SUPSI University of Applied Sciences and Arts of Southern Switzerland

CASE STUDY

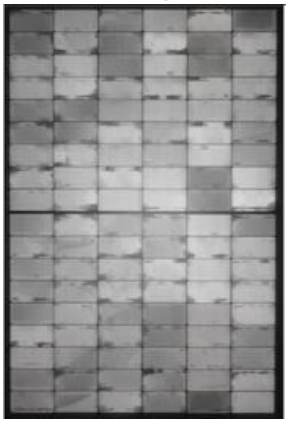
UV AND THERMAL STRESS-INDUCED DEGRADATION

N-type TOPCon monofacial modules were evaluated after more than two years of field operation. Identical module types were exposed to different UV dosages and module temperatures. This allowed assessment of the combined impact of ultraviolet and thermal stress. Two principal findings were identified:

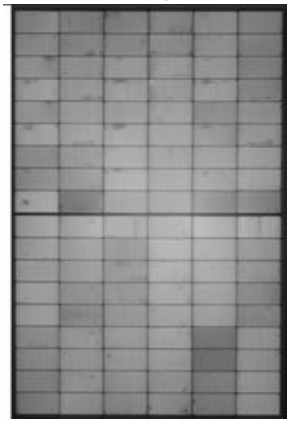
- **Higher UV exposure:** The module subjected to higher UV doses showed more pronounced reductions in open-circuit voltage (Voc) and fill factor (FF). Electroluminescence (EL) imaging revealed characteristic checkered patterns, consistent with ultraviolet-induced degradation (UVID) mechanisms reported in the literature and observed in controlled laboratory testing at SUPSI PVLab.

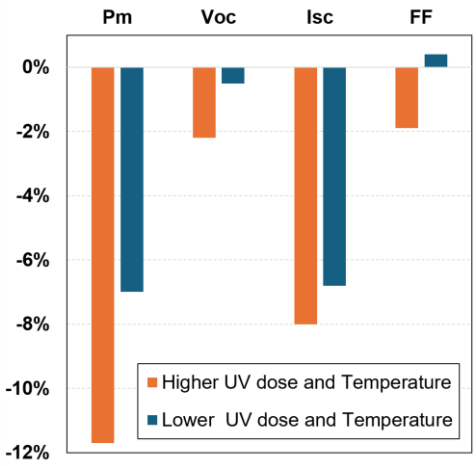
- **Higher thermal stress:** The module subjected to higher thermal stress underwent more intense temperature cycling, leading to more severe metallization damage, such as solder bond fatigue and finger interruptions. Comparable but less pronounced defects were observed also on the module which was under lower thermal stress, suggesting an inherent manufacturing sensitivity that was exacerbated by elevated thermomechanical loading.

Higher UV dose and Module Temperature



Lower UV dose and Module Temperature





SUPSI PVlab's UV stress test (UVID) and thermal cycling test sequences effectively identify and characterise the sensitivity of these module types to UVID, solder bond fatigue, and finger interruptions. The strong correlation between field observations and laboratory stress testing confirms the relevance of controlled UV and thermal cycling test sequences for evaluating long-term module robustness.

Mitigation Strategies

- Select module technologies with demonstrated resistance to UVID, validated through UV stress testing (UVID).

- Improve module production quality to reduce solder bond fatigue and related metallization defects.

- Incorporate extended laboratory qualification sequences, including UV and thermal stress tests, into procurement and due diligence processes.