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FACING THE CHALLENGES OF OUR TIME

Paving the way to Perovskite PV industrialization at CSEM

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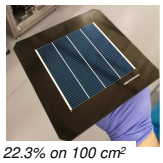
Perovskite/silicon (PK/Si) tandem solar cells have recently reached an efficiency of 30% at the laboratory scale (1 cm^2). However, the commercial exploitation of perovskite photovoltaics hinges upon the scalability of the fabrication processes and the long-term stability of the perovskite cell. CSEM is working on these key aspects by developing fabrication processes compatible with full-size industrial Si wafers (>250 cm^2), encapsulation protocols to prevent extrinsic degradation, and by improving the operationnal stability of perovskite solar cells using inputs from accelerated aging tests.

Upscaling the perovskite deposition process

All-in-one solution process

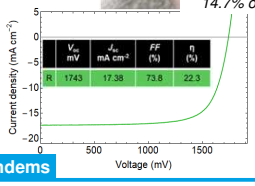
- All the perovskite precursor salts (PbI_2, CsBr and the organic halides) are dissolved in the same solution, which is then deposited by blade coating.
- The method is better suited to smoother wafers (for tandems) or flat glass substrates (for single-junction applications).
- Requires the use of hazardous solvents and a controlled atmosphere with very low humidity.
- Successfully used on a full M6 wafer size or on 10x10 cm^2 glass substrates

14.7% on 58 cm^2



22.3% on 100 cm^2

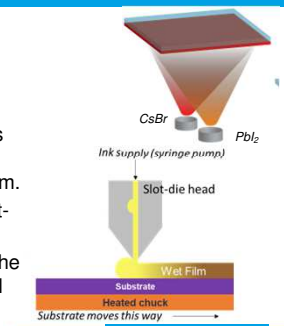
15.4% on 274 cm^2



PK/Si tandems

2-step evaporation-solution process

- Evaporation of the inorganic PbI_2/CsBr template, followed by the deposition of organic halides in an alcohol solution to convert the template into a perovskite film.
- The solution step is done by slot-die coating or ink-jet printing.
- The method is compatible with the textured topography of industrial Si wafers.
- Only employs green, non-hazardous solvents and can be carried out in an ambient atmosphere.
- Fabrication of PK/Si tandems soon.

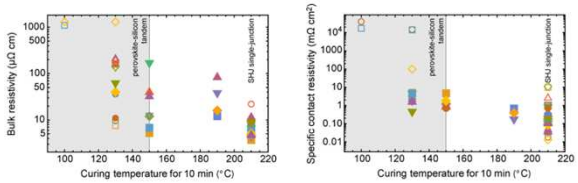


Up to 16% with 1 cm^2 cells

Metallization, interconnections, encapsulation

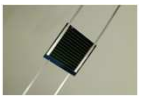
Silver grid deposited by screen-printing at the industrial level

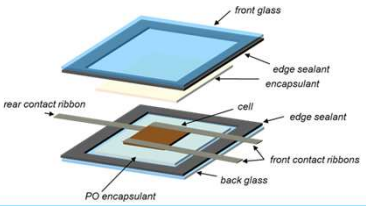
- Low bulk resistivity with ITO after curing at 130°C



Interconnection by electrically conductive adhesive (ECA)/ribbons

- Possible to reach <5%rel loss in PCE induced by low-temperature ECA process





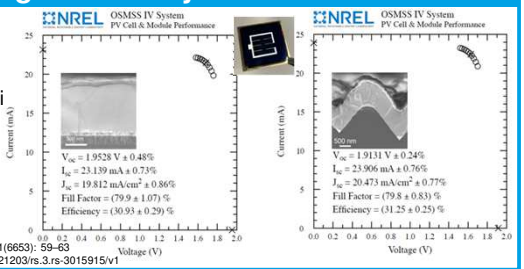
Glass-glass encapsulation at the industrial level

- Thermoplastic lamination foil
- Edge sealant as additional moisture ingress barrier

High efficiency at lab scale

In collaboration with EPFL PVLab

- 30.9% on flat Si
- 31.25% on textured Si



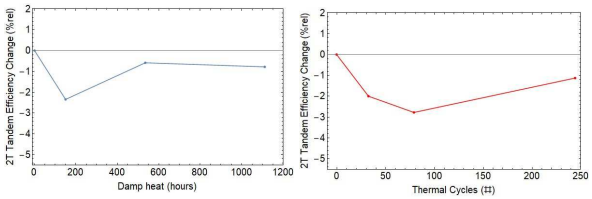
Chin, XY et al. 2023, *Science* 381(6653): 59–63
Türkay, D et al. 2023, doi.org/10.21203/rs.3.rs-3015915/v1

Accelerated stability tests

2T perovskite/Si tandems pass the IEC 61215 damp heat & thermal cycling tests with less than 5%rel efficiency loss after

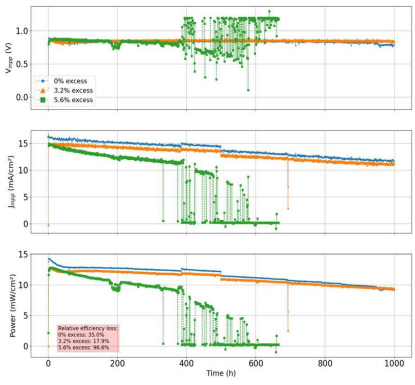
- >1000 hours of damp heat testing (85°C/85%RH)
- >200 thermal cycles (-40°C to 85°C)

Mechanical stress is one of the main challenge



Light soaking tests at high temperature (>65°C) is studied now on perovskite single junction cells

- The perovskite composition plays a key role, in particular an excess of >5% of PbI_2 is found to be detrimental



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