

SEMI M3-0304 (Withdrawn 0707) SPECIFICATIONS FOR POLISHED MONOCRYSTALLINE SAPPHIRE SUBSTRATES

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NOTICE: This document was balloted and approved for withdrawal in 2007.

1 Purpose

1.1 Sapphire substrates are utilized for heteroepitaxial growth of silicon films for certain types of device structures. The properties of the films depend in part on the properties of the substrate used. These specifications are intended to provide specifications for the criteria necessary for growth of films suitable for device production.

2 Scope

2.1 These specifications cover requirements for five sizes (from 2 inch to 150 mm) of monocrystalline high-purity polished sapphire substrates. Dimensional and crystallographic orientation characteristics are the only standardized properties set forth herein. A purchase specification may require that additional physical properties be defined. Many of these properties are listed, together with test methods suitable for determining their magnitude. Additional information and recommended specification levels for several of these properties are provided in Related Information sections.

2.2 These specifications are directed specifically to sapphire substrates with one polished surface. Substrates polished on both sides, or unpolished, or with epitaxial deposits, are not covered; however, purchasers of such substrates may find these specifications to be a useful guide in defining their requirements.

2.3 Appendix 1 covers dimensional requirements for reclaimed 3 inch sapphire substrates.

2.4 For referee purposes, U.S. customary units shall be used for substrates of 2 and 3 in. nominal diameters, and SI (System International, commonly called metric) units for 100 mm and larger diameter substrates.

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 M1 — Specifications for Polished Monocrystalline Silicon Wafers

SEMI MF26 — Test Methods for Determining the Orientation of a Semiconductive Single Crystal

SEMI MF523 — Practice for Unaided Visual Inspection of Polished Silicon Wafer Surfaces

SEMI MF533 — Test Method for Thickness and Thickness Variation of Silicon Wafers

SEMI MF534 — Test Method for Bow of Silicon Wafers

SEMI MF671 — Test Method for Measuring Flat Length on Wafers of Silicon and Other Electronic Materials

SEMI MF847 — Test Methods for Measuring Crystallographic Orientation of Flats on Single Crystal Silicon Wafers by X-Ray Techniques

SEMI MF928 — Test Methods for Edge Contour of Circular Semiconductor Wafers and Rigid Disk Substrates

SEMI MF1810 — Test Method for Counting Preferentially Etched or Decorated Surface Defects in Silicon Wafers

SEMI MF2074 — Guide for Measuring Diameter of Silicon and Other Semiconductor Wafers

3.2 *ASTM Standard*¹

E 122 — Practice for Choice of Sample Size to Estimate the Average Quality of a Lot or Process

3.3 *Other Standard*²

ANSI/ASQC Z1.4-1993 — Sampling Procedures and Tables for Inspection by Attributes

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

4 Terminology

4.1 *Definitions*

4.1.1 *lot* — for the purposes of these specifications, (a) all of the substrates of nominally identical size and characteristics contained in a single shipment, or (b) subdivisions of large shipments consisting of substrates as (a) above which have been identified by the supplier as constituting a lot.

4.1.2 *sapphire (in silicon-on-sapphire technology)* — single crystal aluminum oxide (Al_2O_3) having a definite orientation that allows epitaxial silicon deposition.

4.1.3 *substrate* — the polished sapphire slice upon which the epitaxial layer of silicon is grown.

5 Ordering Information

5.1 Purchase orders for sapphire substrates furnished to these specifications shall include the following items:

5.1.1 Nominal diameter (see Table 1),

5.1.2 Crystal growth method (see Note 1),

5.1.3 Surface orientation (see Table 1 and Figures 1 and 2),

5.1.4 Lot acceptance procedures (see § 9),

5.1.5 Certification (if required) (see § 12), and

5.1.6 Packing and marking (see § 13).

5.2 The following items may be specified optionally in addition to those listed in § 5.1:

5.2.1 Crystal perfection,

5.2.2 Surface defect and contaminant levels,

5.2.3 Impurities,

5.2.4 Front surface finish quality level (see Figures R2-1 through R2-4),

5.2.5 Back surface finish,

5.2.6 Secondary flat (see Figure 3),

5.2.7 Flatness (see Table 2), and

5.2.8 Edge Profile.

NOTE 1: The crystal growth method (for example, Czochralski or EFG ribbon) is difficult to ascertain in the finished substrates. Verification test procedures or certification of these characteristics (see § 12) shall be agreed upon between the supplier and the purchaser.

NOTE 2: Items in § 5.2 are less commonly specified than the others but are included for completeness as parameters for which methods of evaluation have been developed.

1 Volume 14.02 of the *Annual Book of ASTM Standards*, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA. Telephone: 610.832.9585, Fax: 610.832.9555; <http://www.astm.org>

2 American Society for Quality Control, 611 East Wisconsin Avenue, Milwaukee, WI 53202; <http://www.asqc.org>

6 Dimensions and Permissible Variations

6.1 The material shall conform to the dimensions and dimensional tolerances as specified in Table 1 for the following parameters.

6.1.1 Diameter,

6.1.2 Center Point Thickness,

6.1.3 Total Thickness Variation,

6.1.4 Primary Flat Length,

6.1.5 Secondary Flat Length,

6.1.6 Flat Locations, and

6.1.7 Bow.

6.2 The orientation of the substrate material shall be identified by a flat system as defined in § 11.

6.3 If specified in the purchase order or contract the front surface flatness shall be identified in accordance with the classification system in Table 2.

6.4 If specified in the purchase order or contract, the edge shall be rounded and beveled.

7 Materials and Manufacture

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

8 Physical Requirements

8.1 The material shall conform to the crystallographic orientation details listed in Table 1 (see Figure 1).

8.2 The following items, if included, shall conform to the requirements specified in the purchase order or contract:

8.2.1 Crystal perfection,

8.2.2 Surface defect and contaminant levels (See Related Information 1 for surface defect definitions and Table R1-1 for suggested allowable levels of surface defects.),

8.2.3 Amount of impurities,

8.2.4 Front surface finish quality level (see Related Information 2 and Figures R2-1 through R2-4 for information on recommended front surface finish quality levels), and

8.2.5 Back surface finish (see Related Information 2 for recommended back surface finish level).

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 Z1.4-1993. Each quality characteristic shall be assigned an acceptable quality level (AQL) and lot total percent defective (LTPD) value in accordance with ANSI/ASQC Z1.4-1993 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 *Dimensions* — Measure as follows:

10.1.1 *Diameter* — Determine by a method agreed upon between the supplier and the purchaser at locations specified in Configuration 1 of SEMI MF2074.

NOTE 3: Sapphire substrates are highly susceptible to surface damage. While the mechanical dimensions of a slice can be measured by use of tools such as micrometer calipers and other conventional techniques, the substrate may be damaged

physically in ways that are not immediately evident. Special care must therefore be used in the selection and execution of measurement methods.

10.1.2 *Thickness, Center Point* — Determine at the center of the substrate (Point 2 in Figure 4) in accordance with SEMI MF533.

10.1.3 *Total Thickness Variation (5 point)* — Determine in accordance with SEMI MF533, except that thickness measurements shall be made at the five locations in Figure 4 instead of the locations specified in SEMI MF533. Points 1, 3, 4, and 5 in Figure 4, which define the locations of the edge measurements, are located 6 mm in from the wafer periphery.

10.1.4 *Flat Length* — Determine in accordance with SEMI MF671.

10.1.5 *Bow* — Determine in accordance with SEMI MF534.

10.2 *Flat Orientation* — Determine in accordance with SEMI MF847.

10.3 *Surface Orientation* — Determine in accordance with the x-ray method of SEMI MF26.

10.4 *Crystal Perfection* — Unless otherwise specified, determine in accordance with SEMI MF1810.

10.5 *Surface Defects and Contamination* — Determine defects in accordance with SEMI MF523.

10.6 *Other Impurities* — Determine by methods agreed upon between the supplier and the purchaser.

10.7 *Front Surface Finish* — Determine by methods agreed upon between the supplier and the purchaser.

10.8 *Back Surface Finish* — Determine by methods agreed upon between the supplier and the purchaser.

10.9 *Flatness* — Determine by a method agreed upon between the supplier and the purchaser.

10.10 *Edge Profile* — Determine by a method agreed upon between the supplier and the purchaser. Method B of SEMI MF928 is a non-destructive way of evaluating the shape of the edge profile; if this method is used, the template to be used shall be agreed upon between the supplier and the purchaser.

11 Flat System

11.1 Figures 2 and 3 describe the primary and secondary flat system.

11.1.1 *Primary Flat*: $45^\circ \pm 2^\circ$ in the counter-clockwise direction from the projection of the c-axis along an r-plane.

11.1.2 *Secondary Flat (Optional)*: $90^\circ \pm 2^\circ$ in the counter-clockwise direction from the primary flat, along an r-plane.

11.2 The a-axis lies between the two flats bisecting the 90° angle. Projection of the c-axis lies 45° in the clockwise direction from the primary flat and 90° in the clockwise direction from the a-axis.

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 § 11. However, if the purchaser performs the test and the material fails to meet the requirements, 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 slices 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 substrates supplied under these specifications 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 substrates