

SEMI PV58-0115

SPECIFICATION FOR ALUMINUM PASTE USED IN BACK SURFACE FIELD OF CRYSTALLINE SILICON SOLAR CELLS

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1 Purpose

1.1 This Specification covers the requirements for aluminum paste (hereafter referred to as Al paste) used in back surface field of crystalline silicon solar cells.

1.2 This Specification provides common characteristics of Al paste based on currently widely used for photovoltaic applications. And this Specification also includes requirements for Al paste after firing.

2 Scope

2.1 This Specification covers the common characteristics of Al paste, including but not limited to appearance, granularity, solids percentage, viscosity; and the requirements of Al paste after firing, including but not limited to adhesion test, bowing test and hot water test.

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 Upon agreement between user and supplier, other additional Al paste property tests than those stated in this Standard can be added into incoming quality test.

3.2 In case of nonconformance of the requirement stated in this Standard or supply agreement, user shall provide feedback to supplier within 30 days after receiving paste.

4 Referenced Standards and Documents

4.1 IEC Standard¹

IEC 61215 — Crystalline Silicon Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Refer to the SEMI International Standards Compilation of Terms (COTs) for a list of the current Abbreviations, Acronyms, Definitions, and Symbols.

5.2 Abbreviations and Acronyms

5.2.1 *BSF* — back surface field

5.2.2 *EVA* — ethylene-vinyl acetate thin film

5.2.3 *FOG* — fineness of grind (same as granularity)

5.2.4 *TPT* — Tedlar-PET-Tedlar thin film

5.3 Definitions

5.3.1 *adhesion* — aluminum layer adhesion with silicon bulk for Al paste after firing.

¹ International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211 Geneva 20, Switzerland. Telephone: 41.22.919.02.11; Fax: 41.22.919.03.00; <http://www.iec.ch>

5.3.2 *solids percentage* — weight of sample after firing divided by weight of sample.

6 Test Methods

6.1 *Appearance*

6.1.1 Al paste to be checked is stirred in as received container by using a spatula properly for 2 minutes. Then the visual inspection is carried out.

6.2 *Solids Percentage Test*

6.2.1 This Test Method covers measurement of the weight percentage of solid in Al paste by determine of mass difference between the Al paste before and after firing.

6.2.2 *Test Procedure*

6.2.2.1 After mixing the paste properly, place 0.5~1.0 g Al paste sample into the tared porcelain crucible. Measure the Al paste weight using analytical weighing scale, and record as W_0 rounded to 0.001 g.

6.2.2.2 Place the porcelain crucible with Al paste sample into first box oven at $150^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 30 minutes, and then move into second box oven, which is preheated to temperature of $500^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for another 30 minutes. Finally remove from second box oven and cooling down to room temperature in a desiccator.

6.2.2.3 Measure the total weight of porcelain crucible with Al paste sample using analytical weighing scale again, and record the Al paste weight W_t accurate to 0.001 g.

6.2.2.4 *Calculation*

6.2.2.4.1 Solids percentage X% is calculated using equation below:

$$X\% = W_t / W_0 \times 100\% \quad (1)$$

where:

W_t = Al paste weight after firing.

W_0 = Al paste weight before firing.

6.2.2.4.2 Determine the Al paste solids percentage according to above equation, round to 0.01%. Report the solid content using average of three parallel sample results. The absolute difference value between solids percentage of three parallel samples shall be less than 1%.

6.3 *FOG Test*

6.3.1 This Test Method covers measurement of the FOG of Al paste. Al paste to be checked is spread uniformly by drawing a straight-edged scraper from the deep end to the shallow end of the fineness gauge's path. Particles or agglomerates too large to pass between the moving scraper and the gage path are revealed as 'scratches' or 'points', where these occur is read directly on the calibrated gage shoulder. This Test Method is applicable to any dispersion that is fine enough to fall within the 0 to 50 μm range of the specified fineness gauge.

6.3.2 *Test Procedures*

6.3.2.1 Place the fineness gauge on the horizontal table. After mixing the Al paste properly, place the Al paste in the deep end of the fineness gauge's path, so that it overflows the path slightly. When using the double-path fineness gage, place the Al paste in both paths.

6.3.2.2 Holding the scraper in both hands, nearly vertical but inclined slightly toward the operator; draw down the Al paste from the length of the path toward the shallow end of the fineness gage with a uniform, brisk motion approximately in 3 s. Or use machine to draw down the Al paste from the fineness gauge's path as same method. Exert upon the scraper only sufficient pressure to clean excess material from the face of the fineness gage. Make a reading as suggested in § 6.3.3.

6.3.3 *Readings*

6.3.3.1 Streaks will be seen in the reading if particles are present. Observe the scratch where it starts to appear.

6.3.3.2 Toward light ray to observe the fineness gage from its side at an angle of 20 to 30 degrees approximately in 3 s. Record the depth where second longitudinal continuous scratch starts to appear on the fineness gage. Report reading to the nearest bigger scale.

6.3.3.3 The sample measurement shall be tested three times. If the range of three readings is not more than $2.5\ \mu\text{m}$, then record the average of three readings as the result. If the range of three readings is greater than $2.5\ \mu\text{m}$, another sample shall be retest until readings meet above requirement. FOG result takes three significant figures.

6.4 Viscosity Test

6.4.1 This Test Method covers the determination of the apparent viscosity of Al paste by rotational viscometer (Brookfield viscometer or equivalent). The Al paste viscosity is determined by measuring the torque on the cone or spindle at a constant rotation speed in the material at controlled temperature. There are two test procedures as follows.

6.4.2 Test Procedure 1

6.4.2.1 Calibrate the rotational viscometer such as Brookfield CAP2000+ with CAP-8 or other suited cone and plate following equipment calibration procedures, with measurement error of the rotational viscometer being less than $\pm 1\%$ in the full scale range, and repeatability of torque being less than $\pm 0.2\%$.

6.4.2.2 Maintain the cone and plate at temperature within $25^\circ\text{C} \pm 0.5^\circ\text{C}$. Place about 1 g paste uniformly on the center of the plate, and load the plate onto the equipment. Upon sample loading onto the viscometer, maintain the sample motionless for 5 s, and then step by step rise the rotate rate to 9 rpm at the shear rate of $18\ \text{s}^{-1}$. Record the reading of viscosity after rotating of 30 s.

6.4.2.3 Repeat viscosity measurement using two parallel samples, and then average the two measurement results. The absolute difference between viscosities of two parallel samples shall be less than 3%.

6.4.3 Test Procedure 2

6.4.3.1 Calibrate the rotational viscometer such as Brookfield HBT with CP-51 or other suited spindle following equipment calibration procedures, with measurement error of the rotational viscometer being less than $\pm 1\%$ in the full scale range, and repeatability of torque being less than $\pm 0.2\%$.

6.4.3.2 Maintain the small sample adapter at temperature within $25^\circ\text{C} \pm 0.5^\circ\text{C}$. Load the cup with a well, but gently, mixed sample so that when the spindle is inserted in the cup, the level will rise to the top of the cup but not above. In no case should the level be below the small ridge, which is 1/8 inch above the top of the bob. Be sure there are no air bubbles or voids in the sample as this will result in false readings. Assemble the cup and spindle to the viscometer. The sample has to reach the correct temperature. If no incubator can be used, wait 5 to 10 minutes in the water bath.

6.4.3.3 Set the speed control knob to the speed indicated at 5 rpm. Start the viscometer and observe the reading after 5 minutes. Then back down to 2.5 rpm at the shear rate of $9.6\ \text{s}^{-1}$. Record the reading of viscosity after rotating of 1 minute.

6.4.3.4 Repeat viscosity measurement using two parallel samples, and then average the three measurement results. The absolute difference between viscosities of two samples shall be less than 3%.

NOTE 1: Test Procedure 1 or 2 is carried out according to agreement between users and suppliers.

6.5 Peel Strength Test

6.5.1 This Test Method covers measurement of the peel strength of Al paste by determining the force needed to peel the aluminum layer away from solar cell substrate.

6.5.2 Prepare a piece of glass, two pieces of encapsulant films (such as EVA) and a piece of backsheet (such as TPT). This encapsulation materials combination should be certificated according to IEC 61215. Lay the above materials and the solar cells from the bottom up in this order: glass, EVA, solar cell (BSF upward), EVA, TPT (see Figure 1).

6.5.3 Follow normal module manufacture process to laminate the solar cells to a module, cooling and stabilize the module to room temperature for 12 h after lamination. Then, cut the TPT into $1\ \text{cm} \times 30\ \text{cm}$ strips.

6.5.4 Separate the TPT and solar cells by manual for a length of about 2 cm and bend the TPT backward 180 degrees to parallel to the BSF (see Figure 2). Fix the sample on to the test device, and pull the TPT away from the substrate at a speed of 120 mm/min. Record the average force applied on the TPT peeled away for a 10 cm length. Average the peel force collected on at least two sample strips ($10\ \text{cm} \times 2$) as the peel strength.