

Moisture ingress rate and route into c-Si PV modules

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1. Introduction

Background

- The reliability of photovoltaic (PV) module is related to the moisture ingress in some cases.
- However, the moisture ingress rate and the route into PV modules have not been clarified.
- It is necessary to understand an accurate ingress rate and route to obtain guiding principle of appropriate material.

Objective

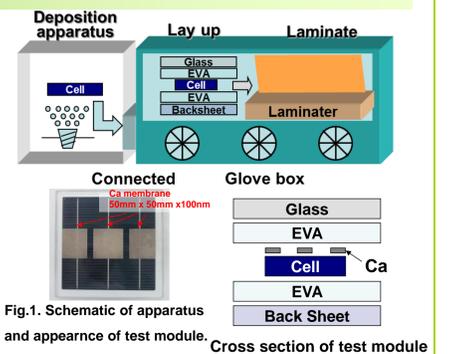
To develop measuring method of moisture ingress into PV modules

2. Methods

- In order to detect the moisture ingress rate and route into the module, we used Ca as a sensor.

$$\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$$

(metal color) (transparent)
- Ca was evaporated on the material surface of the single cell module using multi-crystalline Si cells.
- To examine influence of permeability of back material, we prepared test modules using the back material of different water vapor transmission rates (WVTRs).



Back materials: **PET / Al / PET (PAP)** **SiOx BS** **Tedlar / PET / Tedlar (TPT)** **50µm ETFE** ETFE : ethylene tetrafluoroethylene

Low ← WVTRs → High

3. Results and Discussion

Damp Heat Test (DHT)

- Ca is an effective material to detect moisture ingress.
- Major moisture ingress route is back material.

Backsheet	WVTR @40°C/90%RH [g/m ² /day]	Initial	DH40h	DH81h	DH145h	DH191h
PAP	Extremely low					
SiOx BS	0.2					
TPT	2.0					
#50ETFE	14					

Fig.2. Change of appearance under DHT.

Backsheet	Edge seal	Initial	DH108h
PAP	Silicone sealant		
PAP	Butyl rubber		
TPT	Butyl rubber		

Fig.3. Change of appearance under DHT.

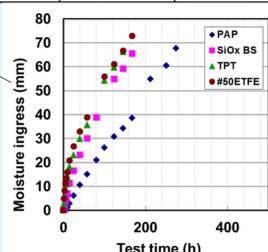


Fig.4. Moisture ingress under DHT.

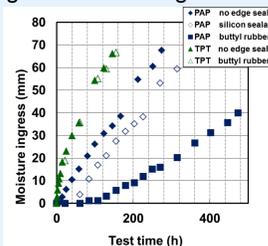


Fig.5. Moisture ingress under DHT.

- Moisture ingress rate into test module with higher WVTRs is larger.
- Edge seal does not affect moisture ingress rate for test module with TPT.

Field exposure test

- Moisture ingress rate is larger by 28-34 times under DHT than field exposure test. (ingress from edge)
- Moisture ingress rate is larger by 18-24 times under DHT than field exposure test. (ingress from back material)



Field exposure test has been done at Kyushu Center, National Institute of Advanced Industrial Science and Technology. Climate division of Kyushu is the Temperate Zone. Test started on Feb. 7th, 2013, in winter. One year has past since test started.

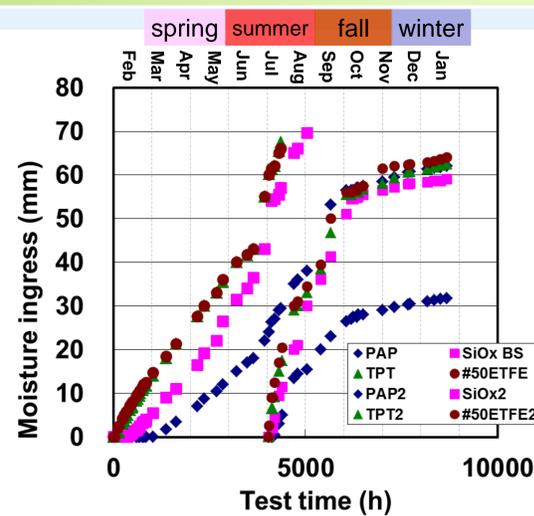
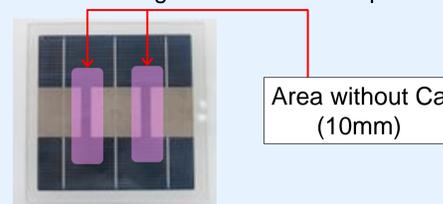


Fig.6. Moisture ingress under field exposure test.



Accelerating effect is defined as

moisture ingress rate under DH / moisture ingress rate under field exposure

Moisture ingress rate is defined as

moisture ingress distance / test time

Considering effect of area without Ca, we used two kinds of moisture ingress: measured value and measured value minus 10mm (area without Ca)

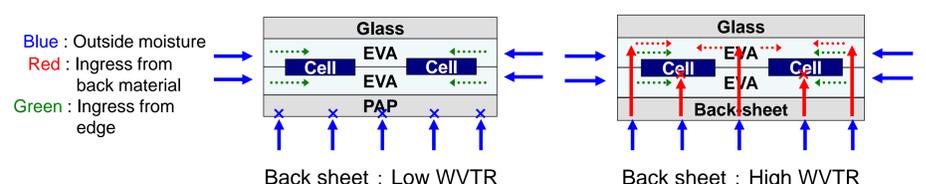
Table 1. Accelerating effect for each test module

Backsheet	PAP	SiOx BS	TPT	ETFE
Accelerating effect	28.1 - 33.5	21.1 - 23.4	18.8 - 23.5	18.5 - 20.2
Time equivalent to DH1000h (year)	3.2 - 3.8	2.4 - 2.7	2.1 - 2.4	2.1 - 2.3

4. Conclusions

- Major moisture ingress route is backsheet and moisture ingress rate depends on WVTR of backsheet.
- Moisture ingress rate from edge under DHT is 28 - 34 times larger than that under field exposure test.
- Moisture ingress rate from backsheet under DHT is 18 - 24 times larger than that under field exposure test.

Estimated moisture ingress route



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