PV Module Reliability Workshop – Standards
Proposed Test Protocols – New Tests:

Accelerated TC Test

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Task Statements 1/3

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< Thermal-Cycling Test >

No significant power loss is revealed in the increasing of cycle number up to 1,500. Therefore, we do not require the increasing of cycle number in TC test.

- Options:
Instead of the increasing of cycle number, we would like to propose to raise the upper level of the temperature to accelerate the degradation.

We think that the damp heat (DH) or humidity freeze (HF) test prior to the TC test is significant. For this sequential testing, we will have joint meetings with domestic Task Group-3 and Task Group-5.

Targets

- Time Saving : TC200 + alpha

- Effective stress(es) to induce the degradation of PV modules, which closely-associated with the thermal fatigue

- For the deteriorations by thermal fatigue, the highly accelerated test-procedure should be proposed for the rating of PV modules.

Accelerated TC Test [INITIAL PROPOSAL]

A1*: Damp Heat
(500 or 1,000 h)

(*A1 and B1 are options)

B1*: Humidity Freeze
(10 cycles)

Thermal Cycle (A2 / B2)

1. Cycling Profile (A2/B2 : not determined so far)

A2) Thermal Cycling with High Temp.:
- -40 / 95 °C or -40 / 100 °C
- 100 °C/h
- 200 cycles
- max. 6 h/cycle (dwell : > 10 min)

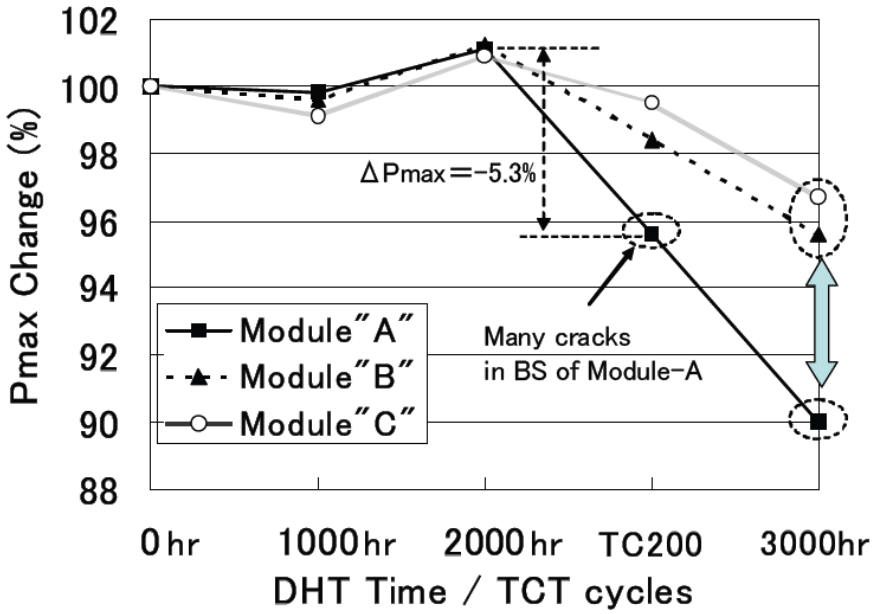
B2) Rapid Thermal Cycling:
- -40/85 °C
- ca. 400 °C/h
- max. 600 cycles
- 2 h/cycle (dwell: >ca. 15 min)

2. Measurements
- Visual Inspection (IEC 61215 -10. 1)
- Power Loss (IEC 61215 -10. 2)
- Insulation (IEC 61215 -10. 3)
- WLCT (IEC 61215 -10.15)
- EL Imaging to quantify the cell-crack
- IR imaging to detect the compensating heat interconnectors with the interconnector-failures
- *In situ* Impedance Monitoring

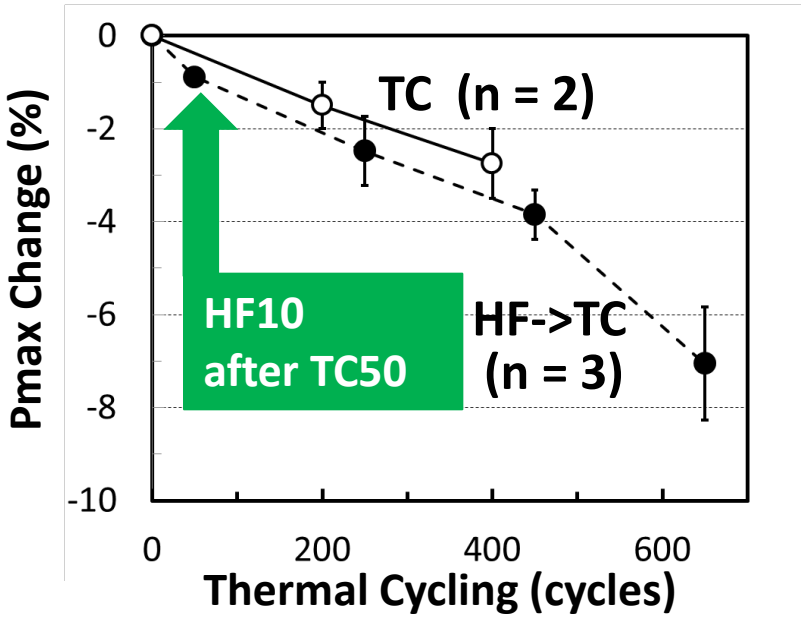
APPENDIX

Effect of Humidity-Stress prior to Thermal-Cycling

DH -> TC*



HF -> TC**



DH -> TC: Pretreatment with DH induced the variance of power-loss with TC.

HF -> TC: It seems that the pretreatment with HF (Humidity Freeze) likely to change the degradation rate during TC.

These effects should be faithfully confirmed in the various types of PV modules.

*Arai, T. et al., "Observing Mini PV Module Deterioration Through Successive Damp Heat Testing and Thermal Cycle Testing Procedure", 21st PVSEC, 2011, Fukuoka, Japan.

** "Research Report of the Consortium Study on Fabrication and Characterization of Solar Modules with Long life and High Reliability (AIST, Japan)", 2011.

Elevation of Upper-level Temp. in Thermal Cycling

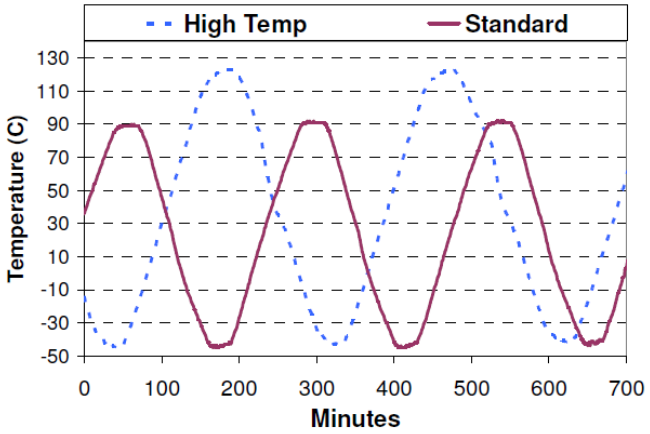


Figure 5: Thermal cycling profiles
High Temp Profile: -40 to 125°C
Standard Profile: -40 to 90°C (UL Thermal Cycling test)

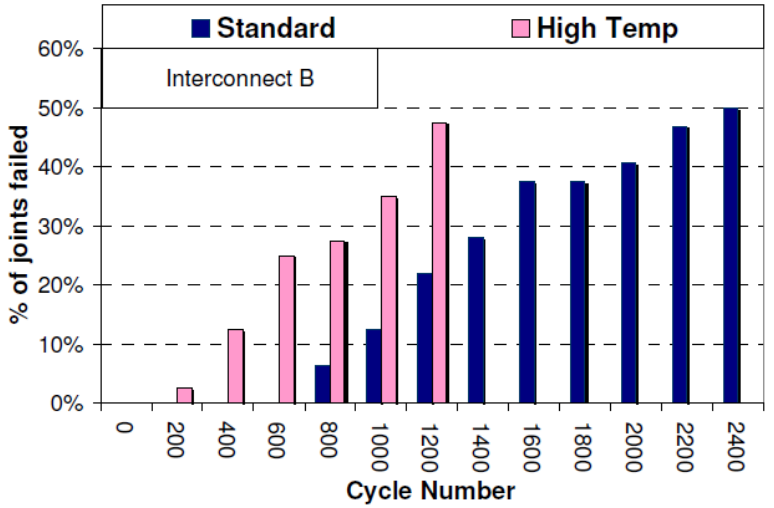


Figure 7: Joints failed with interconnect B

By the raising of upper level of temperature in TC (125°C), the acceleration of degradation concerned with thermal fatigue was observed in the test vehicle (Back contact type).

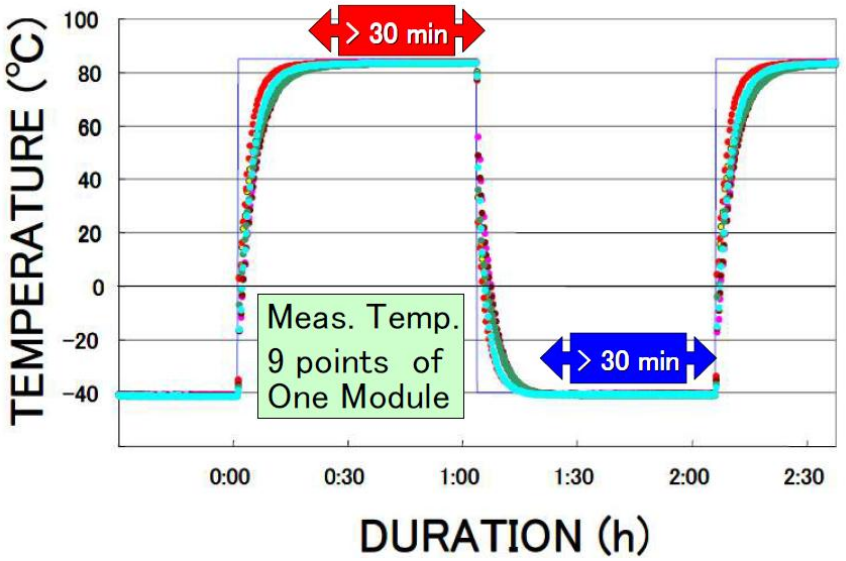
It would be crucial to higher the temperature to save the testing-period, but it is difficult because the components of PV modules (including Junction Box and Cable) have a limit at ca. 100°C.

Then, we are planning the thermal cycling test with 95-100°C as upper temp.

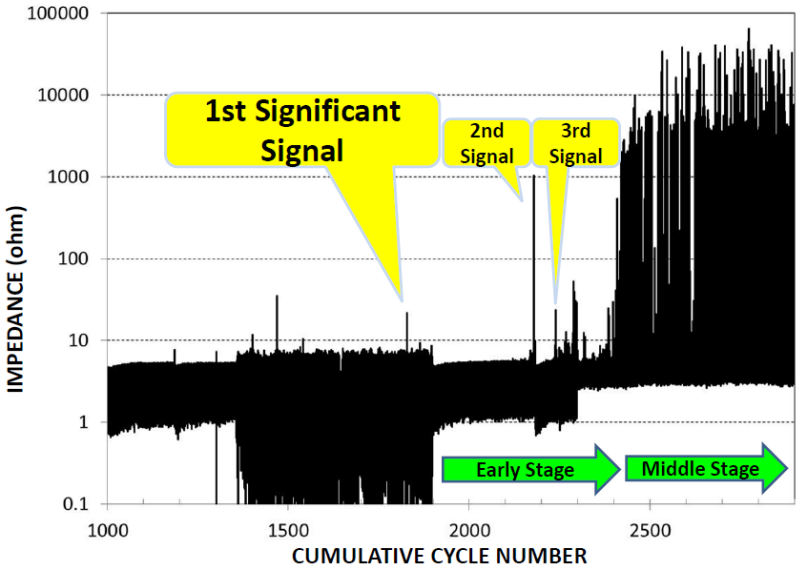
Meydbray, Y. et al., "Solder Joint degradation in High Efficiency All Back Contact Solar Cells", 22nd European PVSEC, 2007, Milano, Italy.

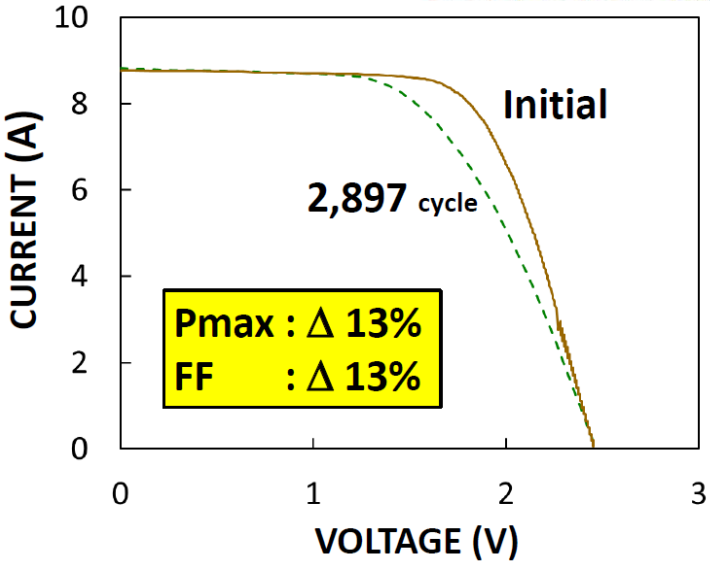
Rapid Thermal-Cycling with *in situ* Impedance Meas.

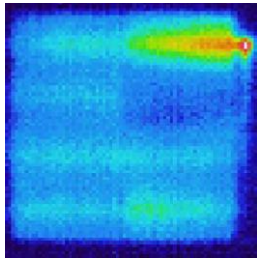
Temperature on Module Surface during Rapid TC



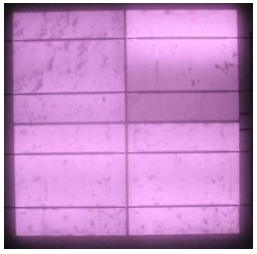
Impedance Elevation during Rapid TC







IR Imaging



EL Imaging

The rapid thermal-cycling with *in-situ* monitoring of module-impedance may be a useful procedure for the early detection of inter-connection failures.

Tanahashi, T. "Photovoltaic Module Reliability Testing: 400°C/hr", 2012 PV Module Reliability Workshop