

JEDEC STANDARD

Test Method for Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes

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JEDEC SOLID STATE TECHNOLOGY ASSOCIATION



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TEST METHOD A121

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Disclaimer

This document is ***not a qualification standard***. It contains a suite of recommended tin whisker growth tests. If these common tests are adopted, then the industry can collect common and comparable data that may improve the understanding of the fundamentals of whisker growth and allows comparisons between technologies. Tests in this document may be changed in the future as a better understanding of the mechanisms causing tin whisker growth is developed.

Based on a variety of testing and data review from around the globe, three test conditions have been identified that appear to be suitable for monitoring tin whisker growth. The three test conditions include two isothermal conditions with controlled humidity and a thermal cycling condition. However, these test conditions have not been correlated with longer environmental exposures of components in service. Thus, there is at present no way to quantitatively predict whisker lengths over long time periods based on the lengths measured in the short-term tests described in this document. At the time of writing, the fundamental mechanisms of tin whisker growth are not fully understood and acceleration factors have not been established. However until such time that acceleration factors are determined all acceptance requirements for commercial tin finishes are provided in JEDEC standard JESD201. Certain applications, e.g., military or aerospace, may require additional and/or different tin whisker tests or evaluations.

Introduction

The predominant terminal finishes on electronic components have been Sn-Pb alloys. As the industry moves toward Pb-free components and assembly processes, the predominant terminal finish materials will be pure Sn and alloys of Sn, including Sn-Bi and Sn-Ag.

Pure Sn and Sn-based alloy electrodeposits and solder-dipped finishes may grow tin whiskers, which could electrically short across component terminals or break off the component and degrade the performance of electrical or mechanical parts.

TEST METHOD A121

Test Method For Measuring Whisker Growth On Tin And Tin Alloy Surface Finishes

(From JEDEC Board ballot JCB-08-42, formulated under the cognizance of the JC-14.1 Subcommittee on Reliability Test Methods for Packaged Devices.)

1 Scope

The methodology presented in this document, see Annex A for process flow, is applicable for studying tin whisker growth from finishes containing a predominance of tin (Sn). This test method may not be sufficient for applications with special requirements, e.g., military or aerospace. Additional requirements may be specified in the appropriate requirements document.

The purpose of this standard is to:

- Provide an industry-standardized suite of tests for measurement and comparison of whisker propensity for different plating or finish chemistries and processes.
- Provide a consistent inspection protocol for tin whisker examination.
- Provide a standard reporting format.

2 Normative references

JESD22-A104, *Standard for Temperature Cycling*

IPC 7530, *Guidelines for Temperature Profiling for Mass Soldering (Reflow & Wave) Processes*

JESD201, *Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes*

3 Terms and definitions

3.1 surface corrosion: A localized corrosion of the silver-colored tin surface finish appearing in an optical microscope as non-reflective dark spots ranging in size from about 25 microns on the longest dimension to the entire terminal.

3.2 whisker: A spontaneous columnar or cylindrical filament, usually of monocrystalline metal, emanating from the surface of a finish.

NOTE 1 Whiskers have the following characteristics:

- they have aspect ratios (length/width) greater than 2;
- they can be kinked, bent, or twisted;
- they usually have a uniform cross-sectional shape;
- they typically consist of a single columnar filament that rarely branches;
- they may have striations along the length of the column and/or rings around the circumference of the column;
- they have lengths of 10 micrometers or greater; features shorter than 10 micrometers may be deemed important for research but are not considered significant in JESD22-A121A.

NOTE 2 Whiskers are not to be confused with dendrites: fern-like growths on the surface of a material, which can be formed as a result of electrochemical migration of an ionic species or produced during solidification.

3.3 whisker density: The number of whiskers per unit area on a single lead or coupon area.

3.4 whisker growth: Measurable changes in whisker length and/or whisker density after exposure to a whisker test condition for a certain duration or number of cycles.

3.5 whisker length: The straight line distance from the point of emergence of the whisker to the most distant point on the whisker (i.e., the radius of a sphere containing the whisker with its center located at the point of emergence), see Figure 5

3.6 whisker test coupon: A piece of metal of specified size and shape that is plated or dipped with a tin finish for the purpose of measuring the propensity for whisker formation and growth.

4 Apparatus

4.1 Temperature cycling chambers

Air to air temperature cycling chamber(s), capable of cycling from -55(+0/-10) °C to +85(+10/-0) °C or from -40(+0/-10) °C to +85(+10/-0) °C. The temperature cycling chamber(s) must be able to satisfy the cycle conditions defined in Table 4.

4 Apparatus (cont'd)

4.2 Temperature humidity chambers

Temperature–humidity (T&H) chambers capable of non-condensing 55 ± 3 °C, 85 $\pm 3\%$ RH and 30 ± 2 °C, 60 $\pm 3\%$ RH environment.

NOTE 1 The elevated temperature–humidity condition of 55 ± 3 °C, 85 $\pm 3\%$ RH is close to the condensation point. If water condenses on the tin finish during environmental exposure, the condensed moisture and resulting corrosion may affect the final test results. To prevent condensation in the T & H chamber, the chamber dry-bulb temperature must exceed the wet-bulb temperature at all times by not less than 2.4 °C (or equivalent for electronic sensors). Before opening of the chamber door for loading and unloading, the chamber temperature and humidity should be ramped down sufficiently close to room ambient (recommended within 10 °C and 10% RH) to prevent condensation on the test samples and chamber walls.

NOTE 2 During operation, condensation is most likely to occur on the T & H test chamber walls and ceiling; therefore, it is recommended that the test samples be sufficiently shielded from any condensed water that may drip from the chamber ceiling and/or walls onto the samples.

NOTE 3 When loading the test samples into the T & H test chamber, the sample temperature must be sufficiently higher than the chamber ambient temperature to avoid condensation on the test samples. It is recommended that the test samples and all sample trays or holders be preheated (to a temperature equal to the test temperature of the T & H test chamber) in a dry-bake oven prior to loading them into the T & H test chamber.

NOTE 4 Frequent wet-bulb maintenance is required for proper control of this test condition.

4.3 Optical stereomicroscope (Optional)

Optical stereomicroscope with adequate lighting capable of 50X to 150X magnification and capable of detecting whiskers with a minimum length of 10 microns, per Annex B. If tin whiskers are measured with an optical system, then the system must have a stage that is able to move in three dimensions and rotate, such that whiskers can be positioned perpendicular to the viewing direction for measurement.

4.4 Optical microscope (Optional)

Optical microscope with adequate lighting capable of 100X to 300X magnification and capable of measuring whiskers with a minimum length of 10 microns, per Annex B. For tin whisker measurements, the optical system must have a stage that is able to move in three dimensions and rotate, such that whiskers can be positioned perpendicular to the viewing direction for measurement.

4.5 Scanning electron microscope

Scanning electron microscope (SEM) capable of at least 250X magnification. An SEM fitted with an X-ray detector is recommended for elemental identification.

4.6 Convection reflow oven (Optional)

A convection reflow system capable of achieving the reflow profiles of Table 3.

5 Sample requirements and optional preconditioning

For acceptance requirements of tin finishes for commercial use, the relevant test conditions, read points, and durations are given in JEDEC standard JESD201. For evaluating the whisker propensity of tin finishes for other purposes (e.g., scientific study, preliminary evaluations of various platings, etc.), it is recommended that all three conditions defined in Table 4 be used and that the durations given in JESD201, Table 4a for Class 1 and 2 products be used. In addition, each test condition is to be performed independently on separate samples.

5.1 Acceptance requirements:

For acceptance requirements of tin finishes for commercial use: Use JEDEC standard JESD201 for the following:

- Test conditions
- Test samples
- Read Points
- Durations
- Sample size
- Test sample preconditioning
- Reporting

NOTE Coupons are not acceptable for acceptance requirements.

5.2 Scientific studies

For evaluating the whisker propensity of tin finishes for other purposes (e.g., scientific study, preliminary evaluations of various platings, etc.), it is recommended that all conditions defined in JESD201 for Class 2 products are used. In addition, each test condition is to be performed independently on separate samples. Test coupons may be used for scientific studies.

5.2.1 Test coupons

For comparison purposes, if using coupons, a total inspection area of at least 75 mm² on at least 3 coupons is required for each test condition. For small coupons, it is recommended that there be sufficient coupons so that the total area inspected adds up to a minimum of 75 mm², as described in Table 1.