JEITA

Standard of Japan Electronics and Information Technology Industries Association

EIAJ ED-4701/400-1

Environmental and endurance test methods for semiconductor devices (Stress test II) (Amendment 1)

Published in February, 2005

Investigated by

Technical Standardization Committee on Semiconductor Devices

Published by

Japan Electronics and Information Technology Industries Association

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Standard of Japan Electronics and Information Technology Industries Association

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Remarks: The Process of deliberation and technical description of each test methods are given to the test methods as Explanation.

COMMENTS

1. PURPOSE OF ESTABLISHMENT OF THE AMENDMENT 1

It was recondite where the latest test methods was entered, it was resulting the confusion of users. So establishment of new numbering system that was easy to use both users and manufacturers was decided, and the standard has been established as **EIAJ ED-4701/400** “Environment and endurance test methods for semiconductor devices (Stress test Ⅱ)” in August, 2001.

The change of a technical matter is needed in the test methods in part, we decided after that to publish only the test methods of requiring change as the Amendment. However, every three years it will be established as not the Amendment but the latest version of the standard “Environment and endurance test methods for semiconductor devices (Stress test Ⅱ)” that includes the whole test methods of **EIAJ ED-4701/400**.

2. EVOLUTION OF THE DELIBERATIONS

The evolution of the deliberations is conformed to the explanation of each test methods.

3. DELIBERATING MEMBERS

Deliberation of this standard has been made by “Sub-Committee on Semiconductor Devices Reliability” of the Technical Standardization Committee on Semiconductor Devices/Semiconductor Devices Reliability Group.

Below are listed the members of deliberation of this standard.

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TEST METHOD 401A
Terminal strength

1. Scope

This standard provides for the method to evaluate the resistance of terminals of semiconductor devices against forces applied during their handling and/or normal assembly work.

Remark: It is recommended to apply the Method I (pull test), Method II (torsion test), Method III (bending test), Method IV (torque test of screw terminal), Method V (fatigue test), Method VI (shear test) to the various terminals according to **Table 1**.

Table 1 Test methods for the terminal strength in terminal shape

Terminal shape	Test method					
	I (Pull)	II (Torsion)	III (Bending)	IV (Torque)	V (Fatigue)	VI (Shear)
Lead wire terminal (can type, etc.)	○	○	○		○	
Plate terminal I (DIP, SIP, etc.)	○		○		○	
Plate terminal II (SOP, QFP, TSOP, QFI, etc.)	○		○			
Plate terminal III (SOJ, QFJ, etc.)			○			
Stud terminal (power diode, etc.)				○		
Pin terminal (PGA, etc.)	○					
Ball terminal (BGA, etc.)						○
Bump terminal (FC, etc.)						○

Remarks:

1. A circle mark (○) indicates that the method is applied.
2. These test methods are not applied to the terminals (SON,QFN, etc.) that forces are not applied during their handling.

2. Test equipment

The equipment to be used in these tests consists of appropriate jigs, vices, etc., to apply the specified load. Care shall be taken not to cause scratches and deformations that could exert influence on the results of the tests.

3. Procedure

3.1 Preliminary treatment

Whenever necessary, relevant specifications provide for the pre-treatment.

3.2 Initial measurement

Carry out the initial measurements in conformity with the items and conditions specified in the relevant specifications. In addition, carry out a visual inspection.

3.3 Test

There are 6 test methods, I, II, III, IV, V and VI.

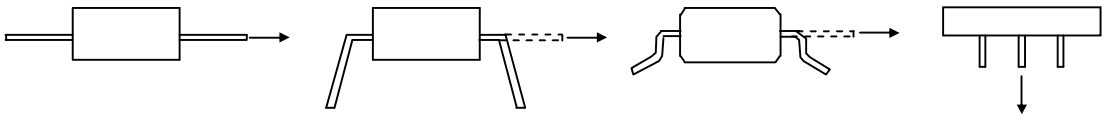
Select the most appropriate method according to the shape of the specimen (Refer to **Table 1**). The relevant specifications provide one or more method. The terminals to be tested shall be 3 or more terminals, except when otherwise specified. All terminals shall be tested when there are less than 3 terminals.

3.3.1 Method I (Pull test)

The component body will be rigidly held with a suitable fixture and a tension of 2.2 N ± 0.1 N, unless otherwise specified, shall be applied without shock to each lead to be tested in a direction parallel to the axis of the lead or terminal and the tension shall be maintained for 30 s minimum. For leads with a diameter of less than 0.25 mm (or cross sectional area of less than 0.05 mm^2) a tension of 1 N ± 0.1 N shall be applied. The tension shall be applied as close to the end of the lead as practicable. (Refer to **Figure 1**).

Remarks:

1. Component body is the part of the specimen excluding the terminals.
2. Since SMD with J-lead cannot be pulled in the terminal direction, it was decided not to apply this test.
3. Forming leads like DIP or QFP shall be straightened to an original lead style or cut a forming portion using appropriate jigs and then the tension shall be applied in the direction parallel to the axis of the lead.



(1) Lead wire terminal (2) Plate terminal I (3) Plate terminal II (4) Pin terminal

Figure 1 Example of pull direction in the pull test

3.3.2 Method II (Torsion test)

This test is applied only to lead wire terminals.

a) Procedure for devices with circular cross section terminals or leads

The component body will be rigidly held with a suitable fixture and the specified torque shall be applied without shock for 15 s minimum to the lead to be tested, about the axis of the lead. The torque shall be applied between the lead or terminal and the component body in a direction which tends to cause loosening of the lead.

Remark: In **IEC 60749-14**, a torque of 0.15 Nm ± 0.01 Nm is recommend for UHF and microwave

diodes.

b) Procedure for devices with rectangular cross section leads

The component body shall be rigidly held and a torque of 0.02 Nm ± 0.002 Nm, unless otherwise specified, shall be applied to the lead at a distance of 3 mm ± 0.5 mm from the component body or at the end of the lead, if it is shorter than 3 mm. The torque shall be applied about the axis of the lead, once in each direction (clockwise and counter-clockwise). When devices have leads which are formed close to the component body, the torque may be applied 3 mm ± 0.5 mm from the form. For device leads that twist noticeably, when less than the specified torque is applied, the twist shall be continued until the twist angle reaches 30° ± 10° or the specified torque is achieved, whichever condition occurs first. The lead shall then be restored to its original position.

3.3.3 Method III (Bending test)

a) Procedure for devices with lead wire terminals

1) If its section modulus (in the least rigid direction) is less than or equal to that of a rectangular lead with a cross section of 0.15 mm x 0.5 mm or round leads ≦ 0.5 mm in diameter, its leads shall be bent through an arc of at least 45° (Refer to **(1)** of **Figure 2**), measured at a distance 3 mm ± 0.5 mm along the lead from the component body unless otherwise specified.

2) If its section modulus (in the least rigid direction) greater than that of a rectangular lead with a cross section of 0.15 mm x 0.5 mm or round leads greater than 0.5 mm in diameter, its leads shall be bent through an arc of a least 30° (Refer to **(2)** of **Figure 2**), measured at the lead extremities, unless otherwise specified.

(1) Leads with small section modulus **(2) Leads with large section modulus**

Figure 2 Bending test method for the lead wire terminal

Remark: For rectangular strip terminations, the section modulus is given by the following formula:

$$Z_x = \frac{b \cdot a^2}{6}$$

where

a is the thickness of the rectangular strip perpendicular to the bending axis.

b is the other dimension of the rectangular strip.

Z_x is the section modulus.

b) Procedure for devices with plate terminal I

Leads shall be bent inward through an angle sufficient to cause the lead to retain a permanent bend (i.e. after stress removal) of at least 15°, measured at the lead extremities about the first bend (Refer to **(1)** of **Figure 3**). For packages that have the shoulder restrained (Refer to **(2)** of **Figure 3**), the angle of the bend shall be measured from the seating plane to the lead extremities. At the completion of the initial bend, the leads shall be returned to their approximate original position.

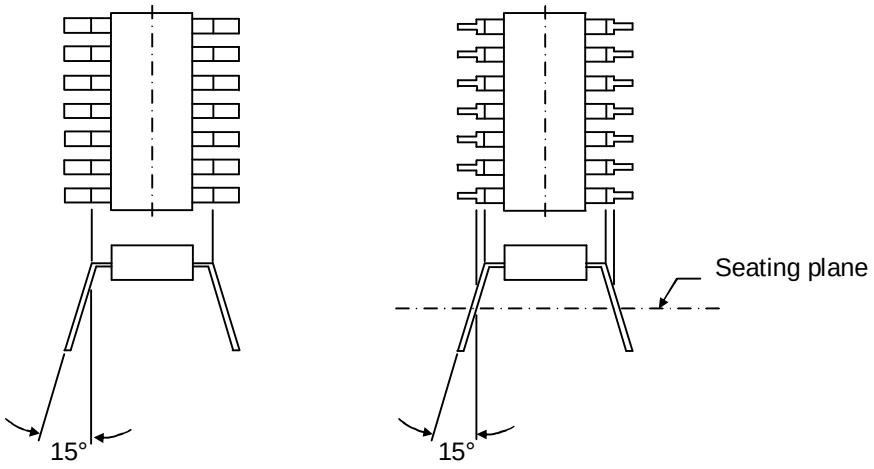


Figure 3 Bending test method for plate terminal I

c) Procedure for devices with plate terminal II

Bend leads outward at 15°, then inward 30°, then returned to the original position (Refer to **Figure 4**).

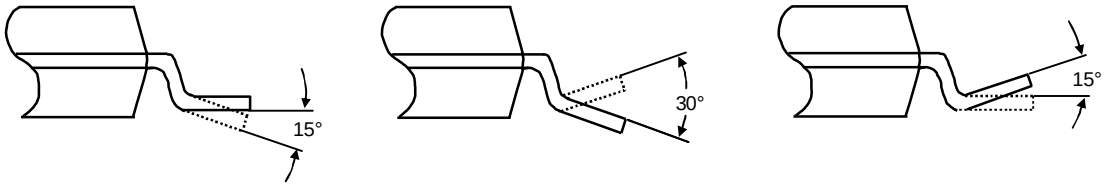


Figure 4 Bending test method for plate terminal II

d) Procedure for devices with plate terminal III

Carefully straighten the "J" bend portion using suitable jigs (fixture, tweezers etc.) (Refer to **Figure 5**). Then perform the following tests.

Remark: Inspect each lead after straightening. Do not test any leads damaged by straightening operation.

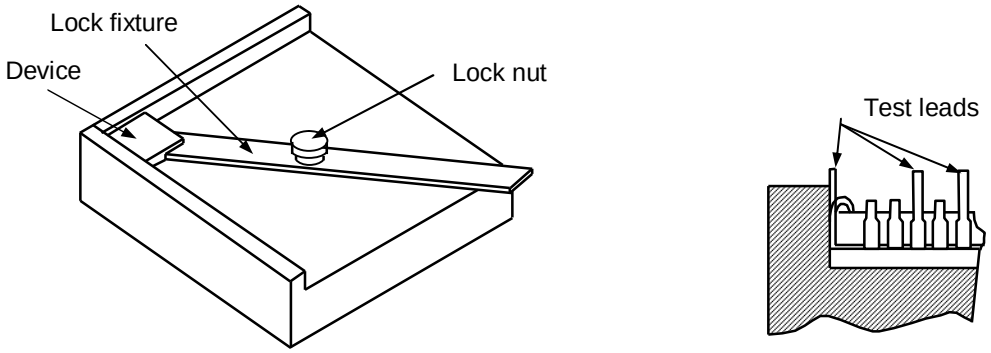


Figure 5 Example of jigs for straightening plate terminal III

1) Test in accordance with **3.3.3(b)** except that the direction of bend shall be outward from the package (Refer to **(1)** of **Figure 6**).

2) Select another untested lead and attach a 450 g ± 20 g weight below the standoff (neck down) portion of the straightened lead. Rotate the component body through a 30° arc and return to its original position. This completes one cycle and shall take 2 s to 5 s (Refer to **(2)** of **Figure 6**).

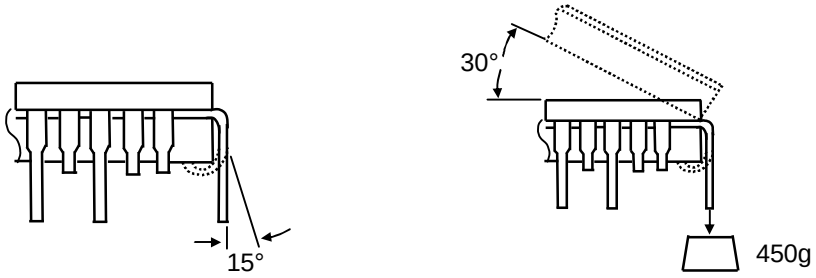


Figure 6 Bending test method for plate terminal III

3.3.4 Method IV (Torque test of screw terminal)

A flat steel washer, of a thickness equal to six threaded pitches of the stud being tested, and a new steel nut of the same thread as the stud, shall be assembled, in that order, on the stud. The specified torque shall be applied to the nut for the specified period of time. The nut and washer shall then be disassembled from the device.

3.3.5 Method V (Fatigue test)

Unless there are specific requirement, this test is not applied to surface mount device (SMD).

a) Procedure for devices with lead wire terminals

The component body shall be held in such a manner that the axis of the lead is vertical and a weight of 220 g ± 10 g, unless otherwise specified, shall be applied to each lead to be tested. For leads with a section modulus is less than or equal to that of a rectangular lead with a cross section of 0.15 mm x 0.5 mm, or round lead with a diameter less than 0.5 mm in diameter, the weight shall be 85 g ± 10 g. The component body is then inclined through an angle of 90°± 5° in the vertical plane and returned to its original position; this operation constitutes one bend. Three bends on a single lead shall be made in the same direction and in the same plane without lead restriction. A bending cycle shall be completed in 2 s to 5 s (Refer to **Figure 7**). For devices with rectangular or ribbon leads, the plane of the arcs shall be perpendicular to the flat plane of the lead.

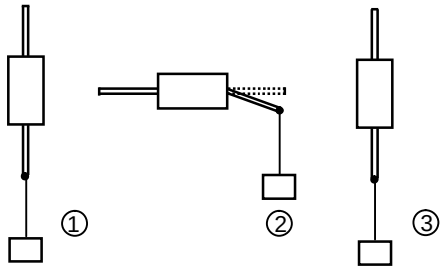


Figure 7 Operation methods for single bend

b) Procedure for devices with plate terminal I

Devices with plate terminal I shall be subjected to three cycles in accordance with **3.3.3 b)**.

3.3.6 Method VI (Shear test)

The width of the shear probe shall be about the width of the solder ball so it does not interfere with adjacent solder balls during the shear test. Align the probe so that it is 90°± 5° to the solder ball and moves parallel to the surface of the BGA module. The edge of the probe nearest the module surface sets between 1/4 the solder ball height and 0.05 mm on a substrate. Put the probe onto the side of solder ball in parallel, and load the ball at the rate of 300 µm/s ± 50 µm/s. Record the load and continue loading until the load reaches a maximum. Allow the loading to continue until the load falls to at least 3/4 of the maximum load before stopping. (Refer to **Figure 8**).

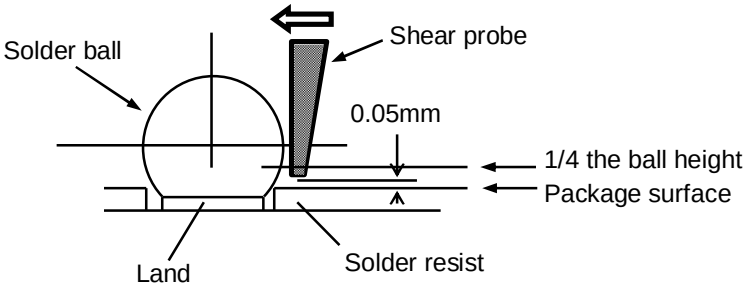


Figure 8 Shear test method of ball terminal

3.4 Post treatment

Specified in the relevant specifications, when necessary.

3.5 End-point measurement

a) Method I, II, III, IV and V

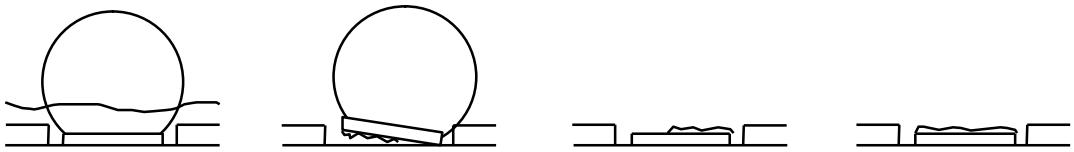
After finishing the tests, inspect the external visual with magnification of 10 to 20 times, and make sure that there is no cut, breakage and looseness. When there are specified items in the relevant specifications, carry out the measurements in conformity with the specified items and conditions.

b) Method VI

After finishing the tests, inspect the external visual with magnification of 10 to 20 times, and check the fracture mode of a solder ball junction part. Acceptable failure modes are: Mode A, Solder ball shear, and Mode B, Pad lifts. Unacceptable failure mode is Mode C, resulting from lack of solder wetting to the pad. Intermetallic failure, Mode D, can be allowed if the shear force meets with acceptable shear force in the relevant specifications. Priority is given to the result when satisfying junction intensity. When there are specified items in the relevant specifications, carry out the measurements in conformity with the specified items and conditions. Classifications of fracture mode in solder ball are as follows. (Refer to **Table 2** and **Figure 9**).

Table 2 Classifications of fracture mode

Mode	Note
A	Ball shear (concentrated fracture in the solder ball)
B	Pad lift (stripping between the land and the board)
C	Ball lift (lack of solder wetting)
D	Intermetallic break



Mode A **Mode B** **Mode C** **Mode D**

Figure 9 Classifications of fracture mode

4. Information to be given in the relevant specification

(1) Preliminary treatment (when required) [Refer to **3.1**]

(2) Items and conditions of the initial measurements (when required) [Refer to **3.2**]

(3) Types of test methods [Refer to **3.3**]

(4) Number of terminals to be tested (cases other than the specified ones) [Refer to **3.3**]

(5) Pull force of the pull test (cases other than the specified ones) [Refer to **3.3.1**]

(6) Duration applied the pull force in the pull test
(cases other than the specified ones) [Refer to **3.3.1**]

(7) Torque, rotational position and rotational direction of the torsion test
(cases other than the specified ones) [Refer to **3.3.2**]

(8) Bending direction, bending angle and load of the bending test
(cases other than the specified ones) [Refer to **3.3.3**]

(9) Torque and torque duration of the screw terminal
(cases other than the specified ones) [Refer to **3.3.4**]

(10) Number of cycles and load of the fatigue test
(cases other than the specified ones) [Refer to **3.3.5**]

(11) Fracture classification of the shear test (when required) [Refer to **3.3.6**]

(12) Post treatment (when required) [Refer to **3.4**]

(13) Items and conditions of the end-point measurement (when required) [Refer to **3.5**]

(14) Minimum shear fracture force [Refer to **3.5 b)**]

(15) Combination of judgment standards and fracture classification
(when required) [Refer to **3.5 b)**]

REFERENCE 1. SUPPLEMENTARY INFORMATION ON THE TEST METHOD

1. Remark

Application to TCP (Tape carrier package): It is difficult to apply this standard to the lead terminals of TCP with extremely small cross-sectional areas comparing with conventional packages.

2. For difference with another standard

There is the following standard as another standard.

a) For difference with IEC 60749-14

IEC 60749-14 standard is almost same with this standard with all the test items and conditions except for the ball shear test.

b) For difference with JIS C 0051 (**IEC 60068-2-21**)

JIS standard (or **IEC 60068-2-21**) have the same test items as this standard. But, the test conditions are very different. Also, **JIS** standard have the terminal strength pushing test method that is not specified in this standard. There were not a proof of data and were as a future theme regarding this test method.

Also, there are standard applied to semiconductor surface mounting devices on board. It is specified as **EIAJ ED-4702A** “Mechanical stress test methods for semiconductor surface mounting devices” in **JEITA**.

c) For difference with JEDEC JESD 22 B105-C

JEDEC standard is almost same with this standard with all the test items and conditions except for the ball shear test.

The test conditions have almost same content and, it supposed to refer from “**MIL-STD-883E**”.

3. Purpose and process of the revision

a) Harmony with IEC

IEC 60068 standard was already presented in **IEC** standard as a general standard that was intended for electronic components. It had been used for not only electronic components but also semiconductor devices.

Recently, **IEC 60749-14** was established as the terminal strength test standards of the semiconductor device. Accordingly, this standard was reconsidered from a viewpoint of the harmony with **IEC** and was revised as follow.

1) Significant revision of the test conditions for the conventional test items.

2) Addition of the terminal fatigue test as method V.

b) Response to the ball terminals

While terminal strength measuring method for plate terminal, including QFP, has been provided, that for ball terminal (BGA, etc.) has yet to be done. Due to increasing general BGA packages, it is pressing need to provide a test method for those.

Method VI (shear test) is provided after examination of terminal strength measuring method for ball terminal packages, such as BGA. This measuring method is applied also to bump terminal, such as FC.

About the failure criteria after shear test in Method VI, there was also an opinion that it judges by fracture intensity. However, since it was difficult to decide a judgment value of fracture intensity, the judgment by fracture mode was adopted this time. In addition, in the case of the fracture mode A, the

guideline for the judgment value of fracture intensity is 15.0 N/mm^2.

EIAJ ED-4701/400-1

Published in February, 2005

Published by Technical Standardization Center of Japan Electronics & Information Technology Industries Association

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