SEMI F105-0708
GUIDE FOR METALLIC MATERIAL COMPATIBILITY IN GAS DISTRIBUTION SYSTEMS

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1 Purpose

1.1 The purpose of this guide is to document the industry acceptable compatibility of metallic materials with semiconductor process gases.

2 Scope

2.1 This guide is applicable to metallic materials that are exposed to process gases within the gas distribution systems of semiconductor manufacturing equipment. It is not applicable to high pressure, bulk delivery systems.

2.2 This guide is specific to High Purity and Ultra-High Purity chemical delivery systems.

NOTICE: This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard 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 only applicable when the process gases have less than 1 ppm water vapor. Higher levels of water vapor in some process gases other than the inert category have been known to cause corrosion in gas delivery systems.

3.2 This guide is only applicable for temperatures less than 60°C. At temperatures above 60°C, corrosion mechanisms such as stress corrosion cracking may occur and more detailed analysis is recommended.

3.3 The compatibility is limited to the gas phase of the chemistries listed. Liquid phase compatibility is not considered in this Guide.

3.4 This guide only addresses the degradation of the metallic materials when exposed to the applicable chemistries. It does not address potential issues associated with catalytic decomposition of gases in the presence of metal alloys. For information on this subject, see the Proceedings of the Institute of Environmental Sciences[1].

4 Referenced Standards and Documents

4.1 *SEMI Standards*

SEMI E52 — Practice for Referencing Gases, Gas Mixtures, and Vaporizable Materials Used in Digital Mass Flow Controllers

SEMI F19 — Specification for the Surface Condition of the Wetted Surfaces of Stainless Steel Components

SEMI F20 — Specification for 316L Stainless Steel Bar, Forgings, Extruded Shapes, Plate, and Tubing for Components Used in General Purpose, High Purity and Ultra-High Purity Semiconductor Manufacturing Applications

4.2 *ASTM Standard*[2]

ASTM F2063 — Standard Specification for Wrought Nickel-Titanium Shape Memory Alloys for Medical Devices and Surgical Implants

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1 Yasuyauki Shirai, Seok-kui Lee, Shinji Miyoshi, and Tadahiro Ohmi,"The Evaluation of Thermal Decomposition Characteristics of Active Specialty Gases on Various Metal Surfaces using FTIR Method," *Proceedings of the Institute of Environmental Sciences, 1995*

2 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

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4.3 *SAE International*[3]

HS-1086 — Metals and Alloys in the Unified Numbering System

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

5 Terminology

5.1 *Abbreviations and Acronyms*

5.1.1 *UNS* — Unified Numbering System

5.1.2 *ppm* — parts per million by volume

5.2 *Definitions*

5.2.1 *halides* — binary compounds, one part of which is a halogen atom and the other part is an element or a radical that is less electronegative than the halogen.

5.2.2 *halogenated hydrocarbons* — hydrocarbons with one or more hydrogen atoms substituted by halogen atoms.

5.2.3 *halogens* — elements in Group 17 (Old style VIIA) of the periodic table, namely, Fluorine, Chlorine, Bromine and Iodine.

5.2.4 *hydrocarbons* — gases with a chemical structure consisting of only carbon and hydrogen elements. These gases have a carbon backbone and have hydrogen atoms attached to this backbone.

5.2.5 *hydrides* — compounds of hydrogen with a more electropositive element.

5.2.6 *inerts* — gases that are not reactive under normal conditions.

5.2.7 *oxides* — compounds of oxygen with other elements.

6 Metallic Material Compatibility

6.1 *Baseline Material* — The Ultra High Purity grade material described in SEMI F20 when combined with the Ultra High Purity grade conditioning of the surfaces as described in SEMI F19 is assumed to be compatible with all process gases used in chemical delivery systems for semiconductor manufacturing equipment (within the limitations described in § 3).

6.2 *Alternate Materials* — Alternate materials other than the Ultra High Purity grade material described by SEMI F19 and SEMI F20 may be allowed in chemical delivery systems. The materials considered by this Guide are described in Table 1. UNS numbers are used (where possible) to identify the chemical composition and unless otherwise noted, all commercial alloys that comply with the applicable UNS/ASTM specification are considered equivalent. If listed as compatible (see Table 3), these alternative materials are considered to be at least as resistant to reaction as the Ultra High Purity grade material defined in SEMI F19/SEMI F20.

Table 1 Alternative Metallic Materials

Metal Alloy	*Alloy Class*
S31603 UHP	Austenitic Stainless Steel (SEMI F19/SEMI F20 Ultra High Purity Grade)
S31603 HP	Austenitic Stainless Steel (SEMI F19/SEMI F20 High Purity Grade)
S31603 GP	Austenitic Stainless Steel (SEMI F19/SEMI F20 General Purpose Grade)
S31603	Austenitic Stainless Steel
S31600	Austenitic Stainless Steel
N06625	Nickel Based Alloy
N06600	Nickel Based Alloy
N07750	Nickel Based Alloy

3 SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001 USA. Telephone: 877.606.7323; Fax: 248.273.2494; http://www.sae.org

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Metal Alloy	*Alloy Class*
N08825	Nickel Based Alloy
R30003	Cobalt Based Alloy
R30004	Cobalt Based Alloy
N06022	Nickel Based Alloy
N10276	Nickel Based Alloy
Spron® 100	Cobalt Based Alloy
Spron® 510	Cobalt Based Alloy
N02200	Non-Ferrous Alloy
S31703	Austenitic Stainless Steel
S31726	Austenitic Stainless Steel
S32100	Austenitic Stainless Steel
S31254	Super Austenitic Stainless Steel
N08367	Super Austenitic Stainless Steel
N08020	Super Austenitic Stainless Steel
S32205	Duplex Stainless Steel
S32750	Super Duplex Stainless Steel
N07718	Nickel Based Alloy
S31277	Super Austenitic Stainless Steel
S30200	Austenitic Stainless Steel
S30400	Austenitic Stainless Steel
N04400	Non-Ferrous Alloy
ASTM F2063	Shape Memory Alloy
KM38®	Ferritic Stainless Steel
KM45®	Ferritic Stainless Steel

NOTE 1: The UNS number is derived from the SAE International/ASTM book "Metals and Alloys in the Unified Numbering System".

NOTE 2: The Spron® materials do not have UNS numbers. For detailed information of the chemical composition of these alloys, contact Seiko Instruments Incorporated.

NOTE 3: The KM38 and KM45 materials do not have a UNS number. For detailed information of the chemical composition of these alloys, contact Tohoku Steel Company Ltd.

6.3 *Process Gases* — The process gases were derived from SEMI E52. The categorization is based on expected reaction mechanisms and is not related to safety classifications.

Table 2 Applicable Process Gases by Category

Category	*Gases*	*Formula*	*SEMI Gas Code*
Inerts	Nitrogen	N_2	13
	Argon	Ar	4
	Xenon	Xe	6
	Helium	He	1

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