



■ Glass-glass solar panel with 72 bi-facial silicon heterojunction solar cells installed on Microcity roof-top – EPFL Neuchatel.

Damp Heat induced Degradation of SHJ Glass/Glass Modules with EVA : Insights into Root-causes and Mitigation Strategies

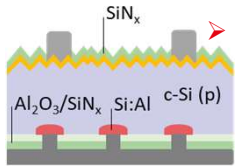
Luca Gnocchi¹, Olatz ArriagaArruti¹,
Alessandro Virtuani¹, Christophe Ballif^{1,2}

¹Photovoltaics and thin-films electronics laboratory
(PV-lab), EPFL, Neuchatel (CH)

²PV Center, Suisse center for electronics and
microtechnology (CSEM), Neuchatel (CH)

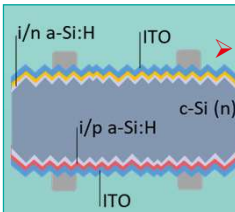
Luca.gnocchi@epfl.ch

Motivation & Experimental methodology



➤ PERC

Mainstream c-Si technology
(≈80% market share)



➤ SHJ

Huge effort in the development
at PV-Lab (24,4% eff.)

Easy to process bi-facial with
few process steps (low cost
with high efficiency)

01 April 2022

**Enel Green Power signs grant
agreement with the EU for solar
panel Gigafactory in Italy**

NEWS

**Meyer Burger optimising production
expansion to 1.4GW in Germany to
cater for European demand**

By Jonathan Tourino Jacobo

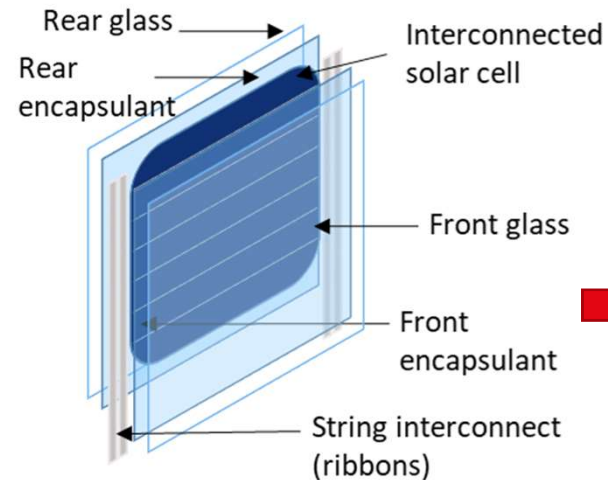
April 29, 2022



**EVA IS NOT A SUITABLE
ENCAPSULANT FOR SHJ MODULES!
WE GO FOR POs**

....WHY??

1-cell module

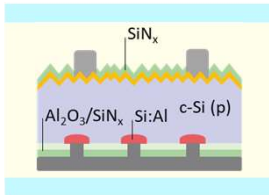


Damp Heat :
85°C, 85% RH
(Water ingress)

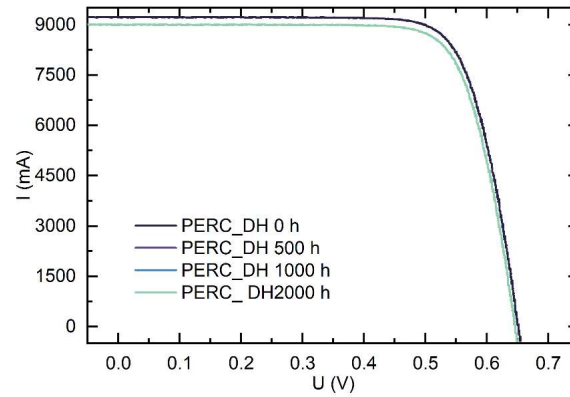
Extended DH test (2000 hrs)

RH=85%, T=85°C

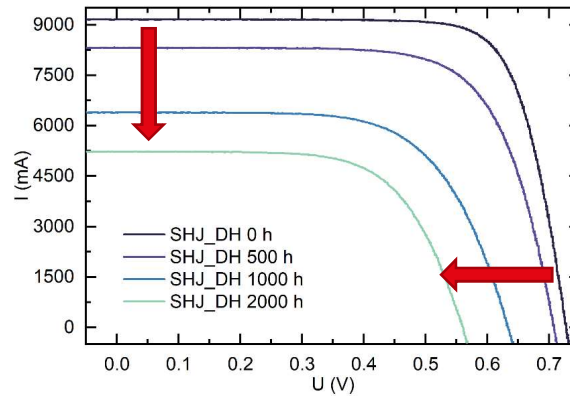
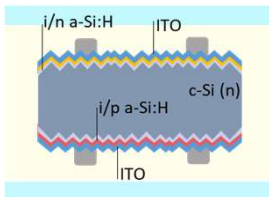
PERC



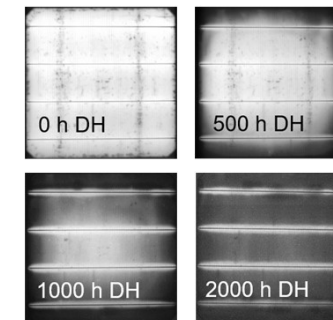
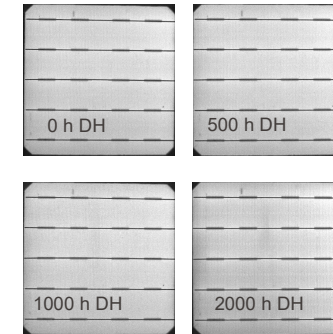
I-V curves



SHJ



Electroluminescence images



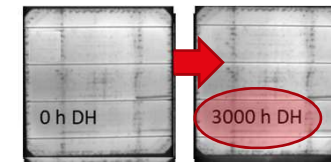
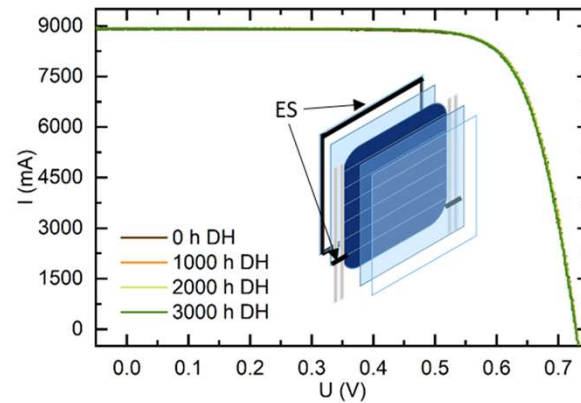
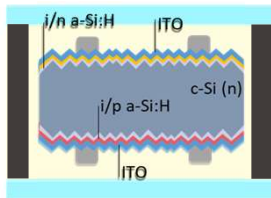
G-G SHJ: results during extended DH test

RH=85%, T=85°C

I-V curves

Electroluminescence images

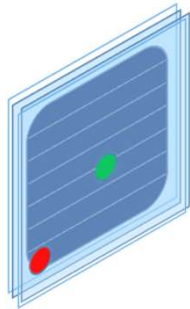
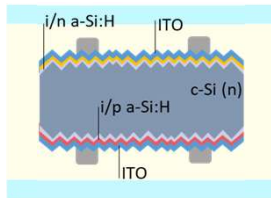
➤ SHJ + ES



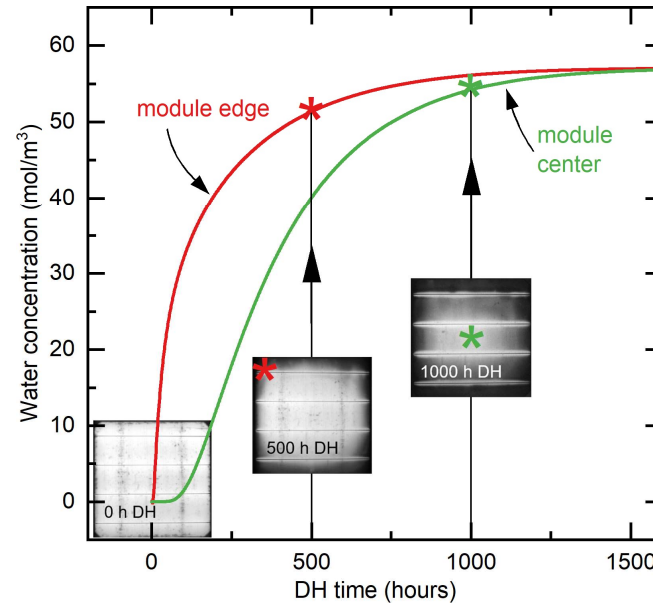
- In presence of an edge seal, the **degradation is prevented.**
- It can be correlated to the water ingress inside the module.

Water ingress and EVA properties

➤ SHJ

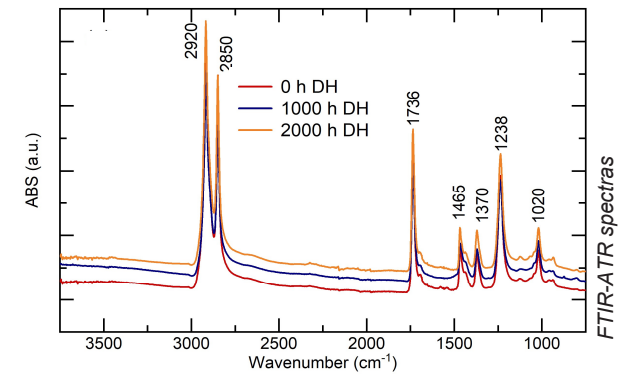
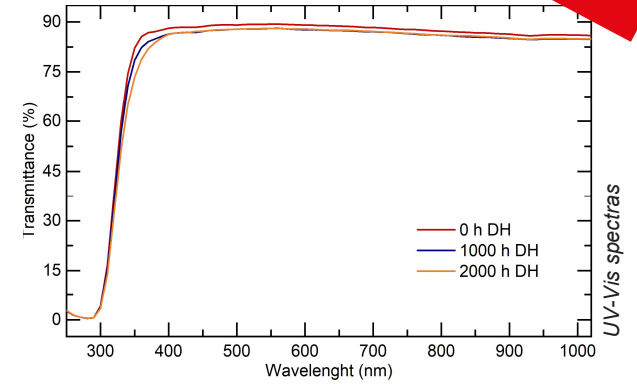


Moisture diffusion model



EVA properties

RH=85%, T=85°C



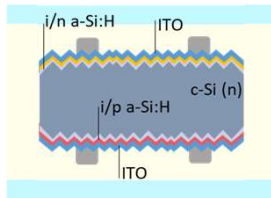
■ WCPEC-8, Milano – September 29th 2022

- The kinetics of the moisture diffusion and module degradation are in agreement.
- The EVA shows a good stability.

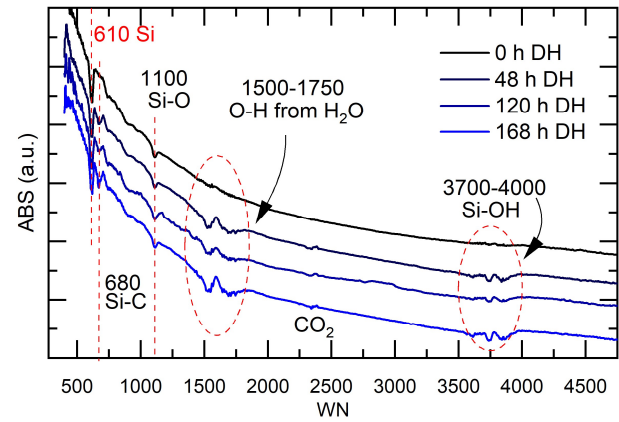
Direct effect of the moisture on the cell

RH=85%, T=85°C

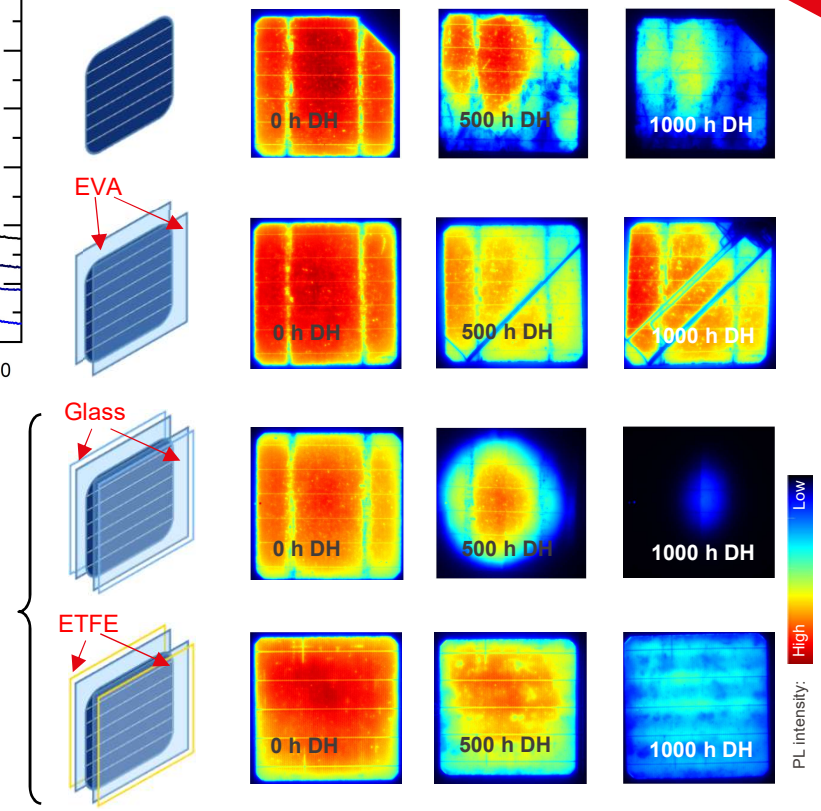
➤ SHJ



FTIR spectras



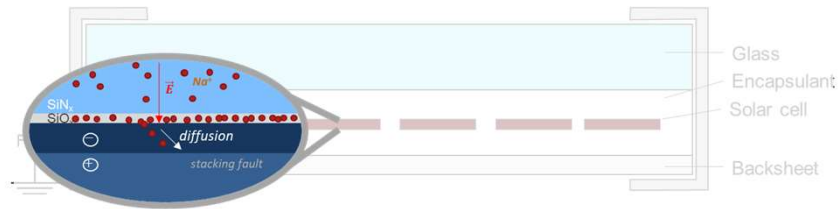
Photoluminescence images



- Water only is not enough to explain the degradation mechanism.
- The **presence of the glass** seems to be the **key point** for the SHJ degradation.

Glass corrosion and the role of sodium

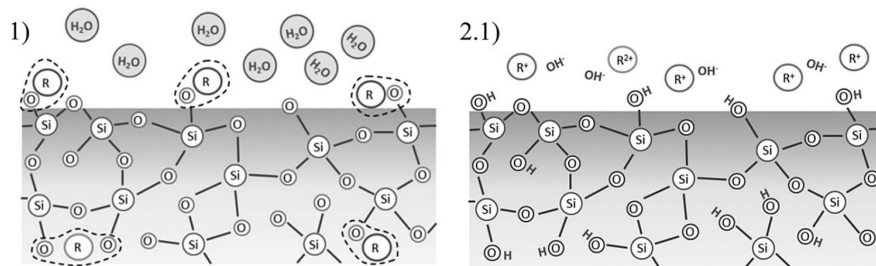
- Potential induced degradation (PID)



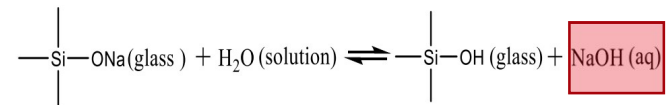
- Na⁺ are driven by an electric field from the glass towards the cell

E. Annigoni,
PVDays
(2018)

- Damp Heat aging test



- The corrosion of the glass (i.e. leaching mechanism) produces Na⁺ in DH conditions.

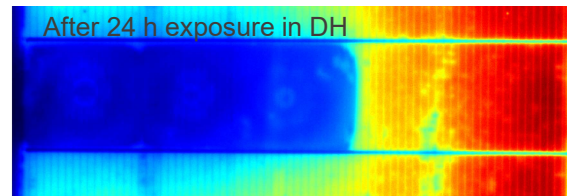
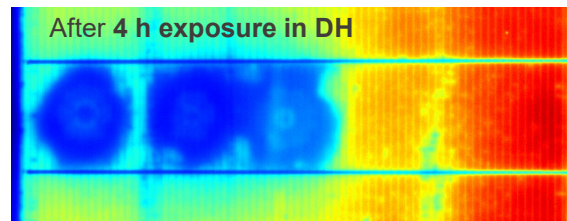
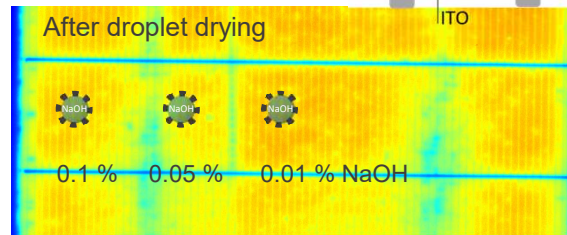
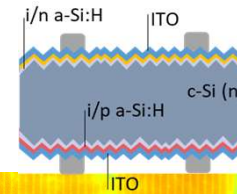


Guiheneuf,
Vincent, et
al. Corrosion
Engineering,
Science and
Technology 52.3
(2017): 170-177.

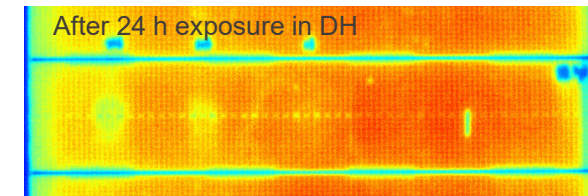
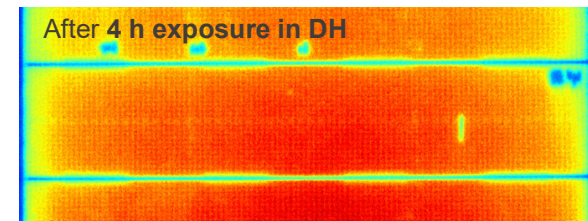
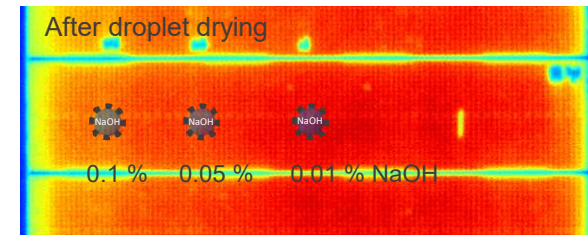
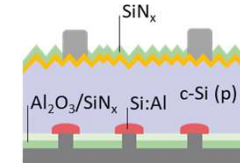
NaOH Droplet test



SHJ cell type



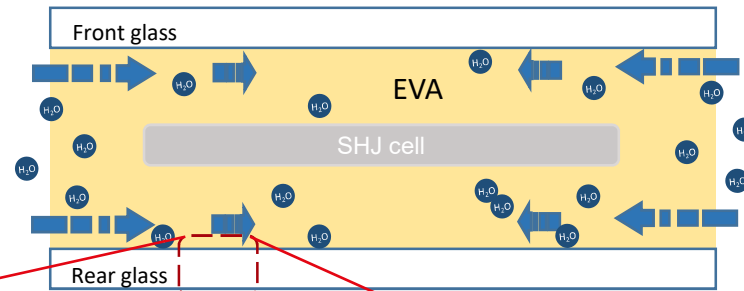
PERC cell type



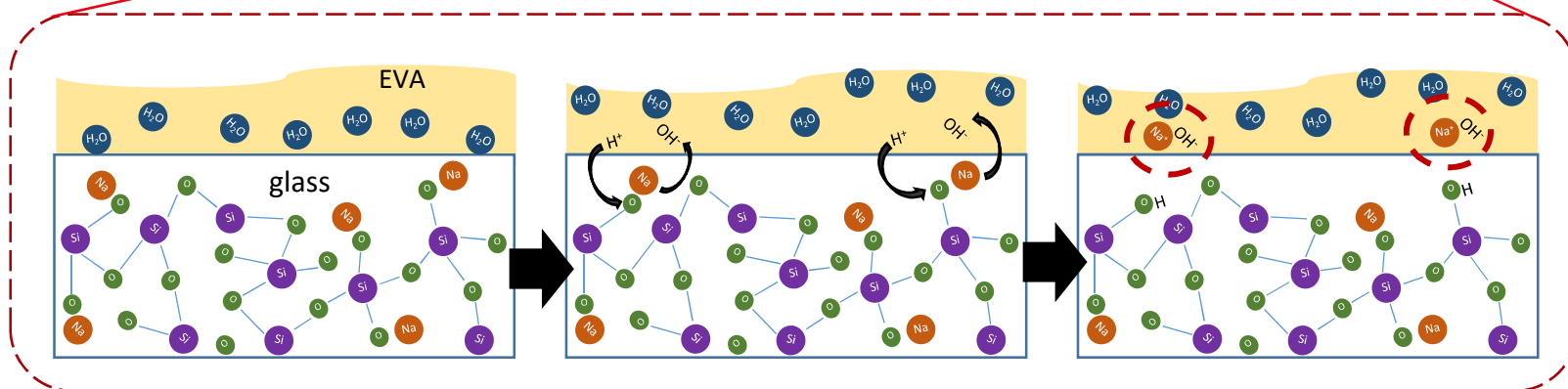
PL intensity: High Low

Microscopical model

1) Water diffusion through the EVA

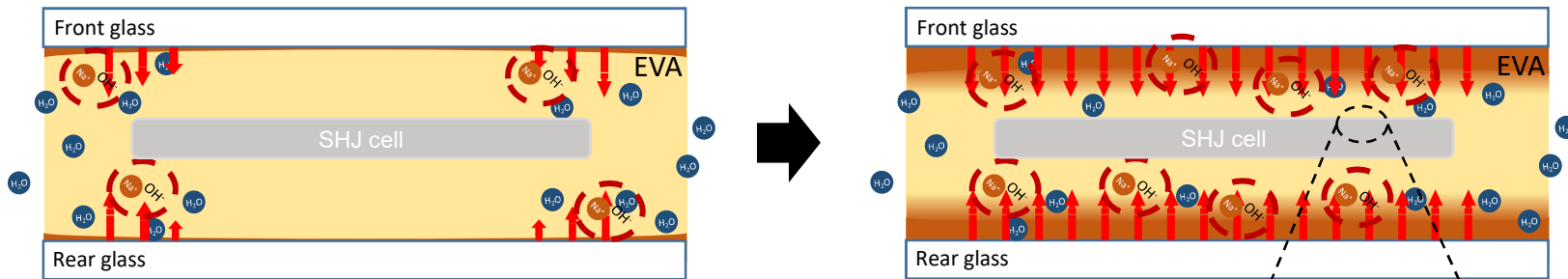


2) Ion exchange at the EVA-glass interface → Na⁺ are released in the EVA

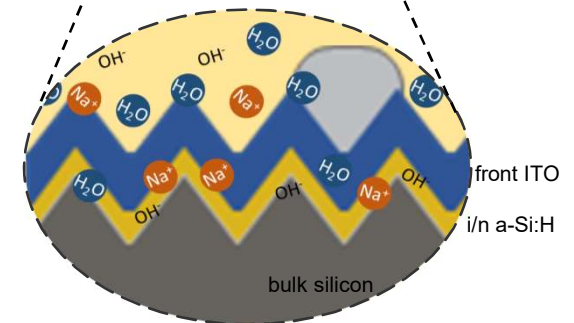
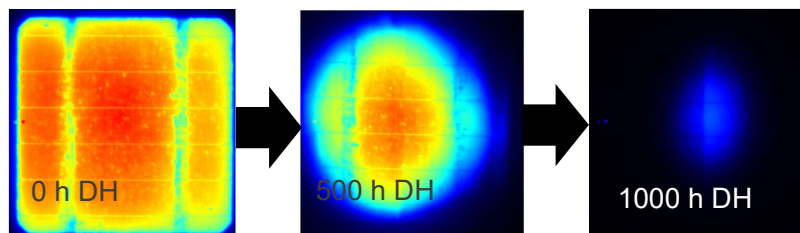


Microscopical model

3) Gradual diffusion of Na⁺ towards the cell

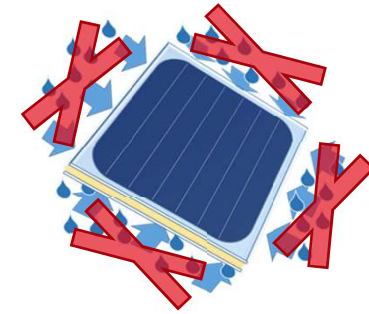


4) Na⁺ cross the ITO and degrade the passivation properties of the SHJ cell

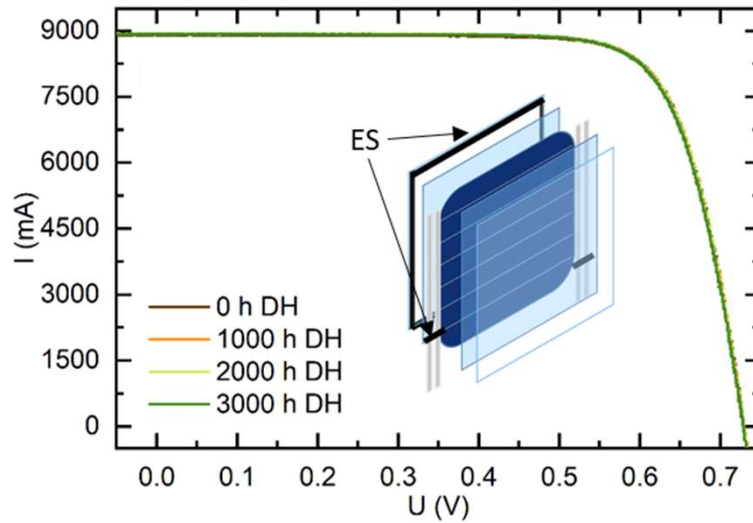


Mitigation strategies

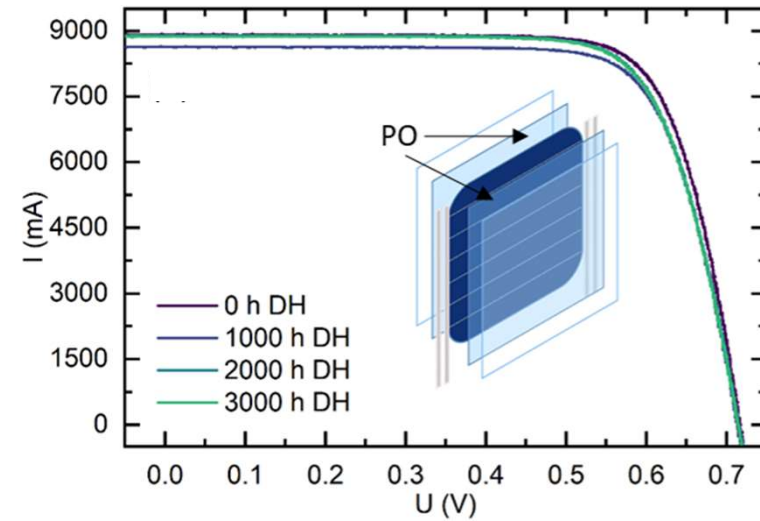
1) Avoid or reduce the water ingress



EVA + edge sealant (ES)



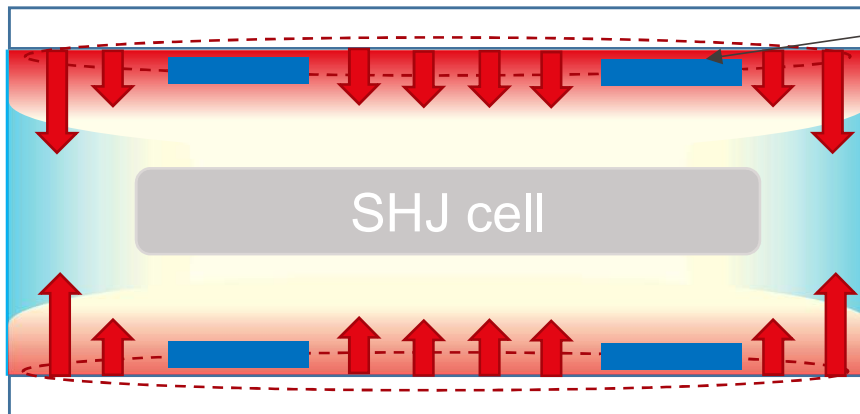
PO encapsulant



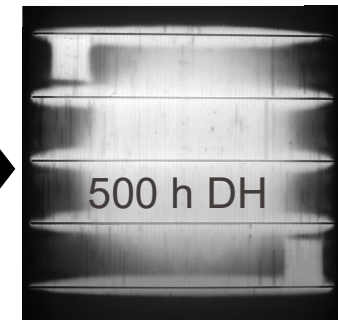
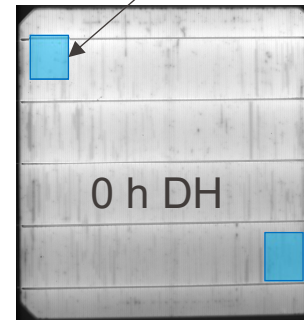
Mitigation strategies

2) Avoid the generation of NaOH

NaOH source at the **glass-EVA interface**



ETFE
protecting layer



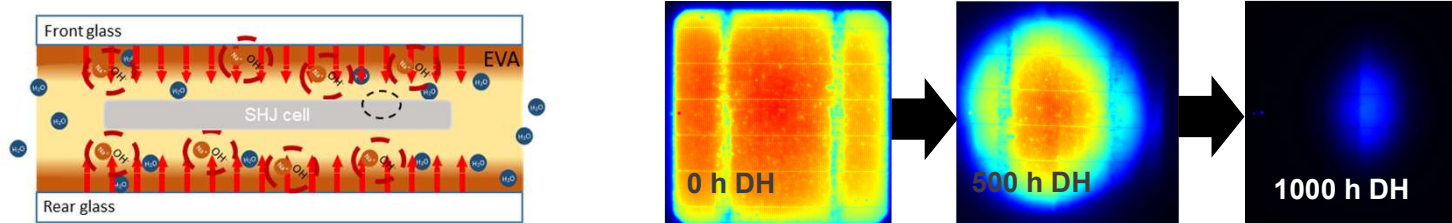
The presence of a protecting layer prevents the cell degradation!

Further strategies to be investigated:

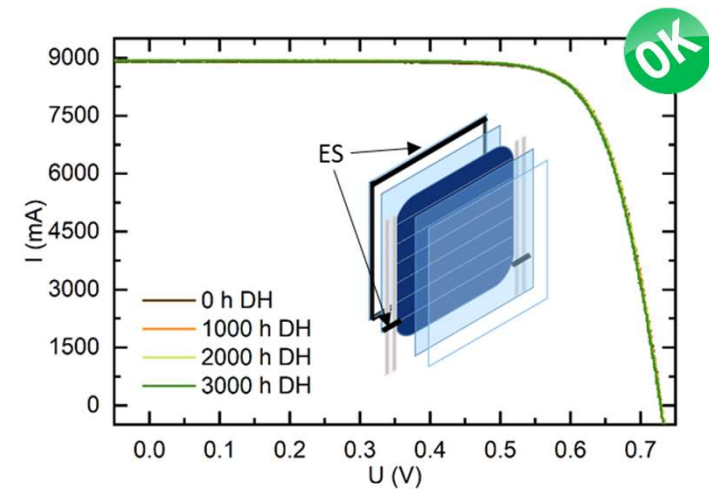
- Deposition of a SiN_x capping layer on top of the ITO;
- Deposition of a *Na-barrier* layer on the inner surface of the glass (to prevent also the PID..)
- Others...

Summary

- We developed a **microscopical model** which describes the degradation mechanism of **SHJ cells** in a G-G structure, using EVA as encapsulant **during Damp Heat**.



- We proposed mitigation strategies to prevent the Na+ induced degradation (i.e. use of an edge sealant or a PO encapsulant).



EPFL



Thank you for your attention!