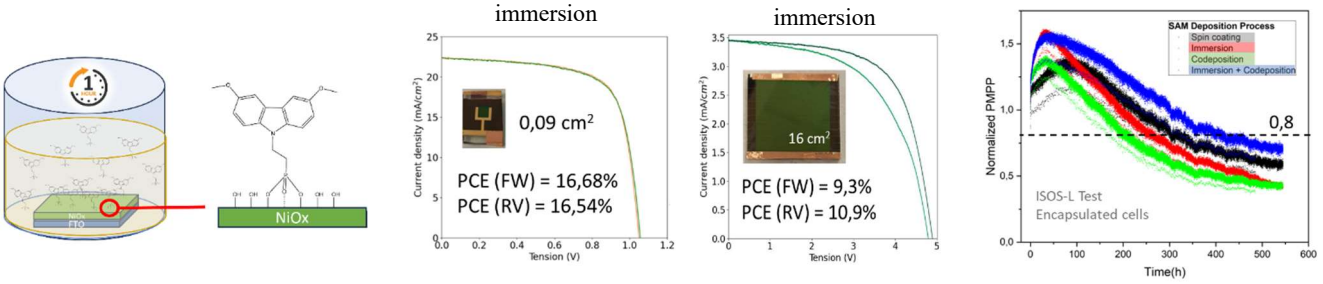
In the landscape of photovoltaic technologies, perovskite-based solar cells (PSCs) have been showcasing rapid advancements in power conversion efficiency (PCE) achieving 26.1%, rivaling the conventional silicon-based counterparts [1]. Within the perovskite solar cells technology, the inverted (p–i–n) configuration has gathered significant attention due to their high stability and decent efficiency [2]. Since 2018, self-assembled monolayers (SAMs) have emerged in the inverted configuration, as hole transport layers (HTLs) or as a passivation. Indeed, when applied on top of Nickel Oxide (NiO_x), SAMs contribute to work function alignment, enhancing charge extraction while mitigating undesirable charge carrier recombination. Consequently, SAMs have evolved into indispensable components in all inverted perovskite batches.

The predominant deposition technique of these molecules is the especially simple spin coating method. However, this technique is not compatible with large-scale production lines. Nevertheless, one of today's challenges lies in its industrial feasibility. In this regard, in literature different upscale deposition techniques have been reported for SAMs deposition like evaporation, immersion, dip coating, spray coating [3]. In addition to the upscaling challenge, inverted PSCs face other problems such as the poor coverage of the perovskite over layer with the NiO_x [4].

In the current study, we aim to introduce a low-cost, rapid, and accessible process tailored for large-scale deposition using a solution-based method, specifically through the immersion technique. In comparison to the studies done in the PSC community [5, 6], the optimized immersion in this study is significantly faster, taking only one hour instead of 8 hours or more. This technique will be compared to the spin coating technique and to another large-scale deposition method optimized in this study: the co-deposition of SAMs within the perovskite. Initially conducted on cells, this study has demonstrated efficiencies of 16.7%FV. Stability tests has been performed over 550 hours. The production of modules using only scalable techniques (slot die, evaporation, sputtering, ALD, immersion) has been achieved demonstrated efficiencies of 10.9%FV for 16cm2 active area. However, this process is still under optimization for module. To have a better understanding of our method various characterization techniques such as electrical measurements as well as in-depth analyses such as XPS, PL, contact angle, XRD, SEM, and zeta potential have been performed. A complementary objective of this work is to improve this layer and address perovskite coverage issues through chemical engineering strategies by utilizing molecules such as PFN-Br, 6dpa as additives to SAMs solution and mixing different SAMs molecules.



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