

SEMI HB10-1018

SPECIFICATION FOR SINGLE CRYSTAL SAPPHIRE INTENDED FOR USE FOR MANUFACTURING HB-LED WAFERS

This Standard was technically approved by the HB-LED Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on July 6, 2018. Available at www.semiviews.org and www.semi.org in October 2018.

NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

1 Purpose

1.1 Sapphire has become the most popular substrate material in the HB-LED industry. This Standard identifies and defines the key parameters of sapphire intended for use in manufacturing HB-LED wafers. The properties of sapphire are decided by physical and chemical parameters and crystal defects. These key parameters of the sapphire are intended to provide the necessary information to specify the sapphire material for manufacturing HB-LED wafers.

2 Scope

- 2.1 This Standard includes the physical and chemical parameters of sapphire, and the crystal defects.
- 2.2 The physical and chemical parameters include hardness, transmission, and the purity.
- 2.3 The crystal defects include etch pit density (EPD), bubbles, cloud, grain boundary, inclusion, color, and crack.
- 2.4 This Standard does not define the physical shape or geometry of a sapphire. It only defines the necessary parameters of the single crystal sapphire material used for HB-LED wafers.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 SEMI Standards and Safety Guidelines

SEMI M36 — Test Method for Measuring Etch Pit Density in Low Dislocation Density Gallium Arsenide Wafers

SEMI M40 — Guide for Measurement of roughness of Planar Surfaces on Polished Wafers

3.2 ASTM® Standards¹

ASTM C978 — Standard Test Method for Photoelastic Determination of Residual Stress in a Transparent Glass Matrix Using a Polarizing Microscope and Optical Retardation Compensation

ASTM E384 — Standard Test Method for Knoop and Vickers Hardness of Materials

ASTM F1316 — Standard Test Method for Measuring the Transmissivity of Transparent Parts

ASTM F1593 — Standard Test Method for Trace Metallic Impurities in Electronic Grade Aluminum by High Mass-Resolution Glow-Discharge Mass Spectrometer

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

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 EPD — etch pit density

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA; Telephone: +1.610.832.9585, Fax: +1.610.832.9555, <http://www.astm.org>. ASTM trademark is owned by ASTM International.

4.1.2 *GB* — grain boundary

4.1.3 *OHT* — optical homogeneity testing

4.2 Definitions

4.2.1 *bubble* — a crystal defect that exists in single crystal sapphire that presents itself as a void in the crystal, and includes gaseous and vacuum voids.

4.2.2 *cloud* — dense micro bubbles that diminish the clarity of the crystal and appear as fog when the material is illuminated with bright light.

4.2.3 *color* — a selective absorption of light caused by impurity elements or crystal internal defects (color center) that presents a different hue.

4.2.4 *grain boundary* — the interface between two grains, or crystallites, in a polycrystalline material.

4.2.5 *inclusion* — any element that is trapped inside the crystal during its formation.

5 Test Methods

5.1 Test methods shall follow the SEMI or ASTM standard for the items which selected from § 7 and specified in the purchase order.

5.2 If several standard test methods could be chose for one specification, it is particularly important to specify the applicable method of test in the purchase order.

5.3 If no standard test method for an item is available, the value of the attribute must be determined by a method agreed upon by the supplier and the purchaser.

6 Ordering Information

6.1 Purchase orders for sapphire for HB-LED wafers shall include the following items:

6.1.1 Growth method;

6.1.2 Bubble, inclusion, cloud and grain boundary requirements;

6.1.3 EPD, transmission (T%), Hardness, color.

6.2 In addition, ordering information shall include other specific requirements for specific goods.

NOTE 1: In the case of sapphire in bulk form (ingot, brick, etc.). These specifications should not be used for rejection of an entire ingot which has defects. The two parties to the transaction should negotiate and document the reject criteria for the bulk material as part of the purchase order.

7 Requirements

7.1 Physical Properties

7.1.1 *Hardness* — Vickers-hardness of single crystal sapphire shall be 1800 to 2500 HV on C-plane, 1800 to 2300 HV on A-plane or M-plane according to the method specified in ASTM E384.

7.1.2 *Light Transmission* — For HB-LED wafers, the light transmission shall be >60% at 250 to 400 nm wavelength, and ≥85% at 400 to 900 nm wavelength. The test method specified in ASTM F1316 shall be used. A transmission map, as a sample, is shown in Figure 1.

7.1.2.1 Light transmission depends on the thickness and the surface quality of the sample. Therefore, the transmissivity of sapphire wafers shall be measured under the following conditions.

1. *Thickness of Test Sample* — 0.5 ± 0.05 mm, parallelism of surfaces <30 in.
2. *Size of the Test Sample* — Shall be defined between the parties so that it can fit into the test apparatus.
3. *Surface Finish* — Both sides polished, roughness <0.3 nm. Surface roughness to be tested by AFM using the test method specified in SEMI M40.
4. *Incident Angle* — $0^\circ \pm 1^\circ$.

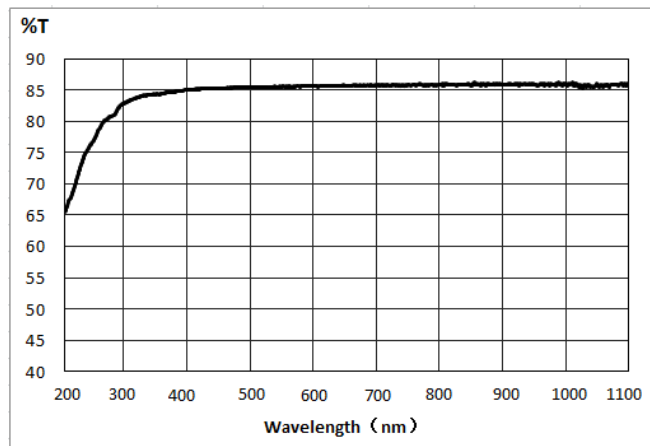


Figure 1
Dependence of Transmission on Wavelength

7.2 Defects

7.2.1 *Purity* — Al_2O_3 purity of single crystal sapphire intended for use for manufacturing HB-LED wafers shall be greater than 99.996% wt. Table 1 gives the maximum impurities allowed for specific elements. Purity is to be tested using the glow discharge mass spectrometry (GDMS) test method specified in ASTM F1593.

Table 1 Chemical Impurities (unit: ppm wt.)

<i>Na</i>	<i>Si</i>	<i>Fe</i>	<i>Mg</i>	<i>Ni</i>	<i>Ti</i>	<i>Cr</i>	<i>Mn</i>	<i>Ca</i>	<i>Cu, Mo, W</i>
<8	<4	<2	<1	<1	<1	<2	<1	<2	<3

7.2.2 *EPD* — EPD for single crystal sapphire for HB-LED wafers must be less than 1000 cm^{-2} .

7.2.2.1 The testing for EPD shall be performed under the follow conditions:

1. *Sample* — Diameter 2 in. or larger sapphire wafer with polished surface. Surface roughness of $R_a < 0.3 \text{ nm}$ as measured by AFM using the testing method specified in SEMI M40.
2. *Etching Method* — Soak in KOH which is heated to 320°C for 15mins.
3. Calculate the EPD according to the method specified in SEMI M36.

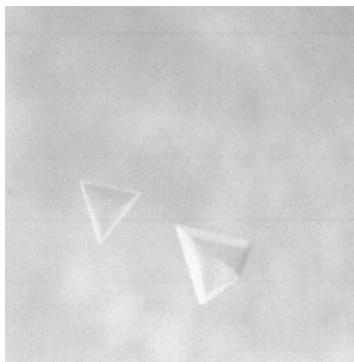


Figure 2
EPD Sample