

ICS 31.080.99



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

GB/T 44842-2024

**Micro-electromechanical systems(MEMS) technology - Bend
testing methods of thin film materials**

微机电系统（MEMS）技术 薄膜材料的弯曲试验方法
(English Translation)

Issued on: October 26, 2024

Implemented on: October 26, 2024

Issued by: State Administration for Market Regulation

Table of Contents

Foreword...	3
1 Scope...	4
2 Normative references...	4
3 Terms and definitions...	4
4 Symbols and definitions...	4
5 Test structure...	5
5.1 Design of test structures...	5
5.2 Preparation of test structures...	6
5.3 Width and thickness of the test structure...	6
5.4 Storage prior to testing...	6
6 Test methods...	7
6.1 General...	7
6.2 Installation method for the test structure...	8
6.3 Loading methods...	8
6.4 Test speed...	9
6.5 Displacement measurement...	9
6.6 Test environment...	9
6.7 Data analysis...	9
6.8 Materials for test structures...	10
7 Test report...	10
Annex A (informative) Considerations for testing structure/substrate contacts...	12

1 Scope

This document describes a bending test method for thin-film materials with a length and width of less than 1 mm and a thickness ranging from 0.1 μm ~10 μm . Thin films serve as primary structural materials in micro-electromechanical systems (MEMS) and micromechanics.

As primary structural materials in devices such as micro-electromechanical systems (MEMS) and micromechanical components, thin films possess unique characteristics - specifically, dimensions on the order of a few micrometers, fabrication via processes such as deposition and photolithography, and/or the utilization of non-machined test structures. This document describes the bending test method and the geometry of smooth,

cantilever-type test structures at the micro-scale, designed to ensure testing accuracy commensurate with the unique characteristics of thin-film materials.

2 Normative references

The following referenced documents are indispensable for the application 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 62047-6.2009, Semi-conductor devices -- Micro-electromechanical devices --
Part 6.Axial fatigue testing methods of thin film materials

3 Terms and definitions

This document contains no terms or definitions requiring definition.

4 Symbols and definitions

The symbols and their definitions are listed in Table 1.

Table 1 -- Symbols and definitions for test structures

Figure 1 -- Schematic diagram of a test structure with substrate

5.1 Design of test structures

The test structure takes the form of a cantilever beam, as illustrated in Figure 1. Its cross-sectional shape shall be simple - such as a rectangle or a trapezoid - to facilitate the calculation of the area moment of inertia. The dimensions of the parallel section of the test structure - specifically its length (L), width (W), and thickness (S) - shall satisfy the following relationships. $5 < L/W < 10$ and $10 < L/S < 100$.

The fixed end of the test structure shall be positioned within the substrate as shown in

Figure 1. The selection of the contact point between the test structure and the substrate is critical to prevent plastic deformation - or even fracture - at the root of the test structure and the substrate contact point caused by stress concentration (see Annex A).

When employing test structures of different geometries whose elastic deformation behavior does not conform to formula (1) (see 6.7), the geometry of the test structure and the corresponding alternative equation shall be recorded.

To minimize the influence of size effects, the dimensions of the test structure shall be comparable to those of the target device.

5.2 Preparation of test structures

Since the mechanical properties of the test structure depend on the fabrication process, the test structure shall be fabricated using the same thin-film processing techniques as those used for the actual device. The test structure shall also be fabricated in accordance with the procedures specified in 4.2 of IEC 62047-6.2009. The substrate removal process shall be selected with care to prevent damage to the supporting parts of the substrate (see Annex A) and the supporting parts of the test structure.

Thin films exhibiting an internal stress distribution across their thickness cannot be tested, as they curl upon release from the substrate.

5.3 Width and thickness of the test structure

Since the film thickness across the entire wafer is typically non-uniform, the width and thickness of each test structure shall be measured. The measurement accuracy for the width and thickness of the parallel sections of the test structure shall be within $\pm 1\%$ and $\pm 5\%$, respectively. Direct measurement of each test structure is recommended (see 4.3 "Test structure thickness" in IEC 62047-6.2009).

5.4 Storage prior to testing

The storage environment affects the mechanical properties of the film (see 4.4 "Storage prior to testing" in IEC 62047-6.2009).

6.1 General

The test equipment employed incorporates displacement, loading, and positioning functions, and shall preferably be equipped with a force and displacement measurement system.

During measurement, a spherical or knife-edge loading tool is used to apply a load to a specific location on the cantilever beam test structure, as shown in Figures 2 a) and 2 b). It is recommended to record the position of the loading point on the test structure (A, B, or C), as well as the relationship between the force (P) and displacement (δ) of the cantilever beam, as shown in Figure 2 c). The positional accuracy of the designated loading points along the parallel section of the test structure shall be within $\pm 1\%$ of the test structure's length. The radius of the knife-edge tip shall be 5 μm . Collinearity shall be accurate to within $\pm 1\%$ of the test structure's length. The angle between the longitudinal axis of the knife-edge and the surface of the test structure shall be within

2°, and the angle between the knife-edge and the longitudinal axis of the test structure shall be within 4°. These data shall be measured and recorded.

Figure 2 -- Measurement methods

.....