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Semiconductor devices - Micro-electromechanical devices - Part 1: Terms and definitions (IEC 62047-1:2016)

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Semiconductor devices - Micro-electromechanical devices - Part 1: Terms and definitions (IEC 62047-1:2016)

Dispositifs à semi-conducteurs - Dispositifs microélectromécaniques - Partie 1: Termes et définitions (IEC 62047-1:2016)

Halbleiterbauelemente - Bauelemente der Mikrosystemtechnik - Teil 1: Begriffe (IEC 62047-1:2016)

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Europäisches Komitee für Elektrotechnische Normung

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European foreword

The text of document 47F/232/FDIS, future edition 2 of IEC 62047-1, prepared by SC 47F "Microelectromechanical systems" of IEC/TC 47 "Semiconductor devices" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62047-1:2016.

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IEC 62047-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Micro-electromechanical devices –
Part 1: Terms and definitions

Dispositifs à semiconducteurs – Dispositifs microélectromécaniques –
Partie 1: Termes et définitions

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 1: Terms and definitions

FOREWORD

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International Standard IEC 62047-1 has been prepared by subcommittee 47F: Micro-electromechanical systems, of IEC technical committee 47: Semiconductor devices.

This second edition cancels and replaces the first edition published in 2005. This edition constitutes a technical revision.

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

a) removal of ten terms;
b) revision of twelve terms;
c) addition of sixteen new terms.

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

FDIS	Report on voting
47F/232/FDIS	47F/238/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.

A list of all parts in the IEC 62047 series, published 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 stability 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 1: Terms and definitions

1 Scope

This part of IEC 62047 defines terms for micro-electromechanical devices including the process of production of such devices.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1 General terms and definitions

2.1.1
micro-electromechanical device
microsized device, in which sensors, actuators, transducers, resonators, oscillators, mechanical components and/or electric circuits are integrated

Note 1 to entry: Related technologies are extremely diverse from fundamental technologies such as design, material, processing, functional element, system control, energy supply, bonding and assembly, electric circuit, and evaluation to basic science such as micro-science and engineering as well as thermodynamics and tribology in a micro-scale. If the devices constitute a system, it is sometimes called as MEMS which is an acronym standing for "micro-electromechanical systems"

2.1.2
MST
microsystem technology
technology to realize microelectrical, optical and machinery systems and even their components by using micromachining

Note 1 to entry: The term MST is mostly used in Europe.

Note 2 to entry: This note applies to the French language only.

2.1.3
micromachine

2.1.3.1
micromachine, <device>
miniaturized device, the components of which are several millimetres or smaller in size

Note 1 to entry: Various functional device (such as a sensor that utilizes the micromachine technology) is included.

2.1.3.2
micromachine, <system>
microsystem that consists of an integration of micromachine devices

Note 1 to entry: A molecular machine called a nanomachine is included.

2.2 Terms and definitions relating to science and engineering

2.2.1

micro-science and engineering

science and engineering for the microscopic world of MEMS

Note 1 to entry: When mechanical systems are miniaturized, various physical parameters change. Two cases prevail: 1) these changes can be predicted by extrapolating the changes of the macro-world, and 2) the peculiarity of the microscopic world becomes apparent and extrapolation is not possible. In the latter case, it is necessary to establish new theoretical and empirical equations for the explanation of phenomena in the microscopic world. Moreover, new methods of analysis and synthesis to deal with engineering problems must be developed. Materials science, fluid dynamics, thermodynamics, tribology, control engineering, and kinematics can be systematized as micro-sciences and engineering supporting micromechatronics.

2.2.2

scale effect

change in effect on the object's behaviour or properties caused by the change in the object's dimension

Note 1 to entry: The volume of an object is proportional to the third power of its dimension, while the surface area is proportional to the second power. As a result, the effect of surface force becomes larger than that of the body force in the microscopic world. For example, the dominant force in the motion of a microscopic object is not the inertial force but the electrostatic force or viscous force. Material properties of microscopic objects are also affected by the internal material structure and surface, and, as a result, characteristic values are sometimes different from those of bulks. Frictional properties in the microscopic world also differ from those in the macroscopic world. Therefore, those effects must be considered carefully while designing a micromachine.

2.2.3

microtribology

tribology for the microscopic world

Note 1 to entry: Tribology deals with friction and wear in the macroscopic world. On the other hand, when the dimensions of components such as those in micromachines become extremely small, surface force and viscous force become dominant instead of gravity and inertial force. According to Coulomb's law of friction, frictional force is proportional to the normal load. In the micromachine environment, because of the reaction between surface forces, a large frictional force occurs that would be inconceivable in an ordinary scale environment. Also a very small quantity of abrasion that would not be a problem in an ordinary scale environment can fatally damage a micromachine. Microtribology research seeks to reduce frictional forces and to discover conditions that are free of friction, even on an atomic level. In this research, observation is made of phenomena that occur with friction surfaces or solid surfaces at from angstrom to nanometer resolution, and analysis of interaction on an atomic level is performed. These approaches are expected to be applied in solving problems in tribology for the ordinary scale environment as well as for the micromachine environment.

2.2.4

biomimetics

creating functions that imitate the motions or the mechanisms of organisms

Note 1 to entry: In devising microscopic mechanisms suitable for micromachines, the mechanisms and structures of organisms that have survived severe natural selection may serve as good examples to imitate. One example is the microscopic three-dimensional structures that were modelled on the exoskeletons and elastic coupling systems of insects. In exoskeletons, a hard epidermis is coupled with an elastic body, and all movable parts use the deformation of the elastic body to move. The use of elastic deformation would be advantageous in the microscopic world to avoid friction. Also, the exoskeleton structure equates to a closed link mechanism in kinematics and has the characteristic that some actuator movement can be transmitted to multiple links.

2.2.5

self-organization

organization of a system without any external manipulation or control, where a nonequilibrium structure emerges spontaneously due to the collective interactions among a number of simple microscopic objects or phenomena

2.2.6
electro wetting on dielectric
EWOD
wetting of a substrate controlled by the voltage between a droplet and the substrate covered with a dielectric film

Note 1 to entry: The contact angle of a liquid droplet, typically an electrolyte, on a substrate can be electrically controlled because the solid-liquid surface interfacial tension can be controlled with the energy stored in the electric double layer which works as capacitor. Covering the electrode with a dielectric material of determined thickness, the capacitance can be determined with ease. Electro wetting on dielectric is used typically in microfluidic devices.

Note 2 to entry: This note applies to the French language only.

2.2.7
stiction
phenomenon that a moving microstructure is stuck to another structure or substrate by adhesion forces

Note 1 to entry: When structures become smaller, stiction appears significant due to the scale effect that surface forces predominate over body forces. Stiction frequently occurs in the MEMS fabrication process when small structures are released during wet etching processes due to the surface tension of liquid. Representative adhesion forces to cause stiction are van der Waals force, electrostatic force, and surface tension of liquid between structures.

2.3 Terms and definitions relating to materials science

2.3.1
silicon-on-insulator
SOI
structure composed of an insulator and a thin layer of silicon on it

Note 1 to entry: Sapphire (as in SOS), glass (as in SOG), silicon dioxide, silicon nitride, or even an insulating form of silicon itself is used as an insulator.

Note 2 to entry: This note applies to the French language only.

2.4 Terms and definitions relating to functional element

2.4.1
actuator, <micro-electromechanical devices>
mechanical device that converts non-kinetic energy into kinetic energy to perform mechanical work

2.4.2
microactuator
actuator produced by micromachining

Note 1 to entry: For a micromachine to perform mechanical work, the microactuator is indispensable as a basic component. Major examples are the electrostatic actuator prepared by silicon process, the piezoelectric actuator that utilizes functional materials like lead zirconate titanate (PZT), the pneumatic rubber-actuator, and so on. Many other actuators based on various energy conversion principles have been investigated and developed. However, the energy conversion efficiency of all these actuators deteriorates as their size is reduced. Therefore, the motion mechanisms of organisms such as the deformation of protein molecules, the flagellar movement of bacteria, and muscle contraction are being utilized to develop special new actuators for micromachines.

Note 2 to entry: Micro-electrostatic actuators are actuated by a micro-electrostatic field, magnetic microactuators are driven by a micromagnetic field, and piezoelectric microactuators depend on a microstress field to convey motion and power.

2.4.3
light-driven actuator
actuator that uses light as a control signal or an energy source or both

Note 1 to entry: Since the development of photostrictive materials, various light driven actuators have been proposed. These actuators have simple structures and can be driven by wireless means. A motor is proposed that utilizes the spin realignment effect, in which a magnetic material absorbs light and the resulting heat changes the direction of magnetization reversibly. Actuators utilizing thermal expansion, and exploiting polymer photochemical reactions, are also being studied.

2.4.4
piezoelectric actuator
actuator that uses piezoelectric material

Note 1 to entry: Piezoelectric actuators are classified into the single-plate, bimorph, and stacked types, and the popular material is lead zirconate titanate (PZT). The features are: 1) quick response, 2) large output force per volume, 3) ease of miniaturization because of the simple structure, 4) narrow displacement range for easier microdisplacement control, and 5) high efficiency of energy conversion. Piezoelectric actuators are used for the actuators for micromachines, such as ultrasonic motor, and vibrator. An applied example is a piezoelectric actuator for a travelling mechanism which moves by the resonance vibration of a piezoelectric bimorph, and a micropositioner piezoelectric actuator which amplifies the displacements of a stacked piezoelectric device by a lever.

2.4.5
shape-memory alloy actuator
actuator that uses shape memory alloy

Note 1 to entry: Shape-memory alloy actuators are compact, light, and produce large forces. These actuators can be driven repeatedly in a heat cycle or can be controlled arbitrarily by switching the electric current through the actuator itself. Lately, attempts have been made to use the alloys to build a servosystem that has an appropriate feedback mechanism and a cooling system, intended for applications where quick response is not necessary Application examples under development are microgrippers for cell manipulation, microvalves for regulating very small amounts of flow and active endoscopes for medical use.

2.4.6
sol-gel conversion actuator
actuator that uses the transition between the sol (liquid) state and the gel (solid) state

Note 1 to entry: A sol-gel conversion actuator can work in a similar way to living things. For example, if electrodes are put on a small particle of sodium polyacrylate gel in an electrolytic solution and a voltage is applied, the particle repeatedly changes its shape. Sol-gel conversion actuators can be connected in series, sealed in a thin pipe and fitted with multiple legs, to make a microrobot that moves in one direction and that looks like a centipede. Another application being conceived is a crawler microrobot that automatically moves through a thin pipe.

2.4.7
electrostatic actuator
actuator that uses electrostatic force

Note 1 to entry: Since the electrostatic actuator has a simple structure and its output force per weight is increased as the size is reduced, much research is ongoing to apply these characteristics to the actuators of micromachines. Application examples developed so far on an experimental basis include a wobble motor and a film electrostatic actuator.

2.4.8
comb-drive actuator
electrostatic actuator, consisting of a series of parallel fingers, fixed in position, engaged and interleaved with a second, movable set of fingers

Note 1 to entry: The application of an electrostatic charge to the first set of fingers attracts the fingers of the second set, such that they become more fully engaged in the interdigit spaces of the first set. Then the static