

SEMI PV84-0818

TEST METHOD FOR POLYMER FOIL DEPENDENT DISCOLORATION OF SILVER FINGERS ON PHOTOVOLTAIC MODULES

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1 Purpose

1.1 The purpose of this Standard is to standardize the accelerated evaluation method for discoloration of silver fingers on photovoltaic (PV) modules. The test is performed with designed mini module in a pressure cooker with moisture condensing or moisture saturated steam environment.

1.2 Pressure cooker test (PCT) is a highly accelerated test which employs high pressure, humidity and temperature under condensing conditions to accelerate moisture penetration into laminated mini modules.

1.3 The PV polymer foil suppliers, PV module manufactures and buyers, or any other party interested, can thus have common standards to test and select PV encapsulation materials for PV modules efficiently.

2 Scope

2.1 This test is used to evaluate the susceptibility and occurrence of discoloration of PV finger metallization. The influence of encapsulation materials used in PV modules such as ethylene-vinyl acetate (EVA), back sheet polymer foil or any other materials that protect crystalline Si cells in PV modules can be tested with this method.

2.2 Some cautions should be considered when performing this test and evaluating test results. Failure mechanisms, both internal (e.g., due to embrittlement of PET) and external (e.g., moisture ingress from non-sealed edge), may be produced which are not applicable to the intended application use conditions.

2.3 This Standard defines the specific testing methods, testing conditions and evaluation method for PV polymer foils.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Standard does not predict the lifetime of PV modules.

3.2 This Standard is not to completely simulate extended Damp Heat test.

4 Referenced Standards and Documents

4.1 None.

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *CMYK* — cyan, magenta, yellow, key

5.1.2 *c-Si* — crystalline silicon

5.1.3 *EVA* — ethylene-vinyl acetate

5.1.4 *PCT* — pressure cooker test

5.1.5 *PV* — photovoltaic

5.1.6 *RGB* — red, green, blue

5.1.7 *RH* — relative humidity (%)

6 Summary of Test Method

6.1 The sample is prepared by the conventional solar module lamination process, which is the sandwich of glass/encapsulant/solar cell/encapsulant/polymer foil (back sheet). Figures 1 and 2 show the cross-sectional image and the overview of a single-cell-laminate. For each test with different encapsulation materials, three samples are suggested to be prepared, in which one is reference sample and another one is testing sample.

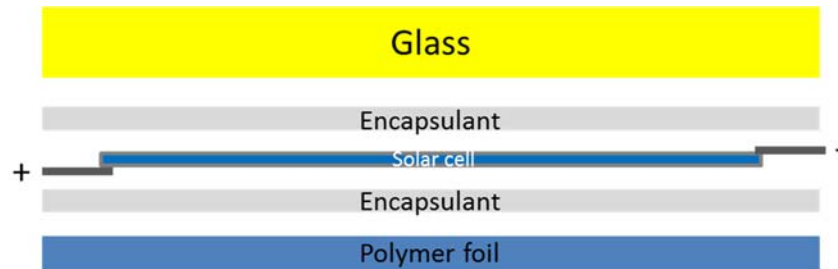


Figure 1
Section View of a Mini Module

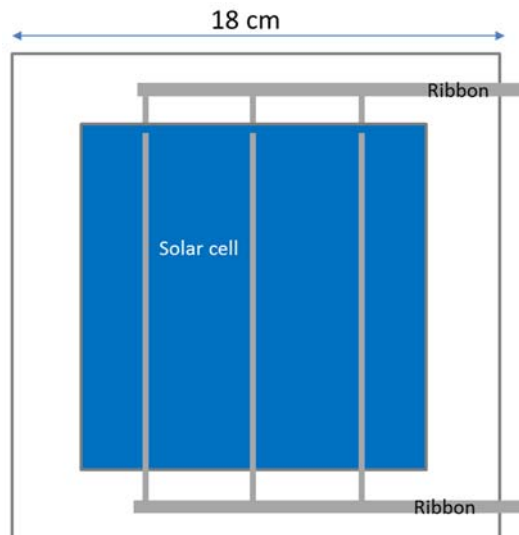


Figure 2
Schematic of a Laminated Mini Module

7 Apparatus

7.1 Reliability Tests

7.1.1 *Pressure Cooker Apparatus* — A testing chamber which is used to age the sample of interest.

1. A pressure cooker with automatic temperature and humidity control, capable of subjecting one or more samples to the test condition specified in Table 1.
2. Means for mounting or supporting the module(s) in the chamber, so as to allow free circulation of the surrounding air. The thermal conduction of the mount or support shall be low, so that, for practical purposes, the module(s) is (are) thermally isolated.
3. Means for measuring and recording the module temperature to an accuracy of $\pm 1^\circ\text{C}$. (It is sufficient to monitor the temperature of one representative sample, if more than one sample is being tested.)

7.2 Analytical Tools for Post-Treatment

7.2.1 *Light Microscope* — A device which is used to check color of silver fingers in microscopic detail.

7.2.1.1 The magnification should be at least (50~100) fold and the image resolution should be 72 dpi or better.

7.2.2 *Degree of Discoloration* — A software which is able to quantify the image colors within a region of interest (i.e., grid fingers). The result should be given as red, green, blue (RGB) or cyan, magenta, yellow, key (CMYK) values.

8 Procedure

8.1 The measured performance result of PCT for PV modules is highly responsive to the encapsulation method of mini modules. A reasonable evaluation result requires the same encapsulation scheme that has been shown in § 6. The details of the color quantification after PCT should be clearly described in the report. Figure 3 shows the testing procedure for the PCT test and color evaluation.

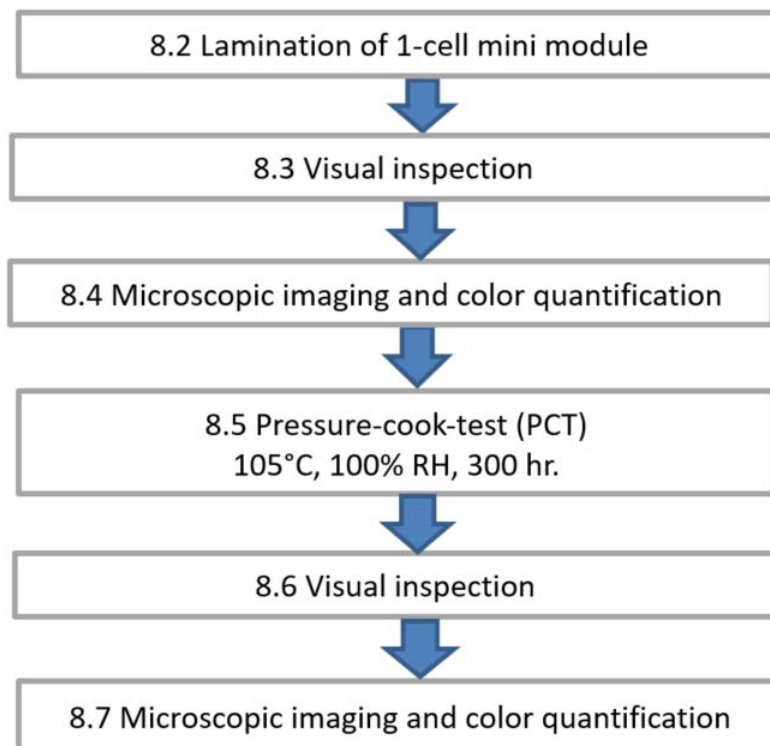


Figure 3
Testing Procedures

8.2 Lamination of One-Cell Mini Module

8.2.1 To laminate the module in order of glass/encapsulant/solar cell/encapsulant/polymer foil (back sheet).

8.3 Visual Inspection

8.3.1 Check and document (photo) the overall status of the mini module: back sheet, glass, contacts, delamination.

8.4 Microscopic Imaging and Color Qualification

8.4.1 The rationale behind the analysis is the finding that the discoloration known as snail trails occurs at cell edges or cell cracks where water can reach the cell surface due to diffusion. In the test suggested here, no intentional cracks are needed. Instead, just the edges of the one-cell-module are inspected carefully. Therefore, the following procedure describes the microscopic analysis of grid finger discoloration at the cell edges compared to a position at the center of the cell which should remain unaffected throughout the testing period. Optical observations such as microscope or