

# Stability of inks used for masking metallic interconnects in BIPV modules

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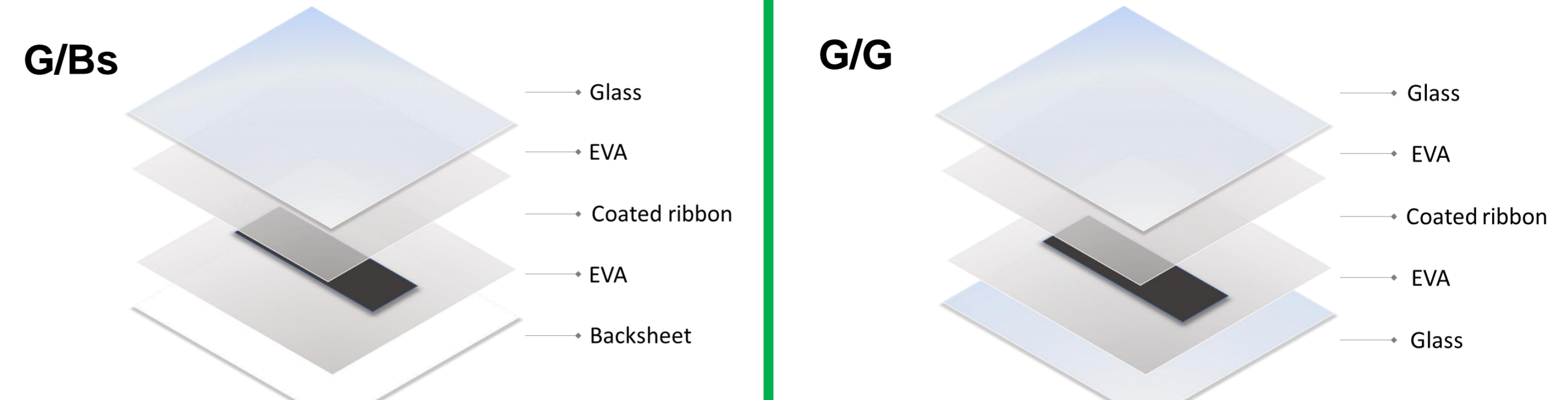
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## Motivation and Goals

- **Aesthetics** plays a **major role** for integration of PV modules in the built environment [1]
- Metallic interconnects are highly visible, so masking them can **improve the visual appearance** of a product
- Masking BIPV modules can be accomplished with inks [2]
- We investigate the **long-term stability of three commercial black inks** applied to the metallic ribbons using **2 different module configurations** under a **protocol** of ultraviolet (UV) exposure and damp heat (DH) conditions

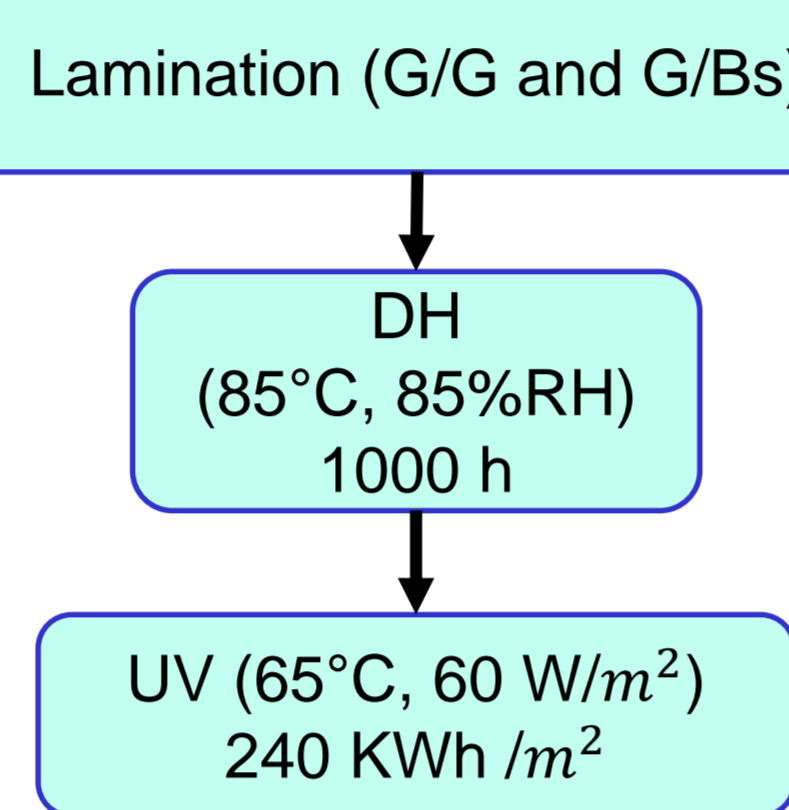
## Configurations



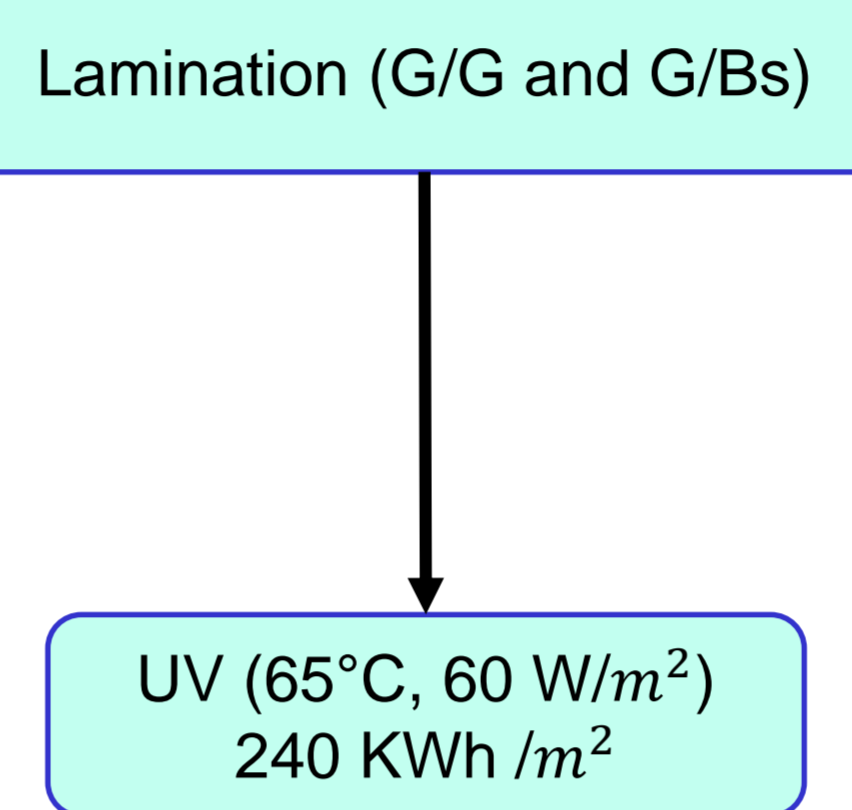
## Experimental

- 1) Three commercial black colored inks were used to mask the metallic ribbons in the G/G and G/Bs configurations
- 2) The samples are subjected to **2 main sequences**
  - **UV exposure** → IEC 62788-7-2 A3 conditions
    - Chamber air temperature: 65°C
    - Relative humidity: 20%
    - Lamp source Xe-arc lamp (with daylight filter)
  - **Damp Heat (DH)** → IEC 61215-2
    - Chamber air temperature: 85°C
    - Relative humidity: 85%

### 1. Sequence DH+UV



### 2. Sequence UV



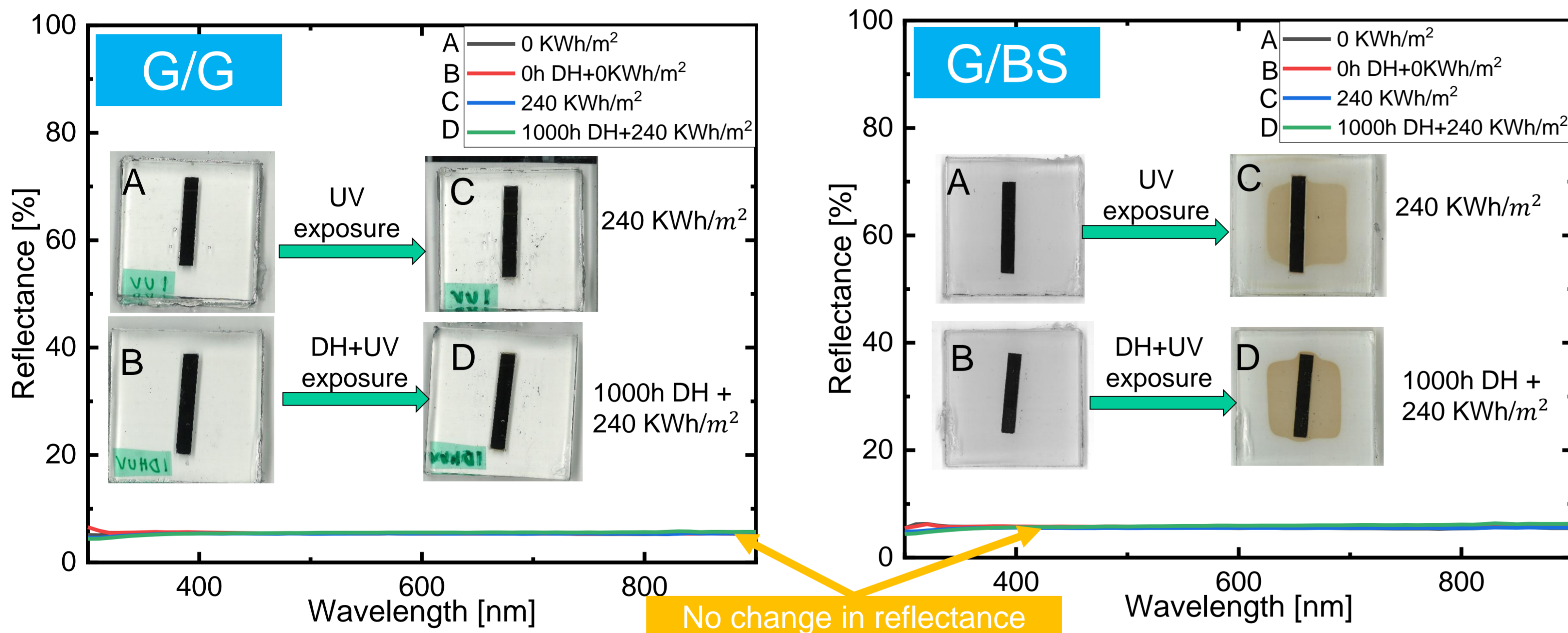
### 3) Characterization techniques

- UV-Vis-NIR spectroscopy
- Reflectance from 300nm to 900nm of the masked ribbons
- Visual inspection
- High and constant illumination

## Results

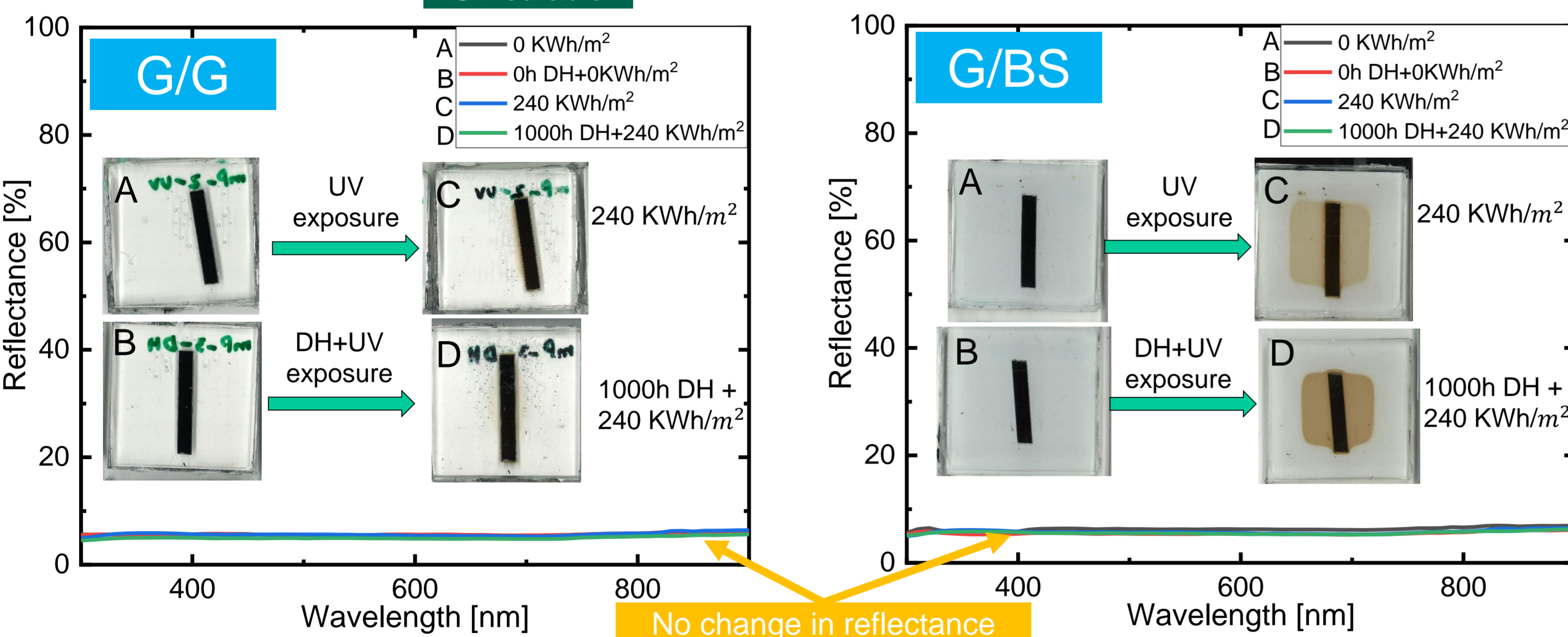
### Ink A

Solvent based



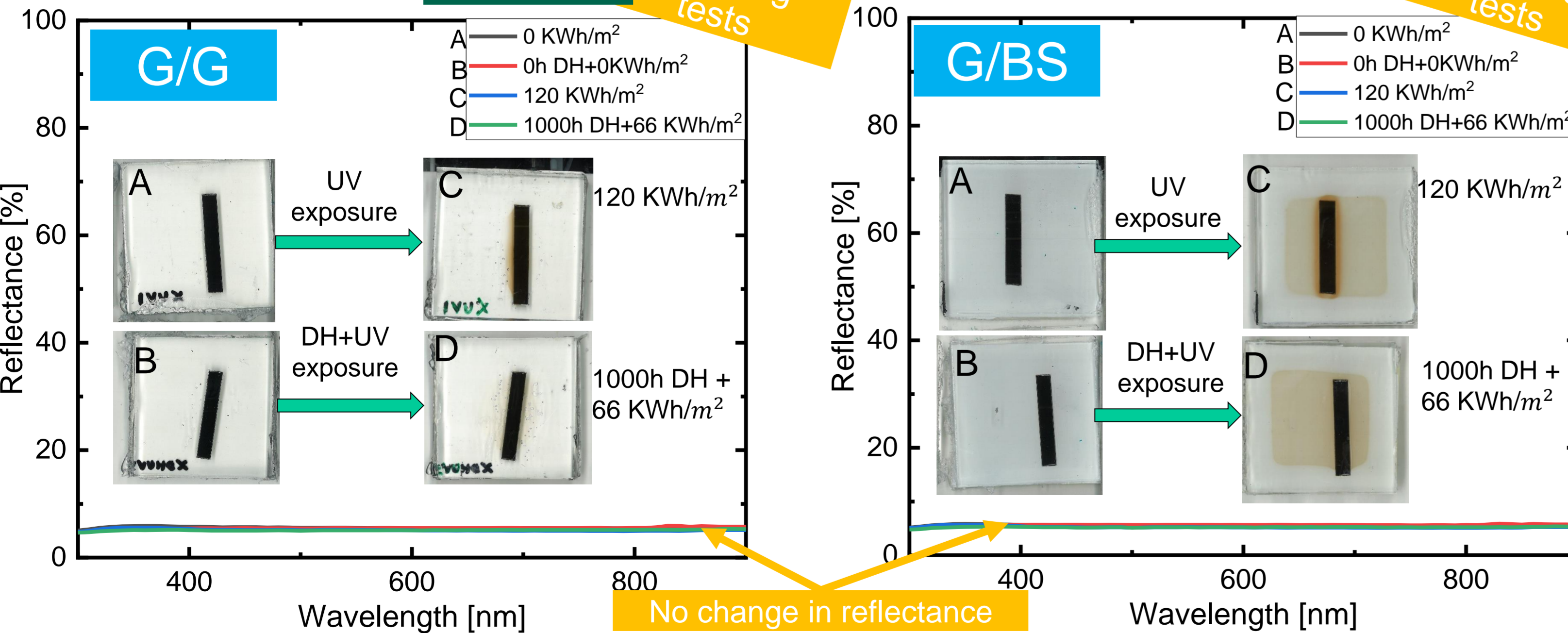
### Ink B

UV curable



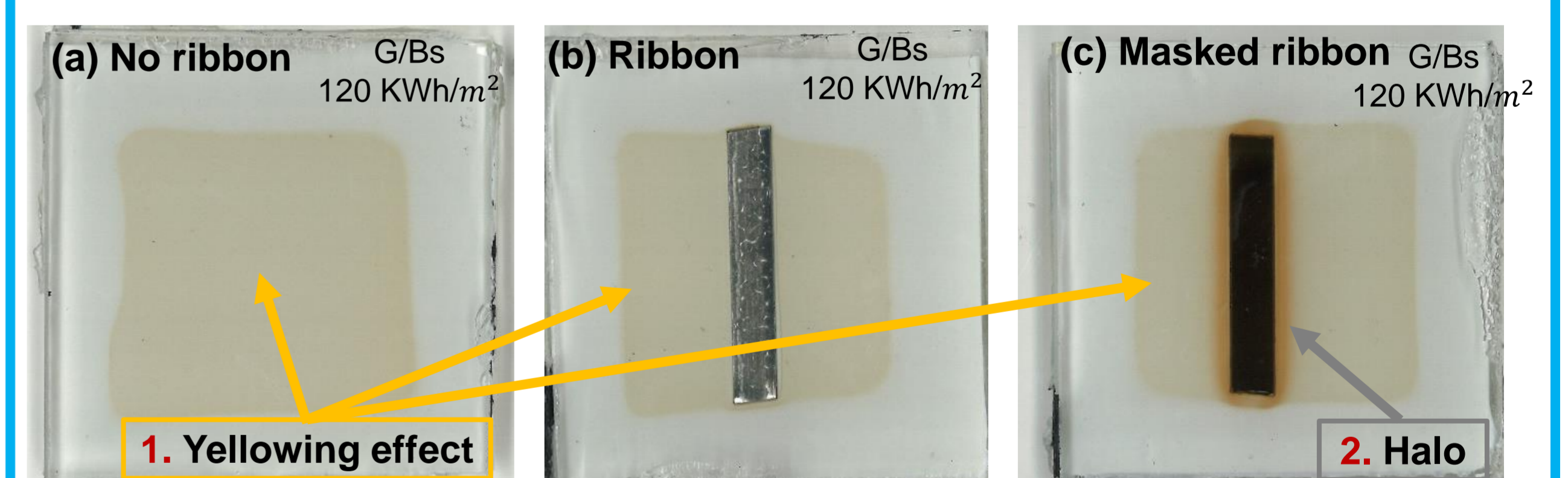
### Ink C

UV curable



- All inks are compatible with conventional lamination processes
- There is **no change in the reflectance** of the metallic ribbons for any ink
- The metallic ribbons preserve their black colored appearance after UV exposure and DH+UV exposure
- All samples with G/Bs configuration present a **yellowing effect after UV exposure**, this effect is also shown in [3]
- DH does not seem to contribute to the yellowing effect
- A halo is produced in both configurations (G/G and G/Bs) of ink B and C following the sequence that **only involves UV exposure**
- DH+UV exposure has not produced the halo up to now (tests are ongoing, the sequences are not finished for ink C)
- Ink C presents a larger halo than ink B after UV exposure, while ink A does not show it at all
- Ink A is more stable than ink B and C

### 2 main effects



- G/Bs configuration after 120 KWh/m<sup>2</sup> of UV exposure
  - (a) without metallic ribbon
  - (b) with metallic ribbon
  - (c) with masked metallic ribbon with ink C
- The **yellowing effect does not depend on the ribbon** while the **halo effect depends on the ink**

## Conclusions

- We study the stability of inks for masking ribbons in BIPV modules in G/G and G/Bs configurations following a protocol of 2 main sequences, UV and DH+UV.
- The metallic ribbons **preserve their black colored appearance** for all the studied inks and configurations.
- UV exposure produces a yellowing effect in all G/Bs configurations.
- A halo is produced in all configurations of ink B and C following the sequence that **only involves UV exposure**, the halo does not appear with ink A. It **might be ink migration to the encapsulant**. With DH+UV exposure, the halo is not observed up to now. Further investigation will be done.
- Ink A is more stable than ink B and C

[1] C. Ballif et al., 2018, DOI: 10.1038/s41560-018-0176-2  
[2] L. H. Slooff et al., 2018, DOI: 10.4229/35thEUPVSEC20182018-6A0.8.4  
[3] J. Kim et al., 2021, DOI: 10.1109/JPHOTOV.2021.3053657

## 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). We gratefully acknowledge support from all PV-Lab team members.