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Stability Analysis on Shingled High-Efficiency BAPV Modules

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ABSTRACT

Current BAPV modules are based on p-type PERC solar cells, have half-cut cells and realized in glass-backsheet designs. However, the next module generation is already in the starting blocks. It is characterized by highly efficient solar cells such as n-type SHJ or TOPCon, shows high cell-to-module (CTM) values to due shingled module interconnection and has been developed sustainably in glass-glass design.

Within the EU funded HighLite project such modules were developed and in this study the prototypes were detailed on their stability tested. Next to the thermo-mechanical resistance we are also focused on the LID, LeTID and PID sensitivity of those modules. The outcome of this investigation is development of degradation image pattern at the different cell technologies and the novel shingling of solar cells. Finally, we will close the paper with a risk analysis.

Keywords: n-type solar cells, shingled, long term stability

Applied Test Sequence and PV-Modules

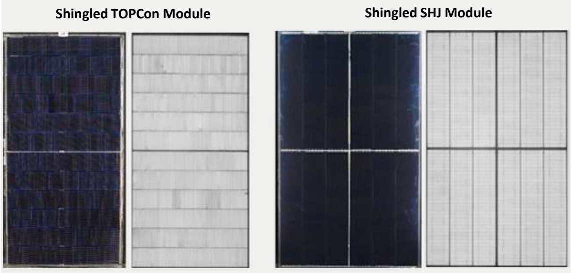
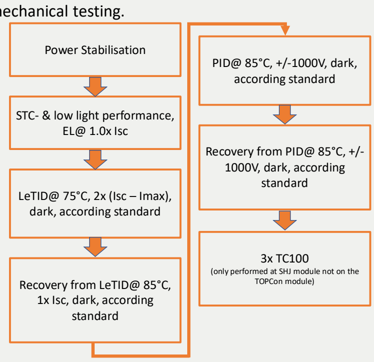


Figure 1: Within the HighLite project the first full size shingled BAPV modules with TOPCon and SHJ cells were developed. The cells at these modules were 1/6 cutted and assembled using different layouts (twin design with 6 horizontal strings for the TOPCon module vs block design with vertical strings for the SHJ module). The modules are designed in glass – glass. The intial EL-images displays the quality of the cut-edge process and the cell handling at the cell string manufacturing.

Figure 2 shows the test sequence we applied to the modules. The initial characterisation is followed by LID, LeTID and PID testing as well as thermo-mechanical testing.



LID Effect

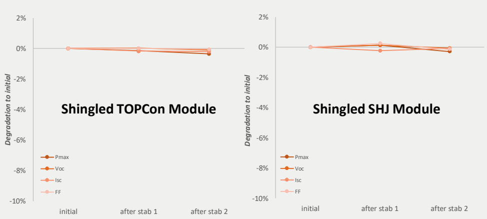


Figure 3: Light Induced Degradation (LID)

The figure shows the results of the power stabilisation of the TOPCon and SHJ shingled modules. Both panels show a negligible LID degradation on their electrical key parameter. The observed data change is < 1%. The stabilized power of the modules at STC are:

	TOPCon Module	SHJ Module
P_{max} / W_p	393.04	324.13
FF / %	79.06	78.16

LeTID Effect

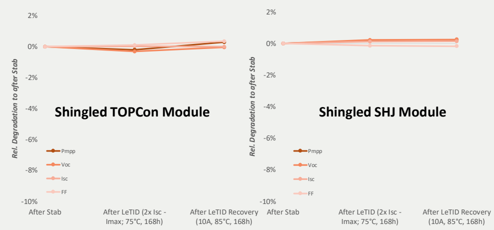


Figure 4: Light and Temperature Induced Degradation (LeTID)

The stress at 75°C and an induced current equal to 2x (Isc - Imax), which in both cases was around 1A, took place in the dark for 168h, as well as the subsequent LETID recovery at 10A and a temperature of 85°C. Also, in the dark and for 168h, resulted in no significant degradation in the main electrical parameters of the n-type solar cells. In the spatially resolved characterization using the EL technique (not shown here) there are no changes in contrast visible.

PID Effect

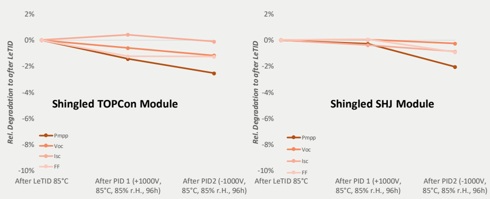


Figure 5 shows the relative degradation (top) and EL images (bottom) of the modules after PID with positiv firstly and negativ potential finally. TOPCon shows some degradation with both potential while SHJ sohws degradation at negative potential.

Temperature Cycle Stability

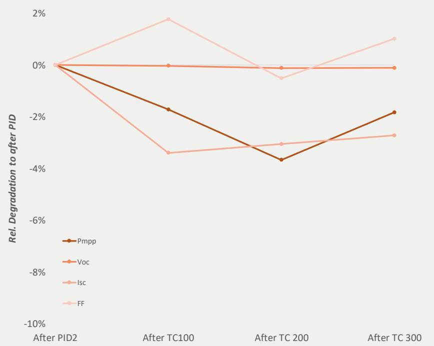


Figure 6 shows the relative degration of a 1/6 shingled module with SHJ solar cells designed in double glass (each glass plate has a thickness of 2 mm). Three cycles of TC100 were applied to the module and after 100 cycles the IV curve and the EL image were taken. These TC tests were done a second second SHJ module. As it is visible in the diagram, the module has maxium in power degradation of -4% after 2x TC100, before the power increases again to -2% after 3x TC100.

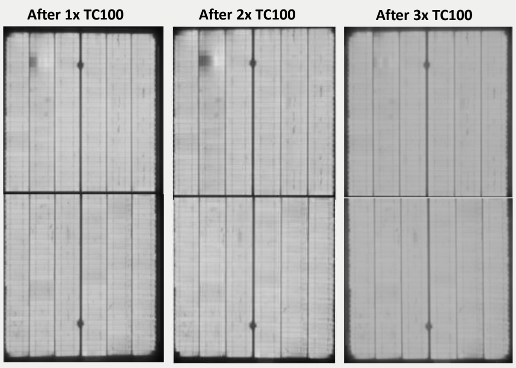


Figure 7 shows the EL images each after 100 temperature cycles of the second module. The module shows issues at the interconnection (bright spot), which has a highest intensity after 3xTC100 and its corelates with the losses in Pmax, shown in Figure 6. After 3x TC100 the spot disappeared again.
The two dark spots on the centerline are probably due to moisture penetrating the module during the PID test. The framing is probably also due to moisture penetrating over the edge of the module.

CONCLUSIONS

Within the HighLite project the first full size shingled BAPV modules with TOPCon and SHJ cells were developed. The cells at these modules were 1/6 cutted and assembled using different layouts (twin design with 6 horizontal strings for the TOPCon module vs block design with vertical strings for the SHJ module). The modules are designed in glass – glass. The test sequence we applied to those modules covers initial characterisation followed by LID, LeTID and PID testing (-)(+) as well as thermo-mechanical testing. We we could thereby determine the following:

- Low risk of LID at modules with TOPCon and SHJ cells;
- Low risk of LeTID at modules with TOPCon and SHJ cells;
- Low risk of LeTID at modules with TOPCon and SHJ cells;
- A certain risk PID susceptibility (but less then -5%) at modules with TOPCon and SHJ cells;
- Some issues at shingled interconnection at temperature cycles

In summary The BAPV Demo's modules developed within the HighLite project show good results.

ACKNOWLEDGEMENTS: This research was supported by the European Union's Horizon 2020 Programme for research, technological development and demonstration under Grant Agreement number 857793 (Project name: HighLite).