SEMI M35-1107
GUIDE FOR DEVELOPING SPECIFICATIONS FOR SILICON WAFER SURFACE FEATURES DETECTED BY AUTOMATED INSPECTION

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1 Purpose

1.1 Inspection of silicon wafer surfaces is a standard outgoing test on all commercially sold silicon wafers.

1.2 Older specifications referred to visual inspection of wafer surfaces, but with advanced technologies, the sizes of many important surface features are too small to be seen visually and so other types of surface inspection become necessary.

1.3 This guide provides a specification framework for reporting measurements of silicon wafer surface features through the use of scanning (or automated) surface inspection systems (SSIS).

2 Scope

2.1 This guide addresses specifications related to localized light scatterers (LLSs) as well as extended light scatterers (XLSs). Examples of LLSs are particles and pits. Examples of XLSs are scratches and regions of high roughness (surface haze). Illustrative examples of many of the features discussed in this guide may be found in SEMI MF154.

2.2 Surface scanners, which have discriminated between XLSs and LLSs for several years, are now discriminating (and selectively reporting) between different types of LLSs (e.g., pits and particles).

2.3 Specific numbers limiting feature levels and/or densities are to be agreed upon between suppliers and customers. This guide provides a framework for that communication that result in specifications flexible enough to accommodate variations in measurement due to different SSIS models.

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 The following measurement considerations impose limitations on the guidelines.

3.1.1 Histograms calculated in latex sphere equivalents may be distorted, because a given surface has in general LLSs of different size, shape, and material.

3.1.2 Measurement results do not always compare well between systems, because different SSIS designs employ different geometries and gather light scattered in different directions. Haze maps may have different levels and localized surface features may have different calculated sizes.

3.1.3 All scanning systems have a minimum LSE size of LLSs that can be reliably mapped and sized. The limitation is due to a combination of system electrical noise and the detection of non-particle light scatter signals, such as those created by Rayleigh scatter, surface roughness and system optics. Operation near this noise floor limits the utility of this guide for LLSs of those sizes.

3.1.4 Measurements made near the wafer edge often result in large numbers of false counts called edge blast. These counts are caused by small amounts of stray light propagating near the incident beam that scatter from the relatively rough wafer edge back into the detector optics. Under certain combinations of sensitivity and edge exclusion, light scattered from these effects may cause false counts within the FQA.

3.1.5 Types of LLS signals that may be mis-identified as scratches include lines of particles, pits, false counts, stacking faults, slip, and spin dry residue.

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3.1.6 Closely spaced features may be counted as a single scattering event because the scanning spot size is generally much larger than the feature diameter.

3.1.7 Scratch orientation usually affects scanner response. Thus the minimum detectable scratch cross-section may vary with orientation.

4 Referenced Standards and Documents

4.1 *SEMI Standards*

SEMI M1 — Specifications for Polished Mono-crystalline Polished Silicon Wafers

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

SEMI M59 — Terminology for Silicon Technology

SEMI MF154 — Guide for Identification of Structures and Contaminants Seen on Specular Silicon Surfaces

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

5 Terminology

5.1 Terminology used in this guide is defined in SEMI M59.

6 Discussion

6.1 *Discussion of LLS Measurement Issues*

6.1.1 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. Because there is considerable variation in the scatter characteristics of different LLSs, they have been historically sized in latex sphere equivalents (LSE). In other words, the signal received from an unknown LLS is equivalent to that which would be obtained from a polystyrene latex (PSL) sphere of known size.

6.1.2 Automated scanning systems typically display a map of LLS location as well as a histogram of LSE size.

6.1.3 The instrumentation industry is building SSISs that discriminate some LLSs from others based on differences in measured scatter that depend on feature size, shape and material. This raises the question of whether identified LLSs should continue to be sized using latex sphere equivalents, or if some new (more accurate) standard would be more acceptable. For example, if an LLS signal could be identified as coming from a pit, then it might become appropriate to develop a standard pit wafer. In this case, pits (either manufactured or found naturally) could be measured via atomic force microscope (AFM) and be made available on a calibration wafer to size pits via their measured scatter. Another option, would be to use a model-based standard that resides in the SSIS software.

6.1.4 The presence of LLS's does not necessarily decrease the utility of the wafer.

6.2 *Discussion of XLS Measurement Issues*

6.2.1 Some SSISs have sensors for reporting XLSs. XLSs can be observed as increased haze under dark field conditions. Under bright field conditions, an XLS can be observed as a decrease in the intensity of the specularly reflected beam, sometimes called a light channel defect.

6.2.2 Identification of scratches is typically done (in part) through software that identifies a string of connected LLS signals. Defects with dimensions such that the length is at least five times the width are defined as scratches. Customers and suppliers may agree on scratch aspect ratios different from 5:1. SSIS software often provides a customer-settable aspect ratio, as well as a minimum overall length, as criteria for classification of an SSIS defect or group of defects as a scratch. Depending on SSIS design, scratch sensitivity may also be a function of scratch orientation. Currently, scratch signals are also calibrated in latex sphere equivalents; however, in the future it may become useful to calibrate scratch signals with a standard obtained from a scratch that has been either manufactured to a known size, or has been measured via AFM.

6.2.3 In a scanning surface inspection system, haze results in a background signal; this signal and laser light-scattering events together comprise the signal due to light-scattering from a wafer surface. Haze is specified as parts per million (ppm) of measured scattered optical power relative to the incident optical power on the surface. All of

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