# Automated Extraction of Cell Parameters in a Fully Packaged Solar Module

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## Abstract

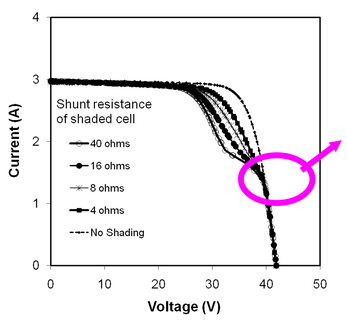
**A fully automated methodology is developed for the extraction of cell level parameters in a fully packaged solar module using a computer controlled partial shading screen. The shading screen uses smart window technology to selectively shade individual cells of a module, leaving all other cells clear for full illumination. Under illumination, the partially shaded cell becomes the current limiting cell in the string allowing performance parameters of the individual cell to be extracted from the current-voltage curves and differential impedance analysis of the module. The shunt resistance, short circuit current and peak power output of each cell is extracted from the IV curves in less than ten seconds / cell.**

## Purpose

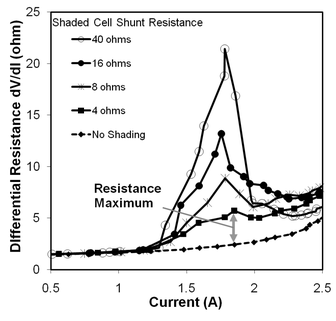
- **Identification of shunted or low performing cells in module**
- **Improved statistics on module after reliability / field testing**
- **Quantitative determination of variation in cell performance**

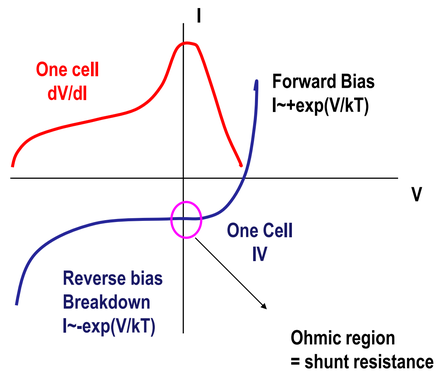
## Technique: Simulations of 50% shading of one cell

Shading cell = kink in IV




"Kink" ~ shunt R

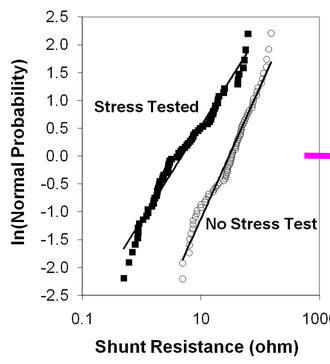



**Shunt resistance of shaded cell = (peak dV/dI) – (Module resistance)**

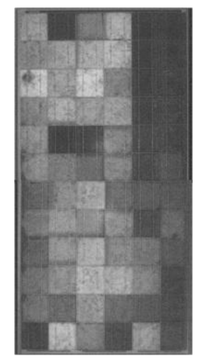
## Application to accelerated lifetime test

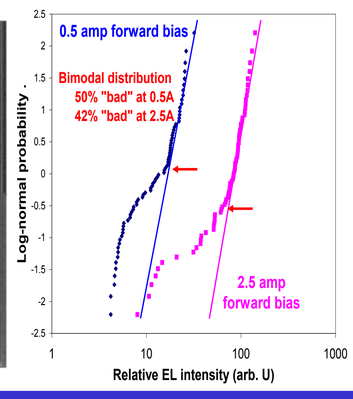
Module after 85% RH / 85°C / 600V




| | | | | | |
|---|---|---|---|---|---|
| 20 | 2.1 | 5.9 | 7.1 | 0.6 | 1.1 |
| 21 | 63 | 45 | 25 | 1.4 | 1.3 |
| 18 | 43 | 26 | 16 | 1.4 | 1.2 |
| 15 | 55 | 11 | 38 | 1.4 | 1.7 |
| 14 | 5.1 | 5.3 | 1.8 | 1.8 | 2.2 |
| 11 | 2.0 | 2.3 | 6.3 | 2.4 | 3.5 |
| 2.8 | 43 | 53 | 2.1 | 2.3 | 2.5 |
| 4.8 | 15 | 3.3 | 7.9 | 2.3 | 3.4 |
| 3.7 | 8.5 | 2.8 | 10 | 6.6 | 3.3 |
| 2.8 | 18 | 17 | 20 | 8.0 | 2.5 |
| 4.7 | 2.5 | 15.2 | 4.4 | 3.3 | 3.1 |
| 1.5 | 58 | 1.5 | 1.5 | 7.5 | 1.5 |

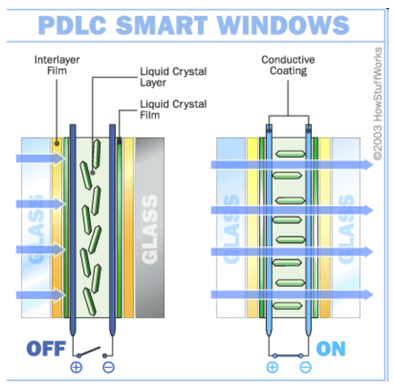
Electroluminesence

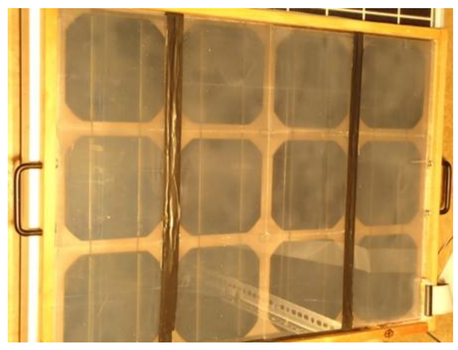


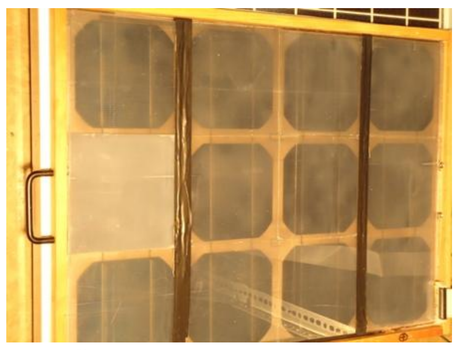


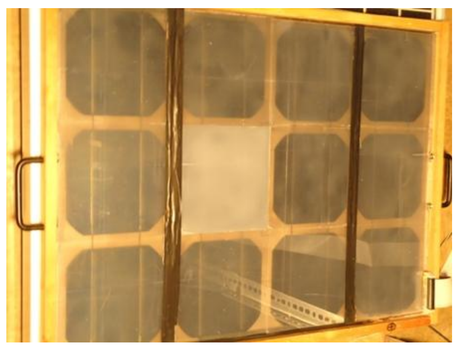

**Quantitative mapping of cell shunt resistance consistent with EL image**

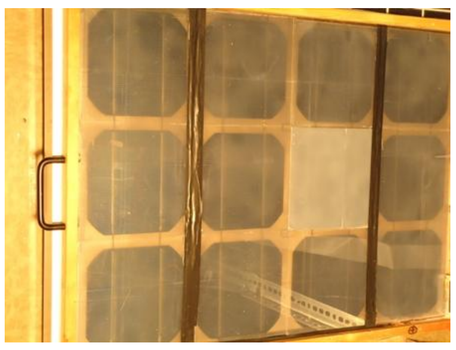
## Automation of process

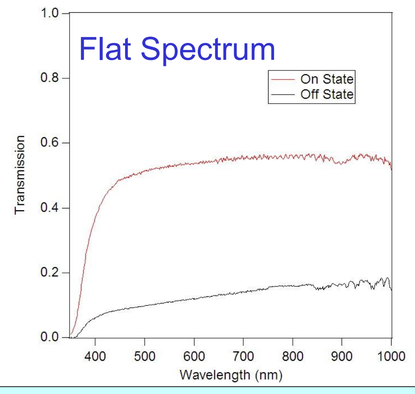


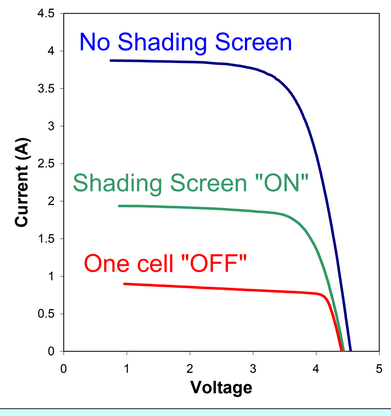



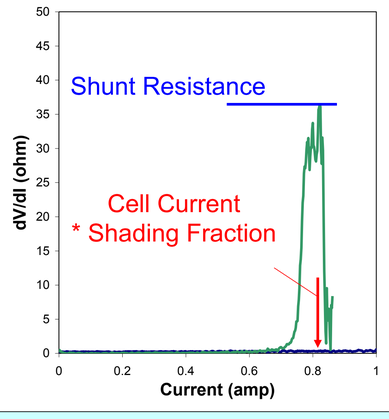


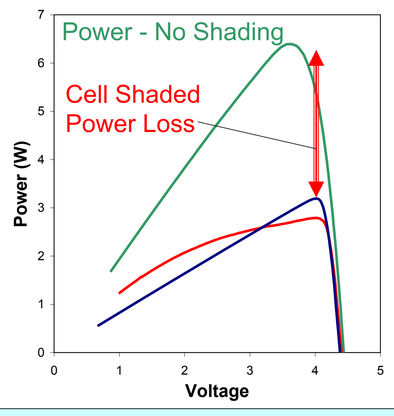


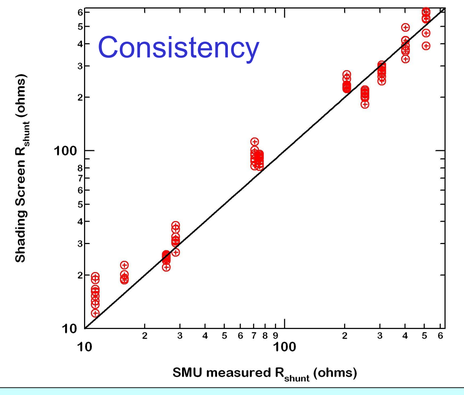




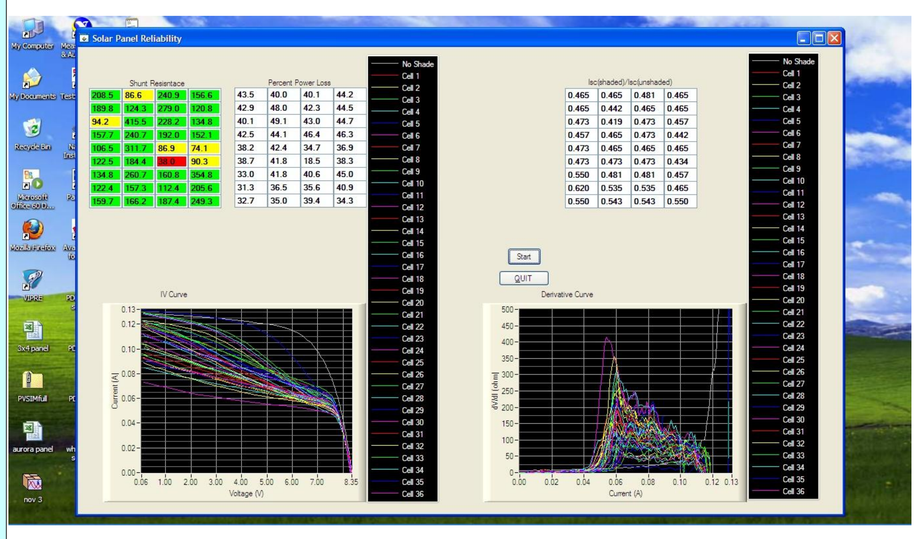



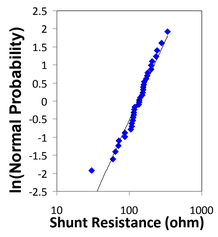



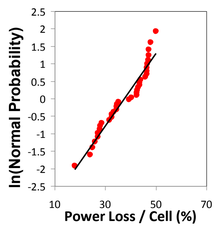



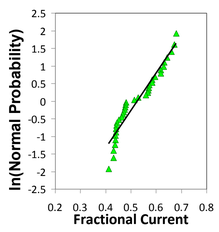

## Application to commercial 36 cell module

Shunt resistance
Screen layout: Power loss / cell
Short Circuit Current / cell




## Application to commercial 36 cell module

- **Automated shading screen for extraction of cell parameters**
- **External illumination**