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Semiconductor devices – Micro-electromechanical devices – Part 38: Test method for adhesion strength of metal powder paste in MEMS interconnection

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CONTENTS

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 38: Test method for adhesion strength of metal powder paste in MEMS interconnection

FOREWORD

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IEC 62047-38 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:

FDIS	Report on voting
47F/378/FDIS	47F/382/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/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.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 38: Test method for adhesion strength of metal powder paste in MEMS interconnection

1 Scope

This part of IEC 62047 specifies a test method for measuring the adhesion strength of metal powder paste in the electrical interconnection between micro-electromechanical systems (MEMS) and a circuit board. The typical examples of metal powder paste are anisotropic conductive paste, solder paste, and nanoscale metallic inks. This testing method is valid for metal powder diameters from 10 μm and 500 μm.

In this test method, a uniaxial compression load is applied to metal powder paste using a glass lens simulating an actual MEMS device; then, the adhesion strength is measured by retracting the lens. This test method is proper when the adhesion strength should be analyzed by considering the actual contact area between the MEMS device and metal powder particles.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

3.1
contact load
P_L
predetermined force when the lens is contacted with metal powder paste

Note 1 to entry: Contact load is expressed in N.

3.2
maximum pulling force
P_C
maximum of pulling force endurable for a test piece

Note 1 to entry: Maximum pulling force is expressed in N.

3.3
contact area only with metal powder
A_{MP}
contact area made with metal powder only when the contact load(P_L) is applied

Note 1 to entry: Contact area only with metal powder is expressed in m^2.

3.4
contact area with metal powder paste
A_{MPP}
contact area made with metal powder paste when the contact load(P_L) is applied

Note 1 to entry: Contact area with metal powder paste is expressed in m^2.

3.5
adhesion strength
S_C
maximum pulling force (P_C) divided by the contact area

Note 1 to entry: Adhesion strength is expressed in N/m^2.

3.6
separation speed
V_{SEP}
predetermined speed when the test pieces are retracted from the lens

Note 1 to entry: Separation speed is expressed in μm/s.

3.7
contact radius
a
radius of contact area when the contact area with metal powder paste is assumed to the area of a circle

Note 1 to entry: Contact radius is expressed in m.

3.8
radius of curvature
R
radius of curvature of the lens, which simulates an actual device

Note 1 to entry: Radius of curvature of the lens is expressed in m.

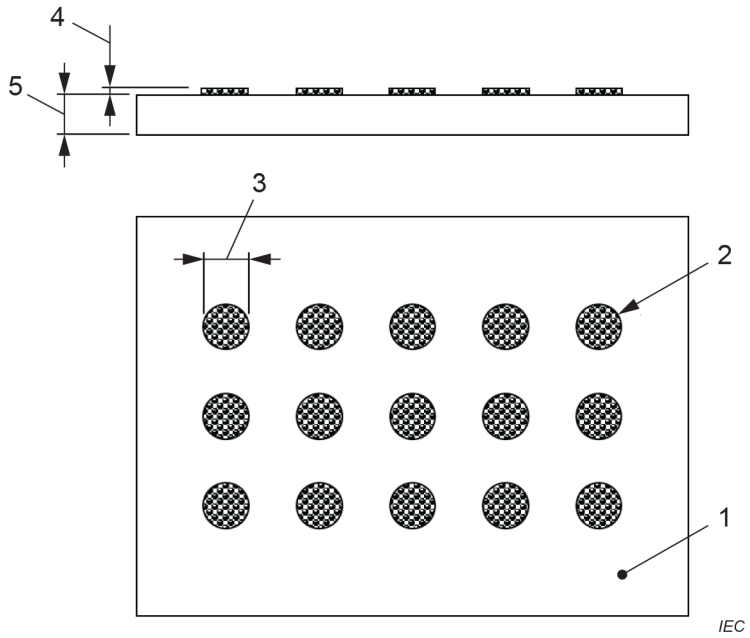
4 Test piece

4.1 General

The test piece for metal powder paste shall be prepared using the same preparation process for MEMS interconnection. The circular patterns of a metal powder paste shown in Figure 1 is formed by screen printing, ink-jet printing, or other deposition techniques. The interface between the metal powder paste and the substrate and the interface between the metal powder paste and the counterpart lens shall be identical to the situation of MEMS interconnection.

4.2 Shape of a test piece

The shape of the test piece and its components are presented in Figure 1. The overall shape of the test piece is similar to a circular disk with a diameter and thickness. Circular disks are formed on a substrate material.



Key

1 substrate material

2 circularly patterned metal powder paste

3 diameter of circularly patterned metal powder paste

4 thickness of metal powder paste

5 thickness of the substrate

Figure 1 – Circularly patterned test piece for metal powder paste

The radius of a test piece shall be at least 50 times smaller than the radius of curvature of lens (R). The thickness of a test piece shall be at least 2 times larger than that of the diameter of a single metal particle. The distance between test pieces shall be large enough to avoid interference during the test.

4.3 Measurement of dimensions

To analyze the test results, the dimensions of the contact area shall be accurately measured because the dimensions are used to determine the adhesion strength of test materials. The contact area between the glass lens and metal powder or metal powder paste should be measured using an optical microscope and image analysis with an error of less than ± 5 %. Information on dimensional measurement can be found in Annex C of IEC 62047-2:2006 and in Clause 6 of IEC 62047-3:2006.

4.4 Evaluation of adhesion strength

The adhesion strength (S) of metal powder paste is evaluated using the following Formula (1):

$$S = P_C/A_{MPP}. \quad (1)$$

The adhesion strength (S_C) of metal powder is evaluated using the following Formula (2):

$$S_C = P_C/A_{MP}. \quad (2)$$

Here, P_C is the maximum pulling force, A_{MPP} is the contact area between the glass lens and metal powder paste, and A_{MP} the contact area between the glass lens and metal powder.

5 Testing method and test apparatus

5.1 Test principle

The test is performed by applying the contact load on the metal powder paste using a cleaned glass lens with a few millimetre curvature, and then by detaching the lens from the paste to evaluate the adhesion strength of the paste. A test example can be found in Annex A. During the loading process, the metal powder in the paste is deformed by the contact with the lens and the contact area between the lens and the metal powder is formed. The changes in the contact area are recorded by an optical microscope and CCD camera. The contact area is calculated by analyzing the recorded images after the test. During the unloading process, the contact load is decreased and a pulling force is applied on the interface between the lens and the paste due to the adhesion between them. After the maximum pulling force reaches, the contact area is rapidly decreased and the lens is completely separated from the paste. The adhesion strength of the metal powder paste can be evaluated by dividing the maximum pulling force with the contact area between the lens and the metal powder measured before the unloading process. The lens can be coated with thin metal films such as Au and Al for simulating the electrode materials of MEMS.

5.2 Test apparatus

The test machine is shown in Figure 2. The glass lens is fixed on the top of the chamber by clamping and the metal powder paste test piece is installed on the sample stage. The test piece is moved toward the glass lens by moving the z-axis motorized stage for the loading process and then is separated from the lens by moving down the z-axis stage for the unloading process. During the test, the force is measured by loadcell, and optical images of the contact area are recorded using an optical microscope and CCD camera. The contact area images shall be recorded at a speed larger than 30 Hz using a camera with a microscope objective of 20x or more.

5.3 Test procedure

The test procedure is as follows:

a) install a test piece on the sample stage and start to record loadcell output signal and optical microscope images;

b) apply a contact load to the test piece by moving the Z-axis stage. This is a loading process. The test piece is made contact with the glass lens fixed on the chamber and compressed, so the contact area between the lens and paste is formed;

c) hold the contact for a holding time of a few seconds. This is for stabilizing the contact interface;

d) separate the test piece from the lens by moving down the z-axis stage with a separation speed. This is the unloading process;

e) after testing, remove the test piece from the test machine with caution. If possible, preserve the test piece for investigation using electron and optical microscopes.