Slot-die coating as an industrially relevant tool for interfaces passivation and growth of stable charge extracting layers in perovskite solar modules

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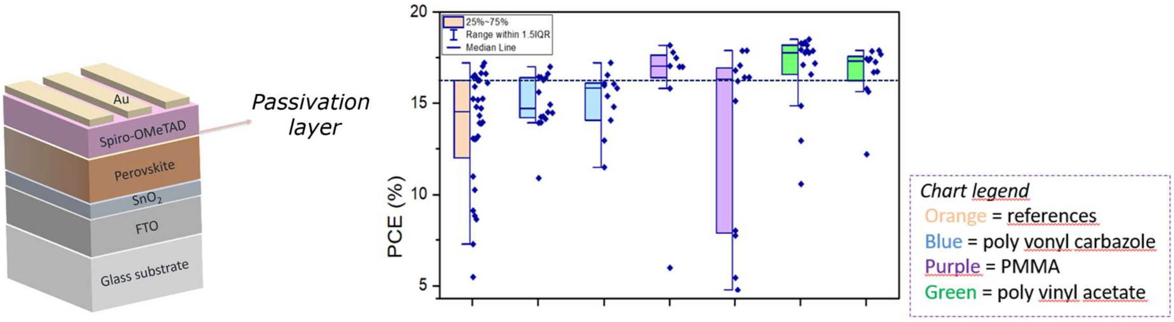
Over the last decade perovskite solar cells (PSCs) have emerged as a highly promising alternative photovoltaic (PV) technology with efficiencies already approaching the ones of mono-crystalline silicon solar cells. Up to date most of the perovskite research is performed on a relatively small sample size using spin-coating as the preferred deposition method. However, commercializing PSCs requires the development of industrially relevant deposition techniques. Different fabrication methods have been explored for upscaling PSC including liquid based deposition (blade coating, slot-die coating, inkjet printing), vacuum deposition (thermal evaporation) as well as combinations of the two (sequential perovskite deposition). In the current study the focus lies in developing slot-die coating as a scalable tool for thin-layers deposition. While many efforts are directed towards optimization of the perovskite layer, little research is done upscaling the passivation processes and the charge extracting layers. [1] [2]

Passivation layers are important in reducing the defects in the semiconducting thin films in a PSC. Passivation thereby not only improves the efficiency of the final device but also prevents defect induced degradation, improving the overall solar cell stability. [2]

In the current study, polymers of the polyvinyl family have been selected and tested to be introduced in passivation layers on top of the perovskite in NIP solar devices configuration. Indeed, polymers are chains of functional groups that will interact with the perovskite material, therefore changing the surface morphology of the perovskite film and its properties, probably also its aging across time. [1][2] The introduction of such molecules have been realized by spin-coating deposition first to obtain a proof of concept, then tested also by slot-die. The study demonstrated an increase of 4%, reaching efficiencies of 19.5% for 1.19V of VOC for solar cells with an active area of 0.09mm². However, the study now investigates the upscaling by slot-die, the optimization of the deposition on larger plates and modules, and the stability of the studied layer. To gain understanding of the underlying phenomena, various characterization techniques have been performed: confocal microscope images, SEM images, contact angle studies, photoluminescence measurements, and others to come. A complementary study on transferring the passivation layer to PIN devices has also been started.



[1] Wang, S., Gong, X. Y., Li, M. X., Li, M. H., & Hu, J. S. (2024). Polymers for Perovskite Solar Cells. *JACS Au*, *4*(9), 3400-3412.
[2] Liu, D., Wang, X., Wang, X., Zhang, B., Sun, X., Li, Z., ... & Pang, S. (2023). Polymerization strategies to construct a 3D polymer passivation network toward high performance perovskite solar cells. *Angewandte Chemie International Edition*, *62*(18), e202301574.7