SEMATECH Provisional Test Method for Visual Characterization of Surface Roughness for Plastic Surfaces of UPW Distribution System Components

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Abstract: This document describes a technique for preparing test specimens of plastic ultrapure water distribution system components and defines a method for visually characterizing the prepared specimens. The document includes an appendix that contains information on other analytical techniques that may provide greater resolution of surface defects and topography (roughness). The method applies to all surfaces of plastic components used in ultrapure water distribution systems. This document is in development as an industry standard by Semiconductor Equipment and Materials International (SEMI). When available, adherence to the SEMI standard is recommended.

Keywords: Ultrapure Water Distribution Systems, Testing, Surface Tests, Visual Evaluation, Surface Roughness

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SEMATECH Provisional Method for Sample Preparation and Visual Characterization of Plastic Surfaces of UPW Distribution System Components

1. Introduction

This document presents a test method that may be applied for the visual evaluation of one or more components considered for use in ultrapure water (UPW) distribution systems. The appendix of this document includes information on other analytical techniques that may provide greater resolution of surface defects and topography (roughness).

1.1 *Purpose*—This document describes a technique for preparing test specimens of plastic ultrapure water distribution system components and defines a method for visually characterizing the prepared specimens.

1.2 *Scope*—This method applies to all surfaces of plastic components used in ultrapure water distribution systems.

1.3 *Limitations*

1.3.1 This methodology assumes that the operator is adequately skilled to use the apparatus.

1.3.2 This document does not address surface contamination measurement techniques such as electron spectroscopy for chemical analysis (ESCA), auger spectroscopy, and secondary ion mass spectroscopy (SIMS).

2. Referenced Documents

2.1 ANSI B46.1 — Surface Texture (Surface Roughness, Waviness, and Lay)[1]

2.2 *ASTM Standards*[2]

ASTM D1193	Standard Specification for Reagent Water
ASTM D4449	Standard Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearances
ASTM D5127	Standard Guide for Electronic Grade Water
ASTM F109	Surface Imperfections on Ceramics, Definition of Terms Relating to

2.3 *SEMATECH Test Methods*[3]

SEMASPEC #92010951B–STD	SEMATECH Provisional Test Method for Optical Analysis of Plastic Surface Condition of UPW Distribution System Components
SEMASPEC #92010952B–STD	SEMATECH Provisional Test Method for Determining the Surface Roughness of UPW Distribution System Components (AFM Method)

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[1] American National Standards Institute. 1430 Broadway. New York, NY 10018.

[2] American Society for Testing and Materials. 1916 Race St. Philadelphia, PA 19103.

[3] SEMATECH. 2706 Montopolis Dr. Austin TX 78741.

SEMASPEC #92010953B–STD	SEMATECH Provisional Test Method for Determining the Surface Roughness of UPW Distribution System Components (STM Method)
SEMASPEC #92010954B–STD	SEMATECH Provisional Test Method for Determining the Surface Roughness of UPW Distribution System Components (Noncontact Optical Profiling Techniques)
SEMASPEC #92010955B–STD	SEMATECH Provisional Test Method for Analyzing the Plastic Surface Condition of UPW Distribution System Components (SEM Method)

3. Terminology

3.1 *Acronyms and Abbreviations*

3.1.1 R_a—roughness average

3.1.2 *UPW*—ultrapure water

3.2 *Definitions*

3.2.1 *artifact*—any contribution to an image from other than true surface topography.

3.2.2 *defect* or *anomaly*—a pit, tear, groove, inclusion, or other surface feature that is either characteristic of the material or a result of its processing and that is not a result of the sample preparation. [ASTM F109]

3.2.3 *surface aspects*—defined in ASTM D4449.

3.2.4 *ultrapure water*—type E-1 electronic grade water as defined in ASTM D5127.

4. Summary of Test Method

The sample is placed under a lamp, oriented under the lamp at various reflection angles, and observed for several visual characteristics. Types and numbers of surface defects are reported.

5. Significance and Use

In general, the smoothness and perfection of a UPW component surface is inversely proportional to the component's contaminating potential. Particles introduced into water from contaminating components can adversely affect the performance of the semiconductor manufacturing process. A method of visually characterizing UPW component surfaces to detect and define surface anomalies has broad applicability. Since the contaminant particles are often of microscopic size, however, additional analyses are needed to supplement visual characterization. Application of this test method is expected to yield comparable visual observations of UPW components tested.

6. Apparatus

Equipment required for the surface analysis methods listed in Appendix A are listed in the individual methods.

6.1 *Lamps*

6.1.1 Lamp A—A modified fluorescent lamp with a reflector that is painted matte black. (See ASTM D4449.)

6.1.2 Lamp B—A bare incandescent bulb mounted on an adjustable angle fixture. (See ASTM D4449.)

6.2 *Cutting Tools*

6.2.1 Saw Blade—A fine-toothed saw blade with a cutting surface that has at least 32 teeth/in. is required. The blade shall be uncoated, clean, dry, and sharp. Other cutting blades (with a greater number of teeth/in.), such as jewelers' saws, can be used. The saw shall be hand powered.

6.2.2 The use of cutting lubricants is not permitted due to possible contamination of the surface by the lubricant or interaction between the lubricant and the polymer. All cutting blades shall be uncoated, dry, sharp, and clean (e.g., scalpel).

7. Materials

7.1 *Nitrogen*, clean, dry, and filtered to < 0.1 µm.

7.2 *Test Fluid*, water meeting a minimum of ASTM D1193 Type IV specification, filtered with a fresh filter to < 0.2 µm.

7.3 *Comparison Sample Surfaces*. When the visual technique is used as part of a specification, comparison samples should be prepared for all rating systems.

8. Precautions

8.1 *Safety Precautions*—This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address the safety considerations associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations before using this method.

9. Sampling, Test Specimens, and Test Units

9.1 *Sample Preparation*—Proper sample preparation should provide a test specimen with an area representative of the component surface. Take care during preparation to prevent artifacts and to prevent contamination or distortion of the surface to be tested. The cutting speed should be slow enough to prevent heating the surface to be observed to temperatures greater than 40°C (104°F).

9.1.1 Remove components that are as received from the supplier from the component packaging. Carefully remove external contamination sources that could affect the visual observations or subsequent surface analyses.

9.1.2 The specimen size needed will vary with the technique used. The specimen must be representative of the component under investigation and must be of a size compatible with the microscope or with whatever surface analysis technique is being used.

9.1.3 After cutting, blow loose particles from the surface with nitrogen and then rinse the specimen with reagent water. Blow specimens dry with nitrogen. Analyze immediately or place the specimens in a nitrogen-filled, resealable, particle-free, non-outgassing container.

10. Test Procedures for Visual Characterization

10.1 *Sample Appearance*—Orient the specimen under the lamp at approximate reflection angles of 40°, 120°, and 170°, and observe the surface for reflected image distortion, distinctness, gloss, haze, directionality or other visual effects. When comparing with a reference surface, report a rating or ranking.[4]

[4] See ASTM D4449 for details.

10.2 *Surface Defects*—The types and number of defects shall be reported per unit area defined either in the report or specified by a cited document. Specific (subjective) comments may be included if desired.[5]

11. Data Presentation

11.1 If applicable, the report shall include a summary of visual observations and comparisons. The defect terminology shall conform to ASTM F109.

11.2 Illustrations of defects and types of image reflectances are given in the ASTM documents cited in Section 2.

12. Precision and Bias

12.1 *Statement of Precision*—Repeatability of comparison results should be consistent with ASTM D4449.

12.2 *Statement of Bias*—Since surface defects vary in number and kind from surface to surface, the visual characterization described in this procedure cannot be repeatable and will not conform to any reference standards. Therefore, determinations of bias are not applicable to this procedure.

APPENDIX

Nonmandatory Information

A1. Guide to Selection of Surface Roughness Analysis Techniques

The techniques are separated into two classes covering:

1. Optical and electron microscopy methods
2. Profilometry methods

The techniques are listed in increasing resolution of surface topography. Information about these techniques can be found in documents listed in Section 2. The noncontact profilometry techniques detailed below (AFM, PMI, and STM) can be used interchangeably to yield comparable results.

Analysis areas should cover a representative sampling of the component surface. The number, size, and location of surface areas analyzed will vary with the technique used.

A1.1 *Microscopic Techniques*—See Figure A-1 for selection of techniques for magnification level.

A1.1.1 Optical Microscopy (OM)

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Optical microscopy is used to observe surface defects greater than 5 µm.

Magnification level: 10 to 100×

A1.1.2 Scanning Electron Microscopy (SEM)

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Scanning electron microscopy is used to observe surface defects greater than 0.1 µm.

[5] Paraphrased from ASTM F109.

Magnification level: 100 to 3500×

A1.2 *Profilometry Techniques*—See Figure A-2 for comparison of feature heights.

A1.2.1 Contact Profilometry

Stylus-type instruments may be used to perform contact profilometry characterizing plastic surfaces of ultrapure water components. ANSI B46.1 describes stylus-type instruments and contact profilometry. ANSI B46.1 also provides definitions of terms related to the measurement of surface texture.

[CAUTION: The results of contact profilometry using stylus-type instruments will be affected by stylus-caused elastic and/or permanent deformation of the surface. The resolution of surface features will vary with the stylus tip used. See ASTM F109 and additional references for a discussion of several types of technique-induced surface damage.]

A1.2.2 Noncontact Profilometry—Atomic Force Microscopy (AFM)

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Atomic force microscopy is a noncontact method of profilometry, which may be used to measure surface features in the nanometer to micrometer size range. It provides three-dimensional data describing surface texture or topography.

Feature definition: (vertical)

Minimum:	1 nm
Maximum:	5000 nm (5 µm)

Feature area:

Minimum:	10 nm × 10 nm
Maximum:	100,000 nm × 100,000 nm (100 µm × 100 µm)

A1.2.3 Optical Noncontact Profilometry—Phase measuring interferometry (PMI)

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Phase measuring interferometry (PMI) uses a visible light source to measure surface topography. The measurement is made by determining the phase change of reflected light due to interaction with the sample surface.

Feature definition: (vertical)

Minimum:	1 nm (Ra)
Maximum:	1000 nm (1 µm) (Ra)

Feature area:

Minimum:	50 µm × 50 µm
Maximum:	250 µm × 250 µm

A1.2.4 Noncontact Profilometry—Scanning Tunneling Microscopy (STM)

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Scanning tunneling microscopy (STM) is a noncontact method of profilometry that may be used to measure surface features in the nanometer to micrometer size range. It provides three-dimensional data describing surface texture or topography.

Feature definition: (vertical)

Minimum:	10 nm
Maximum:	5000 nm (5 μm)

Feature area:

Minimum:	10 nm × 10 nm
Maximum:	100,000 nm × 100,000 nm (100 μm × 100 μm)

A1.3 *Illustrations*

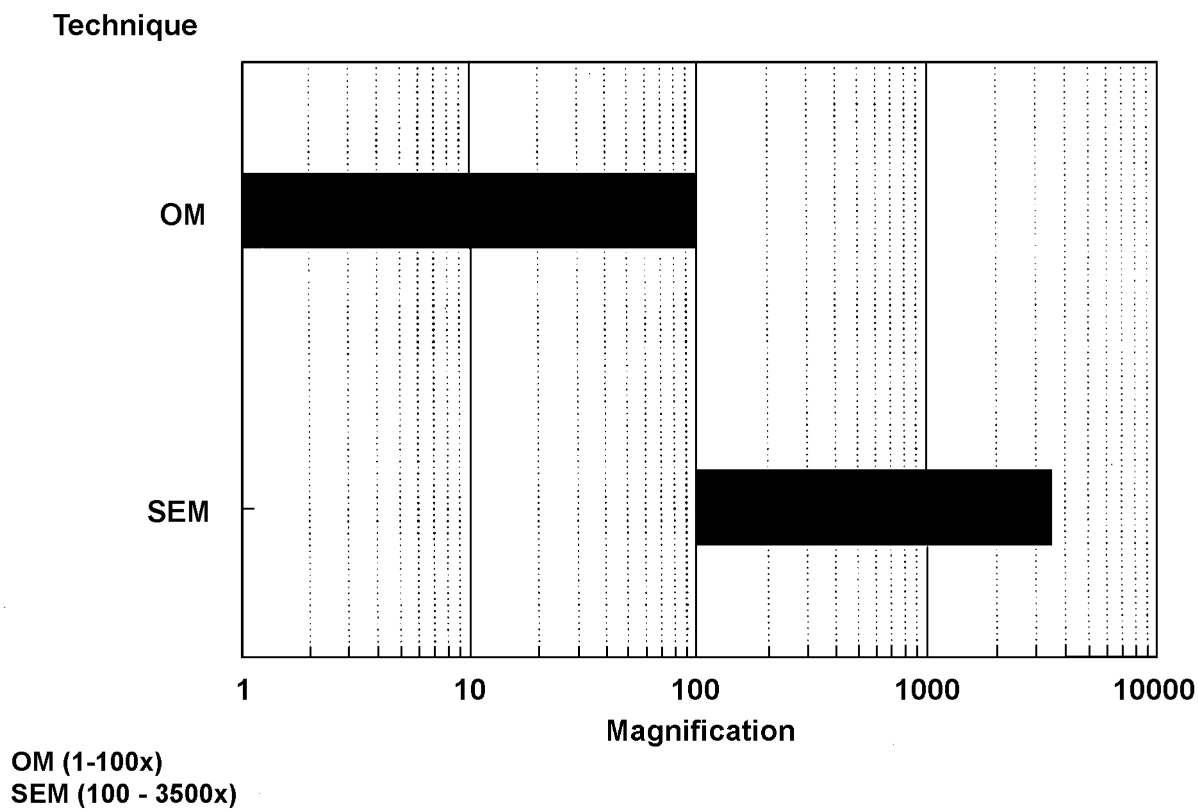
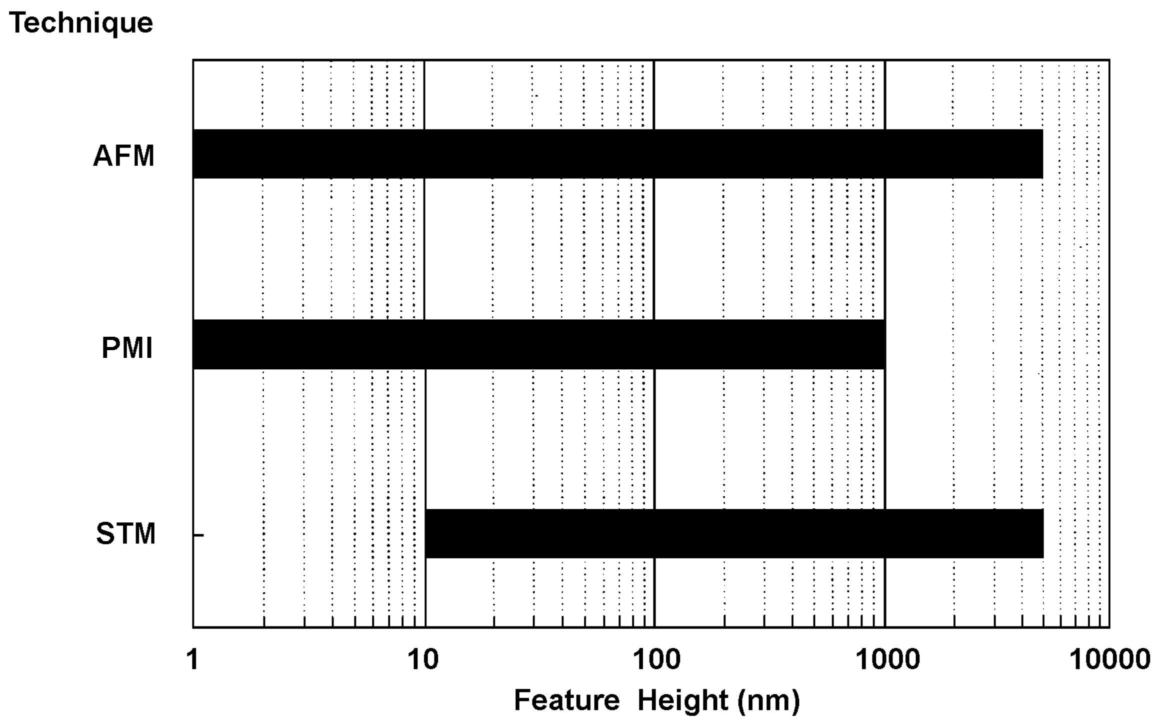


Figure A-1 Magnification Range



AFM (1-5,000 nm)
PMI (1-1,000 nm)
STM (10-5,000 nm)

Figure A-2 Noncontact Profilometry Feature Height

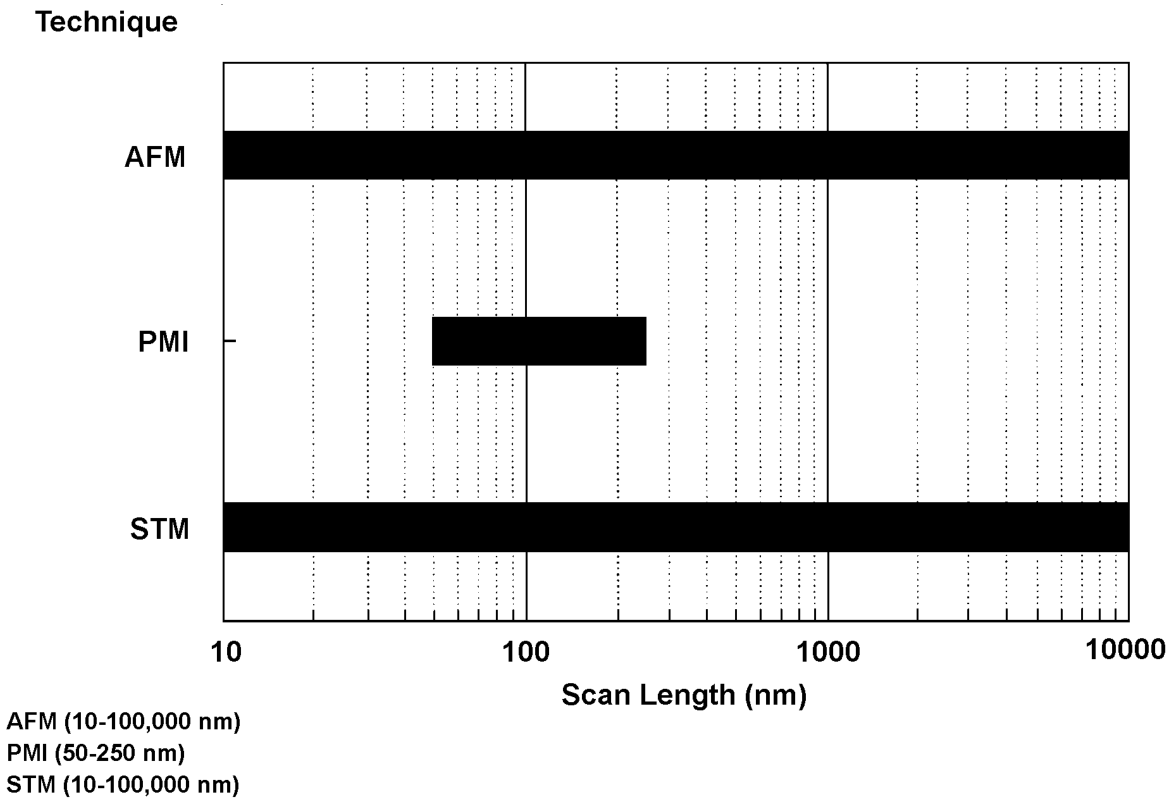


Figure A-3 Noncontact Profilometry Scan Length

Additional References

Goodman, John. 1990. "Surface Finish," Foil 2.2.2 of "Materials for High-Purity Chemical Distribution Systems." Paper presented at Microcontamination Tutorial, October 30, at Santa Clara Convention Center, Santa Clara, California.

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