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**NATIONAL STANDARD OF THE
PEOPLE'S REPUBLIC OF CHINA**

GB/T 47239.1-2026

**Semiconductor devices - Flexible and stretchable
semiconductor devices - Part 1: Bending test method for
conductive thin films on flexible substrates**

(English Translation)

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Foreword

This document complies with the provisions of GB/T 1.1-2020 "Standardization Work Guidelines Part 1: Structure and Drafting Rules of Standardization Documents".

Drafting.

This document is Part 1 of GB/T 47239 "Semiconductor Devices - Flexible and Stretchable Semiconductor Devices". GB/T 47239 has been issued.

The following sections were laid out.

- Part 1: Bending test method for conductive thin films on flexible substrates;
- Part 2: Evaluation methods for electron mobility, subthreshold swing and threshold voltage of flexible devices;
- Part 3: Performance evaluation of thin-film transistors on flexible substrates in a raised state;
- Part 4: Fatigue evaluation of flexible conductive films on flexible semiconductor device substrates;
- Part 5: Test methods for thermal properties of flexible materials;
- Part 6: Thin-film resistance testing methods for flexible conductive films;
- Part 7: Test methods for barrier properties of flexible organic semiconductor packaging films;

--Part 8: Test methods for the ductility, flexibility and stability of flexible resistive memory;

--Part 9: Performance testing method for one-transistor-one-resistor (1T1R) resistor memory cells.

This document is equivalent to IEC 62951-1:2017 "Semiconductor devices - Flexible and stretchable semiconductor devices - Part 1: Flexible substrates".

The following minimal editorial changes have been made to this document.

--The URLs for the ISO and IEC terminology databases have been removed from the terminology and definitions section.

Please note that some content in this document may involve patents. The issuing organization of this document assumes no responsibility for identifying patents.

This document was proposed by the Ministry of Industry and Information Technology of the People's Republic of China.

This document is under the jurisdiction of the National Semiconductor Device Standardization Technical Committee (SAC/TC 78).

Introduction

Flexible and stretchable semiconductor devices possess characteristics such as stretchability, bendability, deformability, light weight, and variable shape, and can be used in robot skin, etc.

Applications include wearable devices, optoelectronic products, and energy storage products. With the development of semiconductor device technology and flexible, stretchable semiconductors...

The widespread application of these components has placed higher demands on product quality and reliability. GB/T 47239 "Flexible and Tensile Semiconductor Devices" the "Flexible Stretchable Semiconductor Devices" standard is a fundamental standard for testing and experimenting with flexible and stretchable semiconductor devices, and is essential for evaluating these devices.

--Part 1: Bending Test Methods for Conductive Thin Films on Flexible Substrates. The purpose is to specify the bending test methods for conductive thin films on flexible semiconductor substrates.

Curved test method.

--Part 2: Evaluation methods for electron mobility, subthreshold swing, and threshold voltage of flexible devices. The aim is to define the bending state.

Evaluation methods for electrical parameters such as mobility, subthreshold swing, and threshold voltage of flexible thin-film transistor devices.

--Part 3: Performance Evaluation of Thin Film Transistors on Flexible Substrates in a Raised State. The aim is to define the performance of flexible substrates in a raised state.

Evaluation methods for thin-film transistor characteristics.

--Part 4: Fatigue Evaluation of Flexible Conductive Thin Films on Flexible Semiconductor Device Substrates. The aim is to specify the requirements for flexible semiconductor device substrates.

A fatigue evaluation method for flexible conductive films on a board.

--Part 5: Test methods for thermal properties of flexible materials. The purpose is to specify the test methods for the thermal properties of flexible materials.

--Part 6: Sheet Resistance Test Methods for Flexible Conductive Thin Films. The purpose is to specify the sheet resistance test methods for flexible conductive thin films.

--Part 7: Test methods for barrier properties of flexible organic semiconductor packaging films. The purpose is to specify the barrier properties of flexible organic semiconductor packaging films.

Test methods for membrane barrier properties.

--Part 8: Test methods for the ductility, flexibility, and stability of flexible resistive memory. The purpose is to specify the requirements for flexible resistive memory.

The terminology and definitions, as well as the testing equipment and procedures for ductility, flexibility and stability.

--Part 9: Performance Test Methods for Transistor-Resistor (1T1R) Resistor Storage Cells. The purpose is to specify the performance test methods for transistor-resistor (1T1R) memory cells.

Terminology and definitions for resistive (1T1R) memory cells, as well as testing apparatus and test excitation for the performance parameters of resistive memory cells.

Incentive and testing process.

GB/T 47239 (all parts) corresponds to IEC 62951 (all parts), unifying the testing of flexible and stretchable semiconductor devices.

And testing methods to support the development of the flexible semiconductor device industry.

Part 1: Bending Test Methods for Conductive Thin Films on Flexible Substrates

1 Scope

This document describes a bending test method for conductive thin films deposited or bonded on non-conductive flexible substrates to measure the electromechanical properties

of the films.

Or flexibility. Conductive thin films are widely used in flexible semiconductor devices; they refer to thin films deposited or bonded to non-conductive flexible substrates, such as gold.

These include thin films, transparent conductive electrodes, and silicon thin films. Due to the interfacial adhesion between the thin film and the substrate, the thin film on the flexible substrate and the independent...

Thin films and substrates have different electromechanical properties. The purpose of this document is to establish methods for evaluating the electromechanical properties or flexibility of conductive thin films on flexible substrates.

Simple and repeatable test methods. The bending test methods in this document include external bending test and internal bending test.

2 Normative references

The contents of the following documents, through normative references within the text, constitute essential provisions of this document. Dated citations are listed below.

For references to documents, only the version corresponding to that date applies to this document; for undated references, the latest version (including all amendments) applies.

This document.

GB/T 42709.2-2026 Semiconductor devices and microelectromechanical devices-Part 2: Thin film materials-Tension testing methods (IEC 62047-2:2006, IDT) GB/T 42709.22-2026 Semiconductor Devices - Microelectromechanical Devices - Part 22: Electromechanical Stretching of Conductive Thin Films on Flexible Substrates Elongation test method (IEC 62047-22:2014, IDT)

3.1 Terms and Definitions

The following terms and definitions apply to this document.

3.1.1

The radius of curvature of the test sample as shown in the bending test.

3.1.2

critical bending radius the bending radius when the device resistance exceeds the specified value, and/or when thin film breakage, delamination, potential cracks or substrate damage occur.

Note: This usually refers to the minimum bending radius that the conductive film can withstand.

3.1.3