

SEMI F51-0917

GUIDE FOR ELASTOMETRIC SEALING TECHNOLOGY

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1 Purpose

1.1 O-rings were originally developed for industrial markets and much later for aerospace. Current industry standards do not specifically relate to semiconductor seal performance. This Document is a basic guide for the use of seals in semiconductor fabrication equipment. This Document also provides guidance for choosing appropriate sealing materials by understanding their diverse chemical and physical properties for various process applications in order to reduce cost of ownership and improve uptime of the process equipment in which seals are incorporated. Furthermore, this Document establishes terminology that enables communication among equipment users, suppliers, OEMs, and seal manufacturers especially when actual performance of the equipment is being discussed. Finally, this Document provides information on proper seal cleanliness, packaging, and handling aimed to maintain optimum seal performance.

2 Scope

2.1 This Guide is applicable to the use of seals in operating environments used in the fabrication of semiconductor devices. This Guide will aid in defining the criteria by which sealing performance can be judged in comparable measurements and seal materials can be chosen.

2.2 Considerations for seal performance in semiconductor equipment and components are provided in Table 1.

Table 1 Relative Importance of Seal Performance Criteria with Regard to Various Applications/Process Areas (Rate 1-5, 1: most important; 5: least important)

<i>Applications /Process areas</i>	<i>Wet Etch</i>	<i>Dry Etch</i>	<i>CVD/PVD</i>	<i>Diffusion</i>	<i>Sub-Fab</i>
<i>Properties</i>					
<i>Specifications</i>					
<i>Sealing Characteristics</i>					
Seal Etch Rate	5	1	3	5	2
Sealing Force Retention	1	1	1	1	1
<i>Impurities</i>					
Leachable	1	5	5	5	3
Ash	5	1	1	1	2
Outgassing	5	2	1	3	5
Permeation	5	1	1	3	3
TOC	1	5	5	2	5

2.3 This Guide also provides information on how seals are cleaned and packaged at the supplier site as well as provisions for handling and storing them at the customer site.

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 The application of this Guide is limited to elastomeric seals that are used in semiconductor manufacturing and related process equipment.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI C3 — Specifications for Gases

SEMI D9 — Definitions for Flat Panel Display Substrates

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 E49 — Guide for High Purity and Ultrahigh Purity Piping Performance, Subassemblies, and Final Assemblies

SEMI F21 — Classification of Airborne Molecular Contaminant Levels in Clean Environments

SEMI F40 — Practice for Preparing Liquid Chemical Distribution Components for Chemical Testing

SEMI F57 — Specification of Polymer Materials and Components Used in Ultrapure Water and Liquid Chemical Distribution Systems

SEMI F61 — Guide for Ultrapure Water Systems Used in Semiconductor Processing

SEMI F75 — Guide for Quality Monitoring of Ultrapure Water Used in Semiconductor Manufacturing

SEMI P5 — Specification for Pellicles

SEMI S4 — Safety Guideline for the Separation of Chemical Cylinders Contained in Dispensing Cabinets

4.2 ASTM Standards¹

ASTM D395 — Standard Test Methods for Rubber Property-Compression Set

ASTM D412 — Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension

ASTM D575 — Standard Test Methods for Rubber Properties in Compression

ASTM D1414 — Standard Test Methods for Rubber O-Rings

ASTM D1415 — Standard Test Method for Rubber Property—International Hardness

ASTM D1434 — Standard Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting

ASTM D2240 — Standard Test Method for Rubber Property—Durometer Hardness

ASTM D5904 — Standard Test Method for Total Carbon, Inorganic Carbon, and Organic Carbon in Water by Ultraviolet, Persulfate Oxidation, and Membrane Conductivity Detection

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

4.3 IEST Standards²

IEST-RP-CC031.3 — Method for Characterizing Outgassed Organic Compounds from Cleanroom Materials and Components

¹ ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA; Telephone: +1.610.832.9585, Fax: +1.610.832.9555, <http://www.astm.org>

² Institute of Environmental Sciences and Technology, IEST, Arlington Place One, 2340 S. Arlington Heights Road, Suite 620, Arlington Heights, IL 60005, USA; Telephone: +1.847.981.0100, Fax: +1.847.981.4130, <http://www.iest.org>

4.4 ISO Standards³

ISO 37 — Rubber, Vulcanized or Thermoplastic – Determination of Tensile Stress-Strain Properties

ISO 48 — Rubber, Vulcanized or Thermoplastic – Determination of Hardness (Hardness Between 10 IRHD and 100 IRHD)

ISO 815 — Rubber, Vulcanized or Thermoplastic – Determination of Compression Set – Part 1: At Ambient or Elevated Temperatures

ISO 3601-3N — Fluid power systems — O-rings — Part 3: Quality acceptance criteria

ISO 7619 — Rubber, Vulcanized or Thermoplastic – Determination of Indentation Hardness – Part 1: Durometer Method (Shore Hardness)

ISO 7743 — Rubber, Vulcanized or Thermoplastic – Determination of Compression Stress-Strain Properties

ISO 15105-1 — Plastics – Film and sheeting – Determination of gas-transmission rate – Part 1: Differential-pressure Methods

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *ATM* — atmospheric

5.1.2 *BCDS* — bulk chemical distribution system

5.1.3 *CVD* — chemical vapor deposition

5.1.4 *DI* — deionized

5.1.5 *FTIR* — Fourier transform infrared spectroscopy

5.1.6 *HDP* — high density plasma

5.1.7 *HF* — hydrofluoric acid

5.1.8 *LPCVD* — low pressure chemical vapor deposition

5.1.9 *MOCVD* — metal organic chemical vapor deposition

5.1.10 *OEM* — original equipment manufacturer

5.1.11 *PE* — polyethylene

5.1.12 *ppb* — parts per billion

5.1.13 *PTFE* — polytetrafluoroethylene

5.1.14 *PVD* — physical vapor deposition

5.1.15 *RF* — radio frequency

5.1.16 *RTP* — rapid thermal process

5.1.17 *SEM/EDX* — scanning electron microscopy with energy dispersive X-ray spectroscopy

5.1.18 *TOC* — total oxidizable (organic) carbon

5.1.19 *UPDI* — ultra pure deionized

5.1.20 *UV* — ultraviolet

³ International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.749.01.11, Fax: +41.22.733.34.30, <http://www.iso.org>

5.2 Definitions

5.2.1 *acid* — a corrosive material whose chemical reaction characteristic is that of an electron acceptor. [SEMI F21, SEMI S4]

5.2.2 *anion* — a negatively charged ion that is attracted to an anode in electrolysis.

5.2.3 *cation* — a positively charged ion; an ion that is attracted to the cathode in electrolysis. These are typically ions of metallic elements.

5.2.4 *chemically assisted elastomeric degradation* — the breakdown process of a seal surface caused by polymer degradation that involves a change of the polymer properties due to a chemical reaction with the polymer's surroundings.⁴

5.2.5 *mechanical deformation* — the alteration of a seal caused by mechanical means, such as abrasion, rubbing, and compression.

5.2.6 *chemical property* — a measure of corrosion or attack of a smooth and unattached surface when subjected to a specific reagent, such as acid, base, or water at a specific concentration for a specific time and temperature.

5.2.7 *chemical reaction* — a process that involves change in the structure of ions or molecules.

5.2.8 *seal chemical compatibility* — the ability of the molecules of a seal to coexist with process chemistries without the degradation of either.

5.2.9 *corrosives* — a chemical that causes visible destruction or irreversible alterations by chemical action at the site of contact.

5.2.10 *deionized water* — (specified with resistivity $\geq 18 \text{ M}\Omega/\text{cm}$, cations: Na, Fe, Ca $\leq 0.2 \text{ }\mu\text{g/l}$). [SEMI E45]

5.2.11 *degradation* — a chemical reaction leading to the reduction to a simpler molecular structure. Sometimes also called chemical breakdown.

5.2.12 *ion* — an atom or group of atoms that has lost or gained one or more electrons.

5.2.13 *outgassing* — a phenomenon wherein a substance spontaneously releases volatile constituents in the form of vapors or gases. In rubber compounds, these constituents may include water vapor, plasticizers, air, inhibitors, etc.

5.2.14 *particle* — a minute fragment or quantity of matter.⁵

5.2.15 *permeation* — process by which a gas or liquid to pass through a seal structure by diffusion.

6 Measuring Methodology/Sample Preparation

6.1 Total Organic Carbon (TOC) Testing

6.1.1 Sample preparation and leaching conditions: Follow SEMI F40 and SEMI F57.

6.1.1.1 It is important to maintain sufficient surface area to liquid volume ratio to satisfy the detection limit and specification requirements of SEMI F57 or other applicable specification.

6.1.1.2 TOC leaching test should be conducted using high purity materials for container in order to maintain detection limits within criteria of SEMI F57.

6.1.2 *Testing* — Analyze per ASTM D6317. If carbon content exceeds the limits of ASTM D6317 use ASTM D5904.

6.1.3 TOC Reporting

6.1.3.1 The reporting units are microgram per m^2 .

6.1.3.2 A complete sample description including manufacturer, material type, part number, lot number, processing conditions, surface treatment, cutting or other sample manipulation for testing, and other sample history should be included.

⁴ In Wikipedia, modified on 3 October 2013, at 14:18; from http://en.wikipedia.org/wiki/Chemically_assisted_degradation_of_polymers

⁵ Oxford English Dictionary (3rd ed.). Oxford University Press. September 2005.