SEMI M43-0418
GUIDE FOR REPORTING WAFER NANOTOPOGRAPHY

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1 Purpose

1.1 This Guide provides a framework for reporting of nanotopography surface features on silicon wafers.

2 Scope

2.1 This Guide addresses reporting the characterization of nanotopography surface features found on wafer surfaces. Nanotopography is the non-planar deviation of the whole front wafer surface within a spatial wavelength range of approximately 0.2 to 20 mm and within the fixed quality area (FQA). Typical examples include dips, bumps or waves on the wafer surface that vary in peak to valley height from a few nanometers to a several hundred nanometers.

2.2 This Guide provides a framework for communicating specific values limiting feature levels and/or densities as agreed upon between suppliers and users. It is intended to apply to polished wafers as specified in SEMI M1.

2.2.1 Although nanotopography measurements have not been needed for 0.25 µm generation devices, they are expected to be required for smaller feature sizes to meet CMP requirements. Nanotopography on a wafer surface prior to CMP processes can result in variations in post-CMP dielectric thickness with potential negative consequences for circuit performance and yield; features as small as 20 nm (peak to valley) can result in post CMP discoloration of dielectrics as a result of local thickness variation of the remaining dielectric.[1] Height variations over specified distances (determined by CMP issues and/or lithography systems) need to be properly controlled to assure that wafers are acceptable for selected process steps. In the case of CMP, the issue is control of film thickness variation introduced by nanotopography. The metrology industry is building tools that will measure and map surface features at nanotopography amplitudes and spatial wavelengths. Nanotopography features are characterized by their height variation within an area, and are discriminated from other features of similar height by their spatial wavelength range.

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 The reported surface features are influenced by limitations and parameters of the measurement tool, as follows:

3.1.1 The finite surface spatial bandwidth of the tool and the applied filtering prevents surface variations outside the bandwidth of operation from being measured. Also, the finite bandwidth of filtering produces non-physical artifacts that may be apparent in regions where the power in the rejected bands is high.

3.1.2 Bandwidth edges are not always well defined. Measurement results do not always agree well between systems, because different tool designs employ different geometries and operate them over different spatial bandwidths.

3.1.3 All surface profiling measurement systems have a minimum height variation sensitivity that will distort signals near the noise floor.

3.1.4 The reported shape of some features may also depend on the pixel grid orientation employed by the instrument.

3.1.5 The pixel size and the size and shape of the sampled area both affect the bandwidth limits.

3.2 Reported profiles also vary with interactions between wafer and tool. These variations include:

3.2.1 Measurements made near the wafer edge may result in false readings. Under certain conditions, this may cause incorrect height measurement within the FQA.

[1] Boning, D., Lee, B., Poduje, N., Valley, J., and Baylies, W. "Modeling and Mapping of Nanotopography Interactions with CMP." Chemical-Mechanical Planarization, Materials Research Society Symposium Proceedings Vol. 732, Cambridge University Press (2002): pp. 28–39.

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3.2.2 Closely spaced features may be counted as a single feature, or as no feature, if the pixel size is larger than the feature, or is larger than the spacing between features. Reported features may result from the combination of the actual surface features, the manner in which the wafer is chucked, or be caused by particles trapped between the wafer back surface and the chuck.

3.2.3 High-pass (spatial frequency) filtering is typically used with these measurements to remove the (long-spatial wavelength) effects of wafer shape (such as bow, warp and sori). This filtering may affect the reported results.

3.3 Nanotopography characterization does not include microroughness, which applies to a shorter spatial wavelength range.

3.4 The location of defective areas as calculated in section 6 may not coincide with the location of the surface features that lead to those values. This may cause lack of spatial correlation between reported defective areas and device process defect areas.

3.5 The height map used to create nanotopography reports may be affected by wafer shape and measurement chuck effects.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI M1 — Specification for Polished Single Crystal Silicon Wafers

SEMI M59 — Terminology for Silicon Technology

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

5 Terminology

5.1 Acronyms, definitions, and symbols used in silicon technology may be found in SEMI M59.

6 Measurements

6.1 Obtain a height map from a front-surface measurement. An explicit reference plane is not used for calculating and assigning values.

NOTE 1: Other methods of analyzing nanotopography may require the use of an explicit reference plane.

6.2 Remove the long spatial wavelength wafer tilt and topography effects by means of a high-pass filter, effectively creating a global reference surface.

6.3 Determine the peak to valley height (P-V) variation among the pixels included in the analysis area, and assigns that variation in nanometers to the center of the analysis area. Perform the calculation for every analysis area within the FQA of the wafer.

NOTE 2: These calculations may be repeated for analysis areas of different dimension, *D*.

NOTE 3: This calculation describes the 'full-analysis area' method. There is another calculation, the 'partial analysis area' method, where the calculation is performed for every analysis area whose center pixel is within the FQA of the wafer. The partial analysis area method, not defined in this Document, is being addressed by SEMI for inclusion in a Standard.

6.4 Report the following measurement elements:

6.4.1 *Filtering*

1. Spatial cutoff of high pass filter
2. Type of Filter
3. Pixel spacing

NOTE 4: Filtering is used to remove long wavelength shape components from the raw height data.

6.4.2 *Analysis Area* — Specify this analysis area's:

1. Shape (e.g., square, circle) and
2. Dimension *D* of the analysis area

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