4th Atlas/NIST Workshop on Photovoltaic Materials Durability
December 5 – 6
Session 4

Short-term and long-term field experiences in Japan in terms of PV encapsulant

December 6th 2017

Tsuyoshi Shioda
Mitsui Chemicals, Inc.

Mitsui Chemicals' contribution to healthy PV market

Mitsui Chemicals

Analyze aged PV modules
Develop accelerated test

2009~2013

Shared at workshops on 2011 and 2013

↓

Know PV modules installed in PV plants

2014~

launch services business
warning as needed

Shared at last workshop on 2015

↓

Understand what happens in PV plants under operation

2016~

through services

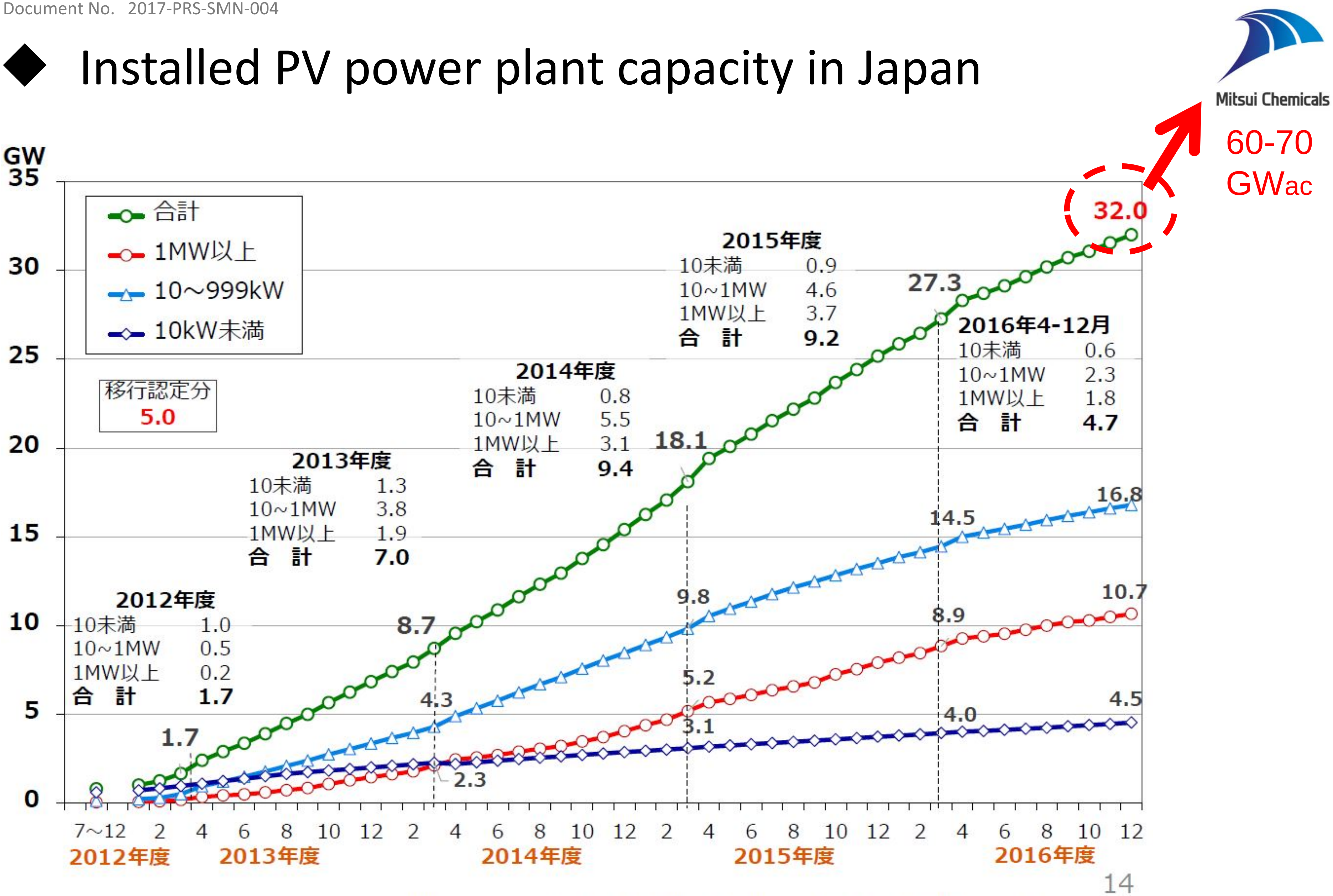
↓

Feedback to accelerated test conditions accordingly

Outline

1. Mitsui Chemicals' adviser services for PV project
2. Actual examples of Findings of PV modules in Japan
3. Short-term and long-term field experiences in terms of PV encapsulant
4. Summary

◆ Installed PV power plant capacity in Japan



出典：METI　HP「なっとく再生可能エネルギー」設備導入状況資料　JPEA作成

1. Mitsui Chemicals' adviser services for PV project

Since 2014

Mitsui Chemicals

Project Phases

Planning → Construction → Commissioning → Operation → Secondary -Transaction-

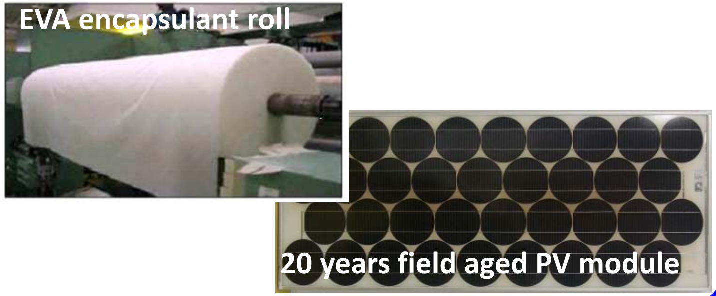
Service Menu

	One- Stop Solution		Best Practice	Technical Due Diligence
PV Modules	• Quality Assurance • Factory Visit • Acceptance Inspection for Module Installation		IR/EL Analysis (on-site)	Yield Assessment for the remaining period of FIT based on: • Yield Performance • Plant Inspection • Evaluation of O&M Performance/costs
For Power Plant	• Yield Assessment • Design Evaluation • Contract Review • Compliance Check with laws and Regulations	Plant Construction Site • Supervision During Construction • Inspection Upon Work Completion	• Plant Inspection • Periodical Yield Performance Assessment • Evaluation of O&M Performance	

Mitsui Chemicals Expertise in PV Industry

Manufacturer of PV encapsulant

- <Subsidiary> Manufacturer and global supplier of competitive encapsulant sheets for over 25years,
- 20 years of degradation study of PV modules and encapsulants.



Investor/Owner of PV plants

- Possess and manage several PV plants in Japan,
- Continuous improvement of technical skills and knowledge by studying various data and records from several plants including possessed plants.

Experiences worldwide through PI

- Part of our solid field inspection and laboratory testing is derived from expertise of an accredited lab, PI Berlin.

Outline

1. Mitsui Chemicals' adviser services for PV project
2. Actual Findings of PV modules in Japan
3. Short-term and long-term field experiences in terms of PV encapsulant
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2. Actual findings of PV modules in Japan

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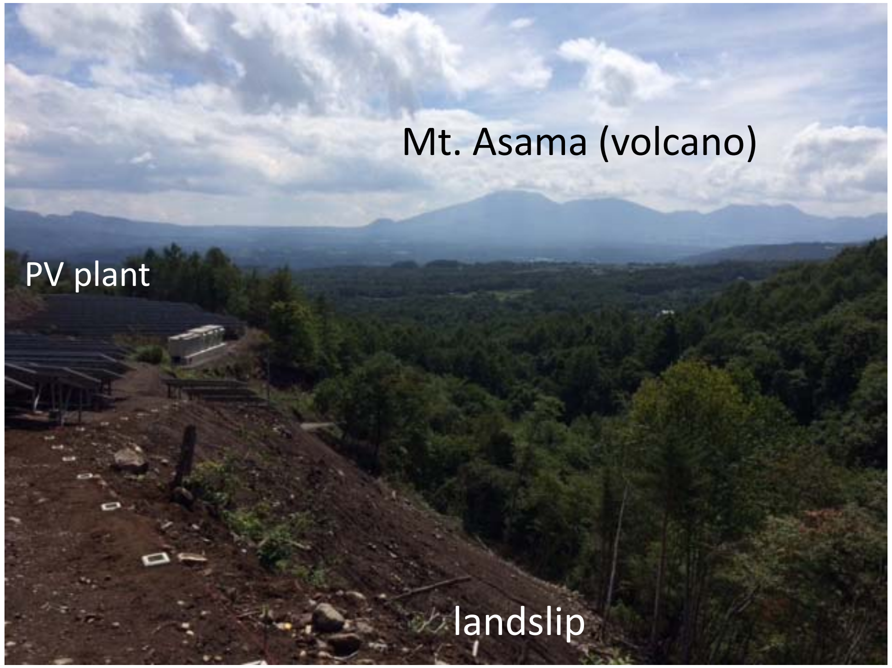
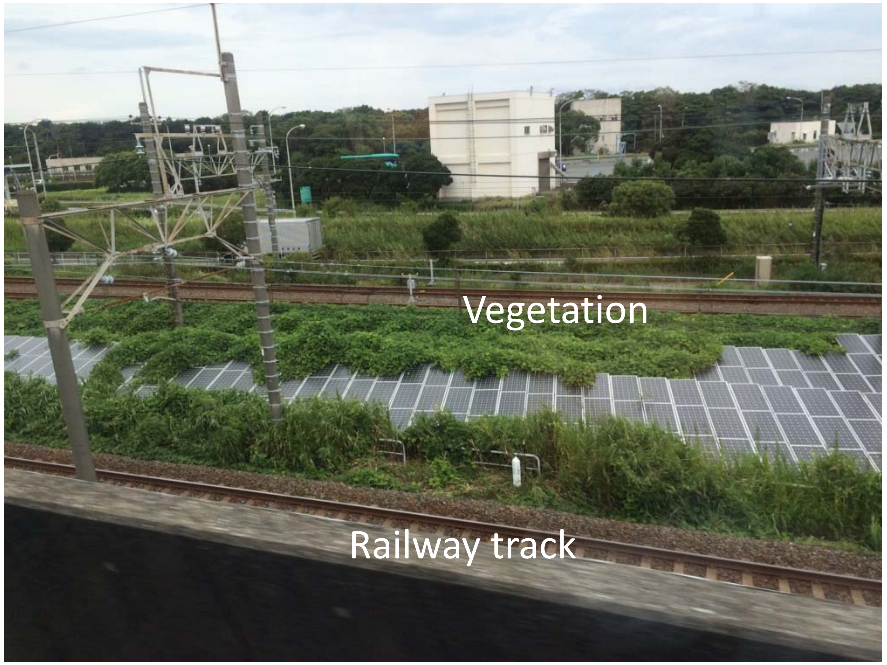
Let's see some photos of PV plants taken in Japan.





◆ Failures related to solder bonding

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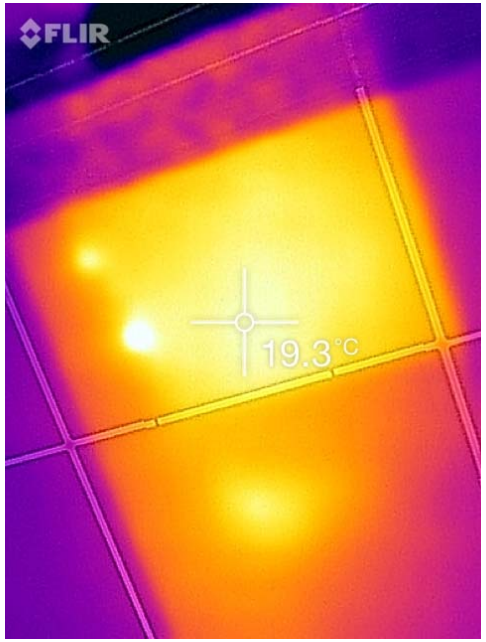
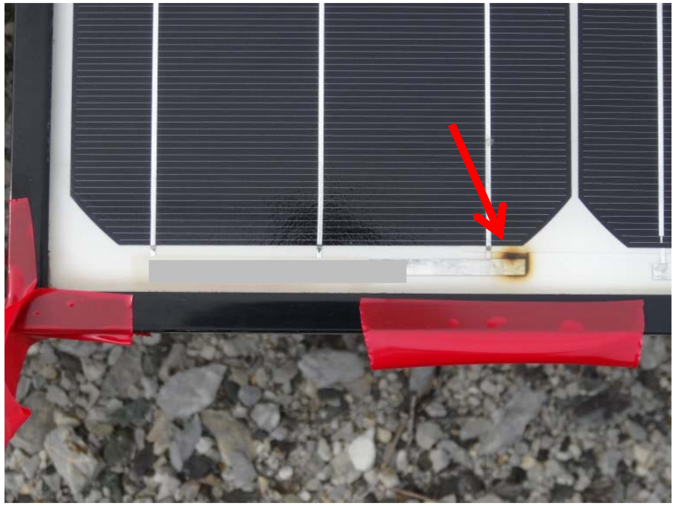
cell string



~2y operation

busbar



◆ Failures related to encapsulant

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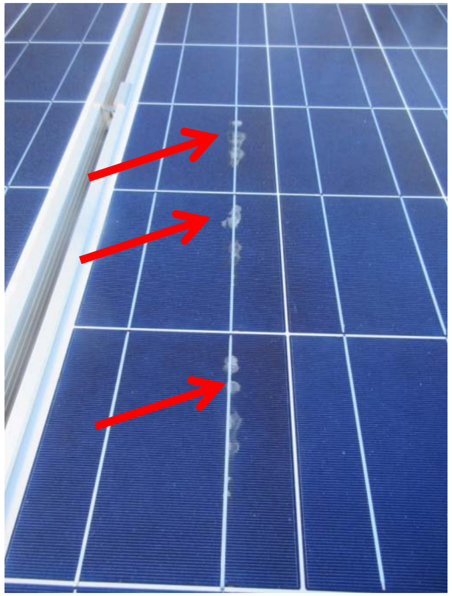
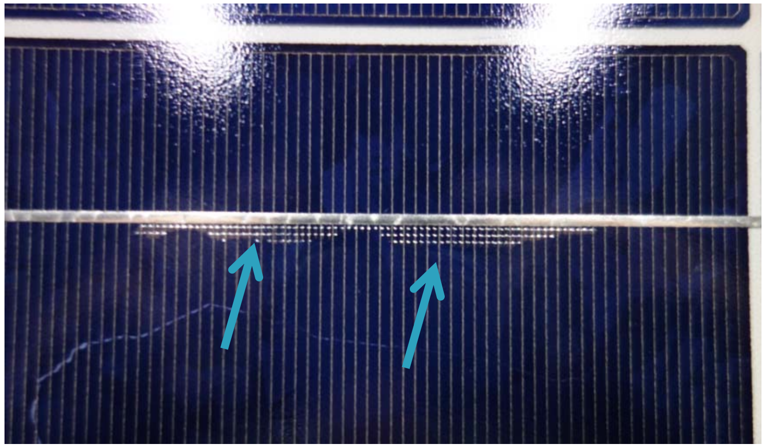
delamination

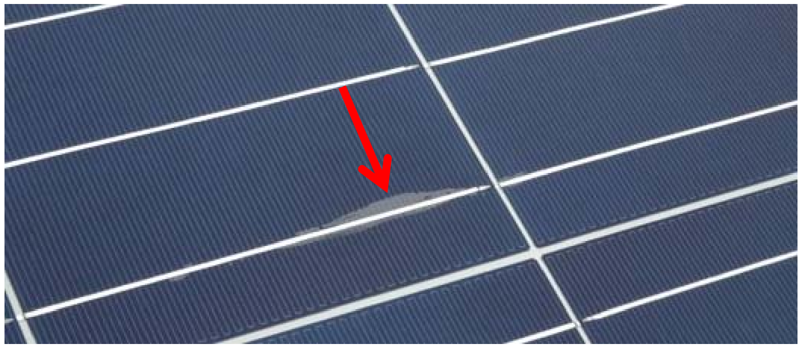




glass

during storage (~1y) in our temperature controlled warehouse

interconnector



~2y operation

edge of module

◆ Others

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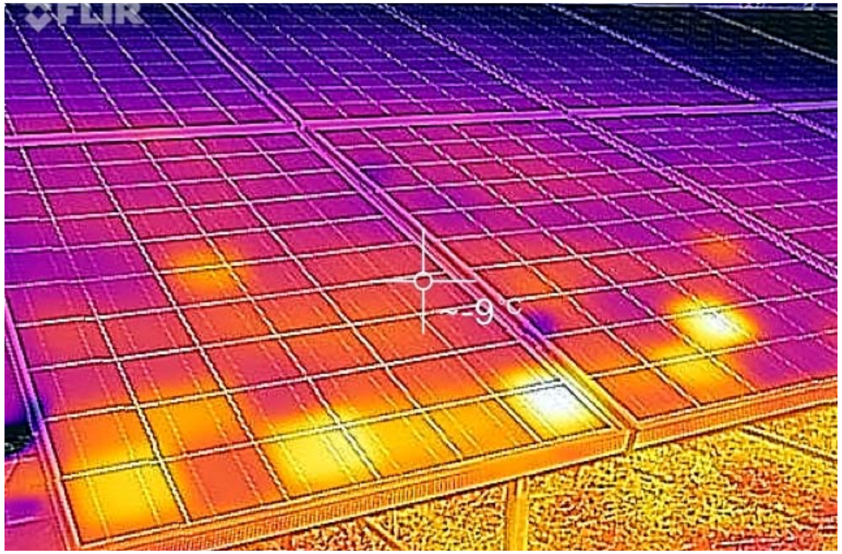
Broken glass and corrosion

PID?



~2y operation

Snail trail and delamination

~2y operation

◆ Summary of findings observed in Japan

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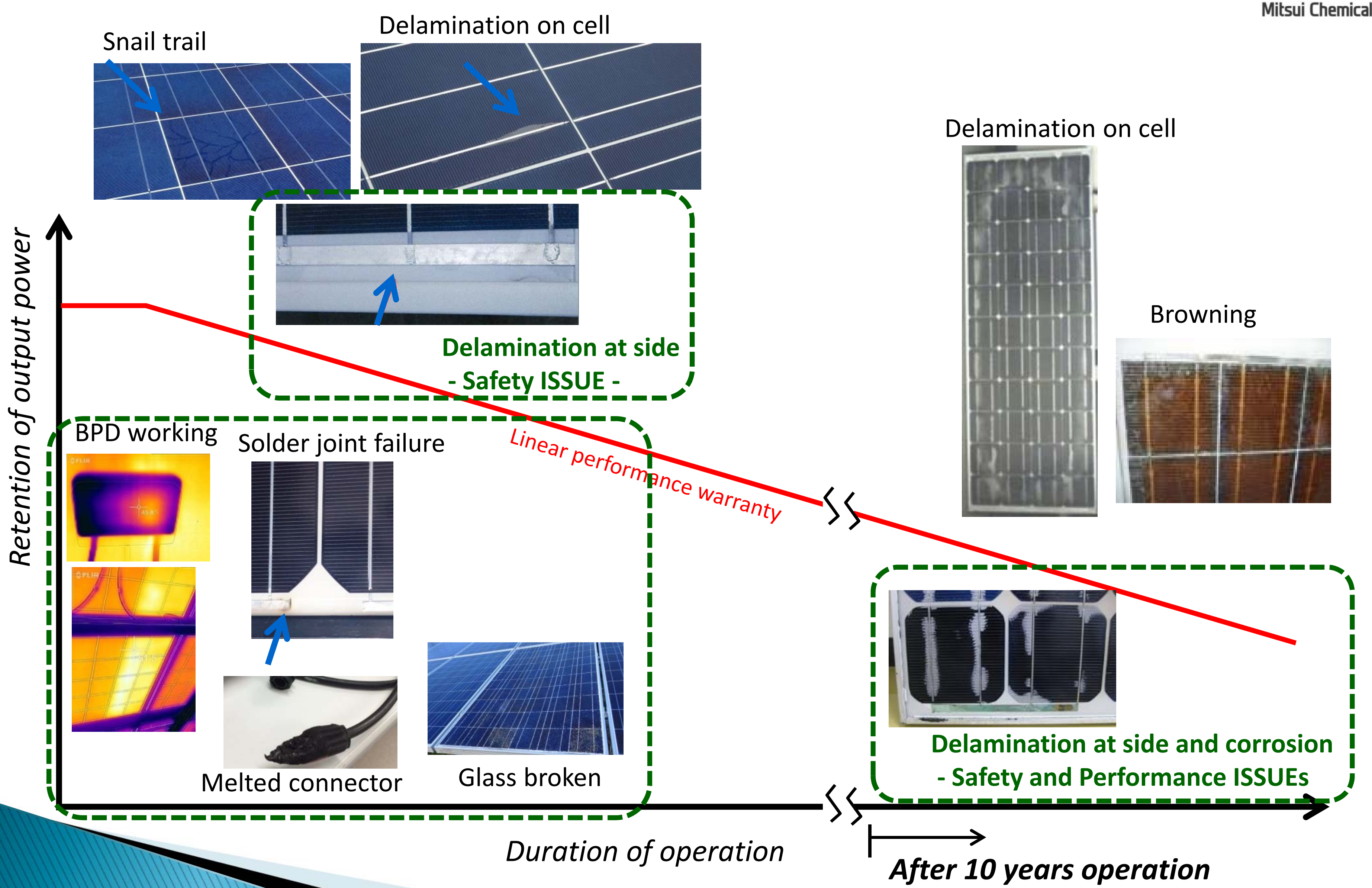

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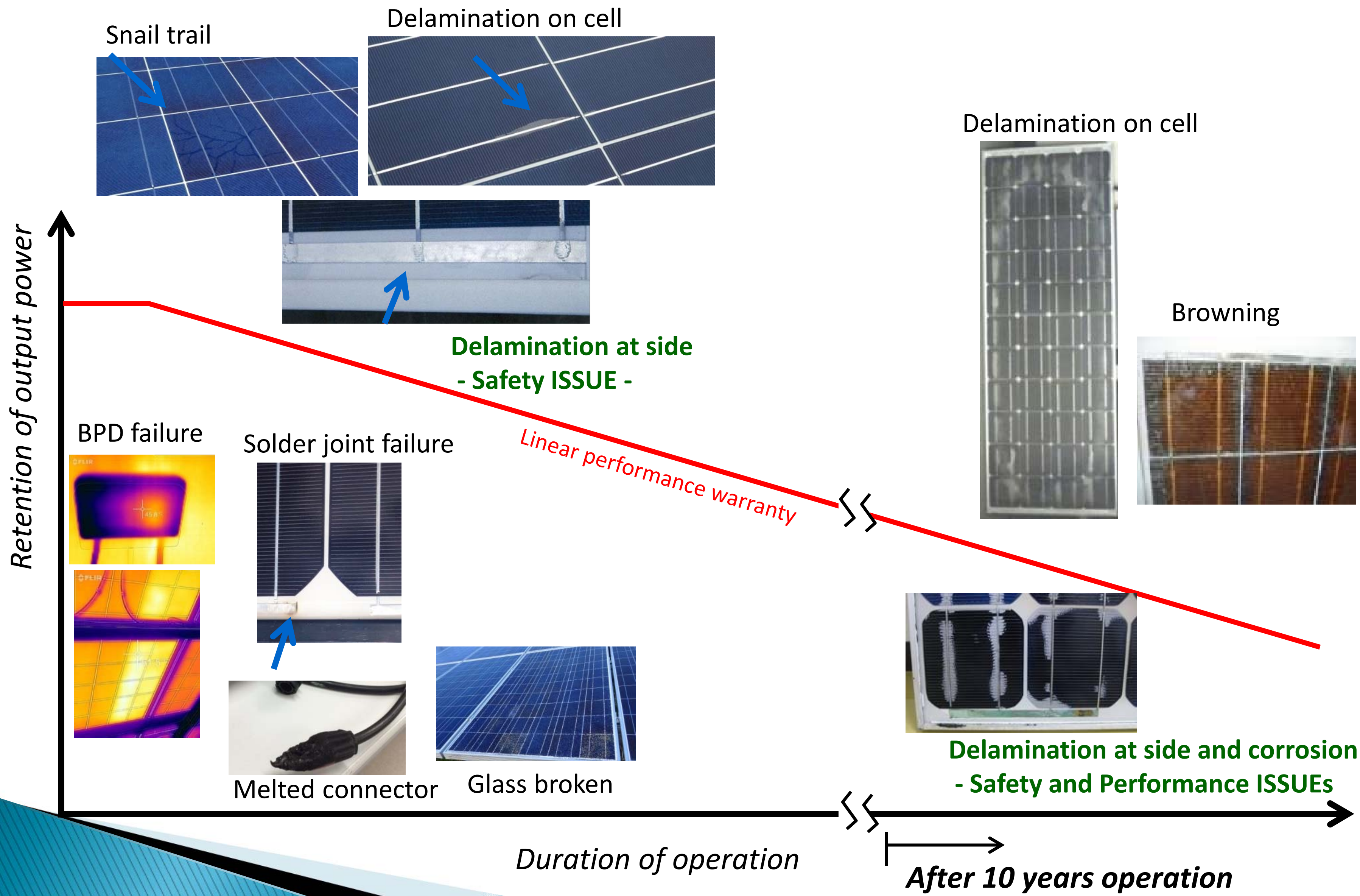
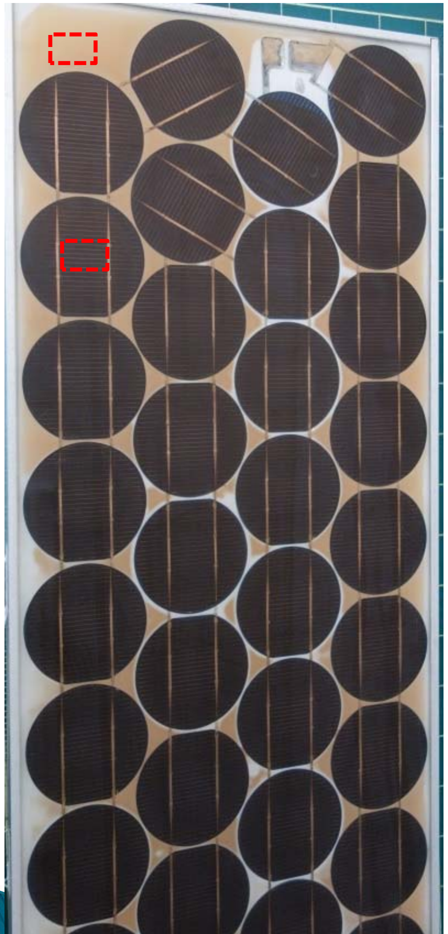
◆ Summary of findings observed in Japan

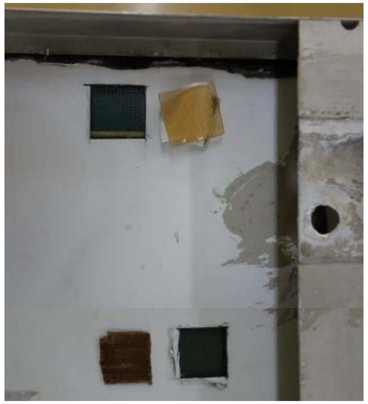


RISK	Failure	Probable cause -phase-	Severity	Frequency in Japan
Lower energy yield	Delamination on solar cell	Manufacturing	low	Medium
	browning	Design of EVA encapsulant	low	High (Aged) Low (recently)
	Snail trail	Manufacturing Shipping Installing	low	Medium
	Failed solder joint	Manufacturing	High	Low (Specific type / manufacturer)
	Broken glass	in operation	High	High
	Failed bypass diode	Manufacturing	High	Medium
	Melted connecter	Installing	High	Low
Safety Electric shock, firing, stopping inverter, etc.	Delamination at side and corrosion	Manufacturing	High	Low (Specific type / manufacturer)
	Scratch of backsheet	Installing	Medium	High
	Failed solder joint	Manufacturing	High	Low (Specific type / manufacturer)
	Broken glass	in operation	High	High (Some case: long time deployed)
	Melted connecter	Installing	High	Low

◆ Browning – cross sectional view

17 years field aged PV module





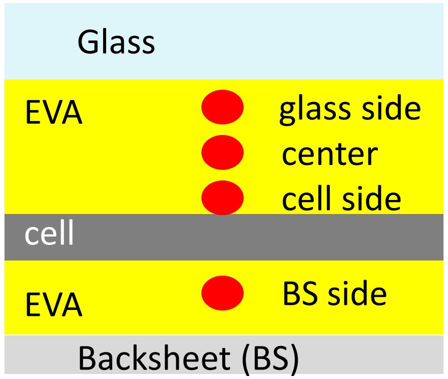
T-peel strength to glass or backsheet was low. It would be around 1~5N/cm (initial ~15N/cm).

There are no delamination failures.

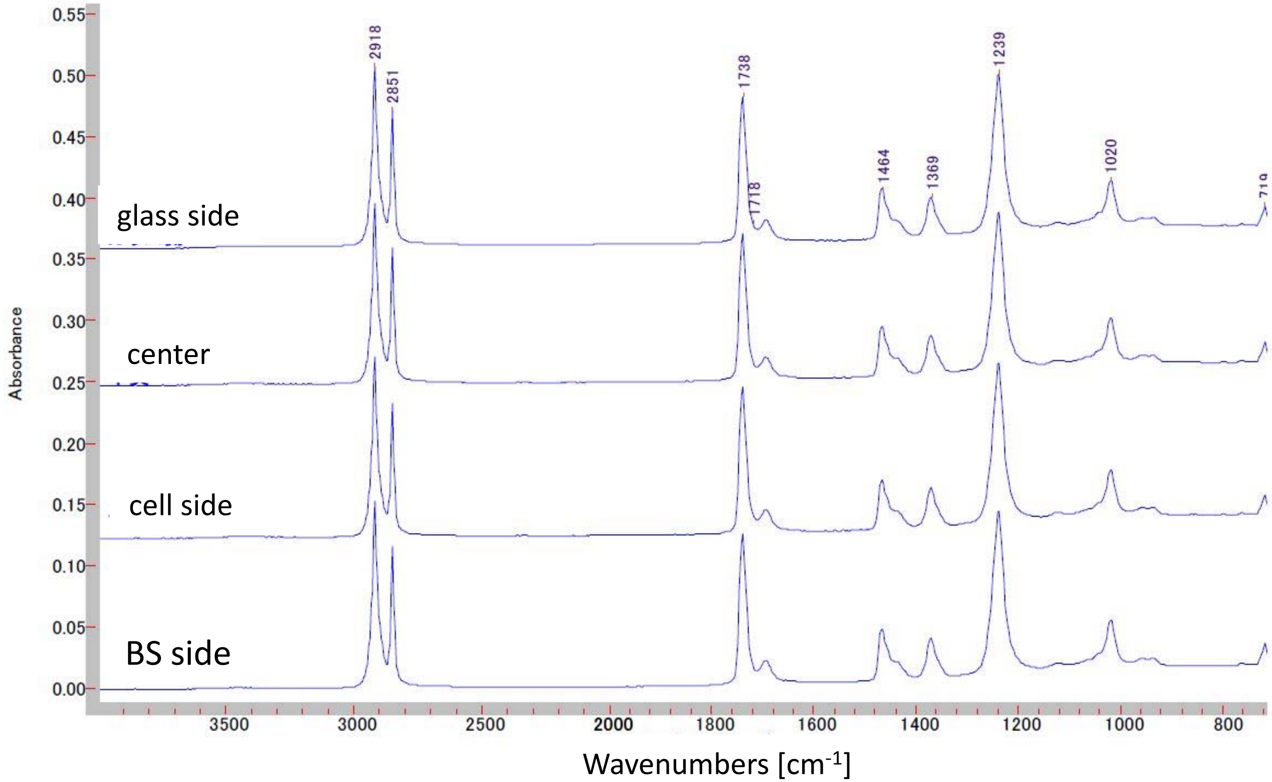
Browning led by additive degradation has been happened at a thin layer of EVA.

◆ Chemical change of EVA – cross sectional view

Measurement points
in cross section



IR Spectra of field aged EVA – microscopic FT-IR/ATR



There were no differences in IR spectra of EVA in thickness direction.

◆ Chemical change of EVA – cross sectional view

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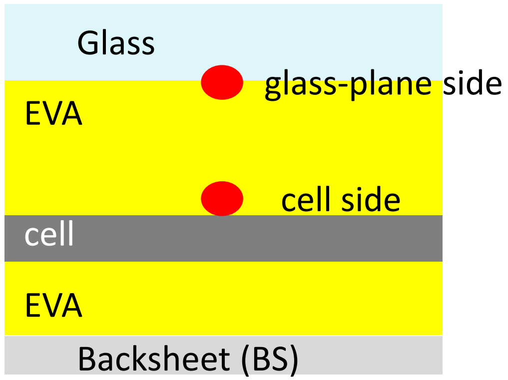
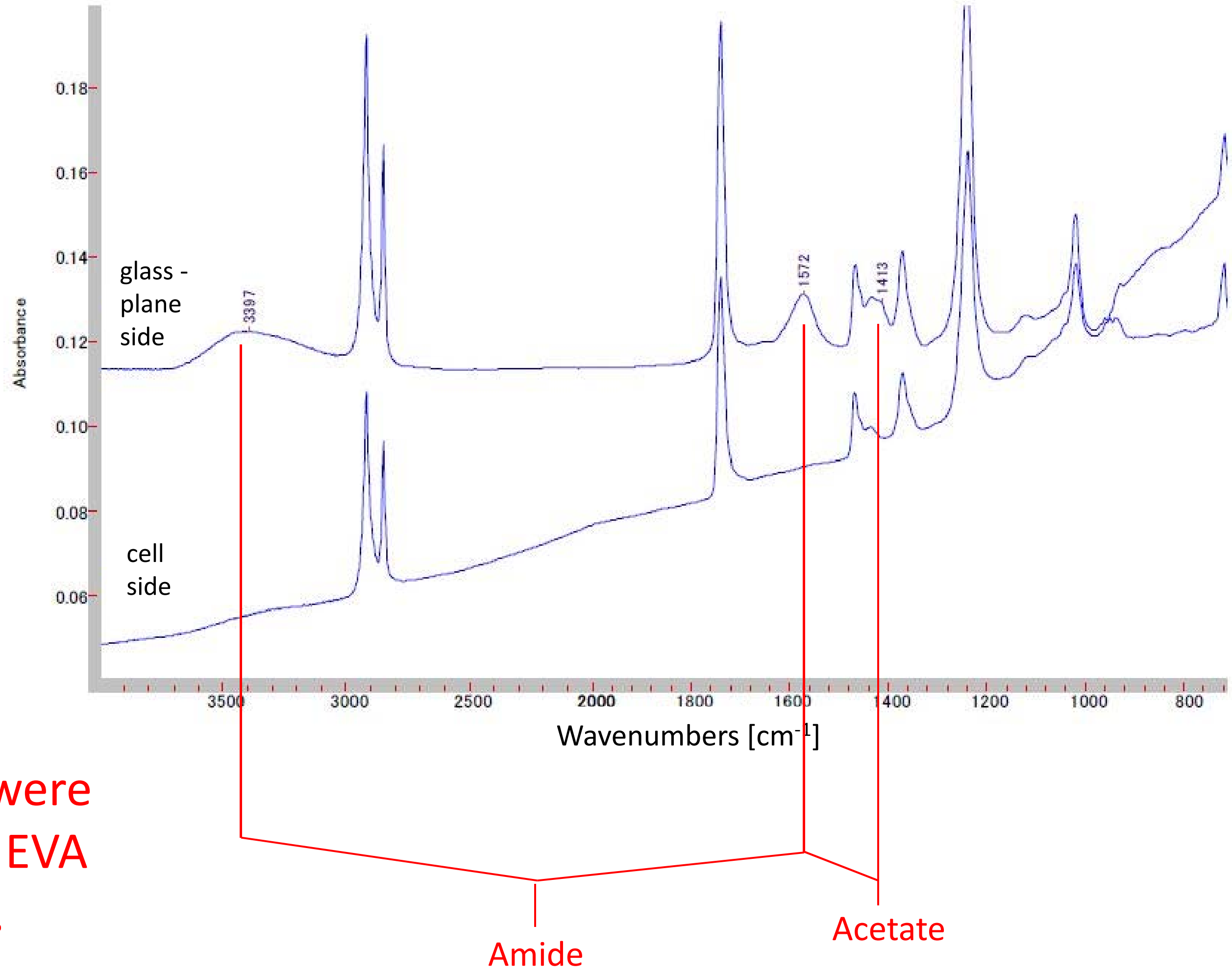
Measurement points
in cross section



IR spectra of glass-face side EVA compared to that of cell side EVA



Chemical changes of EVA were observed in the vicinity of EVA layer contacted with glass.

◆ Chemical change of EVA – cross sectional view

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- ✓ Chemical change of EVA encapsulant including additives are happened at thin layer contacting glass.
- ✓ As for EVA at cell side, there have been no typical changes compared to initial one.
- ✓ When we study delamination failure concerning EVA, we have to consider interfaces and chemical change of EVA in thickness direction.

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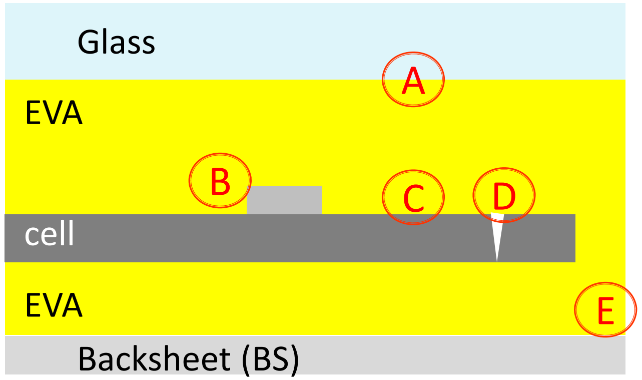
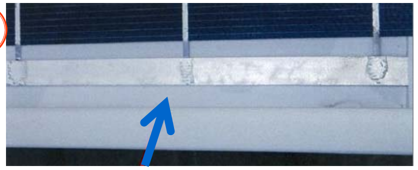
◆ Delamination – cross sectional view



B

D

E



	Interface	Potential Causes	Frequency (in Japan)	Risk (safety)
A	Glass/EVA	inadequate lamination, formulation of EVA	Rare case?	high
B	EVA/interconnector	Inadequate lamination, flux, formulation of EVA	Often	low
C	EVA/cell	inadequate lamination, AR coating, formulation of EVA	Aged specific PV modules	low
D	EVA/cell, finger electrode Snail trail (micro crack)	Ag paste for finger electrode, formulation of EVA	Often (specific types)	low
E	EVA/Backsheet	inadequate lamination, adhesiveness of Inner layer of backsheet, formulation of EVA	Rare case?	high

◆ Delamination – cross sectional view

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- ✓ Inadequate lamination, which means that inadequate lamination condition and/or quality control issue lead to insufficient thermal history for EVA including additives, causes delamination as an infant mortality.
- ✓ Originally durable adhesion of EVA has been designed for interface between glass and EVA with a silane coupling agent. Further its durability, which means that no delamination on glass was happened, has been proven by many long-term field aged PV modules with EVA having certain sliane coupling agent.
- ✓ Adhesion of EVA/backsheet has sometimes become issues for long-term reliability. These days, UV absorber has been removed from glass side EVA. Thus inner layer of backsheet would be suffered by UV light compared to older type of PV module.
- ✓ PV module manufacturer shall conduct long-term UV exposure test using a PV module with EVA encapsulant with its lower limit or less of gel content, certain backsheet and interconnector to be used.

4. Summary

- ✓ Field failures related to encapsulant is mainly delamination in Japan. It would be led by inadequate lamination condition and/or quality control issue of PV module manufacturers.

- ✓ Delamination at edge of PV module would become safety issues such as ground fault. Of course, it would be mainly lamination problem which leads to infant mortality. However issues related to design of reliability, such as additive of EVA, inner adhesion of backsheet remain in terms of long-term reliability.

- ✓ PV module manufacturer shall conduct long-term UV exposure test using a PV module with EVA encapsulant with its lower limit or less of gel content, certain backsheet and interconnector to be used.