3rd Atlas/NIST Workshop on Photovoltaic Materials Durability
December 8 - 9

Mitsui Chemicals

PV modules' reliability deployed in Japanese PV power plant from viewpoint of encapsulant

December 8th 2015

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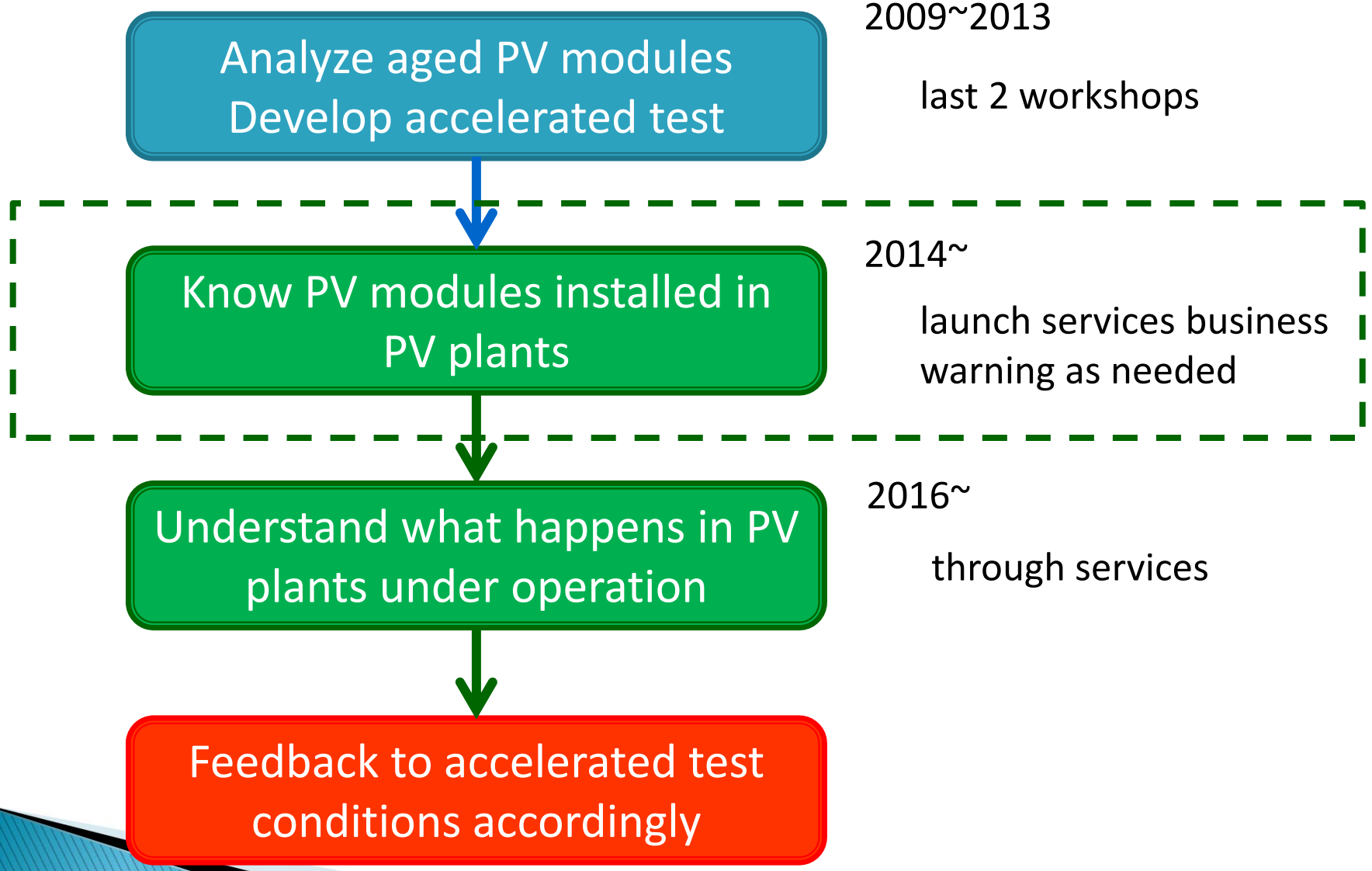
Mitsui Chemicals' contribution to healthy PV market



Outline

1. Mitsui Chemicals' services for PV plant
2. Actual examples of Failure of PV modules in Japanese PV plants
3. Influence of encapsulant on PV modules' reliability, based on experiences through Mitsui's services
4. Summary

Market of PV Plant in Japan

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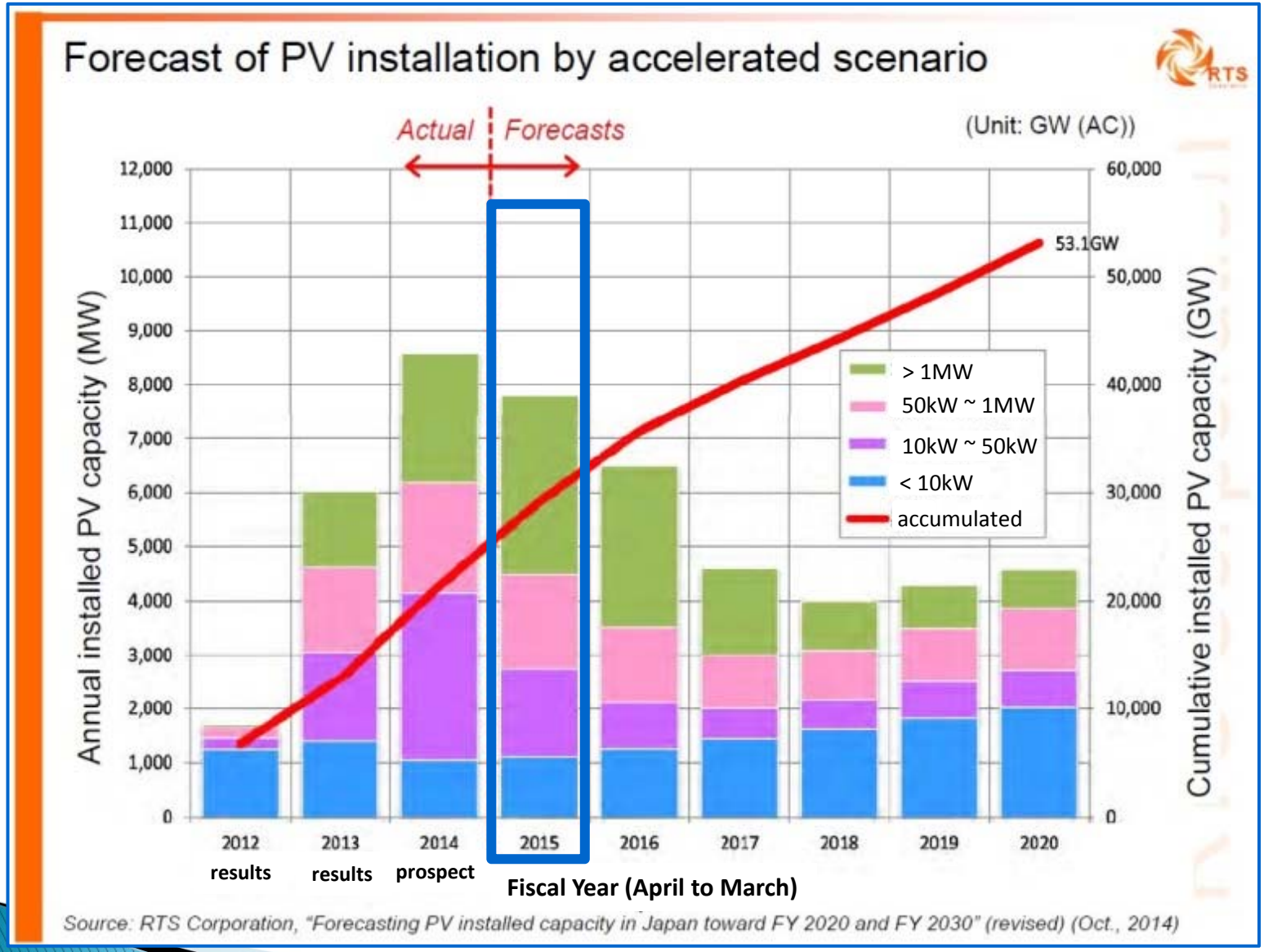

I. Kaizuka; "Trends of Japanese PV Market", Solar Assetmanagement Asia 2015, June 2015

Lack of third party's checks for PV plant in Japan

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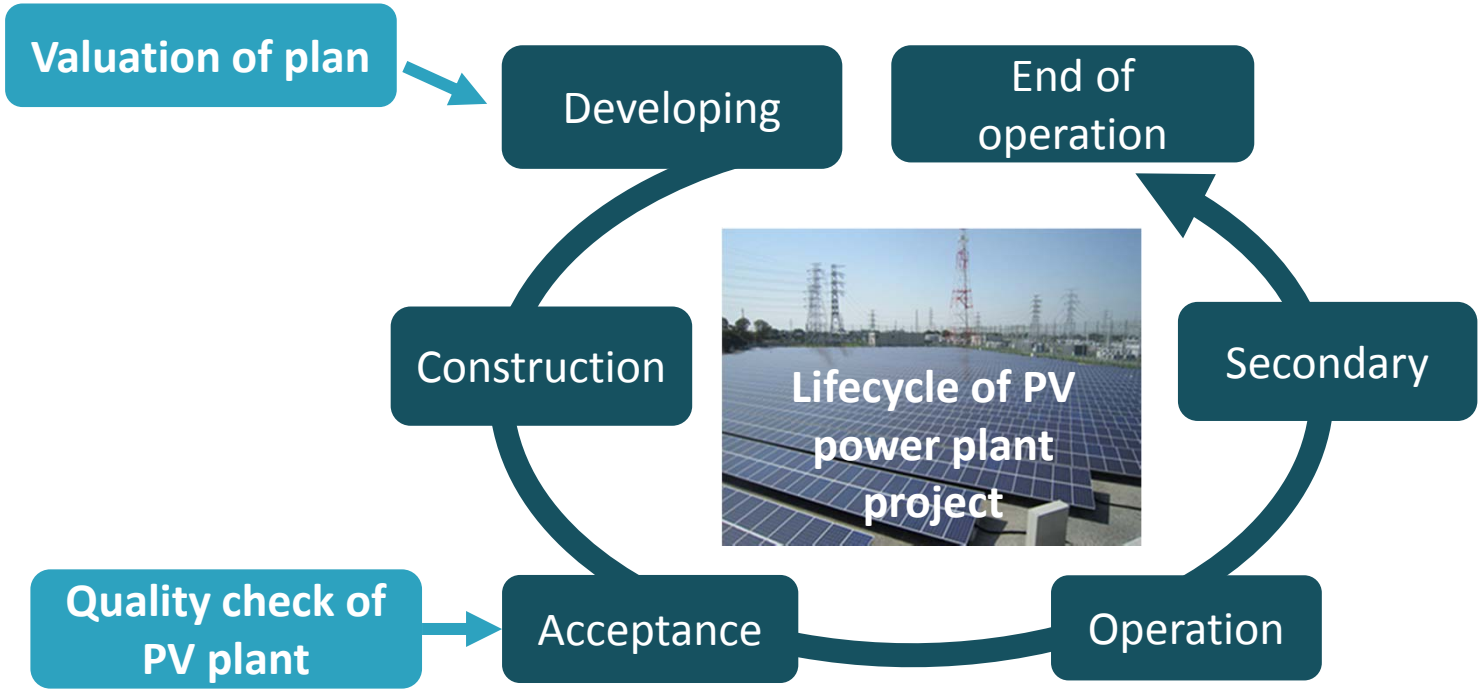


- ✓ So far, third party's inspection of PV plant had been insufficient for developing a PV plant.
- ✓ Consulting firms who had less expertise in PV field have performed as a third party. There were no consulting firms who have expertise in PV field at initial stage of PV market.
- ✓ Most JP banks had tended to see credit of participants of PV plant PJ even project finance.
- ✓ These days, they have concerns about use of PV modules produced by non-Japanese companies, accuracy of energy yield estimation by a consulting firm and so on.

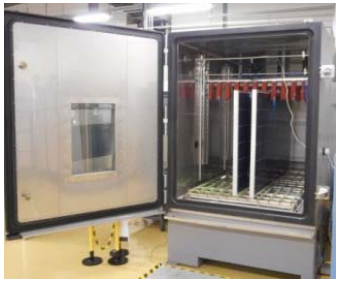
Mitsui Chemicals' services for a PV project

- since March 2014 -

Mitsui Chemicals

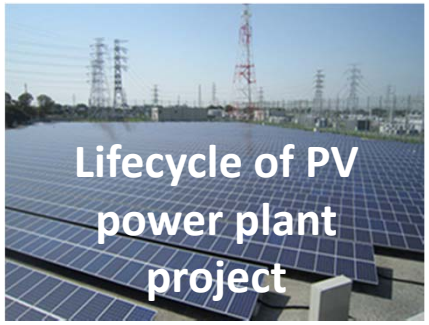
Valuation of plan

Quality check of PV module



Developing

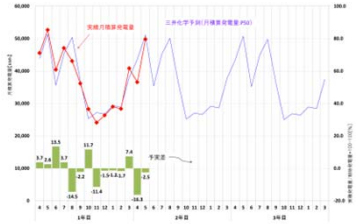
Construction



End of operation

Secondary

Valuation of PV plant



Quality check of PV plant

Acceptance

Operation

Yield data analysis -to find failure-

With Mitsui Chemicals' services,

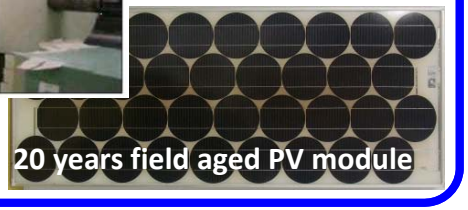
- ✓ you can have high quality of PV power plant.
- ✓ you can understand intrinsic risks in PV power plant.
- ✓ you can maximize value of PV power plant.
- ✓ you can know fair value of PV power plant to be purchased / sold.

Mitsui Chemicals' strength –unrivalled expertise in Japan –

Reliability of PV module

Our subsidiary has supplied encapsulant sheets worldwide for >25years.
We have analyzed long term aged PV modules and encapsulant using our test facilities for understanding what happened for 20 years.


EVA encapsulant roll


20 years field aged PV module

Investor/Owner of PV plants

We have several plants in Japan and have known difficulties and value chain of developing PV plant.
With our PV plants, we can estimate
- accurate expected irradiance and loss factors
- appropriate O&M cost.


Tahara PV plant with 50MWp


Mobara PV plant with 335kWp


Sodegaura R&D center /mini- site

Experiences in Europe

We can utilize expertise in Europe through our partner, PI Berlin who is an accredited lab. for PV modules and has expertise for PV plant diagnosis worldwide.

Cutting edge technology

We have supported cutting edge researches of PV manufacturers and EPC.
We have made invited talks for international workshops and conferences.

Actual performances of our services in Japan

Mitsui Chemicals

Services	Features	Total PV capacity
Valuation of Plan	Yield assessment Documentation review	~100 MW
Quality check of PV module	Factory inspection/ shipping inspection Evaluation of PV materials/modules PID test	~300 MW
Quality check of PV plant	Supervise during construction Documentation review Quality check of facilities	~200 MW
Yield data analysis	Performance ratio (PR) analysis	~10 MW
Valuation of PV plant for 2ndary market	Yield assessment Documentation review Quality check of facility Track record/PR analysis	~100 MW

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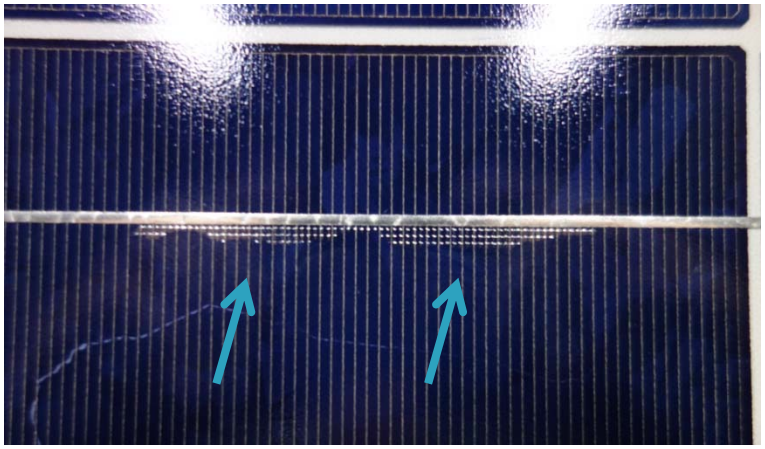
2. Actual examples of failure of PV modules in Japanese PV plants

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

Lesson learn from actual cases in Japan
-from evaluation of PV module-



delamination between Si and EVA
during storage (~1y) in our warehouse

pulling cable off “easily” from connector

MC4 compatible connector

Lesson learn from actual cases in Japan
-same type but different material-

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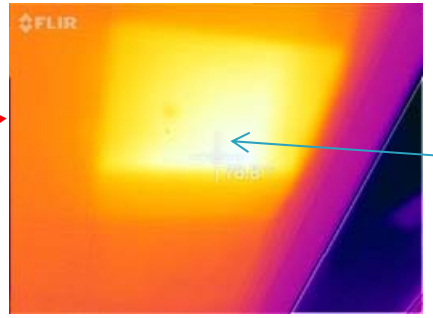
Same type of a PV module

Different backsheet

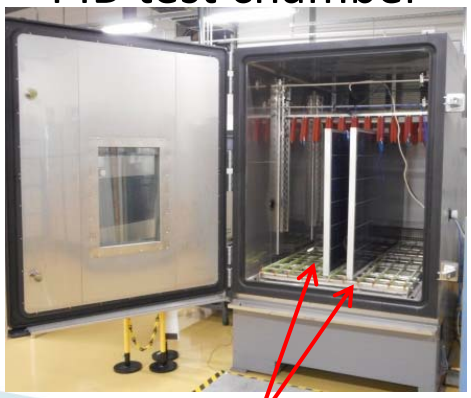
Infra-red observation



Hotspot

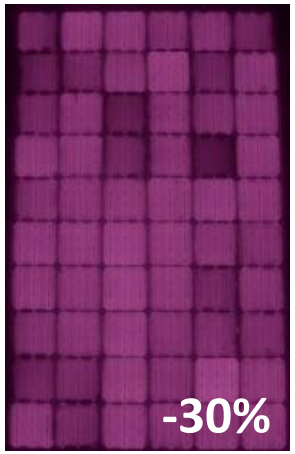
Solder joint failure

PID test chamber



Same type of a PV module

Electroluminescence (EL) images after PID test



Different encapsulant

Lesson learn from actual cases in Japan

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- ✓ We have seen some troubles and failures of PV modules and PV plants in Japan.
- ✓ According to our services' results, there were some cases that use of different PV materials for same type PV modules led to different durability and reliability of the PV modules.

Let's see recent trend of encapsulant through our services.

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Degradation prediction of EVA with Xe light exposure

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YI change and acetic acid production during UV test

2013.11.13

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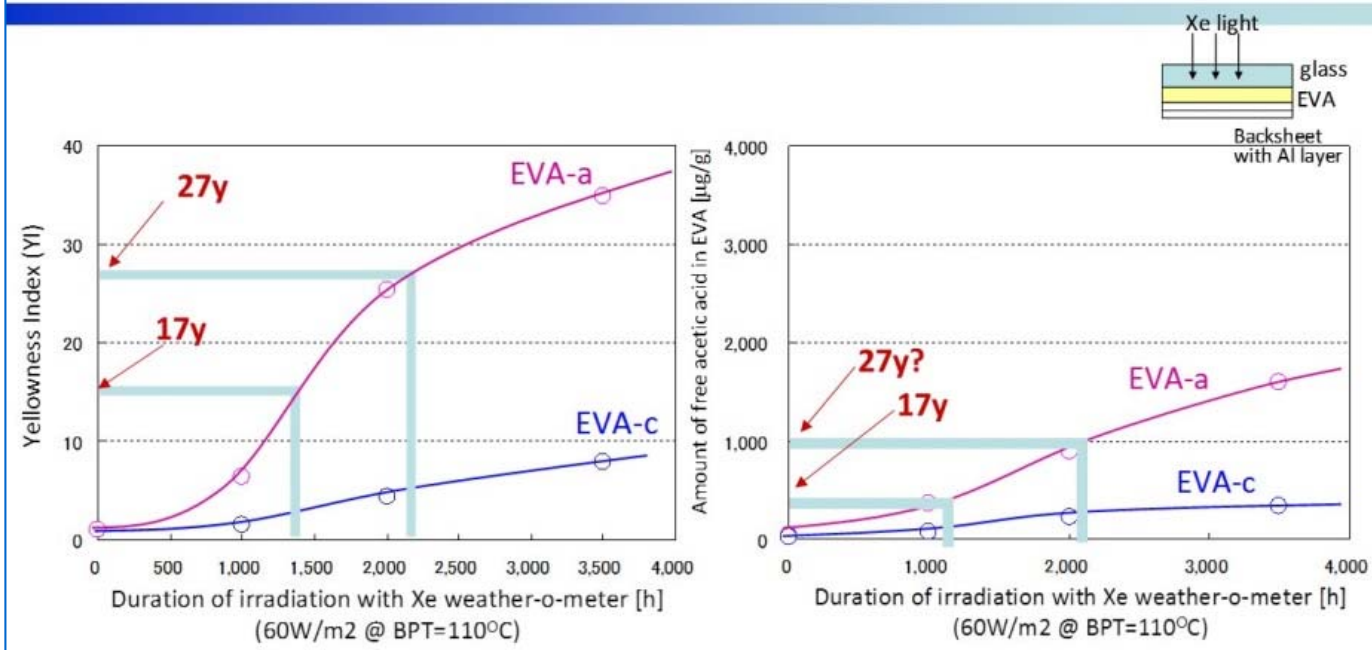

Xe light irradiation for **1300** / **2100** h roughly corresponds to outdoor exposure for **17** / **27** y.
(60W/m² @ BPT=110°C)

*Note: it depends on sample geometry.

T. Shioda: 2nd ATLAS/NIST PV material durability workshop 2013

EVA encapsulant is one of key materials for reliability and durability of a PV module.

Importance of formulation of EVA encapsulant

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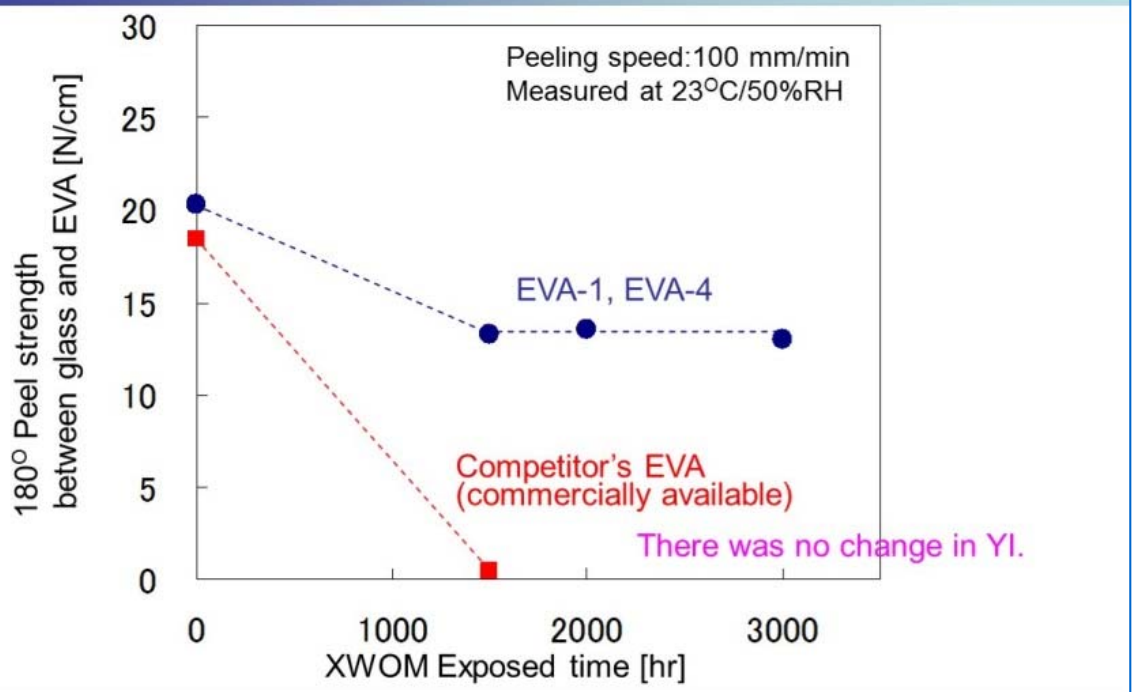
Peel strength change during UV accelerated test

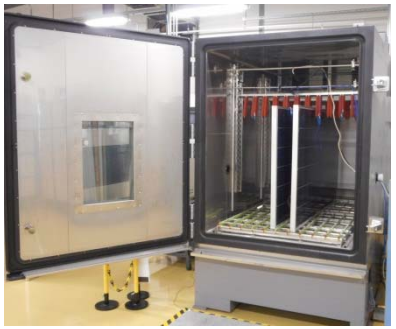


This result indicates that delamination in PV modules with the competitor's EVA would be appeared near future!!

T. Shioda: 1st ATLAS/NIST PV material durability workshop 2011

This phenomenon is due to **lack of "additive" related to durability of light exposure**.
(not UV absorber)

Mitsui Chemicals' services for PV module



6 modules / lot

Appearance check
IV, EL

2 modules

PID test

IV, EL

2 modules

2 modules

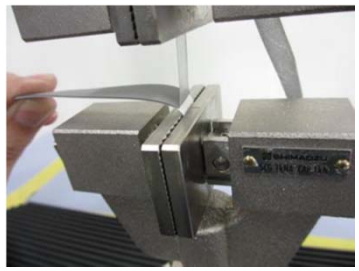
Cure state of EVA

Additive analysis of EVA

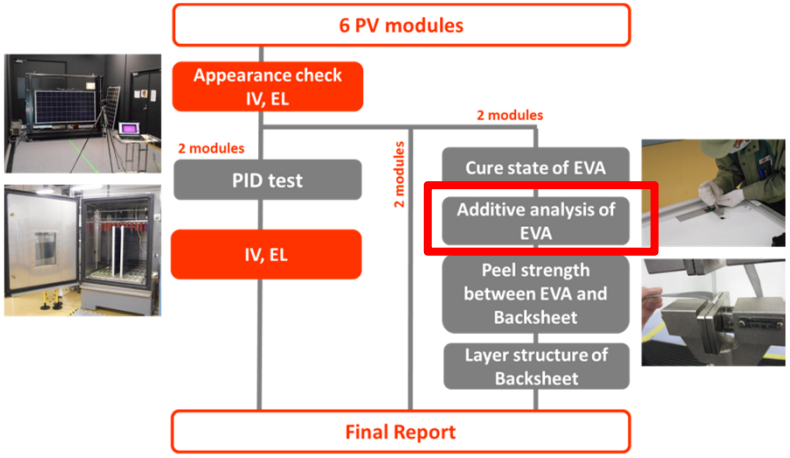
Peel strength between EVA and Backsheet

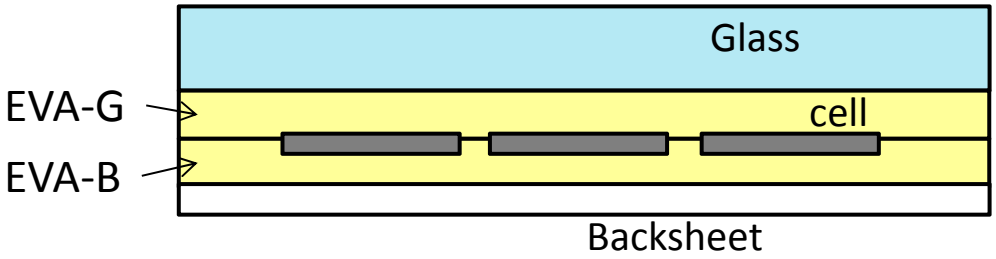
Layer structure of Backsheet

Final Report



Recent trend of formulation from our additive analysis results





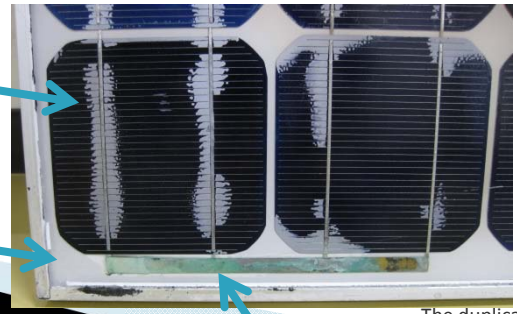
CASE (additive "A" related to light resistance)		2014	2015
EVA-G EVA-B	not detected not detected	~40%	0%
EVA-G EVA-B	detected not detected	0%	~40%
EVA-G EVA-B	detected detected	~60%	~60%

Recent trend of formulation from our additive analysis results

Mitsui Chemicals

CASE		2014		2015	
		UV absorber	Additive "A" (light resistance)	UV absorber	Additive "A" (light resistance)
~40% EVA-G EVA-B	Glass side	not detected	not detected	not detected	detected
	Backsheet side	detected	not detected	detected	not detected
~60% EVA-G EVA-B	Glass side	detected	detected	not detected	detected
	Backsheet side	detected	detected	detected	detected

- ✓ Some PV modules evaluated on 2014 have high risk of delamination according to our additive analysis.
- ✓ However the risk for those evaluated on 2015 would be low and not zero.
- ✓ We have to beware that function of UV absorber in EVA is mainly to protect backsheet against UV damage and completely differs from that of additive "A".



15 years field aged PV module with delamination and corrosion
(Both EVA has two additives shown in the table…)

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- ✓ Japanese PV market is still growing.
- ✓ Needs for third party's assessment become high, because some PV plants have trouble and failures of PV modules.
- ✓ Mitsui Chemicals provide several services for PV plant as a third party.
- ✓ We found some risks for PV modules installed on 2014 from encapsulant point of view.
- ✓ PV module manufacturers should see reliability and durability of PV materials as well as those of PV module.