Multi-Crystalline Silicon Solar Cell Modules: Crack Formation and Development due to Climate Chamber Thermal Cycle Testing

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1 Abstract

In the previous years more and more interest is shown in the investigation of photovoltaic (PV) modules by means of electroluminescence (EL) imaging. This holds not only for the manufacturers but also for their distributors and/or customers.
Being confronted with the assessment of EL-images several questions arise: How do EL-visible failures influence the degradation of PV-modules? Is it possible to do a forecast about the module degradation from the initial EL-image? There is still a lack of direct correlation between reliability testing in a laboratory and the lifetime of a PV module in field. Nevertheless we know that certain failure mechanisms can be accelerated by means of climate chamber testing.

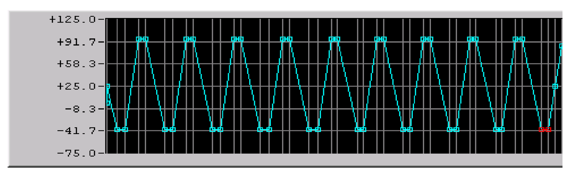
We like to present a study in which we used 40 multi-crystalline glass-foil silicon solar cell modules. The modules have been produced during the last two years. They have been part of the routine quarterly year climate chamber tests performed at SCHOTT Solar. A database has been set up containing the number of cracks before and after stress testing and the power degradation of the modules due to the TC testing.
Furthermore the development of cracks has been assessed during the tests with means of intermediate EL imaging

2 Experimental Setup

40 glass-foil modules with 5" (40 %) and 6" (60 %) multi-crystalline solar cells have been under investigation.

The modules have undergone 400 thermal cycles (TC) in a temperature range from - 40 °C to + 90 °C which is equivalent to double the DIN EN (IEC) 61215 testing time with a slightly higher temperature range (according to UL 1703).

- Intermediate tests every 100 thermal cycles
- Measurement of the module power by a AAA Halm flasher with a reproducibility of +/- 0,1 % in module power for repeated measurements at standard test conditions.
- Electroluminescence setup equipped with a CoolSamBa Camera from Sensovaton. Exposure time was 10 s at a current of 7,5 A or 40 s and 15 A respectively
- 400 Cycles (200 % IEC): -40°C ⇒ +90°C



Crack Counting:

- A cell with multiple cracks counts as one
- Fingerpeeling is not counted as a crack
- The size of the crack is not taken into account

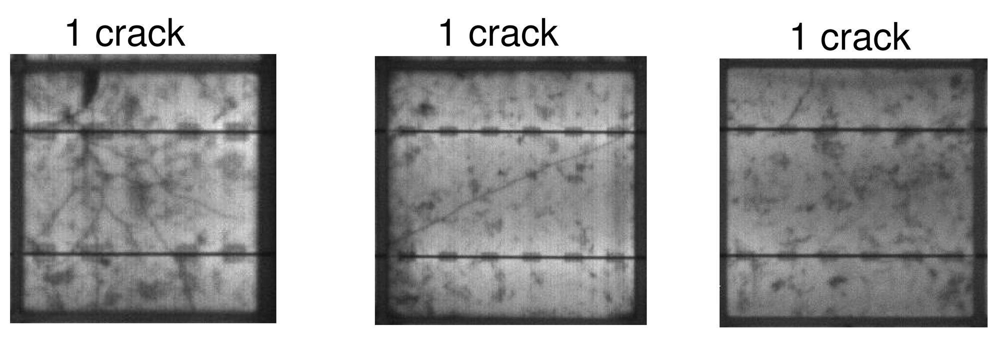


Fig. 1: Examples for crack counting

3 Results

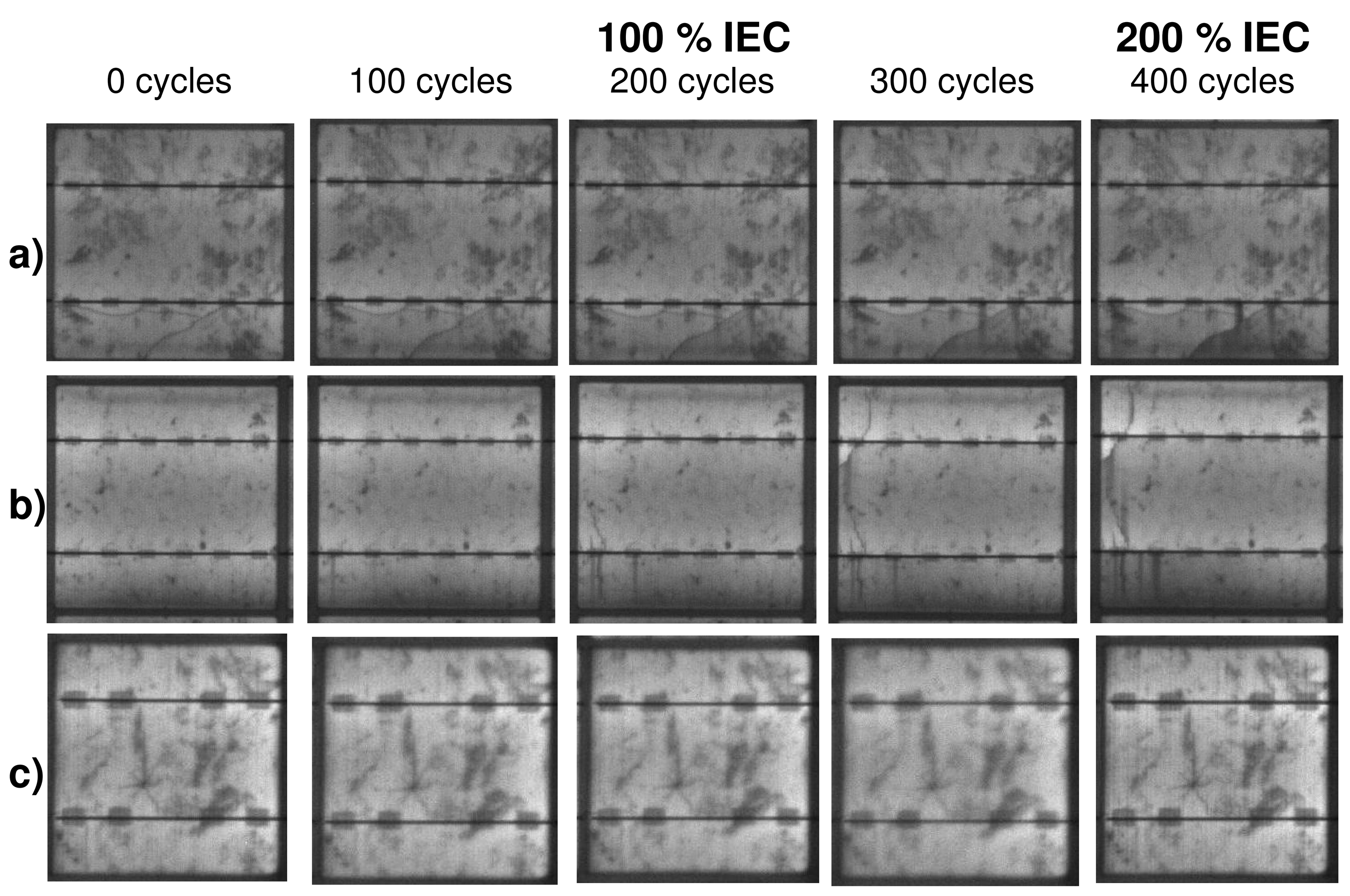


Fig. 3: Different development of cracks during the thermal cycle test

a) Cracked cell at start with developing degradation

b) No cracked cell at start

c) Non developing crack

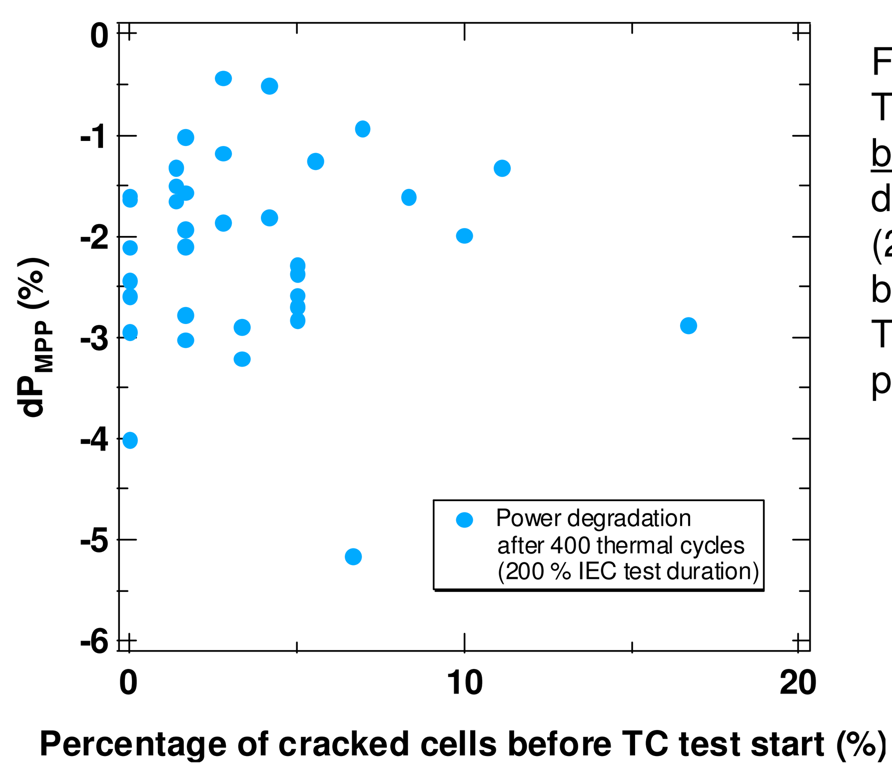
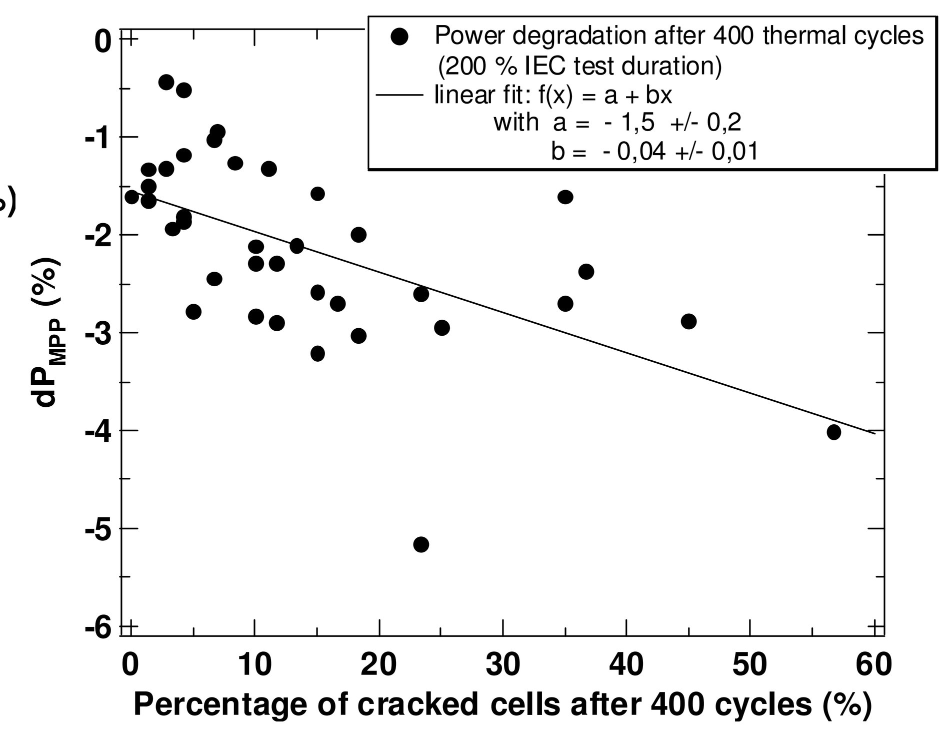


Fig. 4:
To the left the percentage of cracked cells before the thermal test start versus the power degradation after 400 thermal cycles is shown (200 % IEC). There is no visible correlation between those two sets of data.
The spread of the data points for a certain percentage of cracks is very high.

Fig. 5:
On the graph to the right the percentage of cracked cells after 400 thermal cycles versus the power degradation after 400 thermal cycles is shown (200 % IEC).
As expected it can be seen that the power degradation rises with the number of cracked cells (linear fit).



4 Discussion

The results show that it is not possible to do a forecast about the module degradation due to accelerated aging based on the number of cracked cells on the initial inspection by means of electroluminescence measurements. There are several reasons:

-The development of initially present cracks during stress testing is not clear without ambiquity. 38 % of the cracks were not developing during the tests (Fig. 3 c).

-The separation between degradation due to cracks and degradation due to other failure modes (e.g. finger separation) was impossible.

-A high number of cracks was either not present or not visible in the initial electroluminescence image (Fig. 3b).

-The spread of data points in case of the number of initial cracks before the test start and the resulting power degradation after 400 thermal cycles is very high (Fig. 4).

The study shows that even modules with a relatively high number of cracked cells do not give rise to a high degradation after double the IEC 61215 testing time. For further analysis in particular regarding the qualification of cracks in PV modules please see as well [1].

References:
[1] M. Köntges et al., Quantifying the risk of power loss in PV modules due to micro cracks, 25th PVSEC Valencia 2010

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