The impacts of the encapsulation quality of Photovoltaic modules on their long-term reliability

Heng-Yu Li[1], Yun Luo[2#], Christophe Ballif[1], Laure-Emmanuelle Perret-Aebi[3]

[1] École Polytechnique Fédérale de Lausanne (EPFL), Institute of Microengineering (IMT), Photovoltaics and Thin Film Electronics Laboratory, Rue de la Maladière 71b, 2000 Neuchâtel, Switzerland

[2] MEYER BURGER AG, Schorenstrasse 39,CH-3645 Gwatt (Thun), Switzerland

[3] CSEM, PV-center, Jaquet-Droz 1, 2000 Neuchâtel, Switzerland

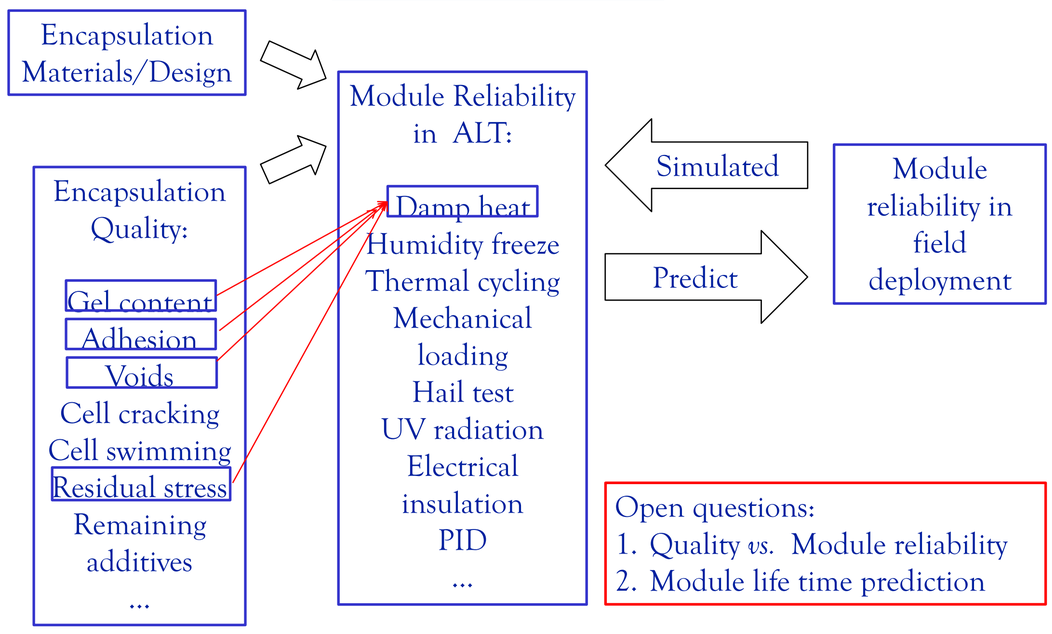
[#]Now: with PlusMat AG, Höheweg 55, 3054 Schüpfen, Switzerland.

Email: Hengyu.Li@epfl.ch

Motivations and goals

- **Currently, there exists a missing link between the encapsulation quality and the reliability of PV modules.**
- **This work aims at studying the effects of several encapsulation quality factors on the reliability of PV modules in DH test.**

Target of the work

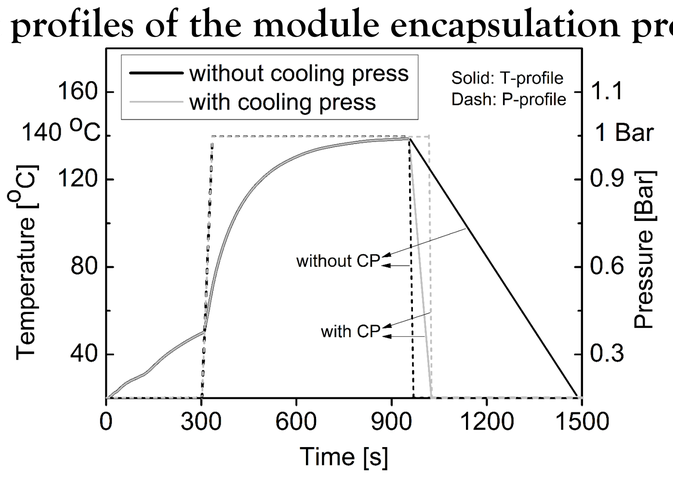


Li, H.-Y., et al. Submitted (2014)

- Focusing on the missing link between EVA gel content/Voids/ Adhesion/Residual stress and the module reliability in DH.

Experimental setup

T-P-t profiles of the module encapsulation process

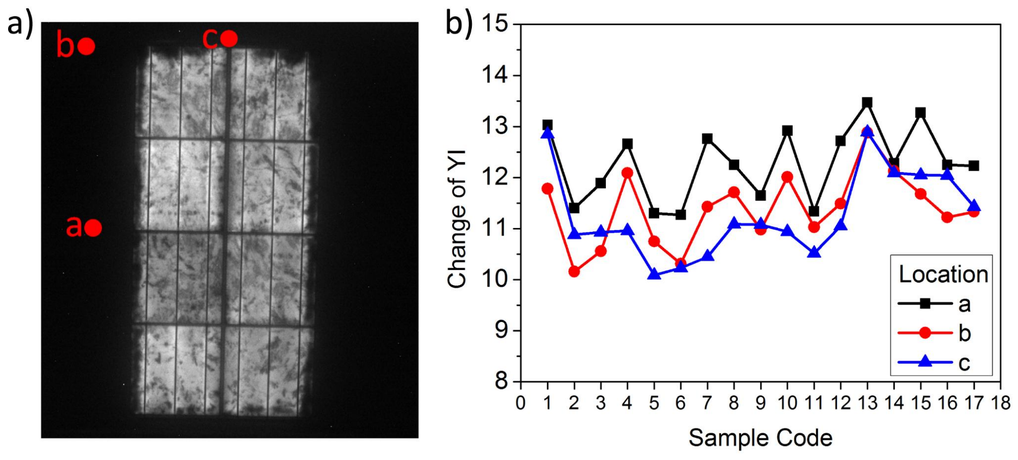


Li, H.-Y., et al. Prog. Photovolt: Res. Appl.. doi: 10.1002/pip.2409

- All g-bs modules were exposed to 3000h of 85/85 DH testing.
- Modules with and without Type-II voids.
- Modules with different EVA gel content.
- Modules with different glass/EVA adhesion and residual stress as a result of the cooling press.

General observation

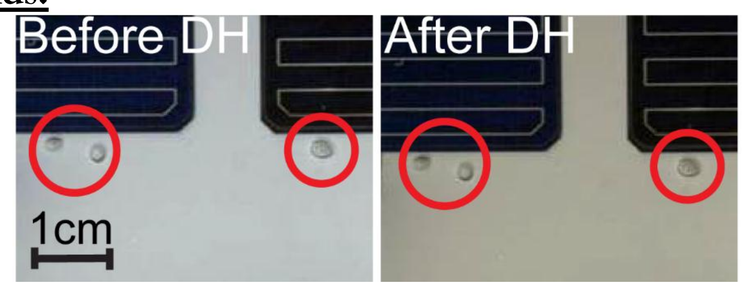
Typical hydrothermal degradation:



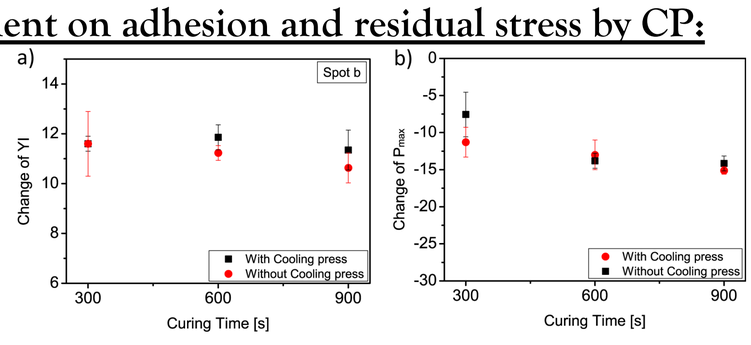
- Acetic acid production+moisture => corrosion;
- Discoloration competing with oxygen bleaching;
- Degradation of IV performance, with dropping I_{sc} and rising R_s.

Effects of Type-II voids and cooling press (CP)

Type-II voids:



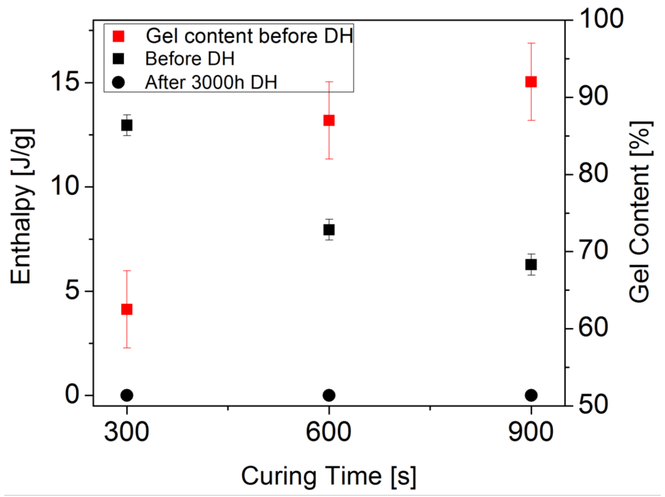
Improvement on adhesion and residual stress by CP:



- No effect of Type-II voids on module reliability in 3000h of DH;
- No effect of improvements by CP on module reliability in 3000h of DH.

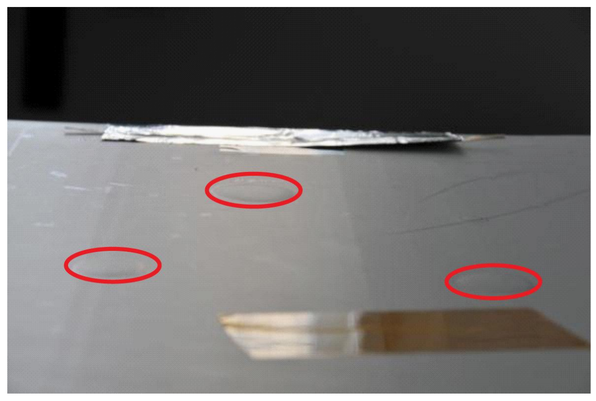
Effect of EVA gel content

On the gel content after DH:



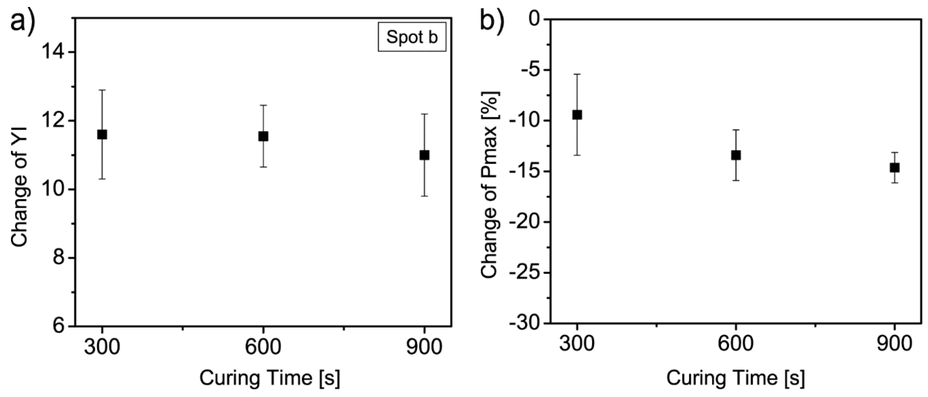
- Post curing due to degradation in EVA

On the Type-I voids:



- Type-I voids and EVA creeping appear only on module with low initial gel content.

On the EVA hydrothermal degradation:



- Too long curing time results in higher degradation rate of EVA and modules.

Summary

- This work studies the missing link between the module encapsulation quality and the module reliability in 3000h of DH test.
- The Type-II voids did not evolve and showed no impacts on the module reliability in 3000h of DH.
- Enhancements on adhesion and residual stress by cooling press showed no impacts on the module reliability in 3000h of DH.
- EVA gel content after encapsulation affects the module reliability in DH, mainly on the aspects of Type-I voids formation, EVA creeping, EVA hydrothemal degradation and degradation of the IV performance of modules.