Stability of efficient triple-mesoscopic perovskite solar cells and modules under real outdoor working conditions.

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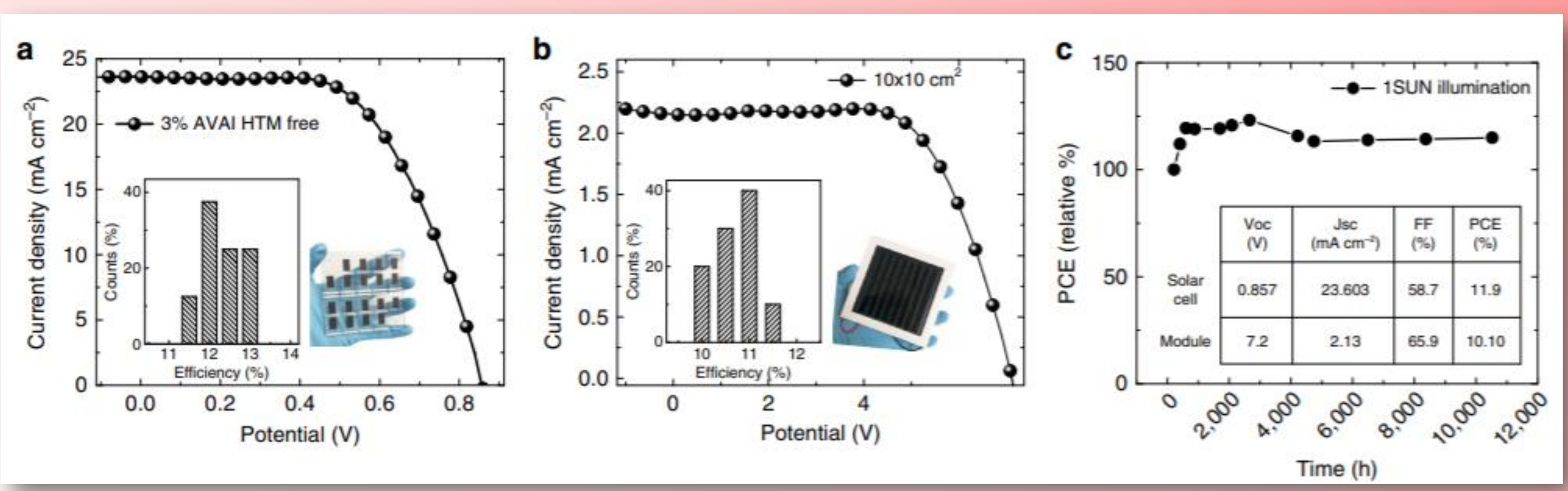
Short background

In 2017, we published[1] a structure proven to be stable for more than 10,000 h under controlled standard conditions, by engineering an ultra-stable 2D/3D perovskite junction. This structure is based on a fully printable architecture made of three mesoporous layers in which the perovskite is embedded.



One year stable perovskite solar cells by 2D/3D interface engineering

Today's purpose is to study the stability of these devices under real outdoor working conditions.

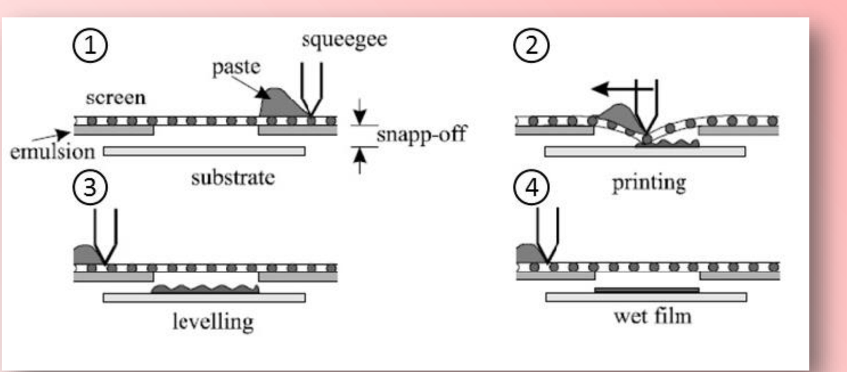
[1] Grancini et al. Nature Communications 8, 15684 (2017). One-Year stable perovskite solar cells by 2D/3D interface engineering

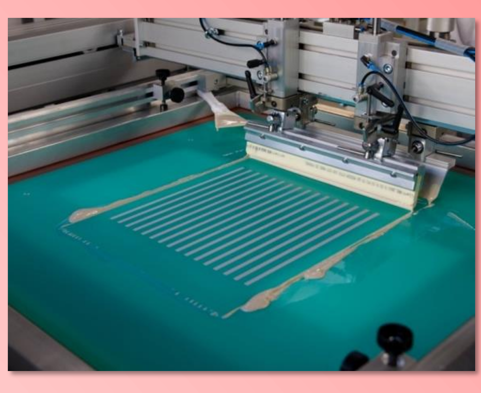
Cell manufacturing

Screen printing

Screen-printing is a printing technique using a woven mesh to support an ink-blocking stencil. The ink is pressed through the mesh as a sharp-edged image (Fig 1.). The thickness of the film depends on the size of the mesh and the ink concentration. The electrode is shaped using this method before the deposition of the active material (perovskite).

Fig 1. Illustration of the screen-printing process



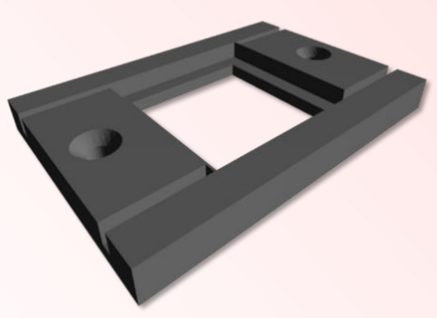


Inkjet printing and crystallization

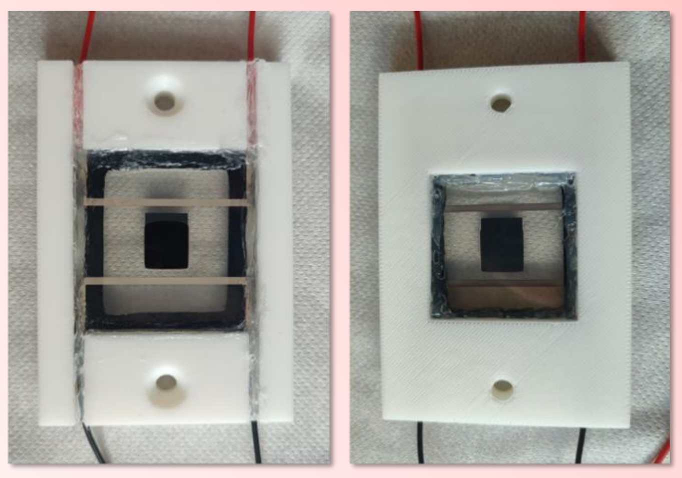
Inkjet printing is a relatively new developed thin films deposition method. It is an easy and quick process and has the ability to print at nanoscale. The perovskite is deposited by this method to impregnate the mesoporous network.

Annealing and a humidity treatment are then carried out in order to optimize the crystallization of the perovskite.

Preparation of a 3D printed support and encapsulation of the device



3D model of the support



Final device

Outdoor test

Working in real conditions requires taking into account many constraints that are not encountered under controlled conditions.

Measurement optimization

Perovskite systems are dynamics, which means that at each voltage pulse, a migration of ions is observed. Under controlled conditions, we are used to working with very slow acquisition times (delay of 1 sec per point) in order to work under <u>steady state</u> conditions

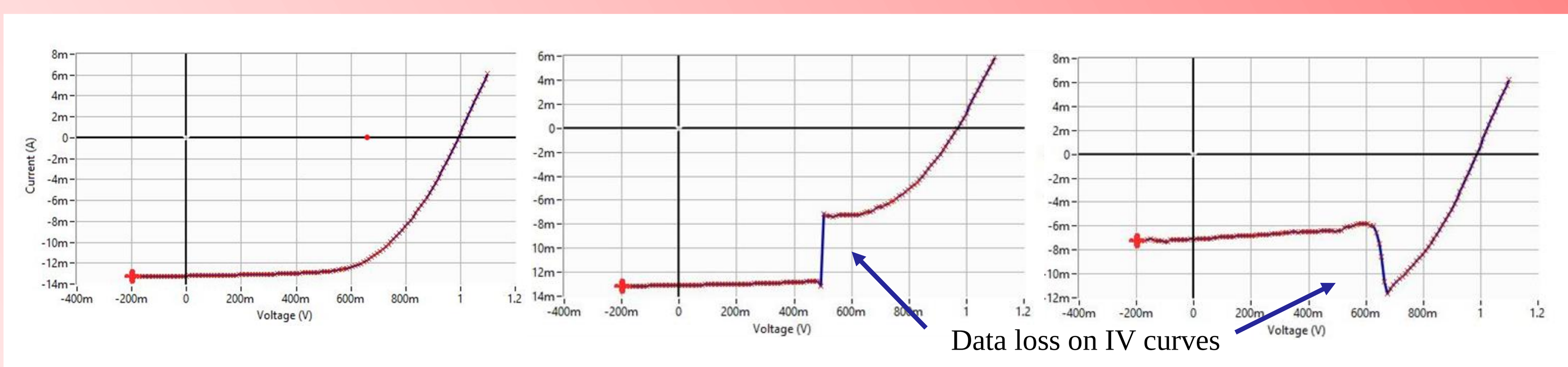
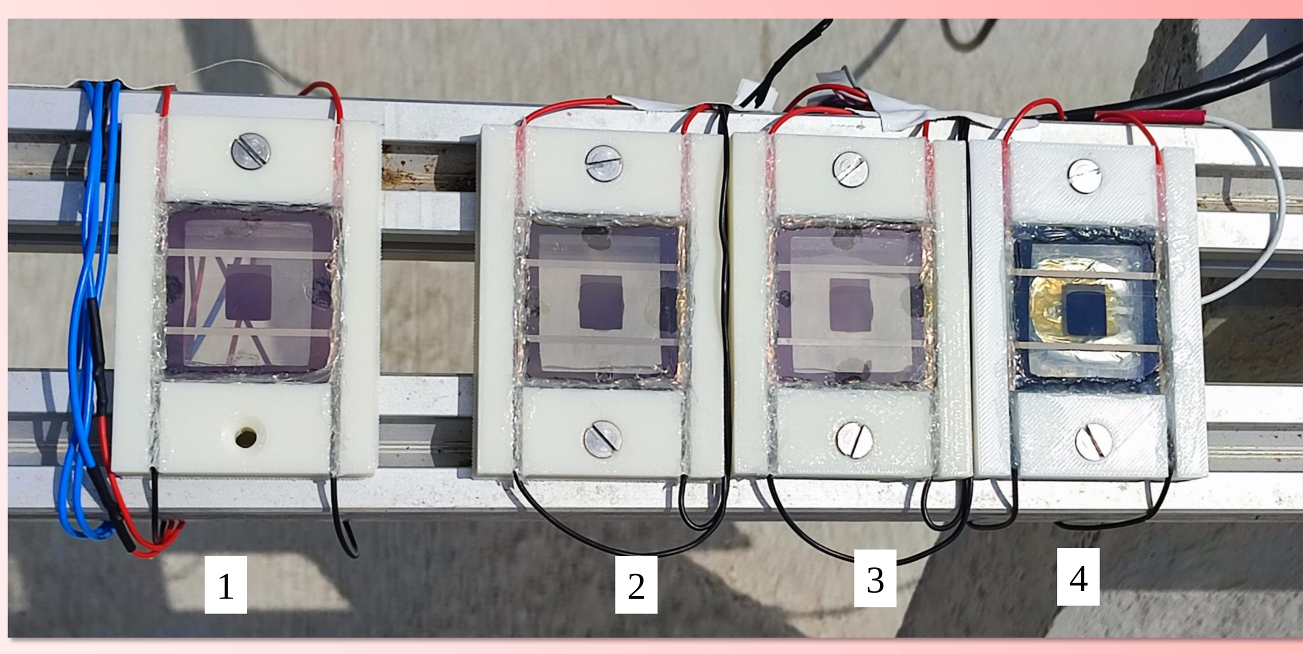


Fig 2. Simulation of the passage of a cloud during the measurement under solar simulator

As seen in Fig 2, it is necessary to decrease the acquisition time (usually 4 min) for outdoor tests in order to avoid the loss of information which can be caused by clouds. After optimization, the measurement last now 25 seconds.

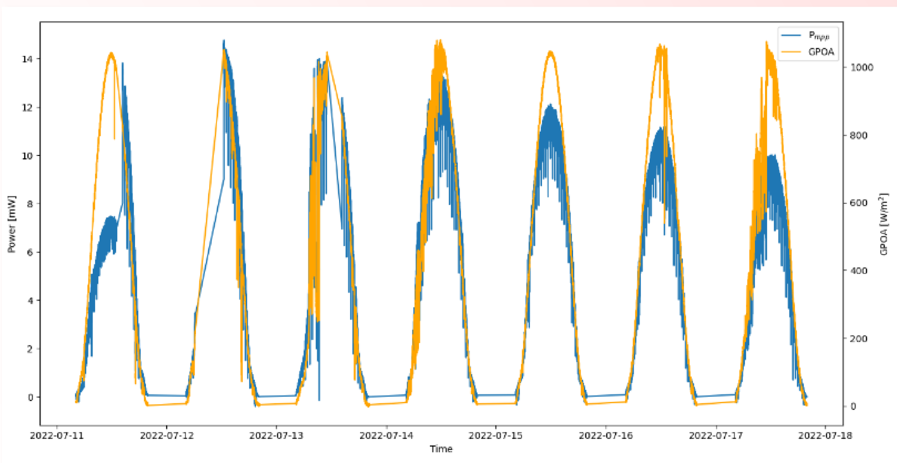
Installation of the test bench



The test bench is south-oriented with a tilt angle of 30°

1. Short-circuit reference cell
2. Connected to fixed resistance of 50Ω
3. IV and MPP tracking
4. Temperature tracking

First results and perspectives



Comparison of solar irradiance (orange) with cell power (blue)

-Performance degradation during the first days of experiment

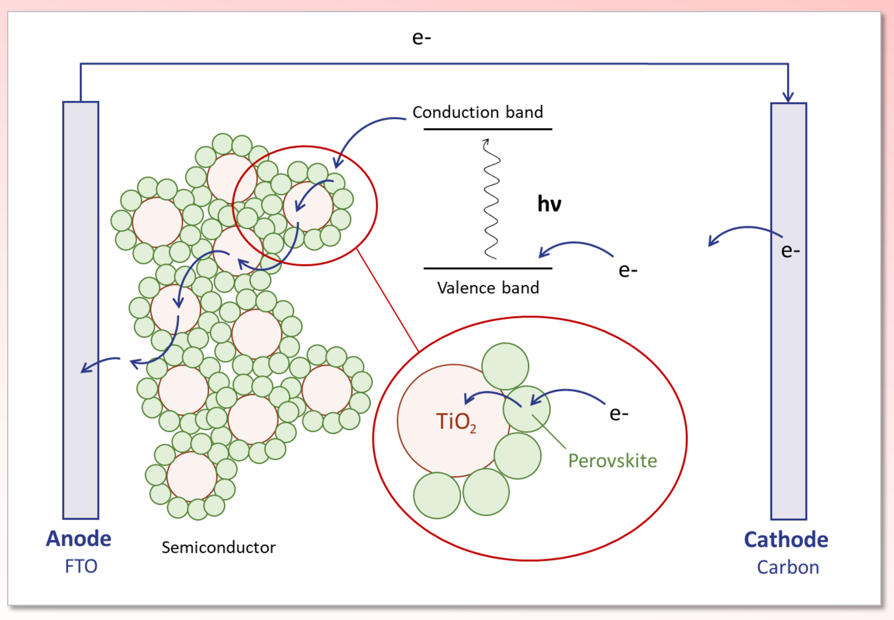
-Investigation into MPP tracking procedure on such dynamic system

-Optimization of measurement protocol

-In depth study of perovskite content, composition to match indoor results

-What causes degradation? Measurement protocol, cell composition, external factors?

High efficiency printed perovskite solar cells



Working principle of perovskite cells

Triple mesoscopic perovskite solar cell