

SEMI E146-0306

TEST METHOD FOR THE DETERMINATION OF PARTICULATE CONTAMINATION FROM MINIENVIRONMENTS USED FOR STORAGE AND TRANSPORT OF SILICON WAFERS

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1 Purpose

1.1 This Standard defines a test method for the determination of particulate contamination from minienvironments used for storage and transport of silicon wafers in semiconductor manufacturing.

2 Scope

2.1 The particulate contamination performance of a minienvironment used for storage and transport of silicon wafers is measured in terms of the number of added particles within fixed ranges of size on the surface of silicon wafers exposed to those minienvironments under variable storage, transport, or environmental conditions.

2.2 Both user and supplier of the minienvironment shall agree upon all important parameters defined in this Test Method, for example:

- the minienvironment used to store and transport the silicon wafers,
- the silicon wafers exposed to the minienvironment,
- the test equipment used for variable storage, transport, or environmental tests of the minienvironment,
- the analytical equipment used for particulate contamination measurements on the surface of the silicon wafers,
- the environmental conditions around the test equipment and the analytical equipment, and
- the statistical evaluation of the particulate contamination measurement results from the analytical equipment.

2.3 These definitions ensure that communication between the user and the supplier of the minienvironment takes place on the same level when specifying these parameters.

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 This Test Method is only applicable to minienvironments used for storage and transport of silicon wafers, for example, a front opening unified pod (FOUP) (SEMI E47.1), a front opening shipping box (FOSB) (SEMI M31), a single-wafer box (SEMI E103).

3.2 This Test Method requires analytical equipment capable of detecting localized light scatterers (LLSs) and of performing defect classification by distinguishing between particles and other defect types, like COPs or scratches.

3.3 This Test Method requires silicon wafers with a low number of initial defects on the surface to guarantee proper statistical evaluation of the results as the expected particulate contamination from a minienvironment is low.

3.4 The identification of the source and the composition of particles is outside the scope of this Test Method.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E15 — Specification for Tool Load Port

SEMI E19.4 — Specification for 200 mm Standard Mechanical Interface (SMIF)

SEMI E47.1 — Mechanical Specification for FOUPs Used to Transport and Store 300 mm Wafers

SEMI E87 — Specification for Carrier Management (CMS)

SEMI E91 — Specification for Prober Specific Equipment Model (PSEM)

SEMI E103 — Mechanical Specification for a 300 mm Single-Wafer Box System that Emulates a FOUP

SEMI E108 — Test Method for the Assessment of Outgassing Organic Contamination from Minienvironments Using Gas Chromatography/Mass Spectroscopy

SEMI M1 — Specifications for Polished Monocrystalline Silicon Wafers

SEMI M31 — Mechanical Specification for Front-Opening Shipping Box Used to Transport and Ship 300 mm Wafers

SEMI M50 — Test Method for Determining Capture Rate and False Count Rate for Surface Scanning Inspection Systems by the Overlay Method

SEMI M52 — Guide for Specifying Scanning Surface Inspection Systems for Silicon Wafers for the 130-nm Technology Generation

SEMI M53 — Practice for Calibrating Scanning Surface Inspection Systems Using Depositions of Monodisperse Polystyrene Latex Sphere on Unpatterned Semiconductor Wafer Surfaces

4.2 ISO® Standards¹

ISO 14644-1 — Cleanrooms and Associated Controlled Environments – Part 1: Classification of Air Cleanliness

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *COP* — crystal originated particle/pit

5.1.2 *LLS* — localized light scatterer

5.1.3 *LPD* — light point defect

5.1.4 *LSE* — latex sphere equivalent

5.1.5 *PNH* — particle number after handling and transport

5.1.6 *PNI* — particle number initial

5.1.7 *PNT* — particle number after static or dynamic test

5.1.8 *PAH* — particles added during handling and transport

5.1.9 *PAT* — particles added during static or dynamic test

¹ International Organization for Standardization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401-1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, Fax: +41.22.733.34.30, <http://www.iso.org>. ISO trademark is owned by International Organization for Standardization.

5.1.10 SSIS — scanning surface inspection system

5.2 Definitions

5.2.1 *analytical environment* — environment where all analysis measurements are carried out. [SEMI E108]

5.2.2 *analytical equipment* — an instrument which carries out analysis measurements on silicon wafers.

5.2.3 *bin (of a particle measurement instrument)* — a subset of the total size range of particles counted during particulate contamination measurements with an analytical equipment. Also called channel.

NOTE 1: Many particulate contamination measurement instrument designs allow the user to set the size ranges of the bins.

5.2.4 *box* — a protective portable container for a cassette and/or substrate(s). [SEMI E19.4]

5.2.5 *carrier* — any cassette, box, or pod that are used to transport substrates. [SEMI E15]

5.2.6 *cassette* — an open structure that holds one or more substrates. [SEMI E19.4]

5.2.7 *channel* — refer to bin.

5.2.8 *crystal originated particle/pit (COP)* — a pit of approximately 100 nm in size bounded by crystallographic planes, and formed by the intersection of the polished surface with voids in the crystal. [SEMI M52]

5.2.8.1 *Discussion* — When the surface is cleaned, etched, or oxidized the shape of the pit is modified and the light scattering characteristics change. The spatial distribution of scattered light from COPs and particles is different, and therefore these two classes of defects may be distinguished by an appropriately equipped SSIS. COPs were first detected by SSIS and believed to be small particles. It was also noticed that after repeated cleaning (etching) the number of the COPs increased as the etching process enlarged the pits and changed their scattering characteristics. Later these defects were identified as voids caused by the coalescence of vacancies during the cooling of the silicon crystal from its growth temperature. The term crystal originated particle had already become accepted, and even today many people still refer to COPs by their original, though incorrect name. [SEMI M52]

5.2.9 *dynamic test* — a test performed to determine particle contribution from a minienvironment as a result of a specific minienvironment movement (e.g., acceleration, vibration) to simulate transport, or environmental conditions.

5.2.10 *haze* — nonlocalized light-scattering resulting from surface topography (microroughness) or from dense concentrations of surface or near-surface imperfections. [SEMI M1]

5.2.10.1 *Discussion* — Haze due to the existence of a collection of imperfections is a mass effect; individual imperfections of the type which result in haze cannot be readily distinguished by the eye or other optical detection systems without magnification. In a particle counter (SSIS), haze results in a background signal and laser light-scattering events together comprise the signal due to light-scattering from a wafer surface. [SEMI M1]

NOTE 2: Different SSIS instrument types may give significantly different haze values on a given sample.

5.2.11 *hydrophilic* — having a strong affinity for water; wettable.

NOTE 3: Hydrophilic surfaces have little affinity for particles due to enhanced static discharge.

5.2.12 *hydrophobic* — having little affinity for water; non-wettable.

NOTE 4: Hydrophobic surfaces have strong affinity for particles due to increased static charge.

5.2.13 *latex sphere equivalent (LSE)* — the diameter of a monodisperse polystyrene latex sphere that, under identical test conditions, produces the same detected scattering intensity as the LLS under investigation. [SEMI M53]

5.2.13.1 *Discussion* — If the LLS is assumed to be due to a particle (or pit), the LSE size (diameter) of the particle (or pit) is given in units of length followed by LSE; for example, 0.12 μm , LSE. This unit varies in different ways for different materials from instrument to instrument because of differences in the optical systems and signal processing procedures of different instruments. Therefore, a particular LLS generally does not have the same LSE size when measured on different model instruments or on different channels of the same instrument. If elements of the optical system, such as incidence angle, collection solid angle, or polarization, of an SSIS can be varied, the LSE size of a particular LLS is not necessarily the same for each configuration of the optical system. [SEMI M53]

5.2.14 *light point defect (LPD)* — refer to localized light scatterer (LLS).

5.2.15 *localized light scatterer (LLS)* — an isolated feature, such as a particle or a pit, on or in a wafer surface, resulting in increased light scattering intensity relative to that of the surrounding wafer surface; historically called *light point defect* because under high intensity optical illumination features of sufficient size appear as an isolated point of light. [SEMI M53]

5.2.15.1 *Discussion* — Localized light scatterers are observed by automated inspection techniques as laser-light scattering events. Automated inspection techniques are quantitative in the sense that scatterers with different scattering intensities can be segregated. However, the amplitude of the scattered light intensity, or ‘laser-light scattering event’, as measured by any combination of incident beam direction and collection optics, does not by itself convey topographical information about the LLS; particles and pits cannot be distinguished solely on the basis of single-channel amplitude data. Also, the observer cannot deduce the size, shape, or composition of the LLS from single-channel amplitude alone. The presence of LLSs does not necessarily decrease the utility of the wafer. [SEMI M53]

5.2.16 *minienvironment* — a localized environment created by an enclosure to isolate the product from contamination and people. [SEMI E47.1]

5.2.17 *particles per wafer pass (PWP)* — average number of particles added to a wafer as it passes through an equipment, expressed in particles per wafer pass or in (particles/m²)/pass.

5.2.18 *particulate contamination* — on a semiconductor wafer, a particle or particles on the surface of the wafer.

5.2.19 *particle* — a small, discrete piece of foreign material or silicon not connected crystallographically to the wafer. Also, refer to the Discussion related to this definition in SEMI M1. [SEMI M53]

5.2.20 *particle number after handling and transport (PNH)* — the particulate contamination on a silicon wafer measured by an analytical equipment after handling and transport of the minienvironment.

5.2.21 *particle number initial (PNI)* — the initial particulate contamination on a silicon wafer measured by an analytical equipment.

5.2.22 *particle number after static or dynamic test (PNT)* — the particulate contamination on a silicon wafer measured by an analytical equipment after the static or dynamic test of the minienvironment.

5.2.23 *particles added during handling and transport (PAH)* — the particulate contamination on a silicon wafer added during handling and transport of the minienvironment, calculated from the values PNI and PNH.

5.2.24 *particles added during static or dynamic test (PAT)* — the particulate contamination on a silicon wafer added during the static or dynamic test of the minienvironment, calculated from the values PNT, PNH, and PAH.

5.2.25 *scanning surface inspection system (SSIS)* — an instrument for rapid examination of the entire quality area on a wafer to detect the presence of localized light scatterers or haze or both, also called particle counter and laser surface scanner. [SEMI M52]

5.2.26 *slot* — a physical location within a cassette capable of containing a substrate (Also referred to as a carrier location). [SEMI E91]

5.2.27 *static test* — a test performed to determine particle contribution from a minienvironment as a result of no specific minienvironment movement to simulate storage or environmental conditions.

5.2.28 *substrate* — material held within a carrier. This can be product, or durables such as reticles. [SEMI E87]

5.2.29 *test environment* — environment where all storage, transport, or environmental conditions for minienvironments are simulated.

5.2.30 *test equipment* — an instrument which simulates storage, transport or environmental conditions for minienvironments.

6 Summary of Method

6.1 *Introduction* — This Test Method comprises static or dynamic tests of minienvironments in a test environment to simulate variable storage, transport, or environmental conditions. The impact of the static or dynamic tests on the number of particles added to the surfaces of silicon wafers inside the minienvironments is measured by an analytical equipment in an analytical environment.

6.2 *Test Setup* — The setup for each test always includes an analytical equipment in the analytical environment as well as a test equipment in the test environment. The environmental conditions of the analytical environment and the test environment shall be defined by the user and the supplier of the minienvironment.

6.3 *Test Application* — This Test Method is applicable to evaluate different aspects of the use of a minienvironment. The impact on the particulate contamination on the silicon wafers inside the minienvironment may be assessed for:

- loading/unloading procedures of silicon wafers into/from the minienvironment, which includes opening/closing of the minienvironment,
- storage and transport of silicon wafers inside the minienvironment,
- different particulate contamination values outside the minienvironment,
- different environmental conditions outside the minienvironment (e.g., humidity, temperature, pressure), and
- cross contamination due to contaminated silicon wafers inside the minienvironment.

6.4 *Test Sequence* — This Test Method includes a sequence of steps for analytical measurements of the silicon wafers as well as for the transports and the test of the minienvironment. Figure A1-1 in Appendix 1 explains this sequence.

6.4.1 The initial particulate contamination on the silicon wafers is measured by the analytical equipment located in the analytical environment (refer to ① in Figure A1-2 in Appendix 1). Then the silicon wafers are loaded in the minienvironment.

NOTE 5: Recommended values for the amount and slot location of wafers stored in the minienvironment are given in Appendix 1.

6.4.2 The loaded minienvironment is transported to the test equipment in the test environment. The minienvironment is returned immediately to the analytical equipment in the analytical environment.

6.4.3 The transport of the minienvironment between analytical environment and test environment is critical. If both locations are not in the same cleanroom environment, the minienvironment shall be protected in a way to avoid external contamination due to handling. In addition, exposure to changes in temperature, air-pressure and humidity shall be minimized. Therefore, the means of protection of the minienvironment and the environmental conditions shall be recorded.

6.4.4 The particulate contamination on some silicon wafers is measured after handling and transport with the same analytical equipment as in ¶ 6.4.1 (refer to ② in Figure A1-2 in Appendix 1). The user and the supplier of the minienvironment shall agree upon how many silicon wafers are measured and from which slot locations of the minienvironment these silicon wafers are taken. Each silicon wafer shall be returned into the same slot of the same minienvironment after particulate contamination measurement.

NOTE 6: Recommendations concerning which wafers from the minienvironment shall be measured are given in Appendix 1.

6.4.5 For each silicon wafer, the number of particles added during handling and transport is calculated.

6.4.6 The loaded minienvironment is transported again to the same test equipment in the test environment as in ¶ 6.4.2.

6.4.7 Static or dynamic test conditions are applied to the loaded minienvironment by the test equipment to simulate specific storage, transport or environmental conditions (refer to ③ in Figure A1-2 in Appendix 1). The detailed test conditions shall be agreed upon between the user and the supplier of the minienvironment. The loaded minienvironment remains closed during the static and dynamic tests.

6.4.8 After the static or dynamic tests, the loaded minienvironment is returned to the analytical equipment in the analytical environment.

6.4.9 The particulate contamination on the same silicon wafers like in ¶ 6.4.4 is measured after the static or dynamic test with the same analytical equipment as in ¶ 6.4.1 (refer to ④ in Figure A1-2 in Appendix 1). Each silicon wafer shall be returned into the same slot of the same minienvironment after particulate contamination measurement.

6.4.10 For each silicon wafer the number of particles added during the static or dynamic test is calculated and interpreted.