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Encapsulant effect on PID durability of various crystalline PV cells

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Motivation

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- In PV modules, cross-linked EVA encapsulants are commonly used because of their transparency, thermal creep resistance and durability
- Mitsui Chemicals Tohcello (MCTI) is PV encapsulant manufacturer and has over 30 years history in this business
- For demand of the high reliability module in PV market, we have developed polyolefin encapsulant(POE)
- We performed DH, XWOM, PID tests compared them between MCTI-POE and other type encapsulants

Design concept of polyolefin encapsulant

Typical properties of encapsulant

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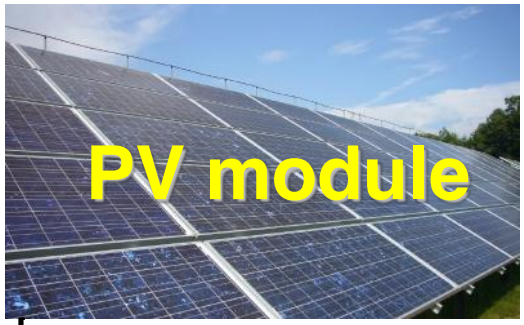


MCTI's POE is designed and developed to meet requirements for PV module encapsulant

Superior to EVA | Equivalent to EVA

- Module efficiency → Transparency
- Long term durability
  - Cell crack → Low stiffness
  - Thermal stability → Cross linking
  - Discoloration → UV durability
  - Moisture corrosion → Adhesiveness, Low WVTR, Acid free
  - PID → High volume resistivity

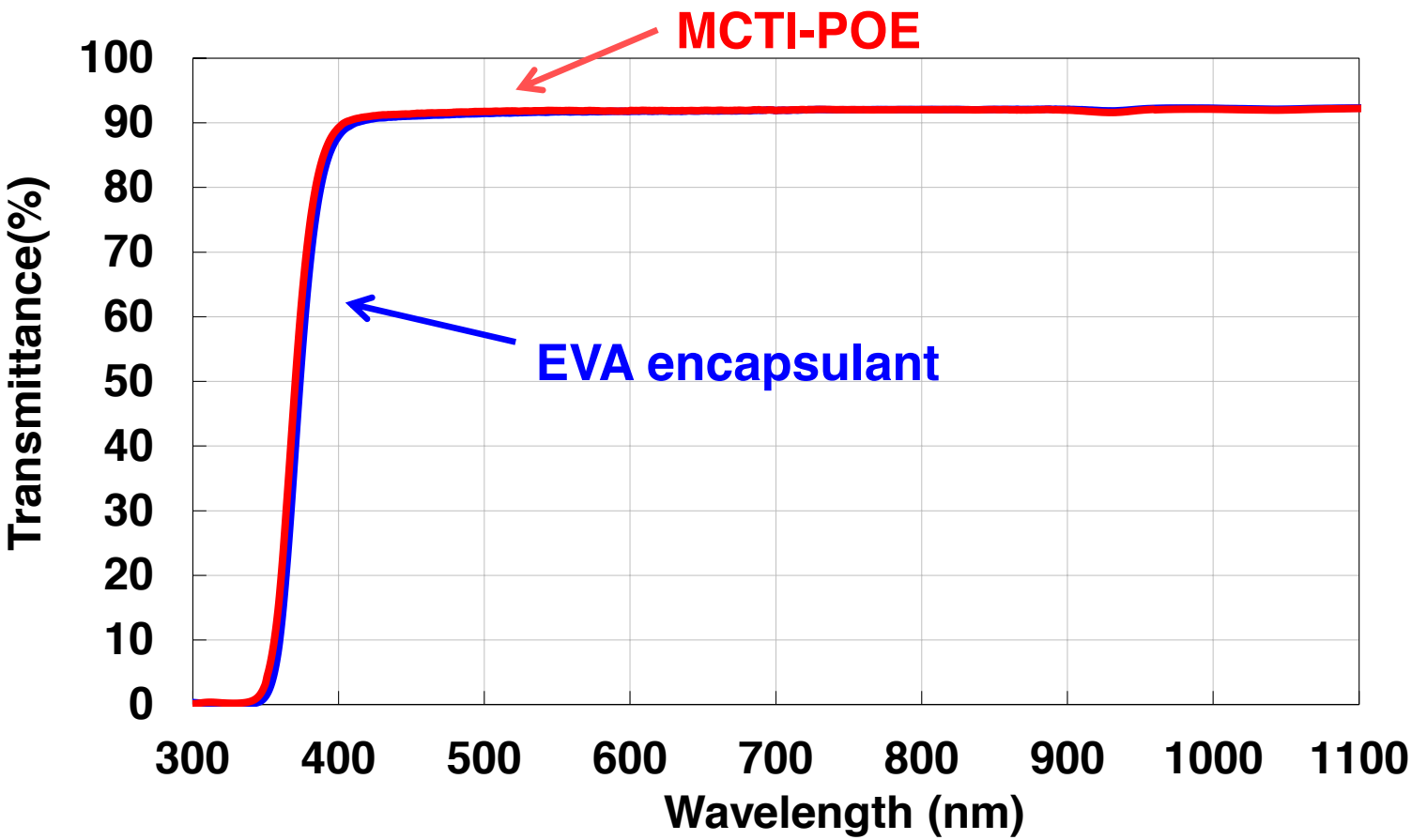
Encapsulant properties

Property table

Items		Unit	MCTI-POE	EVA encapsulant
Base polymer		-	Polyolefin	EVA
Thermo plastic or Cross-linked		-	Cross-linked	Cross-linked
Optical transmittance (400-1100nm)		%	92	92
Water absorption (23°Cx24hr)		%	≤ 0.01	0.1
Water vapor permeability (23°C/90%RH)		g·mm/m2/day	0.6	5
Volumetric Resistivity (23°C)		Ω·cm	$\geq 1 \times 10^{17}$	$\geq 1 \times 10^{14}$
Young's modulus		MPa	10	15
Adhesive strength to Glass	w/o Backsheet	N/cm	18	20
	with Backsheet	N/cm	≥ 100	≥ 100

Design concept of polyolefin encapsulant

Optical transmittance



MCTI-POE and EVA encapsulant have the same optical property.

Thermal Stability

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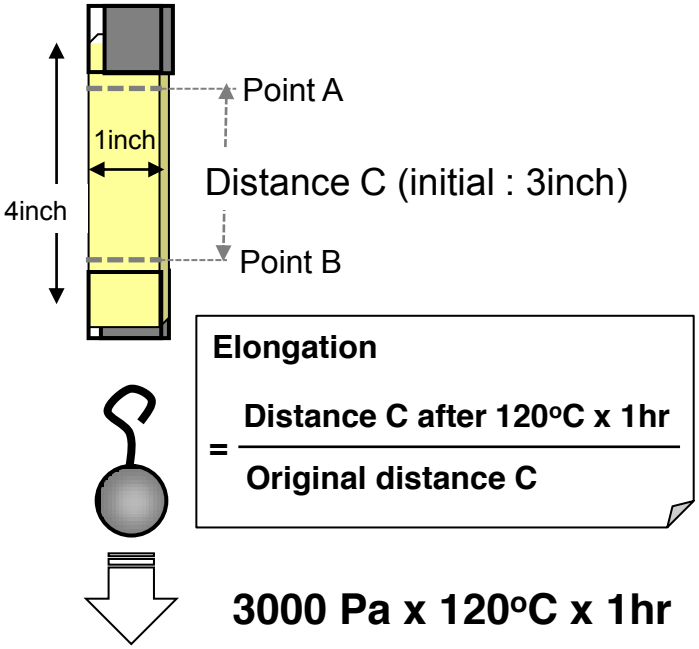
Elongation of encapsulant at 120°C

grade	type	elongation
MCTI-POE	Cross-linking	**0%** No creeping
EVA encapsulant	Cross-linking	**0%** No creeping
Conventional POE	Thermo plastic	**>200%** creeping



* 3000Pa is about 30 times stress compared to actual module stress.

- **Cross-linked MCTI-POE and EVA is thermally stable even at 120℃.**
- **In case of thermo plastic type, significant creeping is observed.**

DH durability with polyolefin encapsulant

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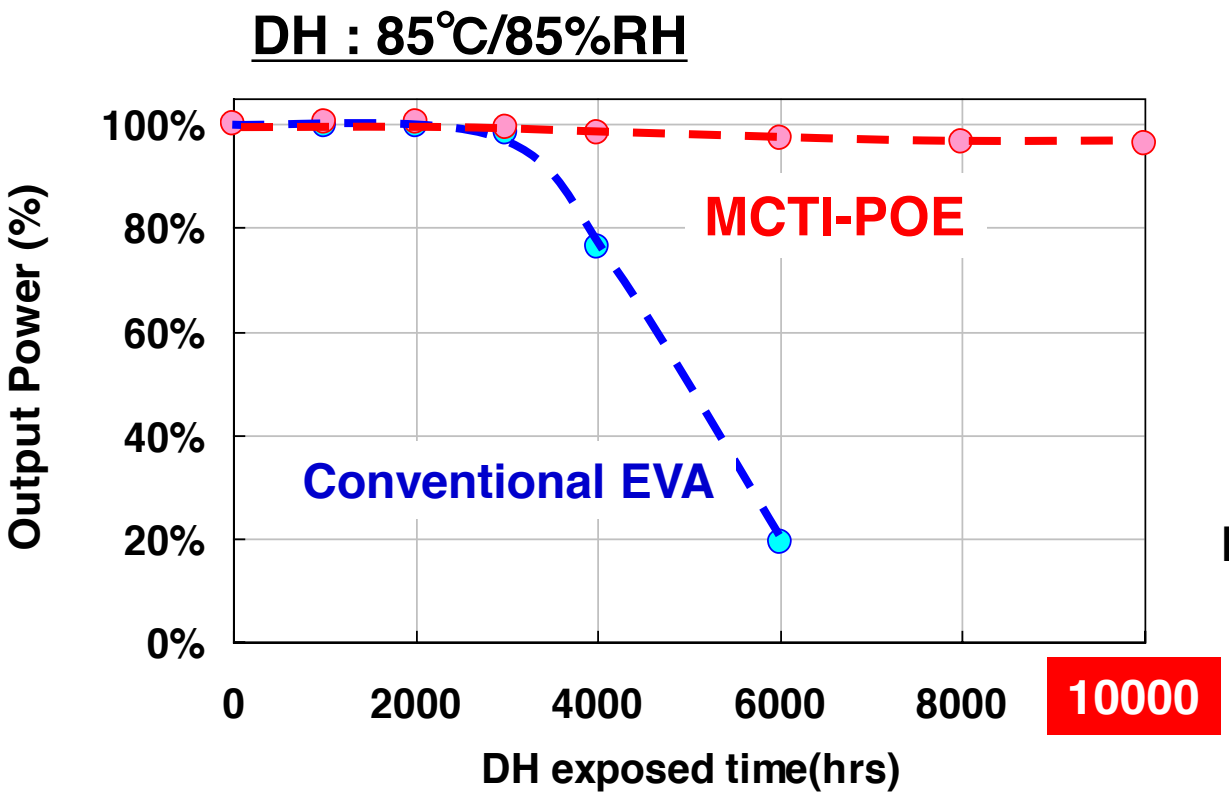

Multi-crystalline module
(18cells,250mm x 300mm)

- **MCTI-POE, which is acid-free, does not cause the corrosion.**
- **Power loss of module is less than 5% even after DH10000hrs.**

XWOM durability of module

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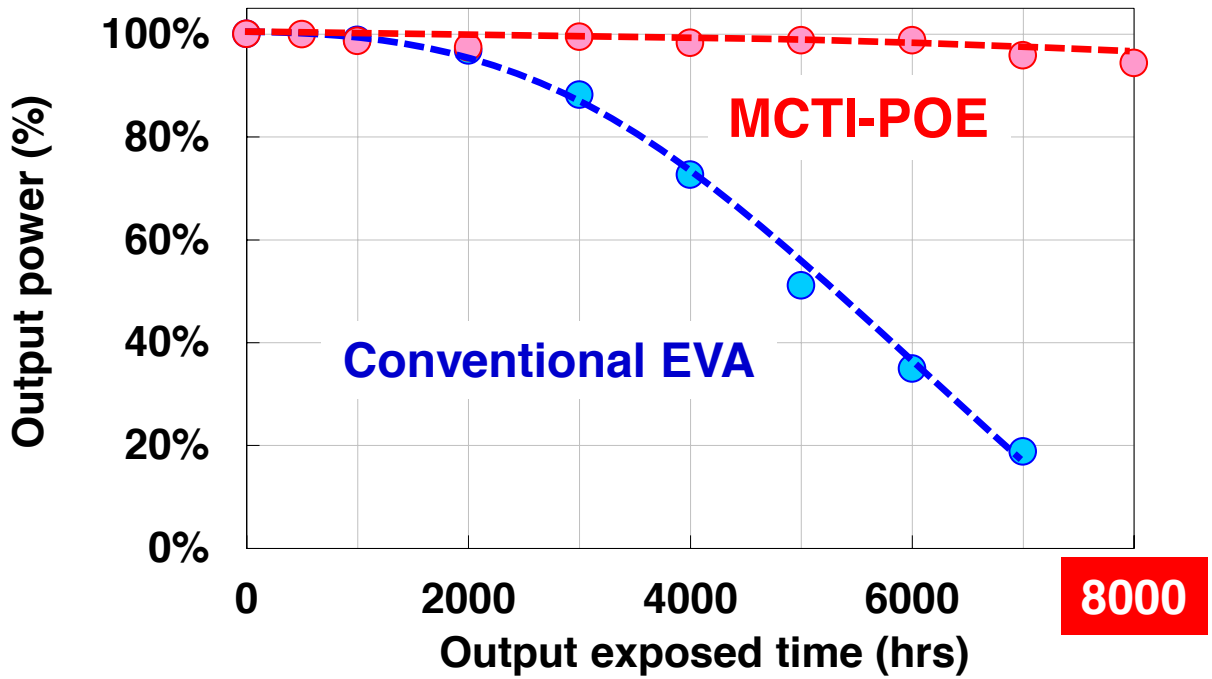
XWOM, 3SUN(180W/m2@300-400nm) B.P.T 110°C



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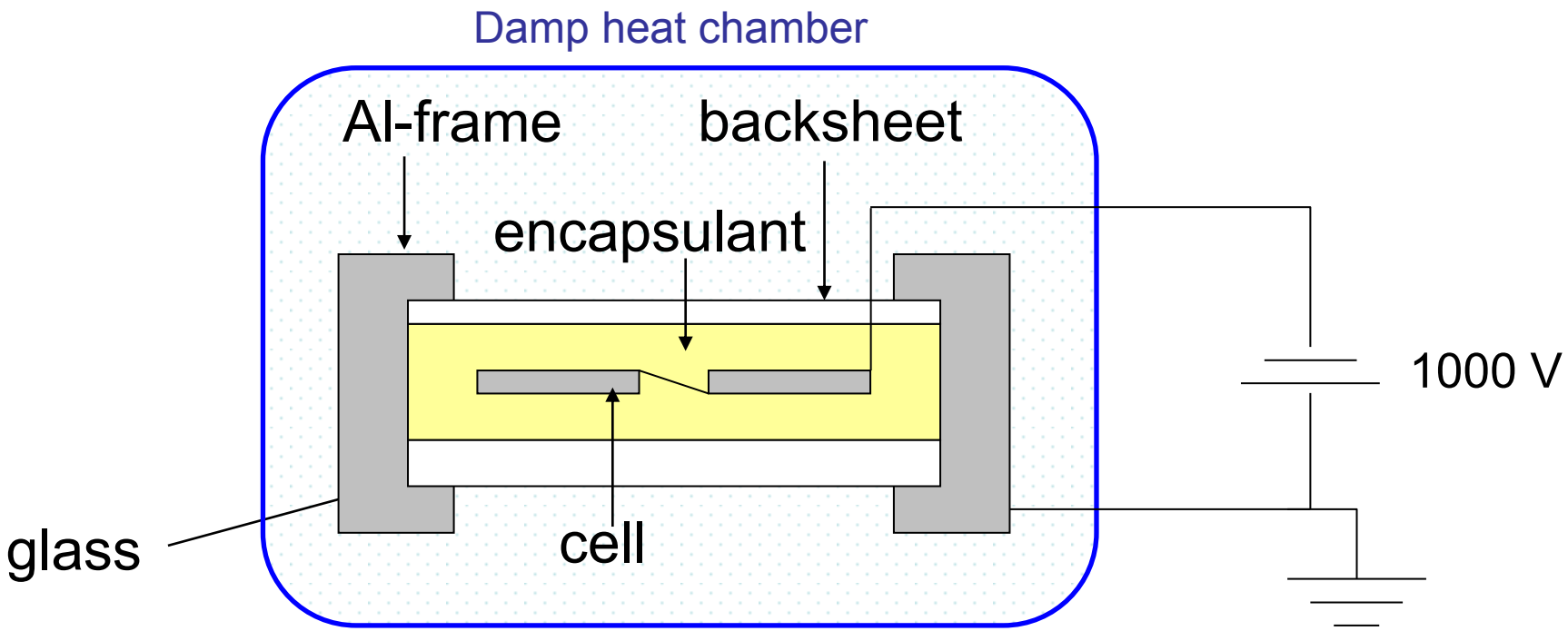
PID acceleration tests method



Test conditions

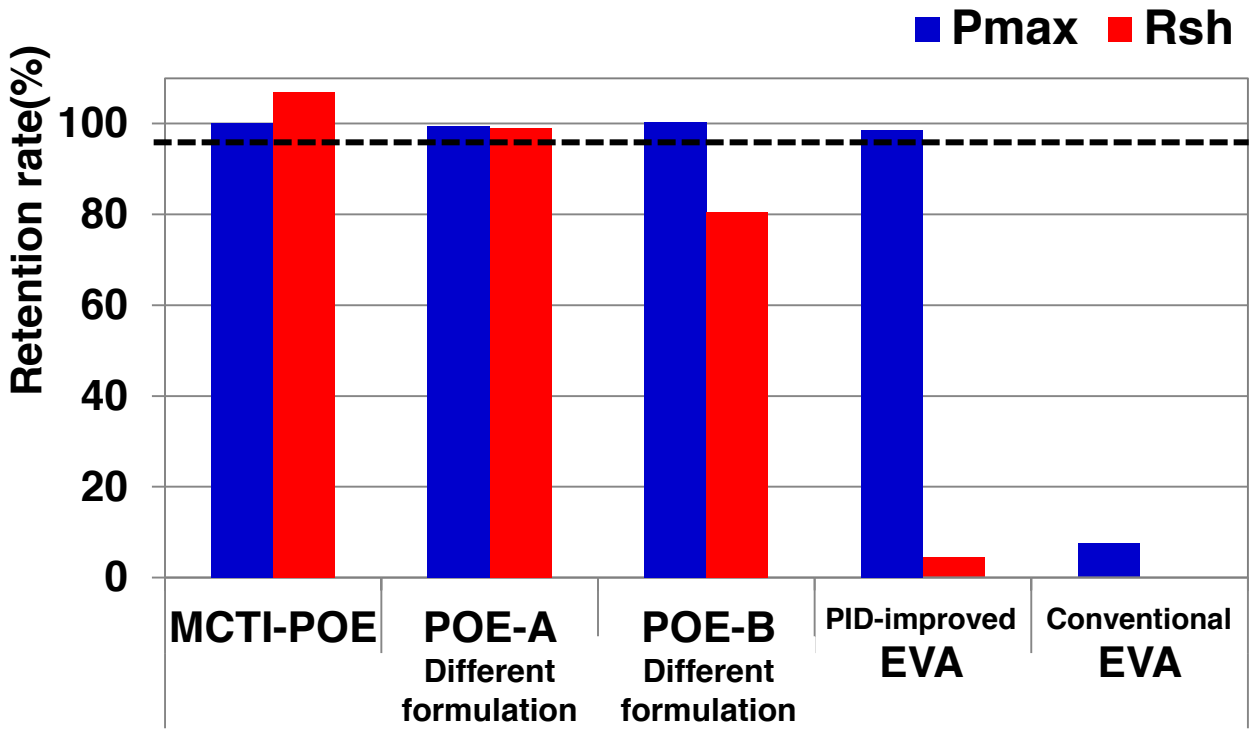
Cell :single cell or full module

Exposure time : 96h - 240hr

Voltage : -600V or -1000V

Temp. : 60^0C85% or 85^0C85%

PID durability with "P type PID-durable" cell

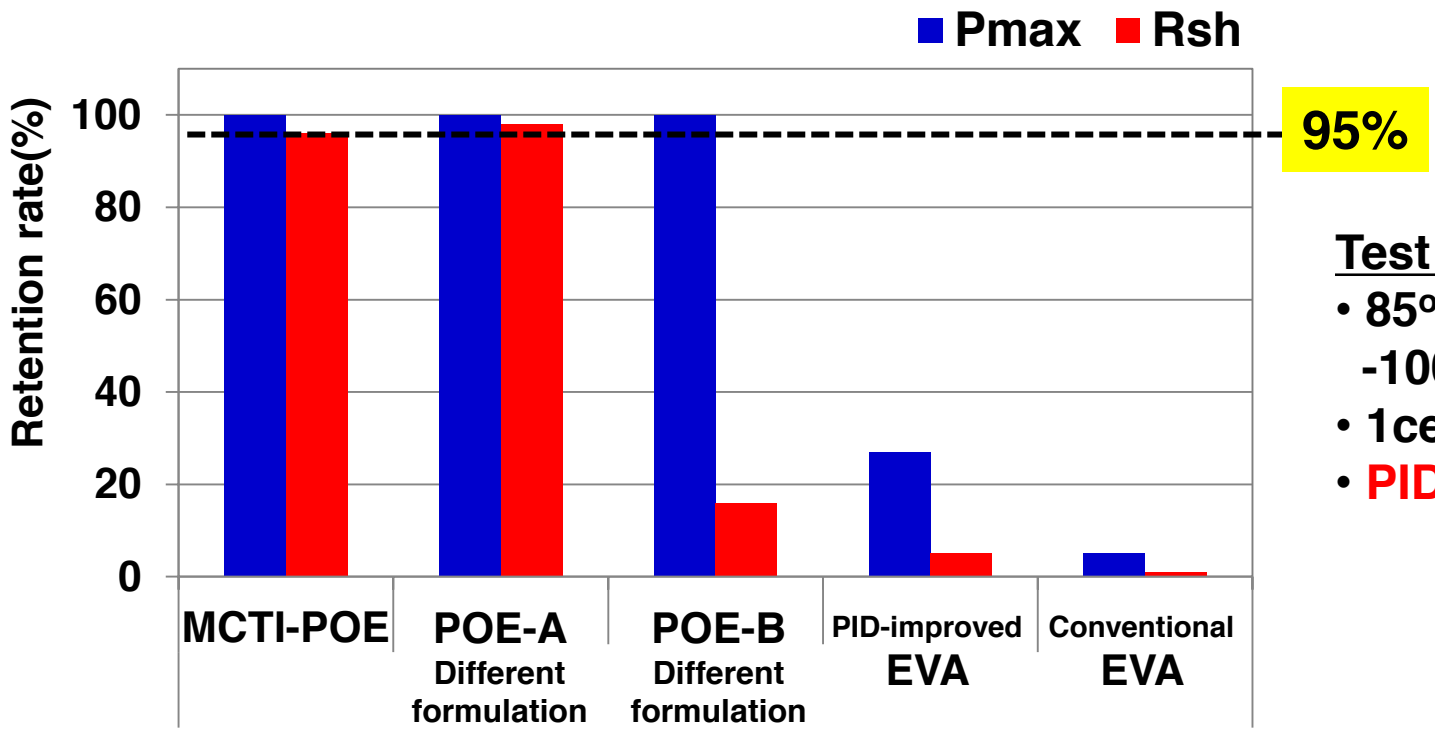


95%

Test condition
- evaluated by third-party
- 60°C85%RH, Water covered, -1000V, 96hr
- 4cells (2x2cells)
- **PID-durable cell**

- **PID-improved EVA can be improved PID durability and keep the initial level of Pmax.**
  But Rsh is decreased, which represent the beginning of PID phenomena.
- **MCTI-POE shows no degradation on both Pmax and Rsh.**

PID durability with "P type PID-sensitive" cell

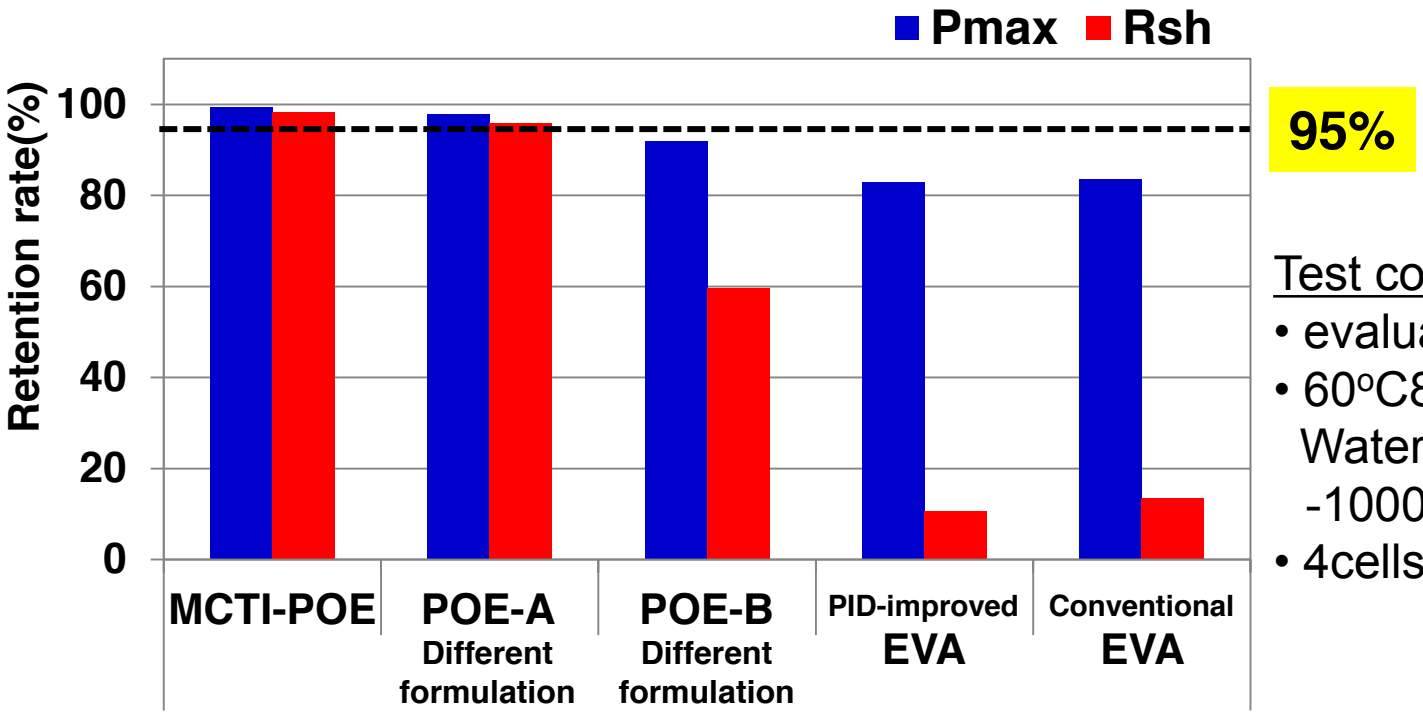


Test condition

- 85°C85%RH, -1000V, 24hr
- 1cells
- PID-sensitive cell

- PID-improved EVA occur power loss in severe PID test condition.
- POE keeps initial output power even if using PID-sensitive cell.

PID durability with "N type" cell



Test condition
- evaluated by third-party
- 60°C85%RH, Water covered, -1000V, 96hr
- 4cells (2x2cells)

- **PID-improved EVA can NOT keep initial level of Pmax.**
- **MCTI-POE shows no degradation on both Pmax and Rsh. But POE-B occur power loss.**
- **PID powerloss is observed on POE-B module.**

PID EL-image of “MCTI-POE”

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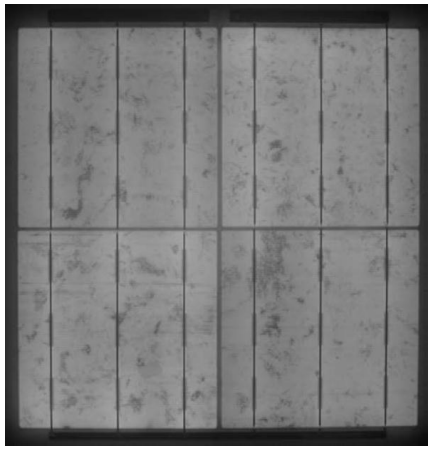
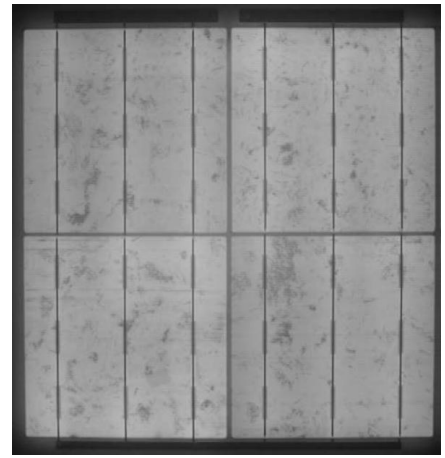
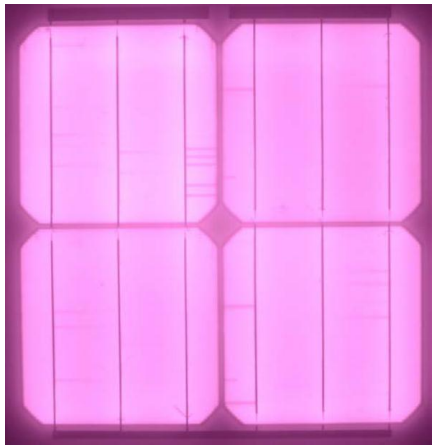
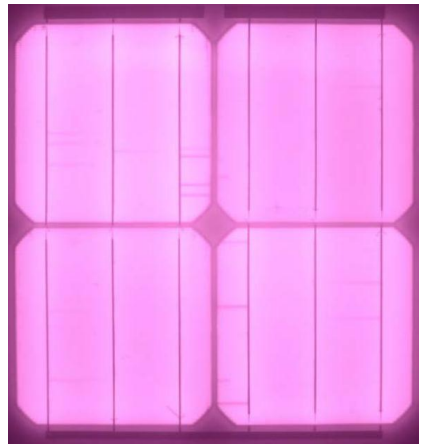
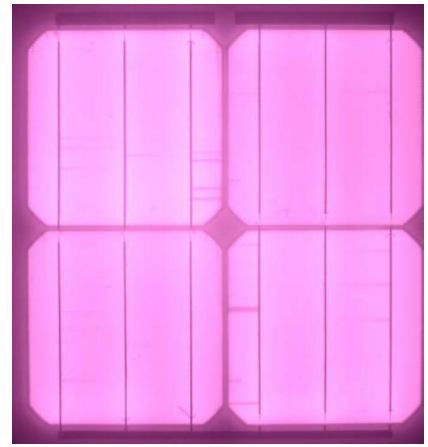
	0hr	24hr	96hr
P type PID-sensitive			
N type			

PID EL-image of “Conventional EVA”

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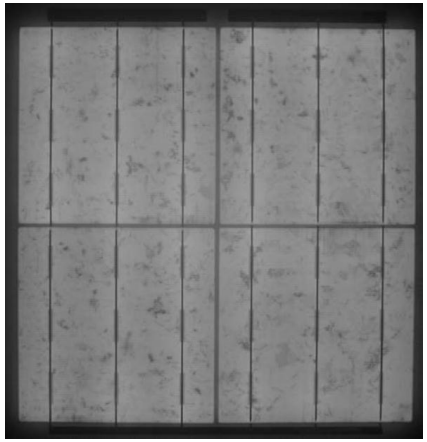
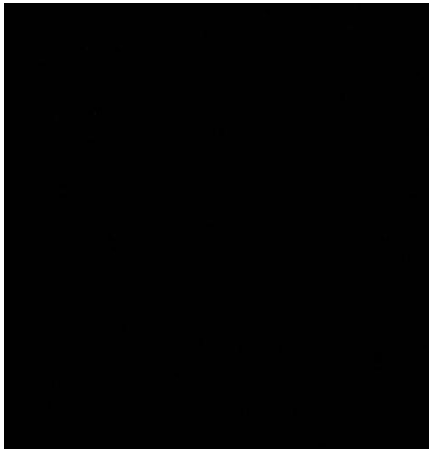
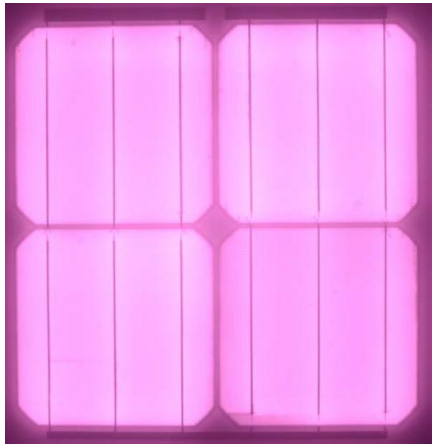
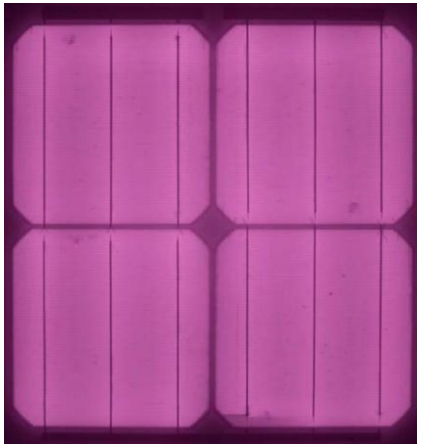
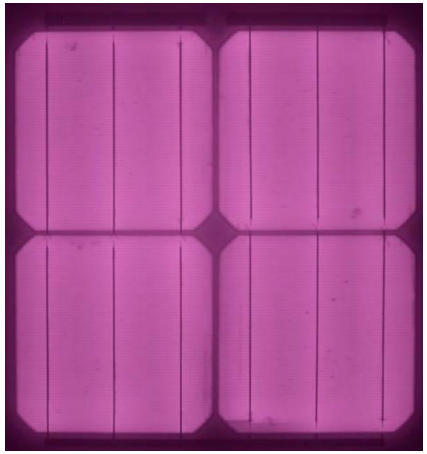
	0hr	24hr	96hr
P type PID-sensitive			
N type			

Summary

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- **Durability of PV modules laminated with POE and EVA encapsulants were compared**

- **MCTI-POE , which is cross-linking polyolefin, shows excellent reliability on the all tests**

- **MCTI-POE can pass PID tests in both P type" and "N type" cell.**

  ***We continue to investigate the root cause of N-type cell's PID phenomena**

- **We have already started mass production of the cross-linking polyolefin encapsulant named "SOLAR ASCE™".**