ENCAPSULANT SELECTION FOR INCREASED PID RESISTANCE IN MODULES MADE WITH HETEROJUNCTION SOLAR CELLS

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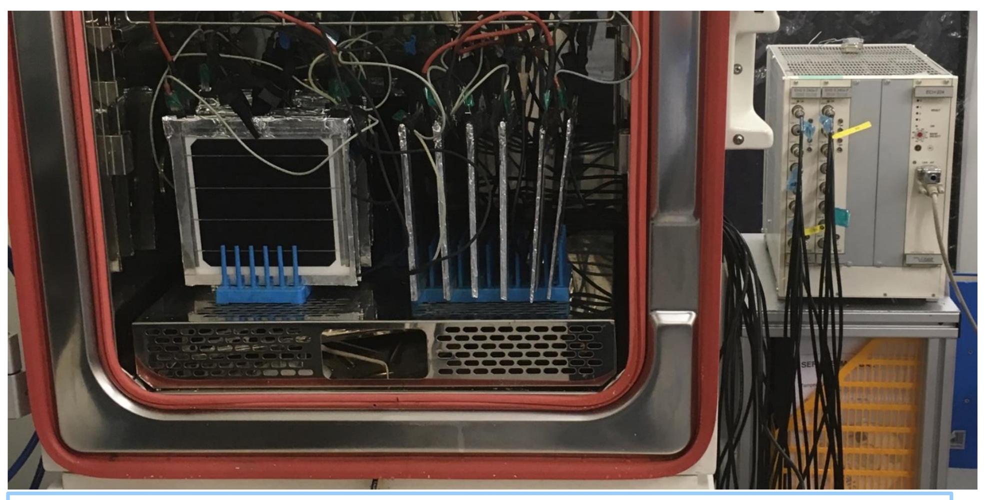
Goals and Motivations

- Potential induced degradation (PID) causes a severe performance loss in PV modules in the field.
- PID is widely studied in conventional crystalline silicon (c-Si) modules (i.e. Al-BSF)[1], but not in new technologies that will have the largest market share in the near future (e.g. silicon heterojunction (SHJ) solar cells).
- In conventional PV modules, PID can be prevented by using high-volume resistivity encapsulants[2].
- We study the impact of seven different encapsulants in SHJ glass/glass (G/G) modules encapsulated with and without an edge seal.

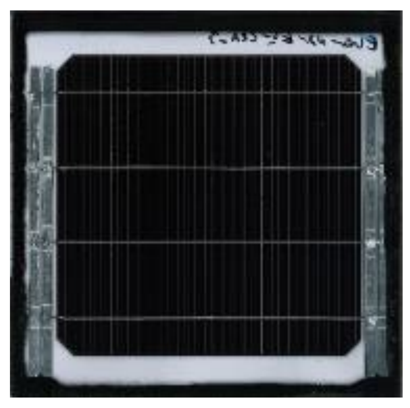
Experimental work

Temperature/ RH	Cell technology	Encapsulants	Module design	Voltage
85°C/85%	SHJ	Ionomer TPO 3 POEs (A, B, C) EVA PVB	G/G	-1000 V (2x)
				0 V (2x)
				+1000 V (2x)
			G/G – ES	-1000 V (2x)
				0 V (2x)
				+1000 V (2x)



IEC TS 62804-1:2015[3]: 60°C/85°C, 85% RH, 96h

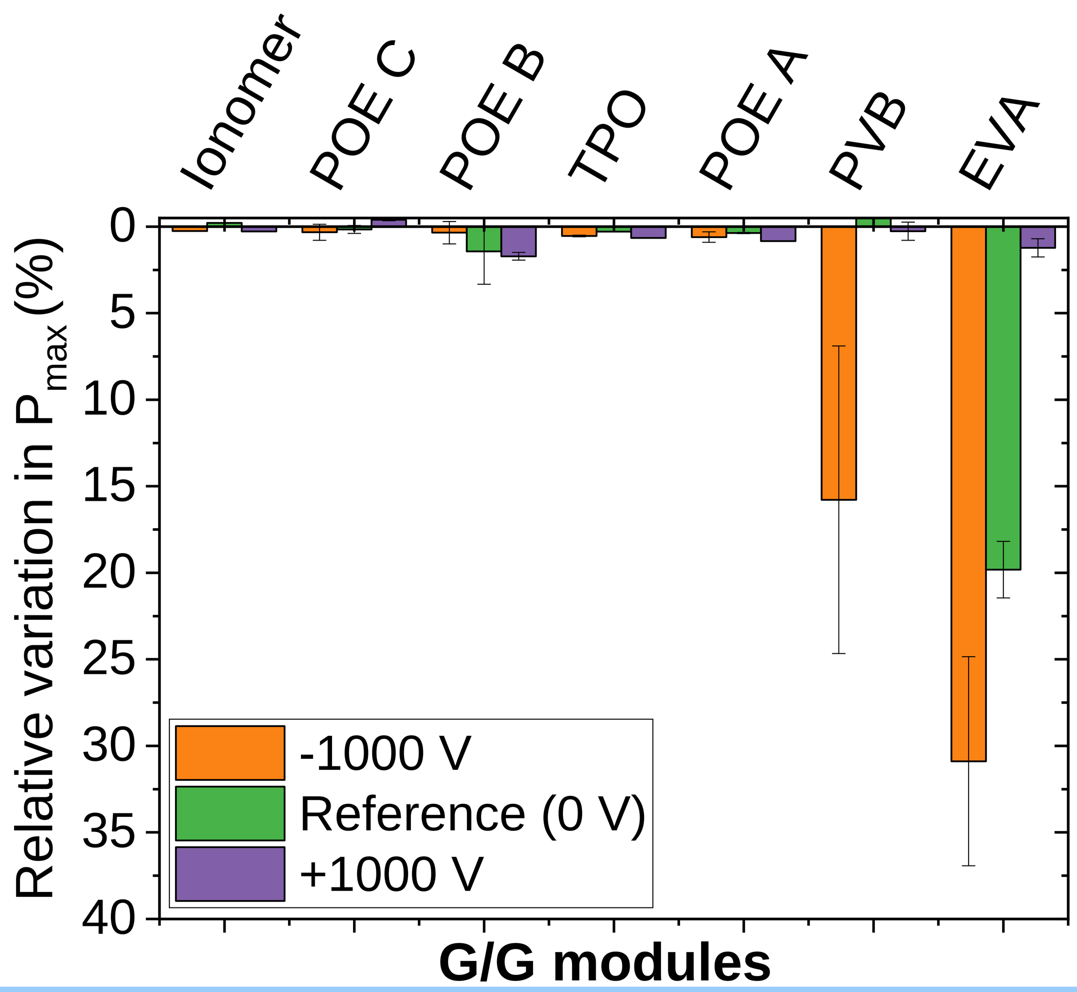
G/G



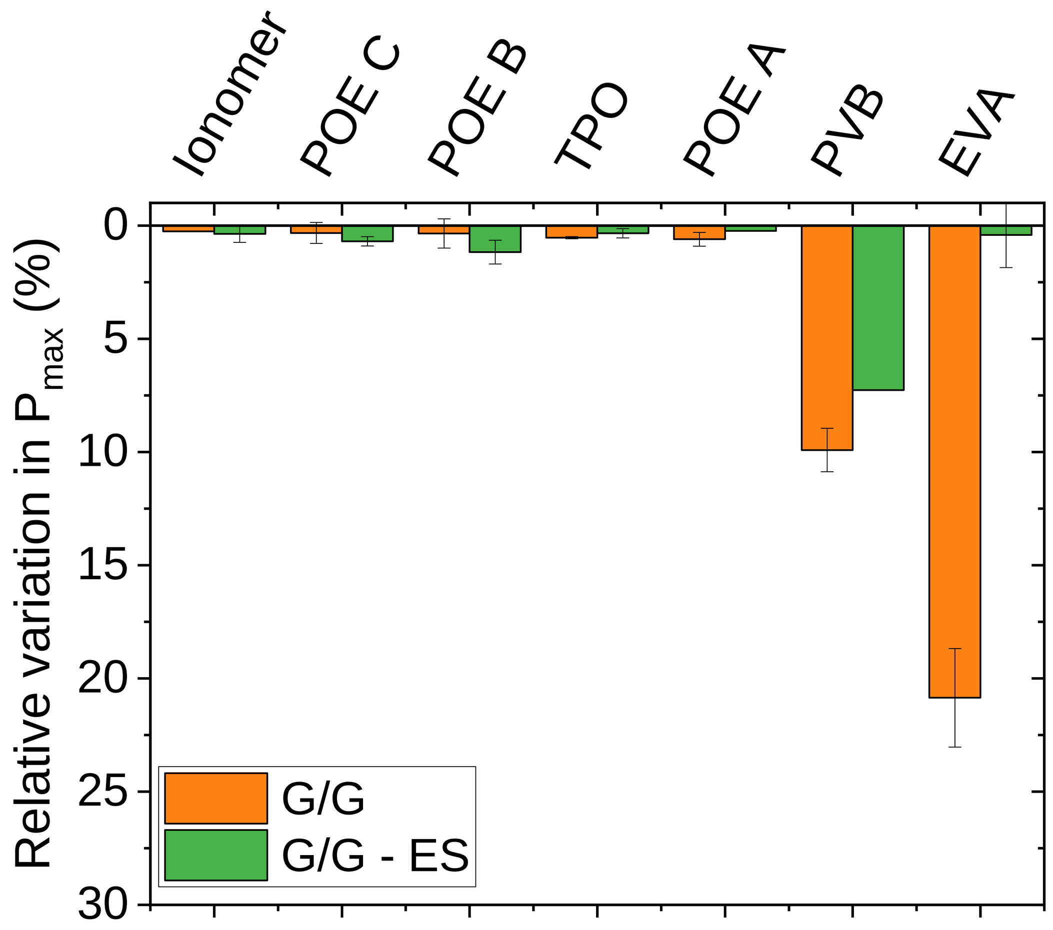
G/G-ES

Results

1. Comparison of Applied Voltage in G/G modules vs Module Configuration at -1000 V – 500 h of test

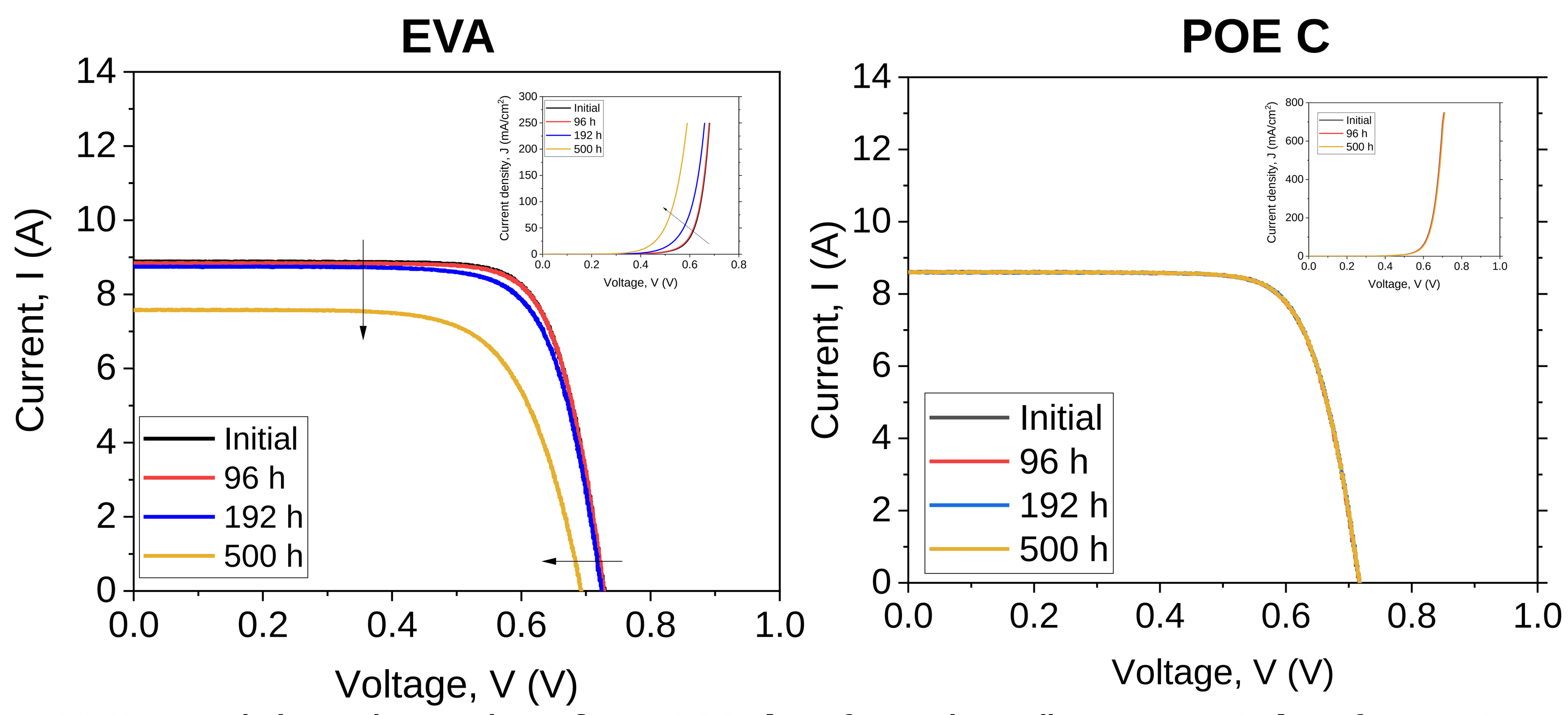


- PID caused by **negative voltage** (-1000 V).
- Modules encapsulated with Ionomer, POE and TPO **do not degrade** in any case.
- Degradation on G/G modules with PVB and EVA.



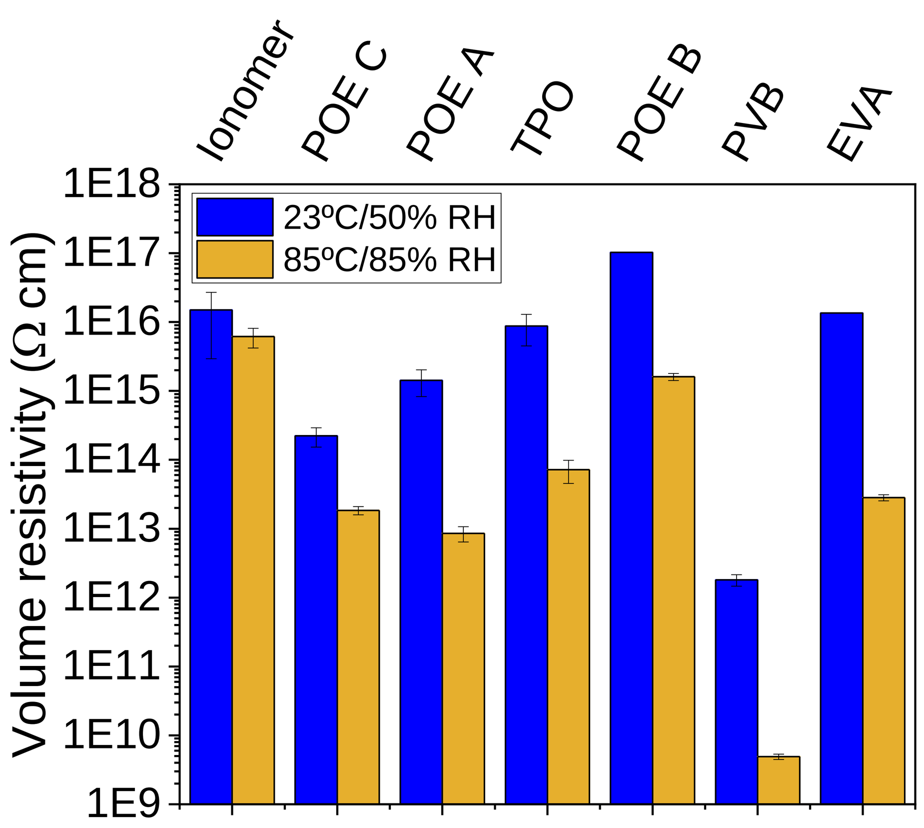
- PID can be **prevented** in modules encapsulated with EVA using an **edge sealant (ES).**
- In G/G-ES modules with PVB, the ES attenuates the degradation.

2. Light and dark I-V curves of G/G modules – EVA vs POE C



- EVA modules degrade **after 192 h** of testing (i.e. **2x 96 h** of IEC TS 62804-1[3]).
- Degradation in $\mathbf{J_{SC}}$ and $\mathbf{V_{OC}}$ → **optical** and **passivation** losses.

3. Volume resistivity of encapsulants



- Encapsulant resistivity highly depends on temperature and relative humidity (RH)[2].
- Resistivity decreases when temperature and RH increase – especially **PVB** and **EVA**.
- Similar resistivities for EVA and POE → only the modules encapsulated with EVA degrade.
- **Encapsulant resistivity is not the only key parameter** in PID mechanism → water vapour transmission rate (WVTR)[4].

Conclusions

- **PID can be prevented** in SHJ modules using the **appropriate encapsulant** and **module configuration** design.
- PID in SHJ modules takes place when the cells are **negatively biased** with respect to the grounded frame (i.e. -1000 V).
- Modules encapsulated with **Ionomer, POE and TPO do not suffer from PID** (even after 500 h of test).
- **PID is prevented** in modules encapsulated with EVA **by using an edge sealant**.

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[1] Luo, Wei, et al. "Potential-induced degradation in photovoltaic modules: a critical review," *Energy & Environmental Science* (2017).
[2] Virtuani, Alessandro, et al. "One-type-fits-all-systems: Strategies for preventing potential-induced degradation in crystalline silicon solar photovoltaic modules," *Progress in Photovoltaics: Research and Applications* (2018).
[3] IEC, "IEC TS 62804-1:2015 Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon," (2015).
[4] López-Escalante, M. C., et al. "Polyolefin as PID-resistant encapsulant material in PV modules." *Solar Energy Materials and Solar Cells* (2016).