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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Micro-electromechanical devices –
Part 4: Generic specification for MEMS

Dispositifs à semiconducteurs – Dispositifs microélectromécaniques –
Partie 4: Spécification générique pour les MEMS

IEC 62047-4:2008

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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 62047-4 has been prepared by subcommittee 47F: Micro-electromechanical systems, of IEC technical committee 47: Semiconductor devices.

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

FDIS	Report on voting
47/1975/FDIS	47/1985/RVD

Full information on the voting for the approval on 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.

A list of all the parts in the IEC 62047 series, under the general title *Semiconductor devices – Micro-electromechanical devices*, can be found on the IEC website.

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

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- withdrawn,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

SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 4: Generic specification for MEMS

1 Scope

This part of IEC 62047 describes generic specifications for micro-electromechanical systems (MEMS) made by semiconductors, which are the basis for specifications given in other parts of this series for various types of MEMS applications such as sensors, RF MEMS, excluding optical MEMS, bio MEMS, micro TAS, and power MEMS. This standard specifies general procedures for quality assessment to be used in IECQ-CECC systems and establishes general principles for describing and testing of electrical, optical, mechanical and environmental characteristics.

This part of IEC 62047 aids in the preparation of standards that define devices and systems made by micromachining technology, including but not limited to, material characterization and handling, assembly and testing, process control and measuring methods. MEMS described in this standard are basically made of semiconductor material. However, the statements made in this standard are also applicable to MEMS using materials other than semiconductor, for example, polymers, glass, metals and ceramic materials.

2 Normative references

The following referenced documents are indispensable for the application 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 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60068-2 (all parts), *Environmental testing – Part 2: Tests*

IEC 60617, *Graphical symbols for diagrams*

IEC 60747-1:2006, *Semiconductor devices – Part 1: General*

IEC 60749 (all parts), *Semiconductor devices – Mechanical and climatic test methods*

IEC 61193-2, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

IEC 62047-1, *Semiconductor devices – Micro-electromechanical devices – Part 1: Terms and definitions*

IEC QC 001002-3:2005, *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure – Part 3: Approval procedures*

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

3 Terms, definitions, units and symbols

For the purposes of this document, terms shall, wherever possible, be taken from IEC 62047-1; units, and graphical and letter symbols shall, wherever possible, be taken from IEC 60027, IEC 60617 and ISO 1000.

Any other units, symbols or terminology peculiar to one of the devices covered by this generic specification shall be taken from the relevant IEC or ISO standards (see Clause 2) or derived in accordance with the principles of the standards listed above.

Table 1 shows the categories and terms on MEMS area.

Table 1 – MEMS categories and terms

Category	Sub-category	Terms
General		MEMS, MST, micromachine, micromachine technology
Science and engineering		Microscience and engineering, scale effect, mesotribology, microtribology, biomimetics, ciliary motion, self-organization
Material science		Shape memory polymer, modification
Functional element	**Actuator**	Actuator, micro-actuator, electrostatic actuator, light driven actuator, piezoelectric actuator, shape memory alloy actuator, sol-gel conversion actuator, comb drive actuator, wobble motor
	Sensor	Microsensor, biosensor, integrated microprobe, ion sensitive field effect transistor (ISFET), accelerometer, micro-gyroscope
	Other	Diaphragm structure, microcantilever, microchannel, micromirror, scanning mirror, microswitch, optical switch, microgripper, micropump, microvalve, integrated mass flow controller, micro fuel cell, photoelectric transducer
Machining technology	**General**	Micromachining
	Silicon process	Silicon process, thick film technology, thin film technology, bulk micro-machining, surface micromachining, photolithography, electron beam lithography, photomask, photoresist, silicon-on-insulator (SOI)
	LIGA process	LIGA process, UV-LIGA, X-ray lithography
	Beam process	Beam processing, sputtering, focused ion beam machining
	Etching process	Etching process, wet etching, dry etching, isotropic etching, anisotropic etching, etch stop, lost wafer process, sacrificial etching, reactive ion etching (RIE), DRIE, ICP
	Deposition process	Vapour deposition, physical vapour deposition process (PVD), electroforming
	Other removal process	Micro-electro-discharge machining
	Plastic working	Hot embossing process
	Other	Micro-moulding, STM machining
Bonding/ assembling technology	**Bonding**	Bonding, adhesive bonding, anodic bonding, diffusion bonding, silicon fusion bonding
	Other	Micro-manipulator, non-contact handling, packaging, wafer level packaging
Evaluation technology	**Microscope**	Scanning probe microscope (SPM), atomic force microscope (AFM), scanning tunneling microscope (STM), near-field microscope
	Other	Aspect ratio, power-to-weight ratio
Application technology	**General**	Bio-MEMS, RF-MEMS, MOEMS, lab-on-a-chip, micro TAS, micro-reactor
	Biomedical use	Microscopic surgery (micro-surgery), active catheter, fibre endoscope, smart pill, bio-chip, DNA-chip, protein chip, cell handling, cell fusion, polymerase chain reaction (PCR)
	Industrial use	Microfactory

4 Standard environmental conditions

Standard environmental conditions for the measurement of characteristics, tests and operating conditions shall be at a temperature of 25 °C ± 3 °C, a relative humidity of 25 % to 85 %, and a pressure of 86 kPa to 106 kPa.

5 Marking

5.1 Device identification

The marking on the device shall have clear identification of the device and its quality level.

5.2 Device traceability

The device shall be provided with a traceability code which enables back-tracking of the device to a certain production or inspection lot.

5.3 Packing

Marking on the packing shall state

a) the device identification code;
b) the traceability code(s) of the enclosed devices;
c) the number of enclosed devices;
d) the required precautions, if any.

This marking shall be in accordance with Customs regulations.

NOTE Additional requirements can be specified in the relevant detail specification.

6 Quality assessment procedures

6.1 General

When this standard, and related standards, are used for the purpose of a full quality assessment system such as IEC Quality Assessment System for Electronic Components (IECQ), this Clause 6 applies.

6.1.1 Eligibility for qualification and/or capability approval

A type of device becomes eligible for qualification and/or capability approval when the rules of the following procedures as set out below, are satisfied.

Clause 3 of IEC QC 001002-3 describes the procedure for qualification approval (QA), the release for delivery and validity of release.

6.1.2 Primary stage of manufacture

The primary stage of manufacture is defined in the sectional specification.

6.1.3 Formation of inspection lots

See 3.3.1 of IEC QC 001002-3.

6.1.4 Structurally similar device

See 3.3.2 of IEC QC 001002-3.

6.1.5 Subcontracting

The use of subcontracting is permitted, unreservedly.

See 3.1.2.3 to 3.1.2.7 of IEC QC001002-3.

6.1.6 Incorporated components

See 5.2.3 of IEC QC 001002-3.

6.1.7 Validity of release

See 3.2.2 of IEC QC 001002-3.

6.2 Qualification approval procedure

6.2.1 Qualification approval testing

Method a), b) or c) of 3.1.4 of IEC QC 001002-3 may be used at the manufacturer's discretion in accordance with the inspection requirements given in the sectional or blank detail specifications.

Samples may be composed of appropriate structurally similar devices.

All measurements called for in the detail specification shall be recorded.

The qualification report shall include a summary of all the test results for each group and subgroup, including number of devices tested and number of devices failed. This summary shall be derived from the recorded data. The manufacturer shall retain all data for submission to the NSI on demand.

6.2.2 Environmental and climatic tests

For environmental and climatic tests, refer to the IEC 60749 series.

6.2.3 Granting of qualification approval

See the rules of procedure given in 3.1.5 of IEC QC 001002-3.

Quality conformance tests are those tests which are performed on a lot-by-lot basis and periodically on specimens taken from production to establish that the quality of the product is being maintained. The sectional or detail specification shall prescribe those tests which have to be performed.

Lot-by-lot tests are carried out on each inspection lot. The results are used to determine whether the lot complies with the specified requirements.

Lot-by-lot tests may be divided into two groups:

– Group A, covering visual and dimensional inspection of the devices and the principal characteristics of the devices (initial measurement);

– Group B, covering additional important characteristics.

Each group may be divided into two or more subgroups. The following subgroups are recommended.

Subgroup A1

This subgroup comprises a visual examination as specified in 6.2.1.

Subgroup A2

This subgroup comprises measurements of primary electrical characteristics of the device.

Subgroup A3

This subgroup comprises measurements of primary optical characteristics of the device.

Subgroup A4 and A5

These subgroups may not be required. They comprise measurements of secondary characteristics of the device. The correct requirements for each device quality category are given in the relevant sectional or blank detail specification. The choice between subgroups A4 or A5 for given measurements is essentially governed by the desirability of performing them at a given quality level.

6.2.3.1 Periodic inspection

Periodic inspection is carried out on a sample drawn either from an individual lot or from a number of lots. The lot(s) from which the sample is drawn shall have been shown to comply with the requirements for lot-by-lot inspection. The results from tests in this category are used to verify that the level of technical performance is being maintained.

Periodic tests are combined into Group C, which may be divided into two or more subgroups as described in 6.2.3.

Group D may be added containing additional tests required for the maintenance of QA.

6.2.3.2 Division of Group B and Group C into subgroups

To enable comparison and to facilitate change from Group B to Group C and vice versa when necessary, tests in these groups are divided among subgroups bearing the same number for corresponding tests as shown in Table 2.

Table 2 – Subgrouping for Group B and Group C

Subgroup	Characteristics
B1/C1	Comprises measurements that control dimensional interchangeability of the devices.
B2/C2	Comprises measurements that assess the electrical properties of the device design
B3/C3	Comprises measurements that assess the optical properties of the device design
B4/C4	Comprises measurements that further assess some of the electrical and optical characteristics of the device already measured in Group A by measurement under different voltage, current, temperature or optical conditions
B5/C5	Comprises verification of ratings of the device, where appropriate
B6/C6	Comprises tests intended to assess mechanical robustness of the device
B7/C7	Comprises tests intended to assess interconnection ability of the device
B8/C8	Comprises tests intended to assess the ability of the device to withstand climatic stress, for example change of temperature, sealing
B9/C9	Comprises tests intended to assess the ability of the device to withstand mechanical stresses, for example vibration, shock
B10/C10	Comprises tests intended to assess the ability of the device to withstand long-term humidity
B11/C11	Comprises tests intended to assess electrical and optical properties of the device under storage conditions at extremes of temperature
B12/C12	Comprises tests intended to assess performance of the device under different conditions of air pressure
B13/C13	Comprise tests intended to assess failure characteristics of the device under endurance testing
B14/C14	Comprises tests on the permanence of marking

These subgroups may not all be required. The required subgroups are specified in the relevant sectional or blank detail specification.

6.2.3.3 Inspection requirements

The statistical sampling procedures described in 6.2.4 shall be used.

6.2.3.3.1 Procedure in case of failure in periodic tests

When a group B failure occurs, the corresponding group C tests (see 6.2.3.3) are invalid. In the event of failing periodic inspection tests, see the rules of procedure given in 3.1.8 of IEC QC001002-3.

6.2.3.4 Switching rules for reduced inspection in Group C

The procedure is applicable to subgroups of Group C tests having a periodicity of 12 months or less when specifically permitted by the sectional specification. It shall not be applied to endurance tests unless otherwise prescribed in the relevant specification.

The relevant specification shall describe any limitations with respect to values, styles, etc., of a device in the use of this procedure.

See the switching rules of procedure given in 3.2.8 of IEC QC 001002-3.

6.2.3.5 Delivery of device subjected to destructive or non-destructive tests

Tests considered as destructive are marked (D) in the sectional or blank detail specification. Devices subjected to destructive tests shall not be included in the lot for delivery. Devices subjected to non-destructive environmental tests may be delivered provided they are re-tested according to Group A requirements and satisfy them.

6.2.3.6 Delayed deliveries

Before delivery of lots which have been stored longer than the storage time, and in conditions specified in the relevant sectional or blank detail specification, the lots or the quantities to be delivered shall undergo the specified Group A inspection and Group B interconnection ability tests.

6.2.4 Statistical sampling procedures

6.2.4.1 General

For Group A, B and C inspections, either the AQL sampling procedure or the zero-defects sampling procedure shall be used. The detail specification shall specify which of the procedures is to be used.

6.2.4.2 AQL sampling plans

See ISO 2859-1 and Annex A. There are three types of sampling plans: single, double and multiple. When several types of plans are available for a given AQL and code letter, any one may be used.

6.2.4.3 Zero-defects sampling plans

See IEC 61193-2 and Annex A.

6.2.5 Endurance tests

Endurance tests shall be specified in the detail specification.

6.2.6 Endurance tests where the failure rate is specified

6.2.6.1 General

Failure rate used in this standard is defined as a percentage per thousand hours. Endurance tests with the specified failure rate shall be specified in the detail specification. Endurance tests performed on devices at, or within, their maximum ratings shall be considered non-destructive.

6.2.6.2 Selection of samples

Samples for endurance tests shall be selected at random from the inspection lot (see Annex A). The sample size for a 1 000 h test shall be given in the detail specification (see 6.2.4).

The acceptance number shall be the one associated with the particular sample size chosen.

6.2.6.3 Failure

A device which fails at one or more of the end-point limits specified for endurance tests shall be considered a failure. If the sample fails, the test may be terminated at the discretion of the manufacturer.

6.2.6.4 Endurance test time and sample size

When the failure rate is specified, the endurance test time shall be 1 000 h initially. Once a lot has passed the 1 000 h test, endurance tests can be reduced to a certain period, as specified in the detail specification.