SEMI M50-0310
TEST METHODS FOR DETERMINING CAPTURE RATE AND FALSE COUNT RATE FOR SURFACE SCANNING INSPECTION SYSTEMS BY THE OVERLAY METHOD

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1 Purpose

1.1 SEMI M52 defines capture rate (CR) requirements to be met by a scanning surface inspection system (SSIS) to be used for the 130 nm through 45 nm technology generations.

1.2 These test methods cover determination of the CR, the false count rate (FCR) and the cumulative false count rate (CFCR) of an SSIS as a function of light scattering equivalent (LSE) size of localized light scatterers (LLSs).

NOTE 1: In the context of this document the term "size" refers to the LSE diameter of the LLS.

2 Scope

2.1 These test methods address calculating and reporting SSIS capture rate from measurements of either PSL depositions or other LLSs on wafers in LSE units.

2.2 Two test methods are covered:

2.2.1 *Static Method* — In which the test is conducted under level 1 variability conditions (without removing the wafer from the stage of the SSIS between scans).

2.2.2 *Dynamic Method* — In which the test is conducted under level 2 variability conditions (with removing the wafer from and reloading it to the stage of the SSIS between scans).

2.3 Specific wafer surfaces (by wafer product, type of film or type of polish) that may affect the measured capture rate and false count rate of an SSIS are to be agreed upon between suppliers and customers.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard 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 limited to use on unpatterned wafers.

3.2 This test method is limited to use on calibrated scanners operated in a production mode.

4 Referenced Standards and Documents

4.1 *SEMI Standards*

SEMI E89 — Guide for Measurement System Analysis (MSA)

SEMI M1 — Specification for Polished Single Crystal Silicon Wafers

SEMI M52 — Guide for Specifying Scanning Surface Inspection Systems for Silicon Wafers for the 130 nm, 90 nm, 65 nm, and 45 nm Technology Generations

SEMI M53 — Practice for Calibrating Scanning Surface Inspection Systems Using Certified Depositions of Monodisperse Reference Spheres on Unpatterned Semiconductor Wafer Surfaces

SEMI M59 — Terminology for Silicon Technology

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4.2 *ISO Standard*[1]

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 General terms, acronyms, abbreviations and symbols associated with silicon technology, some of which are used in this standard are listed and defined in SEMI M59. This standard also includes definitions of some terms used in statistical analysis of test methods such as this one.

5.2 Some additional terms associated with measurement system analysis are defined in SEMI E89.

5.3 Terminology related to reference materials may also be found in ISO Guide 30.

6 Summary of Methods

6.1 The Static Method or the Dynamic Method is selected.

6.2 The *XY* coordinate uncertainty of the SSIS under test is either known or determined under static or dynamic conditions, without (if the Static Method is to be used) or with (if the Dynamic Method is to be used) removing the wafer from and reloading it to the stage between scans (see Appendix 1 for static and dynamic default test procedures for this determination).

6.3 The reference wafer to be used in this test is selected.

6.4 The selected wafer is scanned *Z* times on the SSIS under test by applying static or dynamic measurement conditions. The first two scans are used to qualify the reference wafer before continuing with the remaining *Z*–2 scans.

NOTE 2: Typical values for *Z* are between 30 and 1000 scans for the Static Method and between 30 and 1000 scans for the Dynamic Method.

6.5 The scans are analyzed to determine and record the number of times each LLS event occurs in each location (to within a distance approximately six times the scanner *XY* uncertainty) during the *Z* scans. The capture rate, standard size deviation, false count rate, and cumulative false count rate are determined from this data set.

7 Apparatus

7.1 *SSIS Under Test* — Installed in its position of use with clean room rating recommended by the manufacturer.

7.2 *Off-line Analysis Software Program* — To track each observed count and determine the capture rate, standard size deviation, the number of false counts at each LLS size, the false count rate, and the cumulative false count rate.

NOTE 3: The analysis software may be incorporated into the SSIS, if desired.

8 Test Specimens

8.1 Use any wafer with (1) natural LLS with density <10 LLS/cm^2 and (2) a surface roughness typical of the wafers to be measured in production (see ¶ 2.3).

8.1.1 The minimum distance between any two LLS found during any one scan and used in the data set to be analyzed shall be larger than six times the scanner *XY* uncertainty. Clusters of LLS (found in any one scan and closer together than six times the scanner *XY* uncertainty) and scratches must be excluded from the analysis.

8.1.2 Determine the scanner *XY* uncertainty from previous knowledge, from the scanner manufacturer specifications, or from the positional accuracy determined in accordance with Appendix 1.

8.2 Alternatively, a wafer with deposited polystyrene latex spheres can be used to evaluate the capture rate more accurately at a specific particle size. The same particle density, particle spacing, and defect cluster conditions, as in ¶ 8.1 shall be observed.

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NOTE 4: A wafer with deposited PSL spheres may be a certified reference material, but this is not required.

9 Procedure

9.1 Select the appropriate test method, including recipe settings, as agreed between the parties to the test.

NOTE 5: If the SSIS under test has different operating conditions or sensitivity between static and dynamic modes of operation, the test method for the mode that is to be used in production is most appropriate. If the operating conditions and sensitivity of the SSIS are the same for both modes, the test method with the smaller scanner *XY* uncertainty (see ¶ 8.1.2) is probably the more appropriate.

9.2 *Static Method*

9.2.1 Select a test specimen and qualify it for appropriate density of LLS (see ¶ 8.1) and LLS separation (see ¶ 8.1.1).

9.2.2 Scan the wafer once and determine position, P_m, and size, S_m, of each of the M_1 detected LLS events with $m = [1, 2, \ldots M_1]$.

9.2.3 To determine that there are enough repeating LLS events to make the CR calculation meaningful, scan the wafer a second time without removing the wafer from the stage and compare the detected LLS events with respect to the positions of those detected during the first scan. Define the total number of LLS events that repeat their position in the first scan to within six times the scanner *XY* uncertainty as M_2. Consider the wafer qualified for the test if the share of repeat LLS events on the wafer, M_2, is larger than 0.75 M_1.

9.2.4 Without removing the wafer from the scan stage, scan the wafer a total of *Z* times to obtain CR, FCR, and CFCR data (see Note 2). Record each LLS event detected during the *Z* scans according to its position *P* and size *S*. If a new LLS event is recorded on any scan, record the number of this scan as o_i and associate this number with this LLS event.

NOTE 6: The two scans obtained in ¶ 9.2.2 and ¶ 9.2.3 can be used as part of this data set, but the wafer must remain on the scan stage during the entire set of *Z* scans to perform the measurement sequence under level 1 variability conditions.

9.3 *Dynamic Method*

9.3.1 Select a test specimen and qualify it for appropriate density of LLS (see ¶ 8.1) and LLS separation (see ¶ 8.1.1).

9.3.2 Scan the wafer once and determine position, P_m, and size, S_m, of each of the M_1 detected LLS events with $m = [1, 2, \ldots M_1]$.

9.3.3 Remove the wafer from the scan stage and reload it in the same location, and scan the wafer a second time. To determine that there are enough repeating LLS events to make the CR calculation meaningful, compare the detected LLS events with respect to the positions of those detected during the first scan. Define the total number of LLS events that repeat their position in the first scan to within six times the scanner *XY* uncertainty as M_2. Consider the wafer qualified for the test if the share of repeat LLS events on the wafer, M_2, is larger than 0.75 M_1.

9.3.4 Removing and reloading the wafer on the scan stage, scan the wafer a total of *Z* times to obtain CR, FCR, and CFCR data. Record each LLS event detected during the *Z* scans according to its position *P* and size *S*. If a new LLS event is recorded on any scan, record the number of this scan as o_i and associate this number with this LLS event.

NOTE 7: The two scans obtained in ¶ 9.3.2 and ¶ 9.3.3 can be used as part of this data set, but the wafer must be removed and reloaded on the scan stage between each of the entire set of *Z* scans to perform the measurement sequence under level 2 variability conditions.

10 Analysis

10.1 *Initial Analysis*

10.1.1 Determine the locations on the wafer where an LLS event has been detected at least once by comparing all recorded positions (within the constraint of the six-sigma *XY* uncertainty) of the multiple scans as reported by the SSIS. These locations, L_i, with $i = [1, 2, \ldots, N]$ represent the complete set of LLS events to be used in the analysis. Each location is characterized by the number of scans H_i, in which the LLS event at that position has been detected, by the H_i reported sizes S_{ih}, where $h = [1, 2, \ldots, H_i]$, for the LLS event and by the number of scan o_i, when the LLS event was detected for the first time.

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