Designation: D 5127 – 99

Standard Guide for Ultra Pure Water Used in the Electronics and Semiconductor Industry[1]

This standard is issued under the fixed designation D 5127; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides recommendations for water quality related to current electronics and semiconductor industry requirements.

1.2 Water is used for washing and rinsing of semiconductor components during manufacture. It is also used for cleaning and etching operations, making steam for oxidation of silicon surfaces, photomask preparation and luminescent material deposition. Other applications are in the development and fabrication of solid state, thin film, communication lasers, light emitting diodes, photo-detectors, printed circuits, memory, vacuum tube, or electrolytic devices.

1.3 This guide also provides recommendations for ultra pure water quality related to industry requirements for production of devices having line widths from 5 to 0.18 µm.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1129 Terminology Relating to Water[2]

D 1193 Specification for Reagent Water[2]

D 1976 Test Method for Elements in Water by Inductively-Coupled Argon Plasma Atomic Emission Spectroscopy (ICP-AES)[2]

D 2791 Test Method for Continuous Determination of Sodium in Water[2]

D 3919 Practice for Measuring Trace Elements in Water by Graphite Furnace Atomic Absorption Spectrophotometry[2]

D 4191 Test Method for Sodium in Water by Atomic Absorption Spectrophotometry[2]

D 4192 Test Method for Potassium in Water by Atomic Absorption Spectrophotometry[2]

D 4327 Test Method for Anions by Chemically Suppressed Ion Chromatography[2]

D 4453 Practice for Handling of Ultra Pure Water Samples[2]

D 4517 Test Method for Low-Level Total Silica in High-Purity Water by Flameless Atomic Absorption Spectroscopy (GFAAS)[3]

D 4779 Test Method for Total, Organic or Inorganic Carbon in High-Purity Water by Ultraviolet (UV) or Both, or by High Temperature Combustion Followed by Gas Phase NDIR or Electrolytic Conductivity[3]

D 5173 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 Electrolytic Conductivity[2]

D 5391 Test Method for Electrical Conductivity and Resistivity of a Flowing High Purity Water Sample[2]

D 5462 Test Method for On-Line Measurement of Dissolved Oxygen in Water[2]

D 5542 Test Methods for Trace Anions in High Purity Water by Ion Chromatography[2]

D 5544 Test Method for On-Line Measurement of Residue after Evaporation of High-Purity Water[2]

D 5673 Test Method for Elements in Water by Inductively-Coupled Argon Plasma Mass Spectrometry (ICP-MS)[2]

D 5996 Test Method for Measuring Anionic Contaminants in High-Purity Water by On-Line Ion Chromatography[2]

D 5997 Test Method for On-Line Monitoring of Total Carbon, Inorganic Carbon, in Water by Ultraviolet, Persulfate Oxidation, and Membrane Conductivity Detection[2]

F 1094 Test Methods 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. Terminology

3.1 *Definitions*— For definitions of terms used in this guide refer to Terminology D 1129.

[1] This guide is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.02 on General Specifications, Technical Resources, and Statistical Methods.

Current edition approved June 10, 1999. Published September 1999. Originally published as D 5127 – 90. Last previous edition D 5127 – 98.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 11.02.

[4] *Annual Book of ASTM Standards*, Vol 10.04.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *endotoxins*, *n*—substances or by-products usually produced by gram negative microorganisms that give a positive test for pyrogens, determined in accordance with the limulus lysate test (9.2).

3.2.2 *total bacterial counts*, *n*—total number of viable microorganisms present in the named sample, excluding anaerobic organisms, determined in accordance with Test Methods F 1094.

3.2.3 *total organic carbon (TOC)*, *n*—carbon measured after inorganic carbon response has been eliminated by one of the prescribed ASTM test methods (such as elimination in accordance with Test Method D 4779).

3.2.4 *water*, *n*—water prepared in accordance with Specification D 1193, reagent grade Type I.

4. Significance and Use

4.1 This guide recommends the water quality required for the electronic and microelectronic industry. High purity water is required to prevent contamination of products during manufacture, which would otherwise result in an unacceptable, low yield of electronic devices.

4.2 The range of water purity is defined in accordance with the manufacturing process. The types of ultra pure water are defined with respect to device line width.

4.3 The limits on the impurities are related to current contamination specifications and to available analytical methods performed in a suitable, clean laboratory or using on-line methods. On-line and off-line methods are used in accordance with current industry practice. Concentration of the sample may be required to measure the impurities at the levels indicated in Table 1.

TABLE 1 Requirements for Water Used in the Electronics and Semiconductor Industry

Parameter	Type E-1	Type E-1.1	Type E-1.2	Type E-2	Type E-3	Type E-4
Linewidth (microns)	1.0–0.5	0.5–0.25	0.25–0.18	5.0–1.0	> 5.0	—
Resistivity, 25°C	18.2	18.2	18.2	17.5	12	0.5
Endotoxin unit (EU/mL)	0.03	0.03	0.03	0.25	—	—
TOC (µg/L)	5	2	1	50	300	1000
Dissolved oxygen (µg/L)	1	1	1	—	—	—
Residue after evaporation (µg/L)	1	0.5	0.1	—	—	—
SEM particles/L (micron range)						
0.1–0.2	1000	1000	200	—	—	—
0.2–0.5	500	500	100	3000	—	—
0.5–1	50	50	1	—	10 000	—
10	—	—	—	—	—	100 000
On-line particles/L (micron range)						
0.05–0.1	500	500	100	—	—	—
0.1–0.2	300	300	50	—	—	—
0.2–0.3	50	50	20	—	—	—
0.3–0.5	20	20	10	—	—	—
> 0.5	4	4	1	—	—	—
Bacteria/100 mL						
100 mL Sample	1	1	1	—	—	—
1 L Sample	1	1	0.1	10	10 000	100 000
Silica – total (µg/L)	3	0.5	0.5	10	50	1000
Silica – dissolved (µg/L)	1	0.1	0.05	—	—	—
Ions and metals (µg/L)						
Ammonium	0.1	0.10	0.05	—	—	—
Bromide	0.1	0.05	0.02	—	—	—
Chloride	0.1	0.05	0.02	1	10	1000
Fluoride	0.1	0.05	0.03	—	—	—
Nitrate	0.1	0.05	0.02	1	5	500
Nitrite	0.1	0.05	0.02	—	—	—
Phosphate	0.1	0.05	0.02	1	5	500
Sulfate	0.1	0.05	0.02	1	5	500
Aluminum	0.05	0.02	0.005	—	—	—
Barium	0.05	0.02	0.001	—	—	—
Boron	0.05	0.02	0.005	—	—	—
Calcium	0.05	0.02	0.002	—	—	—
Chromium	0.05	0.02	0.002	—	—	—
Copper	0.05	0.02	0.002	1	2	500
Iron	0.05	0.02	0.002	—	—	—
Lead	0.05	0.02	0.005	—	—	—
Lithium	0.05	0.02	0.003	—	—	—
Magnesium	0.05	0.02	0.002	—	—	—
Manganese	0.05	0.02	0.002	—	—	—
Nickel	0.05	0.02	0.002	1	2	500
Potassium	0.05	0.02	0.005	2	5	500
Sodium	0.05	0.02	0.005	1	5	1000
Strontium	0.05	0.02	0.001	—	—	—
Zinc	0.05	0.02	0.002	1	5	500