



Designation: F2358 – 04

Standard Guide for Measuring Characteristics of Sapphire Substrates¹

This standard is issued under the fixed designation F2358; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers a nondestructive procedure to determine the form of clean, dry sapphire substrates.

1.2 This guide is applicable to substrates 25 mm or larger in diameter, with a minimum thickness of 100 μm . This guide is independent of surface finish.

1.3 The measurements described in this guide may be applied to the entire global surface of the substrate, or to smaller localized areas.

1.4 The value of the measurements described in this guide will be affected by the amount of edge exclusion (that is, the area around the perimeter of the part which is ignored). The amount excluded should be agreed upon by the producer and consumer using this standard.

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

2. Referenced Documents

2.1 SEMI Standard:²

M3 Specifications for Polished Monocrystalline Sapphire Substrates

3. Terminology

3.1 *General Definitions:*

3.1.1 *back surface*—the surface opposite the front surface. If there is no difference between the front and back surfaces, then the surfaces may be determined arbitrarily, and are therefore interchangeable.

3.1.2 *best-fit plane*—the theoretical plane established by using the least squares fit method, based on data obtained from the quality area only.

3.1.3 *best-fit sphere*—the theoretical sphere established by using the least squares fit method, based on data obtained from the quality area only.

3.1.4 *front surface*—the preferred surface, as defined by the user.

3.1.5 *quality area*—the central area of a wafer surface, defined by a nominal edge exclusion, over which the specified values of a parameter apply. If the quality area is not circular, the “circle defining the quality area” shall be defined as the minimum diameter circle which contains all of the data within the quality area.

3.1.6 *reference plane*—the plane from which deviations are measured.

3.1.7 *restrained condition*—this refers to the state of the substrate under test, when one side of the substrate is clamped to an ideally flat surface; for example, when pulled down by a vacuum onto an ideally clean flat chuck.

3.1.8 *sapphire substrate*—generic term for any flat wafer, window, wafer carrier, or substrate made of sapphire material. These terms may be used interchangeably in this standard.

3.1.9 *thickness*—the distance through the substrate between corresponding points on the front and back surfaces.

3.1.10 *unrestrained condition*—this refers to the state of the substrate under test, when the substrate is in a stress-free condition with minimal deformation due to gravity.

3.2 *Definitions of Unrestrained Parameters:*

3.2.1 *sag*—the distance from the apex of the best-fit sphere to a plane intersecting the sphere in a circle with a diameter equal to the diameter of the circle defining the quality area, measured in an unclamped condition. This value will be positive (+) if the measured surface is convex, and negative (–) if the surface is concave. See Fig. 1.

3.2.2 *sori*—the maximum distance above, plus the maximum distance below the front surface best-fit plane of a free, unclamped substrate. See Fig. 2.

3.3 *Definitions of Restrained Parameters* (see Note 1):

3.3.1 *front-to-front deviation (FFD)*—the maximum distance above, plus the maximum distance below the front surface best-fit plane of a substrate, measured with the back surface restrained. See Fig. 3.

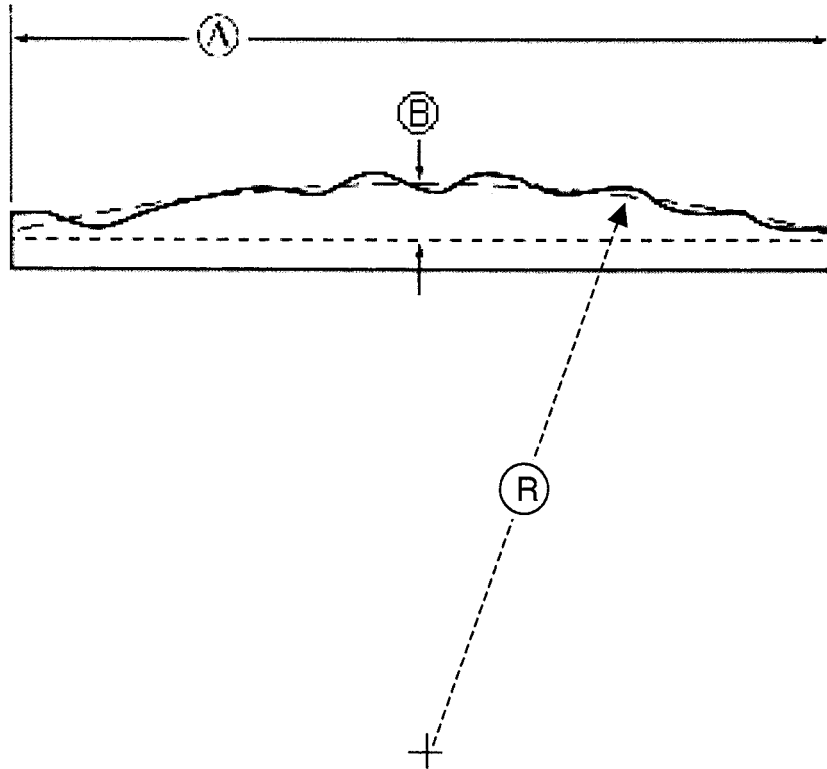
3.3.2 *taper*—the linear component of the variation in thickness across a substrate, indicated by the angle between the best-fit plane to the front surface and the ideally flat back surface of the substrate. See Fig. 4.

3.3.3 *total thickness variation (TTV)*—the difference between the maximum and minimum values of the thickness of the substrate. See Fig. 5.

¹ This guide is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.15 on Compound Semiconductors.

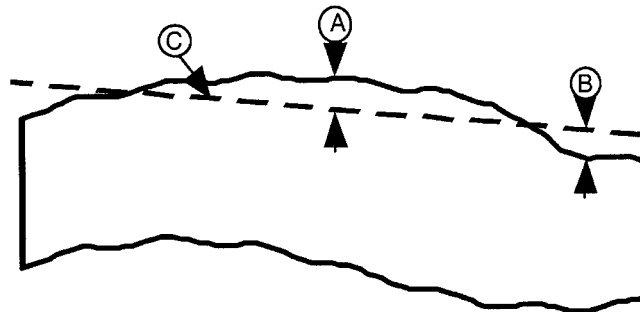
Current edition approved May 1, 2004. Published June 2004. DOI: 10.1520/F2358-04.

² Available from Semiconductor Equipment and Materials International (SEMI), 3081 Zanker Rd., San Jose, CA 95134.



A – Diameter of quality area
R – Radius of best-fit sphere

FIG. 1 Sag, $B = R - \frac{1}{2}\sqrt{4R^2 - A^2}$
(positive if convex, negative if concave)



A – Maximum distance above the best-fit front-surface plane
B – Maximum distance below the best-fit front-surface plane
C – Best-fit front-surface plane

FIG. 2 $S_{ori} = |A| + |B|$

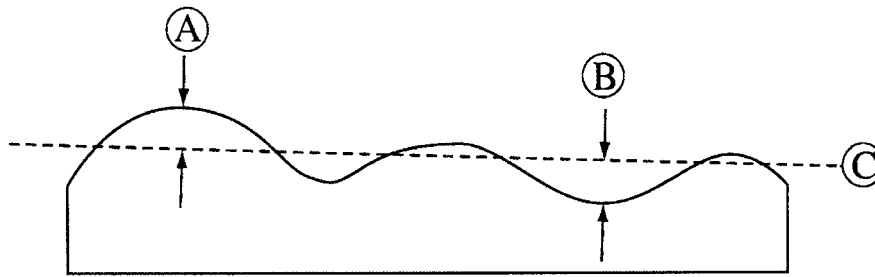
NOTE 1—Even though the above parameters define the variation of a theoretically restrained substrate, the measurements may be performed in the unrestrained state, with calculations performed to simulate the restrained condition.

4. Summary of Guide

4.1 The surfaces of samples under test may be measured using optics, interferometry, or any other technique that effec-

tively characterizes the form of the sapphire sample. It is important to hold the sample properly to achieve accurate measurements.

4.1.1 *Condition of Unrestrained Substrate Under Test*—The sample shall be supported in such a way as to represent as closely as possible a stress-free state of the substrate.

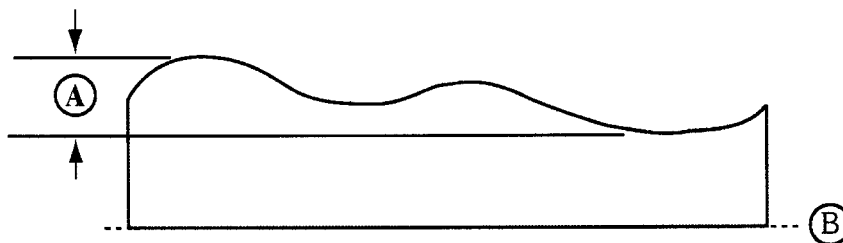


A – Maximum distance above the best-fit plane
B – Maximum distance below the best-fit plane
C – Best-fit plane

FIG. 3 Front-to-Front Deviation (FFD) = $|A| + |B|$
(back surface restrained)



FIG. 4 Taper = $A \cdot \tan \theta$



A – TTV
B – Back reference surface

FIG. 5 TTV = $|A|$
(shown measured in the restrained condition)

4.1.2 Condition of Restrained Substrate Under Test—The sample shall be supported such that it represents as closely as possible the back surface of the substrate in the restrained state, when one side of the substrate is clamped to an ideally flat surface.

5. Significance and Use

5.1 The measurements described in this guide can significantly affect the function of the sapphire substrate.

5.2 Substrates with excessive form errors in the free state may cause processing errors in production.

5.3 The restrained state of the substrate is intended to simulate as closely as possible the form that the substrate will take in one of its intended uses. During processing, one surface of the substrate is sometimes forcibly restrained to a flat state

through either vacuum or adhesion to a flat surface. The measurements in the clamped state are intended to model the form of the front surface of the substrate when the back surface is constrained to the reference plane. The form in the clamped state may have a direct impact on the performance of the substrate in use.

5.4 The user should determine whether the unrestrained or restrained measurements are most pertinent to the application and specify the appropriate parameters accordingly.

5.5 Knowledge of these characteristics can help the producer and consumer determine if the dimensional characteristics of a specimen substrate satisfy given geometrical requirements.