IEC 62047-43

Edition 1.0 2024-03

INTERNATIONAL STANDARD

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Semiconductor devices – Micro-electromechanical devices – Part 43: Test method of electrical characteristics after cyclic bending deformation for flexible micro-electromechanical devices

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 43: Test method of electrical characteristics after cyclic bending deformation for flexible micro-electromechanical devices

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IEC 62047-43 has been prepared by subcommittee 47F: Micro-electromechanical devices, of IEC technical committee 47: Semiconductor devices. It is an International Standard.

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

Draft	Report on voting
47F/459/FDIS	47F/464/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
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INTRODUCTION

In the recent trend toward ubiquitous sensor society and the world of internet of things, demand and thus the market for softer electronic devices are quickly expanding. That is what flexible micro-electromechanical devices are for, some of which are already released into the market. Even a so-called foldable device is under development and will soon appear in the market. However, to operate trillions of such devices for the comfort and safety of human beings, the reliability of the individual devices is a critical concern. Especially in the case of flexible devices, robustness against bending deformation is an important issue which will be shared among all the producers and users of such devices. In addition, since such devices are bent usually not only once but some numbers of cycles, information on performance deterioration along with the number of cycles is also important.

In order to understand how safe a situation is, even after numbers of cycles, performance deterioration behaviour of those devices as a function of loading levels and cycles needs to be evaluated so as to ensure secure operation during expected service periods. This standard procedure of testing is designed with the emphasis on such points and with the applicability not only to already emerging flexible devices but also to so-called foldable devices which still function even when the device is folded.

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 43: Test method of electrical characteristics after cyclic bending deformation for flexible micro-electromechanical devices

1 Scope

This part of IEC 62047 specifies the test method of electrical characteristics after cyclic bending deformation for flexible electromechanical devices. These devices include passive micro components and active micro components on the flexible film or embedded in the flexible film. The desired in-plane dimensions of the device for the test method ranges typically from 1 mm to 300 mm and the thickness ranges from 10 μm to 1 mm, but these are not limiting values. The test method is so designed as to understand and further visualize the entire performance deterioration behaviour after cyclic bending deformation in a concept of 3D (P-S-N: Performance – Severity of bending – Number of cycles) plot over the loading space of severity of bending and number of repeated cycles. This document is essential to estimate safety margin over the operation period under a certain level of cyclic bending deformation and indispensable for reliable design of the product employing these devices.

2 Normative references

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IEC 62047-43:2024

IEC 62047-35:2019, *Semiconductor devices – Micro-electromechanical devices – Part 35: Test method of electrical characteristics under bending deformation for flexible electro-mechanical devices*

3 Terms and definitions

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

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

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

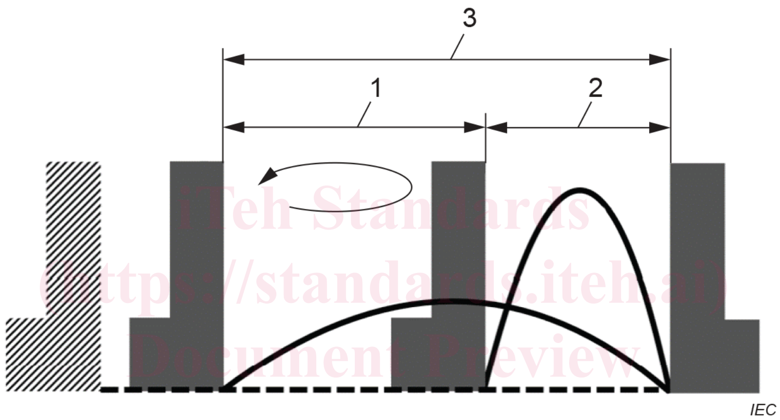
3.1
d_{max}
maximum folding distance
maximum distance between two loading walls, representing severity of bending, i.e. loading level, applied to the device, as indicated in Figure 1

3.2
d_{min}
minimum folding distance
minimum distance between two loading walls, representing severity of bending, i.e. loading level, applied to the device, as indicated in Figure 1

Note 1 to entry: The degree of bending given to the device is here represented by the distance between two walls approaching close to each other to bend the device, which is denoted as folding distance.

Note 2 to entry: This measure may be optionally converted to the radius of curvature *r* and also converted to the bending strain ε given around a bending axis. The strain is one of the suitable parameters for estimating the damage of materials through cyclic mechanical loading. But here it may not be uniform between the two walls especially when the rigidity distribution around the bending axis is not homogeneous due to the heterogeneity of structures. The nominal value of the radius is proportional to the distance, and the bending strain is in inverse proportion to the radius. Thus, the maximum of nominal bending strain occurs at the minimum folding distance.

3.3
shuttle range
travel distance of moving wall, as indicated in Figure 1



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1 shuttle range
2 minimum folding distance
3 maximum folding distance

Figure 1 – Schematic explanation of cyclic bending test

4 Test piece

4.1 General

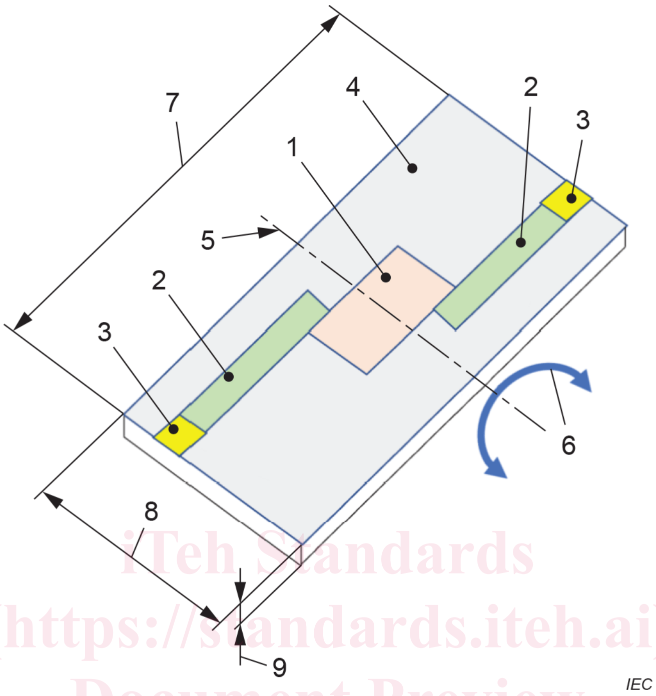
Flexible MEMS device, which is bent in use, can be in principle a test piece as it is and subjected to the evaluation of this document. In principle, this test-method is applicable without restriction on size and shape of devices. However, for the ease of load application, it may be cut into a rectangular shape with target parts to be loaded at the centre as mentioned in 4.2.

4.2 Shape of a test piece

A rectangular shape of test piece should be used for the ease of experiment as shown in Figure 2. It can be necessary to cut out a part of devices for the test, especially when the target part to be tested, which determines its own functional feature, is not located in the centre of the device. In this case, the test piece shall be prepared in a rectangular form by cutting a part out of the entire device with the target part located at the centre of two parallel edges which should also be parallel to the bending axis. This is because the point to be loaded to the end is limited in this test method only along the bending axis likely coming out at the centre due to the loading scheme explained in 5.1.

In this document, the length l and the width w of test piece is the dimension of the test piece in perpendicular and parallel direction to the bending axis, respectively. Because of the structures assembled on or embedded in the flexible substrate, the thickness can be not uniform over the entire device and hence depends on the location.

NOTE Length and width could be interchangeable when bending axis is rotated by 90 degrees, which are symbolically illustrated in Figure 3.



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1 target part

2 interconnects

3 electrodes

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4 flexible substrate

5 bending axis

6 bending direction

7 length

8 width

9 thickness

Figure 2 – Schematic illustration of flexible MEMS test piece