SEMI F63-0213
GUIDE FOR ULTRAPURE WATER USED IN SEMICONDUCTOR PROCESSING

This Standard was technically approved by the global Liquid Chemicals Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on December 20, 2012. Available at www.semiviews.org and www.semi.org in February 2013; originally published July 2001; previously published February 2011.

1 Purpose

1.1 This Guide may be used:

- To establish performance criteria when purchasing ultrapure water (UPW) purification equipment.
- To set the process control parameters for UPW-system operation.
- To establish quality expectations for the supplied UPW.

NOTE 1: These suggested guidelines are published as technical information and are intended for informational purposes only.

2 Scope

2.1 UPW is used extensively in the production of semiconductor devices for all wet-processing steps (including wafer rinsing). UPW purity is therefore critical to the manufacture of semiconductors. This Guide provides UPW quality parameters and background information for the decision-making process related to new or retrofit facilities that manufacture semiconductors with line widths of 65 nm and smaller.

2.2 The goal of members of the International Technology Roadmap for Semiconductors (ITRS) UPW committee is to look years ahead on a continual basis to assess the semiconductor industry's future UPW technology requirements. In addition to ITRS input, the SEMI committee contributed its knowledge of the feasibility and cost viability of the technical solutions required to support UPW quality values specified in this Guide.

2.3 The information in this Guide has been developed from the following sources:

- ITRS risk assessment with input from facility- and manufacturing-experts and technology providers in the semiconductor manufacturing industry.
- The results of UPW testing at semiconductor manufacturing sites as measured by independent laboratories that test high purity water for the semiconductor industry.
- Specifications from water-system equipment manufacturers.
- Input from UPW producers and users at SEMI Standards committee meetings, and also through the balloting process.

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 This Guide is not intended to define UPW system performance requirements. It only provides a reference set of parameters and their values, considered to be satisfactory for the advanced semiconductor manufacturing needs. In some cases the values are limited by the feasibility of the available treatment technology or metrology. It is expected that semiconductor company experts will define the performance requirements for the UPW system based on specific manufacturing process sensitivities, with reference to the information provided in this Guide.

3.2 The purity of water generated in water systems differs. These guidelines were developed for properly maintained, state-of-the-art UPW systems as found in high-end semiconductor manufacturing plants and may not reflect the needs of lesser demanding end-users.

3.3 This Guide is not intended to be used to define the criteria needed for selecting process tools.

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3.4 This Guide defines parameters that apply to the quality of UPW required in semiconductor processing when proper analytical hookup and tool installation is made.

3.5 This Guide may include suggested values that are at the detection limit of today's available, cost-viable, analytical instrumentation or techniques. UPW system owners, engineers, and technicians are expected to decide whether the benefits of meeting the suggested values outweigh the associated time and costs. The quality of the data measured will depend on which testing method and calibration techniques are used. Laboratory or metrology vendors may be requested to provide additional analytical validation data to confirm detection limits before internal specification values are set.

4 Referenced Standards and Documents

4.1 *SEMI Standards and Safety Guidelines*

SEMI C1 — Guide for the Analysis of Liquid Chemicals

SEMI C10 — Guide for the Determination of Method Detection Limits

SEMI F61 — Guide For Ultrapure Water System Used in Semiconductor Processing

4.2 *ASTM Standards*[1]

ASTM D859 — Standard Test Method for Silica in Water

ASTM D4327 — Standard Test Method for Anions in Water by Chemically Suppressed Ion Chromatography

ASTM D4517 — Standard Test Method for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy

ASTM D5127 — Standard Guide for Ultra Pure Water Used in the Electronics and Semiconductor Industry

ASTM D5173 — Standard Test Method for On-Line Monitoring of Carbon Compounds in Water by Chemical Oxidation, by UV Light Oxidation, by Both, or by High Temperature Combustion Followed by Gas Phase NDIR or by Electrolytic Conductivity

ASTM D5391 — Standard Test Method for Electrical Conductivity and Resistivity of a Flowing High Purity Water Sample

ASTM D5544 — Standard Test Method for On-Line Measurement of Residue After Evaporation of High-Purity Water

ASTM D6317 — Standard Test Method for Low Level Determination of Total Carbon, Inorganic Carbon and Organic Carbon in Water by Ultraviolet, Persulfate Oxidation, and Membrane Conductivity Detection

ASTM D7126 — Standard Test Method for On-Line Colorimetric Measurement of Silica

ASTM F1094 — Test Method for Microbiological Monitoring of Water Used for Processing Electron and Microelectronic Devices by Direct- Pressure Tap Sampling Valve and by the Pre-Sterilized Plastic Bag Method

4.3 *Other Documents*

International Technology Roadmap for Semiconductors (ITRS)[2]

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

5 Terminology

5.1 General terms and acronyms used in this standard are listed and defined in SEMI F61.

6 Use of the Guidelines

6.1 Supplemental information, including recommendations on how to use this Document, is provided at the end of the guide. The supplemental information is critical to understanding the intent of this Guide.

[1] American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, USA. Telephone: 610.832.9585; Fax: 610.832.9555; http://www.astm.org

[2] http://www.itrs.net

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6.2 The supplemental information should be considered when making decisions on UPW performance requirements. Any additional data about manufacturing process sensitivities should also be considered when making a final decision about appropriate UPW quality.

7 Units

7.1 Parts per million (ppm) is equivalent to µg/mL or mg/L, where 1 L approximately equals 1 kg.

7.2 Parts per billion (ppb) is equivalent to ng/mL or µg/L, where 1 L approximately equals 1 kg.

7.3 Parts per trillion (ppt) is equivalent to pg/mL or ng/L, where 1 L approximately equals 1 kg.

7.4 Micrometer (µ) is a unit of length equal to one millionth of a meter, or one thousandth of a millimeter.

7.5 Colony forming units (CFU) is a measurement of bacteria organisms as referred to in ASTM F1094.

8 Description of Parameter Tests

NOTE 2: SEMI Guides do not require analytical data to support analytical methods, therefore the recommendations of specific analytical methods are only for informational purposes. Alternative methods may also be applicable (see SEMI C1 for analytical validation methodology).

8.1 *Resistivity (megohm·centimeters or MΩ·cm)*

8.1.1 Resistivity (conductivity) is measured accurately with only on-line instrumentation. 18.18 MΩ·cm is the theoretical upper limit for pure water at 25°C.

8.2 *Temperature*

8.2.1 Temperature stability (K) is defined as a range of the temperature deviation from the facility-specified temperature target. The temperature is measured with an on-line sensor installed inline.

8.2.2 Temperature gradient (K per interval) is defined as the rate of change of temperature within a specific interval of time.

8.3 *Non-volatile Residue (NVR)*

8.3.1 NVR or a residue after evaporation (usually expressed in units of ppt) is measured using an online, NVR monitor.

8.4 *Total Organic Carbon (TOC) (usually expressed in units of ppb) also known as Total Oxidizable Carbon*

8.4.1 Conductivity cells or infrared photometry can be used to measure the carbon dioxide created by the oxidation of organic materials.

8.5 Dissolved oxygen (usually expressed in units of ppb) is measured accurately with only on-line instrumentation.

8.6 *Particulate Matter (Particles/L)*

8.6.1 Currently, accurate trend analysis requires online methods using optical particle counters.

8.7 *Bacteria (CFU/L)*

8.7.1 Triplicate samples are cultured based on the ASTM F1094 using a minimum sample size of 1 L.

8.8 *Silica*

8.8.1 Total Silica (usually expressed in units of ppb) is measured by graphite furnace atomic absorption spectrophotometry (GFAAS), inductively-coupled plasma atomic emission spectroscopy (ICP-AES), or high resolution-inductively coupled plasma-mass spectroscopy (HR-ICP-MS).

8.8.2 Dissolved silica (usually expressed in units of ppb as SiO_2) is measured by heteropoly blue photometry, or by ion chromatography.

8.9 *Ions and Metals (usually expressed in units of ppt)*

8.9.1 Anions and cations such as ammonium, bromide, chloride, fluoride, nitrate, nitrite, phosphate, and sulfate, can be detected using ion chromatography.

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