Fast and reproducible test method to investigate Hot-spot sensitivity of c-Si solar cells

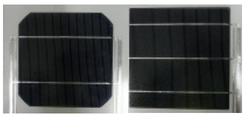
B. Jaeckel, J. Novak, R. Won, and A. Krtschil
Q-Cells SE, Sonnenallee 17-21, 06766 Thalheim, Germany

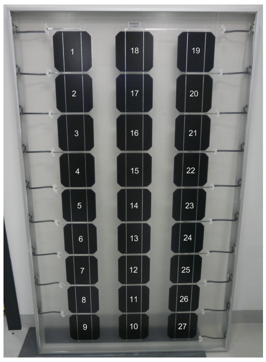
Introduction

To guarantee the long term reliability of a PV-system it is important to investigate possible failure modes in a regular, easy to use and reproducible way. However, each failure mode might require an individual setup. Among them, the Hot-Spot effect is one of the major and most critical failure modes for PV modules.
We present a test station that enables the user to screen a high number of c-Si cells in dependence of string length in a very short time and very realistically way in terms of possible Hot-Spot failures. This approach provides an excellent statistics of cells from mass production.

Experimental Setup

The experimental setup requires first a sun-simulator of at least class C as a light source, second a specially constructed PV module that acts as a constant power source during the test and third, single cell samples made out of cells with different cell sorting parameters. Both sample and power source modules are kept at a temperature of about 50°C. The design of the source module allows the test expert to vary the maximal voltage depending on whether the product is attributed to 12, 16, 18, 20, 24 of 28 cells/bypass diode. The Hot-Spot test is performed following the procedure described in IEC 61215 ed.2 by varying the size of the shading tool. At critical high temperatures the test time has to be exceeded to more than 5 hours.

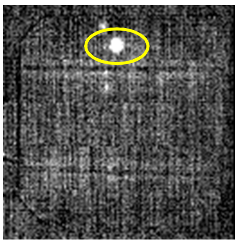




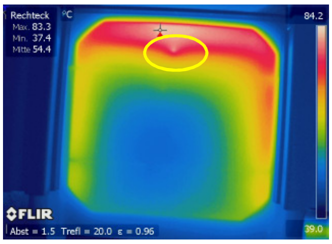
Experimental Results

The following sequence of images shows the cell temperature behaviour as a function on the number of serially connected cells. The black-white-picture of the cell-tester is a differential image with arbitrary units, indicating areas of high Hot-spot risk. The other images are taken with an infrared (IR) camera showing effective cell temperatures.

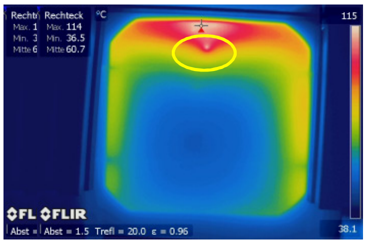
IR-cell-tester



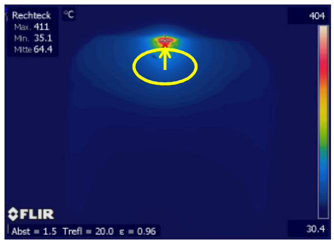
Cell in a 12cell-string
Tm= 84°C



Cell in a 20cell-string
Tm= 114°C



Cell in a 24cell-string
Tm= 411°C



By increasing the number of serially connected cells from 12 to 20 cells the temperature is increasing. Here the hottest spot in the IR pictures corresponds to the cell tester data. By crossing a certain voltage level (here at 24 cells with 0.6V from each cell), a new mechanism is getting active. This leads to a significant increase in temperature and a new hot spot mode arising at the cell edge. For that special cell (solar cells with damaged laser edge isolation) a maximum temperature of nearly 500°C was observed. These high temperatures lead to a full destruction of the laminate, but not of the cell as it can be seen in the EL-picture. Repeating this test with the same cell, pictures of 12 to 20 cell strings are reproducible, but not for 24 cells. Here the Hot-Spot moves to another region of the cell edge, dependent on the position of the shading tool.
The observed change in hot-spotting mechanism shows, that our test system allows the analysis of different Hot-Spot failures by varying the test conditions. This includes conventional Hot-Spot risks visible in the cell tester IR-images and, moreover, additional risks due to damaged edge isolation which are not visible there.

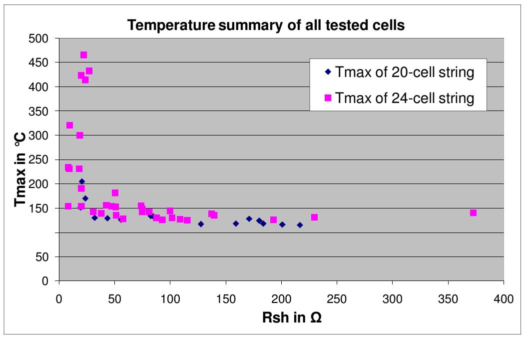
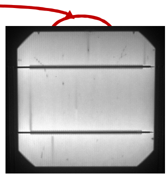


Photo after Hot-Spot Test with defective encapsulation



EL-picture after Hot-Spot Test

Conclusions

Using this setup it is easily possible to investigate and understand the influence of different Hot-Spot failure modes by means of critical temperatures, power dissipation and the size and position of a Hot-Spot.
The results also demonstrate that under more extreme test conditions additional Hot-Spot risks might appear which are difficult to detect in the cell tester IR-data before.

contact: b.jaeckel@q-cells.com