

SEMI MF533-0310 (Reapproved 1023) TEST METHODS FOR THICKNESS AND THICKNESS VARIATION OF SILICON WAFERS

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (§) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and §§) the symbols are used to reference more than one section or paragraph, respectively.

NOTICE: Paragraphs entitled ‘NOTE:’ are not an official part of this Standard or Safety Guideline and are not intended to modify or supersede the official Standard or Safety Guideline. These have been supplied by the global technical committee to enhance the usage of the Standard or Safety Guideline.

1 Purpose

1.1 Wafer thickness and thickness variations must be controlled to suit the requirements of fixtures and equipment used in microelectronic processing. Estimates of these parameters, based on a representative sample from a given lot of wafers, aids in determining whether or not wafers from that lot are acceptable for the intended processing steps.

1.2 Wafers that are too thin may break during normal processing operations. Wafers that are too thick may cause mechanical jamming. Wafers with thickness outside the desired tolerance may not have appropriate thermal mass or electrical resistance for certain processing steps.

1.3 Excessive thickness variations may cause problems with mechanical handling of the wafers during processing. In addition, such variations may cause deviations from surface flatness that adversely affect photolithographic processes. The effect of thickness variations on photolithographic processes depends on the line width and registration requirements of individual circuit designs, as well as on the specific optical and mechanical design of the photolithographic processing equipment being used.

1.4 This Test Method is intended for use for materials acceptance and process control purposes. The test methods may be applied at any point during the processing of unpolished wafers into polished wafers or substrates.

1.5 When the test method was developed for flatted wafers in the 1970s, noncontact thickness gages employing manual wafer positioning, which are the basis of this Test Method, were in routine use. More recently, faster, automated instruments have replaced these manual gages for most common uses in the semiconductor industry. In these automatic systems, microprocessors or microcomputers are used to control wafer positioning, operate the instrument and to analyze the data (refer to SEMI MF1530).

1.6 Despite the fact that this Test Method is not commonly used in its present form, it embodies all the basic elements of the measurement method and a simple analysis of data. Thus, this Standard provides useful guidance in the fundamentals and application of differential noncontact wafer thickness measurements. It is also suitable for use with very large diameter wafers before the automatic systems become available.

2 Scope

2.1 This Test Method covers measurement of the thickness of silicon wafers, polished or unpolished, and estimation of the variation in thickness across the wafer for both flatted and notched wafers. For flatted wafers of 200 mm diameter or less, a five-point pattern offset from the bisector of the primary flat is used. For notched wafers of 200 mm diameter or more, either a symmetrical five-point or nine-point pattern is used.

NOTE 1: DIN 50441-1 is an equivalent method.

2.2 This Test Method is intended primarily for use with wafers that meet the dimension and tolerance requirements of SEMI M1. However, it can be applied to circular silicon wafers or substrates of any diameter and thickness that can be handled without breaking.

2.3 This Test Method is suitable for both contact and contactless gaging equipment. Precision statements have been established for each in the case of the five-point method applied to flatted wafers.

2.4 The values stated in inch-pound units are to be regarded as the standard for measurements on wafers of 3 inch diameter or less while the values in metric units are to be regarded as the standard for measurements on wafers of 100 mm diameter or more.

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 Since the determination of total thickness variation by this Test Method is based on measurements of wafer thickness at only five or nine sites, irregular geometrical variations in other parts of the wafer will not be detected.

3.2 Local changes in thickness at any site may result in erroneous readings. Such local changes in thickness may be caused by surface defects such as chips, contaminants, mounds, pits, saw steps, waves, and so forth.

3.3 Since the instrument in this Test Method uses a 2 mm² or 130 mm² probe at the measurement points (refer to ¶ 7.1), it should not be expected to yield the same values as a more modern instrument with 0.2 mm² measurement area at the same measurement points.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI M1 — Specification for Polished Single Crystal Silicon Wafers

SEMI M59 — Terminology for Silicon Technology

SEMI MF1530 — Test Method for Measuring Flatness, Thickness, and Thickness Variation on Silicon Wafers by Automated Noncontact Scanning

4.2 DIN Standards¹

DIN 50441-1 — Testing of Materials for Semiconductor Technology – Determination of the Geometric Dimensions of Semiconductor Wafers – Part 1: Thickness and Thickness Variation

4.3 ISO[®] Standards²

ISO 14644-1 — Cleanrooms and Associated Controlled Environments – Part 1: Classification of Air Cleanliness by Particle Concentration

4.4 United States Federal Standards³

Federal Specification GGG-G-15C — Gage Blocks and Accessories (20 Mar 1975)

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

5 Terminology

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

¹ Deutsches Institut für Normung e.V., Am DIN-Platz, Burggrafenstrasse, D-10787 Berlin, Germany; Telephone: +49.30.2601.0, Fax: +49.30.2601.1231, <http://www.din.de>. DIN trademark is owned by Deutsches Institut für Normung e.V.

² International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401-1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, Fax: +41.22.733.34.30, <http://www.iso.org>. ISO trademark is owned by International Organization for Standardization.

³ United States Federal Standards, available as freely downloadable PDF files from the ASSIST Quick Search website at <http://quicksearch.dla.mil>.

6 Summary of Test Method

6.1 The thickness of the wafer is measured at its center and at four or eight other sites whose positions are defined with respect to the primary flat or notch. Two of the sites fall along a diameter and two along a second diameter, perpendicular to the first.

6.2 The thickness measured at the center of the wafer is generally taken as the thickness of the wafer in determining whether the wafer thickness is within the specified tolerance.

6.3 The maximum difference between any two of the thickness measurements is taken as the total thickness variation of the wafer.

7 Apparatus

7.1 *Thickness Gage* — Suitable for measuring the thickness of semiconductor wafers over the anticipated range. The least count of the instrument shall be no larger than 0.0001 in. or 2 μm . The contact area for contact-type gages shall not exceed 0.003 in.² or 2 mm². For contactless gages, the probed area shall not exceed 0.2 in.² or 130 mm².

NOTE 2: Thickness ranges for standard silicon wafers are given in SEMI M1. A thickness gage covering the range from 0.005 in. to 0.050 in., or 0.13 mm to 1.3 mm should be adequate for most wafers. A wafer with thickness outside this range may be mechanically accommodated by the gage; an appropriate offset is then applied to the value indicated by the gage.

7.2 *Fixture* — To support the wafer during thickness measurements. The fixture shall include provision for rotating the wafer about its center in the wafer plane and sufficient markings to facilitate positioning of the wafer so that thickness measurements can be made within 0.08 in. (2 mm) of each specified measurement site.

7.3 *Clean Facility* — A controlled-environment work station satisfying the Class 7 requirements of ISO 14644-1.

7.4 *Thickness Calibration Standards* — A set of thickness standards, traceable to the National Institute for Standards and Technology, whose thickness values range from 0.005 in. to 0.050 in. or 0.13 mm to 1.27 mm in steps of 0.005 in. $\pm$ 0.001 in. or 0.13 mm $\pm$ 0.025 mm.

7.4.1 Standard thickness values shall be known to within 10 $\mu\text{in.}$ or 0.25 $\mu\text{m.}$

7.4.2 For contactless gages, the calibration standards shall have an area of at least 0.25 in.² or 1.6 cm² with a minimum side length of 0.5 in. or 13 mm. The thickness variation must be less than 0.0001 in. or 2 μm , as determined for any two points 1 in. or 25 mm apart. For further details, refer to Federal Specification GGG-G-15C.

7.4.3 For contact gages, normally available standards of 0.36 in. $\times$ 1.12 in. or 9.1 mm $\times$ 28.4 mm shall be acceptable.

8 Sampling

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

9 Test Specimen

9.1 Generally, the specimen wafer has a primary flat or a notch, such as is specified in SEMI M1, to indicate the orientation on the measuring fixture.

NOTE 3: If the wafer does not have such a fiducial, a scribe may be used to place an index mark at a point near the periphery of the back surface of the wafer.

9.2 Ensure that the specimen has an identifiable surface to enable interlaboratory location of measurement sites.

9.2.1 If the front and back specimen surfaces are different in appearance, specify the front surface.

9.2.2 If both surfaces are identical, an indication or mark identifying the surface to be measured, which will not interfere with the measurement, shall be placed on the surface of the specimen taken as the back surface.

NOTE 4: Small adhesive labels and certain felt-marking pens have been found satisfactory for this purpose.

10 Calibration

10.1 From the set of calibration standards, select a standard with a thickness within 0.005 in. or 0.13 mm of the thickness value of the specimen wafer.