5.2 Items which may be specified when ordering silicon wafers are listed in attached specification tables. Not all of these items are required for ordering premium wafers.

6 Dimensions and Permissible Variations

6.1 The material shall conform to the dimensions and dimensional tolerances in attached specification tables.

7 Materials and Manufacture

7.1 The material shall consist of wafers from crystals grown by the process specified in the purchase order or contract.

8 Physical Requirements

8.1 The material shall conform to the details specified in the purchase order.

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 Z1.4. Each quality characteristic shall be assigned an acceptable quality level (AQL) and lot total percent defective (LTPD) value in accordance with ANSI/ASQC Z1.4 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

10.1 Table 1 of SEMI M18 contains a complete listing of ASTM, DIN, and JEIDA/JIS test methods that may apply to the testing of specified premium silicon wafers. These attributes are listed in the order they are found in the specification (which corresponds to the order in SEMI M18).

10.2 *Conductivity Type* — Use any of the methods in ASTM Test Methods F 42, JIS H 0607, or DIN 50432 for confirming the conductivity type of silicon wafers covered by this specification.

10.3 *Dopant* — Confirm the dopant of high resistivity silicon by the photoluminescence method of ASTM Test Method F 1389 or by the low-temperature infrared method of ASTM Test Method F 1630 or DIN 50438/3.

10.4 *Resistivity* — Determine the electrical resistivity of the wafer in accordance with ASTM Test Method F 673 or DIN 50445 (eddy current), or ASTM Test Method F 84, JIS H 0602, or DIN 50431 (four point probe) using a suitable fixture to hold the wafer.

10.5 *Carrier Recombination Lifetime* — Determine in accordance with F 1535 or JEIDA 53.

10.6 *Oxygen Content* — Determine the interstitial oxygen content of wafers with resistivity greater than a few ohm-cm by infrared absorption. ASTM Test Method F 1188 is the method that was used in analyzing the results of the international round robin experiment that established the IOC-88 conversion coefficient. DIN 50438/1 provides improved procedures of correcting for back surface roughness and multiple internal reflections. ASTM Test Method F 1619, based on work carried out in JEIDA (JEIDA 61) and SEMI Japan, is an alternative procedure for significantly reducing errors associated with these two phenomena.

10.7 *Carbon Content* — For all but very heavily doped epitaxial substrates, establish the carbon content in accordance with ASTM Test Method F 1391, JEIDA 56, or DIN 50438/2.

10.8 *Total Bulk Iron* — No standardized test method exists for direct determination of total bulk iron content in silicon. ASTM Test Method F 978 can be used for direct determination of the electrically active iron. Extensions of the surface photovoltage method (ASTM Test Method F 391) and of the microwave lifetime method (ASTM Test Method F 1535) have been reported in the literature to provide information on total bulk iron content of boron-doped silicon; both these extensions are based on the iron-boron pairing process.

10.9 *Structural Characteristics* — When feasible observe crystal defects such as dislocation etch pits, slip, lineage, twins, etc., in accordance with ASTM Test Method F 1725, JIS H 0609, or DIN 50434. These methods are destructive, and with the exception of JIS H 0609 are based on chromium-containing etchants. Some structural defects, especially slip, can be determined nondestructively by means of X-ray topographic analysis in accordance with DIN 50443/1. Swirl and oxidation induced stacking faults (OSFs) are best observed after heat treatment such as those specified in ASTM Practice F 1726. However, the heat cycles in this practice were developed for 100 mm wafers and are not suitable for 300 mm wafers. Accordingly, thermal cycles used shall be agreed upon between supplier and purchaser. For observation of OSFs, a 2-hour heat treatment at 1100°C in steam is recommended. Observe shallow pits in accordance with ASTM Practice F 1049.

10.10 *Diameter* — Diameter may be determined in accordance with ASTM Test Method F 613 or DIN 50441/4. Because notched wafers do not have flats, it is not necessary to make the measurements along the particular diameters identified in ASTM Test Method F 613; rather it is suggested that measurements be made along the diameter perpendicular to the <100> orientation fiducial axis (0° in the coordinate system specified in SEMI M20), the diameter 120° counter-clockwise, and the diameter 240° counterclockwise. However, a more precise method of determining the diameter is to find the circle that best fits the circumference of the wafer by a least squares method; the diameter of the wafer is twice the radius of this circle.

10.11 *Flat Orientation* — Determine in accordance with ASTM Test Method F 847.

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

10.12.1 If flat diameter is specified instead of flat length, determine in accordance with Section 5.2.1 of DIN 50441/4 or by a dial gauge method (see NOTE 8) as agreed upon between supplier and purchaser.

10.13 *Notch Dimension* — Determine the depth and angle of the fiducial notch in accordance with ASTM Test Method F 1152 with the use of a wafer holding fixture appropriate for silicon wafers.

10.14 *Notch Orientation* — No test method for verifying the crystal axis of the orientation fiducial axis of notched wafers has yet been standardized. Accordingly, test procedures for making this determination shall be agreed upon between supplier and purchaser. A starting point may be an extension of ASTM Test Method F 847 with fixturing appropriate to notched wafers.

10.15 *Edge Profile Shape* — Determine the suitability of the edge profile in accordance with ASTM Test Method F 928 or DIN 50441/2.

10.16 *Edge Surface Finish* — Establish the surface finish of the edge region of the wafer by a method agreed upon between supplier and purchaser.

10.17 *Thickness, Center Point* — Determine thickness, center point may in accordance with ASTM Test Method F 533, JIS H 0611, or DIN 50441/1; special jigs or fixtures may be needed to allow the probe to reach the center point of the wafer.

10.18 *Total Thickness Variation* — Determine in accordance with ASTM Test Method F 533, ASTM Test Method F 657, DIN 50441/1, and JIS H 0611.

NOTE 2: ASTM Test Method F 533, DIN 50441/1, and JIS H 0611 are all 5-point methods, while Test Method F 657 involves a continuous scan pattern. JIS H 0611 differs from ASTM Test Method F 533 and DIN 50441/1 in that the measurements in JIS H 0611 are taken at the center and at 5 mm from the edge on diameters parallel and perpendicular to the major flat, while the measurements in the latter two test methods are taken at the center and at the same radial distance (R nominal - 6 mm) on diameters 30 degrees and 120 degrees counterclockwise from the bisector to the primary flat or notch (with the wafer facing front surface up).

10.19 *Surface Orientation* — Determine the crystallographic orientation of the wafer surface in accordance with ASTM test methods F 26, JEIDA Method 18, or DIN 50433 using a suitable fixture to hold wafer.

10.20 *Bow and Warp* — Determine bow in accordance with ASTM Test Method F 534 and warp in accordance with ASTM Test Method F 1390 or Test Method F 657.

NOTE 3: ASTM has standardized two methods for measuring warp. ASTM Test Method F 1390 is an automated, non-contact method which provides for correction of the wafer deflection due to gravitational effects. The scan pattern covers the entire fixed quality area. ASTM Test Method F 657 is a manual, non-contact method which has a continuous, prescribed scan pattern which covers only a portion of the wafer surface. There is no provision for correction of the wafer deflection due to gravitational effects. As noted in Appendix 2, different reference planes are used for the two methods. Because Test Method F 657 employs a back surface reference plane, the measured warp may include contributions from thickness variation of the wafer. Test Method F 1390 employs a median surface reference plane and is not susceptible to interferences from thickness variations. In general, Test Method F 1390 is preferred, especially for wafers 150 mm in diameter and larger, although ASTM Test Method F 1530 may also be used for this determination.

10.21 *Sori* — If sori is specified in lieu of bow or warp or both, determine by a method agreed upon between the supplier and the purchaser.

NOTE 4: Because sori is a property of the top surface of an unclamped wafer, it may be measured on many types of flatness measuring instruments. ASTM Test Method F 1451 may, in principle, be used for determination of sori.

10.22 *Flatness* — Determine by a method agreed upon between the supplier and the purchaser. It is recommended that site flatness is determined in accordance with ASTM Test Method F 1530 using a site-by-site front surface reference (indicated by the acronym SFQR in the Flatness Decision tree (see SEMI M1, Figure A1-1)). The percent usable area (PUA) shall be calculated as the percentage of the total number of full sites within the FQA that meet the specification.

10.23 *Surface Metal Contamination* — Determine surface metal contamination by a method agreed upon between supplier and purchaser; ASTM Test Method F 1617 is suitable for sodium and aluminum, and ASTM Test Method F 1526 is suitable for chromium, iron, nickel, copper, and zinc at the specified levels. Other, more sensitive methods may also be utilized by agreement between supplier and purchaser.

10.24 *Back Surface Gloss* — Determine test method in accordance with ASTM D523 or JIS Z8741 using a 60 degree of incidence and referencing the zero to a mirror polished wafer front surface instead of reference gloss surface as described in these feat method.

11 Surface Defect Criteria

11.1 Front surface defect criteria are shown in Item 8 in attached specification tables.

11.2 *Minimal Conditions or Dimensions* — The minimal conditions or dimenions for defects stated below shall be used for determining wafer acceptability. Anomalies smaller than these limits shall not be considered defects.

11.2.1 *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.

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

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

11.2.4 *dimple* — Any smooth surface depression greater than 3 mm in diameter.

11.2.5 *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.

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

11.2.7 *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.)

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

11.2.9 *particulate contamination* — Distinct particles, resting on the surface, which are revealed under collineated light as bright points.

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

11.2.11 *saw marks* — Any surface irregularities conforming to the definition that are observable under diffuse illumination.

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

11.2.13 *slip* — Any pattern of short ridges aligned along <111> directions and visible under diffuse illumination.

11.2.14 *striations* — Any helical features conforming to the definition and visible under diffuse illumination.

11.3 Back surface defect criteria are specified in attached specification tables.

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 10. 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. Iden-tification shall include, as a minimum, wafer classifi-cation, nominal diameter, surface orientation, growth method, lot number, and origin. In addition, identifi-cation of premium wafers shall include conductivity type and resistivity range of the lot. The lot number, either (1) assigned by the original manufacturer of the wafer, or (2) assigned subsequent to wafer manufacture but providing reference to the original lot number, shall provide easy access to information concerning the fabrication history of the particular wafers in that lot. Such information shall be retained on file at the vendor's facility for at least one month after that particular lot has been accepted by the purchaser.

Table 2 Specification for Polished Monocrystaline Silicon Premium Wafers for 250 nm Design Rule Usage

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*

(The specification is deleted in SEMI M24, the original table can be referred to in SEMI M24 1999 to 2001 versions.)

Table 3 Specification for Polished Monocrystalline Silicon Premium Wafers for 180 nm Design Rule Usage

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
1. GENERAL CHARACTERISTICS				
1.1 Growth Method	Cz or MCz	Cz or MCz	Cz or MCz	
1.2. Crystal Orientation	(100) ± 1°	(100) ± 1°	(100) ± 1°	ASTM F 26, DIN 50433
1.3 Conductivity Type	n or p	n or p	n or p	ASTM F 42, JIS H607 DIN 50432
1.4 Dopant	P or B	P or B	P or B	ASTM F 1389, F 1630, DIN 50438/3
1.5 Nominal Edge Exclusion (Fixed Quality Area) (See Note 1.)	300 mm: 2 mm 200 mm: 3 mm	300 mm: 2 mm 200 mm: 3 mm	300 mm: 2 mm 200 mm: 3 mm	
2. ELECTRICAL CHARACTERISTICS				
2.1 Resistivity, Center Point	NS	≥ 1 Ω-cm (See Note 4.)	NS	ASTM F 84, F 673, JIS H 602, DIN 50431, 50445
2.2 Radial Resistivity Variation	NS	NS		ASTM F 81, DIN 50435
2.4 Minority Carrier Lifetime (Carrier Recombination Lifetime)	NS	≥ 325 µs (See Note 4.)		JEIDA 53, F 1535
3. CHEMICAL CHARACTERISTICS				
3.1 Oxygen Concentration: Spec. Range of Center Point: Target	NS	$\leq 1.2 \times 10^{18}$ /cm^3	NS	ASTM F 1188, F 1619 DIN 50438/1, JEIDA 61
3.1.1 Oxygen Concentration: Tolerance Around Center Point: Target		≤ 10%		
3.2 Radial Oxygen Variation		NS		
3.3 Carbon Concentration		≤ 0.2 ppma		ASTM F 1391, DIN 50438/2, JEIDA 56

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
3.- Total Bulk Iron Concentration		$\leq 5 \times 10^{10}$ /cm^3		ASTM F 978
4. STRUCTURAL CHARACTERISTICS (See Note 9.)				
4.1 Dislocation Etch Pit Density	NS	$\leq$ 500/cm^2	NS	ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.2 Slip		None		ASTM F 1725 JIS H 609, DIN 50434, 50443/1
4.3 Lineage		None		ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.4 Twin		None		ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.5 Swirl		None		ASTM F 1726, JIS H 614, DIN 50443/1
4.6 S-pits		None		ASTM F 1726, F 1049
4.7 Oxidation Induced Stacking Faults (OSF)		User/Vendor		ASTM F 1726, User/Vendor mutual agreement
4.8 Oxide Precipitates (BMD) Interstitial Oxygen Reduction (Δ Oi)		User/Vendor		ASTM F 1239, User/Vendor mutual agreement
5.WAFER PREPARATION CHARACTERISTICS				
5.1 Wafer ID Marking (See Note 2.)	Optional	Optional	Optional	
5.3 Denuded Zone	NS	NS	NS	
5.4 Extrinsic Gettering Treatment	None	None	None	
5.5 Backseal	NS	None	NS	
5.6 Annealing	NS	Donor Annih. Only	NS	
6. MECHANICAL CHARACTERISTCS				
6.1 Diameter	200 and 300 mm	200 and 300 mm	200 and 300 mm	ASTM F 613, DIN 50441/4, JEIDA27
6.2 Primary Flat Length/Diameter Notch Dimensions	SEMI M1	SEMI M1	SEMI M1	ASTM F 671, F 1152, DIN 50441/4 JEIDA 27,
6.3 Primary Flat/ Notch Orientation				ASTM F 847
6.4 Secondary Flat Length				ASTM F 671, DIN 50441/4
6.5 Secondary Flat Location				ASTM F 847
6.6 Edge Profile	SEMI M1	SEMI M1	SEMI M1	ASTM F 928, DIN 50441/2
6.- Edge Surface Finish	Polished	Polished	Polished	
6.7 Thickness, Center Point	SEMI M1	SEMI M1	SEMI M1	ASTM F 533, JIS H 611, DIN 50441/1
6.- Nine-point Thickness Variation	-	-	-	

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
6.8 Total Thickness Variation, GBIR	≤ 10 µm	≤ 10 µm	≤ 5 µm	ASTM F 533, F 657, JIS H 611, DIN 50441/1
6.9 Surface Orientation	-	-	-	ASTM F 26, JEIDA 18, DIN 50433
6.10 Bow	-	-	-	ASTM F 534, JIS H 611
6.11, 12 Warp, Sori	NS	NS	300 ≤ 100 µm 200 ≤ 75 µm	ASTM F 657, F 1390, F 1451
6.13 Flatness/Global, GFLR	NS	NS	NS	ASTM F 1530, JEIDA 43
6.14 Flatness/Site, SFQR (25 × 25 mm, PUA 90%) SFSR (25 mm × 32 mm)			≤ 180 nm ≤ 150 nm	
7. FRONT SURFACE CHEMISTRY				
7.1 Surface Metal Concentration (atoms/cm^2)	(See Note 6.)	(See Note 5.)	(See Note 6.)	User/Vendor Mutual Agreement, ASTM F 1526, ASTM F 1617
Sodium	$\leq 5.0 \times 10^{10}$ /cm^2	$\leq 1.8 \times 10^{10}$ /cm^2	$\leq 5.0 \times 10^{10}$ /cm^2	
Aluminum	$\leq 1.0 \times 10^{11}$ /cm^2	$\leq 1.0 \times 10^{11}$ /cm^2	$\leq 1.0 \times 10^{11}$ /cm^2	
Chromium	$\leq 5.0 \times 10^{10}$ /cm^2	$\leq 1.8 \times 10^{10}$ /cm^2	$\leq 5.0 \times 10^{10}$ /cm^2	
Iron	$\leq 5.0 \times 10^{10}$ /cm^2	$\leq 1.8 \times 10^{10}$ /cm^2	$\leq 5.0 \times 10^{10}$ /cm^2	
Nickel	$\leq 5.0 \times 10^{10}$ /cm^2	$\leq 1.8 \times 10^{10}$ /cm^2	$\leq 5.0 \times 10^{10}$ /cm^2	
Copper	$\leq 5.0 \times 10^{10}$ /cm^2	$\leq 1.8 \times 10^{10}$ /cm^2	$\leq 5.0 \times 10^{10}$ /cm^2	
Zinc	$\leq 1.0 \times 10^{11}$ /cm^2	$\leq 1.0 \times 10^{11}$ /cm^2	$\leq 1.0 \times 10^{11}$ /cm^2	
Calcium	$\leq 1.0 \times 10^{11}$ /cm^2	$\leq 1.8 \times 10^{10}$ /cm^2	$\leq 1.0 \times 10^{11}$ /cm^2	
8. FRONT SURFACE INSPECTION CHARACTERISTICS				
8.1 A Scratches, Macro	None	None	None	ASTM F 154, F 523, JIS H 614
8.1 B Scratches, Micro	None	≤ 1/10 × D mm	≤ 1/10 × D mm	ASTM F 154, JIS H 614
8.2 Pits	None	None	SEMI M1	ASTM F 154, F 523, JIS H 614
8.3 Haze	None	None	SEMI M1	ASTM F 154, F 523, JIS H 614
8.4 Localized Light Scatterers (LLSs) (≥ 90 nm) (See Note 3.)	≤ 0.29/cm^2	NS	NS	SEMI M25, ASTM F 523, F 1620, F 1621
(≥ 180 nm) (See Note 7.)	-	≤ 0.15/cm^2	≤ 0.15/cm^2	
8.5 Contamination/Area	None	None	None	ASTM F 154, F 523, JIS H 614
8.6 Edge chips	None	None	None	ASTM F 154, F 523, JIS H 614
8.7 Cracks, Crow's Feet	None	None	None	ASTM F 154, F 523, JIS H 614
8.8 Craters	None	None	None	ASTM F 154, F 523, JIS H 614
8.9 Dimples	None	None	None	ASTM F 154, F 523, JIS H 614
8.10 Grooves	None	None	None	ASTM F 154, F 523, JIS H 614

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
8.11 Mounds	None	None	None	ASTM F 154, F 523, JIS H 614
8.12 Orange Peel	None	None	None	ASTM F 154, F 523, JIS H 614
8.14 Saw Marks	None	None	None	ASTM F 154, F 523, JIS H 614
8.15 Dopant Striation Ring	None	None	None	ASTM F 154, F 523, JIS H 614
8.- Microroughness	NS	NS	NS	
9. BACK SURFACE VISUAL INSPECTION CHARACTERISTICS				
9.1 Edge Chips	None	None	None	ASTM F 154, F 523, JIS H 614
9.6 Roughness, rms	NS	NS	NS	
9.7 Brightness (Gloss)	300 mm ≥ 80% 200 mm NS	300 mm ≥ 80% 200 mm NS	300 mm ≥ 80% 200 mm NS	ASTM D 523, JIS Z8741
9.8 Localized Light Scatterers (LLSs)	NS	NS	NS	ASTM F 523, F 1620, F 1621, JIS H 614
9.9 Scratches, Macro	≤ 0.25 × D mm	≤ 0.25 × D mm	≤ 0.25 × D mm	ASTM F 154, F 523, JIS H 614
9.10 Scratches, Micro	NS	NS	NS	ASTM F 154

NOTE 1: Nominal Edge Exclusion: 2 mm can be achievable in new 300 mm equipment; however, it will be difficult in conventional 200 mm equipment. Edge Exclusion Task Force is now making activities for developing a guide containing definition of edge exclusion when a measurement is made over a finite sampling area.

NOTE 2: Wafer ID Marking: SEMI M1 specification shall be applied, if ID mark is applied.

NOTE 3: LLSs: LLSs for particle counting wafer is specified only by the half size of design rule. These specification values shall be reviewed when the evaluation techniques for distinguishing particle and COP are established. The nominal particle size can be transferred to another particle size using coefficient value and the latter can be applicable for the usage.

NOTE 4: Carrier Recombination Lifetime: Carrier recombination lifetime is affected by carrier concentration (resistivity) and metallic impurities. Specified resistivity and bulk iron concentration are only necessary conditions for obtaining the specified carrier recombination lifetime.

NOTE 5: Surface Metal Contamination for Furnace and Thermal Process: The proposed specification values are recommended ones considering NTRS 1997 and current measuring technology and accuracy.

NOTE 6: Surface Metal Contamination for Particle Counting and Lithography & Patterning: The values are proposed considering current process capabilities and the necessary level for their usage.

NOTE 7: LLSs for Furnace & Thermal Process and Lithography & Patterning: The values are proposed considering current process capabilities and the necessary level for their usage.

NOTE 8: The nominal particle size can be transferred to another particle size using coefficient value and the latter can be applicable for the usage.

NOTE 9: ASTM F47-94 (Discontinued 1998) was replaced by ASTM Guide F1725, and ASTM F416-94 (Discontinued 1998) was replaced by ASTM Practice F1727.

Table 4 Specification Guide for Polished Monocrystalline Silicon Premium Wafers for 130 nm Design Rule Usage

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
1. GENERAL CHARACTERISTICS				
1.1 Growth Method	Cz or MCz	Cz or MCz	Cz or MCz	
1.2. Crystal Orientation	(100)	(100)	(100)	ASTM F 26, DIN 50433
1.3 Conductivity Type	n or p	n or p	n or p	ASTM F 42, JIS H607 DIN 50432

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
1.4 Dopant	P or B	P or B	P or B	ASTM F 1389, F 1630, DIN 50438/3
1.5 Nominal Edge Exclusion (See Note 1.) (Fixed Quality Area) 300 mm 200 mm	 2 mm 3 mm	 2 mm 3 mm	 2 mm 3 mm	
2. ELECTRICAL CHARACTERISTICS				
2.1 Resistivity, Center Point	NS	≥ 1 Ω-cm	NS	ASTM F 84, F 673, JIS H 602, DIN 50431, 50445
2.2 Radial Resistivity Variation	NS	NS		ASTM F 81, DIN 50435
2.4 Minority Carrier Lifetime (Carrier Recombination Lifetime)	NS	≥ 325 µs		JEIDA 53, ASTM F 1535
3. CHEMICAL CHARACTERISTICS				
3.1 Oxygen Concentration	NS	≤ 1.2 × 10^{18} /cm^3	NS	ASTM F 1188, F 1619 DIN 50438/1, JEIDA 61
3.1.1 Oxygen Concentration Tolerance: Tolerance around Center Point		≤ 10%		
3.2 Radial Oxygen Variation		NS		
3.3 Carbon Concentration		≤ 0.2 ppma		ASTM F 1391, DIN 50438/2, JEIDA 56
3. Total Bulk Iron Concentration		≤ 5 × 10^{10} /cm^3		ASTM F 978
4. STRUCTURAL CHARACTERISTICS (See Note 8.)				
4.1 Dislocation Etch Pit Density	NS	≤ 500/cm^2	NS	ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.2 Slip		None		ASTM F 1725 JIS H 609, DIN 50434, 50443/1
4.3 Lineage		None		ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.4 Twin		None		ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.5 Swirl		None		ASTM F 1726, JIS H 614, DIN 50443/1
4.6 S-pits		None		ASTM F 1726, F 1049
4.7 Oxidation Induced Stacking Faults (OSF)		User/Vendor		ASTM F 1726, User/Vendor mutual agreement
4.8 Oxide Precipitates (BMD) Interstitial Oxygen Reduction (Δ Oi)		User/Vendor		ASTM F 1239, User/Vendor mutual agreement
5.WAFER PREPARATION CHARACTERISTICS				

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
5.1 Wafer ID Marking (See Note 2.)	Optional	Optional	Optional	
5.3 Denuded Zone	NS	NS	NS	
5.4 Extrinsic Gettering Treatment	None	None	None	
5.5 Backseal	NS	None	NS	
5.6 Annealing	NS	Donor Annih. Only	NS	
6. MECHANICAL CHARACTERISTCS				
6.1 Diameter	200 and 300 mm	200 and 300 mm	200 and 300 mm	ASTM F 613, DIN 50441/4, JEIDA27
6.2 Primary Flat Length/Diameter Notch Dimensions	SEMI M1	SEMI M1	SEMI M1	ASTM F 671, F 1152, DIN 50441/4 JEIDA 27,
6.3 Primary Flat/ Notch Orientation				ASTM F 847
6.4 Secondary Flat Length				ASTM F 671, DIN 50441/4
6.5 Secondary Flat Location				ASTM F 847
6.6 Edge Profile	SEMI M1	SEMI M1	SEMI M1	ASTM F 928, DIN 50441/2
6.- Edge Surface Finish	Polished	Polished	Polished	
6.7 Thickness, Center Point	SEMI M1	SEMI M1	SEMI M1	ASTM F 533, JIS H 611, DIN 50441/1
6.8 Total Thickness Variation, GBIR	≤ 5μm	≤ 5 μm	≤ 3 μm	ASTM F 533, F 657, JIS H 611, DIN 50441/1
6.9 Surface Orientation	0 ± 1.0°	0 ± 1.0°	0 ± 1.0°	ASTM F 26, JEIDA 18, DIN 50433
6.11, 12 Warp, Sori 300 mm 200 mm	 NS NS	 NS NS	 ≤ 100 μm ≤ 75 μm	ASTM F 657, F 1390, F 1451
6.13 Flatness/Global, GFLR	NS	NS	NS	ASTM F 1530, JEIDA 43
6.14 Flatness/Site, SFSR (25 × 32 mm, PUA 90%)			≤ 130 nm	
7. FRONT SURFACE CHEMISTRY				
7.1 Surface Metal Concentration (atoms/cm^2) Sodium Aluminum Chromium Iron Nickel Copper Zinc Calcium	(See Note 4.) ≤ 1.8×10^{10} /cm^2 ≤ 1.0×10^{11} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.0×10^{11} /cm^2 ≤ 1.8×10^{10} /cm^2	(See Note 3.) ≤0.88×10^{10} /cm^2 ≤ 1.0×10^{11} /cm^2 ≤ 0.88×10^{10} /cm^2 ≤ 0.88×10^{10} /cm^2 ≤ 0.88×10^{10} /cm^2 ≤ 0.88×10^{10} /cm^2 ≤ 1.0×10^{11} /cm^2 ≤ 0.88×10^{10} /cm^2	(See Note 4.) ≤ 1.8×10^{10} /cm^2 ≤ 1.0×10^{11} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.8×10^{10} /cm^2 ≤ 1.0×10^{11} /cm^2 ≤ 1.8×10^{10} /cm^2	User/Vendor Mutual Agreement, ASTM F 1526, ASTM F 1617
8. FRONT SURFACE INSPECTION CHARACTERISTICS				

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
8.1 A Scratches, Macro (See Note 5.)	None	None	None	ASTM F 154, F 523, JIS H 614
8.1 B Scratches, Micro (See Note 5.)	None	$\leq 1/10 \times D$ mm	$\leq 1/10 \times D$ mm	ASTM F 154, JIS H 614
8.2 Pits	None	None	None	ASTM F 154, F 523, JIS H 614
8.3 Haze (See Note 5.)	None	None	None	ASTM F 154, F 523, JIS H 614
8.4 Localized Light Scatterers (Particulate 90 nm Contamination; LLSs) (See Note 6.)				SEMI M25, ASTM F 523, F 1620, F 1621
300 mm	≤ 60/wf	NS	NS	
200 mm	≤ 27/wf	NS	NS	
(Particulate 0.13 µm Contamination; LLSs) (See Note 7.)	-	$\leq 0.15/cm^2$	$\leq 0.15/cm^2$	
8.5 Contamination/Area	None	None	None	ASTM F 154, F 523, JIS H 614
8.6 Edge chips	None	None	None	ASTM F 154, F 523, JIS H 614
8.7 Cracks, Crow's Feet	None	None	None	ASTM F 154, F 523, JIS H 614
8.8 Craters	None	None	None	ASTM F 154, F 523, JIS H 614
8.9 Dimples	None	None	None	ASTM F 154, F 523, JIS H 614
8.10 Grooves	None	None	None	ASTM F 154, F 523, JIS H 614
8.11 Mounds	None	None	None	ASTM F 154, F 523, JIS H 614
8.12 Orange Peel	None	None	None	ASTM F 154, F 523, JIS H 614
8.14 Saw Marks	None	None	None	ASTM F 154, F 523, JIS H 614
8.15 Dopant Striation Ring	None	None	None	ASTM F 154, F 523, JIS H 614
8.- Microroughness	NS	NS	NS	
9. BACK SURFACE VISUAL INSPECTION CHARACTERISTICS				
9.1 Edge Chips	None	None	None	ASTM F 154, F 523, JIS H 614
9.6 Roughness, rms	NS	NS	NS	
9.7 Brightness (Gloss)				ASTM D 523, JIS Z8741
300 mm	$\geq 80\%$	$\geq 80\%$	$\geq 80\%$	
200 mm	User/Vendor	User/Vendor	User/Vendor	
9.8 Localized Light Scatterers (LLSs)	NS	NS	NS	ASTM F 523, F 1620, F 1621, JIS H 614
9.9 Scratches, Macro	$\leq 0.25 \times D$ mm	$\leq 0.25 \times D$ mm	$\leq 0.25 \times D$ mm	ASTM F 154, F 523, JIS H 614
9.10 Scratches, Micro	NS	NS	NS	ASTM F 154

NOTE 1: Nominal Edge Exclusion is proposed as the same as in Table2 and as in Table3, however, more discussion will be necessary. Edge Exclusion Task Force is now making activities for developing a guide containing definition of edge exclusion when a measurement is made over a finite sampling area.

NOTE 2: Wafer ID Marking: SEMI M1 specification shall be applied, if ID mark is applied.

NOTE 3: Surface Metal Contamination for Furnace and Thermal Process: The specification values are based on ITRS '99 Roadmap.

NOTE 4: Surface Metal Contamination for Particle Counting and Lithography & Patterning: The specified values are based on 180 nm process requirement in ITRS 1999.

NOTE 5: Visual techniques are neither sufficient nor appropriate for 0.13 µm design rules. Automatic surface inspection tools can be used for reporting values such as scratches and haze. Test method and standardization for automatic surface inspection tools is under development, visual inspection is now used as a supplemental method.

NOTE 6: LLSs (Localized Light Scatterers: 90 nm): These specification values shall be reviewed when the evaluation techniques for distinguishing particle and COP are established. Critical surface LLS size should be the half of CD, however, tools are not well established. 65 nm count limit was transferred to 90 nm count limit using draft international standard: ISO/DIS 14644-1 which follows the equation: 90 nm LLS counts per wafer = 65 nm LLS counts per wafer /(90 nm /65 nm)^2.

NOTE 7: LLSs for Furnace & Thermal Process and Lithography & Patterning: New concept is proposed for LLSs for Furnace and Thermal Process. The critical surface LLS size for prime wafer is proposed as a half size of CD in IRTS Roadmap. The half of CD is not necessarily requested for monitor test wafers. In actual business, an additional specification of LLS, the size of which is around CD is used, however, the size is not standardized. TF proposes the additional LLS size as the same size as CD. This size is used for specifying LLS for Furnace & Thermal Process.

NOTE 8: ASTM F47-94 (Discontinued 1998) was replaced by ASTM Guide F1725, and ASTM F416-94 (Discontinued 1998) was replaced by ASTM Practice F1727.

Table 5 Specification for Polished Monocrystalline Silicon Premium Wafers for 90 nm Design Rule Usage

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
1. GENERAL CHARACTERISTICS				
1.1 Growth Method	Cz or MCz	Cz or MCz	Cz or MCz	
1.2. Crystal Orientation	(100)	(100)	(100)	ASTM F 26, DIN 50433
1.3 Conductivity Type	n or p	n or p	n or p	ASTM F 42, JIS H607 DIN 50432
1.4 Dopant	P or B	P or B	P or B	ASTM F 1389, F 1630, DIN 50438/3
1.5 Nominal Edge Exclusion (See Note 1.) (Fixed Quality Area) 300 mm 200 mm	 2 mm 2 mm	 2 mm 2 mm	 2 mm 2 mm	
2. ELECTRICAL CHARACTERISTICS				
2.1 Resistivity, Center Point	NS	$\geq$ 1 Ω•cm	NS	ASTM F 84, F 673, JIS H 602, DIN 50431, 50445
2.2 Radial Resistivity Variation	NS	NS		ASTM F 81, DIN 50435
2.4 Minority Carrier Lifetime (Carrier Recombination Lifetime)	NS	$\geq$ 325 µs		JEIDA 53, ASTM F 1535
3. CHEMICAL CHARACTERISTICS				
3.1 Oxygen Concentration	NS	$\leq 1.2 \times 10^{18}$ /cm^3	NS	ASTM F 1188, F 1619 DIN 50438/1
3.1.1 Oxygen Concentration Tolerance: Tolerance around Center Point		$\leq$ 10%		

CLASSIFICATION ITEMS (SEMI M18)	*Particle Counting*	*Furnace & Thermal Process*	*Lithography & Patterning*	*Test Method*
3.2 Radial Oxygen Variation		NS		
3.3 Carbon Concentration		≤ 0.2 ppma		ASTM F 1391, DIN 50438/2
3.- Total Bulk Iron Concentration		$\leq 5 \times 10^{10}$ /cm^3		ASTM F 978
4. STRUCTURAL CHARACTERISTICS (See Note 2.)				
4.1 Dislocation Etch Pit Density	NS	≤ 500/cm^2	NS	ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.2 Slip		None		ASTM F 1725 JIS H 609, DIN 50434, 50443/1
4.3 Lineage		None		ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.4 Twin		None		ASTM F 1725, JIS H 609, DIN 50434, 50443/1
4.5 Swirl		None		ASTM F 1727, JIS H 614, DIN 50443/1
4.6 S-pits		None		ASTM F 1727, F 1049
4.7 Oxidation Induced Stacking Faults (OSF)		User/Vendor		ASTM F 1727, User/Vendor mutual agreement
4.8 Oxide Precipitates (BMD) Interstitial Oxygen Reduction (Δ Oi)		User/Vendor		ASTM F 1239, User/Vendor mutual agreement
5.WAFER PREPARATION CHARACTERISTICS				
5.1 Wafer ID Marking (See Note 3.)	Optional	Optional	Optional	
5.3 Denuded Zone	NS	NS	NS	
5.4 Extrinsic Gettering Treatment	None	None	None	
5.5 Backseal	NS	None	NS	
5.6 Annealing	NS	Donor Annih. Only	NS	
6. MECHANICAL CHARACTERISTCS				
6.1 Diameter	200 and 300 mm	200 and 300 mm	200 and 300 mm	ASTM F 613, DIN 50441/4, JEIDA27
6.2 Primary Flat Length/Diameter Notch Dimensions	SEMI M1	SEMI M1	SEMI M1	ASTM F 671, F 1152, DIN 50441/4 JEIDA 27,
6.3 Primary Flat/ Notch Orientation				ASTM F 847
6.4 Secondary Flat Length				ASTM F 671, DIN 50441/4
6.5 Secondary Flat Location				ASTM F 847
6.6 Edge Profile	SEMI M1	SEMI M1	SEMI M1	ASTM F 928, DIN 50441/2

CLASSIFICATION ITEMS (SEMI M18)	Particle Counting		Furnace & Thermal Process	Lithography & Patterning	Test Method
6.- Edge Surface Finish	Polished		Polished	Polished	
6.7 Thickness, Center Point	SEMI M1		SEMI M1	SEMI M1	ASTM F 533, JIS H 611, DIN 50441/1
6.8 Total Thickness Variation, GBIR	≤ 5µm		≤ 5 µm	≤ 3 µm	ASTM F 533, F 657, JIS H 611, DIN 50441/1
6.9 Surface Orientation	0 ± 1.0°		0 ± 1.0°	0 ± 1.0°	ASTM F 26, JEIDA 18, DIN 50433
6.11, 12 Warp, Sori 300 mm 200 mm	NS NS		NS NS	≤ 90 µm ≤ 75 µm	ASTM F 657, F 1390, F 1451
6.13 Flatness/Global, GFLR	NS		NS	NS	ASTM F 1530, JEIDA 43
6.14 Flatness/Site SFQR (See Note 4.) (25×8mm □)				≤ 90 nm (PUA95%) ≤ 65 nm (Partial Site Inactive)	
7. FRONT SURFACE CHEMISTRY					
7.1 Surface Metal Concentration (atoms/cm^2) (See Note 5.) Sodium Aluminum Chromium Iron Nickel Copper Zinc Calcium	$\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2		$\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2	$\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2 $\leq 1.0 \times 10^{10}$ /cm^2	User/Vendor Mutual Agreement, ASTM F 1526, ASTM F 1617
8. FRONT SURFACE INSPECTION CHARACTERISTICS					
8.1 A Scratches, Macro (See Note 6.)	None		None	None	ASTM F 154, F 523, JIS H 614
8.1 B Scratches, Micro (See Note 6.)	None		≤ 1/10 × D mm	≤ 1/10 × D mm	ASTM F 154, JIS H 614
8.2 Pits	None		None	None	ASTM F 154, F 523, JIS H 614
8.3 Haze (See Note 6.)	None		None	None	ASTM F 154, F 523, JIS H 614
8.4 Localized Light Scatterers (Particulate 50 nm Contamination; LLSs) (Particulate 65 nm Contamination; LLSs) (See Note 7.) 300 mm 200 mm	50nm ≤ 100/wf ≤ 50/wf	65nm ≤ 60/wf ≤ 30/wf	NS NS	NS NS	SEMI M25, ASTM F 523, F 1620, F 1621
(Particulate 0.10 µm Contamination; LLSs) (See Note 8.)	-		= 0.15/cm^2	= 0.15/cm^2	

CLASSIFICATION ITEMS (SEMI M18)	Particle Counting	Furnace & Thermal Process	Lithography & Patterning	Test Method
8.5 Contamination/Area	None	None	None	ASTM F 154, F 523, JIS H 614
8.6 Edge chips	None	None	None	ASTM F 154, F 523, JIS H 614
8.7 Cracks, Crow's Feet	None	None	None	ASTM F 154, F 523, JIS H 614
8.8 Craters	None	None	None	ASTM F 154, F 523, JIS H 614
8.9 Dimples	None	None	None	ASTM F 154, F 523, JIS H 614
8.10 Grooves	None	None	None	ASTM F 154, F 523, JIS H 614
8.11 Mounds	None	None	None	ASTM F 154, F 523, JIS H 614
8.12 Orange Peel	None	None	None	ASTM F 154, F 523, JIS H 614
8.14 Saw Marks	None	None	None	ASTM F 154, F 523, JIS H 614
8.15 Dopant Striation Ring	None	None	None	ASTM F 154, F 523, JIS H 614
8.- Microroughness	NS	NS	NS	
9. BACK SURFACE VISUAL INSPECTION CHARACTERISTICS				
9.1 Edge Chips	None	None	None	ASTM F 154, F 523, JIS H 614
9.6 Roughness, rms	NS	NS	NS	
9.7 Brightness (Gloss) 300 mm 200 mm	≥ 80% User/Vendor	≥ 80% User/Vendor	≥ 80% User/Vendor	ASTM D 523, JIS Z8741
9.8 Localized Light Scatterers (LLSs)	NS	NS	NS	ASTM F 523, F 1620, F 1621, JIS H 614
9.9 Scratches, Macro	≤ 0.25 × D mm	≤ 0.25 × D mm	≤ 0.25 × D mm	ASTM F 154, F 523, JIS H 614
9.10 Scratches, Micro	NS	NS	NS	ASTM F 154

NOTE 1: Nominal Edge Exclusion is proposed considering future trends referring ITRS Roadmap, however, more discussion will be necessary.

NOTE 2: ASTM F47-94 (Discontinued 1998) was replaced by ASTM Guide F1725, and ASTM F416-94 (Discontinued 1998) was replaced by ASTM Practice F1727.

NOTE 3: Wafer ID Marking: For 300 mm wafers, Backsurface SEMI T7 mark in accordance with SEMI M1.15 is recommended. For 200mm Wafers; Various types of ID (or No ID) are prevailed in the market.

NOTE 4: Flatness/Site SFQR(25 × 8mm ☐) is proposed referring to the recent ITRS Roadmap discussion and also referring to discussion in Epi SC for the specification guide for 90 nm node usage. Two types of scanning stepper are introduced in industry, with the site of 25 × 8 mm ☐ and the site of 26 × 8 mm ☐.

NOTE 5: Surface metal measurement variation can be significant. Measured results are frequently larger that the actual value. Processes are normally designed and controlled with median values to reduce the impact of measured variation.

NOTE 6: Visual techniques are neither sufficient nor appropriate for 90 nm design rules. Automatic surface inspection tools can be used for reporting values such as scratches and haze. Test method and standardization for automatic surface inspection tools is under development, visual inspection is now used as a supplemental method.

NOTE 7: LLSs (Localized Light Scatterers: 65 nm or 50 nm): Critical surface LLS size is proposed to be the half of CD, however, tools are not well established. Some measurement tools have capability to measure 50 nm (nearly 1/2 of CD) LLS, however, some ones have not enough capability, so that 50 nm count limit was transferred to 65nm count limit using draft international standard, ISO/DIS 14644-1 which follows the equation: 65 nm LLS counts per wafer = 50 nm LLS counts per wafer/(65 nm /50 nm $)^2$. These specification values shall be reviewed when the evaluation techniques for distinguishing particle and COP are established and considering production capability.

NOTE 8: LLSs for Furnace & Thermal Process and Lithography & Patterning: New concept is proposed for LLSs for Furnace and Thermal Process. The critical surface LLS size for prime wafer is proposed as a half size of CD in IRTS Roadmap. The half of CD is not necessarily requested for monitor test wafers. In actual business, an additional specification of LLS, the size of which is around CD is used, however, the size is not standardized. TF proposes the additional LLS size as the same size as CD. This size is used for specifying LLS for Furnace & Thermal Process Wafers.

SEMI M25-95 (Withdrawn 1103)
SPECIFICATION FOR SILICON WAFERS FOR CALIBRATION OF LIGHT POINT DEFECT WAFER INSPECTION SYSTEMS WITH RESPECT TO THE DIAMETER OF POLYSTYRENE LATEX SPHERES

NOTICE: This document was balloted and approved for withdrawal in 2003.

1 Purpose

1.1 This document describes the specifications to be met by bare silicon wafers used for calibrating surface inspection systems with respect to the diameter of polystyrene latex spheres. This document does not intend to establish manufacturing procedures for calibration wafers.

Note 1: This specification might be used as the basis for making calibration substrates with other materials and/or surfaces.

2 Scope

2.1 Bare silicon wafers on which latex-spheres of a known diameter are deposited are used as standards for the calibration of bare wafer inspection systems. The response curve of the systems is generated for the calibration of the systems with respect to the sizing of polystyrene latex (PSL) spheres, not for counting them.

3 Referenced Documents

3.1 *SEMI Standard*

SEMI M1 — Specifications for Polished Monocrystalline Silicon Wafers

4 Terminology

4.1 *Light-Point Defect (LPD)* — An isolated, localized effect on the wafer surface or in the substrate wafers resulting in increased light scattering intensity above a threshold (unit LSE).

Note 2: LPD is a general term and it includes for example latex spheres and other localized surface irregularities.

4.2 *Latex-Sphere Equivalent (LSE)* — The size unit of an LPD expressed as the diameter of a latex-sphere which scatters the same amount of light as the LPD. This is indicated by adding “LSE” to the length unit used, e.g., 0.2 µ m LSE.

Note 3: Sizing may be different for other materials and shapes than PSL spheres because of the different optical designs of inspection systems.

4.3 *Response Curve (RC)* — The relation between measured scattered light intensity and latex-sphere diameters for a calibration surface inspection system. The RC depends on the light source used and may contain non-monotonic regions.

4.4 *LPD histogram* — The distribution of the counts of LPD’s per unit length over their size as expressed in LSE.

5 Requirements

5.1 *Substrates* — The wafers used as substrates for the deposition of latex-spheres must be bare silicon with a native oxide surface and they have to meet the requirements of SEMI M1. In addition to the M1 specification, the surface conditions (for example, roughness) must be in compliance with Section 5.5.2.

Note 4: The substrate wafer must be measured before latex sphere deposition with the same type of instrument to ensure that the conditions of 5.5.2 are fulfilled.

5.2 *Latex-Spheres* — The latex-spheres used must be certified with respect to their diameter and they must be traceable to the Standard Reference Materials (SRM) of the National Institute of Standards and Technology (NIST), former National Bureau of Standards (NBS). The certification methodology must be in accordance with the technologies used by NIST.

Note 5 : If the PSL are not traceable to NIST, the certification method should be fully documented.

5.3 *Range of Latex-Sphere Diameters* — The diameters of the latex-spheres used for calibration must be selected so that the measurement range for the intended application is covered. Sufficient latex-sphere diameters must be used to achieve the required accuracy of the RC.

Note 6: For surface inspection systems using laser light source(s), it is recommended to avoid latex-sphere diameters corresponding approximately to the wavelength of the laser used and its multiples of the laser used.

5.4 *Density of Latex-Spheres Deposited* — The density of the deposited latex-spheres, full or partial wafer coverage, must be selected in such a way that the peak of the histogram of the latex-sphere diameters is at least 100% above the background counts. It has to be verified that the indicated (relevant) peak in the histogram is generated by single, isolated latex-spheres of the specified diameter. A density of 5–15 latex-spheres per square centimeter is recommended.

5.5 *Background Contamination*

5.5.1 Calibration wafers must be handled and stored with great care to avoid contamination and damage.

5.5.2 The bell-shaped peak in the LPD histogram of a calibration wafer which is generated by the latex-spheres must be well-defined and must be well above the background level. The bell-shaped curve has to go down to less than 50% of its peak value on both sides of the maximum within a diameter range of ± 15% as referred to the nominal latex-sphere diameter.

5.6 *Multiple Deposition of Latex-Spheres* — Deposition of latex-spheres with different, well-defined diameters on a calibration wafer is allowed if all the conditions of this specification are met for each kind of deposited latex-sphere size.

6 Packaging

6.1 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.

7 Data to Accompany Calibration Wafers

7.1 Certificate for average and standard deviation of the diameter of the latex spheres used, including the production lot number of latex-spheres used.

7.2 Date of production and certification of calibration wafer.

7.3 Histogram, as defined above.

7.4 Approximate number of deposited latex-spheres in a specified area.

7.5 Wafer identification.

7.6 Name and address of the originator of the calibration wafers.

7.7 LPD's wafer map.

SEMI M26-0304
GUIDE FOR THE RE-USE OF 100, 125, 150 AND 200 mm WAFER SHIPPING BOXES USED TO TRANSPORT WAFERS

This guide was technically approved by the Global Silicon Wafer Committee and is the direct responsibility of the Japanese Silicon Wafer Committee. Current edition approved by the Japanese Regional Standards Committee on January 9, 2004. Initially available at www.semi.org February 2004; to be March 2004. Originally published in 1995; last published in 1996.

1 Purpose

1.1 This document is a guide for box cleaning services, wafer suppliers, and wafer users for the re-use of 100, 125, 150 and 200 mm wafer shipping boxes.

1.2 Its purpose is to reduce the total cost relating to transport of 100, 125, 150 and 200 mm wafers from the wafer supplier to the customers.

2 Scope

2.1 This Guide stipulates materials relating to transport of 100, 125, 150 and 200 mm wafers using shipping boxes.

NOTICE: 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 or other limitations prior to use.

3 Referenced Standards

3.1 *SEMI Standards*

SEMI M31 — Provisional Mechanical Specification for Front-Opening Shipping Box Used to Transport And Ship 300 mm Wafers

SEMI M45 — Provisional Specification for 300 mm Shipping System

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

4 Terminology

4.1 *Defintions*

4.1.1 *bag* — a package used for sealing the outside of the wafer box. Typically two or three types of different plastic film and aluminum film are laminated, and these are usually heat-sealed. (SEMI M45)

4.1.2 *carrier* — an open structure that holds one or more substrates. (SEMI M31)

4.1.3 *label* — The label on the wafer shipping box identifying the product and its manufacturer (see SEMI M45.)

4.1.4 *recycle* — to use an already used item for some other useful purpose. (SEMI M45)

4.1.5 *re-use* — to repeat use of an item in its original shape for the same purpose as initially intended. (SEMI M45)

4.1.6 *seam tape* — adhesive-coated tape employed to seal the seam between the cover and the base of a wafer shipping box.

4.1.7 *secondary container* — the outermost box of the smallest transport unit. Typically cardboard boxes or similar boxes are used. (SEMI M45)

4.1.8 *shipping box* — a protective container for a carrier and/or wafer(s) that is used to ship wafers from the wafer suppliers to their customers. (SEMI M31)

5 Suitability for Re-Use

5.1 The ability to re-use wafer boxes and cassettes is adversely affected by certain characteristics. Some of these characteristics also impact on the ability to recycle.

5.2 *Wafer Shipping Box*

5.2.1 After a customer has transferred an accepted wafer to a fab carrier, the wafer shipping box must be returned to the supplier without having used it for any other purpose. The wafer shipping box will be inserted into a bag sealed prior to return to the wafer supplier using protective bag (agreed upon by supplier and customer).

5.2.2 The wafer shipping box will maintain its dimensional stability throughout its useful life.

5.2.3 Wafer shipping box materials will be recyclable after useful life.

5.2.4 The following characteristics are recommended:

5.2.4.1 generic embossed markings (e.g., model name, model number, manufacturer' s information),

5.2.4.2 embossed recycle symbol, trademark symbol, mold markings,

5.2.4.3 removable labels with low residue, low tack adhesives, 5.2.4.4 removable seam tape with low residue, low tack adhesives,

5.2.4.5 removable methods of identification, and

5.2.4.6 stackable wafer box bases and covers.

5.2.5 The following characteristics are not recommended:

5.2.5.1 “custom” embossed markings,

5.2.5.2 end-user specific logos, symbols, and markings,

5.2.5.3 high residue tape and labels,

5.2.5.4 labels which are difficult to remove or are non-removable, and

5.2.5.5 non-removable marks such as inks and other coloring.

6 Procedural Guidelines

6.1 *Collection Method at the Wafer User Facility*

6.1.1 Unpack secondary containers and save for re-use or recycle.

6.1.2 Exercise care when removing the bag; avoid scuffing or cutting the wafer shipping box surface.

6.1.3 Remove wafers from box in cleanroom area.

6.1.4 Remove all labels from the box.

6.1.5 Place wafer shipping boxes for re-use in a designated collection container or collection area.

6.1.6 Maintain the wafer shipping boxes for re-use in an environment free from contact with metal contaminants and process chemicals.

6.1.7 Periodically return wafer shipping boxes for reclean to the reclean service location or the wafer supplier.

6.1.8 Whenever possible, cycle wafer shipping boxes between the same wafer user and wafer supplier.

6.2 *Wafer Shipping Boxes Cleaning at the Reclean Service Location*

6.2.1 The supplier of the reclean service must engineer the reclean process.

6.2.2 At the service supplier’s option, visually inspect the wafer shipping boxes prior to cleaning. The service supplier and customer should agree to acceptable and unacceptable levels of defects, recognizing that there will be some normal wear. These levels should be provided to the service supplier. Inspect for the following defects:

6.2.2.1 deformation or warp,

6.2.2.2 razor cuts, scuffs, breaks, cracks, voids, and fractures,

6.2.2.3 contamination and imbedded silicon,

6.2.2.4 damage to tension springs or other wafer retention mechanisms, and

6.2.2.5 markings and labels.

6.2.3 Collect defective parts for recycle, and clean acceptable parts as follows:

6.2.3.1 Clean using an aqueous-based or non-aqueous-based chemistry.

6.2.3.2 Chlorofluorocarbon chemistries are not permitted.

6.2.3.3 Confirm the compatibility of the wafer shipping box materials with the cleaning method and drying conditions.

6.2.4 Visually inspect the wafer shipping boxes after cleaning using a high intensity or an ultraviolet light. The wafer user and the wafer supplier should agree to acceptable and unacceptable levels of defects, recognizing that there will be some normal wear. Inspect for all the defects noted in Section 6.2.2 and, in addition, for:

6.2.4.1 residues from labels, markings, or tape, and

6.2.4.2 failure of the wafer shipping box halves to seat and seal together.

6.2.5 Collect defective parts for recycle.

6.2.6 Return acceptable boxes and cassettes to the wafer supplier using box wrap, nesting material, and shipping containers as required to maintain cleanliness and mechanical integrity.

6.3 *Maximum Number of Re-Use Cycles*

6.3.1 Base the total number of re-use cycles on the ability to maintain both mechanical integrity and cleanliness.

NOTICE: SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

The user's attention is called to the possibility that compliance with this standard may require use of copyrighted material or of an invention covered by patent rights. By publication of this standard, SEMI takes no position respecting the validity of any patent rights or copyrights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of any such patent rights or copyrights, and the risk of infringement of such rights, are entirely their own responsibility.

SEMI M29-1296 (Reapproved 1103)
SPECIFICATION FOR 300 mm SHIPPING BOX

This specification was technically reapproved by the Global Silicon Wafer Committee and is the direct responsibility of the Japanese Silicon Wafer Committee. Current edition approved by the Japanese Regional Standards Committee on August 8, 2003. Initially available at www.semi.org September 2003; to be published November 2003. Originally published December 1996.

1 Purpose

1.1 This specification defines a container for safe transportation of 300 mm wafers from a wafer maker to a receiving dock of an IC maker site.

2 Scope

2.1 This specification additionally defines the parts necessary for a shipping box among cassettes specified in SEMI E57 and SEMI E1.9, within the range of the specifications in SEMI E57 and SEMI E1.9.

2.2 This specification also defines the size of a box containing a shipping cassette containing 300 mm wafers.

2.3 Although, as for material, use of plastic is a premise, actual material names are not defined for free selection based on progress of maker's technologies.

2.4 Although this specification directs a high-performance shipping box, this does not concretely define the performance on particle generation and sealing capability.

2.5 As for the count of contained wafers, this defines two sorts, that is, 13 and 25 wafers.

NOTICE: 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 or other limitations prior to use.

3 Referenced Standards

3.1 *SEMI Standards*

SEMI E57 — Mechanical Specification for Kinematic Couplings Used to Align and Support 300 mm Wafer Carriers

SEMI E1.9 —Mechanical Specification for Cassettes Used to Transport and Store 300 mm Wafers

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

4 Terminology

4.1 *Definitions*

4.1.1 *box bottom* — a lower half of an outer box.

4.1.2 *box top* — an upper half of an outer box.

4.1.3 *cassette* — a cassette defined in SEMI E57 and SEMI E1.9.

4.1.4 *clamp* — a part to fix a box top and a box bottom mutually.

4.1.5 *clamping indent* — a groove formed with a box top and a box bottom. The groove which a clamp hooks for setting.

4.1.6 *front retainer* — a retainer which is attached in a front side of a cassette, the front side which is defined in SEMI E1.9.

4.1.7 *gasket area* — an area where gaskets are attached so as to reduce air flow in a shipping box which is generated by the difference between internal pressure and external pressure.

4.1.8 *orientation mark* — a mark expressed on a part for confirmation of cassette direction.

4.1.9 *outer box* — a container part of a shipping box, surrounding the whole objects so as to protect a shipping cassette, except gasket and clamps.

4.1.10 *poka-yoke* — a device applied to a rib so as not to be set in an incorrect direction in order to avoid an orientation failure when the part is set.

4.1.11 *rear retainer* — a retainer which is attached in a rear side of a cassette, the rear side which is defined in SEMI E1.9.

4.1.12 *retainer* — a part to be attached to a shipping cassette for retaining wafers in transportation so that the wafers do not move. There are two types, that is, a front retainer and a rear retainer.

4.1.13 *retainer hook* — a projection formed on a shipping cassette for attaching a retainer.

4.1.14 *setting hole* — a hole formed in a retainer for attaching the retainer. This makes a pair with a retainer hook.

4.1.15 *shipping box* — a whole container containing a shipping cassette. This is composed of a shipping cassette, an outer box, retainers, gasket, and clamps.

4.1.16 *shipping cassette* — a cassette additionally defined herein for shipping among cassettes.

4.1.17 *stacking rib* — a rib formed on a top surface of a box top and on a bottom surface of a box bottom so as not to collapse when shipping boxes are stacked. A rib positioned on the top is called a top rib, and a rib on the bottom a bottom rib.

4.1.18 *supporting rib* — a rib inside an outer box for supporting a cassette.

5 Requirements

5.1 *Part Construction* — A shipping box defined herein is composed of the parts shown in Figure 1.

5.1.1 The appearance of this part is one of embodiments of this definition.

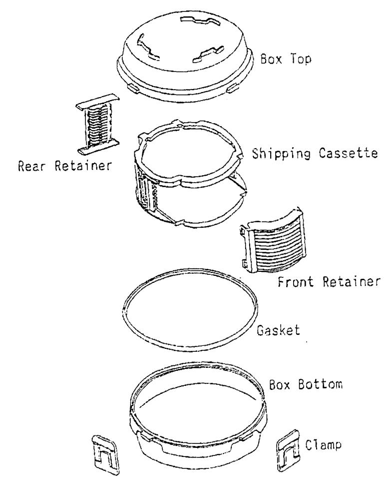

Figure 1
Components

5.2 *Shipping Cassette*

5.2.1 *Additional Dimensions* — Dimensions of a shipping cassette should conform to SEMI E57 and SEMI E1.9. However, in the above documents, there are many Max. or Min. notations, and hence, they are not sufficient to design a shipping box. Therefore, in Figure 2 and Table 1, necessary dimensions are added within the ranges defined in the above documents.

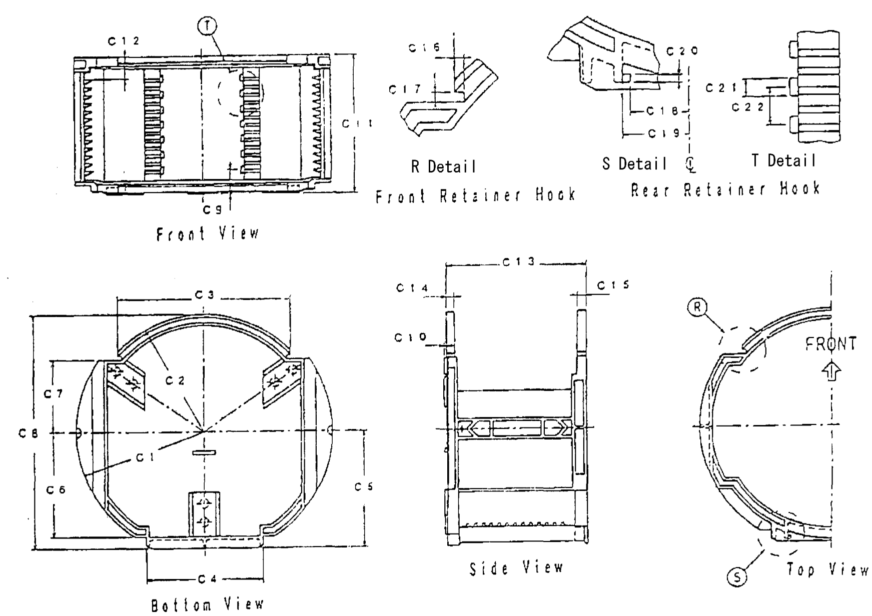

Figure 2
Additional Definition of Shipping Cassette

5.2.2 *Orientation Mark* — The orientation mark indicating the front side of a cassette is shown in Figure 3 and Table 1. This supports a user to manually set a cassette on a box bottom or a platform of equipment.

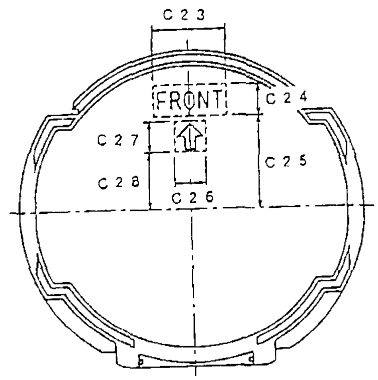

Figure 3
Orientation Mark of Shipping Cassette

Table 1 Dimensions of Shipping Cassette

Unit: mm

Location	*Standardized Dimension*		*Corresponding to SEMI E1.9*
	13 Wafers	*25 Wafers*	
C1	166 ± 0.5	←	r5
C2	153.5 ± 0.5	←	r6
C3	224 ± 1	←	x6 + x6
C4	152 ± 0.5	←	x5 + x5
C5	155 ± 0.5	←	y16
C6	139.5 ± 0.5	←	y23
C7	94 ± 0.5	←	y15
C8	308.5 ± 1	←	r6 + y16
C9	31 ± 0.5	←	z8 - z1
C10	3 ± 0.5	←	
C11	182 ± 1	302 ± 1.5	
C12	29.5 ± 0.5	←	z18
C13	179 ± 3	299 ± 4	
C14	10 ± 1	←	
C15	11 ± 1	←	
C16	5 ± 0.5	←	
C17	5 ± 0.5	←	
C18	51 ± 0.5	←	x1
C19	55 ± 0.5	←	
C20	4 ± 0.5	←	
C21	9 ± 0.5	←	
C22	20 ± 0.5	←	
C23	70 ± 10	←	
C24	30 ± 10	←	
C25	90 ± 10	←	
C26	30 ± 10	←	
C27	30 ± 10	←	
C28	55 ± 10	←	

5.3 *Box Top*

5.3.1 *Outer Dimensions* — Outer dimensions of a box top are shown in Figure 4 and Table 2.

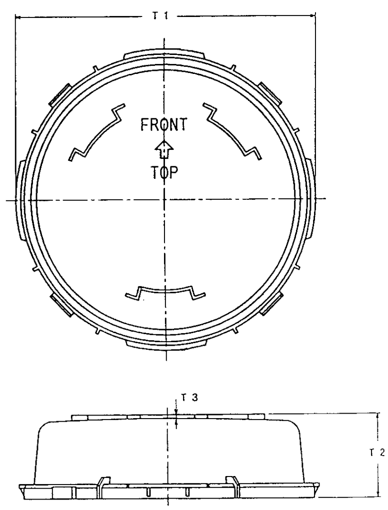

Figure 4
Outer Dimensions of Box Top

5.3.2 *Supporting Rib and Poka-yoke Rib* — Positions of a supporting rib for supporting a shipping cassette inside a box top and a poka-yoke (fool-proof) rib for avoiding setting the box top in a wrong orientation are shown in Figure 5 and Table 2.

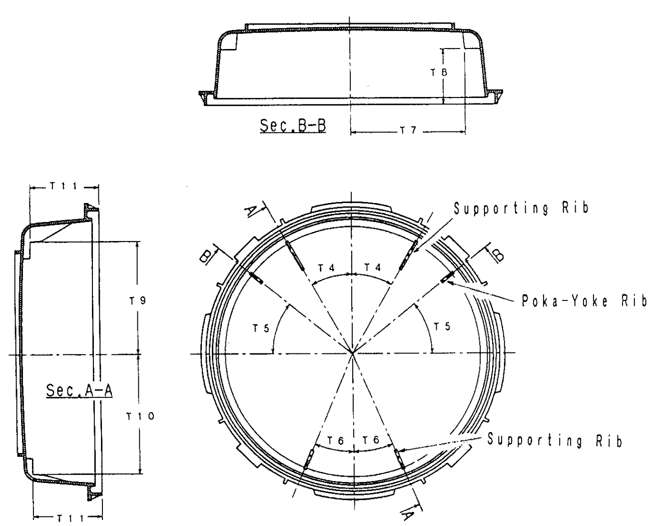

Figure 5
Supporting Rib and Poka-yoke Rib of Box Top

5.3.3 *Gasket Area* — It is required to provide a gasket in an area shown in Figure 6 and Table 2 if the gasket is provided.

5.3.4 *Clamping Indent* — Figure 7 and Table 2 show dimensions of a concave part for receiving a clamp. Refer to Figure 8 and Table 2 for horizontal positions.

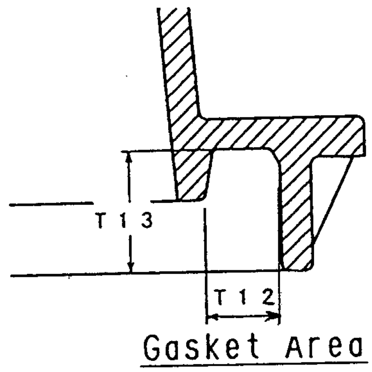

Figure 6
Gasket Area

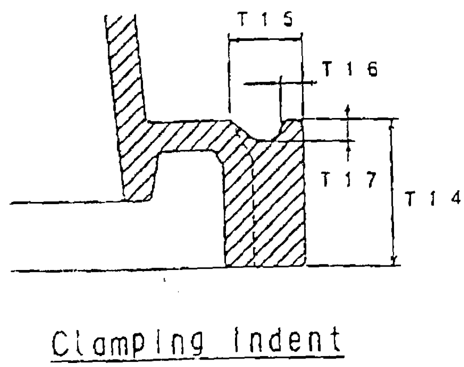

Figure 7
Clamping Indent

5.3.5 *Top Rib and Orientation Mark* — Dimensions of a top rib to avoid collapsing when shipping boxes stacked, and the position of an orientation mark are shown in Figure 8 and Table 2. In addition, since this rib makes a pair with a bottom rib, and is a poka-yoke rib, the shipping boxes can be stacked in a correct direction.

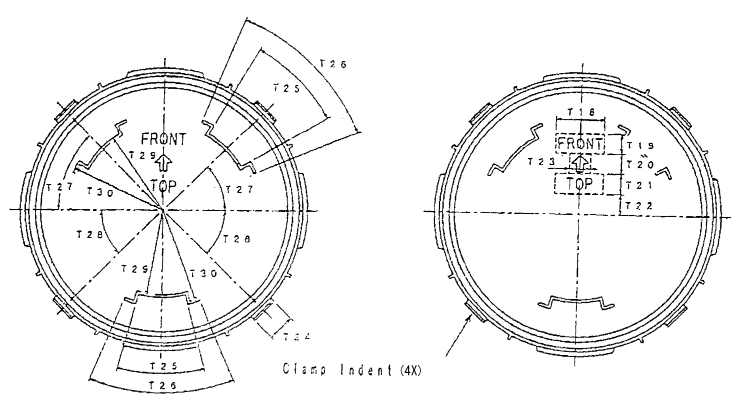

Figure 8
Top Rib and Orientation Mark

Table 2 Dimensions of Box Top

Unit: mm

Location	Standardized Dimension	
	13 Wafers	*25 Wafers*
T1	ø 430 max	ø 450 max
T2	116.5 ± 1	176.5 ± 1
T3	5 min	←
T4	30°	←
T5	38.5°	←
T6	22.5°	←
T7	158 ± 1	←
T8	80 ± 1	140 ± 1
T9	156.5 ± 0.5	←
T10	171.5 ± 0.5	←
T11	95.5 ± 0.5	155.5 ± 1
T12	10 max	←
T13	18 max	←
T14	20.5 ± 0.5	←
T15	10 max	←
T16	3 ± 0.5	←
T17	3 ± 0.5	←
T18	70 ± 10	←
T19	30 ± 5	←
T20	30 ± 5	←
T21	30 ± 5	←
T22	30 ± 10	←
T23	30 ± 5	←
T24	40 ± 1	←
T25	30°	←
T26	45° min	←
T27	45°	←
T28	45°	←
T29	130 ± 1	←
T30	145 ± 1	←

5.4 *Box Bottom*

5.4.1 *Outer Dimensions of Box Bottom* — Outer dimensions of a box bottom are shown in Figure 9 and Table 3.

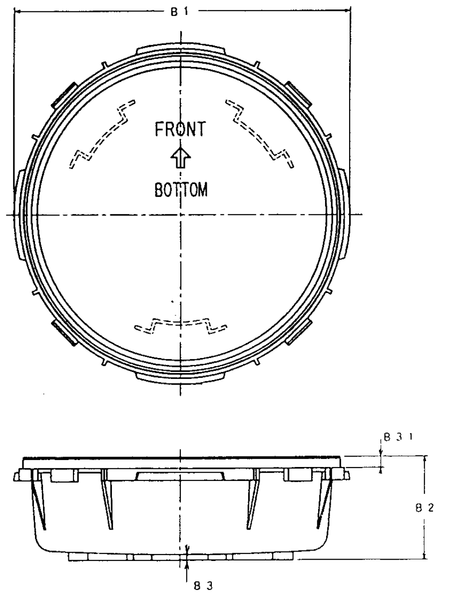

Figure 9
Outer Dimensions of Box Bottom

5.4.2 *Supporting Rib and Poka-yoke Rib* — Positions of a supporting rib for supporting a shipping cassette inside a box bottom and a poka-yoke rib provided for avoiding setting the cassette in a wrong orientation are shown in Figure 10 and Table 3.

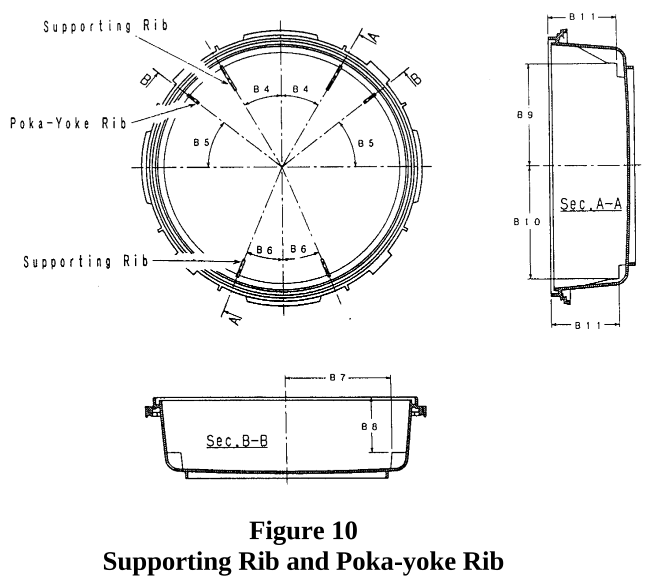

Figure 10
Supporting Rib and Poka-yoke Rib

5.4.3 *Gasket Area* — It is required to provide a gasket in an area shown in Figure 6 and Table 2 if the gasket is provided.

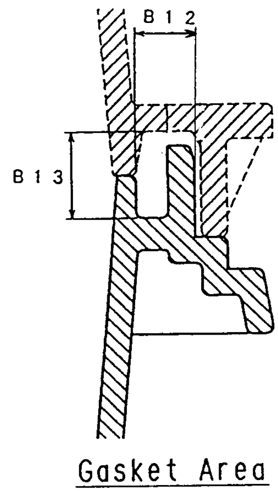

Figure 11
Gasket Area

5.4.4 *Clamping Indent* — Figure 12 and Table 3 show dimensions of a concave part for receiving a clamp.

5.4.4.1 Refer to Figure 13 and Table 3 for horizontal positions.

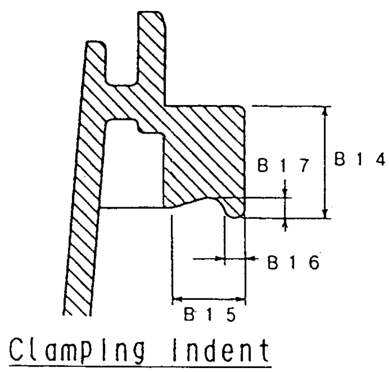

Figure 12
Clamping Indent

5.4.5 *Bottom Rib and Orientation Mark* — The position of a bottom rib and the position of an orientation mark are shown in Figure 13 and Table 3. In addition, since this rib makes a pair with a top rib, this avoids slipping of stacked shipping boxes, and becomes a datum for positioning the box bottom to equipment.

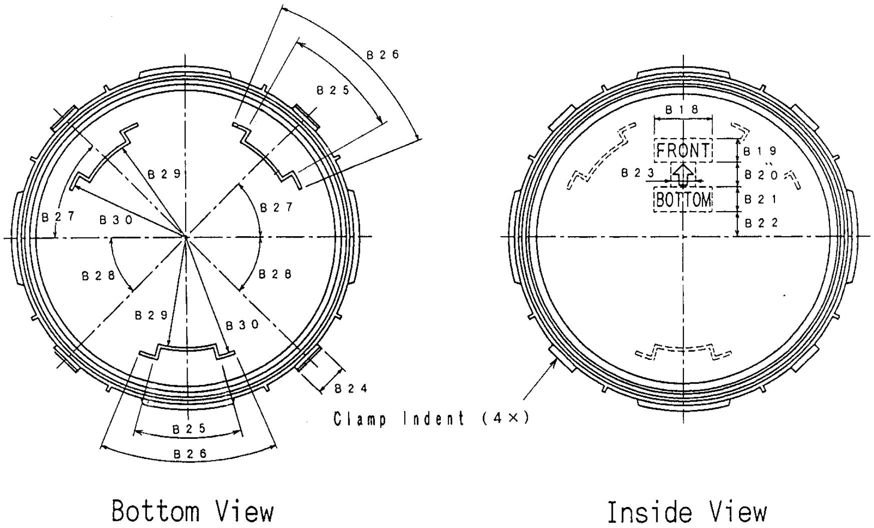

Figure 13
Bottom Rib and Orientation Mark

Table 3 Dimensions of Box Bottom

Unit: mm

Location	*Standardized Dimension*	
	13 Wafers	*25 Wafers*
B1	ø 430 max	ø 450 max
B2	126.5 ± 1	186.5 ± 1
B3	7 min	←
B4	30°	←
B5	38.5°	←
B6	22.5°	←
B7	158 ± 1	←
B8	86 ± 1	146 ± 1
B9	156.5 ± 0.5	←
B10	171.5 ± 0.5	←
B11	101.5 ± 0.5	161.5 ± 1
B12	10 max	←
B13	18 max	←
B14	16.5 ± 0.5	←
B15	12 max	←
B16	3 ± 0.5	←
B17	3 ± 0.5	←
B18	70 ± 10	←
B19	30 ± 10	←
B20	90 ± 10	←
B21	30 ± 10	←
B22	30 ± 10	←
B23	55 ± 10	←
B24	40 ± 1	←
B25	27°	←
B26	45° min	←

Unit: mm

Location	Standardized Dimension	
	13 Wafers	*25 Wafers*
B27	45°	←
B28	45°	←
B29	133 ± 1	←
B30	148 ± 1	←
B31	14 ± 1	←

5.5 *Retainer*

5.5.1 *Front Retainer* — Dimensions of a front retainer are shown in Figure 14 and Table 4.

NOTE 1: Usually, this part is made of an elastic material, and hence, it is difficult to show its form or to measure it. Here, the front view of this part shows the dimensions in the status fitted with a cassette.

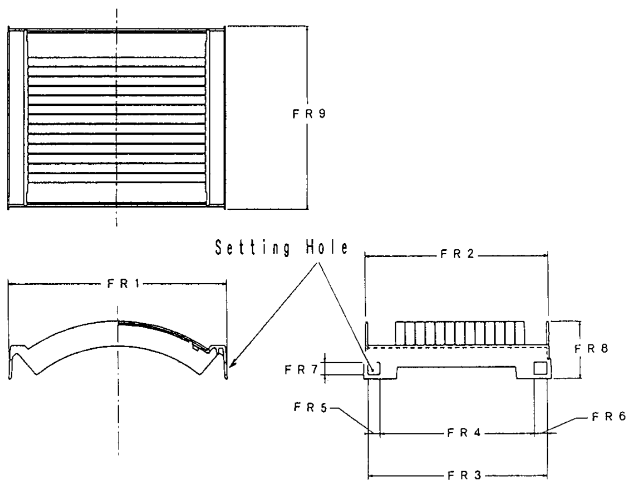

Figure 14
Front Retainer

Table 4 Dimensions of Front Retainer

Unit: mm

Location	Standardized Dimension	
	13 Wafers	*25 Wafers*
FR1	220 ± 1	←
FR2	183 ± 1	303 ± 1.5
FR3	178 ± 1	298 ± 1.5
FR4	153.5 ± 1	273.5 ± 1.5
FR5	11 ± 0.5	←
FR6	13 ± 0.5	←
FR7	12.5 ± 0.5	←
FR8	59 ± 2	←
FR9	187 ± 1	307 ± 1.5

5.5.2 *Rear Retainer* — Dimensions of a rear retainer are shown in Figure 15 and Table 5.

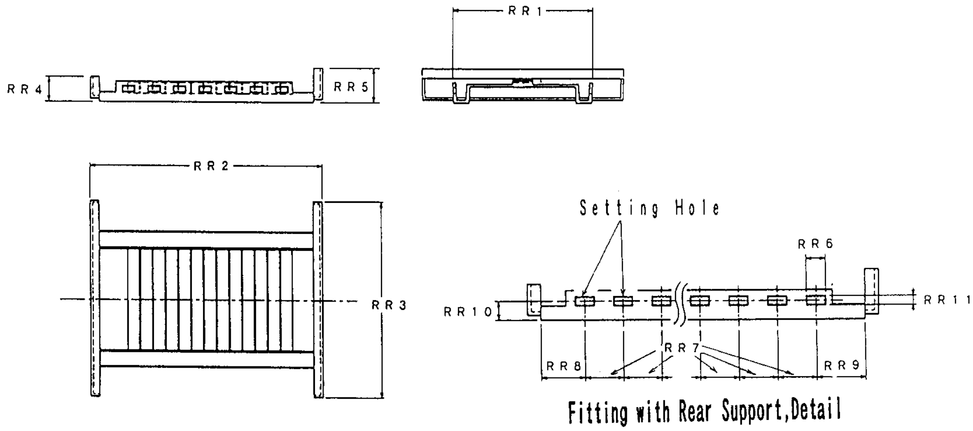

Figure 15
Rear Retainer

Table 5 Dimensions of Rear Retainer

Unit: mm

Location	*Standardized Dimension*	
	13 Wafers	*25 Wafers*
RR1	110 ± 1	←
RR2	184 ± 2	304 ± 3
RR3	157 ± 2	←
RR4	19.5 ± 1	←
RR5	27 ± 1	←
RR6	10 ± 0.5	←
RR7	20 ± 0.5	←
RR8	23 ± 2	←
RR9	25 ± 1	←
RR10	15 ± 5	←
RR11	5 ± 0.5	←

5.6 *Clamp* — Dimensions of a clamp are shown in Figure 16 and Table 6.

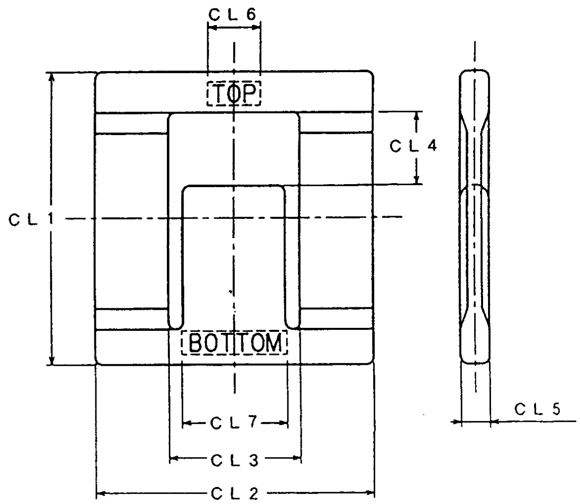

Figure 16
Clamp

Table 6 Dimensions of Clamp

Unit: mm

Location	*Standardized Dimension*	
	13 Wafers	*25 Wafers*
CL1	100 ± 10	←
CL2	95 ± 2	←
CL3	45 ± 2	←
CL4	25 ± 1	←
CL5	10 max	←
CL6	20 ± 5	←
CL7	40 ± 10	←

5.7 *Gasket* — A gasket is a part to be mainly designed with maker's know-how regarding its material and form. In addition, this is frequently revised for increase of quality.

5.7.1 Since there is no practical problem so long as its position is decided, the gasket is not defined. However, it should be provided in the area defined in Sections 5.3.3 and 5.4.3.

APPENDIX 1
APPLICATION NOTES

NOTICE: This appendix was approved as a part of SEMI M29 by full letter ballot procedure.

A1-1 Heat-Resistant Temperature

A1-1.1 Parts defined herein are not considered to be used under high temperature because it is assumed to be used under the usual conditions. As for operating temperature of each part, information from its maker should be confirmed.

A1-2 Orientation of Wafers in Transportation

A1-2.1 It is necessary to vertically keep wafers in transportation. Therefore, it is necessary to clarify vertical holding indicated on buffering material and carton boxes.

A1-3 Using Procedure

A1-3.1 The procedure for using a shipping box defined in this document is shown in Figure A1-1.

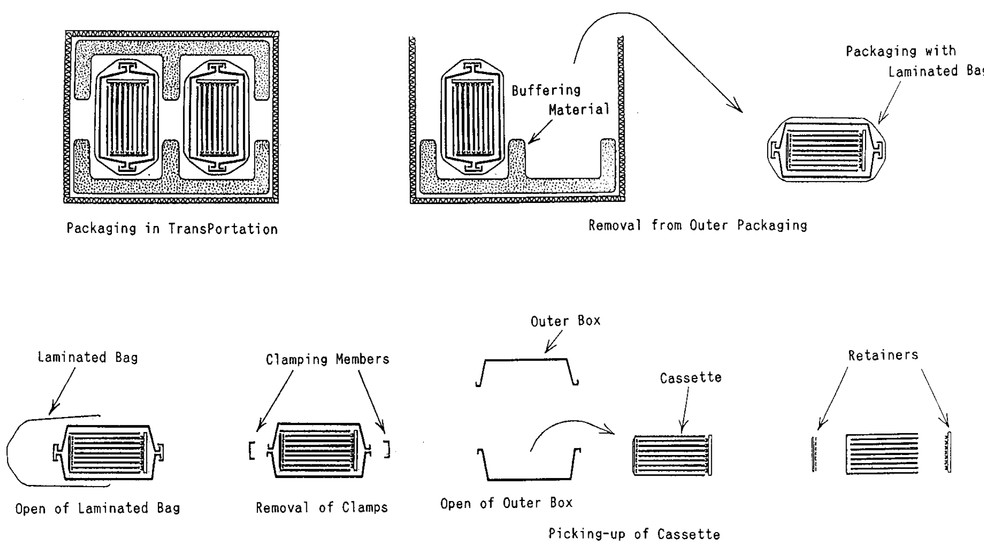

Figure A1-1
Example of Procedure for Using a Shipping Box

A1-4 Maximum Dimensions and Attached Location of Label

A1-4.1 In case it is necessary to attach a label on a shipping box, the label should be attached in the area shown in Figure 18 and Table A1-1, and hence, a designer of a shipping box should not provide a projection in this area.

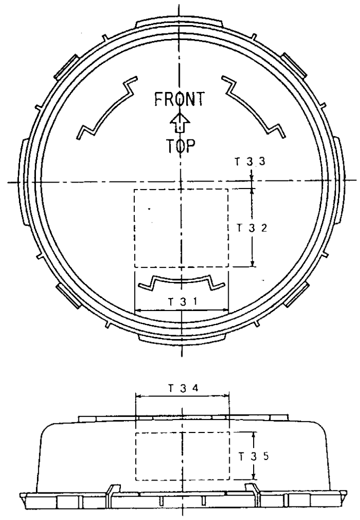

Figure A1-2
Label Area

Table A1-1 Dimensions of Label Area

Unit: mm

Location	*Standardized Dimension*	
	13 Wafers	*25 Wafers*
T31	120 max	←
T32	100 max	←
T33	10 min	←
T34	120 max	←
T35	60 max	←

NOTICE: SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

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SEMI M30-0997

STANDARD TEST METHOD FOR SUBSTITUTIONAL ATOMIC CARBON CONCENTRATION IN GaAs BY FOURIER TRANSFORM INFRARED ABSORPTION SPECTROSCOPY

1 Purpose

The purpose of this document is to test substitutional atomic carbon concentration in GaAs by Fourier Transform Infrared Absorption Spectroscopy (FT-IR).

2 Scope

2.1 This referee test method covers the determination of substitutional carbon concentration in single crystal GaAs.

2.2 The useful range of carbon concentration measurable at room temperature by this test method is from the maximum amount of substitutional carbon soluble in GaAs to 1×10^{15} cm^{-3}. The detection limit depends on the equipment and measurement conditions. It is expected that many users of this test method can reduce the detection limit to 10^{14} cm^{-3} level. 77K measurement is effective to reduce the detection limit. In the case of 77K measurement, the upper limit is 1.3×10^{16} cm^{-3}, as described in the following article:

T.Arai et al : J. Electronic Industry, Vol. 30, 9 (1988) 38

2.3 The test method utilizes the relationship between carbon concentration and absorption coefficient at 580 cm^{-1} for room temperature measurement (around 582 cm^{-1} for 77K measurement), the infrared absorption band is associated with substitutional carbon in GaAs. These specific absorption bands in GaAs have been associated with the local vibration mode of C_{as}.

2.4 The method is applicable to Semi-Insulating (SI) GaAs. Slices can be any crystallographic orientation and should be polished or lapped and etched on both surfaces.

2.5 This test method is intended to be used with FT-IR spectrometers that are equipped to operate in the region including the wave number range from 700 to 500 cm^{-1}.

2.6 This standard may involve hazardous materials, operation, and equipment. This standard does not purport to address all of the safety problems 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.

3 Referenced Documents

3.1 *ASTM Standards*[1]

E 131 — Definitions of Terms and Symbols Relating to Molecular Spectroscopy

E 168 — Recommended Practices for General Techniques of Infrared Quantitative Analysis

E 177 — Practice for Use of the Terms Precision and Bias in ASTM Test Methods

F 120 — Practice for Infrared Absorption Analysis of Impurities in Single Crystal Semiconductor Materials

F 133 (A 894) — Test Method for Thickness and Thickness Variation of GaAs Slices

3.2 *Other Document*[2]

DIN 50449-1 — Bestimmung des Verunreinigungsgehaltes in III-V-Verbindungshalbleitern mittels Infrarotabsorption/Teil 1: Kohlenstoff in Galliumarsenide (Determination of Impurity Content in Semiconductors by Infrared Absorption Part 1: Carbon in Gallium Arsenide)

4 Terminology

4.1 *Acronyms*

4.1.1 *CPAA* — Charged particle activation analysis

4.1.2 *FWHM* — Full width at half maximum, the width of the absorption band at half its magnitude as measured from the baseline.

4.1.3 *MCT* — Mercury cadmium telluride

4.1.4 *TGS* — Triglycine sulfate

4.2 Many of the terms associated with this test method can be found in ASTM Definitions E 131.

4.2.1 *baseline* — A linearly interpolated pattern over a limited spectral region of the ratio recording used to derive an absorption coefficient (see Figure 1 and refer to ASTM Practice E 168).

1 American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohoken, PA 19428-2959

2 Deutches Institut fur Normung, e.v., Beuth Verlag GmbH, Burggrafstrasse 4-10, D-1000 Berlin 30, Germany

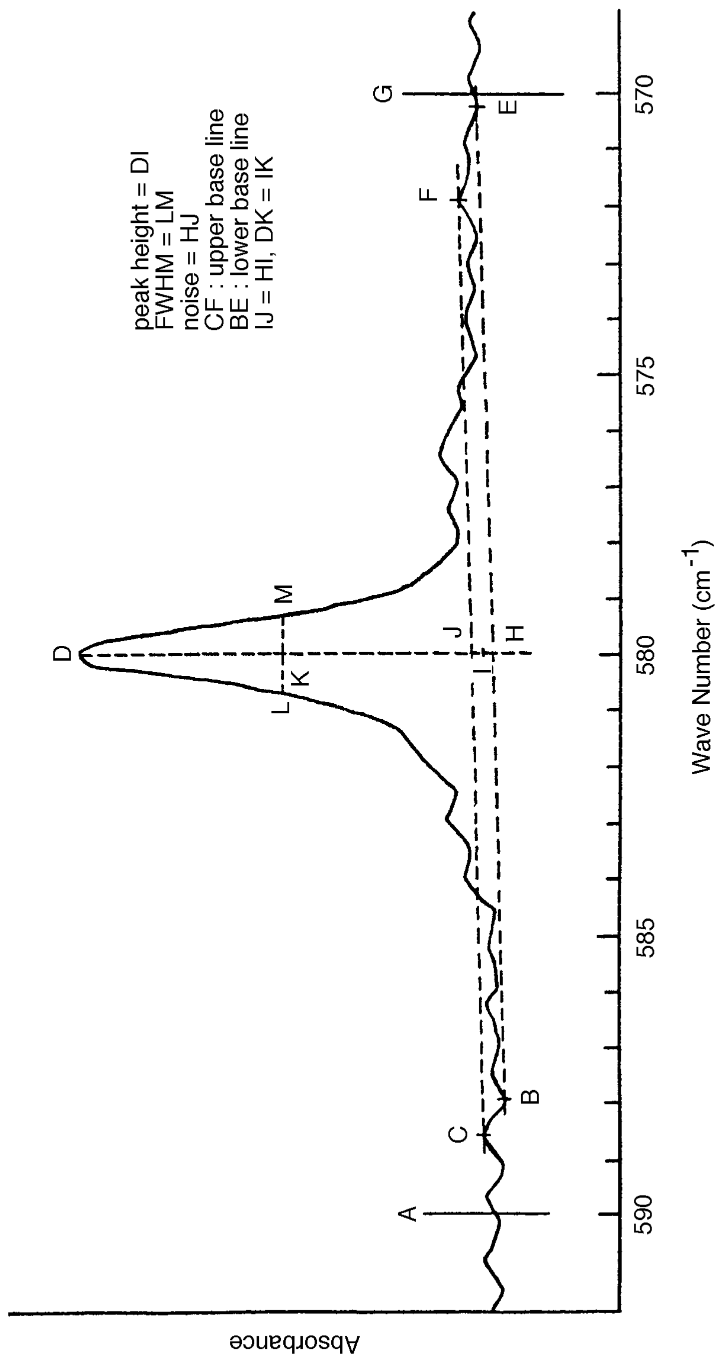

Figure 1
FT-IR Spectrum of C_{as} Local Mode Absorption in GaAs

4.2.2 *calibration coefficient* — Conversion factor to carbon concentration from absorbance or absorption coefficient of each FT-IR instrument.

4.2.3 *carbon concentration* — For purposes of this test method, the volume density of atomic carbon incorporated in the crystal lattice at substitutional positions. It is proportional to the absorption coefficient following Beer's law. Units are atoms per cubic centimeter.

4.2.4 *primary standard samples* — Samples where the carbon concentration is already known, as measured by the CPAA method (see Section 4.1.1). A set of primary standard samples is composed of 4 specimens with each carbon concentration as follows:

No.	*Thickness (mm)*	*Carbon Concentration (cm^{-3})*
#3	5.103	1.4×10^{15}
#5	5.013	12.0×10^{15}
#7	5.015	2.4×10^{15}
#15	4.994	3.2×10^{15}

These samples are preserved at SEMI Japan. Details (actual measured values and measurement errors, etc.) for these samples are described in the following article:

T.Arai et al : J. Electronic Industry, Vol. 30, 9 (1988) 38

4.2.5 *reference sample* — The nearly carbon-free GaAs sample used for calculating the subtracted spectrum which are used for determination of carbon concentration. The reference sample is used for room temperature measurement. It is recommended that the carbon concentration of the reference sample is $< 3 \times 10^{14}$ cm^{-3}.

4.2.6 *secondary standard samples* — The samples of which the carbon concentration was determined in a round-robin test by the FT-IR method using the primary standard samples. More than 3 samples covering the carbon concentration range from 1.5×10^{15} to 10.0×10^{15} cm^{-3} must be used. These samples are preserved as SEMI Japan, and will be lent out for determination of the calibration coefficient for specific FT-IR spectrometers.

5 Summary of Test Method

5.1 Test slices are prepared that are polished or lapped and etched on both sides to a thickness from 3 to 6 mm.

5.2 Apparatus should be calibrated by using the primary standard samples or secondary standard samples. This calibration coefficient is used to calculate the carbon concentration of specimens.

5.3 For room temperature measurement, a baseline is drawn in the differential spectrum (after subtraction of the reference sample spectrum) from which an absorption coefficient is derived. The range of baseline should be wider than ± 10 cm^{-1}. The baseline has to be determined in an interval of the spectra which is neither influenced by main peak at 580 cm^{-1} nor the side peak at 576 cm^{-1}. For 77K measurement, the range of baseline should be wider than ± 1.5 cm^{-1}.

6 Significance and Use

6.1 Carbon plays an important role in the determination of the compensation mechanism which determines the semi-insulating behavior of GaAs. As such the concentration is critical in determining the substrate resistivity.

6.2 As a dominant acceptor in SI-GaAs substrates, carbon could, potentially impact ion implantation activation.

7 Interferences

7.1 Stray light that reaches the detector will tend to reduce the calculated absorption coefficient value and thereby reduce the reported carbon concentration.

7.2 FT-IR instrument instruction manuals should be consulted if problems with the technique are suspected.

7.3 The carbon absorption band half width at room temperature must be less than 2 cm^{-1} for acceptable measurement results. Excessive width can be due to improper thickness matching or stress.

7.4 Specimens that do not exceed the instrument beam size will cause error. Use of apertures, or preferably beam condensers, can correct this problem.

7.5 The minimum detection level of this method is limited by the signal-to-noise ratio of the recording.

8 Apparatus

8.1 FT-IR with an operating range that includes the region of 700 to 500 cm^{-1}. Instrument resolution or spectral resolution at the carbon absorption band of 580 cm^{-1} for room temperature measurement and around 582 cm^{-1} for 77K measurement must not exceed 0.5 cm^{-1}, which means the effective resolution after apodization must not exceed 1.0 cm^{-1}.

8.1.1 Beam sizes and sample holder active areas for both the specimen and the reference must be within 10% of each other.

8.2 Instrument suitable for thickness measurement to an accuracy of 0.0025 mm.

8.3 Holders for these test and reference specimens that prevent any source of infrared radiation from bypassing the specimen.

8.4 For use at 77K, low-temperature cryostat capable of maintaining the specimen and reference at 77K temperature with suitable window materials (refer to ASTM Practice F 120).

8.5 Equipment and materials for slicing and polishing GaAs to a final thickness tolerance of 0.005 mm or less, and a total thickness variation of 0.01 mm or less.

9 Sampling

Unless otherwise specified, a GaAs slice used for the carbon test is to be measured at the nominal slice center. And if a slice is to be reduced in area prior to test, it is shaped such that the original slice center area is that which is tested.

10 Test Specimens

10.1 A single crystal slice of GaAs with a thickness from 3 to 6 mm must be used for carbon determination.

10.2 The test specimen must be carefully shaped to the following criteria:

10.2.1 Thickness variation over the measurement area of 0.005 mm or less.

10.2.2 Same surface preparation on both front and back surfaces. For room temperature measurement, surface preparation of specimen should be same with reference sample. For 77K measurement, mirror polishing on both surface or same surface preparation with standard sample is recommended.

10.2.3 Final thickness agreement between specimen and reference samples of 0.1 mm.

10.2.4 Surface area large enough such that with respect to the holders no incident radiation can bypass either specimen or reference.

11 Procedure

11.1 Prepare FT-IR in accordance with the manufacture's instructions.

11.2 Determine the differential transmission spectrum from 700 to 500 cm^{-1} in accordance with of ASTM Practice F 120.

11.2.1 The FWHM must not exceed 2 cm^{-1} to achieve reliable results. If this is not met, recheck test and reference specimen mechanical properties, use slower scan speed, or longer measuring time, and reverify FT-IR operating conditions.

11.2.2 Reference to Figure 1 and Recommended ASTM Practice E 168, Section 7, for assistance in establishing a baseline on the finished spectrogram. Baseline determination is very important to this method, and becomes more critical as the measured carbon level decreases (refer to ASTM Practice E 168).

11.2.3 For room temperature meansurement, the following conditions are recommended:

- Detector : Broadband MCT (or TGS) (see Sections 4.1.3 and 4.1.4)
- Resolution : 0.5 cm^{-1}
- S/N ratio : > 3
- Range of wave number : including 700 – 500 cm^{-1}
- Aperture : Optimum for each FT-IR
- Apodization function : Triangle
- Smoothing : Not applicable
- Reference : Air, reference sample
- Temperature : 290 ~ 300K

11.2.4 Make the determination at low temperature (77K) if increased sensitivity is required. Follow the same test conditions as described in Sections 11.1 and 11.2 except reference and temperature.

11.3 Determination of the calibration coefficient should be done once or more times per year. Four or more secondary standard samples should be used for this calibration. The user of this method can have and use the internal standard samples to check the spectrometer frequently.

12 Calculations

12.1 Calculate the absorption coefficient, α, using the expression:

$$\alpha = 1X \cdot 1n\ (I_0/I) = 1/X \cdot 2.303 \cdot (\text{peak height of absorption})$$

where :

α = absorption coefficient

X = specimen thickness, cm,

I = transmitted intensity at peak absorption (580 cm^{-1} for room temperature, 582 cm^{-1} for 77K, and

I_0 = baseline intensity at peak absorption, I.

12.2 Determine the calibration coefficient of each FT-IR using the least square method in the following equations:

$$[C_0] = \beta \cdot \alpha_0 \cdot \Delta_0 \quad \text{or} \quad [C_0] = \beta \cdot \alpha_0$$

where :

$[C_0]$ = already known carbon concentration in standard samples

α_0 = absorption coefficient of standard samples

Δ_0 = FWHM of standard samples

β = calibration coefficient of each FT - IR

12.3 Calculate the concentration of substitutional carbon in atoms/cm^3 with the use of the following equations:

$$[C] = \beta \cdot \alpha \cdot \Delta \quad \text{or} \quad [C] = \beta \cdot \alpha$$

where :

$[C]$ = carbon concentration in test specimen

α = absorption coefficient of test specimen

Δ = FWHM of test specimen

β = calibration coefficient of each FT - IR, determined in 12.2

13 Report

13.1 The following information shall be included in the report for referee and research measurements:

13.1.1 Instruments used, detector, resolution, measurement time, range of wave number, aperture, apodization function, smoothing, specimen measurement temperature (room temperature or 77K).

13.1.2 Specimen thickness, and identification.

13.1.3 Calibration coefficient of FT-IR used, width of base line.

13.1.4 FWHM in cm^{-1}, calculated absorption coefficient or absorption, and carbon concentration.

13.1.5 Date of measurement, organization performing test, and location.

13.1.6 Use of any special techniques, such as beam condenser, scale expansion, scan suppression, etc.

NOTICE: These standards do not purport to address safety issues, if any, associated with their use. It is the responsibility of the user of these standards to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

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SEMI M31-0705
PROVISIONAL MECHANICAL SPECIFICATION FOR FRONT-OPENING SHIPPING BOX USED TO TRANSPORT AND SHIP 300 mm WAFERS

This provisional specification was technically approved by the global Silicon Wafer Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on May 20, 2005. It was available at www.semi.org in June 2005 and on CD-ROM in July 2005. Originally published in 1998; previously published March 2005.

1 Purpose

1.1 This standard specifies the front-opening shipping box (FOSB) used to ship 300 mm wafers from wafer suppliers to their customers (typically IC manufacturers), while maintaining wafer quality.

NOTE 1: Refer to SEMI silicon wafer related specifications M-series such as SEMI M1 as for a wafer quality.

2 Scope

2.1 This standard is intended to set an appropriate level of specification that places minimal limits on innovation while ensuring modularity and interchangeability at all mechanical interfaces. However, this standard has been written so that injection-molded plastic FOSBs can be manufactured in conformance with it, and those can be utilized for maintaining wafers quality during transportation, opening and closing the door.

2.2 This standard assumes that the FOSB is used in the last process in wafer manufacturing, in acceptance and inspection, and in transferring the wafers from the FOSB to a FOUP, FOBIT or open cassette inside an IC manufacturing facility. The FOSB is not intended to be used in IC manufacturing processes. It is recommended that wafers be transferred from the FOSB to a FOUP, FOBIT or open cassette using automated methods. As described in ¶5.4, the purchaser needs to specify which type of FOSB door is required:

1) Manual door as described in ¶5.4.1; or

2) Automated–shippable door as described in ¶5.4.2.

2.3 This standard is provisional. This standard will be modified and upgraded from provisional status. Where possible, the specified design features are in accord with like features in SEMI E1.9 and SEMI E47.1.

NOTICE: 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 or other limitations prior to use.

3 Referenced Standards and Documents

3.1 *SEMI Standards*

SEMI E1.9 — Mechanical Specification for Cassettes Used to Transport and Store 300 mm Wafers

SEMI E15 — Specification for Tool Load Port

SEMI E15.1 — Specification for 300 mm Tool Load Port

SEMI E47.1 — Provisional Mechanical Specification for Boxes and Pods Used to Transport and Store 300 mm Wafers

SEMI E57 — Mechanical Specification for Kinematic Couplings Used to Align and Support 300 mm Wafer Carriers

SEMI E62 — Provisional Specification for 300 mm Front-Opening Interface Mechanical Standard (FIMS)

SEMI E119 — Provisional Mechanical Specification for Reduced-Pitch Front-Opening Box for Interfactory Transport of 300mm Wafers

SEMI M45 — Provisional Standard for 300mm Wafer Shipping System

SEMI S8 — Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment

NOTICE: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4 Terminology

4.1 *Definitions*

4.1.1 *bilateral datum plane* — a vertical plane that bisects the wafers and that is perpendicular to both the horizontal and facial datum planes (as defined in SEMI E57).

4.1.2 *box* — a protective portable container for a carrier and/or substrate(s).

4.1.3 *carrier* — an open structure that holds one or more substrates.

4.1.4 *carrier bottom domain* — volume (below *z*6 above the horizontal datum plane) that contains the bottom of the carrier (as defined in SEMI E1.9).

4.1.5 *carrier capacity* — the number of substrates that a carrier holds (as defined in SEMI E1.9).

4.1.6 *carrier sensing pads* — surfaces on the bottom of the carrier for triggering optical or mechanical sensors (as defined in SEMI E1.9).

4.1.7 *carrier side domains* — volumes (from *z*6 above the horizontal datum plane to *z*15 above the top nominal wafer seating plane) that contain the mizo teeth or slots that support the wafer and the supporting columns on the sides and rear of the carrier (as defined in SEMI E1.9).

4.1.8 *carrier top domain* — volume (higher than *z*15 above the top wafer) that contains the top of the carrier (as defined in SEMI E1.9).

4.1.9 *facial datum plane* — a vertical plane that bisects the wafers and that is parallel to the front side of the carrier (where wafers are removed or inserted). On tool load ports, it is also parallel to the load face plane specified in SEMI E15 on the side of the tool where the carrier is loaded and unloaded (as defined in SEMI E57).

4.1.10 *front-opening shipping box (FOSB)* — a shipping box with a front-opening interface.

4.1.11 *front-opening unified pod (FOUP)* — a box (that complies with SEMI E47.1) with a non-removable cassette (so that its interior complies with SEMI E1.9) and with a front-opening interface (that mates with a FIMS port that complies with SEMI E62) (as defined in SEMI E47.1).

4.1.12 *front-opening box for interfactory transport (FOBIT)* — box for interfactory transport between IC manufacturing sites.

4.1.13 *horizontal datum plane* — a horizontal plane from which projects the kinematic-coupling pins on which the carrier sits. On tool load ports, it is at the load height specified in SEMI E15 and might not be physically realized as a surface (as defined in SEMI E57).

4.1.14 *minienvironment* — a localized environment created by an enclosure to isolate the product from contamination and people.

4.1.15 *nominal wafer centerline* — the line that is defined by the intersection of the two vertical datum planes (facial and bilateral) and that passes through the nominal centers of the seated wafers (which must be horizontal when the carrier is placed on the coupling) (as defined in SEMI E57).

4.1.16 *optical wafer sensing paths* — lines of sight for optically sensing the positions of the wafers. Several horizontal optical wafer sensing paths are present in between the carrier side domains. In addition, two vertical optical wafer sensing paths are created by rectangular exclusion zones in the front of the carrier top and bottom (as defined in SEMI E1.9).

4.1.17 *shipping box* — a protective portable container for a carrier and/or wafer(s) that is used to ship wafers from the wafer suppliers to their customers.

4.1.18 *shipping-box front-opening mechanical interface (SFMI)* — optional automated-shippable door style for a FOSB that is compatible with SEMI E62, and must be considered characteristics with exceptions as noted in ¶5.4.2.

4.1.19 *virtual tracking unit* — an entity (which could be a number of substrates or an individual die or mask group) that the factory floor control system treats as a single unit for tracking purposes (as defined in SEMI E1.9).

4.1.20 *wafer carrier* — any cassette, box, pod, or boat that contains wafers (as defined in SEMI E15).

4.1.21 *wafer extraction volume* — the open space for extracting a wafer from the carrier (as defined in SEMI E1.9).

4.1.22 *wafer pick-up volume* — the space that contains entire bottom of a wafer if the wafer has been pushed to the rear of the carrier (as defined in SEMI E1.9).

4.1.23 *wafer set-down volume* — the open space for inserting and setting down a wafer in the carrier (as defined in SEMI E1.9).

5 Requirements

5.1 The FOSB has the following components and sub-components:

Key:

- • Required feature
- ◊ Optional feature

- • Door on front
  - ◊ Manual door (optional)
  - ◊ Automated door (optional)
    - • Holes for latch keys that lock the door to the SFMI interface when the door is unlatched from the box
    - • Holes for registration pins
    - • Door presence sensing areas
- • Top
  - ◊ Top robotic handling flange (optional)
- • Interior
  - • Cassette with supports for 13 or 25 wafers
  - • Wafer retainer
  - • 2 end effector exclusion zones
- • Sides
  - ◊ Ergonomic manual handles (optional)
- • Bottom
  - • 5 carrier sensing pads
  - • 4 Info pads
  - • 3 features that mate with kinematic coupling pins and provide a 10 mm lead-in
  - ◊ 3 features that mate with kinematic coupling pins and provide a 15 mm lead-in (optional)
  - ◊ Retaining features for manual door (optional)
  - • Retaining features for automated-shippable door

5.2 *Kinematic Couplings* — The physical alignment mechanism from the FOSB to the tool load-port (or a nest on a vehicle or in a stocker) consists of features (not specified in this standard) on the top entity that mate with three or six pins underneath as defined in SEMI E57. The three features that mate with the kinematic coupling pins must provide a lead-in capability that corrects a FOSB misalignment of up to *r*69 in any horizontal direction.

5.3 *Inner and Outer Radii* — All required concave features may have a radius of up to *r*65 to allow cleaning and to prevent contaminant build-up. All required convex features may also have a radius of up to *r*66 to prevent small contact patches with large stresses that might cause wear and particles. Note that these limits on the radius of all required features are specified as a maximum (not a minimum) to ensure that the required features are not rounded off too much. The lower bound on the radius is up to the FOSB supplier. Note also that this radius applies to every required feature unless another radius is called out specifically. Here a required feature is an area on the surface of the FOSB supplier. Note also that this radius applies to every required feature unless another radius is called out specifically. Here a required feature is an area on the surface of the FOSB specified by a dimension (or intersections of dimensions) that has a tolerance and not just a maximum or minimum (such as the edges of the robotic handling flange).

5.4 *Door* — It is recommended that the FOSB not be vertical when it is opened or closed. When the FOSB is in a vertical orientation with the door removed, the wafers must be restrained from touching each other by appropriate wafer support design or other retaining techniques.

5.4.1 *Manual Door* — If chosen, the manual door option requires no automation to open the door. An exclusion zone surrounding the manual door area is specified in the standard. There are several possible techniques for sealing and clamping the manual door that meet user requirements. Therefore, only an exclusion zone surrounding the manual door area is specified in this standard. All features of the door and door retaining mechanism must lie within the exclusion zone illustrated in Figure 1 and must not interfere with other specified features (including the kinematic couplings). Figure 1 and dimensions *x*81, *y*50, *y*81, *y*82, *z*47, *z*48 and *z*49 define the manual door area and therefore apply only to the manual door option as described in this section. The *y*81 dimension applies from the horizontal datum plane to the top surfaces of the FOSB (*z*47-*z*48 or *z*47+*z*49 at the upper door frame volume specified by *y*50).

5.4.2 *Automated-shippable Door* — If chosen, the automated-shippable door must be designed to mate with a port that conforms to SEMI E62. However, following characteristics of automate-shippable door must be considered.

5.4.2.1 *Wafer Retaining Structure* — The slot is usually designed that wafers are suspended in the slot without contacting the surface of the slot for preventing the damage during transportation when FOSB door is closed. It should be noted that wafer position of FOSB is different from that of FOUP when the door is closed due to the wafer retaining structure.

5.4.2.2 *Rear of Door* (*y*51) — For manual door, FOSB has a *y*51 ≥ 50 mm to hold wafers in large area at front wafer retainer for keeping wafer quality during transportation. For automated-shippable door, FOSB has a *y*51≥ 140 mm to comply with SEMI E47.1.

5.4.2.3 *Force between Box Door and Box* (*f*34: defined by SEMI E62) — *f*34 is related to wafer retaining force though, need to consider door is pulled by latching too. Even though, *f*34 is increased, minimum force applied to wafer would be recommended for eliminating damage to the wafers in dynamic motion for opening and closing the door.

5.4.2.4 Latch Key Torque (*f*30: defined by SEMI E62) — The required latch key torque depends on the closing force.

5.4.2.5 A FOSB with an automated-shippable door should be able to withstand a force when applied to one of the retaining features of up to 40N (*f*61) in any direction without negative impact to the intended function of the FOSB (e.g. shell deformation, wafer positions, door closing capabilities).

5.5 *Seal Zones for Door* — In the Front Opening Shipping Box Automated Door Option the automated box door is on the front side of the box (corresponding to the front side of the carrier where wafers are accessed so the door is perpendicular to the wafers and parallel to the facial datum plane). The automated door and the carrier frame must have surfaces that mate with the seal zones defined in SEMI E62. Specifically, the FOSB automated box door option and the carrier frame must have surfaces that made with the seal zones and the reserved spaces for vacuum application (which includes all of the circles bounded by *r*38 except for the holes for the registrations at the center of each circle) defined in §5 of SEMI E62 (which specifies *r*38 as well as the seal zone dimensions). These automated door and frame surfaces must be a distance of *y*52 from the facial datum plane and must have a flatness of *y*42. No surface on the automated door may project further from the facial datum plane than the door seal zone and the reserved spaces for vacuum application. The automated door must also be designed so that when the box is pressed against the FIMS port, both latch keys on the port are inserted to their full length. Furthermore, when the latch keys are turned more than 45° toward the position that unlocks the automated door from the box, the latch key holes on the door must be such that the door is not removable from the latch keys. There are no door seal zone requirements for the manual door option, but a FOSB with the manual door must contain a frame seal zone that meets the frame seal zone requirements specified in this section.

5.6 *Wafer Retaining* — When the FOSB is closed, the wafers must be retained in the FOSB to prevent movement during subsequent handling, including shipping. It should be noted that wafers are typically shipped in a vertical orientation and generally require support from a secondary package. It is recommended that this secondary package be designed to allow for easy removal of the FOSB from the secondary package.

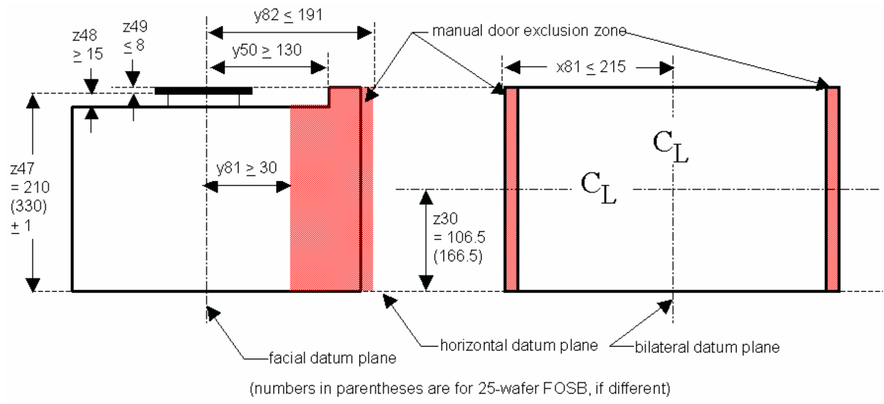

Figure 1
Manual Door Area

5.7 *Wafer Orientation and Numbering* — The wafers must be horizontal when the FOSB is placed on the coupling, and the wafers slots are numbered in increasing order from bottom to top (so the bottom wafer is wafer number 1, the next wafer up is wafer number 2, etc.).

5.8 *Internal Horizontal Dimensions* — Figure 2 shows a cross-section of the horizontal boundaries of the FOSB side domains (which contain the parts of the FOSB higher than *z*6 above the horizontal datum plane and lower than *z*15 above the top wafer). In this and following figures, the most heavy lines are used for surfaces that have tolerances (not surfaces that have only maximum or minimum dimensions).

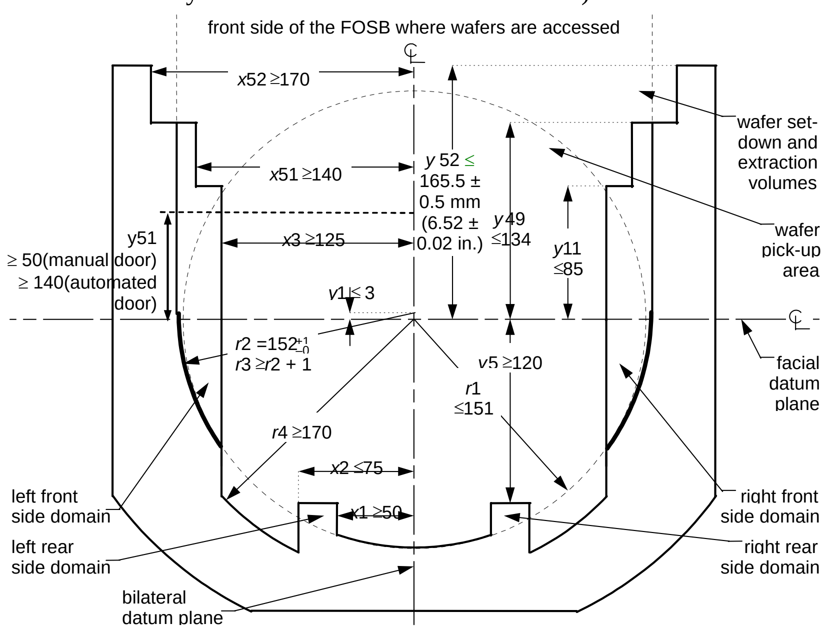

Figure 2
Top View of FOSB Internal Dimensions

5.9 *Internal Vertical Dimensions* — Figures 3 through 7 show the vertical dimensions of the internal FOSB. Note that *z*8 (the height of the bottom nominal wafer seating plane above the horizontal datum plane) and *z*12 (the distance between adjacent nominal wafer seating planes) are given as absolute distances with no tolerance. This means that the sum of actual height variations in the FOSB from the kinematic coupling to the supporting features holding each wafer must be contained within the tolerance of *z*10 with no further stack-up at each higher wafer. The method for meeting this requirement is left up to the FOSB supplier. Table 2 defines all dimensions for Figures 3 through 7.

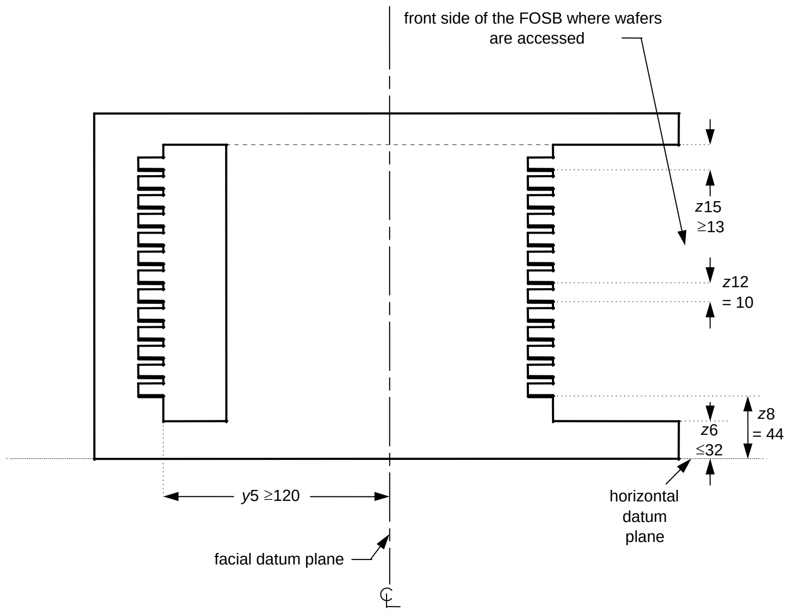

Figure 3
Side View of FOSB Internal Dimensions

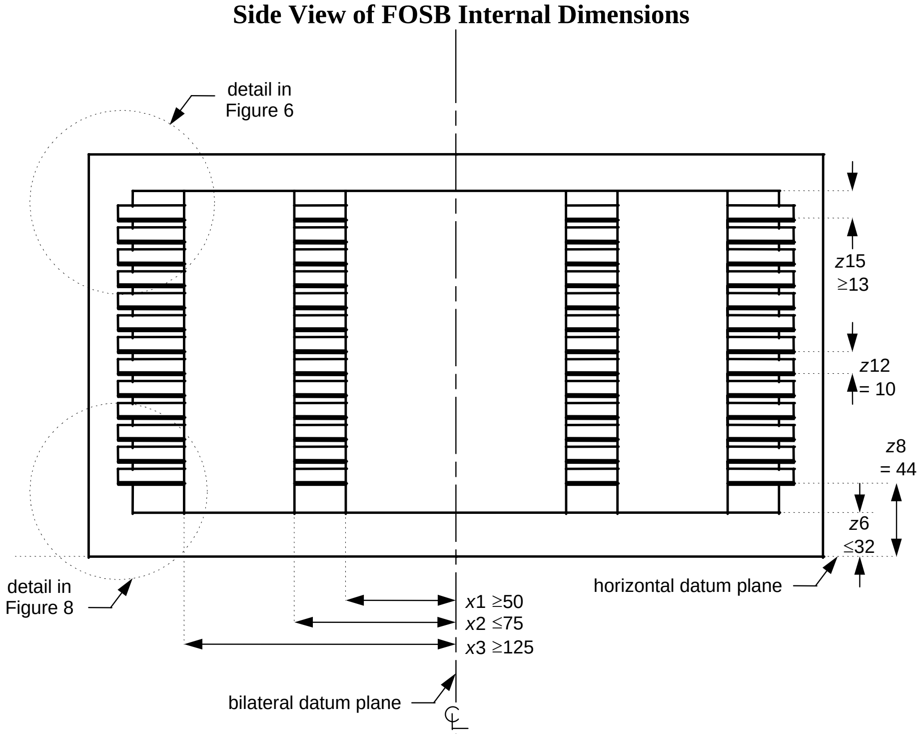

Figure 4
Front View of FOSB Internal Dimensions

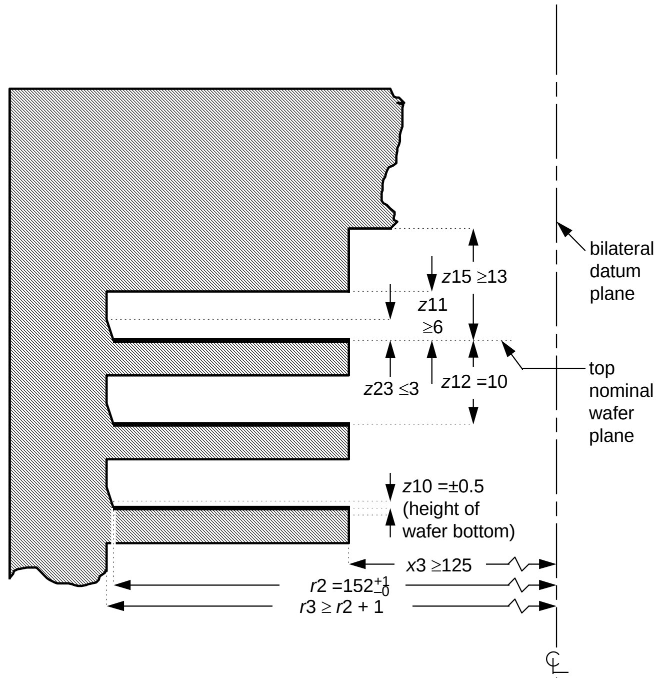

Figure 5
Upper Cross-Section at Facial Datum Plane

5.9.1 *Wafer Set-Down Volume* — The open space for the wafer set-down volume consists of a cylindrical section with radius *r*2 and a main axis parallel to and *y*1 in front of the nominal wafer centerline. The top of this cylindrical section is *z*11 above the nominal wafer seating plane and its bottom is *z*10 above the nominal wafer seating plane. The implications for wafer positioning of the tolerance on *r*2 are as follows. The wafers should be placed in the FOSB within a circle of radius corresponding to the smaller bound on *r*2 to avoid touching the edge of the wafer to the side of the FOSB. Once the wafer has been placed, the FOSB must not allow a wafer to move outside of a circle of radius corresponding to the larger bound on *r*2. There are two exceptions to this limit on wafer movement. When the wafer is pushed toward the rear of the FOSB, the location of the wafer is defined by the wafer pick-up volume (see ¶5.9.3). When the FOSB is gently tilted forward up to 45°, the wafers may slide forward, but it is recommended that they not extend further than *y*20 from the facial datum plane. This may be accomplished by designing the teeth supporting the wafers to include a "wafer stopper" at the front that is outside of *r*2 and under *z*29 as illustrated in Figure 6.

5.9.2 *Wafer Extraction Volume* — The open space for the wafer extraction volume includes a cylindrical section with radius *r*3 and a main axis parallel to and *y*1 in front of the nominal wafer center line. The top of this cylindrical section is *z*11 above the nominal wafer seating plane and its bottom is *z*23 above the nominal wafer seating plane. The wafer extraction volume also includes the extrusion out the front of the FOSB of this cylindrical section and the portion of the wafer set-down volume above *z*29. The implications for wafer extraction of the definition of dimension *r*3 (*r*3 ≥ *r*2 + 1) are as follows. The FOSB must give an extra 1 mm (0.04 in.) of horizontal clearance once the wafer is picked up from wherever it ends up (within the bounds of *r*2) after transport in the FOSB.

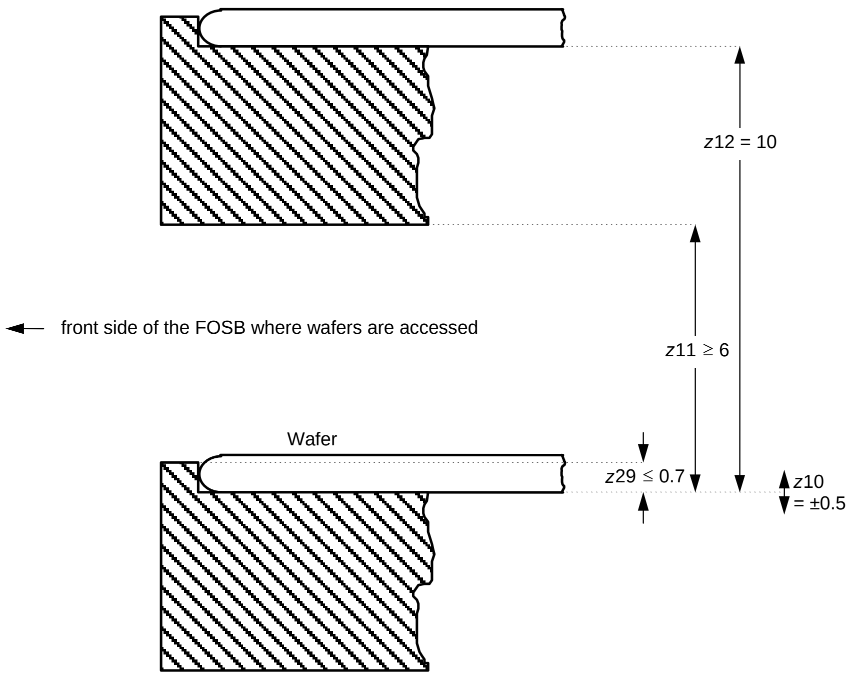

Figure 6
Features That Prevent Wafer Creep-Out

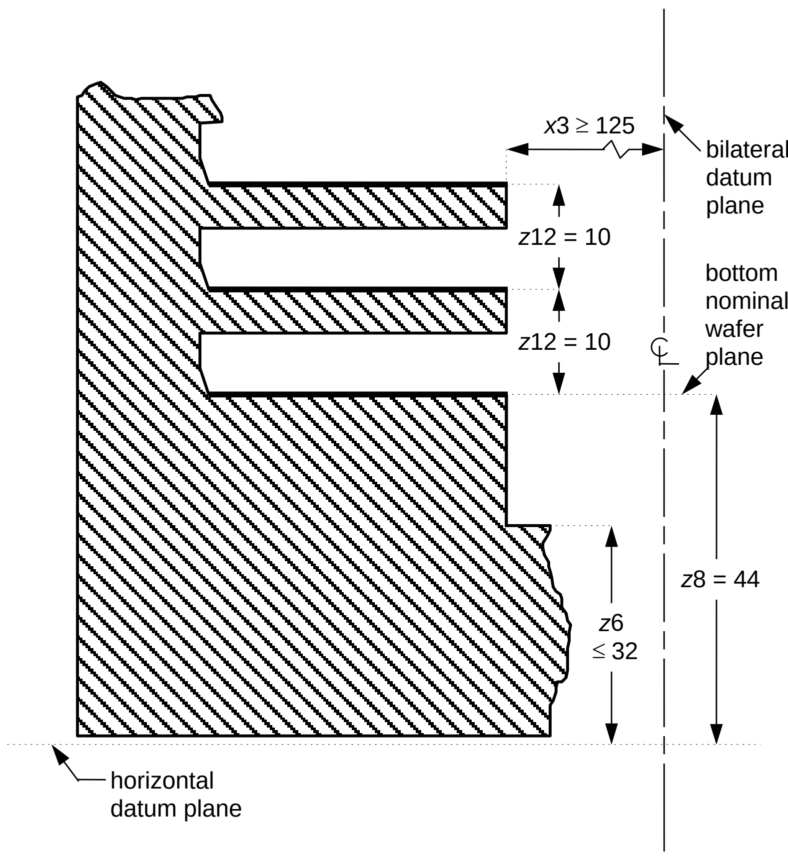

Figure 7
Lower Cross-Section at Facial Datum Plane

5.9.3 *Wafer Pick-Up Volume* — If a wafer is placed in the wafer set-down volume and is then pushed toward the rear of the FOSB, then the entire bottom of the wafer must be contained in the wafer pick-up volume. However, if the wafer is not pushed toward the rear of the FOSB, then the wafer may only be somewhere within the wafer extraction volume. The wafer pick-up volume is defined by a cylindrical section with radius *r*1 and a main axis at the nominal wafer centerline. Its top and bottom are the upper and lower tolerance of *z*10 around the nominal wafer seating plane.

5.10 *Pitch and Capacity* — Table 1 shows the different options with regard to the wafer pitch (spacing) and the FOSB capacity. Again, no tolerance is given on the wafer pitch (*z*12), for reasons given in ¶5.9.

Table 1 Pitch and Capacity Options

Option Number	*FOSB Capacity (c)*	*Wafer Pitch (z12)*	*Wafer Clearance (z11)*
1	13 wafers	10 mm (0.39 in.)	6 mm (0.24 in.) minimum
2	25 wafers	10 mm (0.39 in.)	6 mm (0.24 in.) minimum

Table 2 Internal FOSB Dimensions (Figures 2–7)

Symbol Used	*Figure Number*	*Value Specified*		*Datum Measured from*	*Boundary or Feature Measured to*
		Manual Door	*Auto-door*		
*r*1	2	151 mm (5.94 in.) maximum		nominal wafer centerline	outer edge of wafer pick-up volume
*r*2	2, 5	152 = 1 – 0 mm (5.99 + 0.03 – 0 in.)		*y*1 in front of nominal wafer centerline	encroachment of FOSB side domains on wafer set-down volume
*r*3	2, 5	*r*2 + 1 mm (0.04 in.) minimum		*y*1 in front of nominal wafer centerline	encroachment of FOSB side domains on wafer extraction volume
*r*4	2	170 mm (6.69 in.) minimum		nominal wafer centerline	encroachment of FOSB on end effector exclusion zone between front and rear FOSB side domains
*x*1	2, 4	50 mm (1.97 in.) minimum		bilateral datum plane	inside of rear FOSB side domains
*x*2	2, 4	75 mm (2.95 in.) maximum		bilateral datum plane	outside of rear FOSB side domains
*x*3	2, 4, 5, 7	125 mm (4.92 in.) minimum		bilateral datum plane	inside of front FOSB side domains
*x*51	2	140 mm (5.51 in.) minimum		bilateral datum plane	interior of FOSB sides between *y*11 and *y*49
*x*52	2	170 mm (6.69 in.) minimum		bilateral datum plane	interior of FOSB sides between *y*49 and *y*52
*y*1	2	3 mm (0.12 in.) maximum		facial datum plane	origin of *r*2 and *r*3 on bilateral datum plane
*y*5	2, 3	120 mm (4.72 in.) minimum		facial datum plane	front of rear FOSB side domains
*y*11	2	85 mm (3.35 in.) maximum		facial datum plane	interior of FOSB sides between *x*3 and *x*51
*y*20[#1]	None	158 mm (6.22 in.)		facial datum plane	maximum protrusion of wafers toward the front of the FOSB
*y*49	2	134 mm (5.28 in.) maximum		facial datum plane	interior of FOSB sides between *x*51 and *x*52
*y*51	2	50 mm (1.97 in.) minimum	140 mm (5.51 in.) minimum	facial datum plane	rear of door
*z*6	3, 4, 7	32 mm (1.26 in.) maximum		horizontal datum plane	top of FOSB bottom domain

Symbol Used	*Figure Number*	*Value Specified*		*Datum Measured from*	*Boundary or Feature Measured to*
		Manual Door	*Auto-door*		
*z*8	3, 4, 7	44 mm (1.73 in)		horizontal datum plane	bottom nominal wafer seating plane
*z*10	5, 6	0 ± 0.5 mm (0.00 ± 0.02 in.)		each nominal wafer seating plane	entire bottom of the wafer
*z*11	5, 6	See Table 1.		each nominal wafer seating plane	encroachment of FOSB side domains on clearance above the wafer
*z*12	3, 4, 5, 6, 7	See Table 1.		each nominal wafer seating plane	adjacent nominal wafer seating planes
*z*15	3, 4, 5	13 mm (0.51 in.) minimum		top nominal wafer seating plane	bottom of FOSB top domain
*z*23	5	3 mm (0.12 in.) maximum		each nominal wafer seating plane	bottom of wafer extraction volume
*z*29	6	0.7 mm (0.028 in.) maximum		each nominal wafer seating plane	encroachment of FOSB side domains under wafer extraction volume

[#1] These dimensions are for optional features.

5.11 *External Dimensions* — Figures 8 through 12 respectively show the side view, rear view, top view, robotic flange, and bottom view for the front-opening FOSB. Table 3 defines all of the dimensions. If an identification tag is used, it must be located at the bottom rear centered on the bilateral datum plane and must be contained within the maximum outer dimensions of the FOSB.

5.12 *Human Handles* — All handles for use by humans must either be contained within the maximum outer dimensions of the FOSB, be detached when not in use, or be retractable into the maximum outer dimensions when not in use. Although such handles may extend past *x*53, they must still be contained within *x*50, *y*40, and *r*67. Handles for use by humans (if present) must follow SEMI S8, and they must require the use of both hands (each using a full wrap-around grip, given the minimum clearance requirement in SEMI E15.1). Automation handling features shall not be considered dual purpose unless they are designed to meet SEMI S8 guidelines.

5.13 *Automation Handling* — On the top of the FOSB, there is an optional robotic handling flange for manipulating the FOSB as illustrated in Figure 12. On the bottom of the FOSB, there are optional rails for use with roller conveyors or forklifts. Although they are only required to extend *y*58 to the left and right, it is recommended that they be as long as possible. Beyond *y*58, only the lower bound on *z*43 apply. These optional conveyor rails (defined by *x*56, *x*57, and *z*43) are located on the left and right bottom edges of the front-opening shipping box. The conveyor rails also have vertical cylindrical pin holes for fork lift centering (defined by *d*65).