

# IPC-TM-650

## TEST METHODS MANUAL

|                                                                                                                                                               |          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Number<br>2.2.23                                                                                                                                              |          |
| Subject<br>3-D Surface Laser Imaging and Measurement                                                                                                          |          |
| Date<br>09/2026                                                                                                                                               | Revision |
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| Originating Task Group:<br>Metallic Foil Task Group (3-12a)                                                                                                   |          |

**1.0 PURPOSE** This procedure establishes proper methods and practices for quantifying the areal surface topography/texture of metallic foil using a noncontact, 3-D surface measurement device. The primary reported values will include Sa, Sq, Sz, Sdr, Ssk, Vmc (refer to 7.2) and other relevant measured spatial and functional volume parameters.

### 2.0 APPLICABLE DOCUMENTS

#### 2.1 IPC

**IPC-4562** Metal Foil for Printed Board Applications

#### 2.2 International Standards

**ISO 16610** Geometrical Product Specifications (GPS) – Filtration

**ISO 25178-2** Surface Texture: Areal – Part 2: Terms, Definitions and Surface Texture Parameters

### 3.0 METALLIC FOIL SAMPLE PREPARATION

**3.1** Samples tested **shall** be as received foil taken from a representative location of metallic foil. The sample size of the foil **shall** be no larger than the fixture used to mount the sample. Specific sample orientation (machine or cross direction) is not required.

**3.2** Samples **shall** be tested as is, but proper care must be taken to prevent scratches, dents, or bending to ensure the integrity of the surface. Operators of the measurement machine **shall** follow the recommended manufacturers' recommendation for sample fixturing and measurement.

### 4.0 EQUIPMENT/ENVIRONMENT

**4.1** A non-contact 3D laser imaging and measurement machine **shall** be used. The machine must be equipped with a laser with a wavelength between 325 and 410 nm. The equipment **shall** be capable of being calibrated in accordance with section 5 procedure, and testing foil samples in accordance with section 6 of this procedure.

Example of non-contact 3D laser machines capable of meeting this method's requirements are:

Evident OLS-4100, Keyence VK-X3100 or equivalent.

**4.2** The measurement machine **shall** be installed in accordance with the manufacturer's recommendations to minimize outside environmental interference such as vibration.

**4.3** A Rubert roughness standard, model KB-RS529 (Ra: 0.1µm), is required for machine calibration.

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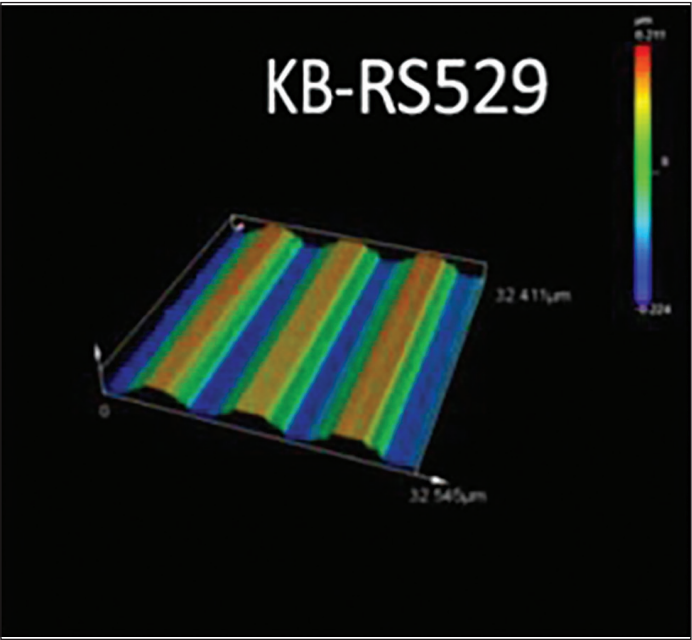
5.0 CALIBRATION PROCEDURE FOR A MACHINE WITH RUBERT STANDARD SPECIMEN

5.1 The operator **shall** program the machine to measure an area from 4,000 to 5,000 square microns with a length to width aspect ratio close to 1:1, The measurement magnification **shall** be between 150 to 200X (Lens NA  $\geq$  0.95) for measuring the areal surface roughness Sa of the Standard. The wavelength of the laser **shall** be shorter than 410 nm.

Appearance of a Rubert roughness standard, model KB-RS529



Representative 3D laser images of the Rubert roughness standard, model KB-RS529.



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## 5.2 Measurement Procedure of the Rubert Standard

Recommended measurement conditions:

|                       |               |                           |          |
|-----------------------|---------------|---------------------------|----------|
| Machine Type          |               | OLS-4500                  | VK-X3100 |
| Laser Wavelength (nm) |               | 405                       | 404      |
| Measurement Settings  | Lens          | X 100                     | X 100    |
|                       | Digital Zoom  | X 2                       | X 1.5    |
|                       | Magnification | X 200                     | X 150    |
| Measurement Areas     |               | 4 areas: 64µm x 64µm each |          |
| Filter                |               | None*                     |          |

\*Adjust noise removal and tilt correction prior to measurement.

Five measurement locations on the Rubert Standard **shall** be made. The five coordinate locations (X,Y), from the top left corner of the standard are:

- A. 4 mm, -5 mm
- B. 6 mm, -5 mm
- C. 15 mm, -13 mm
- D. 17 mm, -13 mm
- E. 27 mm, -21 mm

At each of the five locations, four measurements in adjacent areas of 64 µm × 64 µm **shall** be made in the following array:

|   |   |
|---|---|
| 1 | 2 |
| 3 | 4 |

## 5.3 Data Analysis

To obtain the measured Sa value, first calculate the average of the values measured in the four adjacent areas at each of the five coordinate locations (A through E). Then use the average of the values attained at the five coordinate locations to determine the value for the standard.

Example: Sa measurement and analysis on a Rubert Standard, model KB-RS529, with a calibration certificate of Ra=0.102 µm.

|                  |   | Sa (µm)                         |       |       |       |       |
|------------------|---|---------------------------------|-------|-------|-------|-------|
|                  |   | Measurement Coordinate Location |       |       |       |       |
|                  |   | A                               | B     | C     | D     | E     |
| Measurement Area | 1 | 0.102                           | 0.100 | 0.109 | 0.107 | 0.108 |
|                  | 2 | 1.101                           | 0.098 | 0.108 | 0.107 | 0.108 |
|                  | 3 | 0.099                           | 0.099 | 0.109 | 0.107 | 0.111 |
|                  | 4 | 0.101                           | 0.098 | 0.18  | 0.107 | 0.110 |
| Area Average     |   | 0.101                           | 0.099 | 0.109 | 0.107 | 0.109 |
| Overall Average  |   | 0.150                           |       |       |       |       |
| 3 σ (Std Dev)    |   | 0.014                           |       |       |       |       |

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**5.4** If the measured Sa value is greater than 20% different from the Rubert Standard specimen's certified value, a machine calibration is required.

- First, use only the "L Filter" to remove the waviness of the standard specimen to bring the measured value closer to the certified coupon value.
- Second, remove noise from the measurement using only the "S Filter" to bring the measured value closer to the certified coupon value.
- Use both the "L Filter" and "S Filter" settings identified above.  
When adjusting the value to Sa 0.10µm for calibration, "L Filter" and "S Filter" **shall** be used to calibrate the machine. With regards to assuring universally quantitative profile value, both Filter settings **shall** be used to ensure compatibility of other machines.

**5.5** Prior to measurement of metallic foil samples the machine **shall** be properly calibrated. Verification of calibration **shall** be performed by testing the actual Rubert Standard Specimen at least monthly on the measurement machine.

**5.6** A Rubert Standard Specimen will be placed so the measurement is vertical to the standard surface. Operator will locate the measurement center point in the XY axis to match the specific coordinate locations being measured on the Standard. This is being done to assure measurements are always taken at the same location on the Standard.

## 6.0 PROCEDURE FOR TESTING ON METALLIC FOIL

**6.1** The test machine settings and procedure used for measuring the metallic foil samples **shall** be the same as used for measuring the Rubert Standard.

**6.2** Foil samples **shall** be secured to the microscope stage to prevent movement during the measurement process.

Suggested methods to secure the foil for measurement are as follows:

1. Mount the foil to a standard SEM cylinder fixture using double-sided carbon tape, or equivalent.
2. Use a vacuum fixture to hold the copper foil in place so as not to distort the sample.

## 7.0 MEASUREMENT PARAMETERS AND MACHINE SETUP

**7.1** All measurements **shall** be conducted using the saved set-up and measurement parameters (commonly termed "a template") to ensure that all measurements are done using the exact same test method. Programs and procedures for each piece of specific measurement equipment **shall** be available upon request. It is expected that the measurement template will differ according to the make and model of the measurement machine.

**7.2** The machine manufacturer should be consulted to define the specific measurement machine template needed to assure compliance with this measurement procedure.

The following measurement values may be collected: Sa, Sq, Sz, Sdr, Ssk, and Vmc

- Sa is defined as the average absolute value height in reference to the mean plane.
- Sq is defined as the root mean square (RMS) height in reference to the mean plane.
- Sz is defined as equivalent to the sum of the maximum peak height and maximum valley depth.
- Sdr is defined as the rate of an increase in the surface area.
- Ssk is defined as a parameter used to evaluate deviations in the height distribution.
- Vmc is defined as the volume of the core part of the body and the space part on the load curve.

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**8.0 MEASUREMENT RESULTS**

**8.1** The Sa values measured in accordance with this method **shall** be reported as the surface profile of metallic foils.

|                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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