

# Encapsulant dependence of Ag-ion migration phenomenon during damp heat test with voltage bias

---

<sup>1</sup>Masaaki Odoi, Hirofumi Zenkoh

<sup>2</sup>Tsuyoshi Shioda

<sup>1</sup>Mitsui Chemicals Tohcello, Inc.

<sup>2</sup>Mitsui Chemicals, Inc.

## Motivation

- ✓ Silver used as Photovoltaic cell paste is known as the metal most susceptible to migration and PV modules are often operated under high humidity conditions
- ✓ Encapsulant formulation effect on Silver ion electrochemical migration are investigated using comb-type printed circuit boards
- ✓ PID test was also done for these encapsulant

## Conclusions

- ✓ Ion migration and dendrite was observed for some encapsulant formulation and strongly depend on included additives
- ✓ There were **NO** correlation between migration and PID test

# Test encapsulant samples

Encapsulant			Volume Resistivity ( $\Omega \cdot \text{cm}$ )	PID	Ion migration
EVA	EVA – 1	Traditional EVA formulation	$5 \times 10^{14}$	Poor	Good
	EVA – 2	Changing one additive from EVA-1	$2 \times 10^{15}$	Good	Poor
	EVA - 3	Changing one additive from EVA-1	$2 \times 10^{15}$	Good	Good

✓ There were **NO** correlation between migration and PID test

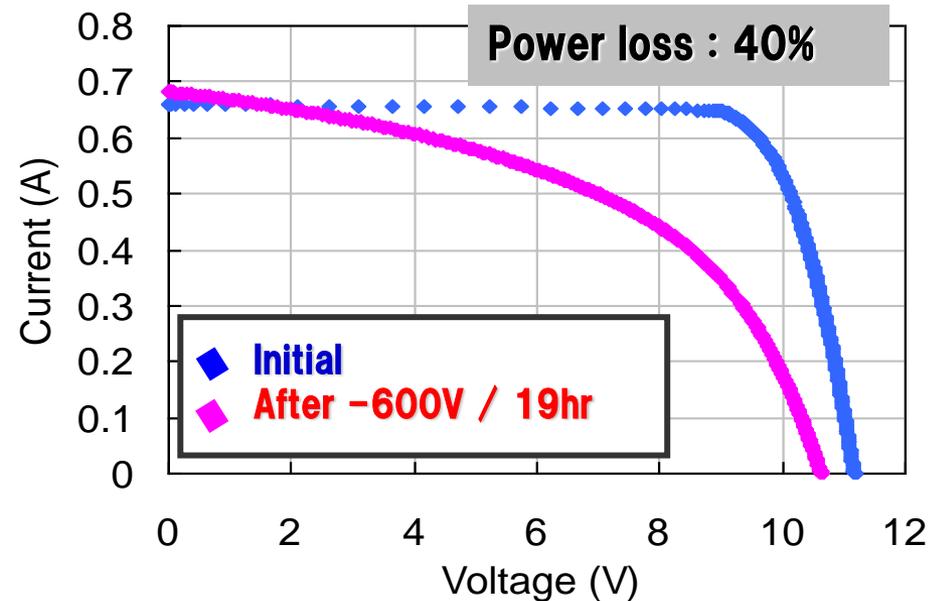
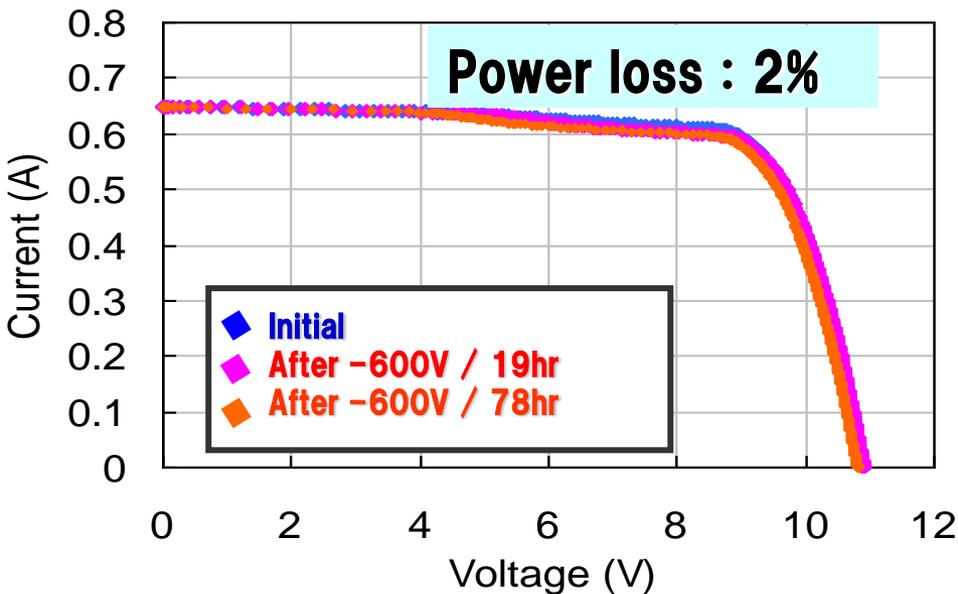
# PID durability test

## PID test condition

- **85°C85% -1000V**
- Cell: 6inch multi-crystalline
- Module : 1 cell

## Measurement of Pmax

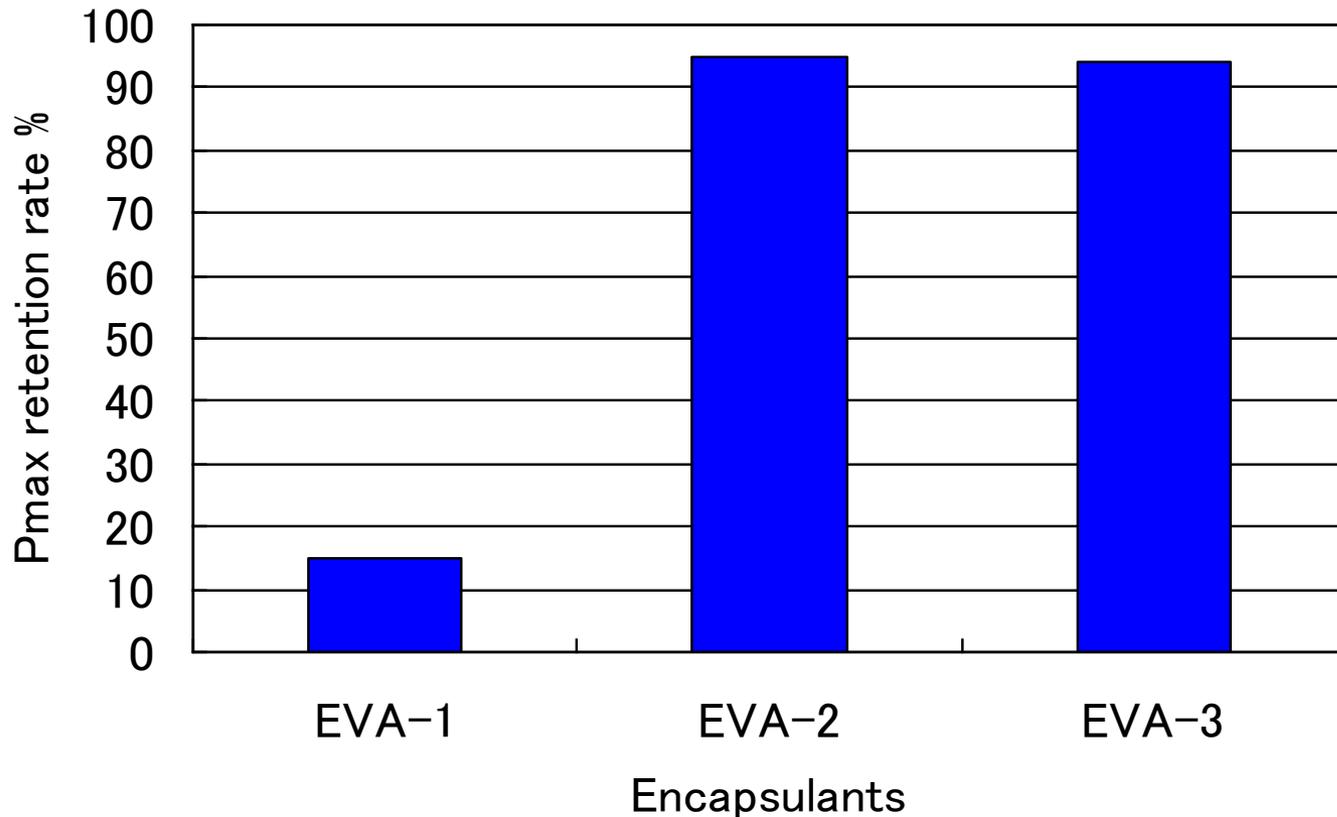
- Irradiance : 1000W/m<sup>2</sup>



**PID prone cell has been selected with EVA-1 encapsulant**

# PID test results

6inch 1cell mini module  
85°C/85%RH, -1kV, 24hr



**EVA-2 and EVA-3 shows better PID durability than EVA-1**

# Ion migration test method

## Test method

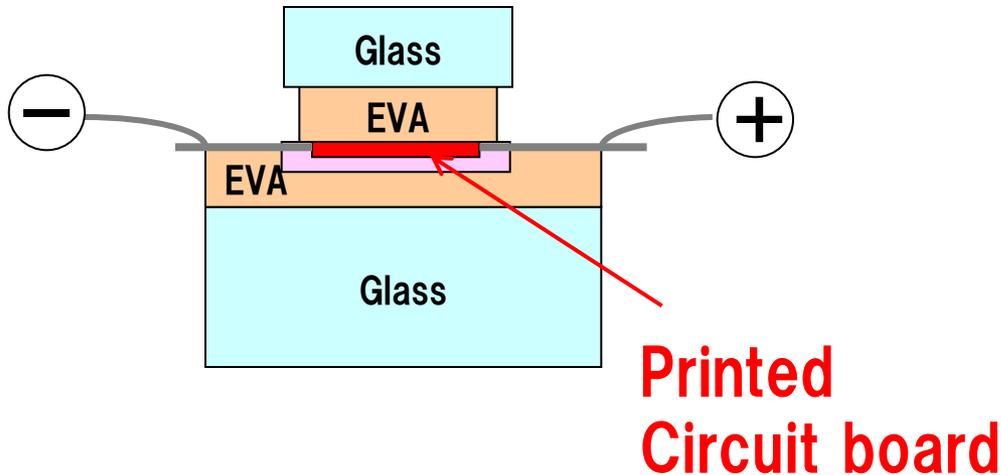
Electrode : Ag printed circuit board

Line/Space : 100um/100um

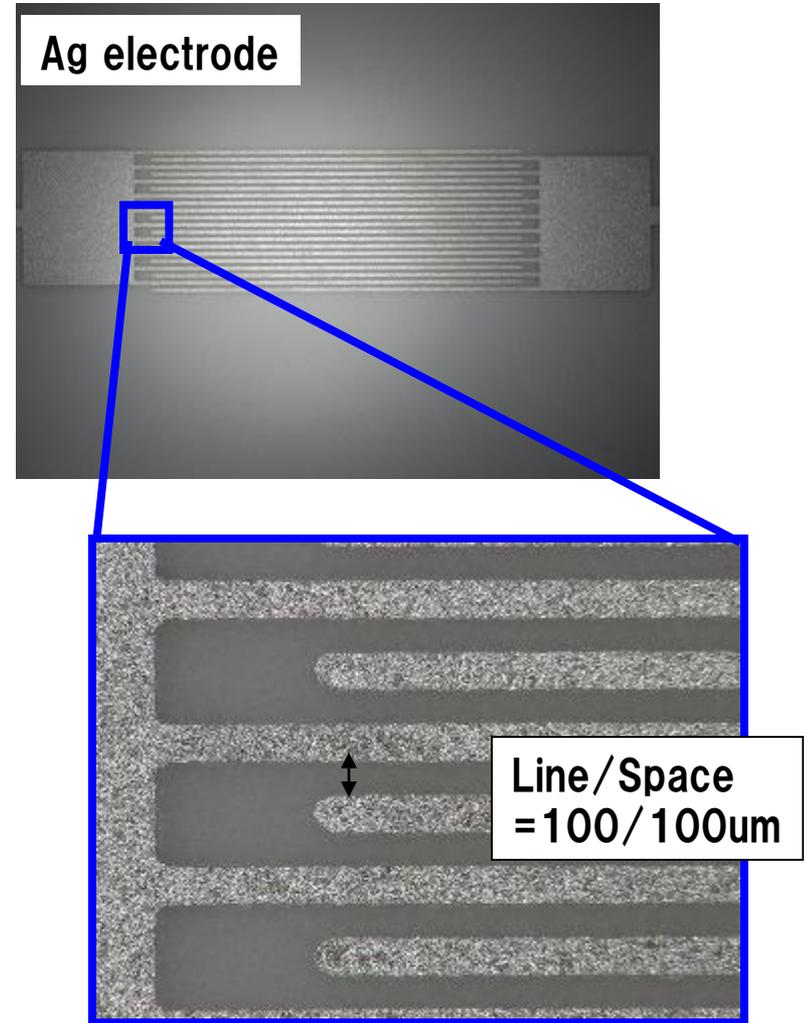
Bias: DC100V

Conditions: 85°C/85%RH

## Sample structure

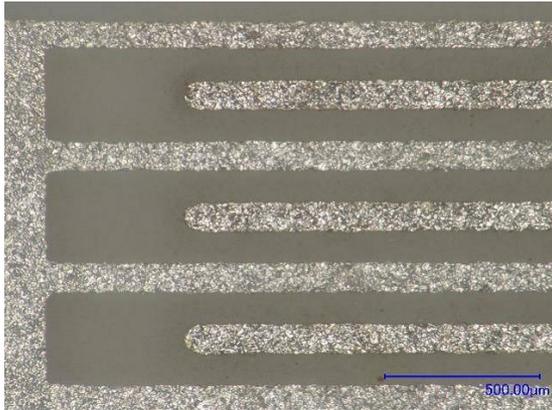


## printed circuit board

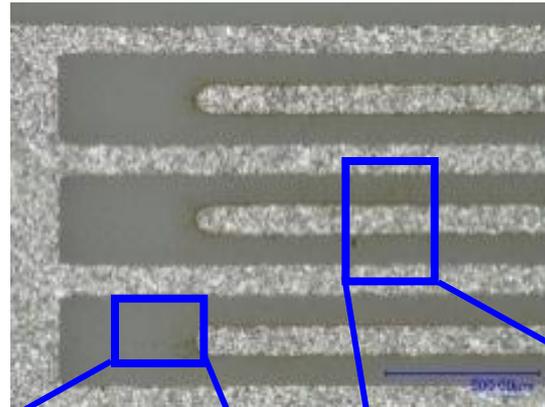


# Ion migration test results (1)

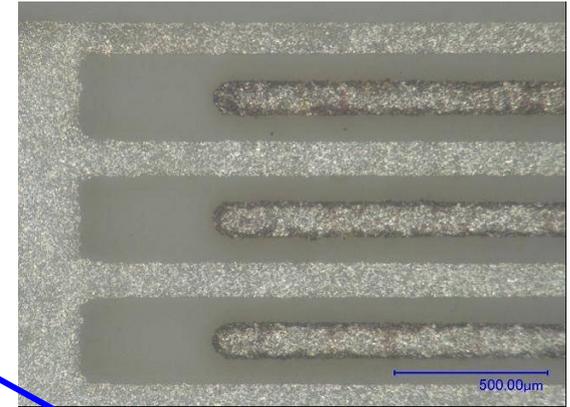
## EVA-1



## EVA-2



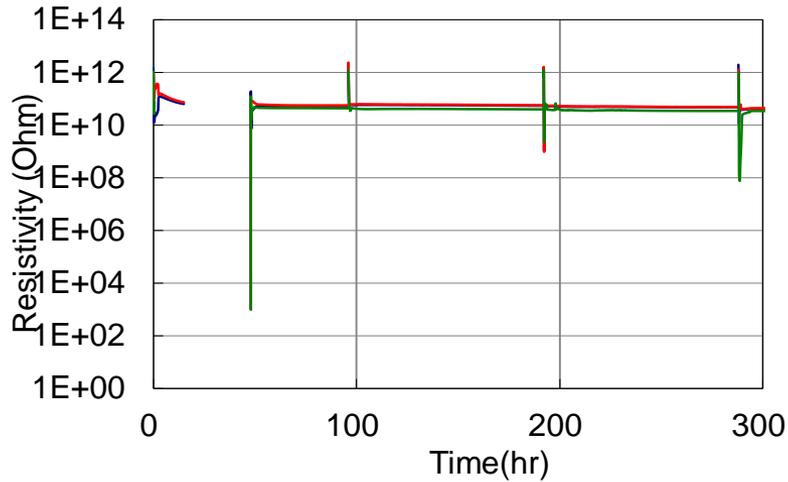
## EVA-3



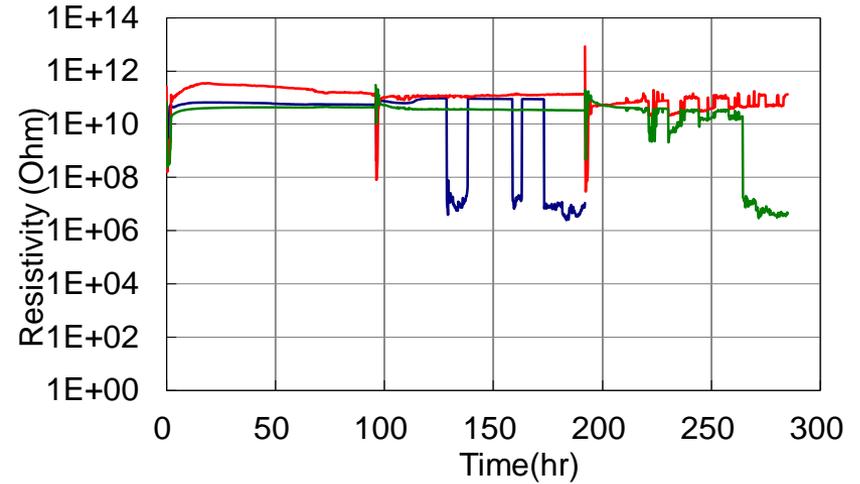
**EVA-2** shows silver dendrite formation between electrodes

# Ion migration test results (2)

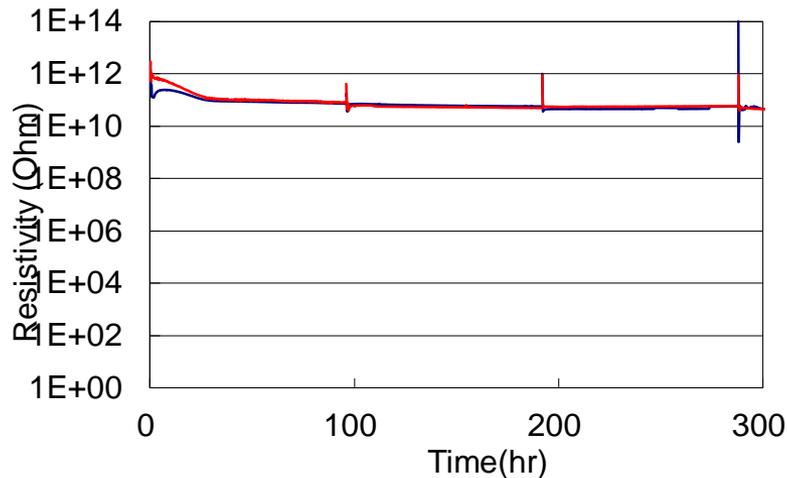
## EVA-1



## EVA-2



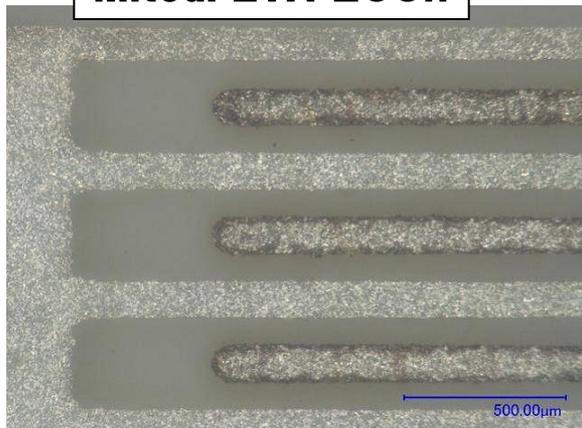
## EVA-3



**EVA-2** shows resistivity break down caused by silver dendrite

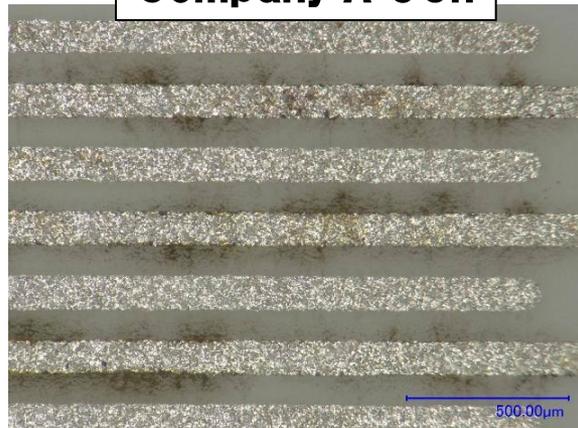
# Ion migration test of various commercial ECP for 300hrs

**Mitsui EVA 288h**



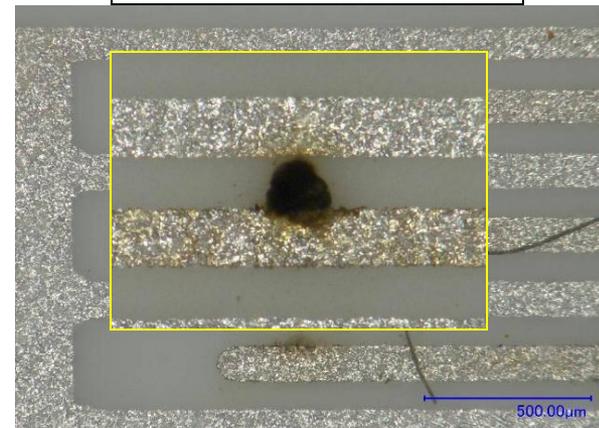
kept initial resistivity

**Company A 96h**



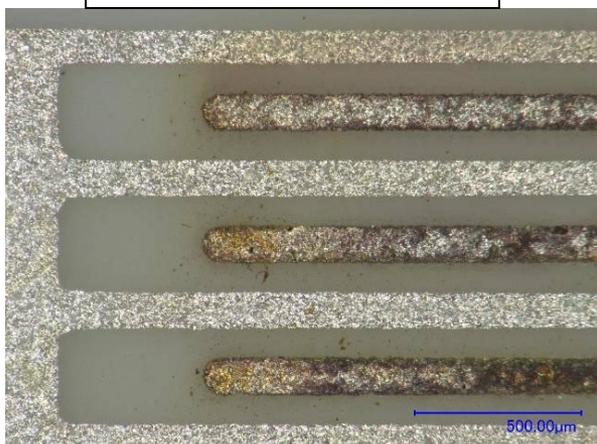
Short-circuited within 100hrs

**Company B 192h**



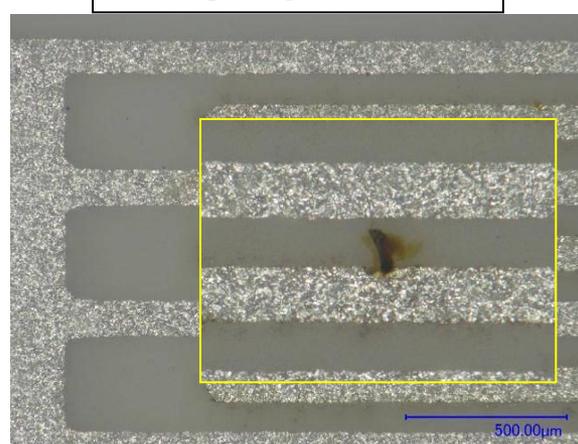
Short-circuited within 300hrs

**Company C 288h**



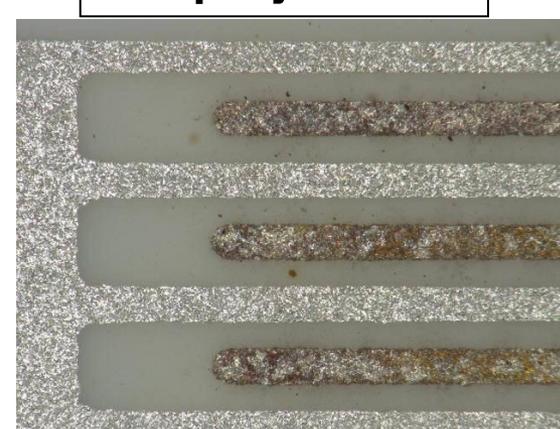
kept initial resistivity

**Company D 288h**



Short-circuited within 100hrs

**Company E 288h**



kept initial resistivity

# Snail track test results<sup>\*)</sup>



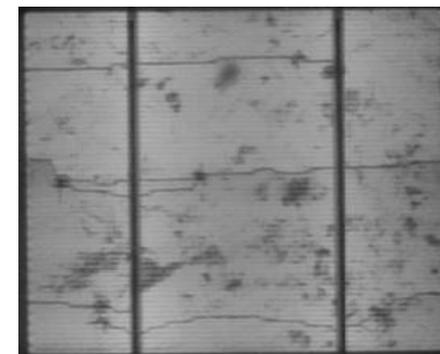
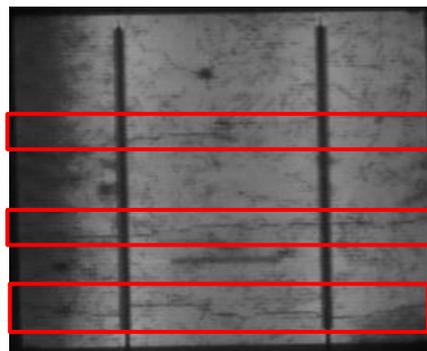
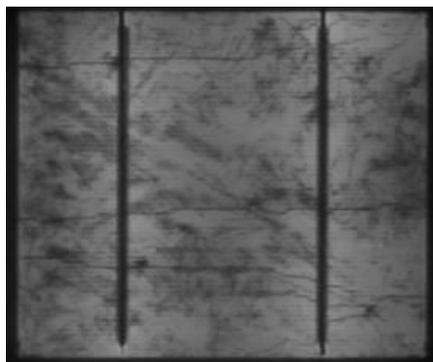
\*) These tests have been done by PI-Berlin

## EVA-1

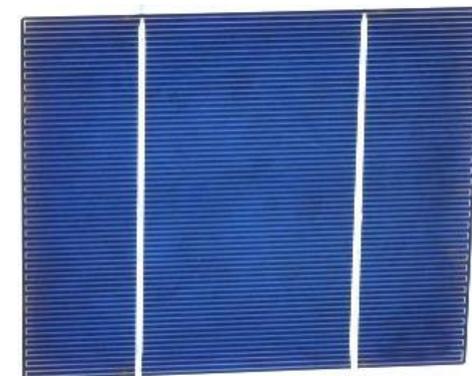
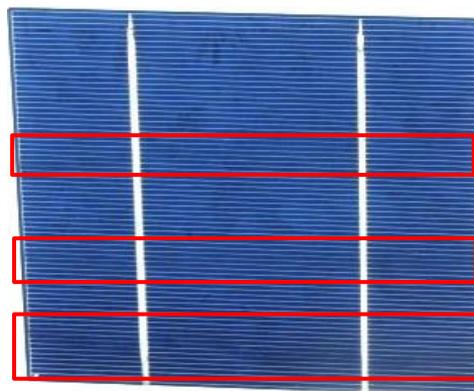
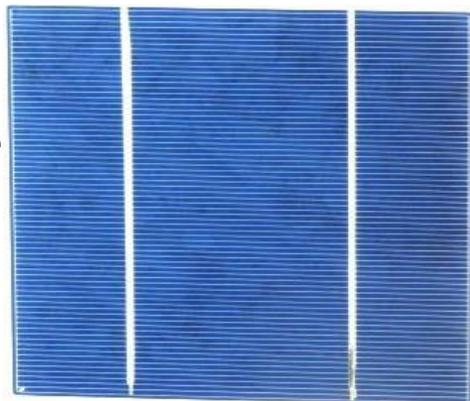
## EVA-2

## EVA-3

EL  
image  
s



Appearance



Snail Tracks are observed on the **EVA-2** module

Mitsui Chemicals Tohcello, Inc.