An examination of the acceleration method of thermal cycling test for crystalline silicon PV modules

Soh Suzuki[1,2], Tadanori Tanahashi[2], Takuya Doi[3] and Atsushi Masuda[3]
[1]Photovoltaic Power Generation Technology Research Association (PVTEC), Japan
[2]ESPEC, Japan, [3]National Institute of Advanced Industrial Science and Technology (AIST), Japan

INTRODUCTION

Background : Though longer service life time is expected for PV modules, existing standards such as IEC 61215, 61730 do not provide the performance assurance in 20 – 25 years. In addition, tests specified in IEC 61215 are not sufficient to guarantee the long-term reliability. Therefore, extension of the test duration and test combination have been implemented in order to ensure long-term reliability.

Purpose : In this study, we have developed the load cycle bending machine with four points and some tests were conducted in order to consider how to accelerate thermal cycling test (TCT).

Fig. 1. Photographs of load cycle bending machine.

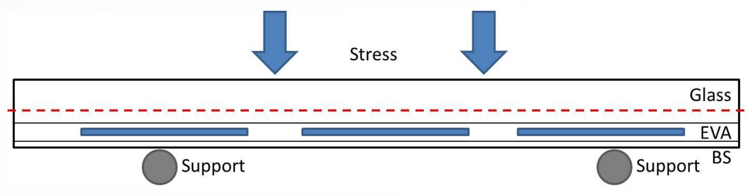


Fig. 2. Images of 4 point stress .

EXPERIMENTS

Table 1. Specifications of materials used in PV module.

Material	Specification	Supplier
Cell	Multicrystalline-Si cell (156 mm × 156 mm)	Q Cells
Glass	Semi-tempered glass	AGC
Encapsulant	EVA (Fast Cure)	Nondisclosure
Interconnector	A-SPS (Leaded, Ag)	Hitachi Cable
Back sheet	Tedlar / PET / Tedlar	Nondisclosure
Size	540 mm × 200 mm × 4 mm	-

Fig. 3. Photograph of PV module sample.

Table 2. Test conditions.

Stress	500 N
Bending / unbending	4 s / 4 s
Bending cycle	10,000 times each test
Temperature	-20℃ / 25℃ / 80℃

SIMULATION

Table 3. Materials properties used in simulation.

Size	540 mm × 200 mm × 4 mm
Young's modulus	73 GPa (7.3 × 10^4 N/mm)
Poisson's ratio	0.21
Specific gravity	2.50 g/cm^3 (2.40 × 10^{-5} N/mm^3)

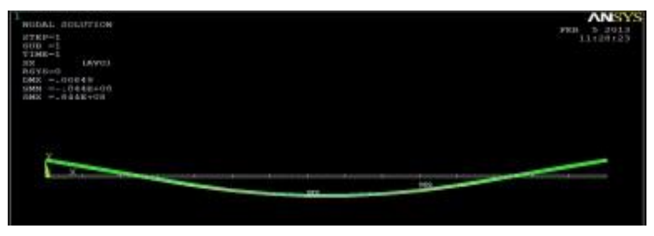


Fig. 4. Results of 4 point bending test.

In order to estimate the suitable stress condition in the load cycle bending test, simulation was made by assuming the property of glass represents those of PV modules. From the results of simulation as shown in Fig.4, the maximum displacement was calculated to 6.2 mm with the stress of 500N.

RESULTS & DISCUSSION

Table 4. Results of 4 point load cycle bending test.

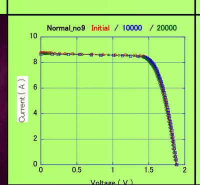
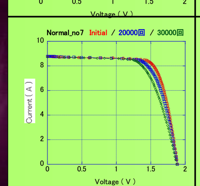
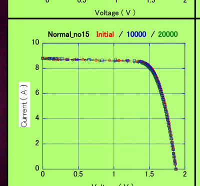
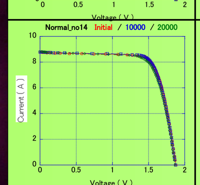
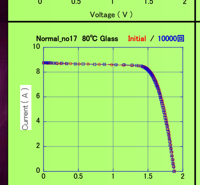
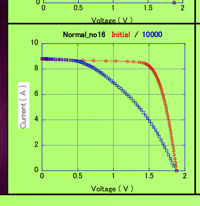
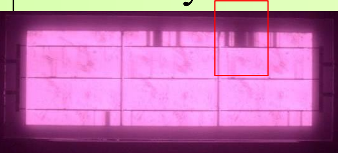
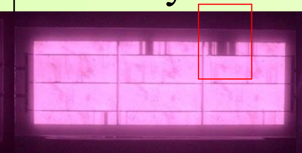
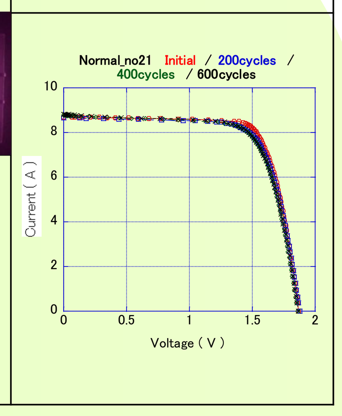
Tem-perature	Stress direction from	EL Initial	After test	I-V	Break point: Cell crack	Break point: Interconnector break
25℃	Glass side 20,000 times				○	×
	BS side 30,000 times				×	○
-20℃	Glass side 20,000 times				○	×
	BS side 20,000 times				○	×
80℃	Glass side 10,000 times				×	×
	BS side 10,000 times				×	○

Table 5. Results of TCT.

	EL Initial	200 cycles	400 cycles	600 cycles	I-V
					
Enlarged view					

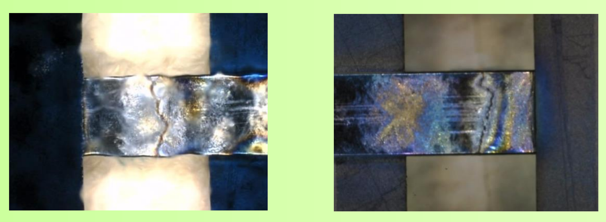


Fig. 5. View from glass side (left) and BS side (right).

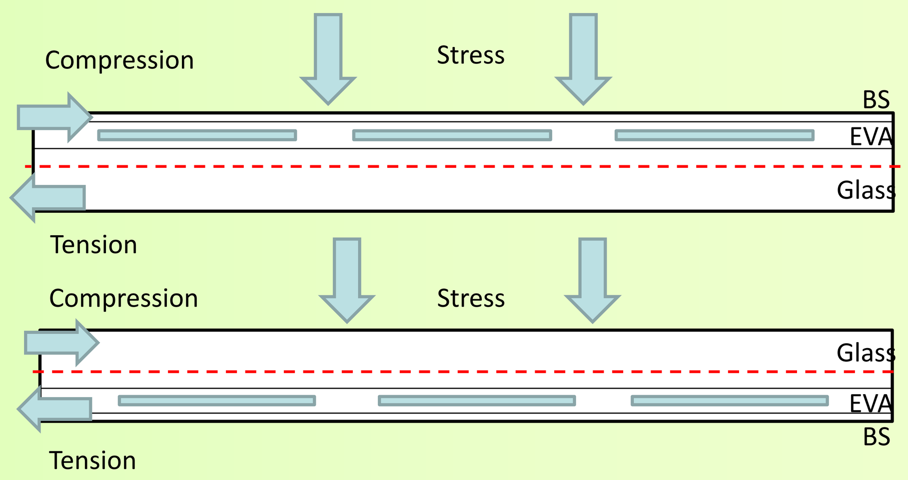


Fig. 6. Image of stress. a) Glass side and b) back side.

1. In case of 25℃, comparison of stress direction → Failure mode was specific, that is, cell crack was observed only in "from glass side" and interconnector break was only in "from BS side". Interconnector break can be confirmed from both side of sample as shown in Fig. 5 by using transparent BS.
2. In case of -20℃ : Only cell crack mode was observed regardless of stress direction. However, the forms were slightly different, that is, cell crack runs vertically to bus bar in "stress from glass side" , on the other hand, it runs diagonally in "stress from BS side". The reason is that EVA's elastic modulus becomes high (stiffer) at -20℃ then the impact from stress transferred strongly to cells, on the other hand, interconnector was subjected lower bending stress.
3. In case of 80℃ : No change was observed in "stress from glass side". The reason is that EVA's elastic modulus becomes low (softer) at 80℃ then the impact from stress was absorbed by EVA. On the other hand, high damage occurs from BS side stress and P_{max} was decreased by 40% since the bending for the interconnector was high.
4. From results of TCT, P_{max} was decreased by about 4% at 200 cycles and decreased slowly thereafter. Cell crack occurred along the bus bar in EL images.
5. The reason for different failure modes between stresses from glass side and BS side is that cell is compressed by BS side stress and receives tension by glass side stress, as shown in Fig. 6.

SUMMARY

In this study, it was found that failure mode is different between TCT and load cycle bending tests. It was possible to accelerate open mode failure in load cycle bending test. Combination of TCT and load cycle bending test seems effective for acceleration.

Contact Person : Soh Suzuki (so-suzuki@espec.co.jp)

This work was supported by New Energy and Industrial Technology Development Organization under Ministry of Economy, Trade and Industry, Japan.