

SEMI F21-1016

CLASSIFICATION OF AIRBORNE MOLECULAR CONTAMINANT LEVELS IN CLEAN ENVIRONMENTS

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NOTICE: The section symbol (§) is used to reference a numbered section, paragraph, or header and all subordinate paragraphs, headers, and embedded material (i.e., EXCEPTIONs, lists) therein. The paragraph symbol (§) is used to reference a particular numbered paragraph and embedded material therein. When duplicated (i.e., §§ and §§) the symbols are used to reference more than one section or paragraph, respectively.

NOTICE: This Standard was completely rewritten in 2016.

1 Purpose

1.1 The purpose of this Standard is to classify microelectronics clean environments with respect to their molecular (non-particulate) contaminant levels. This Classification provides a consistent means of communicating acceptable contaminant levels of groups of specific airborne molecular contaminants. Refer to Related Information 1 appended to this Standard.

2 Scope

2.1 This Classification is to be used in the specification of semiconductor clean environments (including process tool environments) and of contamination control and measurement equipment performance.

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 Referenced Standards and Documents

3.1 None.

4 Terminology

4.1 Definitions

4.1.1 *acid* — a corrosive material whose chemical reaction characteristic is that of an electron acceptor.

4.1.2 *base* — a corrosive material whose chemical reaction characteristic is that of an electron donor.

4.1.3 *condensable* — a substance (other than water), typically having a boiling point above room temperature at atmospheric pressure, capable of condensation on a clean surface.

4.1.4 *dopant* — a chemical element which modifies the electrical properties of a semiconductor material.

4.1.5 *metal* — a trace metal that may exist either in elemental form such as Al, W, Mn, Pb, etc., or as a compound, such as AlCl₃, WF₆, etc.

5 Basis of Classification

5.1 Classification is by the maximum allowable total gas phase concentration of each category of material. This classification system is depicted in § 6. The combination of a quantitative class for each of the four categories yields a classification describing an environment.

5.2 The maximum cumulative gas phase concentrations of the four categories may be different.

5.3 Each category is designated by the letter ‘M,’ followed by the first letter of the category name A, B, C, D or M.

5.4 The integer following the category designator shall indicate the maximum total gas phase concentration in parts per trillion molar (pptm 1×10^{-12}). For example, a category MA-10 has a maximum allowable total concentration of 10 parts per trillion molar for the category of interest.

6 Classification

Table 1

<i>Material Category</i>	<i>1^{#1}</i>	<i>10^{#1}</i>	<i>100^{#1}</i>	<i>1000^{#1}</i>	<i>10,000^{#1}</i>
Acids	MA-1	MA-10	MA-100	MA-1000	MA-10,000
Bases	MB-1	MB-10	MB-100	MB-1000	MB-10,000
Condensables	MC-1	MC-10	MC-100	MC-1000	MC-10,000
Dopants	MD-1	MD-10	MD-100	MD-1000	MD-10,000
Metals	MM-1	MM-10	MM-100	MM-1000	MM-10,000

#1 Concentration, in parts per trillion.

6.1 Molecular acids mainly comprise of hydrofluoric acid, hydrochloric acid, sulfuric acid and nitric acids. Acids in clean environment have detrimental effects in semiconductor manufacturing such as thin film defects, high contact resistance, corrosion of metallic films etc.

6.2 Molecular bases mainly comprise of ammonia, amines and amides. Bases in clean environment also have similar negative effects as molecular acids.

6.3 Molecular condensables include plasticizers, antioxidants, phosphates and silicones. Condensables can cause gate oxide integrity problems, delamination of thin films, and hazing of optics and masks used in lithography tools.

6.4 Molecular dopants in cleanroom air are a result of reaction of acids with borosilicate glass used in HEPA and ULPA filters. They also originate from the flame retardants such as TEP (triethylphosphate) used in filtration systems.

6.5 Molecular metals comprise of elements such as Al, W, Mn, etc. that may be by products of reaction chemistries utilized in semiconductor manufacturing. Increasing use of organometallic precursors in processes such as atomic layer deposition (ALD) will likely contribute to increased presence of molecular metals in clean environments.

7 Reference Test Methods

7.1 Test methods for detecting airborne molecular contaminants include thermal desorption-gas chromatography mass spectroscopy (TD-GCMS), vapor phase decomposition inductively coupled plasma-mass spectroscopy (VPD ICP-MS), ion mobility spectroscopy (IMS), vapor phase decomposition-atomic absorption spectroscopy (VPD-AAS), vapor phase decomposition-total reflection x-ray fluorescence (VPD-TXRF), etc. Specifics of test methods are beyond the scope of this Standard. User is urged to refer to Related Documents.

8 Related Documents

8.1 SEMI Standards and Safety Guidelines

SEMI E45 — Test Method for the Determination of Inorganic Contamination from Minienvironments Using Vapor Phase Decomposition-Total Reflection X-Ray Spectroscopy (VPD-TXRF), VPD-Atomic Absorption Spectroscopy (VPD-AAS), or VPD/Inductively Coupled Plasma-Mass Spectrometry (VPD/ICP-MS)

SEMI E46 — Test Method for the Determination of Organic Contamination from Minienvironments Using Ion Mobility Spectrometry (IMS)

8.2 Other Documents

8.2.1 Alvarez, D., Jr., Tram, A., and Holmes, R.J. "Measurement and Control of Airborne Molecular Contamination During Wafer Storage and Transport." *Solid State Phenomena*, Vols. 103–104 (2004): pp. 259–264.

8.2.2 Berro, N., Cook, J.P.D., *et al.* "Airborne Contamination of Semiconductor Wafers Traced to Humidification Plant Additives." *Journal of the IES*, November 1993, pp. 15–18.