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Test method of gloss for silicon wafer

硅片表面光泽度的测试方法

(English Translation)

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Foreword

This standard is drafted in accordance with the rules given in the GB/T 1.1-2009 *Directives for standardization-Part 1: Structure and drafting of standards.*

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. The issuing body of this document shall not be held responsible for identifying any or all such patent rights.

This standard was jointly proposed and prepared by SAC/TC203 National Technical Committee for Standardization of Semiconductor Equipment and Materials and SAC/TC203/SC2 Sub-technical Committee on Materials of the National Technical Committee for Standardization of Semiconductor Equipment and Materials.

Test method of gloss for silicon wafer

1 Scope

This document specifies a method for determining the gloss of silicon wafer by the light reflection method at the three geometries 20 °,60 ° or 85 °.
This document is applicable to test the gloss of chemically etched silicon wafer, polished silicon wafer and epitaxial silicon wafer, but is not applicable to test the gloss of silicon wafer with patterns on the surface.

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.
GB/T 9754 *Paints and varnishes-Determination of specular gloss of non-metallic paint films at 20°,60°,85°*
GB/T 14264 *Semiconductor materials-terms and definitions*
JJG 696—2015 *Specular gloss meters and gloss plates*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in GB/T 9754 , GB/T 14264 and the following apply.

3.1

gloss
Ratio multiplied by 100 of the luminous flux reflected from a specimen to that reflected by a polished black glass surface with a refractive index of 1.567 in specular direction for a specified reflection angle and specified aperture angles of light source and receptor.
Note 1: To define the gloss scale, polished black glass with refractive index of 1.567 is assigned the value of 100 for 20 °, 60 ° and 85 ° geometries.
Note 2: The evaluation of the gloss of the back side of the double-sided polished silicon wafer is based on the gloss of the front side of the double-sided polished silicon wafer.

4 Theory

Under the condition that the incident angle and the beam are specified, the incident light passes through the lens to illuminate the sample surface to obtain the beam in the direction

of the specular reflection angle. In this context, the intensity of the reflected light is depended on the surface material. The receptor collects the reflected light, compares and calculates the reflected light intensity with the standard surface and obtains the gloss value of the surface finally. The course of beam of the gloss meter is illustrated in Figure 1.

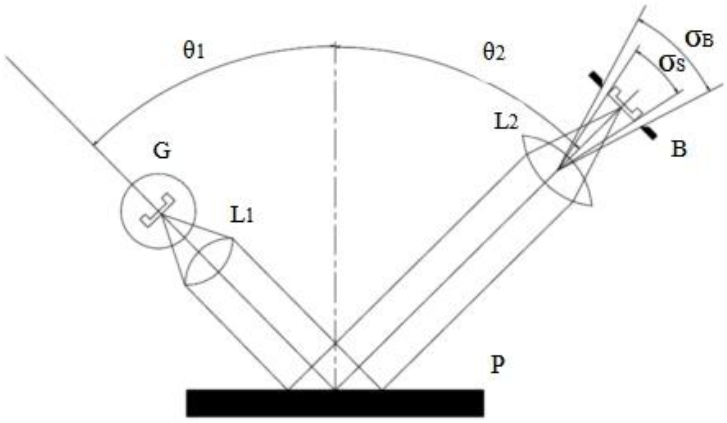


Figure 1 Course of beam of the gloss meter

Key:

G——source;

L_1、L_2——lens;

B——receptor field stop;

P——test surface;

θ_1——incidence angle;

θ_2——reflection angle;

σ_B——receptor aperture angle;

σ_S——source image aperture angle.

5 Interference

5.1 During the test, light leakage and wrong selection of test angle will affect the received luminous flux, thus affecting the accuracy of the test.

5.2 The contamination of the standard plate and the instability of the light source affect the standard value and thus affect the accuracy of the test.

5.3 Any defects such as pinhole, much more particles, contamination covering, fog caused by chemical etched, and unevenness of silicon wafers in test area will affect the light reflection effect, and the test results cannot represent the gloss of the normal area.

5.4 If the ambient humidity is too high, which will affect the reflection of the light, thus affecting the test accuracy.

5.5 The chemical etching mode and crystal orientation of the silicon wafer affect the gloss value.

5.6 For alkali etched silicon wafers with <111> crystal orientation, the gloss values is related to the test directions due to the influence of crystal cell orientation.
5.7 It is applicable to test the gloss of the silicon wafer with any gloss for the 60 ° geometry , but due to the influence of resolution.it is more applicable to test the silicon wafer with high-gloss or low-gloss using the 20 ° or 85 ° geometry.

6 Test condition

Unless otherwise specified, the test shall be conducted under the following conditions:
a) The ambient temperature is (22 ± 5) ℃;
b) The ambient relative humidity is not more than 80%.

7 Apparatus

7.1 Light source: it shall meet the D65 illuminant or A light source as specified in JJG 696-2015.
7.2 Incidence lens: the incident light beam shall be irradiated on the sample surface in a certain way.
7.3 Receptor: The spectral response of the receptor shall conform to the visual function V（λ）in JJG 696-2015.
7.4 Display instrument: it shall give a clear and accurate reading with a deviation of 1% of the full scale maximum.
7.5 Standard plate: it shall be uniform and stable, and the surface shall be free of defects that affect the gloss test, it should be calibrated regularly.

8 Sample

8.1 The surface of the sample shall be flat, smooth, dry and free of pollution, and the test area shall be free of pin holes, mechanical scratches and other appearance defects.
8.2 The sample shall cover the test port completely.

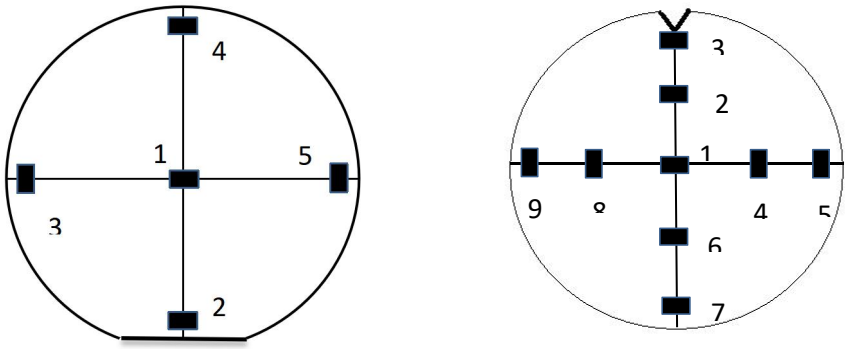
9 Apparatus calibration

9.1 Automatic calibration: for the gloss meter with automatically proceeding routine the calibration will be carried out automatically when starting.
9.2 Manual calibration gloss meter is calibrated according to the following process:
a) Select the test angle according to the test requirements;
b) Place the zeroing test board at the test position and carry out the blank calibration;
c) Place the standard plate at the test position and carry out standard correction. The difference between the test value and the standard plate value is within ±0.5%.
9.3 The instrument can only be used after calibration.

10 Testing procedure

10.1 The gloss meter test port shall be close to the sample surface and completely cover the test area.

10.2 Select a certain incident angle for testing. For silicon wafer samples with a diameter of no more than 150 mm, the five-point method is used, see Figure 2a), that is, one point at the center of the wafer and four points at the edge of the wafer. For silicon wafer samples with a diameter greater than 150 mm, the nine-point method is used, see Figure 2b), namely, one point at the center of the silicon wafer, four points at half of the radius, and four points at the edge of the silicon wafer. When testing the edge positions, the test point is about 2 cm away from the edge of the silicon wafer, and the edge position is tested according to the reference plane position, 90 ° clockwise, 180 ° clockwise and 270 ° clockwise. If there are other requirements for testing, it shall be determined by the supplier and the customer.



a) Silicon wafer with diameter no more than 150 mm 直径不大于150 mm的硅片

b) Silicon wafer with diameter greater than 150 mm 直径大于150 mm的硅片

Figure 2 Diagram of silicon wafer surface gloss test points 硅片表面光泽度测试点示意图

10.3 Each group of samples shall be tested at the same geometric angle.

11 Test data processing

11.1 Gloss values Gs（ θ） of the simple is to be Calculated by means of formula (1):

$$Gs(\theta)=\frac{\Phi_S}{\Phi_{OS}}G_{OS}(\theta) \quad \cdots\cdots (1)$$

where:

Gs（θ）——is the surface gloss value of the sample for the measuring angle θ, in gloss unit (GU);

Φ_s——is the reflected luminous flux of the sample surface for the incidence angle θ, in lumen (lm);

Φ_{0S}——Is the reflected luminous flux of standard plate for the incidence angle θ, in lumen (lm);

G_{0S}（θ）——is the gloss value of the standard plate used, in gloss unit (GU).

11.2 See Table 1 for gloss values of polished black glass with different refractive index and incident angle.

Table 1 Gloss values of polished black glass

Refractive index (n)	Gloss G_{os} (θ) GU		
	Incidence angle (θ)		
	20°	60°	85°
1.400	57.0	71.9	96.6
1.410	59.4	73.7	96.9
1.420	61.8	75.5	97.2
1.430	64.3	77.2	97.5
1.440	66.7	79.0	97.6
1.450	69.2	80.7	98.0
1.460	71.8	82.4	98.2
1.470	74.3	84.1	98.4
1.480	76.9	85.8	98.6
1.490	79.5	87.5	98.8
1.500	82.0	89.1	99.0
1.510	84.7	90.8	99.2
1.520	87.3	92.4	99.3
1.530	90.0	94.1	99.5
1.540	92.7	95.7	99.6
1.550	95.4	97.3	99.8
1.560	98.1	98.9	99.9
1.567	100.0	100.0	100.0
1.570	100.8	100.5	100.0
1.580	103.6	102.1	100.2
1.590	106.3	103.6	100.3
1.600	109.1	105.2	100.4
1.610	111.9	106.7	100.5
1.620	114.3	108.4	100.6
1.630	117.5	109.8	100.7
1.640	120.4	111.3	100.8
1.650	123.2	112.8	100.9
1.660	126.1	114.3	100.9
1.670	129.0	115.8	101.0
1.680	131.8	117.3	101.1
1.690	134.7	118.8	101.2
1.700	137.6	120.3	101.2
1.710	140.5	121.7	101.3

Table 1 Gloss values of polished black glass (Continued)

Refractive index (n)	Gloss G_s (θ) GU		
	Incidence angle (θ)		
	20°	60°	85°
1.720	142.4	123.2	101.3
1.730	146.4	124.6	101.4
1.740	149.3	126.1	101.4
1.750	152.2	127.5	101.5
1.760	155.2	128.9	101.5
1.770	158.1	130.4	101.6
1.780	161.1	131.8	101.6
1.790	164.0	133.2	101.6
1.800	167.0	134.6	101.7

12 Accuracy

Prepare twelve silicon wafers: three pieces 200 mm diameter <100> alkali etched wafers, three pieces 150 mm diameter <100> acid etched wafers, one piece 200 mm diameter polished silicon wafer, two pieces 150 mm diameter <111> alkali etched wafers, two pieces 150 mm diameter <111> acid etched wafers, one piece 150 mm diameter polished silicon wafer. Each sample was tested 10 times in seven laboratories, and the test direction was parallel to the Flat or V notch. After one test the gloss meter was required to remove from the wafer and then put on the test position to test again.

The relative standard deviation of gloss value tested in a single laboratory is not more than 5%; The relative standard deviation of gloss value tested in multiple laboratories is not more than 20%.

13 Test report

The test report shall at least consist of the following information:

a) test date;
b) tester;
c) the name and model of the apparatus;
d) the name and type of the sample;
e) sample number;
f) test angle;
g) test conditions;
h) test results;
i) this document number.