SEMI MF950-1107 (Reapproved 0718)
TEST METHOD FOR MEASURING THE DEPTH OF CRYSTAL DAMAGE OF A MECHANICALLY WORKED SILICON WAFER SURFACE BY ANGLE POLISHING AND DEFECT ETCHING

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1 Purpose

1.1 The principal application of this Test Method is for determining the depth of damage of the nonpolished back surface of a silicon wafer that has had intentionally added work damage. This Test Method is intended for use in process control where each individual location is responsible to determine the internal repeatability to its satisfaction.

1.2 This Test Method provides a means for measuring the depth of mechanical damage in silicon wafers in the range from 5 to 200 µm.

1.3 This Test Method can be used for process control or research and development purposes. It is not recommended for use in material acceptance.

2 Scope

2.1 This Test Method covers a technique to measure the depth of damage, on or beneath the surface of silicon wafers prior to any heat treatment of the wafer. Such damage results from mechanical surface treatments such as sawing, lapping, grinding, sandblasting, and shot peening.

2.2 The damage is revealed by a preferential etch that removes silicon in the region of the deformation. Preferential etching occurs because the chemical potential in the region of the deformation is changed by the stress fields associated with the deformation. The depth of damage is expressed in micrometers.

2.3 The measurement is destructive because a specimen is prepared from a section of a silicon wafer.

2.4 Depth of damage can be measured in the range of 5 to 200 µm using this method.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 *Choice of Bevel Angle* — A bevel angle must be used such that a magnification of the depth of damage is at least a factor of 5, or the damage may not be detected. Bevel angles less than 5°44′ are not recommended because of difficulty in determining the surface edge due to the uneven surface topography generated by the damage, (see Figure 1). Table 1 lists the relationship of bevel angle (α), bevel length (L), and damage depth (T_z).

3.1.1 Even with a 5°44′ angle, there may be difficulty in determining the bevel edge for surface damage that generates a very rough surface. The bevel edge can be determined by the apparent ‘discontinuous’ polished areas, (see Figure 1).

3.2 Damage depth may be nonuniform over a whole wafer area. Because the sample specimens are relatively small with respect to the whole wafer area, depth of damage variations may not be detected; thus, the measurement of the damage depth may be ambiguous.

3.3 Measurement of the bevel angle must be done after lapping and *before* polishing, otherwise the correct angle may not be measured. The alkaline polishing compound may cause a slight surface perturbation near the silicon-nitride interface and at the edges of the specimen.

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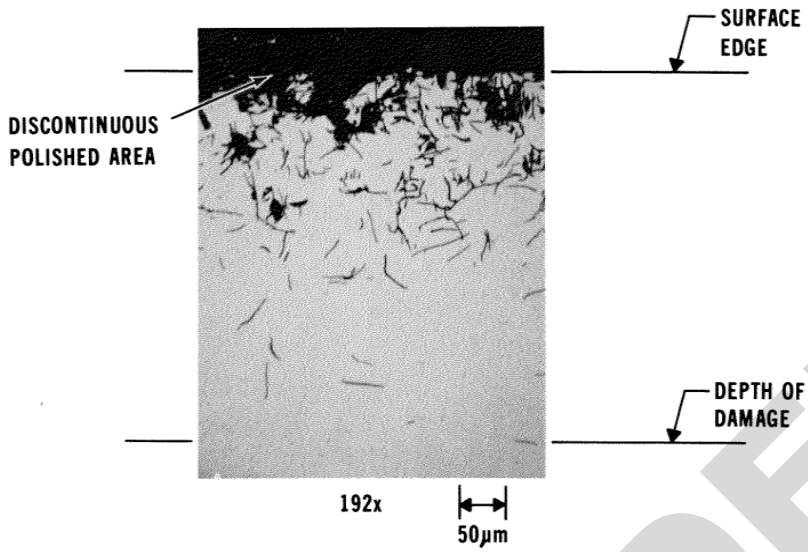

#1 The surface damaged from sandblasting.

#2 The 1 μm thick LPCVD nitride film is not visible in the photomicrograph.

Figure 1
5°44′ Bevel Angle Polished Surface After 1-min Defect Etch

Table 1 Relation of Bevel Angle (α), Bevel Length (L), and Damage Depth (T_z)

Angle (α)	*Sinα*	*Bevel Length (L), mm*			
		Tz = 5 μm	*Tz = 10 μm*	*Tz = 100 μm*	*Tz = 200 μm*
17′ 11″	0.005	1	2	20	40
34′ 23″	0.01	0.5	1	10	20
1° 9′	0.02	0.25	0.5	5	10
2° 52′	0.05	0.01	0.2	2	4
5° 44′	0.10	0.05	0.1	1	2
11° 32′	0.20	0.025	0.05	0.5	1

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI C28 — Specification and Guide for Hydrofluoric Acid

SEMI M59 — Terminology for Silicon Technology

SEMI MF672 — Test Method for Measuring Resistivity Profiles Perpendicular to the Surface of a Silicon Wafer Using a Spreading Resistance Probe

SEMI MF1809 — Guide for Selection and Use for Etching Solutions to Delineate Structural Defects in Silicon

4.2 *ASTM Standards*[1]

ASTM D5127 — Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries

[1] ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA; Telephone: +1.610.832.9585, Fax: +1.610.832.9555, http://www.astm.org

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ASTM E122 — Standard Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process

4.3 *JIS Standard*[2]

JIS H 0609 — Test Methods of Crystalline Defects in Silicon by Preferential Etch Techniques

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Terms relating to silicon and other semiconductor technology are defined in SEMI M59.

6 Summary of Test Method

6.1 A silicon specimen is coated with silicon nitride by a low-pressure plasma method to a minimum thickness of 1 µm.

6.2 The specimen is then beveled at a small angle by a polishing technique that produces no additional mechanical damage.

6.3 The bevel angle is measured.

6.4 The beveled specimen is etched to reveal the damage.

6.5 The length of the damage region is measured from the beveled edge on the beveled section.

6.6 The depth of damage is then calculated from the relationship between the measured damage length and the sine of the bevel angle.

7 Apparatus

7.1 *Apparatus to Bevel Polish the Test Specimen*

7.1.1 *Beveling Jig* — Consisting of a solid cylinder that is free to move within a hollow cylinder. The specimen is wax mounted onto a beveled sample mount that is then attached to the free moving cylinder as shown in Figure 2.

7.1.2 *Hot Plate, Diamond Scriber, and Tweezers*

7.1.3 *Polishing Equipment* — That can vary the polishing pressure and will not produce crystal damage.

7.2 *Cement Removal* — The usual chemical laboratory apparatus such as beakers. Adequate facilities for handling and disposing of chlorinated solvents and their vapors are essential.

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[2] Japanese Standards Association, 4-1-24 Akasaka, Minato-ku, Tokyo 107-8440, Japan; Telephone: +81.3.3583.8005, Fax: +81.3.3586.2014, http://www.jsa.or.jp

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