



Standard Test Method for Measuring Diameter of Semiconductor Wafers¹

This standard is issued under the fixed designation F 613; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers measurement of the diameter of silicon wafers up to 205 mm in diameter. Other semiconductor materials with a circular shape can also be measured.

1.2 This test method is independent of surface finish and may be performed on edge-contoured specimens.

1.3 This test method is to be carried out at a temperature of $23 \pm 5^\circ\text{C}$.

1.4 This test method was developed for use with silicon wafers with standard diameters as given in SEMI Specifications M1, and may be used for wafers of other diameter or materials within the specified limit, provided suitable gage blocks are available and standard flat configurations are used.

1.5 This test method is intended for use as a referee method.

1.6 Roundness is not measured by this method.

1.7 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.8 For wafers of diameter 3 in. or smaller, the values stated in inch-pound units are to be regarded as standard; the values stated in acceptable metric units in parentheses are for information only. For wafers of diameter larger than 3 in., the values stated in acceptable metric units are to be regarded as standard whether or not they appear with parentheses; inch-pound units are for information only.

2. Referenced Documents

2.1 ASTM Standards:

E 1 Specification for ASTM Thermometers²

2.2 Federal Standard:

Fed. Std. No. GGG-G-15C Specification for Gage Blocks and Accessories (Inch and Metric)

2.3 SEMI Standard:

¹ This test method is under the jurisdiction of ASTM Committee F-1 on Electronics and is the direct responsibility of Subcommittee F01.06 on Silicon Materials and Process Control.

Current edition approved Aug. 15, 1993. Published October 1993. Originally published as F 613 – 79. Last previous edition F 613 – 87.

² Annual Book of ASTM Standards, Vol 14.03.

³ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁴ Available from the Semiconductor Equipment and Materials International, Inc., 805 E. Middlefield Rd., Mountain View, CA 94043.

Specifications M 1, Polished Monocrystalline Silicon Wafers

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *diameter*—of a semiconductor wafer, the linear dimension across the surface of a circular wafer that contains the wafer center and excludes flats or other peripheral fiducial geometries.

3.1.2 *indent*—of a semiconductor wafer, an edge defect that extends from the front surface to the back surface.

4. Summary of Test Method

4.1 A specimen wafer is placed in a fixture on the stage of an optical comparator.

4.2 The specimen is moved through the illuminating beam in a manner so that first one specimen edge and then the opposite edge are brought into coincidence with a reference line; the stage translation required is measured by means of a micrometer head assembly and gage blocks. Three such diametral traverses are made along specific diameters.

4.3 Mean diameter and diameter variation are calculated.

5. Significance and Use

5.1 The diameter of semiconductor wafers is an important parameter in microelectronic fabrication, especially for processing steps requiring wafer fixturing. Wafer diameter must conform to the limits specified in SEMI Specifications M 1 or other agreed upon limits, or the product that is otherwise suitable may not fit correctly in process equipment.

5.2 This test method is suitable in principle for use as an incoming quality acceptance test for generating data on diameter variation. Frequently, incoming inspection tests are of a pass-fail nature; however, in fail situations this test method provides supportive data for a final disposition.

5.3 Wafers cut from a perfectly round crystal can have off-axis crystallographic orientation requirements which may result in elliptically shaped wafers. This test method reports the range of three diameters for each wafer measured.

6. Interferences

6.1 If a traverse from one edge of the specimen to the other is intended to be a traverse along a true wafer diameter, but is in fact taken along a lesser chord or is interrupted by a flat, other fiducial geometry, an indent, or an uneven edge, the resulting diameter measurement will be in error.

6.2 Backlash in the micrometer head assembly may result in erroneous measurement of diameter.

6.3 Failure to keep both the stage surface on which the micrometer spindle bears and the spindle tip clean and free of damage is likely to result in erroneous measurement of diameter, as is failure to keep the spindle in contact with the stage during measurement.

6.4 Failure to keep the gage block measuring surfaces clean and free of damage may result in erroneous measurements of diameter.

6.4.1 If two or more gage blocks are thought to be wrung together to form a single length reference, but in fact are not in the degree of contact implied by wringing, the resulting diameter measurement may be in error.

6.4.2 Failure to maintain gage blocks in calibration may result in erroneous measurement of diameter.

6.5 Failure to bring the projected image into sharp focus on the comparator screen will affect the precision of this test method.

7. Apparatus

7.1 *Optical Comparator*, with image magnification in the nominal range from 20 to 40 $\times$, and incorporating the following components:

7.1.1 *Stage*, having translation range of at least 222 mm and vertical motion range of at least 100 mm. The stage shall either be free to move in translation, or if intended to be driven (as with a screw), shall incorporate means for unlocking the drive for free translational motion.

7.1.2 *Micrometer Head Assembly*, screw-type, for measurement and control of stage translation with a resolution of at least as fine as 2.5 μm and configured to accommodate gage blocks (in a track) for extending the measurement range. The micrometer head assembly shall incorporate means to support the head with respect to the main structure of the comparator so that the micrometer spindle may bear upon an appropriate portion of the stage, with movement of the spindle resulting in translation of the stage in at least one direction. Greater spindle extension shall correspond to higher readings.

7.2 *Gage Blocks Set*, blocks used individually or in combination to provide a reference length known to within 2.5 μm (100 $\mu\text{in.}$) corresponding to the nominal diameter of the slices to be measured (Note 1). Blocks in accordance with Fed. Std. No. GGG-G-15C, intended to be used in combination shall have a surface finish permitting them to be wrung together.

NOTE 1—The nominal slice diameters given in SEMI Specifications M 1 are 2 and 3 in. and 100, 125, 150, 200, and 300 mm.

7.3 *Fixture*, to support the specimen on the comparator stage in a manner so that the axis of specimen illumination is perpendicular to the specimen front and back surfaces and the projected image on the comparator screen is in focus during a traverse across a specimen diameter. The fixture shall incorporate means to rotate the specimen 360° with a resolution of $\pm 5^\circ$ and means to be clamped to the stage.

7.4 *Scribed Overlay*, of glass or other suitable transparent material, configured for mounting on the comparator screen so that the two perpendicular scribed lines provide horizontal and vertical reference.

7.5 *Disposable Wipers*, lint-free, for cleaning polished metal surfaces.

7.6 *ASTM Precision Thermometer*, having a range from -8 to 32°C and conforming to the requirements for Thermometer 63C as prescribed in Specification E 1.

8. Sampling

8.1 This test method is intended to be used on a referee basis. Procedures for selecting the sample specimens from each lot to be tested shall be agreed upon by the parties to the test, as shall the definition of what constitutes a lot.

9. Procedure

9.1 Measure and record the room ambient temperature using the ASTM precision thermometer. If the room temperature is not within $\pm 5^\circ\text{C}$ of 23°C, discontinue the test. Periodically, at intervals no greater than 10 min, re-check room ambient temperature. If the temperature changes so as not to be within 5°C of 23°C, discontinue the test. Make sure that gage blocks and test samples have been exposed to the room ambient temperature for at least 15 min.

9.2 Follow the manufacturer's instructions for use of the optical comparator and prepare the instrument to make measurements.

9.3 With the comparator image magnification adjusted to be in the nominal range from 20 to 40 $\times$, mount the overlay on the screen and clamp the specimen fixture to the stage.

NOTE 2—Precise knowledge of image magnification is not required.

9.4 Using Fig. 1, determine the diameter pattern for the specimen.

NOTE 3—Diameter location has an intended tolerance of $\pm 5^\circ$.

9.4.1 For (111) *p*-type wafers and all wafers without secondary flats (including notched wafers), use the diameter parallel to the primary flat and two other diameters $\pm 45^\circ$ from it are used.

9.4.2 For (100) *n*-type wafers with opposing primary and secondary flats (diameter 125 mm or less), use the same pattern as for (111) *p*-type wafers. For (100) *n*-type wafers with 135° secondary flats, use as the first diameter the one parallel with the primary flat, and use as the second and third diameters, the ones 30° and 60° counter clockwise from the first.

9.4.3 For (100) *p*-type wafers with secondary flats, use as the first diameter the one midway between the primary and secondary flats, and use as the second and third diameters, the ones 90° and 120° counter clockwise from the first. The second diameter is perpendicular to the first and the third diameter is 30° from the second.

9.4.4 For (111) *n*-type wafers with secondary flats, use as the first diameter the one parallel to the primary flat, and use as the second and third diameters, the ones 30° and 60° clockwise from the first.

9.5 Clamp a test specimen on the fixture so that a specimen edge is projected on the screen and adjust the comparator focus to obtain a sharp image.

9.5.1 Clamp the specimen so that the desired diameter is in the direction of the comparator stage movement, with a tolerance of $\pm 5^\circ$.