Development of an inorganic perovskite absorber deposited by slot-die coating on a large surface in ambient atmosphere

Lauriane SCHERRER[1,3], Iwan ZIMMERMANN[2], Emmanuelle DELEPORTE[3], Jean ROUSSET[1,2]

1 - EDF, 18 boulevard Thomas Gobert, 91120 Palaiseau; 2 - IPVF, 18 boulevard Thomas Gobert, 91120 Palaiseau ; 3 - LuMIn, Université Paris-Saclay, ENS Paris-Saclay, CentraleSupelec, CNRS, 91190 Gif-sur-Yvette

Today, hybrid halide perovskite solar cells show high power conversion efficiencies (PCE >25%), but volatile organic cations (MA^+, FA^+) can limit their thermal stability. Therefore, inorganic perovskites such as $CsPbI_3$ appear as promising materials for perovskite PV devices [1]. In addition, their band gap, around 1.7 eV, is close to the ideal one for perovskite-on-silicon tandem applications. The inorganic perovskites are considered as good candidates for the development of stable and efficient single junction and tandem solar cells.

Despite many obvious advantages, the PCEs achieved with inorganic $CsPbI_3$ perovskites remain lower than those of their hybrid counterparts. The difference is mainly due to the difficulty of synthesising a stable $CsPbI_3$ perovskite phase. According to Goldschmidt tolerance factor calculations, $CsPbI_3$ is just at the limit of forming a stable perovskite phase due to the relatively small size of Cs^+ cations compared to MA^+ or FA^+ cations. Therefore, the simultaneous formation of non-perovskite phases is often observed during the synthesis of $CsPbI_3$.

Here, we present our strategy to develop inorganic perovskite as an absorber, deposited by slot-die coating in ambient atmosphere, a relevant industrial large area deposition technique that has not yet been explored for this type of perovskite.

Firstly, we focused our attention on the ink preparation to obtain stable inorganic perovskite films. Several additive strategies were investigated and finally, dimethylammonium iodide (DMAI) [2] was chosen to stabilise $CsPbI_3$. Several parameters of the precursor solution, such as the additive ratio, solvent ratio,… were further optimised and the composition was tuned by adding bromide [3]. Secondly, using this ink, the deposition method of the inorganic perovskite thin film by slot-die coating, in ambient atmosphere, was optimised, using morphological, structural, and optical characterisations to refine the protocol. Thin films with a surface area of up to 5x10cm were obtained (Figure 1).

Finally, to test our developed thin films, we implemented the optimised inorganic perovskite absorber in solar cells. We obtained a maximum power conversion efficiency of 11.2% for solar cells containing inorganic perovskite deposited by slot-die coating in ambient atmosphere, a PCE of the same order of magnitude as the PCE obtained for solar cells deposited by spin-coating in ambient atmosphere on a small surface area of 2.5x2.5cm (Figure 2).

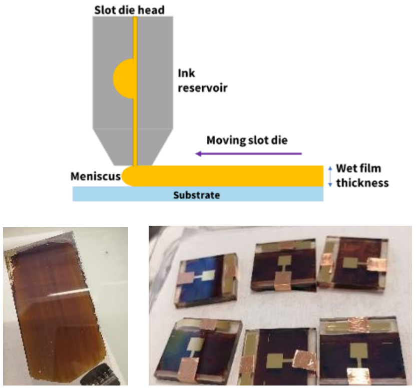

Figure 1: Large surface film deposited by slot-die coating and solar cells

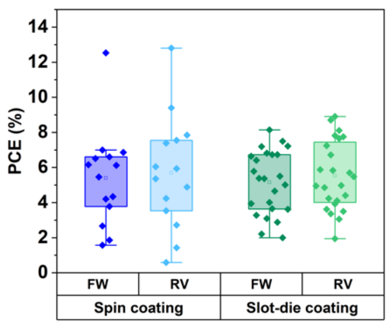

Figure 2: PCE of inorganic perovskite solar cells produced by spin coating (left) and slot-die coating (right)

[1] Xiang, W. et al. (2021). *Energy & Environmental Science*, *14*(4), 2090-2113.
[2] Wang, Yong, et al. *Angewandte Chemie* 131.46 (2019): 16844-16849.
[3] Chu, X. *et al. Nat Energy* 1–9 (2023)