



IPC-TM-650 TEST METHODS MANUAL

1 Scope To determine the tensile strength in Mpa (PSI) and the elongation, in percentage, of electrodeposited copper plating at ambient temperatures by mechanical force testing.

2 Applicable Documents

ASTM E-345 Standard Test Methods of Tension Testing of Metallic Foil

IPC-TM-650 IPC Test Methods Manual

1.7 Reporting, Invalid Test Results

3 Test Specimen

3.1 Plated copper samples prepared in sheet form for cutting or etching into the appropriate pattern, or pattern plating of the appropriate form.

3.2 Samples may be in the form of strips of 13 mm x 152 mm [0.512 in x 5.98 in] or in the form of "dogbone" samples as described in ASTM E-345, Type A. The thickness of the samples 0.05 mm to 0.1 mm [0.00197 in to 0.00394 in]. Testing shall be performed on ten samples (five lengthwise and five crosswise). Specimens must be wrinkle free, clean cut, and free of burrs and nicks.

4 Apparatus or Material

4.1 Constant strain rate tensile tester capable of pulling at rate of 0.05 mm/mm to 0.5 mm/mm [0.00197 in/in to 0.0197 in/in] per minute of the length of the reduced section (or the distance between the grips for straight sided specimens).

4.2 Sample preparation equipment

4.3 Sample Size: 13 mm wide X 150 mm [0.512 in wide x 5.91 in long].

4.4 A sample cutter capable of cutting samples to the appropriate size (see 6.1).

4.5 A phototool of tensile specimen of the appropriate size (strip or dogbone).

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4.6 Stainless steel panel, type 304 or 321, 300 mm X 300 mm [11.8 in x 11.8 in] or of a size identical to that used to produce plated product. The panel surface must be free of pits, nicks, and scratches. Low carbon stainless steel performs best.

4.7 Weighing balance capable of resolving to 1 mg.

4.8 Precision linear measuring device capable of measuring to the nearest 0.025 mm [0.000984 in].

4.9 Precision micrometer capable of measuring to the nearest 0.0025 mm [0.0000984 in].

4.10 An oven capable of maintaining 125 °C ± 5 °C [257 °F ± 9 °F].

5 Procedure

5.1 Samples Preparation Samples may be prepared using the phototool Method 5.1.1 or the cut Method 5.1.2.

5.1.1 Phototool Method

5.1.1.1 Clean the stainless steel panel using a standard acid or alkali cleaner (preferably reverse current) and verify by performing water-break test to insure cleanliness.

5.1.1.2 Apply negative resist to stainless steel plate.

5.1.1.3 Image plate with phototool and develop image using any acceptable method.

5.1.1.4 Inspect image for integrity.

5.1.1.5 Plate the imaged panel with a current density equivalent to production current density to a thickness of 0.05 mm to 0.1 mm [0.00197 in to 0.00394 in].

5.1.1.6 Rinse and dry plate.

5.1.1.7 Remove specimens from the stainless steel by lifting a corner of the sample with a knife or razor exercising care not to bend or in any way damage the sample.

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5.1.1.8 Inspect samples and discard those with nicks or pinholes in the gage length. Specimens should be smooth and undistorted without scratches from the plate in the gage length.

5.1.2 Cut Method

5.1.2.1 Clean the stainless steel panel using a standard acid or alkali cleaner (preferably reverse current) and verify by performing a water-break test to insure cleanliness.

5.1.2.2 Plate the panel with a current density equivalent to production current density to a thickness of 0.05 mm to 0.1 mm [0.00197 in to 0.00394 in].

5.1.2.3 Remove the copper from the stainless steel by lifting a corner of the sample with a knife or razor exercising care not to bend or in any way damage the sample. Cut away and discard the outside 2.5 cm [0.984 in] of the border of the sample.

5.1.2.4 Cut the specimens (five lengthwise and five cross-wise) using the sample cutter. Samples shall be smooth, undistorted (wrinkle free), and free of pinholes, nicks, and scratches.

5.2 Pre-Test Bake Bake all specimens at 125 °C ± 5 °C [257 °F ± 9 °F] for four - six hours, then allow the samples to cool to room temperature.

5.3 Test

5.3.1 Mark Gage Mark or otherwise note a 50 mm [1.97 in] gage length to the nearest 0.01 mm [0.000394 in].

5.3.2 Weighing Samples Weigh tensile sample to at least the nearest milligram (0.001 gm). Record the weight and calculate the mean average cross-sectional area. Note: The density of electrodeposited copper is 8.909 g/cc or 8909 g/mm³.

Mean average thickness in millimeters =

$$\frac{\text{Weight of tensile sample in grams}}{\text{Area of tensile sample in mm}^2 \times \text{density of copper in g/mm}^3}$$

Mean average cross-sectional area in mm² =

$$\frac{\text{Weight of tensile sample in grams}}{\text{Length of tensile sample in mm} \times \text{density of copper in g/mm}^3}$$

5.3.3 General Test Information If the tensile tester is equipped with an area compensator, dial the mean average cross-sectional area into it. If not, then the cross-sectional area has to be used to compute the tensile strength.

Note:

$$\text{Tensile Strength (Pa)} = \frac{\text{Maximum Load (N)}}{\text{Mean average cross-sectional area (m}^2\text{)}}$$

or

$$\text{Tensile Strength (Mpa)} = \frac{\text{Maximum Load (N)}}{\text{Mean average cross-sectional area (mm}^2\text{)}}$$

or

$$\text{Tensile Strength (psi)} = \frac{\text{Maximum Load (lbf)}}{\text{Mean average cross-sectional area (in}^2\text{)}}$$

To convert psi to Pa multiply by 6.895 X 10³.

To convert psi to MPa multiply by 6.895 X 10⁻³.

5.3.3.1 If the tensile tester is equipped with area compensator, after the test is complete, the Tensile Strength can be read directly from the chart.

5.3.3.2 Select an appropriate load range on the tensile tester so that the expected force is within the acceptable load range for the cell.

5.3.3.3 Place the sample in the jaws of the Tensile Tester being careful that it is properly centered and the axis aligned with the jaws.

5.3.4 Test Conditions

5.3.4.1 Gage length: 50 mm [1.97 in]

5.3.4.2 Cross Head Speed: 0.05 mm/mm to 0.5 mm/mm [0.00197 in/in to 0.0197 in/in] per minute of the length of the reduced section or the distance between the grips for straight sided specimens.

5.3.4.3 Chart Speed: 500 mm/min [19.7 in/min]

5.3.5 Evaluation

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5.3.5.1 Activate cross head to break sample and make calculations of tensile strength in Mpa and elongation in %.

5.3.5.2 Percent elongation may be determined by fitting the ends of the fractured specimen together carefully and measuring the distance between the original gage marks to the nearest 0.25 mm [0.00984 in]. Elongation is the increase in length of the gage length, expressed as a percentage of the original gage length.

Percent elongation =

$$\frac{\text{length at break} - \text{original gage length}}{\text{original gage length}} \times 100$$

5.3.5.3 Average all five elongation readings. See IPC-TM-650, Method 1.7, for information about discarding invalid results.

6 Notes

6.1 The JDC-50 sample cutter has been found suitable for cutting specimens to the appropriate dimensions. This cutter is manufactured by Thwing-Albert Instrument Co., 10960 Dutton Road, Philadelphia, PA 19154. (215-637-0100)