



IEC 62047-42

Edition 1.0 2022-09

# INTERNATIONAL STANDARD



---

**Semiconductor devices – Micro-electromechanical devices –  
Part 42: Measurement methods of electro-mechanical conversion characteristics  
of piezoelectric MEMS cantilever**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 31.080.99

ISBN 978-2-8322-5714-2

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD .....	4
1 Scope .....	6
2 Normative references .....	6
3 Terms and definitions .....	6
4 Test bed of MEMS piezoelectric thin film .....	7
4.1 General.....	7
4.2 Functional blocks and components .....	9
4.2.1 General .....	9
4.2.2 Displacement meter .....	10
4.2.3 Power source .....	10
4.2.4 Electric measurement instrument.....	10
5 Microcantilever under testing .....	11
5.1 General.....	11
5.2 Measurement principle .....	11
5.3 Measuring procedures of converse transverse piezoelectric coefficient.....	12
5.4 Measuring procedures of direct transverse piezoelectric coefficient .....	12
6 Test report.....	13
Annex A (informative) Example of measuring method of piezoelectric MEMS cantilever.....	15
A.1 General.....	15
A.2 Measurement procedure .....	15
A.2.1 Structure of piezoelectric microcantilevers .....	15
A.2.2 Microfabrication process .....	15
A.2.3 Mechanical properties of piezoelectric and non-piezoelectric layers.....	16
A.2.4 Electric properties and resonance frequency of microcantilever .....	17
A.2.5 Input displacement of microcantilever for direct piezoelectric coefficient $e_{31,f}^d$ .....	18
A.3 Measurement results.....	19
A.3.1 Converse piezoelectric measurement .....	19
A.3.2 Direct piezoelectric measurement .....	19
A.4 Test report .....	20
Bibliography.....	22
Figure 1 – Test bed of piezoelectric MEMS unimorph cantilever.....	7
Figure 2 – Setup for measurement of converse piezoelectric effect.....	9
Figure 3 – Setup for measurement of direct piezoelectric effect .....	10
Figure A.1 – Structure and photograph of piezoelectric microcantilevers under testing.....	15
Figure A.2 – Fabrication process of piezoelectric microcantilevers .....	16
Figure A.3 – Frequency response of tip displacement of each piezoelectric microcantilevers.....	18
Figure A.4 – Tip displacement and converse piezoelectric coefficient as a function of applied voltage .....	19
Figure A.5 – Direct piezoelectric coefficient as a function of input tip displacement of piezoelectric microcantilevers .....	19
Table 1 – Symbols and designations of test bed .....	8

Table A.1 – Mechanical properties of piezoelectric layer ..... 16

Table A.2 – Mechanical properties of non-piezoelectric layer ..... 17

Table A.3 – Electric properties of microcantilever ..... 17

Table A.4 – Resonance frequencies of microcantilever ..... 17

Table A.5 – Input displacement for direct piezoelectric coefficient  $e^d_{31,f}$ ..... 18

Table A.6 – Test report ..... 20

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**SEMICONDUCTOR DEVICES –  
MICRO-ELECTROMECHANICAL DEVICES –**
**Part 42: Measurement methods of electro-mechanical conversion  
characteristics of piezoelectric MEMS cantilever**

## 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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62047-42 has been prepared by subcommittee 47F: Micro-electromechanical systems, 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/414/FDIS	47F/417/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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/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](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.

**IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## **SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –**

### **Part 42: Measurement methods of electro-mechanical conversion characteristics of piezoelectric MEMS cantilever**

#### **1 Scope**

This part of IEC 62047 specifies measuring methods of electro-mechanical conversion characteristics of piezoelectric thin film on microcantilever, which is typical structure of actual micro sensors and micro actuators. In order to obtain actual and precise piezoelectric coefficient of the piezoelectric thin films with microdevice structures, and this document reports the schema to determine the characteristic parameters for consumer, industry or any other applications of piezoelectric devices. This document applies to piezoelectric thin films on microcantilever fabricated by MEMS process.

#### **2 Normative references**

There are no normative references in this document.