

SEMI MS6-0308

GUIDE FOR DESIGN AND MATERIALS FOR INTERFACING MICROFLUIDIC SYSTEMS

This Standard was technically approved by the MEMS Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on December 20, 2007. Available at www.semiviews.org and www.semi.org in February 2008.

NOTICE: This Standard or Safety Guideline has an Inactive Status because the conditions to maintain Current Status have not been met. Inactive Standards or Safety Guidelines are available from SEMI and continue to be valid for use.

1 Purpose

1.1 This Document provides guidelines for general fluidic interface design and materials selection that can reduce redundant engineering effort and lead to improved design, manufacturability, and operation.

2 Scope

2.1 This includes guidance for general microfluidic design and materials considerations. This Document will provide guidance to users involved in design and development of standard fluidic interfaces.

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 SEMI Standards and Safety Guidelines

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

SEMI F1 — Specification for Leak Integrity of High-Purity Gas Piping Systems and Components

SEMI F79 — Guide for Gas Compatibility with Silicon Used in Gas Distribution Components

3.2 U.S. Military Standard¹

MIL-STD-810 — Environmental Engineering Considerations and Laboratory Tests

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

4 Terminology

NOTE 1: Refer to SEMI's Compilation of Terms (COT) for a list of the most current terms and their definitions.

4.1 Abbreviations and Acronyms

4.1.1 *MEMS* — microelectromechanical systems

4.2 Definitions

4.2.1 *dead volume* — sections or volumes in a flow path where a fluid can fill but is not easily available or returned into the flow stream. The fluid in these areas becomes stagnant and purging of the fluid is very inefficient. Not the same as Hold-up volume.

4.2.2 *dynamic seals* — seals that operate with moving surfaces.

4.2.3 *fluidic adapter* — a physical connector that links a microfluidic component to another micro or macroscale fluidic device.

¹ United States Military Standards, Available through the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120-5099, USA; Telephone: +1.215.697.3321.

4.2.4 *high-purity* — of a system, subsystem, or component used for the control of chemicals (gases or liquids), designed and constructed in such a manner that it does not introduce significant impurities, particulate or molecular, into the flow stream it controls or regulates.

NOTE 2: Such systems, subsystems, or components are designed and constructed such that, if an impurity is introduced into the flow path, it can be readily purged to an insignificant level.

4.2.5 *hold-up volume* — the volume of fluid that is required to fill a device before flow is observed at point of interest or at the outlet.

4.2.6 *hydrophilic* — a property of material or molecule to transiently bond with water through hydrogen bonding. A *hydrophilic* surface is typically charge-polarized and can attract water to its surface to form a continuous film. *Hydrophilic* materials can also dissolve more readily in water.

4.2.7 *hydrophobic* — a property of a surface or molecule that is repelled from a mass of water. Water will typically bead or form discrete droplets on a *hydrophobic* material surface. This is characterized by a high contact angle measurement.

4.2.8 *leak* — a path (or paths) in a sealed system that will pass tracer gas when a pressure differential, a concentration differential, or diffusion path exists. There are two leak mechanisms: a mechanical passage and a material through which gas can diffuse or permeate. A leak may have both mechanisms operating in parallel.

4.2.9 *leakage, inboard* — leakage from outside to inside occurring when the internal pressure is less than the external pressure acting on a component or the concentrations of a given component are different inside and outside generating a non-zero chemical potential. Inboard leakage is typically determined by introducing a tracer gas around the exterior of the piping system or component under test.

NOTE 3: Inboard leak tests are easier tests to conduct to high sensitivity levels than outboard tests, but are typically not indicative of pressurized operating conditions. It is difficult to correlate an inboard leak test to the performance of a component, subsystem, or system when under internal pressure. Also, the internal collapsing forces created by external pressure may mask leaks which may exist under pressurized operating conditions.

4.2.10 *macro to micro sealing* — sealing that connects the micro regime with the macro regime.

4.2.11 *macroscale* — generally, the scale of dimensions of 0.1 millimeters or greater.

4.2.12 *macrosealing* — sealing on components at the macroscale.

4.2.13 *macrosealing dimensions* — flow channel cross sections having an effective diameter of >100 micrometers.

4.2.14 *microfluidic subsystem* — a ‘microfluidic subsystem’ in a fluidic system may contain one or many MEMS components. The subsystem contains control and signaling elements. The subsystem, in turn, is attached to a larger system or subsequent process (e.g., mass flow controller for fluid delivery in lab-on-a-chip).

4.2.15 *microfluidics* — fluid transport, physics, and chemistry on microscale dimensions.

4.2.16 *microscale* — generally, the scale of dimensions between 0.1 microns to 100 microns.

4.2.17 *microsealing* — sealing on components at the microscale.

4.2.18 *microsealing dimensions* — flow channel cross sections having an effective diameter of <25 micrometers; optionally flow channel cross sections having an effective diameter of 25 to 100 micrometers.

4.2.19 *non-specific binding* — when individual or groups of a particular atom, ion, or molecule binds to surface or other reactive species, binding typically occurs at more than one site. When one of the sites that it binds to is the site of interest, we refer to that as the specific site, whereas the other sites are not sites of interest hence these are referred to as the non-specific sites. Non-specific binding is the binding (reaction) of compound of interest to unwanted compounds or molecules. The reaction is thus unintentional, unexpected or desired. This binding results in either a decrease in the potency of the compound or target or will provide by-products that may give a false positive result to the reaction. In most cases it lowers the sensitivity of the signal or efficiency of the reaction and contributes to an increase in noise or background.

4.2.20 *static seals* — seals that operate with non-moving surfaces.

4.2.21 *wettability* — the tendency of a fluid to make contact with a surface.

5 Design Guidelines

5.1 *Purpose* — Define basic design criteria for microfluidic interconnections, considering factors such as fluid type, pressure, flow rate, surface conditions, materials and their compatibilities, etc. Establish a recommended standard scaling rule for dimensions of such interconnections.

5.2 *Scope* — Design for microsealing connections, for applications at all temperatures and pressures.

5.3 Define Design Parameters

5.3.1 Identify overall dimension and weight constraints for the system sub units, such as, MEMS components, subsystems, entire system, and other components such as fittings and manifolds.

5.3.2 For different materials used to join parts, check that the differences in thermal expansion coefficients are acceptable for the temperature range that the component or system will be used in.

5.3.3 For different materials used to join parts check material chemical characteristics are compatible (see § 6 Materials).

5.3.4 For fluid types to be used with MEMS, define gases and liquids; reference SEMI F79-0703, Gas Compatibility with Silicon. List all materials in wetted path.

5.3.5 Volumes should be minimized (internal, connecting, interface/interconnection, dead volumes), give relation to time, process response, and dry-down constraints.

5.3.6 Identify surface roughness requirements.

5.3.7 Design for shock and vibration criteria, Reference MIL-STD-810.

5.3.8 Determine leak integrity requirements: permeability, across the seat, and inboard. Reference SEMI F1 if applicable.

5.3.9 Determine accuracy, repeatability, and control range requirements of the system.

5.3.10 Define purging capability; number of times of full scale should flow for purging, turnover requirement.

5.3.11 Maintain consistent and uniform design rules for direction of flow.

5.3.12 Determine upstream filtration requirements, particle requirements, moisture, and other contamination characteristics. Reference SEMI E49 for high purity and ultrahigh purity gas systems.

5.3.13 Determine component or system orientation constraints.

5.3.14 Identify design for reliability requirements such as mean time to failure (MTTF) mean time between failure (MTBF), and mean time to repair (MTTR)

5.3.15 Determine system temperature limits.

5.3.16 Determine pressure (proof, design, burst, inlet, exhaust) limits.

5.3.17 Identify device flow ranges.

5.3.18 Establish scaling rules for dimensions of interconnections.²

5.3.18.1 Consider scaling rule to be different for different industrial applications. For example gas and liquid cannot use the same scaling rule.

5.3.19 Consider adapter guidelines for smooth transition between macroscale to microscale. In particular, follow such guidelines for the case where a MEMS system is to replace an existing device, and there is a mismatch of the dimensions. A flexible transition may be considered if space is limited.

5.3.20 Surfaces that come into contact with samples, process gasses, or chemicals must not adsorb or react with them.

5.3.20.1 For compatibility, select components or tubing that is:

- Inherently compatible,

² Hsu, Tai-Ran; MEMS and Microsystems Design and Manufacture; McGraw-Hill, 2002, § 6.7.