

SEMI M35-1104

GUIDE FOR DEVELOPING SPECIFICATIONS FOR SILICON WAFER SURFACE FEATURES DETECTED BY AUTOMATED INSPECTION

This guide was technically approved by the Global Silicon Wafer Committee and is the direct responsibility of the North American Silicon Wafer Committee. Current edition approved by the North American Regional Standards Committee on August 16, 2004. Initially available at www.semi.org September 2004; to be published November 2004. Originally published February 1999.

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).

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 (for example: 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.

2.4 The resulting specifications will be 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 Discussion

3.1 Discussion of LLS Measurement Issues

3.1.1 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.

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

3.1.3 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.

3.2 Discussion of XLS Measurement Issues

3.2.1 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.

3.2.2 Haze is specified as parts per million (ppm) of measured scattered optical power relative to the incident optical power on the surface. All of the associated measurement conditions must be given (or implied) with the specified haze value. These conditions include: source incident angle (measured as a polar angle from surface normal), source polarization (S, P, other), source wavelength (or wavelength band), nominal source spot size at the wafer, haze collection angles (given as solid angles with directions). All of these quantities must be part of a haze specification, either by description, or by implication to specific instrumentation (with known or fixed parameters).

3.2.3 Haze is quantified by measuring scattered light power over one or more solid angles and then normalizing by the light power incident on the surface. It is nothing more than the diffuse reflectance of a surface in specified directions for a known source (incident angle, polarization, spot size, wavelength band) and receiver (or detector) configuration (solid angles and locations). Measured haze can be expected to change if the surface is changed, or if any of the measurement parameters change.

3.2.4 Under special conditions, where the source of the haze is known, it may be possible to use a model to predict the haze reading on one instrument from the haze reading on another. For example, if on the basis of product experience and measurements on a few wafers, the surface power spectral density function can be determined, then the haze due to surface roughness can be calculated for an instrument with different parameters. Haze caused by a large number of small particles and/or film contamination is more difficult to model.

3.2.5 An SSIS often reports haze as the arithmetic average of a grid of local haze measurements taken over the FQA. This average can be, and often is, biased by wafer haze distributions that exhibit long, positively skewed tails. SSIS software is being developed that automatically calculates other haze statistics, such as the median haze value, the standard deviation of the haze distribution, and so on.

3.3 The SSIS used for automated inspection of silicon wafer surfaces should be calibrated in terms of latex sphere equivalents in accordance with SEMI M53 or another method agreed upon between supplier and customer.

4 Limitations

4.1 The following measurement considerations impose limitations on the guidelines.

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

4.1.2 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.

4.1.3 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.

4.1.4 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.

4.1.5 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.

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

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

5 Referenced Standards

5.1 SEMI Standards

SEMI M1 — Specifications for Polished Monocrystalline Polished Silicon Wafers

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

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