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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Mechanical and climatic test methods – Part 5: Steady-state temperature humidity bias life test

Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques – Partie 5: Essai continu de durée de vie sous température et humidité avec polarisation

IEC 60749-5:2017-04 (en-fr)

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CONTENTS

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SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 5: Steady-state temperature humidity bias life test

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60749-5 has been prepared by IEC technical committee 47: Semiconductor devices.

This second edition cancels and replaces the first edition published in 2003. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) correction of an error in an equation;
b) inclusion of notes for guidance;
c) clarification of the applicability of test conditions.

This bilingual version (2019-09) corresponds to the monolingual English version, published in 2017-04.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
47/2367/FDIS	47/2383/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The French version of this standard has not been voted upon.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60749 series, published under the general title *Semiconductor devices – Mechanical and climatic test methods*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 5: Steady-state temperature humidity bias life test

1 Scope

This part of IEC 60749 provides a steady-state temperature and humidity bias life test for the purpose of evaluating the reliability of non-hermetic packaged solid-state devices in humid environments.

This test method is considered destructive.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60749-4, *Semiconductor devices – Mechanical and climatic test methods – Part 4: Damp heat, steady-state, highly accelerated stress test (HAST)*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 General

This test employs conditions of temperature, humidity and bias which accelerate the penetration of moisture through the external protective material (encapsulant or seal) or along the interface between the external protective material and the metallic conductors which pass through it.

Where both this steady-state, humidity bias test and the damp heat, highly accelerated stress test (HAST) of IEC 60749-4 are performed, the results of this 85 °C/85 % RH steady-state test will take priority over the results of the HAST test, which is an accelerated test designed to activate the same failure mechanisms.

5 Equipment

5.1 Equipment summary

The test requires a temperature-humidity test chamber capable of maintaining a specified temperature and relative humidity continuously, while providing electrical connections to the devices under test in a specified biasing configuration.

5.2 Temperature and relative humidity

The chamber shall be capable of providing controlled conditions of temperature and relative humidity during ramp-up to, and ramp-down from the specified test conditions.

Care should be taken to ensure that the test chamber dry bulb temperature exceeds the wet bulb temperature at all times.

5.3 Devices under stress

Devices under stress shall be physically located to minimize temperature gradients.

5.4 Minimizing release of contamination

Care shall be exercised in the choice of board and socket materials, to minimize release of contamination, and to minimize degradation due to corrosion and other mechanisms.

5.5 Ionic contamination

The test apparatus (card cage, test boards, sockets, wiring, storage containers, etc.) shall be controlled to avoid ionic contamination of the test devices.

5.6 Deionized water

Deionized water with a minimum resistivity of 1×10^4 Ωm at room temperature shall be used.

6 Test conditions

6.1 Test conditions summary

Test conditions consist of a temperature, relative humidity, and duration used in conjunction with an electrical bias configuration specific to the device.

6.2 Temperature, relative humidity and duration

Unless otherwise required by the detail specification, the temperature, relative humidity and test duration as shown in Table 1 shall be applied.

Table 1 – Temperature, relative humidity and duration

Temperature (dry bulb) °C	Relative humidity [a] %	Temperature [b] (wet bulb) °C	Vapour pressure [b] kPa	Duration [c] h
85 ± 2	85 ± 5	81,0	49,1	$1\,000\ ^{-24}_{+168}$

[a] Tolerances apply to the entire useable test area.

[b] For information only.

[c] The test conditions are to be applied continuously, except during any interim readouts, when the devices should be returned to stress within the time specified in 7.6.

6.3 Biasing guidelines

Apply bias according to the following guidelines:

a) Minimize power dissipation.

b) Alternate pin bias as much as possible.

c) Distribute potential differences across chip metallization as much as possible.

d) Maximize voltage within operating range.

NOTE The priority of the above guidelines depends on the mechanism and specific device characteristics.

e) Either of two kinds of bias can be used to satisfy these guidelines, whichever is more severe:

1) Continuous bias

The DC bias shall be applied continuously. Continuous bias is more severe than cycled bias when the virtual junction temperature is <10 °C higher than the chamber ambient temperature or, if the virtual junction temperature is not known when the heat dissipation of the device under test (DUT) is less than 200 mW. If the heat dissipation of the DUT exceeds 200 mW, then the virtual junction temperature should be calculated. If the virtual junction temperature[1] exceeds the chamber ambient temperature by more than 5 °C then the virtual junction temperature rise above the chamber ambient should be included in reports of test results since acceleration of failure mechanisms will be affected.

NOTE 2 Based on the power dissipation and the thermal resistance or impedance that corresponds to the mode of operation, the virtual junction temperature can be calculated from the formula $T_j = T_{case} + (P \times R_{th})$ or $T_j = T_{amb} + (P \times R_{th})$

where

T_j is the virtual junction temperature;

P is the power dissipation;

R_{th} is the thermal resistance.

2) Cycled bias

The DC voltage applied to the devices under test shall be periodically interrupted with an appropriate frequency and duty cycle. If the biasing configuration results in a temperature rise above the chamber ambient, ΔT_{ja}, exceeding 10 °C, then cycled bias, when optimized for a specific device type, will be more severe than continuous bias. Heating as a result of power dissipation tends to drive moisture away from the die and thereby hinders moisture-related failure mechanisms. Cycled bias permits moisture collection on the die during the off periods when device power dissipation does not occur. Cycling the DUT bias with 1 h on and 1 h off is optimal for most plastic-encapsulated microcircuits. The virtual junction temperature, as calculated on the basis of the known thermal impedance and dissipation, should be quoted with the results whenever it exceeds the chamber ambient by 5 °C or more.

6.4 Biasing choice and reporting

Criteria for choosing continuous or cyclical bias, and whether or not to report the amount by which the virtual junction temperature exceeds the chamber ambient temperature, are summarized in Table 2.

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1 The virtual junction temperature is the theoretical temperature which is based on a simplified representation of the thermal and electrical behaviour of the semiconductor device.

Table 2 – Criteria for choosing continuous or cyclical bias

ΔT_{ja}	Continuous or cyclical bias	Include value of ΔT_{ja} in test report?
ΔT_{ja} < 5 °C or power per DUT < 200 mW	Continuous	No
(ΔT_{ja} ≥ 5 °C or power per DUT ≥ 200 mW), and ΔT_{ja} < 10 °C	Continuous	Yes
ΔT_{ja} ≥ 10 °C	Cyclical [a]	Yes
[a] Cycling the DUT bias with one hour on and one hour off is optimal for most plastic-encapsulated microcircuits.		

7 Procedures

7.1 Mounting

The test devices shall be mounted in such a way as to expose them to a specified condition of temperature and humidity as given in Table 1 with a specified electrical biasing condition. Exposure of devices to excessively hot conditions, dry ambient conditions or conditions that result in condensation on devices and electrical fixtures shall be avoided, particularly during ramp-up and ramp-down.

7.2 Ramp-up

The time to reach stable temperature and relative humidity conditions should be less than 3 h. Condensation shall be avoided by ensuring that the test chamber (dry bulb) temperature exceeds the wet-bulb temperature at all times.

7.3 Ramp-down

Ramp-down should not exceed 3 h. Condensation shall be avoided by ensuring that the test chamber (dry bulb) temperature exceeds the wet-bulb temperature at all times.

NOTE For a DUT with a cavity in the package, condensation can occur due to the length of the ramp down time.

7.4 Test clock

The test clock starts when the temperature and relative humidity reach the set points, and stops at the beginning of ramp-down.

7.5 Bias

Bias application during ramp-up and ramp-down is optional. Bias should be verified after devices are loaded, prior to the start of the test clock. Bias should also be verified after the test clock stops, but before devices are removed from the chamber.

7.6 Read-out

An electrical test shall be performed not later than 48 h after the end of ramp-down.

For intermediate read-outs, devices should be returned to stress within 96 h of the end of ramp-down. Moisture loss can be reduced by placing the device in a moisture barrier bag sealed in ambient air without vacuum or desiccant. When devices are placed in sealed bags, the “test window clock” runs at one-third of the rate of devices exposed to laboratory ambient conditions. Thus the test window can be extended to as much as 144 h, and the time to return to stress to as much as 288 h by enclosing the devices in moisture-proof bags.

The electrical test parameters should be chosen to preserve any defect (i.e. by limiting the applied test current)

Additional time-to-test delay or the return-to-stress delay time is allowed if justified by technical data.

7.7 Handling

Suitable hand-covering shall be used to manage devices, boards and fixtures. Contamination control is important in any accelerated moisture stress test.

8 Failure criteria

A device has failed if it does not pass the specified end point tests or if its functionality cannot be demonstrated under nominal and worst-case conditions as specified in the applicable procurement document or data sheet.

9 Safety

The equipment manufacturer's recommendations and local safety regulations shall be followed.

10 Summary

The following details shall be specified in the applicable procurement document:

a) Test duration, if other than that specified in Table 1.

b) Measurements after test (see 7.6).

c) Biasing configuration (see 6.3).

d) Temperature of die during test if more than 5 °C above the chamber ambient (see 6.3 e) 1)).

e) Frequency and duty cycle of bias if cycled bias is to be used (see 6.3 e) 2)).

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