Current status of TG5 region Japan

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Present approach and activities

1. Collect field failures in Japan, especially sharing efforts of projects led by AIST
2. Pick up field failures focusing on stresses of UV, temperature, humidity
3. Decide failure mode to be discussed considering features of Japanese industry
   Japan has long-term experiences and experienced module and material manufacturers.
4. Categorize the target failure mode.
5. Find indicator which reflects stress level suffered in a PV module.
   (Example: acetic acid, YI for encapsulant, electric performances, not YI for BS…)
6. Come up with appropriate accelerated test for each category.

We had a face to face meeting once a month from this May, jointly with TG3 JP.

As the third step, we decided that delamination was first target failure, taking account of other region’s progresses.
In addition, we attempted to categorize delamination failure in field.

Delamination

Definition of “delamination” :

Delamination is an interface with adhesion strength of completely zero [N]. There is (air-)gap (cavity) at the portion. A void and a cluster of voids are included in delamination failure.

Probable causes :

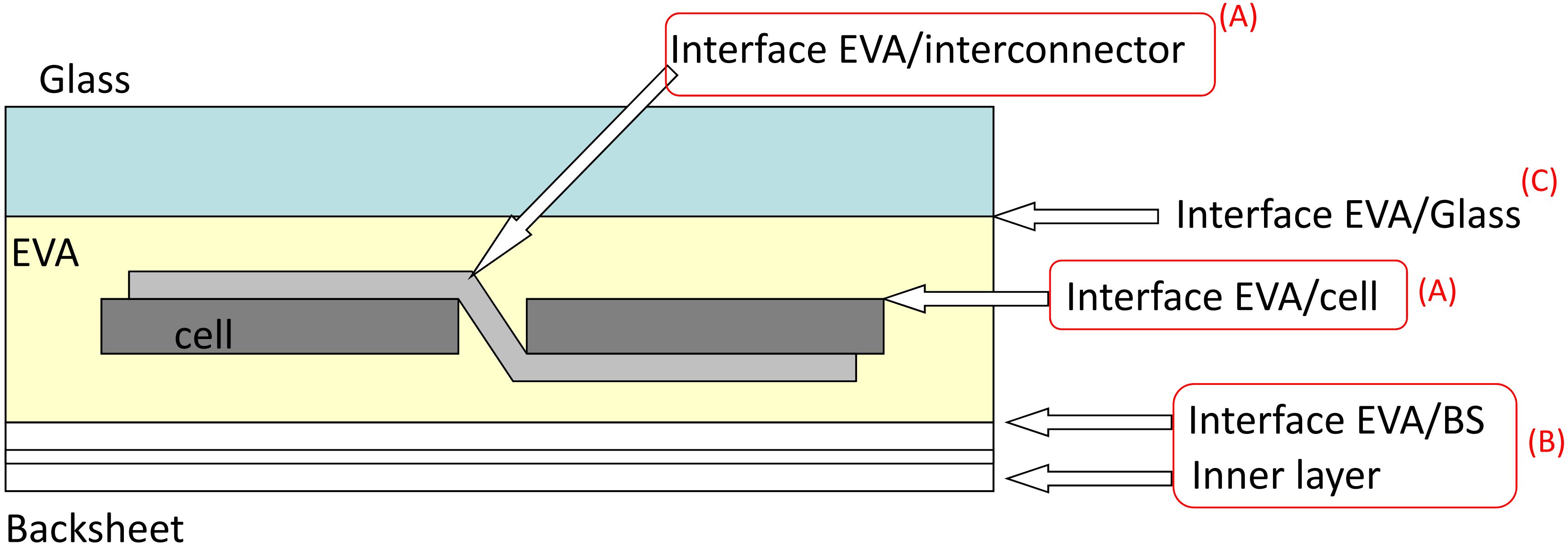
Delamination is due to weaken adhesion strength, mechanical stress, and gases from polymers. Probable causes for each component material are as follow;

Cell : AR coating in front of cell : ex) TiOx
Interconnector : flux (type and amount)
Encapsulant : Missing coupling primer, Degradation of coupling primer due to storage with bad environment and expiration, Large amount of additives
Backsheet : adhesion agent of inner-layer of backsheet / fabrication process?
Lamination process : not enough heat supply to activate coupling primer and soften encapsulant, remaining voids : due to not appropriate lamination condition

Delamination

Which interface did we see delamination failure in field aged PV modules?

We attempt to categorize delamination based on an interface it happened.

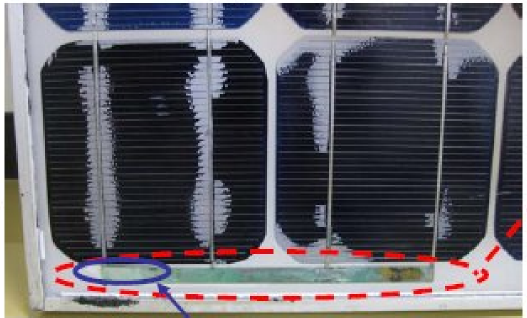


(A)

2013.02.26 Mitsui Chemicals

3.4 Other failures -Corrosion-

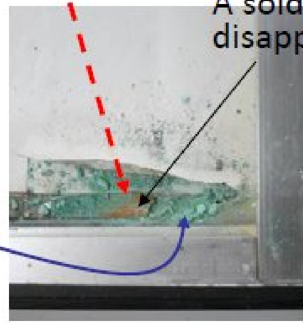
closeup picture



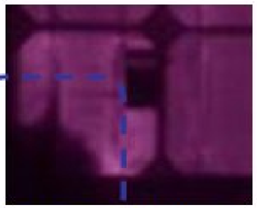
Patina

Severe degradation of copper

A solder layer disappeared.



A part of Copper ribbon disappeared.
= No electrical conduction



EL image

Backsheet/EVA were cut at the bus-bar portion.
We observed the corroded bus-bar.

✓Adhesion strength among inner layers of the backsheet "TAT" was extremely low.

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T. Shioda, NREL PVMRW 2013, Feb 2013.

(A), (B)

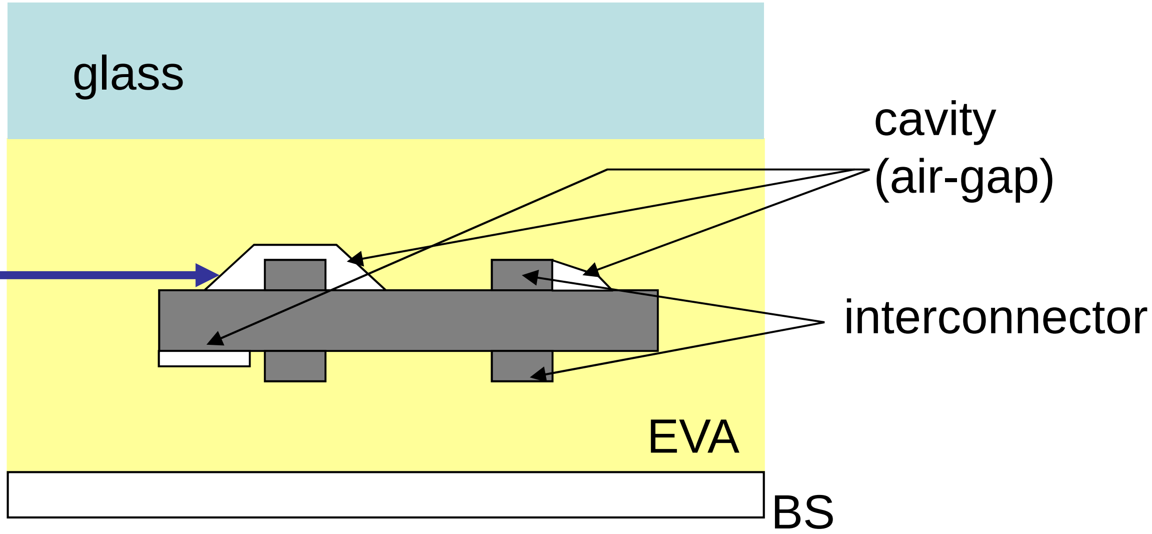
Japan 2013

A 20y-field-aged PV module with delamination failure and induced corrosion

Delamination at inner-layer or inter-layer of backsheet and penetration of water into front side of cell

Category (A) Delamination at interface between EVA and cell / interconnector

Is there a "pass" for liquid water penetration? or isolated?

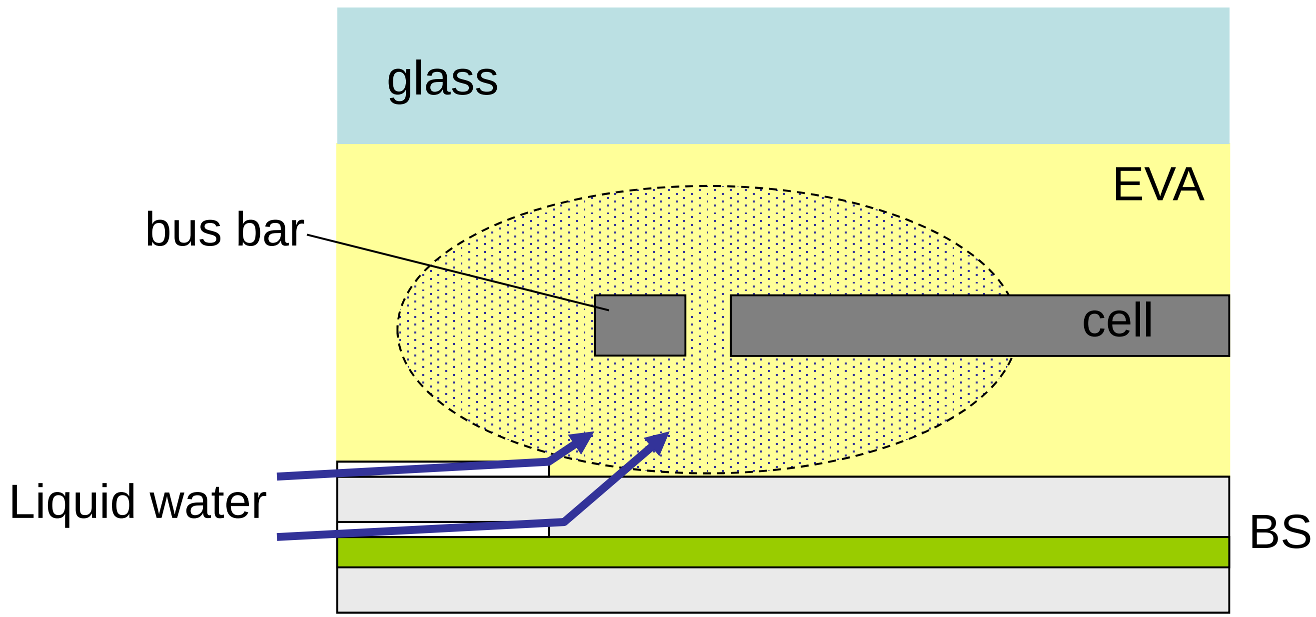


This is considered to be **isolated** from liquid water penetration.

There is a pass for liquid water penetration.

Higher severity
High priority

Category (B) Delamination at interface of inner-layer of BS / BS and EVA



Liquid water induces corrosion and delamination which leads to corrosion.

Thus we will focus on delamination failure which leads to corrosion, in terms of severity.

This failure is typically observed at corners of a PV module and lower side for deployment in field.

Adhesion of the interface between inner layers and BS/EVA would be important.

New test, such as dipping hot water, may be necessary for duplicate this delamination, instead of or after typical chamber tests such as UV, DH, TC and these sequence… We need some ideas and data. Of course, we still collect field failure information concerning delamination.

Tentative Timeframe of TG5 JP

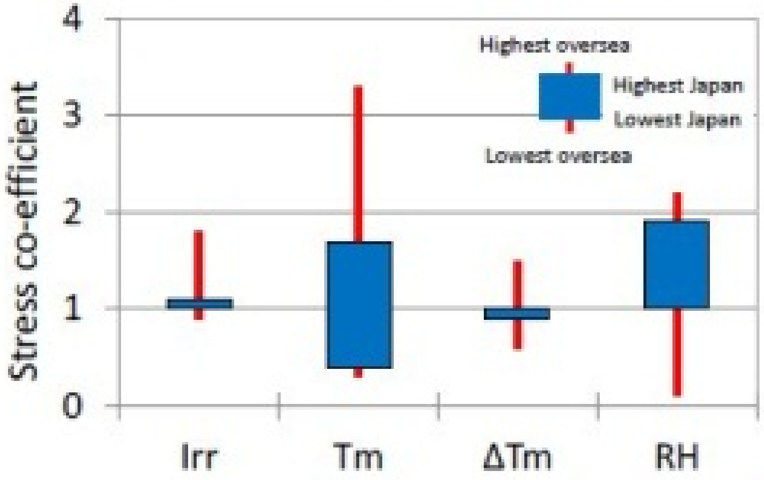
Current status	2014 goal	2015 goal
Confirmation of climate of Japan köppen climate classification Report by Kato of JET	Correct field data in Japan	
Failure modes focused Delamination / Cracks	Analysis of field aged PV modules	
Find Indicators	Insulation ?	Pass/fail criteria
Accelerated test 4 cell mini module combined test (ex) UV+DH+TC)	Accelerated test with a mini module	Determination of test condition and procedures

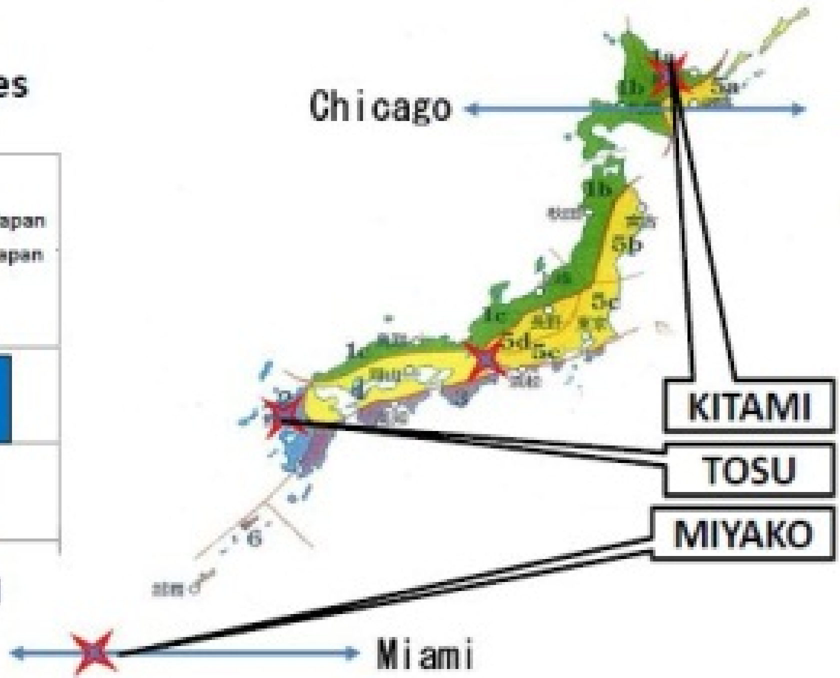
3. OUT-DOOR EXPOSURE TESTS FOR THE DEGRADATION EVENTS (1) PV SITES

Comparison with stress factors at three sites

	UVB	T_m	ΔT_m	Relative Humidity
KITAMI	0.9	0.4	0.9	1.6
TOSU	1.0	1.0	1.0	1.0
MIYAKO	1.2	1.7	1.0	1.9

Comparison of stress factor with overseas cities and three typical sites





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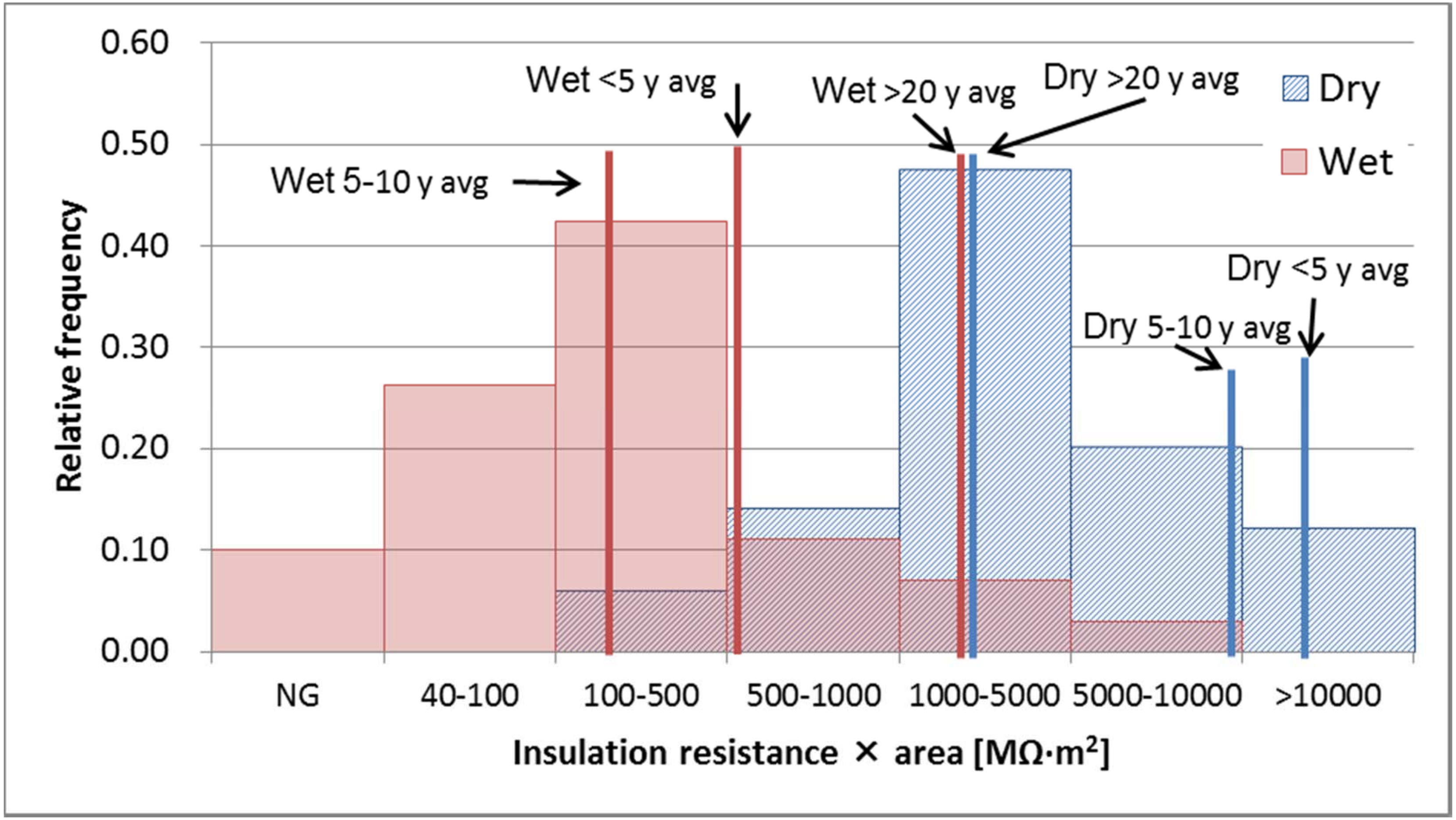
H. Kato, 4th International QA forum in Kyoto Oct. 2013

Histogram of insulation performances of field-aged PV modules with no visible failure modes (delamination, cracks) and deployed in Japan



Applied bias voltage was 500V for both measurements.
Total number of evaluated modules are roughly 100.

Combined test of UV, DH, TC for 4 cell mini modules

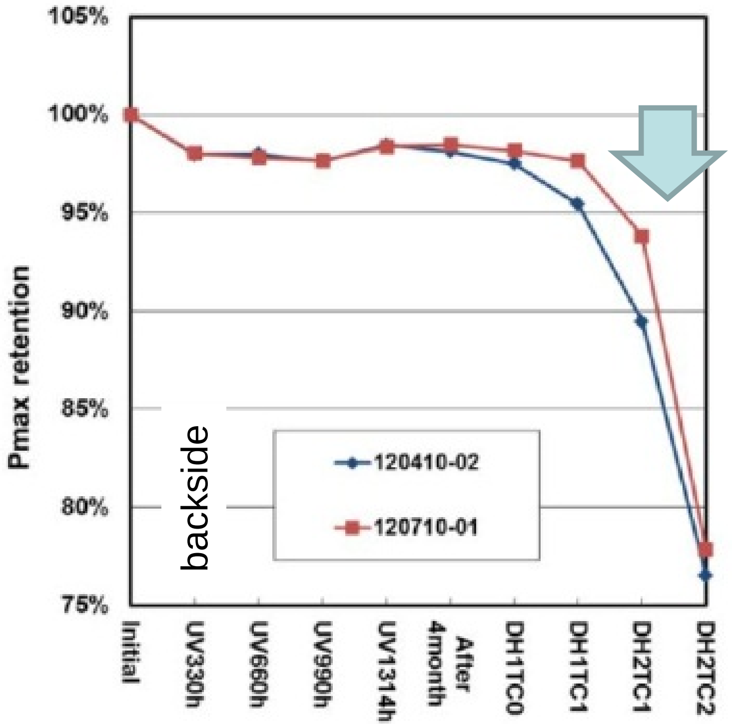
UV irradiation : 90W/m^2 @ 300-400nm
Chamber temperature : 65 ^{O}C
correspond to around 90 ^{O}C of backside module temperature

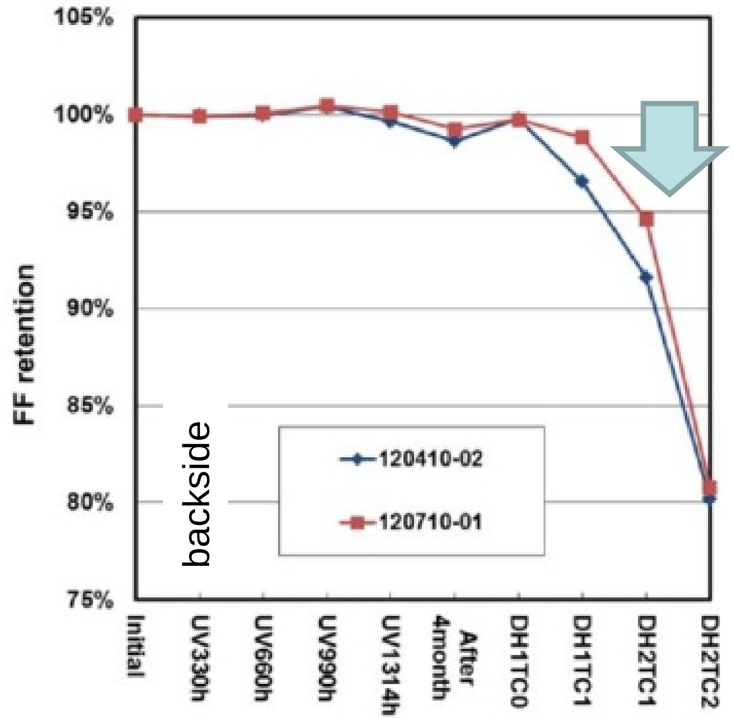
After UV irradiation, 2 cycles of DH500 and then TC100 had been done.

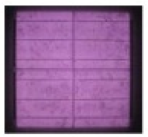
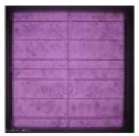
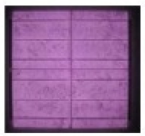
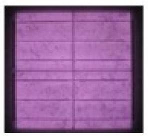
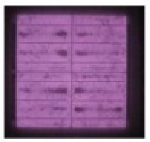
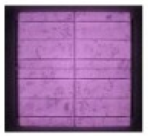
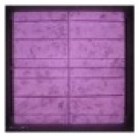
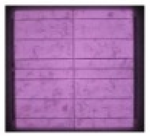
Termination of PV cables of 4 cell mini PV module
During UV irradiation : open
UV irradiation had been done for 984hr for front side and 330hr for backside
During DH test : short
During TC test : short

Monitoring performances of PV modules during these tests
IV curve (Pmax, FF, Isc, Voc)
EL image
Insulation (wet / dry) at bias of 500V
Appearance (Delamination, crack of backsheet, etc)

After 2nd DH500, TC100, Pmax, FF was dramatically reduced.





ID	Initial	UV990h	UV1314h	DH1TC0	DH1TC1	DH2TC1
120410-02						
120710-01						

120410-02 UV+DH+TC

Insulation performances of tested modules were still high.

Insulation test

	dry				wet	
	Leakage current [μA]	Pass	Insulation resistance [GΩ]	Pass	Wet leakage [GΩ]	Pass
Initial	0	○	>99.9	○	4.54	○
UV330h (backside)	0	○	15	○	0.833	○
UV660h	0	○	75	○	1.05	○
UV990h	0	○	>99.9	○	4.29	○
UV1314h	0	○	>99.9	○	5.22	○
DH1TC0	2	○	2.38	○	1.13	○
DH1TC1	0	○	>99.9	○	1.14	○
UV1814h/DH2TC1	0	○	>99.9	○	1.24	○
UV2314h/DH2TC2	0	○	>99.9	○	1.61	○