SEMI M53-1103
PRACTICE FOR CALIBRATING SCANNING SURFACE INSPECTION SYSTEMS USING DEPOSITIONS OF MONODISPERSE POLYSTYRENE LATEX SPHERE ON UNPATTERNED SEMICONDUCTOR WAFER SURFACES

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1 Purpose

1.1 Calibration of a scanning surface inspection system (SSIS) using a deposition of polystyrene latex (PSL) spheres as a known source of scatter signal is a necessary step in matching the responses of SSISs. However, the measured amplitude of the light scatter signal depends on both the characteristics of the SSIS and the characteristics of the scatter source. The use of a deposition of polystyrene latex (PSL) spheres (see ¶ 5.3.4) as a known source of scatter signal allows meaningful comparisons to be made between scatter signals from PSL spheres as measured by dark field detection systems of different designs. On the other hand, calibration with PSL spheres alone does not guarantee meaningful performance comparisons to be made between dark field detection SSISs of the same or different designs when detecting either real particles of materials different from PSL spheres or other surface defects.

1.2 This Practice describes calibration of SSIS dark field channels so that the SSIS accurately sizes PSL spheres deposited on unpatterned polished, epitaxial, or filmed semiconductor wafer surfaces (see Related Information 1).

1.3 This Practice defines the use of latex sphere equivalent (LSE) signals as a means of reporting real surface defects whose identity and true size are unknown.

1.4 This Practice provides a basis for quantifying SSIS performance as used in related standards concerned with parameters such as sensitivity, repeatability and capture rate.

2 Scope

2.1 This Practice covers:

- Requirements for the surface and other characteristics of the semiconductor substrates on which the PSL spheres are deposited to form reference wafers (see § 8.1),
- Selection of appropriate certified depositions of PSL spheres for SSIS calibration (see § 8.2),
- Size distribution requirements to be met by the PSL sphere depositions (but not the deposition method), and
- Multipoint calibration procedures for dark field channels.

2.2 Appendix 1 covers a single-point calibration procedure that may be used in limited production applications.

2.3 PSL spheres from 10 µm to the smallest size that can be detected by the SSIS being calibrated can be used in this Practice.

NOTE 1: At the time of development of this edition of the practice, the smallest practical deposited PSL spheres have diameters approaching 30 nm, but as IC technology evolves to smaller and smaller critical dimensions it is expected that depositions of smaller diameter PSL spheres will become available.

2.4 Background information to enable an understanding of the need for the various requirements imposed on the PSL sphere depositions is provided in Related Information 1.

2.5 Both the deposition process and calibration procedures must be carried out in a Class 4 or better environment as defined in ISO 14644-1.

NOTE 2: ISO class 4 is approximately the same as Class M2.5 (Class 10) as defined in Federal Standard 209E.

2.6 Although it was developed primarily for use in evaluation of SSISs to be used for detection of localized light scatterers (LLSs) on polished silicon wafers with geometrical characteristics as specified in SEMI M1, this Practice

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can be applied to SSISs to be used for detection of LLSs on other unpatterned semiconductor surfaces provided that suitable reference wafers are employed.

2.7 This Practice does not in any way attempt to define the manner in which LSE values are used to define the true size of LLSs other than PSL spheres (see ¶ 3.1).

2.8 This Practice supports requirements listed in SEMI M52.

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 LLSs are normally assigned only LSE sizes, not physical diameters, because the response of an SSIS to an LLS depends on the SSIS optical system characteristics as well as the size, shape, and composition of the LLS. The LSE size assigned to a particular LLS by an SSIS calibrated against PSL spheres may be different from that assigned to the same LLS by another similarly calibrated SSIS, because different SSISs have different optical system characteristics.

3.2 PSL spheres may have specified characteristics (mean diameter uncertainty, diameter distribution, spread between mean and modal diameter) that differ significantly from the characteristics of the resulting deposition due to the transfer function of the deposition system. For this reason, the practice is limited to the use of PSL sphere depositions that are appropriately characterized. See Related Information 1.

3.3 If calibration points occur at, or near, dips in the response curve (see ¶ 5.3.17), the calibration curve will not be single valued; therefore dips must be avoided as calibration points if a monotonic calibration curve is to be obtained. However, if a complete calibration is desired, the locations and magnitudes of the dips must be determined. In this case there may not be a one-to-one correlation between SSIS response and LSE size; that is, a particular instrument response may correspond to more than one LSE size.[1] (See ¶ 5.3.13.1.)

3.4 *Background Contamination*

3.4.1 The presence of localized light scatterers with LSE sizes near that of the nominal PSL diameter on the reference wafer may skew the results. This condition may result in a large error or poor equivalent sizing accuracy.

3.4.2 High levels of localized light scatterers on the reference wafer or wafers may overload the SSIS or obscure the peak of the deposited PSL sphere distribution. This condition may also result in a large error or poor equivalent sizing accuracy.

3.4.3 For these reasons, both the deposition process and calibration procedures must be carried out in a clean environment, and the reference wafers must be handled in such a way as to avoid contamination between deposition process and calibration.

3.5 If the surface roughness of the reference wafer or wafers is excessive, the peak of the PSL sphere distribution may be obscured or distorted.

3.6 If the SSIS being calibrated is not operating in a stable condition, the calibration may not be appropriate for subsequent use of the system. System stability can be evaluated by making repeated calibrations, in accordance with this Practice, over suitable time periods.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI M1 — Specification for Polished Monocrystalline Silicon Wafers

SEMI M20 — Specification for Establishing a Wafer Coordinate System

[1] See, for example, Locke, B. R., and Donovan, R. P. "Particle Sizing Uncertainties in Laser Scanning of Silicon Wafers." *Journal of The Electrochemical Society*, Vol 134, No. 7, 1987, pp. 1763–1771; or Liu, B. Y. H., Chae, S.-K., and Bae, G.-N., "Sizing Accuracy, Counting Efficiency, Lower Detection Limit and Repeatability of a Wafer Surface Scanner for Ideal and Real-World Particles." *ibid*., Vol 140, No. 5, 1993, pp. 1403–1409.

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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 Surface Scanning Inspection Systems for Silicon Wafers for the 130-nm Technology Generation

SEMI MF1241 — Standard Terminology of Silicon Technology

4.2 *Federal Standard*[2]

Fed Std 209E — Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

4.3 *ISO Standards*[3]

ISO 14644-1 Cleanrooms and Associated Controlled Environments – Part 1: Classification of Airborne Particulates

ISO Guide 30-1992 — Terms and Definitions Used in Connection with Reference Materials

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

5 Terminology

5.1 Definitions for general terms for silicon technology are found in SEMI MF1241.

5.2 Additional terminology is defined in SEMI M1.

5.3 *Definitions*

5.3.1 *capture rate* (*CR*) — the probability that a scanning surface inspection system (SSIS) detects a localized light scatterer (LLS) of latex sphere equivalent (LSE) signal value at some specified SSIS operational setting.

5.3.2 *certified reference material (CRM)* — a material accompanied by a certificate, one or more of whose property values are certified by a procedure that establishes its traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence. [ISO Guide 30]

5.3.2.1 *Discussion* — In the context of this Practice, a CRM is a certified PSL sphere deposition on an unpatterned wafer with the same surface films and finish as the wafers to be examined by the calibrated SSIS. The deposition property values that must be certified are the peak sphere diameter and the diameter distribution on the wafer and are determined by both the PSL sphere source and the deposition process. The wafer may contain more than one CRM. See Related Information 1.

5.3.3 *coefficient of variation (CV)* — one standard deviation, σ, expressed as a percentage of the mean of a Gaussian distribution.

5.3.4 *deposition* — an approximately known number of PSL spheres of known size distribution placed in a known location on the surface of a reference wafer.

5.3.5 *deposition process* — the procedure used to place the PSL spheres on the reference wafer.

5.3.6 *dynamic range* — of a scanning surface inspection system, the signal range covered by an instrument with one set of measurement conditions.

5.3.6.1 *Discussion* — The useful dynamic range is limited on the small signal side by the background noise or the inherent resolution of the instrument and on the large signal side by saturation of the detector and/or the related electronics. The small signal limit is usually defined as the smallest PSL diameter than can be measured with a capture rate of at least 95%.

5.3.7 *false count* — a laser-light scattering event that arises from instrumental causes rather than from any feature on or near (in) the wafer surface; also called *false positive*; compare *nuisance count*.

[2] Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS (This standard has been superseded by ISO 14644-1 and may no longer be available.)

[3] 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

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