

SEMI C102-1022

GUIDE FOR REPORTING DENSITY AND POROSITY OF CHEMICAL MECHANICAL PLANARIZATION (CMP) PADS USED IN SEMICONDUCTOR MANUFACTURING

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1 Purpose

- 1.1 This Standard will provide a guide for consistent measurements and reporting measurement conditions of density of chemical mechanical planarization (CMP) pads.
- 1.2 This Standard recommends using additional metrologies for measurements of CMP pad density, such as liquid or gas pycnometer metrologies.
- 1.3 This Standard does not recommend stopping reporting density parameters using industry traditional metrology based on determining the weight and geometry of the pads ('geometric parameters').
- 1.4 This Standard will provide a guide for consistent measurements and reporting of porosity of CMP pads.
- 1.5 This Standard recommends using additional metrologies for measurements of CMP pad porosity, such as mercury or gas porosimetry.
- 1.6 This Standard does not recommend stopping reporting porosity parameters using industry traditional pore count metrology based on scanning electron microscopy (SEM) or optical metrologies.
- 1.7 This Standard will provide references to industry standards for measurements using well-established alternative metrologies, such as apparent density using pycnometer-type metrologies.
- 1.8 This Standard will provide references to metrologies to indirectly assess pad density, such as nano indentation or nano- dynamic mechanical analysis (DMA).
- 1.9 Reference to this Guide can be used in the corresponding certificate of acceptance (CoA), or other quality documentation, from a CMP supplier to its customers.
- 1.10 Reference to this Guide can be used for generating roadmaps for the development of new semiconductor metrologies.

2 Scope

- 2.1 This Guide provides guidance on how density of CMP pads should be reported, for example, on a CoA.
- 2.2 This Guide provides guidance on how porosity of CMP pads should be reported, for example, on a CoA.
- 2.3 Related Information 1 provides background information on the following topics:
 - Metrologies for measuring or assessing density of CMP pads.
 - Metrologies for measuring or assessing porosity of CMP pads.
 - Details of the test conditions to be reported on, for example, CoA for measurements of density of CMP pads.
 - Details of the test conditions to be reported on, for example, CoA for measurement of porosity of CMP pads.

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 Due to the proprietary nature of CMP pads, this Guide will not address any specifics regarding the pad manufacturing process.

3.2 Due to the proprietary nature of CMP pads, this Guide will not address composition or ingredient-related aspects of CMP pads.

3.3 This Guide does not define which measurement technique, test conditions and recipes, or selection of the test coupons should be used for pad density or porosity measurements; it only determines that these techniques, conditions, and coupons should be reported on quality documents, such as, CoAs.

4 Referenced Standards and Documents

4.1 None.

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *CMP* — chemical mechanical planarization

5.1.2 *CoA* — certificate of acceptance

5.1.3 *DMA* — dynamic mechanical analysis

5.1.4 *PSA* — pressure sensitive adhesive

5.1.5 *SEM* — scanning electron microscopy

5.1.6 *TPV* — total pore volume

5.2 Definitions

5.2.1 *polymeric pads* — relatively hard one or two-layered polymer-based pad with usually grooved surface.

5.2.2 *poromeric pad* — relatively soft two multilayered polymer-based pad with embossed surface.

5.2.3 *sub-pad* — a polymer-based ‘pad’ used as a cushion for the main pad; sub-pad is not used for polishing.

5.2.4 *top-pad* — the main pad that can be used individually or in combination with a sub-pad.

5.2.5 *total pore volume* — volume occupied by all pores or voids within the pad.

6 Background to Data Reporting of CMP Pad Density

6.1 Pad density metrologies can be conducted using whole pads or representative pad coupons.

6.2 Traditional industry process of record pad density measurements are based on the measurement of the pad, or pad coupons, weight, and geometry.

6.2.1 Samples for density measurements should be conditioned at a certain temperature and relative humidity.

6.2.2 These conditions should be referenced and available for internal and end user information.

6.3 If the whole pad is used to measure pad density, distribution of density values across pad diameter, or density uniformity, is not available.

6.4 If the pad coupons are used to measure pad density, small size of the coupons can adversely affect accuracy of the measurements.

6.4.1 Collecting of the density data for a number of the pad coupons across pad diameter may provide data on density uniformity across the pad.

6.4.2 Preparation of the pad coupons is a destructive test for the pads.

6.5 Effect of pad orientations with regard to grooves on pad density was not widely researched but can be a factor affecting reported pad density values.¹

¹ Tregub, A., Moinpour, M., and Sorooshian, J. “Effect of Groove Orientation on Thermal and Mechanical Properties of CMP Polishing.” Proceedings of CMPUG Annual Symposium, October 11, 2001, San Jose, CA.

6.6 Alternative pad density metrologies are based on pycnometer-type measurements, including both gas and liquid type pycnometers.

7 Challenges of Reporting of Pad Density for CMP Pads

7.1 Pad density measured in a traditional approach as a ratio weight/volume, may not be able to differentiate pad-to-pad or lot-to-lot variations for porous pads, since porosity is not accounted for in the approach based on weight/volume ratio.

7.2 Density is often reported at a non-specified room temperature and relative humidity.

7.3 The coupon preparation procedure for density measurements is not always consistently reported on CoA or other quality-related documents.

7.4 Information on whether top-pad, sub-pad, or stack coupon is measured is not always specified on CoA or other quality-related documents.

7.5 The following important test details are not always reported on CoA or other test-related documents:

7.5.1 Test coupon location on the pad from where it taken.

7.5.2 Coupon orientation with regard to the groove orientation for the grooved pads.

7.5.3 Information on whether pad density is measured before or after applying pressure sensitive adhesive (PSA).

7.5.4 For multilayer pads, whether density is measured for combined ready-to-use product, or for single layer.

8 Background to Data Reporting of CMP Pad Porosity

8.1 Pad porosity metrologies can be conducted using whole pads or pad coupons.

8.1.1 Most traditional metrologies are based on the measurements conducted for the pad coupons.

8.2 Traditional industry pad porosity measurements are based on counting the number of pores using SEM, confocal, white light spectroscopy, or optical microscopy.

8.2.1 Pores height or area can be reported, along with the pore count.

8.2.2 Pore measurements are typically conducted using cross-sectioned pad coupons.

8.3 Samples for porosity measurements should be conditioned at a certain temperature and relative humidity.

8.3.1 These conditions should be available for internal and end user information.

8.3.2 Test conditioning should be appropriate for the metrology used to measure pad porosity.

8.4 Alternative pad density metrologies are based on total pore volume measurements, using liquid (mercury, other liquids) porosimetry and gas pycnometer.

8.4.1 For liquid porosimetry, mercury use is widespread due to its good wettability, but other media can be also used.

8.4.2 For liquid porosimetry, the tool exists to accommodate the whole pad to provide 'true' total pore volume data.

9 Challenges of Reporting of Pad Porosity for CMP Pads

9.1 Pad porosity based on pore count, or pore area, do not accurately represent pore total volume and pore size distribution, and may not be able to differentiate between pad-to-pad or lot-to-lot variations.

9.1.1 Some pores that do not extend to the surface level, at which measurements are taken, will not be accounted for.

9.1.2 Pores of different sizes are counted equally in pore counting approach, however, contribution to total porosity of large pores may be significantly higher, than contribution of small pores.

9.2 Small size pad coupons, taken from the selected areas on the pads, may not be representative of pore distribution across the whole pad.

9.2.1 Pad porosity may not be uniformly distributed across total pad area or within the pad lots.

9.3 For most pads, porosity is reported at a non-specified room temperature and relative humidity.