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Semiconductor devices – Micro-electromechanical devices – Part 15: Test method of bonding strength between PDMS and glass

Dispositifs à semiconducteurs – Dispositifs microélectromécaniques – Partie 15: Méthode d'essai de la résistance de collage entre PDMS et verre

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IEC 62047-15:2015-03(en-fr)

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CONTENTS

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SEMICONDUCTOR DEVICES –
MICRO-ELECTROMECHANICAL DEVICES –

Part 15: Test method of bonding strength between PDMS and glass

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The text of this standard is based on the following documents:

FDIS	Report on voting
47F/208/FDIS	47F/213/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 15: Test method of bonding strength between PDMS and glass

1 Scope

This part of IEC 62047 describes test method for bonding strength between poly dimethyl siloxane (PDMS) and glass. Silicone-based rubber, PDMS, is used for building of chip-based microfluidic devices fabricated using lithography and replica moulding processes. The problem of bonding strength is mainly for high pressure applications as in the case of certain peristaltic pump designs where an off chip compressed air supply is used to drive the fluids in micro channels created by a twin layer, one formed by bondage between glass with replica moulded PDMS and another between PDMS and PDMS. Also, in case of systems having pneumatic microvalves, a relatively high level of bonding particularly between two replica moulded layers of PDMS becomes quite necessary. Usually there is a leakage and debonding phenomena between interface of bonded areas, which causes unstability and shortage of lifetime for MEMS devices. This standard specifies general procedures on bonding test of PDMS and glass chip.

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2 Normative references

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IEC 62047-9, *Semiconductor devices – Micro-electromechanical devices – Part 9: Wafer to wafer bonding strength measurement for MEMS*

3 Terms and definitions

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

3.1
complete bonded area
bonded wafer without void areas

3.2
hydrophilic
physical property of a molecule that can bond with water (H_2O) through hydrogen bonding

Note 1 to entry: A definition of the term "molecule" can be found on this page: http://en.wikipedia.org/wiki/Molecule.

Note 2 to entry: A definition of "hydrogen bond" can be found on this page: http://en.wikipedia.org/wiki/Hydrogen_bonding.

3.3
hydrophobic
property that tend to be non-polar molecules which form aggregates of like molecules in water and analogous intramolecular interactions

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3.4
PDMS
silicone-based rubber poly dimethyl siloxane having a chemical formula of $(H_3C)_3SiO[Si(CH_3)_2O]_nSi(CH_3)_3$

4 Testing method

4.1 Visual test

4.1.1 General

The visual test should be performed to confirm whether substantial other bonding tests are required. Visual test is a simple qualitative test method.

Optical equipment shall be used to evaluate the bonding interface of glass to PDMS and PDMS to PDMS.

4.1.2 Equipment

One or a few equipments of optical microscope, scanning acoustic microscope, scanning electron microscope (SEM), transmittion electron microscope (TEM) and infra-red (IR) or optical camera can be used.

4.1.3 Procedure

The procedure is as follows:

a) to observe bonding conditions using the optical microscope;

b) to measure voids areas and bubbles using images observed images by optical microscope and IR camera.

4.1.4 Visual test results

The test results can be classified into three classes after observation based on the Key in Table 1 for each.

Table 1 − Result of visual test

Type numbers or serial numbers of objective wafer	Good	Fair	Poor
1			
2			
3			
Key Good – complete bonded area larger than 95 % Fair – complete bonded area larger than 75 % Poor – complete bonded area larger than 50 %			

4.2 Bonding strength test

4.2.1 General

The bond strength is measured using the blister test wherein a blister of 3 mm diameter is made in PDMS using photolithography and replica moulding techniques. General requirements are given in IEC 62047-9.

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4.2.2 Sample preparation

The masks for selective patterning are designed and printed by using a high-resolution printer (see Figure 1).

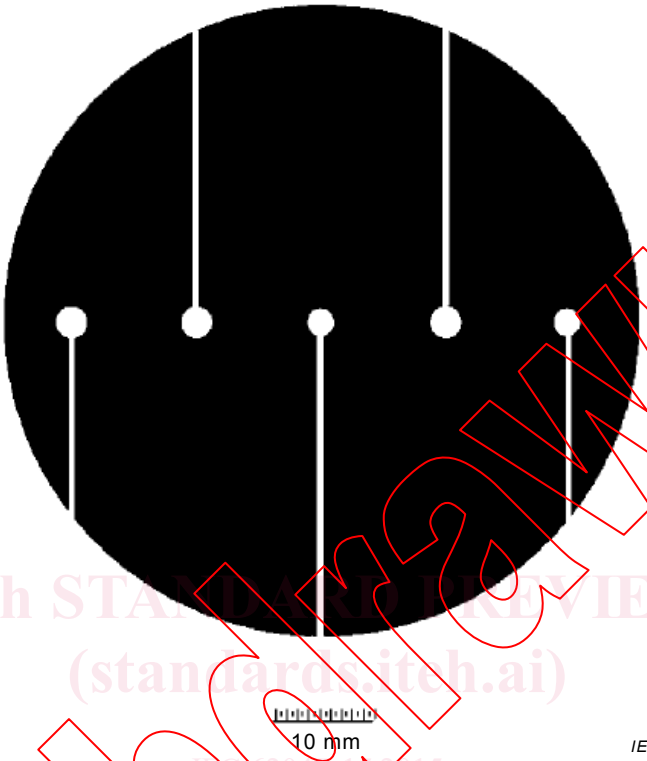

Figure 1 – Blister mask

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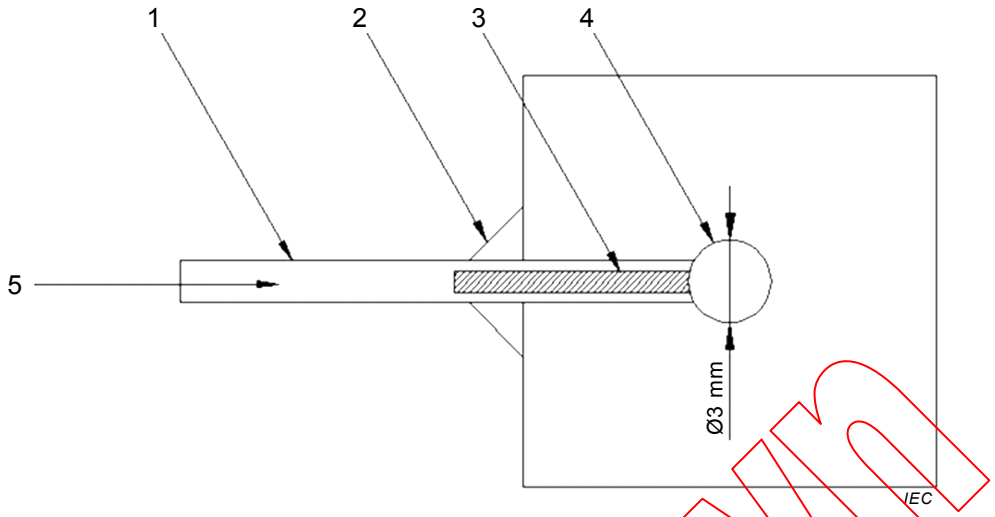
The fabrication of the blister is done in two layers. The negative photoresist is spun onto a cleaned glass wafer of 63,5 mm diameter.

The typical thickness of the resist is about 200 µm after spinning. The negative photoresist is next patterned using the mask as shown in Figure 1. This negative is used to cast the PDMS up to 2,5 mm thickness.

After curing the PDMS cast, pieces of size 12,7 mm × 12,7 mm are cut around the blister shapes. These are then bonded to pieces of plain PDMS, or cleaned glass slides of similar size by plasma treatment. For glass/PDMS bonding, the glass slides are thoroughly cleaned by boiling in piranha solution (5:1 ratio of concentrated and 30% solution) for 3 min to 4 min and then, repeatedly washed in DI water before plasma exposure.

4.2.3 Procedure

After fabricating the blister, an input port is attached to it using a steel pipe and a polyether ether ketone (PEEK) tubing, which is epoxied to one of the edges (see Figure 2). A regulated nitrogen or air supply is connected to the device.



Key

1 PEEK tubing
2 Epoxy
3 Steel tube
4 Blister
5 Compressed nitrogen or air to expand the blister

Figure 2 – PDMS blister

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4.2.4 Result of blister test

The pressure at which the blister starts to fail is noted down. The pressure is proportional to the bonding strength.

4.3 Contact angle measurement

4.3.1 General

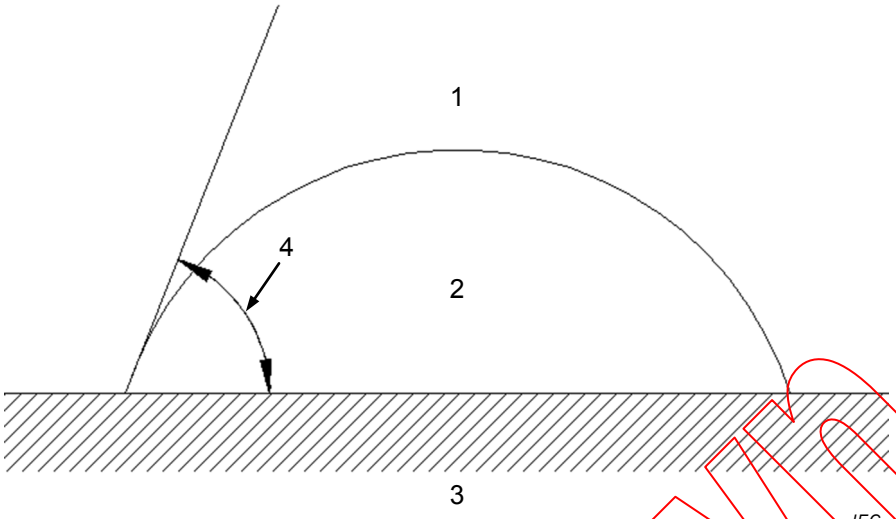
Contact angle measurement is the ideal method to characterize surface wettability and widely used technique of loss and recovery of hydrophobicity of silicone rubbers. So, this method can be used to accurately measure the hydrophilic characteristic of a surface for a polymer like PDMS, whose surface properties change speedily with post exposure time.

4.3.2 Equipment

A camera of the contact angle setup should be used. Simultaneously, a separate set of Glass-PDMS and PDMS-PDMS substrates exposed in the same run of the exposure tool are brought into conformal position with each other after a similar span of time, as required to transit the exposed wafer and put a water drop over it.

4.3.3 Procedure

For accuracy of measurement, the contact angle measurement system used in this part of IEC 62047 is positioned close to the plasma exposure tool. This enables to capture the image of a water droplet, dropped on the plasma treated sample within the first one minute of the plasma exposure. Figure 3 shows the contact angle (θ) between the surface and a water droplet.



Key

1 Air 2 Water

3 PDMS 4 θ

Figure 3 – Contact angle measurement of water drop on PDMS

4.3.4 Result of test

Write down the angle (θ) as shown in Figure 3.

4.4 Hermeticity test

4.4.1 General

This is a kind of leakage test between PDMS and PDMS chip or PDMS and glass chip. This test can be applied in case of having a channel in structure.

4.4.2 Equipment

Prepare for the test set-up as shown in Figure 4.

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