

SEMI M38-1101

SPECIFICATION FOR POLISHED RECLAIMED SILICON WAFERS

This specification was technically approved by the Global Silicon Wafer Committee and is the direct responsibility of the North American Silicon Wafer Committee. Current edition approved by the North American Regional Standards Committee on August 27, 2001. Initially available at www.semi.org September 2001; to be published November 2001. Originally published September 1999; previously published March 2001.

1 Purpose

1.1 This specification covers requirements for reclaimed silicon wafers to be used for testing and process monitoring in semiconductor manufacturing. A reclaimed wafer is a silicon wafer which has been re-conditioned for subsequent utilization.

2 Scope

2.1 A complete purchase specification requires that additional physical properties be defined. These properties are listed, together with test methods suitable for determining their magnitude.

2.2 This specification is directed specifically to silicon wafers with one or both polished surfaces, unpolished, or with epitaxial deposits.

2.3 This specification covers reclaim wafers that are either customer-supplied or third party-sourced. The user should exercise caution when sourcing materials with unknown thermal histories, unknown bulk contamination or unknown deposits, such as gold (Au) films.

2.4 Reclaimed silicon has been divided into four "use" categories: Mechanical, Furnace, Particle, and Lithography. The intent is that a prospective purchaser or reclaimed silicon needs to know which application matches his requirements and which wafer attributes are important for that application.

2.5 For applications placing higher demands on silicon wafers such as particle counting, measuring pattern resolution in a photolithography process, or surface ion contamination monitoring, the user may want to reference SEMI M1, M8, or M24.

2.6 For referee purposes, U.S. customary units shall be used for wafers of 2- and 3-inch nominal diameter and SI (System International), commonly called metric units, for 100 mm and larger diameter wafers.

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

3 Referenced Standards

3.1 SEMI Standards

SEMI M1 — Specification for Polished Monocrystalline Silicon Wafers

SEMI M8 — Specification for Polished Monocrystalline Silicon Test Wafers

SEMI M18 — Format for Silicon Wafer Specification Form for Order Entry

SEMI M24 — Specification for Polished Monocrystalline Silicon Premium Wafers

3.2 ANSI Standard¹

For a comprehensive list of applicable ANSI Standards, see those listed in Table 1 of SEMI M18.

3.3 ASTM Standards²

For a comprehensive list of applicable ASTM Standards, see those listed in Table 1 of SEMI M18.

3.4 DIN Standards³

For a comprehensive list of applicable DIN Standards, see those listed in Table 1 of SEMI M18.

3.5 JIS Standard⁴

For a comprehensive list of applicable JIS Standards, see those listed in Table 1 of SEMI M18.

NOTE 1: Unless otherwise indicated, all documents cited shall be the latest published versions.

1 American National Standards Institute, New York Office: 11 West 42nd Street, New York, NY 10036, USA. Telephone: 212.642.4900; Fax: 212.398.0023 Website: www.ansi.org

2 American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585, Fax: 610.832.9555 Website: www.astm.org

3 Available from Deutsches Institut für Normung e.V., Beuth Verlag GmbH, Burggrafenstrasse 4-10, D-10787 Berlin, Germany, website: www.din.de

4 Japanese Industrial Standards, Available through the Japanese Standards Association, 1-24, Akasaka 4-Chome, Minato-ku, Tokyo 107-8440, Japan. Telephone: 81.3.3583.8005; Fax: 81.3.3586.2014 Website: www.jsa.or.jp

4 Terminology

4.1 Definitions of terms related to silicon wafer technology are given in ASTM Terminology F 1241.

4.2 Definitions for some additional terms are given in SEMI M1.

4.3 The following definitions apply in the context of this specification:

4.3.1 *furnace wafer* — a silicon wafer which can be used for monitoring thermal processes or as an implant monitor and is usually only used in a cleanroom.

4.3.2 *hand scribe mark* — any marking, usually on the back surface of a wafer, scratched manually into the silicon surface, as with a diamond tipped scribe, for purposes of wafer identification.

4.3.3 *lithography wafer* — a silicon wafer used specifically for testing lithography equipment wherein surface flatness is key to process monitoring. This wafer is usually only used in a cleanroom environment.

4.3.4 *mechanical wafer* — a silicon wafer suitable for equipment or process testing which is usually only used outside of a cleanroom environment.

4.3.5 *particle wafer* — a silicon wafer which can be used for monitoring area or process cleanliness and is only used in a cleanroom environment.

4.3.6 *reclaimed wafer* — a silicon wafer which has been reconditioned for subsequent utilization.

4.3.7 *test wafer* — a silicon wafer suitable for process monitoring in semiconductor manufacturing. Also called *monitor wafer*.

5 Ordering Information

5.1 Purchase orders for reclaimed silicon wafers furnished to this specification shall minimally include the following items:

5.1.1 Customer-supplied or third-party sourced, and

5.1.2 Nominal diameter, conductivity type, resistivity, and surface orientation.

5.2 Following are the optional criteria to include in a prospective purchase order:

5.2.1 Lot acceptance criteria,

5.2.2 Certification,

5.2.3 Packing and Marking,

5.2.4 Minimum removal requirements (if any), and

5.2.5 Lot traceability and lot integrity maintenance requirements.

5.3 This specification is divided into four application categories or tables: Mechanical, Furnace, Particle, and Lithography. For ordering purposes, attributes applicable to each use are listed in the appropriate table.

6 Dimensions and Permissible Variations

6.1 The material shall conform to the parameters as specified in Tables 1 through 9.

6.2 The material shall conform to the crystallographic orientation details as listed in the tables.

7 Materials and Manufacture

7.1 The material shall consist of silicon wafers which are capable of being reconditioned for use.

8 Electrical Requirements

8.1 The material shall conform to the details specified in the purchase order or contract, as follows:

8.1.1 Conductivity type

8.1.2 Resistivity

9 Sampling

9.1 Unless otherwise specified, ASTM Practice E 122 shall be used. When so specified, appropriate sample sizes shall be selected from each lot in accordance with ANSI/ASQC Z 1.4. Each quality characteristic shall be assigned an acceptable quality level (AQL) and lot total percent defective (LTPD) value in accordance with ANSI/ASQC Z 1.4 definitions for critical, major, and minor classifications. If desired and so specified in the contract or order, each of these classifications may alternatively be assigned cumulative AQL and LTPD values. Inspection levels shall be agreed upon between the supplier and the purchaser.

10 Test Methods

NOTE 2: Silicon wafers are extremely fragile. While the mechanical dimensions of a wafer can be measured by use of tools such as micrometer calipers and other conventional techniques, the wafer may be damaged physically in ways that are not immediately evident. Special care must therefore be used in the selection and execution of measurement methods.

NOTE 3: The kind of dopant used is difficult to ascertain in finished wafers. Verification test procedures for certification of these characteristics shall be agreed upon between the supplier and the purchaser.

10.1 *Diameter* — Determine in accordance with ASTM Test Method F 613.

10.2 *Thickness, Center Point* — Determine in accordance with ASTM Test Method F 533 or DIN 50441/1, or JIS H 0611.

10.3 *Flat Length* — Determine in accordance with ASTM Test Method F 671.

10.4 *Flat Orientation* — Determine in accordance with ASTM Test Methods F 847.

10.5 *Surface Orientation* — Determine in accordance with ASTM Test Methods F 26 or DIN 50433.

10.6 *Surface Defects and Contamination* — Determine in accordance with ASTM Practice F 523. The following conditions shall be used (unless otherwise specified in the purchase or contract):

a. Background light intensity:

$$8 \pm 2 \text{ fc } (86 \pm 22 \text{ lux})$$

b. Angle α (alpha): $45^\circ \pm 10^\circ$

c. Angle β (beta): $90^\circ \pm 10^\circ$

10.6.1 See Section 10 for surface defect criteria and Table 2 for allowable levels of defects. In the event the wafers fail to meet these criteria, they shall be conditioned according to ASTM Practice F 612 or other cleaning procedure as agreed upon between supplier and user and retested.

NOTE 4: ASTM Practices F 154 is a useful guide for defining a variety of surface features found on silicon surfaces and for establishing commonly understood terms for describing them. It also gives detailed procedures for illumination and microscopical examination of surfaces.

10.7 *Conductivity Type* — Determine in accordance with ASTM Test Methods F 42 or DIN 50432.

10.8 *Resistivity* — Determine by methods agreed upon between the supplier and the purchaser.

NOTE 5: Resistivity of wafers is most appropriately determined for referee purposes by ASTM Method F 84 or DIN 50431. Under some circumstances these tests may be considered destructive, and an alternative means may be required. A widely used nondestructive test is ASTM Test Methods F 673, having a range from 0.0001 to 200 $\Omega \cdot \text{cm}$.

10.9 *Radial Resistivity Variation* — Determine in accordance with ASTM Test Methods F 81 or DIN 50435.

10.10 *Crystal Perfection* — Determine in accordance with ASTM Test Method F 47 or DIN 50434 (to determine grain boundaries, twinning, slip, dislocations, and lineage).

10.11 *Edge Profile* — Determine in accordance with ASTM Test Methods F 928 or DIN 50441/2.

11 Surface Defect Criteria

11.1 *Minimal Conditions or Dimensions* — The minimal conditions or dimensions for defects stated

below shall be used for determining wafer acceptability. Anomalies smaller than these limits shall not be considered defects.

11.2 *area contamination* — any foreign matter on the surface in localized areas which is revealed under the inspection lighting conditions as discolored, mottled, or cloudy appearance resulting from smudges, stains, water spots, etc.

11.3 *crack* — any anomaly conforming to the definition and greater than 0.25 mm (0.010 inch) in total length.

11.4 *crow's foot* — any anomaly conforming to the definition and greater than 0.25 mm (0.010 inch) in total length.

11.5 *dimple* — any smooth surface depression greater than 3 mm in diameter.

11.6 *edge chip and indent* — any edge anomaly including saw exit marks conforming to the definition and greater than 0.25 mm (0.010 inch) in radial depth and peripheral length.

11.7 *hand scribe mark* — any mark such as that caused by a diamond scribe that is visible under diffuse illumination.

11.8 *haze* — haze is indicated when the image of a narrow beam tungsten lamp filament is detectable on the polished wafer surface. (Under some conditions contamination may appear as haze.)

11.9 *orange peel* — any roughened surface conforming to the definition that is observable under diffuse illumination.

11.10 *particulate contamination* — distinct particles resting on the surface which are revealed under collimated light as bright points.

11.11 *pit* — any individually distinguishable non-removable surface anomaly conforming to the definition and visible when viewed under high intensity illumination.

11.12 *saw marks* — any surface irregularities conforming to the definition that is observable under diffuse illumination.

11.13 *scratch* — any anomaly conforming to the definition and having a length-to-width ratio greater than 5:1.

11.14 *slip* — any pattern of short ridges aligned along $\langle 110 \rangle$ directions and visible under diffuse illumination.

11.15 *striations* — any helical features conforming to the definition and visible under diffuse illumination.

12 Certification

12.1 Upon request of the purchaser in the contract or order, a manufacturer's or supplier's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

12.2 In the interest of controlling inspection costs, the supplier and the purchaser may agree that the material shall be certified as "capable of meeting" certain requirements. In this context, "capable of meeting" shall signify that the supplier is not required to perform the appropriate tests in Section 9. However, if the purchaser performs the test and the material fails to meet the requirement, the material may be subject to rejection.

13 Packing and Marking

13.1 Special packing requirements shall be subject to agreement between the supplier and the purchaser. Otherwise all wafers shall be handled, inspected, and packed in such a manner as to avoid chipping,

scratches, and contamination, and in accordance with the best industry practices, to provide ample protection against damage during shipment.

13.2 The wafers supplied under this specification shall be identified by appropriately labeling the outside of each box or other container and each subdivision thereof in which it may reasonably be expected that the wafers will be stored prior to further processing.

14 Tables

14.1 Please note the following terminology for the tables:

unspecified — an attribute which is not specified,

user specified — an attribute which may be specified, and

as-supplied — an attribute which is pre-established in the as-delivered wafer for reclaim.

Table 1 Format for 150 mm, 200 mm, and 300 mm Silicon Reclaim Wafer – Mechanical for Order Entry

EDI Code		Item	Specification
	1.0	General Characteristics	
	1.1	Growth Method	As-supplied
	1.2	Crystal Orientation	As-supplied
	1.3	Conductivity Type	As-supplied
	1.4	Dopant	As-supplied
	1.5	Nominal Edge Exclusion Distance for FQA	Unspecified
	2.0	Electrical Characteristics	
	2.1	Resistivity	User specified
	2.2	Radial Resistivity Variation (RRG)	Unspecified
	2.3	Resistivity Striations	Unspecified
	2.4	Minority Carrier Lifetime	Unspecified
	3.0	Chemical Characteristics	
	3.1	Oxygen Concentration	Unspecified
	3.2	Radial Oxygen Variation	Unspecified
	3.3	Carbon Concentration	Unspecified
	4.0	Structural Characteristics	
	4.1	Dislocation Etch Pit Density	Unspecified
	4.2	Slip	Unspecified
	4.3	Lineage	Unspecified
	4.4	Twins	Unspecified
	4.5	Swirl	Unspecified
	4.6	Shallow Pits	Unspecified

EDI Code		Item	Specification
	4.7	OISF	Unspecified
	4.8	Oxide Precipitates	Unspecified
	5.0	Wafer Preparation Characteristics	Mechanical Wafer
	5.1	Wafer ID Marking	User specified
	5.2	Front Surface Thin Films	Unspecified
	5.3	Denuded Zone	Unspecified
	5.4	Extrinsic Gettering	Unspecified
	5.5	Backseal	Unspecified
	5.6	Annealing	Unspecified
	6.0	Mechanical Characteristics	
	6.1	Diameter	
		150 mm ±	0.50 mm
		200 mm ±	0.50 mm
		300 mm ±	0.50 mm
	6.2	Primary Flat/Notch Dimension	
		150 mm (SEMI M1.8)	As-supplied
		150 mm (SEMI M1.13)	As-supplied
		200 mm	As-supplied
		300 mm	As-supplied
	6.3	Primary Flat/Notch Orientation	As-supplied
	6.4	Secondary Flat Dimension (if applicable)	As-supplied
	6.5	Secondary Flat Location (if applicable)	As-supplied
	6.6	Edge Profile	Unspecified
	6.7	Thickness	
		150 mm (SEMI M1.8)	533–675 µm
		150 mm (SEMI M1.13)	585–725 µm
		200 mm	600–775 µm
			Mechanical Wafer
		300 mm	650–800 µm
	6.8	Thickness Variation (TTV)	Unspecified
	6.9	Surface Orientation	As-supplied
	6.10	Bow	Unspecified
	6.11	Warp (for diameters other than 300 mm)	Unspecified
		Warp (for 300 mm only)	Unspecified
	6.12	Sori	Unspecified
	6.13	Flatness/Global	Unspecified
	6.14	Flatness/Site	Unspecified
	7.0	Front Surface Chemistry	
	7.1	Surface Metal Contamination	
		Sodium	Unspecified
		Aluminum	Unspecified
		Potassium	Unspecified
		Chromium	Unspecified
		Iron	Unspecified

EDI Code		Item	Specification
		Nickel	Unspecified
		Copper	Unspecified
		Zinc	Unspecified
	7.2	Surface Organics	Unspecified
	8.0	Front Surface Visual Characteristics	
	8.1A	Scratches (macro) – total length	Unspecified
	8.1B	Scratches (micro) – total length	Unspecified
	8.2	Pits	Unspecified
	8.3	Haze	Unspecified
			Mechanical Wafer
	8.4	Localized Light Scatterers	Unspecified
	8.5	Contamination/area	Unspecified
	8.6	Edge Chips	Unspecified
	8.7	Edge Cracks	Unspecified
	8.8	Cracks, Crow's feet	Unspecified
	8.9	Craters	Unspecified
	8.10	Dimples	Unspecified
	8.11	Grooves	Unspecified
	8.12	Mounds	Unspecified
	8.13	Orange Peel	Unspecified
	8.14	Saw Marks	Unspecified
	9.0	Back Surface Characteristics	
	9.1	Edge Chips	Unspecified
	9.6	Roughness	Unspecified
	9.7A	Brightness (gloss) (150 & 200 mm)	Unspecified
	9.7B	Brightness (gloss) (300 mm)	≥ 80%
	9.8	Localized Light Scatterers	Unspecified
	9.9A	Scratches (macro)	Unspecified
	9.9B	Scratches (micro)	Unspecified
	10.0	Other Characteristics	
	TBD	Edge condition (for 200 mm and 300 mm only)	Unspecified

Table 2 Format for 150 mm, 200 mm, and 300 mm Silicon Reclaim Wafer – Furnace for Order Entry

EDI Code		Item	Specification
	1.0	General Characteristics	
	1.1	Growth Method	As-supplied
	1.2	Crystal Orientation	As-supplied
	1.3	Conductivity Type	As-supplied
	1.4	Dopant	As-supplied
	1.5	Nominal Edge Exclusion Distance for FQA	User specified
	2.0	Electrical Characteristics	
	2.1	Resistivity	User specified
	2.2	Radial Resistivity Variation (RRG)	Unspecified

EDI Code		Item	Specification
	2.3	Resistivity Striations	Unspecified
	2.4	Minority Carrier Lifetime	Unspecified
	3.0	Chemical Characteristics	
	3.1	Oxygen Concentration	As-supplied
	3.2	Radial Oxygen Variation	As-supplied
	3.3	Carbon Concentration	As-supplied
	4.0	Structural Characteristics	
	4.1	Dislocation Etch Pit Density	Unspecified
	4.2	Slip	None
	4.3	Lineage	None
	4.4	Twins	None
	4.5	Swirl	Unspecified
	4.6	Shallow Pits	Unspecified
	4.7	OISF	Unspecified
	4.8	Oxide Precipitates	Unspecified
	5.0	Wafer Preparation Characteristics	Furnace Wafer
	5.1	Wafer ID Marking	User specified
	5.2	Front Surface Thin Films	None
	5.3	Denuded Zone	Unspecified
	5.4	Extrinsic Gettering	None
	5.5	Backseal	None
	5.6	Annealing	Unspecified
	6.0	Mechanical Characteristics	
	6.1	Diameter	
		150 mm $\pm$	0.50 mm
		200 mm $\pm$	0.50 mm
		300 mm $\pm$	0.50 mm
	6.2	Primary Flat/Notch Dimension	
		150 mm (SEMI M1.8)	As-supplied
		150 mm (SEMI M1.13)	As-supplied
		200 mm	As-supplied
		300 mm	As-supplied
	6.3	Primary Flat/Notch Orientation	As-supplied
	6.4	Secondary Flat Dimension (if applicable)	As-supplied
	6.5	Secondary Flat Location (if applicable)	As-supplied
	6.6	Edge Profile	Unspecified
	6.7	Thickness	
		150 mm (SEMI M1.8)	533–675 μ m
		150 mm (SEM M1.13)	585–725 μ m
		200 mm	600–775 μ m
			Furnace Wafer
		300 mm	650–800 μ m
	6.8	Thickness Variation (TTV)	Unspecified

EDI Code		Item	Specification
	6.9	Surface Orientation	As-supplied
	6.10	Bow	Unspecified
	6.11	Warp (for diameters other than 300 mm)	Unspecified
		Warp (for 300 mm only)	Unspecified
	6.12	Sori	Unspecified
	6.13	Flatness/Global	Unspecified
	6.14	Flatness/Site	Unspecified
	7.0	Front Surface Chemistry	
	7.1	Surface Metal Contamination	
		Sodium	User specified
		Aluminum	User specified
		Potassium	User specified
		Chromium	User specified
		Iron	User specified
		Nickel	User specified
		Copper	User specified
		Zinc	User specified
	7.2	Surface Organics	Unspecified
	8.0	Front Surface Visual Characteristics	
	8.1A	Scratches (macro) – total length	None
	8.1B	Scratches (micro) – total length	$\leq 0.10 \times \text{Diameter}$
	8.2	Pits	Unspecified
	8.3	Haze	Unspecified
		Furnace Wafer	
	8.4	Localized Light Scatterers	
		150 mm	$\leq 0.20/\text{cm}^2 @ \geq 0.20 \mu\text{m}$
		200 mm	$\leq 0.20/\text{cm}^2 @ \geq 0.20 \mu\text{m}$
		300 mm	$\leq 0.20/\text{cm}^2 @ \geq 0.20 \mu\text{m}$
	8.5	Contamination/area	None
	8.6	Edge Chips	None
	8.7	Edge Cracks	None
	8.8	Cracks, Crow's feet	None
	8.9	Craters	None
	8.10	Dimples	None
	8.11	Grooves	None
	8.12	Mounds	None
	8.13	Orange Peel	None
	8.14	Saw Marks	None
	9.0	Back Surface Characteristics	
	9.1	Edge Chips	None
	9.6	Roughness	User specified
	9.7A	Brightness (gloss) (150 & 200 mm)	Unspecified
	9.7B	Brightness (gloss) (300 mm)	$\geq 80\%$
	9.8	Localized Light Scatterers	User specified

EDI Code		Item	Specification
	9.9A	Scratches (macro) – total length	$\leq 0.25 \times \text{Diameter}$
	9.9B	Scratches (micro) – total length	Unspecified
	10.0	Other Characteristics	
	TBD	Edge condition (for 200 mm and 300 mm only)	User specified

Table 3 Format for 150 mm, 200 mm, and 300 mm Silicon Reclaim Wafer – Particle for Order Entry

EDI Code		Item	Specification
	1.0	General Characteristics	
	1.1	Growth Method	As-supplied
	1.2	Crystal Orientation	As-supplied
	1.3	Conductivity Type	As-supplied
	1.4	Dopant	As-supplied
	1.5	Nominal Edge Exclusion Distance for FQA	User specified
	2.0	Electrical Characteristics	
	2.1	Resistivity	User specified
	2.2	Radial Resistivity Variation (RRG)	Unspecified
	2.3	Resistivity Striations	Unspecified
	2.4	Minority Carrier Lifetime	Unspecified
	3.0	Chemical Characteristics	
	3.1	Oxygen Concentration	Unspecified
	3.2	Radial Oxygen Variation	Unspecified
	3.3	Carbon Concentration	Unspecified
	4.0	Structural Characteristics	
	4.1	Dislocation Etch Pit Density	Unspecified
	4.2	Slip	None
	4.3	Lineage	None
	4.4	Twins	None
	4.5	Swirl	Unspecified
	4.6	Shallow Pits	Unspecified
	4.7	OISF	Unspecified
	4.8	Oxide Precipitates	Unspecified
	5.0	Wafer Preparation Characteristics	Particle Wafer
	5.1	Wafer ID Marking	User specified
	5.2	Front Surface Thin Films	Unspecified
	5.3	Denuded Zone	Unspecified
	5.4	Extrinsic Gettering	Unspecified
	5.5	Backseal	Unspecified
	5.6	Annealing	Unspecified
	6.0	Mechanical Characteristics	
	6.1	Diameter	
		150 mm $\pm$	0.50 mm