

SEMI HB5-0615

TEST METHOD FOR MEASUREMENT OF SAW MARKS ON CRYSTALLINE SAPPHIRE WAFERS BY USING OPTICAL PROBES

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1 Purpose

- 1.1 Crystalline sapphire wafers (CSW) are used as substrates for manufacturing compound semiconductor devices, in particular high brightness light emitting diodes (HB-LED).
- 1.2 In SEMI HB1 a multitude of requirements is defined for CSW qualified for device production, including geometry and surface characteristics.
- 1.3 Saw marks and other surface features are important characteristics for depositing layers of III-V compound on CSW during HB-LED manufacturing.
- 1.4 In addition, careful process and quality control of the saw marks during CSW and device manufacturing requires continuous monitoring of saw marks by the supplier as well as by the user of CSW.
- 1.5 An understanding of the measurements methods used for the qualification of CSW is required to enable agreement on specifications. Such an understanding is provided by standardized test methods for the wafer characteristics.
- 1.6 This Document provides a standardized test method for measuring one of the most basic characteristics of CSW, saw marks. In addition, the Document defines terms and metrics needed for quantifying saw marks on CSW.

2 Scope

- 2.1 This Test Method covers the noncontact, nondestructive measurement of saw marks of clean CSW used for manufacturing semiconductor devices.
- 2.2 The thickness range of the CSW to be measured with this Test Method depends on details of the specific set-up used.
- 2.3 This Test method applies to CSW with as-cut surfaces as saw marks on CSW result from wire sawing.
- 2.4 This Test method does not cover measurements in the wafer edge profile.
- 2.5 This Test method may also be applied to wafers of other materials within the constraints of diameter, thickness and surface condition.

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 Limitations

- 3.1 The spatial resolution of the test method depends on a) the diameter of the light spot of the optical probes used, b) the pitch of the measurement points and c) the cut-off wavelength of the filter used.
- 3.2 Vibrations of wafer, wafer support or probes may adversely impact the measurement results.
- 3.3 Precision of the test method depends critically on the precision of the position of the line scans on the wafer faces.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E89 — Guide for Measurement System Analysis (MSA)

SEMI HB1 — Specifications for Sapphire Wafers Intended for Use for Manufacturing High Brightness-Light Emitting Diode Devices

SEMI M1 — Specification for Polished Single Crystal Silicon Wafers

SEMI M20 — Practice for Establishing a Wafer Coordinate System

SEMI MF1569 — Guide for Generation of Consensus Reference Materials for Semiconductor Technology

4.2 ISO Standards¹

ISO 11462-1 — Guidelines for Implementation of Statistical Process Control (SPC) – Part 1: Elements of SPC

ISO 11462-2 — Guidelines for Implementation of Statistical Process Control (SPC) – Part 2: Catalogue of Tools and Techniques

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 CRM — certified reference material

5.1.2 CSW — crystalline sapphire wafer(s)

5.1.3 FQA — fixed quality area

5.2 Definitions

5.2.1 *back face, of CSW* — that face of a CSW that is not intended for manufacturing a semiconductor device.

5.2.2 *center line, of a CSW* — an imaginary line through the wafer center traverse to the saw mark direction.

5.2.3 *front face, of CSW* — that face of a CSW that is intended for manufacturing a semiconductor device.

5.2.4 *maximum back face saw marks depth/height SMB, of a CSW* — the maximum depth/height of all saw marks on the back face of a CSW.

5.2.5 *maximum front face saw marks depth/height SMF, of a CSW* — the maximum depth/height of all saw marks on the front face of a CSW.

5.2.6 *maximum saw marks depth/height SMT, of a CSW* — the maximum absolute value of SMF and SMB.

6 Summary of Test Method

6.1 A line scan of the wafer is performed by moving the wafer between a pair of fixed, opposing optical probes.

6.2 The wafer is supported at 3 points around its circumference near its edge during measurement.

6.3 The wafer is scanned along imaginary horizontal lines parallel to or on the center line and traverse to the saw mark direction across or within the fixed quality area (FQA) of the CSW.

6.3.1 The measurement point pitch l for the line scans is adjusted according to the required horizontal resolution for the saw mark measurement.

6.3.2 The distances between the probes and the respective wafer faces are simultaneously measured and recorded, providing line scans of the surface heights of both wafer faces.

6.3.3 The line scans' data are processed to determine the saw mark depth and width.

7 Coordinate System

7.1 The origin of the coordinate system is at the wafer center and the y-axis is aligned perpendicular to the fiducial orientation flat or bisects the fiducial orientation notch as described in SEMI M20. This Test Method assumes that the wafer rests horizontally on its support.

7.2 The origin of the z-axis is assumed at the beginning of the measurement range.

¹ International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; Telephone: 41.22.749.01.11, Fax: 41.22.733.34.30, <http://www.iso.org>

7.3 If the wafer is held in an upright position during the measurement the coordinate system shall be adjusted accordingly.

8 Apparatus

8.1 *Optical Probe Set* — A pair of opposing probes spaced a distance w apart that measure the distances to the respective wafer faces by using an optical technique the light spot of which has a diameter D (see Figure 1).

8.2 *x-y-Stage* — Supports the wafer at three points around its periphery so that a) the wafer is not contaminated and b) the measurement is not impacted. Stage lateral motion provides appropriate horizontal and vertical positioning.

8.3 *Electronics* — Controlled by a computer that is equipped with software for recording and processing the measured data according to § 14. The computer controls also wafer handling and movement of the wafer support.

9 Safety Precautions

9.1 In case equipment with automated wafer handling is used then the entire equipment shall be placed in a closed housing and secured with a safety lock that stops the robot and safely switches the tool off when the housing is opened.

10 Test Specimens

10.1 Clean, dry sapphire wafers.

11 Preparation of Apparatus

11.1 The suitability of the equipment is determined by performing a statistically-based MSA to ascertain whether the equipment is operating within the manufacturer's stated specification; for example, according to SEMI E89.

11.2 Verify that the probes and the wafer support are aligned and adjusted according to the manufacturer's manual.

11.3 Verify that the equipment is operating within its specified temperature range.

11.4 Define the control limits for SPC for the measurement equipment with a set of selected wafers (see ISO 11462).

12 Calibration and Standardization

12.1 The measurement equipment is calibrated by using reference material (RM), preferably certified reference material (CRM), the saw mark depths/heights of which are known.

12.2 The RM may either be a CSW containing saw marks the depth/height and the uncertainty of which are known at marked positions, or gauge blocks with steps of known height.

12.3 Calibration is established only for the specified linear range of the optical probe pair about the gap position used during this calibration.

12.4 Large changes in product-specified wafer thickness may require changing the calibration.

12.5 Calibration shall be performed under the same ambient conditions (temperature, humidity) as the measurements of the test specimens and within the ranges specified by the supplier of the measurement equipment.

13 Procedure

13.1 Place the wafer on the x-y-stage.

13.2 Choose the number N of line scans and their distances d_n to the center line ($n = 1, 2, \dots, N$) as well as the pitch l and the lengths L_n of the scan lines to be used for the saw mark measurement and report l , N , all L_n and d_n .

13.3 Perform the line scans across the wafer within the FQA traverse to the direction of the saw marks and parallel to or on the center line.

13.4 Record the distances h_{ikn} between both probes and the respective wafer faces ($i = f, b$ for front and back face, $k = 1, 2, \dots, K_n \leq L_n/l$) at K_n points along the lines.

13.5 Calculate the metrics for saw marks according to § 14.

13.6 Report the metrics.