SEMATECH Provisional Test Method for Optical Analysis of Plastic Surface Condition of UPW Distribution System Components

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Abstract: This test method provides a means of testing functional surfaces of plastic components for gross surface morphology (imperfections or defects). It applies to pipes, fittings, and valves being considered for installation into 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, Plastic Piping, Plastic Valves, Surface Roughness, Surface Tests, Optical Measurement

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1. Introduction

This document presents a test method that may be applied for the optical evaluation of one or more components considered for use in ultrapure water (UPW) distribution systems.

1.1 *Purpose*

1.1.1 This document establishes a method for testing functional surfaces of plastic components such as pipes, fittings, and valves for gross surface morphology.

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

1.3 *Limitations*

1.3.1 This methodology assumes that the operator has adequate skill with an optical microscope.

1.3.2 The technique described in this method is intended for the assessment of pits, tears, grooves, inclusions, and other surface anomalies. However, stains and particles that may be produced during specimen preparation should be excluded in the assessment of anomalies.

2. Referenced Documents

2.1 *ASTM Standards*[1]

ASTM D1193	Standard Specification for Reagent Water
ASTM D5127	Standard Guide for Electronic Grade Water
ASTM E20	Particle Size Analysis of Particulate Substances in the Range of 0.2 to 75 Micrometers by Optical Microscopy, Practice for
ASTM F109	Surface Imperfections on Ceramics, Definition of Terms Relating to

2.2 SEMASPEC #92010950B–STD — SEMATECH Provisional Method for Sample Preparation and Visual Characterization of Plastic Surfaces of UPW Distribution System Components[2]

3. Terminology

3.1 *Acronyms and Abbreviations*

3.1.1 *UPW*—ultrapure water

3.2 *Definitions*

3.2.1 *average defect count*—the result of dividing the total number of defects on a single photomicrograph by the number of squares in the grid used.

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

[2] SEMATECH. 2706 Montopolis Dr. Austin, TX 78741.

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 *grid size*—length of the x- and y-axis grid dimension.

3.2.4 *number of defects*—the total number of anomalies per photomicrograph. (See Section 12.)

3.2.5 *ultrapure water (UPW)*—type E-1 electronic grade water as defined in ASTM D5127.

3.3 *Descriptions of Terms*

3.3.1 *grid size*—For this method, grid size is determined from the magnification and size of the photomicrograph in which the x- or y-dimension of a single grid square corresponds to 64 μm of actual feature size (i.e., for a 4 × 5-in. photographic image and 100× magnification, this grid would be 6.4 mm (1/4 in.) by 6.4 mm (1/4 in.)).

4. Summary of Test Method

The optical microscope is used to provide a magnified view of a plastic surface, in order to inspect it for gross imperfections or defects. Magnifications of 10×, 50×, and 100× are photographically recorded. The number of defects observed at 100× is recorded for purposes of evaluation and comparison.

5. Significance and Use

Surface roughness of a plastic component may affect its performance in an ultrapure water delivery system by providing adhesion sites for chemical or bacterial contamination. This test may be used to evaluate surface roughness for gross imperfections or defects. Application of this test method is expected to yield comparable data among components tested for purposes of installation qualification or degradation evaluation.

6. Apparatus

6.1 *Optical Microscope*. The microscope used for this study should have magnification capabilities of 10×, 50×, and 100× total magnification. Direct and oblique fluorescent brightfield illumination shall be used.

6.2 *Photomicrograph Microscope Attachment and Film*

7. Materials

7.1 *Manual Cutting Tools*, clean, dry, uncoated (e.g., scalpel or sharp blade with at least 32 teeth per inch.)

7.2 *Nitrogen*, dry, filtered (≤ 0.1 μm)

7.3 *Test Fluid*, ASTM D1193, Type IV purity water (or better), filtered to ≤ 0.2 μm.

7.4 *Containers*, resealable and clean

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.

8.2 *Technical Precautions*—Sample preparation must not cause the temperature of the sample to exceed 40°C (105°F).

9. Sampling, Test Specimens, and Test Units

9.1 *Sample Preparation*

9.1.1 Cut the sample as required for analysis using any hand operated dry mechanical cutting method that minimizes alteration of the surface. The sample must be of a size compatible with the microscope used and representative of the component under scrutiny. A minimum size of 2 cm × 2 cm is recommended.

9.1.2 After cutting, deburr samples with a scalpel and blow dry with dry, filtered (≤ 0.1 µm) nitrogen. Rinse samples in Type IV purity water (ASTM D1193) and blow dry with dry, filtered (≤ 0.1 µm) nitrogen. Analyze immediately or place the samples in a clean, resealable container.

10. Conditioning

Maintain the test temperature at 25 ± 5°C (77 ± 9°F).

11. Test Procedure

11.1 Place the sample on the optical microscope stage.

11.2 If applicable, orient the sample such that the longitudinal axis of the sample curvature is aligned with the vertical axis of the microscope.

11.3 Move the sample until an area of interest on the sample surface comes into focus. The area of interest should be representative of the whole, avoiding gross deformities.

11.4 Increase the magnification to 100× for final focus, correcting astigmatism and other instrument anomalies to yield a clear image.

11.5 Set the magnification to 100×, 50×, and 10×, and record the images onto photographic media.

11.6 Repeat the procedures in Sections 11.3–11.5 for four additional random sample sites.

12. Data Analysis

The images recorded at 100× shall be overlaid with a grid divided into squares of a size corresponding to 64 µm × 64 µm actual feature size. The grid lines should be as fine as possible and still remain clearly visible. The lower left corner of the grid is to correspond with the lower left corner of the photograph. The number of surface anomalies per square (such as pits, scratches, inclusions, and tears) shall be summed to determine the total defects per micrograph and the average number of defects per square. Defects that appear in one or more adjacent squares shall count as one defect for each square occupied by the defect. Particles that loosely adhere to the surface must be presumed to be artifacts of atmosphere, sample preparation techniques, or other extraneous sources and should be ignored.

13. Data Presentation

The data shall be presented as photomicrographs (three magnifications from each of five sample areas) and in tabular form, showing the total number of defects counted (per area analyzed) in the grid overlay and the average number of defects per square. Photomicrographs must include sample identification, magnification, and date. The data table shall include a summation of the total counts for each of five 100× micrographs, average defect count per grid square, and associated standard deviations.

14. Precision and Bias

Since the number of surface defects varies from surface to surface, the surface measurements described in this procedure cannot be repeatable and will not conform to any reference standards. Also, given the nature of defects on plastic surfaces, subjective measurement differences among different operators will complicate determinations of precision and bias.

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