

SEMI M6-1108 (Withdrawn 0712) SPECIFICATION FOR SILICON WAFERS FOR USE AS PHOTOVOLTAIC SOLAR CELLS

This Standard was technically approved by the global Silicon Wafer Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on June 18, 2012. Available at www.semiviews.org and www.semi.org in July 2012; originally published in 1981; previously published November 2008.

NOTICE: This Document was balloted and approved for withdrawal in 2012. It was replaced by SEMI PV22.

NOTICE: This Document replaces the previous version of SEMI M6 along with SEMI M6.1, SEMI M6.2, SEMI M6.3, SEMI M6.4 and SEMI M6.5 in their entirety.

1 Purpose

1.1 This Specification covers the requirements for silicon wafers for use in photovoltaic (PV) solar cell manufacture.

2 Scope

2.1 The dimensional characteristics, crystalline defects and commonly used wafer electronic properties are described. Two classes of crystalline silicon materials are recognized: monocrystalline and multicrystalline.

NOTE 1: The specification recognizes only two discrete material forms monocrystalline and multicrystalline. In the monocrystalline form one crystallographic orientation describes the whole wafer and in the multicrystalline case there is more than one crystallographic orientation present.

2.2 SI (System International) units are used throughout.

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 M1 — Specifications for Polished Monocrystalline Silicon Wafers

SEMI M59 — Terminology for Silicon Technology

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

SEMI MF28 — Test Methods for Minority-Carrier Lifetime in Bulk Germanium and Silicon by Measurement of Photoconductivity Decay

SEMI MF42 — Test Methods for Conductivity Type of Extrinsic Semiconducting Materials

SEMI MF43 — Test Methods for Resistivity of Semiconductor Materials

SEMI MF84 — Test Method for Measuring Resistivity of Silicon Wafers with an In-Line Four-Point Probe

SEMI MF391 — Test Methods for Minority Carrier Diffusion Length in Extrinsic Semiconductors by Measurement of Steady-State Surface Photovoltage

SEMI MF398 — Test Method for Majority Carrier Concentration in Semiconductors by Measurement of Wavenumber or Wavelength of the Plasma Resonance Minimum

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

SEMI MF657 — Test Method for Measuring Warp and Total Thickness Variation on Silicon Wafers by Noncontact Scanning

SEMI MF673 — Test Methods for Measuring Resistivity of Semiconductor Wafers or Sheet Resistance of Semiconductor Films with a Noncontact Eddy-Current Gage

SEMI MF1188 — Test Method for Interstitial Oxygen Content of Silicon by Infrared Absorption With Short Baseline

SEMI MF1391 — Test Method for Substitutional Atomic Carbon Content of Silicon by Infrared Absorption

SEMI MF1535 — Test Method for Carrier Recombination Lifetime in Silicon Wafers by Noncontact Measurement of Photoconductivity Decay by Microwave Reflectance

SEMI MF1619 — Test Method for Measurement of Interstitial Oxygen Content of Silicon Wafers by Infrared Absorption Spectroscopy with p-Polarized Radiation Incident at the Brewster Angle

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

3.2 *ANSI/ASQ Standards*¹

ANSI/ASQ Z1.4 — Sampling Procedures and Tables for Inspection by Attributes

3.3 *ASTM Standards*²

ASTM E122 — Standard Practice for Choice of Sample Size to Estimate the Average for a Characteristic of a Lot or Process

3.4 *DIN Standards*³

DIN 50430 — Measurement of the Electrical Resistivity of Silicon or Germanium single Crystals in Bars by means of the Two-Point-Probe Direct Current Method

DIN 50431 — Measurement of the Electrical Resistivity of Silicon or Germanium Single Crystals by Means of the Four-Point-Probe Direct Current method with collinear Four Probe Array

DIN 50432 — Determination of the Conductivity Type of Silicon or Germanium by Means of Rectification Test or Hot-Probe

DIN 50433-1 — Determining the orientation of Single Crystals by Means of X-Ray Diffraction

DIN 50433-2 — Determining the orientation of Single crystals by Means of Optical Reflection Figure

DIN 50433-3 — Determination of the Orientation of Single Crystals by Means of Laue Back Scattering

DIN 50438-1 — Determination of impurity Content in silicon by Infrared Absorption - Part 1: oxygen

DIN 50438-2 — Determination of Impurity Content in Silicon by infrared Absorption; Carbon

DIN 50441-1 — Determination of the Geometric Dimensions of Semiconductor Wafers; Part 1: Measurement of Thickness

3.5 *JEITA Standards*⁴

JEITA EM-3502 (53) — Test Method for Carrier Recombination Lifetime in Silicon Wafers by Measurement of Photoconductivity Decay by Microwave Reflectance

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

4 Terminology

4.1 Terms relating to silicon and other semiconductor technology are defined in SEMI M59.

¹ American National Standards Institute, 25 West 43rd Street, New York, NY 10036, USA; Telephone: +1.212.642.4900, Fax: +1.212.398.0023, <http://www.ansi.org>

² 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>

³ Deutsches Institut für Normung e.V., Available from Beuth Verlag GmbH, Burggrafenstrasse 4-10, D-10787 Berlin, Germany; <http://www.din.de>

⁴ Japan Electronics and Information Technology Industries Association, Ote Center Building, 1-1-3, Otemachi, Chiyoda-ku, Tokyo 100-0004, Japan; <http://www.jeita.or.jp>

5 Ordering Information

5.1 Purchase orders for silicon wafers furnished to this Specification shall include the following items:

- 5.1.1 Nominal dimensions,
- 5.1.2 Either monocrystalline or multicrystalline,
- 5.1.3 Crystal growth method,
- 5.1.4 Surface orientation, crystal planes for monocrystalline wafers,
- 5.1.5 Conductivity type and dopant,

NOTE 2: The dopant is difficult to ascertain in the finished wafers. Verification test procedures or certification (see § 9) shall be agreed upon between the supplier and the purchaser.

- 5.1.6 Resistivity or resistivity range,
- 5.1.7 Lot acceptance procedures (see ¶ 6.5.2),
- 5.1.8 Certification (if required) (see § 8),
- 5.1.9 Packing and marking (see § 9),
- 5.1.10 Selection of test method to be used in evaluating those items for which alternate tests exist (see § 7), and
- 5.1.11 Carbon and oxygen content.

5.2 *Optional Criteria* — The following items may be specified optionally in addition to those listed above:

NOTE 3: 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.

- 5.2.1 Impurities other than common doping elements,
- 5.2.2 Diffusion length, and
- 5.2.3 Minority carrier lifetime.

NOTE 4: Up to now diffusion length and minority carrier lifetime cannot be measured with sufficient inter-laboratory accuracy. Subsequent recommendations, following lifetime round robin experiments, will be available in the future and will be presented in an addendum to this standard. Even in the case of comparable and reproducible lifetime and diffusion length measurements, the measured characteristics must be regarded as an indication for solar cell efficiency. There is no general relation between initial minority carrier lifetime and solar cell efficiency as other parameters such as carbon or oxygen content will also influence the wafer in the solar cell process. However, in practical cases a dependence between minority carrier lifetime and solar cell efficiency can be found for a fixed solar cell process and a certain silicon wafer material. If one of them is changed the relation between them is suspect to change too.

6 Requirements

6.1 *Dimensions and Permissible Variations*

6.1.1 *Wafer Thickness and Variation*

6.1.1.1 Wafer thickness is typically 330 mm in 1999. In the future wafers should be specified in 50 mm intervals in the range between 150 and 400 mm.

6.1.1.2 The variation of wafer thickness in a lot as measured according to ¶ 7.2 at the center point of each wafer will be less than 15% of the specified wafer thickness.

6.1.2 *Rectangular Mainly Square Wafer Dimensions* — Depending upon the wafer type, one of the ¶¶ 6.1.2.1, 6.1.2.2 or 6.1.2.3 applies.

6.1.2.1 *Square Crystalline Silicon Wafer Dimensions*

6.1.2.1.1 *Physical Dimensions* — See Figure 1, Table 2.

6.1.2.1.1.1 Rectangular cells are permitted as long as the measures of A and B are according to the nominal size measures in Table 2.