

# SEMI MF1725-1110 (Reapproved 0322) PRACTICE FOR ANALYSIS OF CRYSTALLOGRAPHIC PERFECTION OF SILICON INGOTS

This Standard was technically approved by the Silicon Wafer Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on August 12, 2021. Available at [www.semiviews.org](http://www.semiviews.org) and [www.semi.org](http://www.semi.org) in March 2022; originally published by ASTM International as ASTM F1725-97; previously published November 2015.

**NOTICE:** This Document was reapproved with minor editorial changes.

**NOTICE:** Paragraphs entitled ‘NOTE:’ are not an official part of this Standard or Safety Guideline and are not intended to modify or supersede the official Standard or Safety Guideline. These have been supplied by the global technical committee to enhance the usage of the Standard or Safety Guideline.

**NOTICE:** The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (¶) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and ¶¶) the symbols are used to reference more than one section or paragraph, respectively.

## 1 Purpose

1.1 The use of silicon wafers in many semiconductor devices requires a consistent atomic lattice structure. Crystal defects disturb local lattice energy conditions that are the basis for semiconductor behavior. These defects have distinct effects on essential semiconductor device-manufacturing processes such as alloying and diffusion.

1.2 This Practice provides guidance regarding procedures for analysis of crystal defects of silicon ingots from which silicon wafers are cut.

1.3 This Practice together with the referenced standards may be used for process control, research and development, and materials acceptance purposes.

## 2 Scope

2.1 This Practice covers the analysis of the crystallographic perfection in silicon ingots. The steps described are sample preparation, etching solution selection and use, defect identification, and defect counting.

2.2 This Practice is suitable for use in evaluating silicon grown in either the [111] or the [100] direction and doped either *p*- or *n*-type with resistivity greater than 0.005 Ω·cm.

**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 C18 — Specification for Acetic Acid

SEMI C28 — Specification for Hydrofluoric Acid

SEMI C35 — Specification and Guide for Nitric Acid

SEMI M59 — Terminology for Silicon Technology

SEMI MF26 — Test Method for Determining the Orientation of a Semiconductor Single Crystal

SEM MF523 — Practice for Unaided Visual Inspection of Polished Silicon Wafers

SEMI MF1809 — Guide for Selection and Use of Etching Solutions to Delineate Structural Defects in Silicon

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

### 3.2 ASTM Standards<sup>1</sup>

ASTM D5127 — Standard Guide for Ultra-Pure Water Used in the Electronics and Semiconductor Industries

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

## 4 Terminology

4.1 Acronyms, terms, and symbols related to silicon technology, including those used in these practices, are listed and defined in SEMI M59.

## 5 Summary of Practice

5.1 The end portion of the silicon crystal, which solidified last, may contain dislocations or other defects such as slip. The portion containing the defects is removed by sawing the crystal. A specimen wafer from the end of the remaining ingot is obtained with a second cut.

5.2 This wafer is mechanically lapped, chemically polished, and then etched in a preferential defect etching solution.

5.3 The etched surface is examined under bright light illumination and examined microscopically to count and classify the imperfections highlighted by the preferential defect etching solution.

## 6 Apparatus

6.1 *Slicing Equipment* — Suitable for removing wafers of varied thickness from ingots.

6.2 *Lapping or Grinding Equipment (optional)* — Suitable for removing saw damage.

6.3 *Laboratory Equipment* — Suitable for use with hydrofluoric acid (fluorocarbon, polyethylene, or polypropylene beakers, graduates, pipettes, and nonmetallic wafer pickup tools).

6.4 *Acid Sink* — In a fume hood and facilities for disposing of acids and their vapors.

6.5 *Personnel Safety Equipment* — For handling acids, such as gloves, safety glasses, face shield, and gown.

## 7 Reagents and Materials

7.1 *Purity of Reagents* — All chemicals for which such specifications exist shall conform to the assay and impurity levels of Grade 1 SEMI Specifications. Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water* — Reference to water shall be understood to mean Type E-3 or better water as described in ASTM D5127.

7.3 *Chemical Polishing Solution* — A variety of chemical polishing solutions exist. Those listed in Table 1 have been found to produce satisfactory results.

**Table 1 Volume Proportions**

| <i>Formulation</i> | <i>Nitric Acid,<br/>(Assay: 99.7%)</i> | <i>Hydrofluoric Acid,<br/>(Assay: 49 ± 0.25%)</i> | <i>Acetic Acid,<br/>(Assay: 70%–71%)</i> |
|--------------------|----------------------------------------|---------------------------------------------------|------------------------------------------|
| A                  | 6                                      | 1                                                 | 1                                        |
| B                  | 5                                      | 3                                                 | 3                                        |
| C                  | 5                                      | 10                                                | 14                                       |
| D                  | 5                                      | 1                                                 | 2                                        |

7.4 An aqueous, nonionic surfactant detergent solution.

<sup>1</sup> 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>