IEC 62047-56

Edition 1.0 2026-10

INTERNATIONAL STANDARD

**Semiconductor devices - Micro-electromechanical devices -
Part 56: Test method for characteristics of MEMS metal oxide semiconductor (MOS) type gas sensor**

ICS 31.080.99

ISBN 978-2-8327-1568-0

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2026 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

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

CONTENTS

FOREWORD 2
INTRODUCTION 4
1 Scope 6
2 Normative references 6
3 Terms and definitions 6
4 Working principle of MOS type gas sensor 7
4.1 General 7
4.2 N-type MOS 7
4.3 P-type MOS 7
5 Test method 8
5.1 General 8
5.2 Configuration of the apparatus for characteristics measurement of MEMS MOS type gas sensor 9
5.3 Test procedure 9
6 Data analysis 10
6.1 Calculating results 10
6.2 Test report 11
Annex A (informative) 12
A.1 Photograph of fabricated MEMS MOS type gas sensor as an example 12
A.2 Measured data using MEMS MOS type gas sensor as an example 12
Bibliography 13

Figure 1 – Schematic illustration of MEMS MOS type gas sensor 5
Figure 2 – An exemplary graph showing gas response of a MEMS MOS type gas sensor 7
Figure 3 – Schematic drawing of gas sensing mechanism: (a) N-type and (b) P-type MOS gas sensors 8
Figure 4 – Exemplary graph to define sensitivity of a MEMS MOS type gas sensor 9
Figure 5 – Schematic drawing of the apparatus for characteristics measurement of MEMS MOS type gas sensor 9
Figure A.1 – Photograph of fabricated MEMS MOS type gas sensor as an example 12

Table 1 – Table for test report of characteristics of MEMS MOS type gas sensor 11
Table A.1 – Table for measured data using MEMS MOS type gas sensor as an example 12

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

Semiconductor devices - Micro-electromechanical devices - Part 56: Test method for characteristics of MEMS metal oxide semiconductor (MOS) type gas sensor

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62047-56 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/568/FDIS	47F/575/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

– revised.

INTRODUCTION

Micro-electromechanical systems (MEMS) metal oxide semiconductor (MOS) type gas sensor is one of key components in MEMS technologies including chemical MEMS and bio-MEMS. MEMS MOS type gas sensor, in general, consists of MEMS structure with membrane for thermal isolation, microheater for controlling operation temperature, insulator layer between microheater and microelectrode, and microelectrode for measuring resistance change of gas sensing materials on microelectrode. It is possible to detect specific gas or measure the gas concentration by using highly sensitive and selective gas sensing materials.

Micro-electromechanical systems (MEMS) metal oxide semiconductor (MOS) gas sensors represent a significant advancement in the field of gas detection technology. These sensors leverage the integration of MEMS technology with the gas-sensitive properties of metal oxide semiconductors to offer a compact, efficient, and highly sensitive solution for detecting a wide range of gases. MEMS technology enables the miniaturization of gas sensors, enabling them to be manufactured on a microscopic scale with high precision and at a lower cost. The use of metal oxide semiconductors, such as tin oxide (SnO_2), zinc oxide (ZnO), or titanium dioxide (TiO_2), provides the sensor with the ability to detect various gases through changes in electrical resistance when exposed to target gases like hydrogen disulfide (H_2S), carbon monoxide (CO), nitrogen dioxide (NO_2), or volatile organic compounds (VOCs). The combination of MEMS and MOS technologies results in sensors that are not only small and portable but also exhibit fast response times, low power consumption, and high sensitivity. These attributes make MEMS MOS gas sensors ideal for applications in environmental monitoring, industrial safety, automotive exhaust control, and indoor air quality management. As the demand for more efficient and accurate gas detection increases, MEMS MOS gas sensors are positioned to play a critical role in future sensor technology, offering reliable performance in a wide range of environmental conditions. Figure 1 below illustrates a typical MEMS MOS type gas sensor structure as an example. Figure 1 includes the key components shown.

– Membrane for thermal isolation layer: The thermal isolation layer is typically membrane layer such as SiNx, SiO_2 or hybrid layer with SiNx and SiO_2, etc.

– Microheater: The microheater with pad for interconnection is embedded within the MEMS structure. When electrical current passes through microheater, it generates heat due to resistive heating.

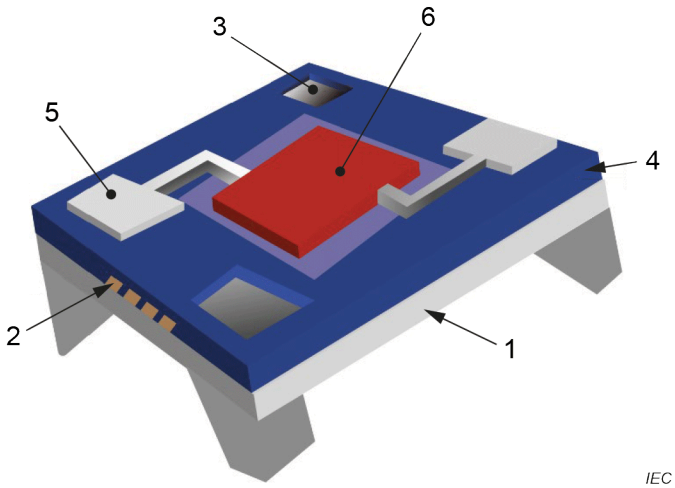
– Pad for microheater: The microheater pad is an element of the MEMS MOS type gas sensor. It is responsible for maintaining the sensor at an optimal operating temperature. The MOS layer requires a specific temperature to interact effectively with gas molecules, which the microheater pad provides by generating heat uniformly across the sensing area. This heating ensures that the sensor responds quickly and accurately to the presence of target gases.

– Insulation layer: The insulator is the material surrounding the microheater. The primary function of insulator is to electrically isolate microheater and MOS gas sensing materials, preventing unwanted electrical currents from interfering with the operation of gas sensor.

– Microelectrode and Pad: The microelectrode and pads for microelectrode are for measuring the electrical signals from the MOS gas sensing materials. Those can be made from materials that ensure good electrical conductivity and strong adhesion to the MEMS substrate.

– MOS Gas Sensing Materials: The sensing materials are typically of two types, n-type MOS, such as SnO_2, ZnO, TiO_2, etc., and p-type MOS such as Co_3O_4, NiO, CuO, etc. When target gases interact with the gas sensing material, its electrical resistance changes. These changes are detected by the electrode and its pads and processed to detect specific target gases and determine the concentration of the target gases. The choice of MOS gas sensing material depends on the specific gases to be detected.

A photograph of fabricated MEMS MOS type gas sensor as an example is shown in Figure A.1.



Key

1 Membrane for thermal isolation layer

2 Microheater

3 Pads for microheater

4 Insulation layer

5 Pads for microelectrode for MOS gas sensing materials

6 MOS gas sensing materials

Figure 1 – Schematic illustration of MEMS MOS type gas sensor

1 Scope

This part of IEC 62047-56 specifies the requirements and test method for characteristics of MEMS metal oxide semiconductor (MOS) type gas sensor.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 62047-1, *Semiconductor devices - Micro-electromechanical devices - Part 1: Terms and definitions*

IEC 60079-29-1, *Explosive atmospheres - Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62047-1, IEC 60079-29-1 and the following apply.

ISO and IEC maintain terminological 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
gas sensor response time
time taken upon exposure to a target gas from the first reaction to the saturated value for particular percentage level, in general, taken as 90 %, is response time

3.2
gas sensor recovery time
recovery time is the time required so as to return to, in general, 90 % of the base resistance when the target gas is removed

3.3
gas sensing materials
materials for sensitive and selective gas detection or measuring the gas concentration

Figure 2 presents an exemplary graph showing gas response of a MEMS MOS type gas sensor.