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AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Practice for Calibrating a Scanning Surface Inspection System Using Monodisperse Polystyrene Latex Spheres Deposited on Polished or Epitaxial Wafer Surfaces[1]

This standard is issued under the fixed designation F 1620; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the size calibration of a scanning surface inspection system (SSIS) by observing the distribution of monodisperse polystyrene latex (PSL) spheres that have been pre-deposited in controlled fashion on the front surface of a clean, unpatterned, polished or epitaxial wafer of the same type that is to be inspected by the SSIS.

NOTE 1—This practice was developed primarily for use in calibrating SSISs intended for inspecting monocrystalline wafers, in which case pre-deposited bare, monocrystalline silicon wafers must be used as calibration wafers. The practice may also be extended to the calibration of SSISs intended to inspect other materials, such as gallium arsenide or other compound semiconducting compounds, in which case, clean, unpatterned, polished wafers of the type to be inspected must be used as calibration wafers. It may also be possible to extend the technique to wafers with other surfaces, such as oxide or polycrystalline silicon films, but the conditions for which this extension of the practice might be valid have not been determined.

1.2 This practice includes procedures for single-point and multipoint calibrations. For single-point calibration, one wafer, pre-deposited with PSL spheres of a single nominal size corresponding to the latex sphere equivalent (LSE) of the localized light scatterers to be measured with the SSIS being calibrated, is used. In the latter, a series of wafers, each pre-deposited with PSL spheres of a single nominal size, is used; the range of sizes employed covers the range over which the SSIS is to be calibrated.

1.3 The procedure must be carried out on an SSIS that is located in a Class M2.5 (Class 10) or better environment as defined in Federal Standard 209E.

1.4 PSL spheres as large as 10 µm can be used in this practice. The smallest size PSL sphere that can be used is the smallest that can be detected by the SSIS being calibrated on the wafer surfaces on which the spheres are deposited.

NOTE 2—At the time of development of this practice, the smallest practical size is 0.08 µm, but it is expected that smaller size spheres will be able to be used as the technology develops.

1.5 This practice does not cover procedures for deposition of the monodisperse PSL spheres. Pre-deposited wafers may be obtained commercially or prepared in accordance with good laboratory practice as summarized in Appendix X1 of SEMI Practice E 14.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

F 1241 Terminology of Silicon Technology [2]

2.2 SEMI Standards:

E14 Measurement of Particle Contamination Contributed to the Product from the Process or Support Tool [3]

M1 Specification for Polished Monocrystalline Silicon Wafers [3]

2.3 Federal Standard:

Fed Std 209E Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones [4]

3. Terminology

3.1 *Definitions:*

3.1.1 *coefficient of variation (CV)*—the standard deviation expressed as a percentage of the estimated value.

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

3.1.2.1 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.

3.1.3 *equivalent sizing accuracy*—the ratio of the coefficient of variation of the measured size distribution of monodisperse polystyrene latex spheres of a specified nominal size deposited

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[2] *Annual Book of ASTM Standards*, Vol 10.05.

[3] Available from Semiconductor Equipment and Materials International, 805 E. Middlefield Rd., Mountain View, CA 94043.

[4] Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

on a wafer to that of the nominal sphere size distribution as stated by the supplier of the sphere suspension.

3.1.3.1 Discussion—If the means of the measured and nominal size distributions are adjusted to be equal, the equivalent sizing accuracy can be expressed as the ratio of the standard deviations of the distributions, as follows:

$$\text{equivalent sizing accuracy} = \sigma_{\text{measured by scanning surface inspection system}}/\sigma_{nominal}. \quad (1)$$

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

3.1.4.1 Discussion—False counts would not be expected to occur at the same point on the wafer surface during multiple inspection scans, and hence they could be considered as random ″noise" that could be identified by examining the results of repeated scans.

3.1.5 *histogram*—a representation of a partitioned (binned) data set as a bar graph in which the widths of the bars are proportional to the sizes of the bins of the data set variable and the height of each bar is proportional to the frequency of occurrence of values of the variable within the bin.

3.1.5.1 Discussion—In presenting data for the size distribution of localized light scatterers (LLSs), the data set variable is usually the derived LLS size; in presenting haze data, the data set variable is usually the haze in ppm. The data set is usually partitioned into bins of equal size on either a linear or logarithmic scale, as appropriate. The bins at the low and high ends of the data set variable range are customarily plotted with the same width as the remainder of the histogram even though they may represent a larger or smaller range of the independent variable than the rest of the bins.

3.1.6 *laser-light scattering event*—a signal pulse that exceeds a preset threshold, generated by the interaction of a laser beam with a localized light scatterer (LLS) at a wafer surface as sensed by a detector; see also haze.

3.1.6.1 Discussion—The amplitude of the signal, as measured by any combination of incident beam direction and collection optics, does not by itself convey topographic information, for example, whether the LLS is a pit or a particle. It does not allow the observer to deduce the size or origin of the scatterer without other detailed knowledge, such as its index of refraction and shape. In a scanning surface inspection system, the background signal due to haze and laser-light scattering events together comprise the signal due to light scattering from a wafer surface.

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

3.1.7.1 Discussion—If the LLS is assumed to be due to a particle (or pit), the LSE 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 when measured on two different instruments. If elements of the optical system, such as incidence angle, collection solid angle, or polarization, of an SSIS can be varied, the LSE of a particular LLS will not necessarily be the same for each configuration of the optical system.

3.1.8 *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; sometimes called light point defect.

3.1.8.1 Discussion—Localized light scatterers of sufficient size appear as points of light under high intensity optical illumination; these points of light can be observed visually, but the observation is a qualitative one. 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 ″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 amplitude data. Also, the observer cannot deduce the size, shape, or composition of the LLS from the signal amplitude alone. The presence of LLSs does not necessarily decrease the utility of the wafer.

3.1.9 *missing count*—the case in which a localized light scatterer does not produce a laser-light scattering event; also called false negative.

3.1.10 *multipoint calibration*—a procedure for calibrating the size response of a scanning surface inspection system (SSIS) using a set of accurately sized particles, most frequently polystyrene latex spheres, deposited on a wafer surface of the type to be inspected by the SSIS.

3.1.10.1 Discussion—The purpose of a calibration is to relate the amount of light captured by an SSIS to the physical size of the light scatterer. The amount of light scattered from a localized light scatterer (LLS) that is captured by the SSIS is a function of both the scattering characteristics of the LLS (including the directional dependence of the scattering) and the geometry of the collection optics of the SSIS. For a given wavelength of incident radiation, regular objects of certain sizes exhibit resonance effects so that the curve of scattering amplitude as a function of physical size of the scatterer is not monotonic; similar objects with physical size slightly larger or smaller than the resonance size can scatter the same amount of light. Different materials may exhibit resonance at different sizes. Because resonance effects are less pronounced for irregular particles such as may be found on polished wafer surfaces, instrument calibration is usually carried out by avoiding the sizes of spheres that exhibit resonance in the SSIS being calibrated. Sometimes, however, it is desired to fully characterize the response of the SSIS to a particular type of scatterer; in this case, the calibration can be carried out with a set of particles with sizes that cover the desired range with adequate density to ensure that any nonlinearities and resonances in the scattering amplitude-size curve are detected.