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RULE 1164
Semiconductor Manufacturing

(a) Applicability

This rule is applicable to all direct, indirect, and support stations associated with the manufacture or production of semiconductor devices. Semiconductor device manufacturing includes all processing from crystal growth through circuit separation and encapsulation, including wafer production, oxidation, photoresist operation, etching, doping, and epitaxial growth operation.

(b) Definitions

For the purpose of this rule, the following definitions apply:

(1) APPROVED EMISSION CONTROL SYSTEM means any system used to reduce VOC emissions and consists of a collection and control device, which are approved in writing by the Executive Officer. The emission control system shall have an overall efficiency of at least 90 percent.

(2) EXEMPT COMPOUNDS are any of the following compounds:

(A) Group I (General)
trifluoromethane (HFC-23)
pentafluoroethane (HFC-125)
1,1,2,2-tetrafluoroethane (HFC-134)
tetrafluoroethane (HFC-134a)
1,1,1-trifluoroethane (HFC-143a)
1,1-difluoroethane (HFC-152a)
chlorodifluoromethane (HCFC-22)
dichlorotrifluoroethane (HCFC-123)
2-chloro-1,1,1,2-tetrafluoroethane (HCFC-124)
dichlorofluoroethane (HCFC-141b)
chlorodifluoroethane (HCFC-142b)
cyclic branched, or linear, completely fluorinated alkanes
cyclic branched, or linear, completely fluorinated ethers with no unsaturations
cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations
sulfur-containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine

(B) Group II
methylene chloride
1,1,1-trichloroethane (methyl chloroform)
trichlorotrifluoroethane (CFC-113)
dichlorodifluoromethane (CFC-12)
trichlorofluoromethane (CFC-11)
dichlorotetralfuoroethane (CFC-114)
chloropentafluoroethane (CFC-115)

The use of Group II compounds and/or carbon tetrachloride may be restricted in the future because they are toxic, potentially toxic, upper atmospheric ozone depleters, or cause other environmental impacts. By January 1, 1996, production of chlorofluorocarbons (CFC), 1,1,1-trichloroethane (methyl chloroform), and carbon tetrachloride will be phased out in accordance with the Code of Federal Regulations Title 40, Part 82 (December 10, 1993).

(3) FREEBOARD HEIGHT is the distance from the top of the solvent or solvent overflow drain to the top of the sink or reservoir.

(4) FREEBOARD RATIO is the freeboard height divided by the smaller of the length or width of the sink or reservoir.

(5) GRAMS OF VOC PER LITER OF COATING, LESS WATER AND LESS EXEMPT COMPOUNDS, is the weight of VOC per combined volume of VOC and coating solids, and can be calculated by:

Grams of VOC per Liter of Coating Less Water and Less Exempt Compounds =

$$\frac{W_s - W_w - W_{es}}{V_m - V_w - V_{es}}$$

Where:
W_s = weight of volatile compounds in grams
W_w = weight of water in grams
W_{es} = weight of exempt compounds in grams
V_m = volume of material in liters
V_w = volume of water in liters
V_{es} = volume of exempt compounds in liters

(6) GRAMS OF VOC PER LITER OF MATERIAL is the weight of VOC per volume of material and can be calculated by:

Grams of VOC per Liter of Material = $$\frac{W_s - W_w - W_{es}}{V_m}$$

Where: W_s = weight of volatile compounds in grams
W_w = weight of water in grams
W_{es} = weight of exempt compounds in grams
V_m = volume of material in liters

(7) MASKING is applying a photoresist maskant material or overlaying a stencil to apply, impress, transfer, or otherwise effect a pattern on or into another substance.

(8) PHOTORESIST MASKANT, MASKANT, OR PHOTORESIST is a coating applied directly to a component to protect surface areas when chemical milling, etching, or other chemical surface operations are performed on the component.

(9) PHOTORESIST OPERATION is a process for the application and development of photoresist masking solution on a wafer, including preparation (except primary cleaning), soft bake, develop, hard bake, and stripping, and can be generally subdivided as follows:

(A) NEGATIVE PHOTORESIST OPERATION is a process where the maskant hardens when exposed to light and the unhardened maskant is stripped, exposing the wafer surface for etching.

(B) POSITIVE PHOTORESIST OPERATION is a process where the maskant softens when exposed to light and the softened maskant is stripped, exposing the wafer surface for etching.

(10) SEMICONDUCTOR MANUFACTURE is any process or operation performed to produce semiconductor devices or related solid state devices. It may include but is not limited to the manufacturing of diodes, zeners, stacks, rectifiers, integrated microcircuits, transistors, solar cells, light-sensing devices, and light-emitting devices.

(11) SOLVENT is any material containing VOC or any exempt compound that dissolves or can dissolve another substance. Developers and stripping agents that contain VOC or any exempt compound are included as solvents.

(12) SOLVENT CLEANING STATION is a workplace equipped to remove surface contaminants using a liquid or vapor solvent containing volatile organic compounds.

(13) STRIPPING is the removal of spent photoresist maskant from the product after etching, or the removal of oxide stencil from the product after diffusion.

(14) VOC COMPOSITE PARTIAL PRESSURE is the sum of the partial pressures of the compounds defined as VOCs.

VOC Composite Partial Pressure is calculated as follows:

$$PP_c = \sum_{i=1}^{n} \frac{\dfrac{W_i}{MW_i} \times VP_i}{\dfrac{W_w}{MW_w} + \dfrac{W_e}{MW_e} + \sum_{i=1}^{n} \dfrac{W_i}{MW_i}}$$

Where:

- W_i = Weight of the "i"th VOC compound, in grams
- W_w = Weight of water, in grams
- W_e = Weight of exempt compound, in grams
- MW_i = Molecular weight of the "i"th VOC compound, in grams per gram-mole
- MW_w = Molecular weight of water, in grams per gram-mole
- MW_e = Molecular weight of exempt compound, in grams per gram-mole
- PP_c = VOC composite partial pressure at 20°C, in mm Hg
- VP_i = Vapor pressure of the "i"th VOC compound at 20°C, in mm Hg

(15) VOLATILE ORGANIC COMPOUND (VOC) is any volatile compound containing the element carbon excluding methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, ammonium carbonate, and exempt compounds.

(c) Requirements

(1) Solvent Cleaning Stations

A person shall not operate a solvent cleaning station at a semiconductor manufacturing facility unless the following requirements are satisfied.

(A) All heated or unheated reservoirs, sinks, tanks and containers which transfer, store, or hold VOC-containing material shall be provided with a full cover or an approved emission control system. These covers must remain closed except while production, sampling, maintenance, or loading or unloading procedures require operator access.

(B) All heated or unheated reservoirs and sinks holding VOC-containing fluids with a VOC composite partial pressure of 33 mm Hg or less at 20°C (68°F), shall have a freeboard ratio greater than or equal to 1.0, or be equipped with an approved emission control system.

(C) Solvent flow of VOC-containing materials shall be applied in a continuous unbroken stream and in a manner which shall prevent liquid loss resulting from splashing.

(D) Liquid solvent leaks of 3 drops per minute or more shall be repaired within 24 hours of detection or the equipment shall be shut down until replaced or repaired.

(E) All equipment at a solvent cleaning station shall be operated and maintained in proper working order.

(2) Photoresist Operations

A person shall not allow photoresist operations at a semiconductor manufacturing facility unless the VOC-containing vapors are vented to an approved emission control system.

(3) Cleanup Solvents

A person shall not use VOC-containing materials for the purpose of cleaning equipment at a semiconductor manufacturing facility unless the following requirements are satisfied.

(A) The VOC content of the fluid shall not exceed 200 grams per liter (1.7 pounds per gallon) of material; or the VOC composite partial pressure shall not exceed 33 mm Hg (0.64 psia) at a temperature of 20°C

(B) (68°F); or the components being cleaned are totally enclosed during the washing, rinsing, and draining processes; or the cleanup solvents are flushed or drained in a manner that does not allow evaporation into the atmosphere; and

(C) only nonabsorbent, closed containers shall be used for the storage, transfer, or disposal of all VOC-containing accessories which include, but are not limited to, cloth, paper, and other materials clearly used for cleanup with solvents.

(4) Alternative Emission Control Plan

An owner/operator may achieve compliance with subparagraph (c)(1) and/or (c)(2) by means of an Alternative Emission Control Plan pursuant to Rule 108.

(5) Recordkeeping

Notwithstanding the provisions of subdivision (g), records shall be maintained pursuant to Rule 109.

(d) Prohibition of Specifications

A person shall not specify the use of any VOC-containing material for any process or operation within the SCAQMD, subject to the provisions of this rule, that does not meet the requirements of this rule. This prohibition shall apply to all written or oral contracts.

(e) Test Methods

(1) Determination of VOC Content

The VOC content of materials subject to the provisions of this rule shall be determined by the following the methods:

(A) United States Environmental Protection Agency (USEPA) Reference Method 24 (Code of Federal Regulations Title 40 Part 60, Appendix A). The exempt compound content shall be determined by SCAQMD Method 303 (Determination of Exempt Compounds) contained in the SCAQMD "Laboratory Methods of Analysis for Enforcement Samples" manual; or,

(B) SCAQMD Method 304 [Determination of Volatile Organic Compounds (VOC) in Various Materials] contained in the SCAQMD "Laboratory Methods of Analysis for Enforcement Samples" manual.

(C) Exempt Perfluorocarbon Compounds

The following classes of compounds:
- cyclic, branched, or linear, completely fluorinated alkanes;
- cyclic, branched, or linear, completely fluorinated ethers with no unsaturations;
- cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations; and
- sulfur-containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine,

will be analyzed as exempt compounds for compliance with paragraph (c), only when manufacturers specify which individual compounds are used in the coating formulation. In addition, the manufacturers must identify the USEPA, the California Air Resources Board, and the SCAQMD approved test methods used to quantify the amount of each exempt compound.

(2) Determination of VOC Composite Partial Pressure

The identity and quantity of components in solvents shall be determined by SCAQMD Method 308 (Quantitation of Compounds by Gas Chromatography) contained in the SCAQMD "Laboratory Methods of Analysis for Enforcement Samples" manual. The VOC composite partial pressure is calculated using equation in paragraph (b)(14).

(3) Determination of Efficiency of Emission Control System

(A) The efficiency of the collection device of the emission control system as specified in subparagraph (c)(1)(A) and (c)(1)(B) shall be determined by the USEPA method cited in 55 Federal Register 26865 (June 29, 1990), or any other method approved by the USEPA, the California Air Resources Board, and the SCAQMD.

(B) The efficiency of the control device of the emission control system as specified in subparagraph (c)(1)(A) and (c)(1)(B),and the VOC content in the control device exhaust gases, measured and calculated as carbon, shall be determined by USEPA Test Methods 25, 25A, or SCAQMD Method 25.1 (Determination of Total Gaseous Non-Methane Organic Emissions as Carbon) as applicable. USEPA Test Method 18, or ARB

(C) Method 422 shall be used to determine emissions of exempt compounds.

(4) Multiple Test Methods

When more than one test method or set of test methods are specified for any testing, a violation of any requirement of this rule established by any one of the specified test methods or set of test methods shall constitute a violation of the rule.

(5) All test methods referenced in this section shall be the most recent approved version.

(f) Rule 442 Applicability

Any operation or facility which is exempt from all or a portion of this rule shall comply with the provisions of Rule 442.

(g) Exemptions

The provisions of this rule shall not apply to facilities that produce less than five pounds of total VOC emissions over any continuous 24-hour period.

[SIP: Approved 2/1/96, 61 FR 3579, 40 CFR 52.220(c)(215)(i)(A)(4); Limited Approval/ Disapproval 9/29/93, 58 FR 50850, 40 CFR 52.220(c)9184)(i)(B)(2)]

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