Challenges of black metallic interconnect for integrated PV module applications

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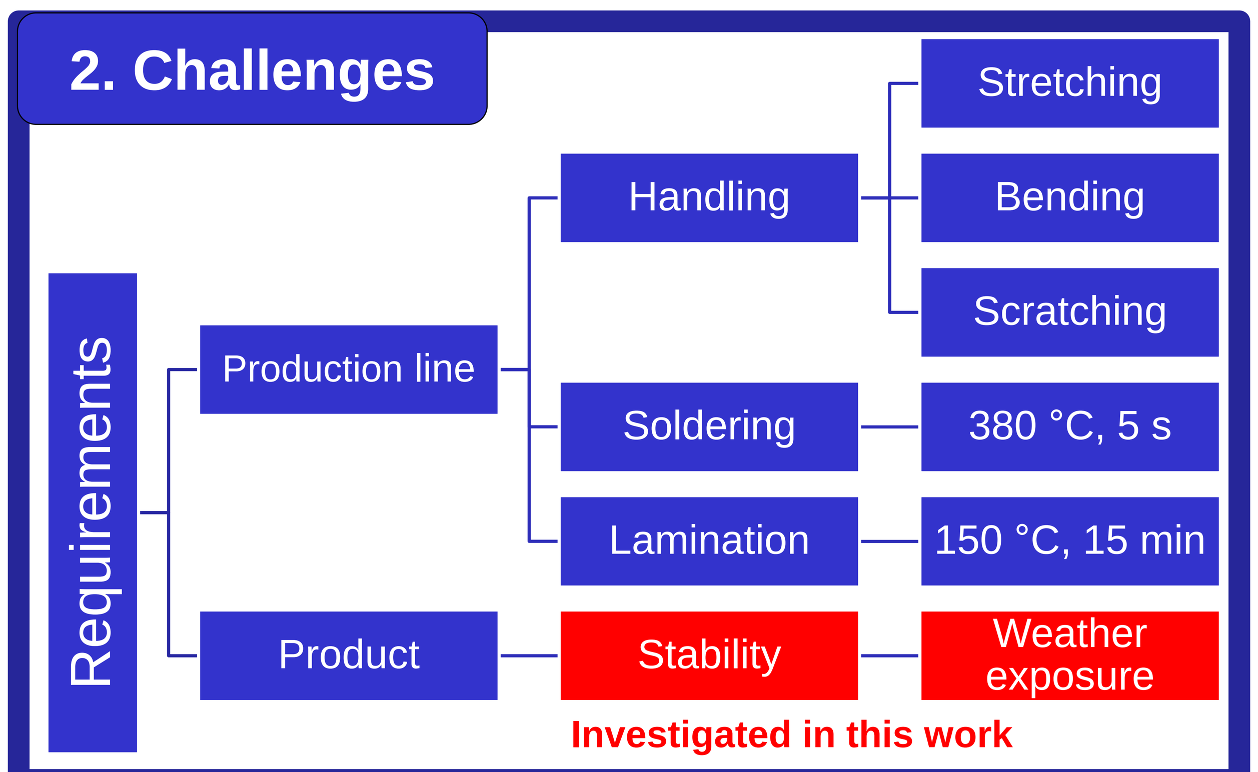
1. Motivation

Black metallic interconnects are commonly used in the integrated photovoltaic (IPV) industry to improve the **aesthetics.** In this work, we **investigate the stability** of black metallic ribbons for IPV applications and the effect of an unstable ink in solar cell mini modules.

2. Challenges

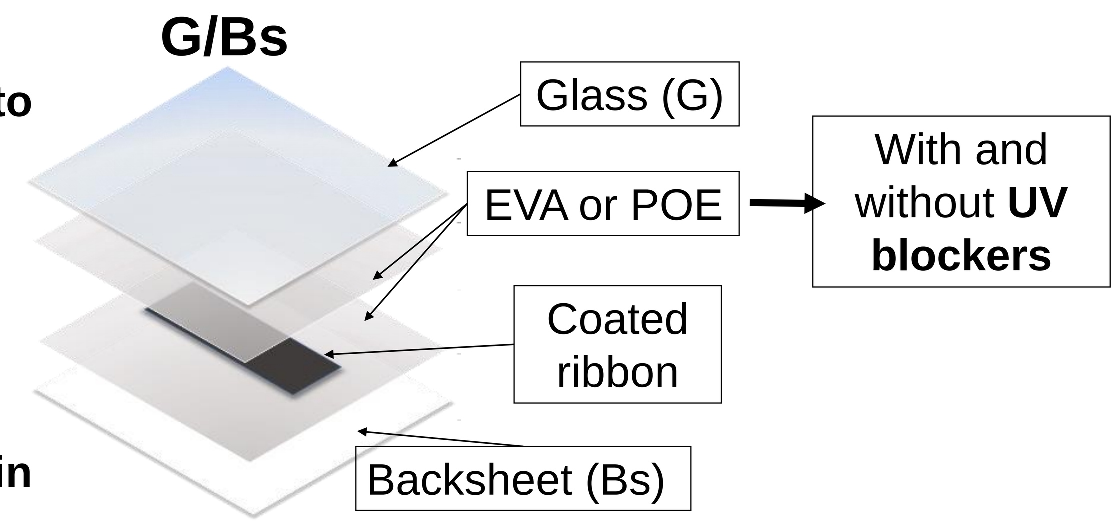


3. Experimental

4 black colored ribbons are encapsulated in **G/Bs** configuration.
The samples are subjected to **light exposure according to existing IEC standards [1]:**

- **UV exposure** → IEC 62788-7-2 A3 [2]
  - Chamber air temperature: 65°C
  - Relative humidity: 20%
  - Lamp source Xe-arc lamp (with daylight filter)

One **unstable ink** is studied further by **degrading** its **main component**.



Sample #	Coloring technique	Ink type
1	In-house inkjet	UV curable
2	In-house inkjet	UV curable
3	Commercial	Unknown
4	Commercial	Unknown

Advantages:

- Fast curing
- Good adhesion
- Printing flexibility
- Coating after handling and soldering

4. Characterization techniques

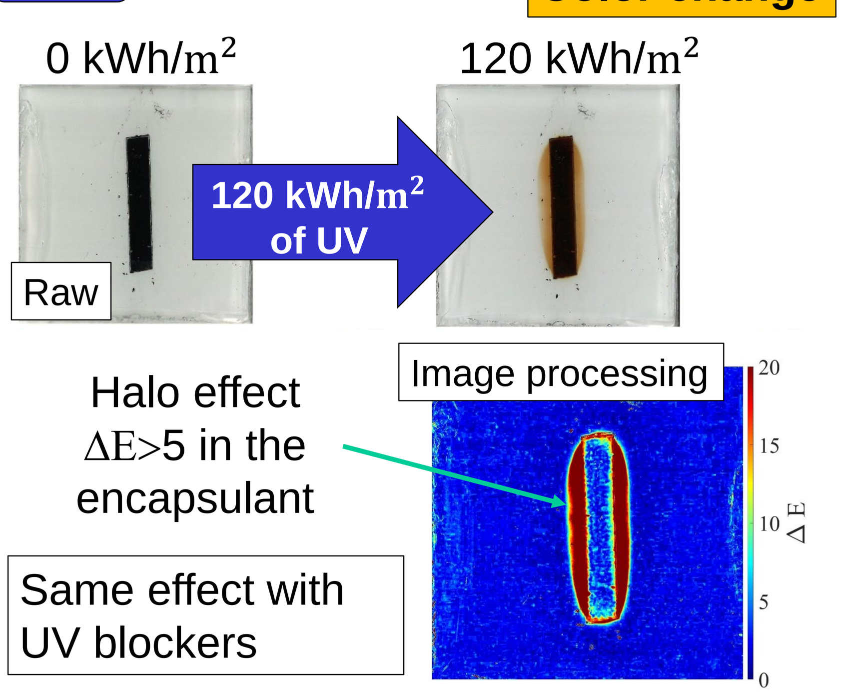
To assess the **ink stability** we use:

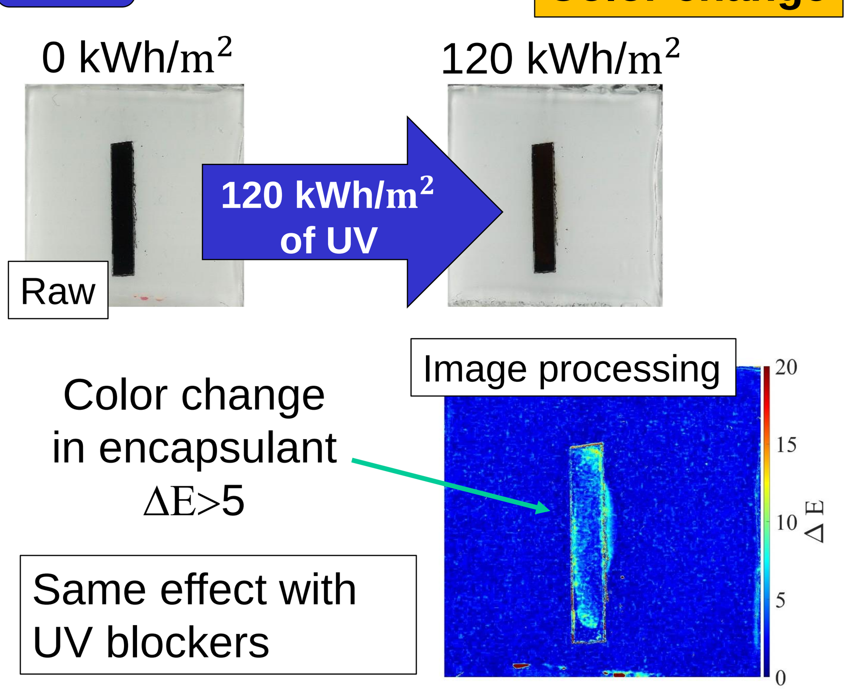
→ **Attenuated Total Reflectance - FTIR**
→ **Image processing**

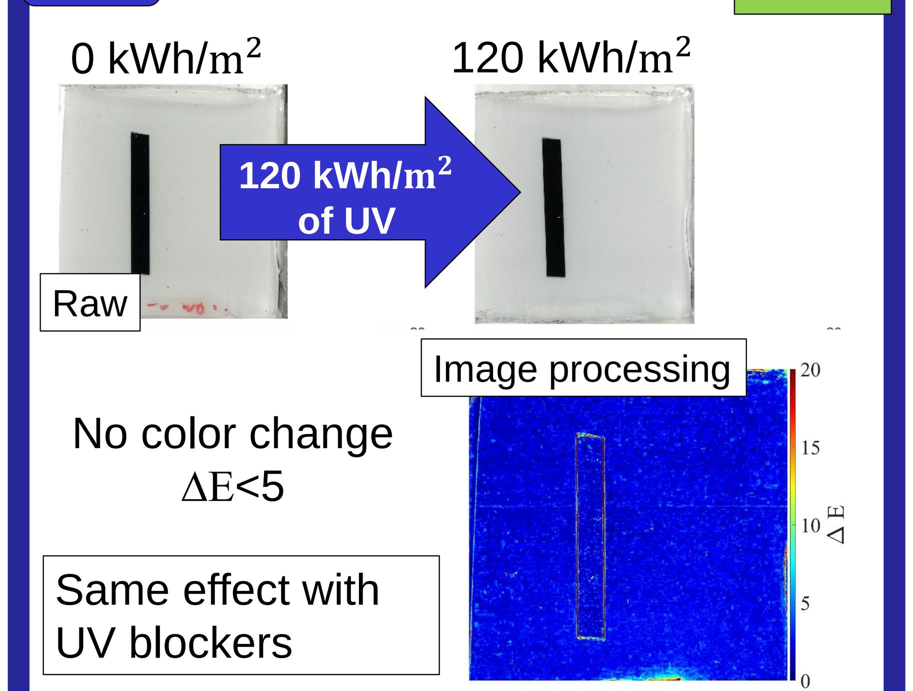
The software **calculates the color change (ΔE) between the non-degraded sample image with respect to the degraded sample image** in RGB coordinates with the same resolution and illumination [3].

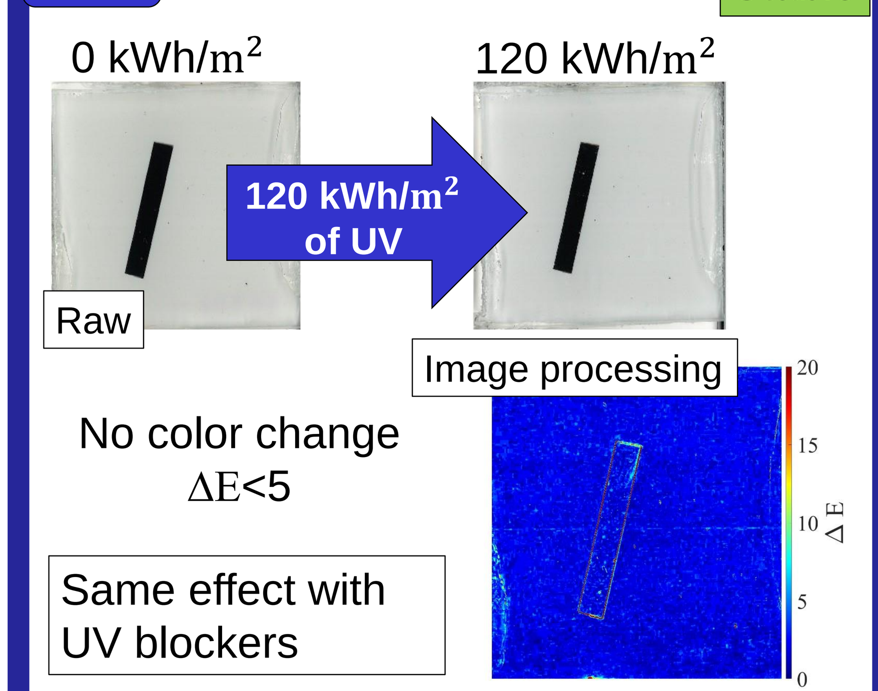
5. Results

Image processing







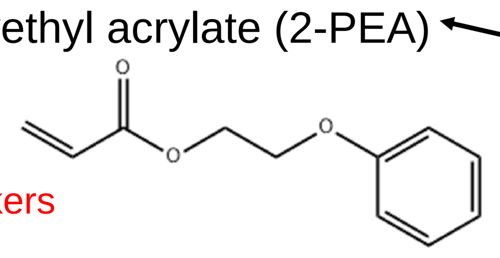


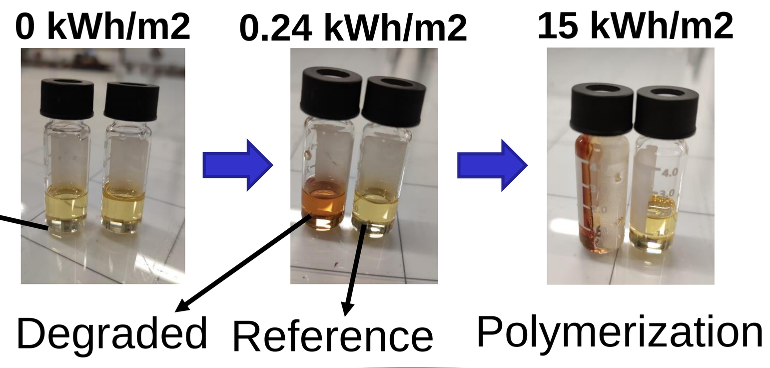
What is happening ?

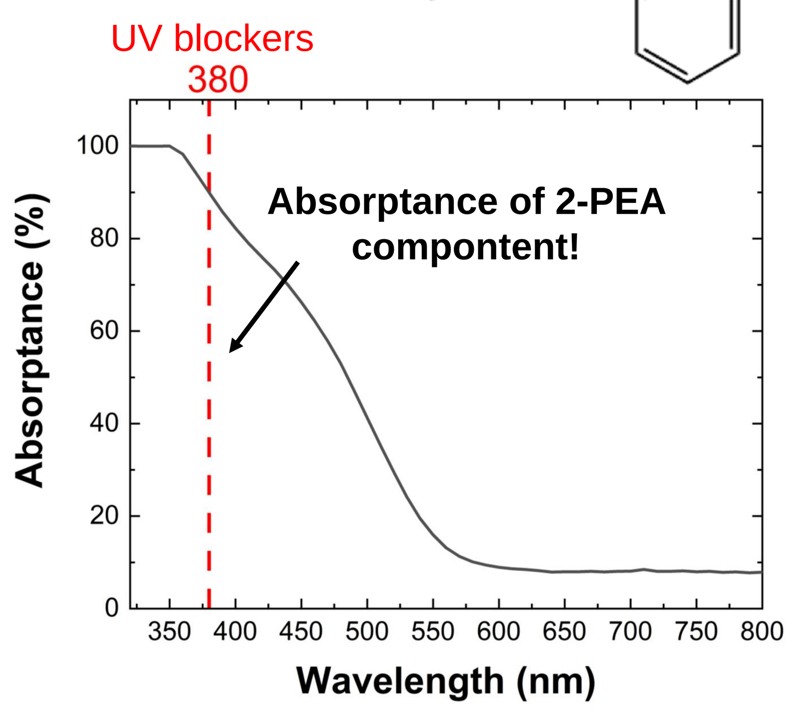
Ink component isolation

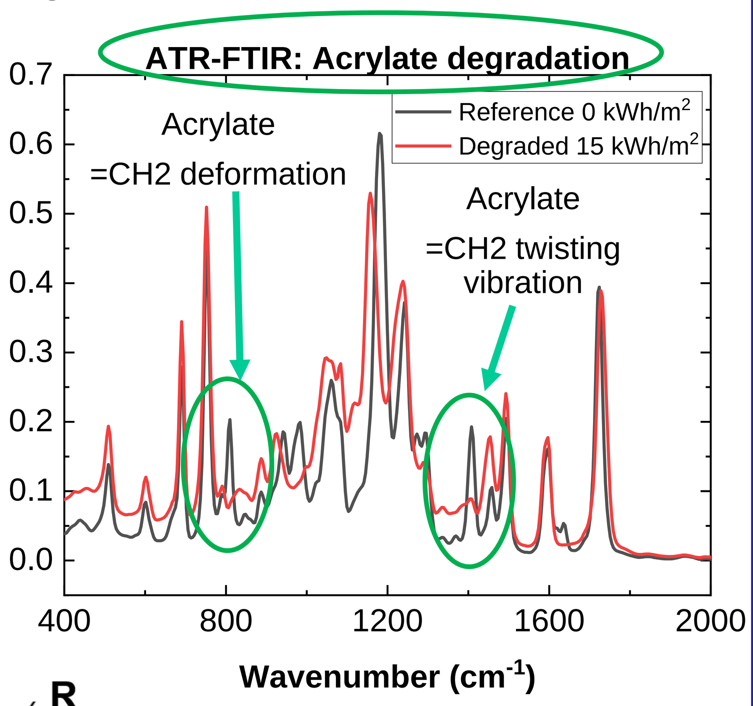
The main component of ink #1 is:

2-Phenoxyethyl acrylate (2-PEA)

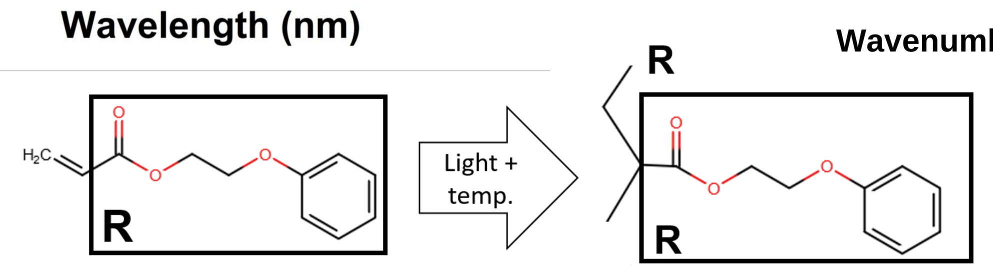






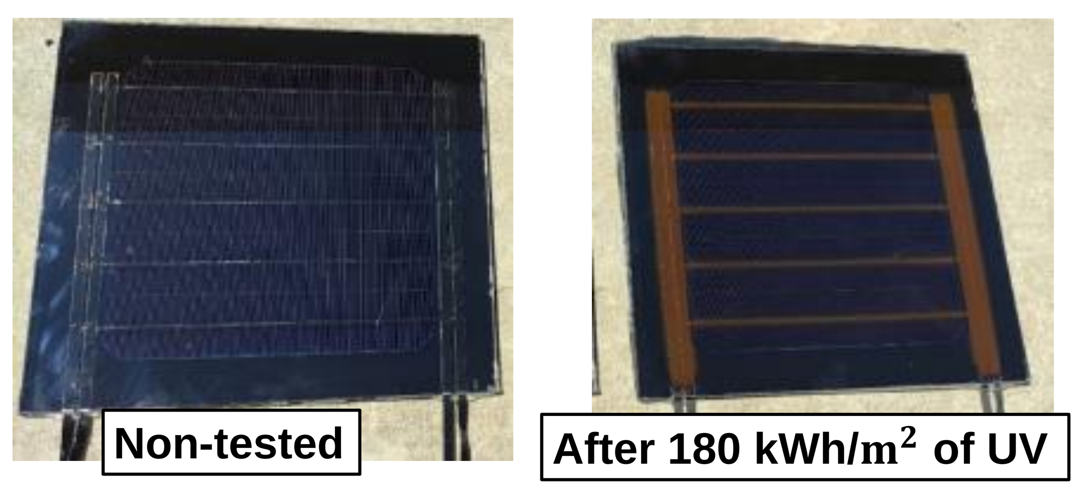


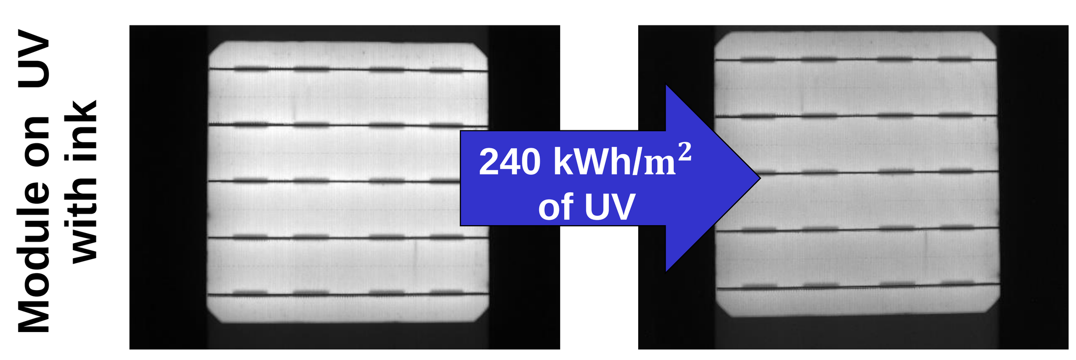
Chemical reaction [4]:



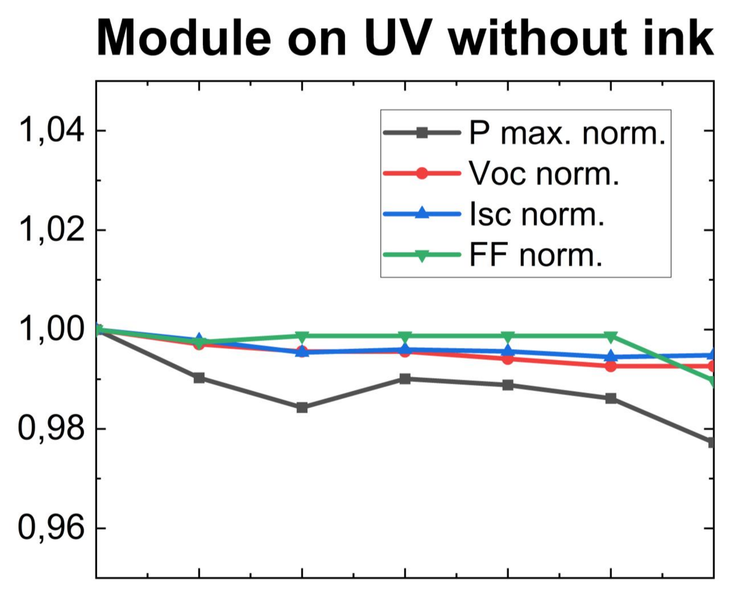
Impact of degraded ink #1 on module performance

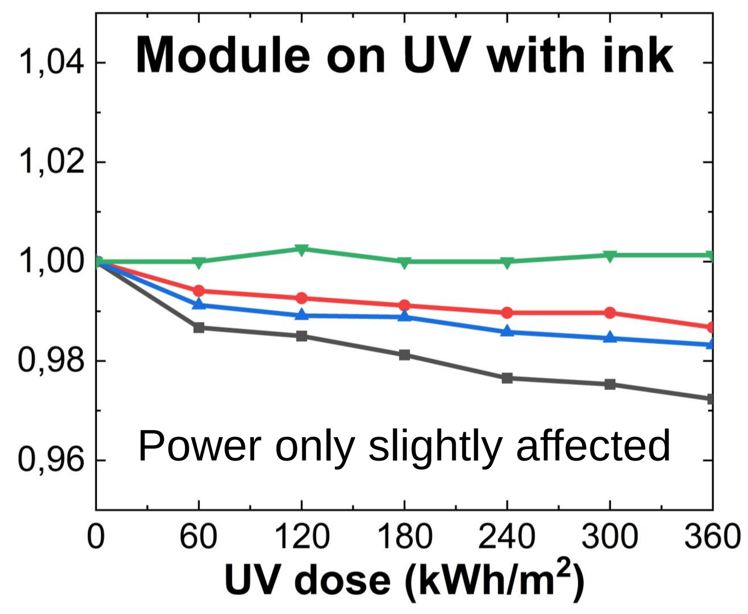
With the **wrong ink**, the **visual appearance** is **strongly modified** after UV aging.





No changes in EL





Conclusions

- We investigated the **stability** of black metallic interconnects in **G/Bs configuration**.
- We followed a protocol of light exposure according to **already existing IEC standards**.
- A **change in color** was observed in all of the black metallic interconnects with UV curable inkjet inks no matter of the configuration used (EVA or POE, with and without UV blockers).
- **Acrylates degradation** of main ink components may be the cause of the color change.
- **UV blocker** encapsulants do **not mitigate** the degradation.
- **Commercial** black metallic interconnects are **stable** under UV light exposure after 120 kWh/m².
- The **consequence** of using the wrong ink would be mainly **aesthetical, performance is only slightly affected.**
- Further activities involve the understanding of the **degradation mechanisms** causing the color change.

References

[1] IEC, "IEC 61215-2: Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures," 2016.
[2] IEC, "IEC TS 62788-7-2: Measurement procedures for materials used in photovoltaic modules - Part 7-2: Environmental exposures – Accelerated weathering tests of polymeric materials," 2017.
[3] G. Sharma, W. Wu, and E. N. Dalal, "The CIEDE2000 color-difference formula: Implementation notes, supplementary test data, and mathematical observations," Color Res. Appl., vol. 30, no. 1, pp. 21–30, Feb. 2005, doi: 10.1002/col.20070.
[4] G. Odian, *Principles of Polymerization*, 1st ed. Wiley, 2004. doi: 10.1002/047147875X.

Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 754354. This work has been funded in part by the European Commission (EC) under the H2020 Be-SMART (#818009) and by EU Horizon Europe programme under Grant Agreement No 101084046 Pilatus Project. We gratefully acknowledge support from all PV-Lab team members.