SLOVENSKI STANDARD

SIST EN 60749-17:2004

julij 2004

Semiconductor devices - Mechanical and climatic test methods - Part 17: Neutron irradiation (IEC 60749-17:2003)

ICS 31.080.01

Referenčna številka
SIST EN 60749-17:2004(en)

EUROPEAN STANDARD **EN 60749-17**

NORME EUROPÉENNE

EUROPÄISCHE NORM April 2003

ICS 31.080.01

English version

Semiconductor devices – Mechanical and climatic test methods Part 17: Neutron irradiation

(IEC 60749-17:2003)

Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques Partie 17: Irradiation aux neutrons (CEI 60749-17:2003)

Halbleiterbauelemente – Mechanische und klimatische Prüfverfahren Teil 17: Neutronenbestrahlung (IEC 60749-17:2003)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Ref. No. EN 60749-17:2003 E

Foreword

The text of document 47/1668/FDIS, future edition 1 of IEC 60749-17, prepared by IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60749-17 on 2003-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2004-01-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2006-04-01

Endorsement notice

The text of the International Standard IEC 60749-17:2003 was approved by CENELEC as a European Standard without any modification.

NORME INTERNATIONALE

INTERNATIONAL STANDARD

CEI
IEC
60749-17

Première édition
First edition
2003-02

Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques –

Partie 17: Irradiation aux neutrons

Semiconductor devices – Mechanical and climatic test methods –

Part 17: Neutron irradiation

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

CODE PRIX
PRICE CODE F

Pour prix, voir catalogue en vigueur
For price, see current catalogue

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 17: Neutron irradiation

FOREWORD

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International Standard IEC 60749-17 has been prepared by IEC technical committee 47: Semiconductor devices.

The text of this standard is based on the following documents:

FDIS	Report on voting
47/1668/FDIS	47/1686/RVD

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

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

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

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

SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 17: Neutron irradiation

1 Scope and object

The neutron irradiation test is performed to determine the susceptibility of semiconductor devices to degradation in the neutron environment. The tests described herein are applicable to integrated circuits and discrete semiconductor devices. This test is intended for military- and space-related applications. It is a destructive test.

The objectives of the test are as follows:

a) to detect and measure the degradation of critical semiconductor device parameters as a function of neutron fluence, and

b) to determine if specified semiconductor device parameters are within specified limits after exposure to a specified level of neutron fluence (see Clause 4).

2 Test apparatus

2.1 Test instruments

Test instrumentation to be used in the radiation test shall be standard laboratory electronic test instruments such as power supplies, digital voltmeters, and pico-ammeters, etc., capable of measuring the electrical parameters required.

2.2 Radiation source

The radiation source used in the test shall be in a pulsed reactor.

2.3 Dosimetry equipment

a) Fast-neutron threshold activation foils such as ^{32}S, ^{54}Fe, and ^{58}Ni.

b) CaF2 thermoluminescence dosimeters (TLDs).

c) Appropriate activation foil counting and TLD readout equipment.

2.4 Dosimetry measurements

2.4.1 Neutron fluences

The neutron fluence used for device irradiation shall be obtained by measuring the amount of radioactivity induced in a fast-neutron threshold activation foil such as ^{32}S, ^{54}Fe, or ^{58}Ni, irradiated simultaneously with the device.

A standard method for converting the measured radioactivity in the specific activation foil employed into a neutron fluence shall be used. The conversion of the foil radioactivity into a neutron fluence requires a knowledge of the neutron spectrum incident on the foil. If the spectrum is not known, it shall be determined by use of a recognised national standard or equivalent.

Once the neutron energy spectrum has been determined and the equivalent monoenergetic fluence calculated, then an appropriate monitor foil (such as ^{32}S, ^{54}Fe, or ^{58}Ni) should be used in subsequent irradiations to determine the neutron fluence. Thus, the neutron fluence is described in terms of the equivalent monoenergetic neutron fluence per unit monitor response. Use of a monitor foil to predict the equivalent monoenergetic neutron fluence is valid only if the energy spectrum remains constant.

2.4.2 Dose measurements

If absorbed dose measurements of the gamma-ray component during the device test irradiations are required, then such measurements shall be made with CaF2 thermo-luminescence dosimeters (TLDs), or their equivalent. These TLDs shall be used in accordance with the recommendations of recognised national standards or their equivalent.

3 Procedure

3.1 Safety requirements

Neutron irradiated devices may be radioactive. Handling and storage of test specimens or equipment subjected to radiation environments shall be governed by the procedures established by the local Radiation Safety Officer or Health Physicist.

3.2 Test samples

A test sample shall be randomly selected and consist of a minimum of 10 devices, unless otherwise specified. All sample devices shall have met all the requirements of the relevant specification for that device. Each device shall be serialised to enable pre- and post-test identification and comparison.

3.3 Pre-exposure

3.3.1 Electrical tests

Pre-exposure electrical tests shall be performed on each device as required. Where delta parameter limits are specified, the pre-exposure data shall be recorded.

3.3.2 Exposure set-up

Each device shall be mounted unbiased and have its terminal leads either all shorted or all open. For MOS devices or any microcircuit containing an MOS element, all leads shall be shorted. An appropriate mounting fixture which will accommodate both the sample and the required dosimeters (at least one actuation foil and one CaF2 TLD) shall be used. The configuration of the mounting fixture will depend on the type of reactor facility used and should be discussed with the reactor facility personnel. Test devices shall be mounted in such a way that the total variation of fluence over the entire sample does not exceed 20 percent. Reactor facility personnel shall determine both the position of the fixture and the appropriate pulse level required to achieve the specified neutron fluence level.

3.4 Exposure

The test devices and dosimeters shall be exposed to the neutron fluence as specified. If multiple exposures are required, the post-radiation electrical tests shall be performed (see 3.5.1) after each exposure. A new set of dosimeters is required for each exposure level. Since the effects of neutrons are cumulative, each additional exposure will have to be determined to give the specified total accumulated fluence. All exposures shall be made at 20 °C ± 10 °C and shall be correlated to a 1 MeV equivalent fluence, as described in 2.4.1.

3.5 Post-exposure

3.5.1 Electrical tests

Test items shall be removed only after clearance has been obtained from the Health Physicist at the test facility. The temperature of the sample devices must be maintained at 20 °C ± 10 °C from the time of the exposure until the post-electrical tests are made. The post-exposure electrical tests as specified shall be made within 24 h after the completion of the exposure. If the residual radioactivity level is too high for safe handling – this level to be determined by the local Radiation Safety Officer –, the elapsed time before post-test electrical measurements are made may be extended to 1 week. Alternatively, provisions may be made for remote testing. All required data must be recorded for each device after each exposure.

3.5.2 Anomaly investigation

Devices which exhibit previously defined anomalous behaviour (e.g., non-linear degradation of 1/β) shall be subjected to failure analysis.

3.6 Reporting

As a minimum, the report shall include the device type number, serial number, manufacturer, controlling specification, the date code and other identifying numbers given by the manufacturer. Each data sheet shall include radiation test date, electrical test conditions, radiation exposure levels, ambient conditions as well as the test data. Where other than specified electrical test circuits are employed, the parameter measurement circuits shall accompany the data. Any anomalous incidents during the test shall be fully explained in footnotes to the data.

4 Summary

The following details shall be specified in the request for test or, when applicable, the relevant specification:

a) device types (see 3.6);

b) quantities of each device type to be tested, if other than specified in 3.2;

c) electrical parameters to be measured in pre- and post-exposure tests (see 3.3.1 and 3.5.1);

d) criteria for pass, fail, record actions on tested devices (see 3.3.1, 3.5.1 and 3.6);

e) criteria for anomalous behaviour designation (see 3.5.2);

f) radiation exposure levels (see 3.4);

g) test instrument requirements (see clause 2);