

SEMI MS9-0611

SPECIFICATION FOR HIGH DENSITY PERMANENT CONNECTIONS BETWEEN MICROFLUIDIC DEVICES

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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 Standard provides specification for interconnection dimensions and performance requirements for permanent microfluidic interfaces. It also provides guidance for interface design. This will help to enable low cost and high volume manufacturing of products having high density permanent interfaces between plastic tube adapters, plastic microfluidic cartridges, and electrofluidic devices.

2 Scope

2.1 Lab-on-a-chip (LOC) technology and microfluidics in general, have few accepted high-density standard designs and methods for interfacing multiple tubes to electrofluidic integrated circuits (EFIC) and multilayer microfluidic routing cards or manifolds. Consequently, there are few, solutions of automated assembly of these components. Currently, companies working in microfluidics development must use 'fittings' and techniques which are much larger than the natural size of the tube interface. This Standard will contribute to the development of miniaturized, lower cost, and mechanically robust fluidic connections in the same way that wirebonds have enabled low cost reliable integration of silicon parts with: packages, printed circuit boards (PCBs), and other microchips. The scope of this Standard includes applications where low cost materials and automated assembly will prevail. Though not expressly excluded, the requirements of some high performance applications such as: ultra-high purity, high vacuum, high pressure, caustic/acidic/corrosives; may not be satisfied by the limited structural and chemical stability performance requirements in this Standard. Other Standards exist for these applications and are referenced where possible. Devices such as 'biosensors' and 'bioMEMS' are intended to be addressed by this Standard.

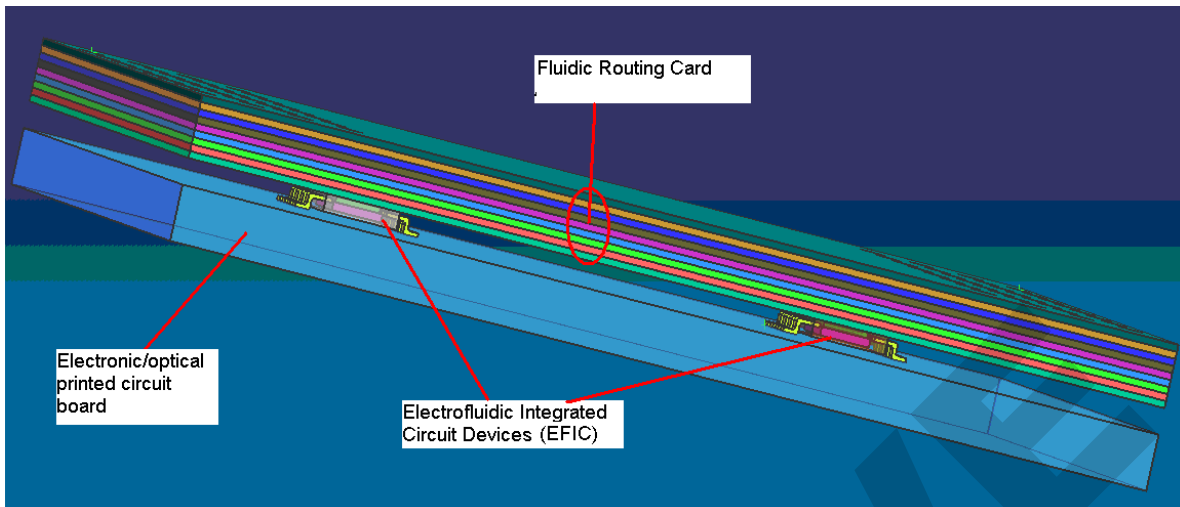
2.2 *Build on Existing Microfluidics Interface Standards Work* — Recent work on the published Standard SEMI MS7-0708 described architectures and methods for designing microfluidic interfaces to electronic device packages. The purpose was to enable the development of new semiconductor and MEMS products that could be integrated into higher level systems. The scope includes any MEMS device that gets connected to any kind of microfluidic structure. Thus, the materials for making these devices and interfaces are unrestricted, ranging from plastics to glass and stainless steel. The corresponding bonding methods are also unlimited, and include welding, adhesive, solvent and ionic.

2.3 *Design Standards and Recommendations* — SEMI MS7-0708 described planar architectures that sandwich EFICs between fluidic routing cards and PCBs (see Figure 1 below).

2.3.1 The present Standard establishes design requirements that, when followed, ensure that these three types of components to fit together in a three dimensional structure.

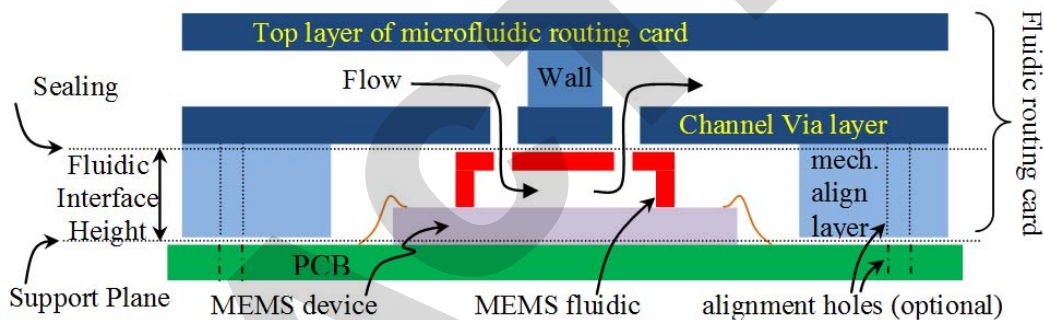
2.3.2 It provides guidance for designing high density tube adapters that connect to these components. It provides guidance on other aspects of fabrication such as bonding, testing, and automated manufacturing.

2.4 *Laminated Fluidic Routing Card Fabrication* — This Standard is meant for enabling connections to and from fluidic routing cards similar in structure to that shown in Figure 1. This is distinct from connections whose mechanical dimensions are based on a method of interconnect like hose barb, luer lock, compression fitting. The nature of laminated fabrication processes allows manufacturers to publish design rules for which their process works. These rules typically include materials, layer thicknesses, x-y dimensions, hole sizes, and layer-to-layer bonding methods.



#1 The EFIC is designed to be compatible with existing PCB technology. The fluidic routing card is made out of multilayer fluidic structures. Several architectures exist for fabricating fluidic routing cards, including plastic + adhesive, glass + bonding, and stainless steel + welding. This is Figure 4 from SEMI MS7-0708.

Figure 1
MEMS EFIC Connected by Fluidic Routing Card and PCB



#1 A cross section of the fluid interface between a chip-on-board (COB) style MEMS sensor and a multilayer fluidic routing card. The fluid path is from left to right in the fluidic card, turns down into and across the MEMS device, and then back up the outlet into the fluidic routing card. The [MEMS device + MEMS fluidic adapter] make up the EFIC. The 'Sealing Plane' and 'Support Plane' are separated by a distance called the 'Fluidic Interface Height'. Specifying this height ensures that the electrofluidic device and fluidic routing card can fit together. The sealing plane is where glue or a gasket is placed to keep the liquid from leaking. The support plane may provide mechanical support as well as additional bonding area, but no fluid is passing through it. The fluidic routing card is constructed by aligning and bonding together multiple cut layers of material.

Figure 2
Interface Planes Shown Using Cross Section of MEMS EFIC Connecting to Microfluidic Routing Card

2.5 MEMS-Microfluidics Architectures are Evolving — The architectures in Standard SEMI MS7-0708 are based around MEMS silicon-based products, their known properties and manufacturing methods. The packaging around the Si chips, and electrical connections from the chip to PCBs are described in realistic detail; Figure 1 here is taken directly from that Standard. Connections to external microfluidic structures, while described at the same level of detail, are more speculative due to the newness of MEMS—Microfluidics interfaces.

2.6 Biochemical Compatibility Restricts Manufacturing Path — Many assembly methods that have been developed for Si chip packaging, such as injection molding around an Si die that is bonded to a Cu lead frame, are incompatible with applications where some biochemical material like DNA must be placed on chip and survive subsequent

packaging, storage, and handling. A standard is needed for applications with these additional biochemical survivability requirements.

2.7 Low-Cost High-Quantity Manufacturing is Needed — The commercialization of MEMS-based biosensor technologies is limited, in part, by the lack of mass manufacturing methods and infrastructure. This Standard will help enable mass manufacturing by defining interfaces and requirements for a narrow area of use.

2.8 Permanent Tube to Fluidics Interface — This Standard focuses on interfaces that are permanent (adhesive, bonding, welded) and not designed to be removable or reusable.

2.9 Enable Technologies — These technologies will be enhanced or enabled by this Standards activity: MEMS, microfluidics, LOC, biosensors, point-of-use and point-of-care diagnostic products, bioanalytical instrumentation, and clinical chemistry analysis.

2.10 Applications — This Standards activity will describe architectures, materials, and methods that are fully compatible with consumer-oriented biosensor products. Biomaterials, such as DNA, proteins, and antibodies, are added during the manufacturing process. These biomaterials are present in the final product, and must perform a biochemical function for the end user. For example, a DNA chip carries single stranded DNA, which must be ‘active’ when the final user of the product runs their analytical test.

2.11 Materials — The scope is narrowed significantly by the range of materials that are appropriate for biosensor products. Some of the current detection means include: visual, micro-optical, electrochemical, fluorescence, and magnetic. Clear materials are desirable, as are non-conducting materials. Plastics, particularly those with sufficient optical properties in the relevant spectrum, are most desirable due to their low cost and ease of forming.

2.12 Manufacturing Process Environment — Survival of on-chip biomaterials places severe constraints on fabrication process temperatures, and the presence of harsh chemicals. Water and solvents like ethyl and isopropyl alcohol are compatible.

2.13 Manufacturing Methods for High-Quantity — Architectures in this Standard are compatible with mass-manufacturing methods. Robotic and automated assembly is the ideal method. However, some scale-up through lower volume methods is inevitable and necessary.

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

SEMI MS7 — Specification for Microfluidic Interfaces to Electronic Device Packages

SEMI MS8 — Guide to Evaluating Hermeticity of MEMS Packages

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

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 *bioMEMS* — biological microelectromechanical systems

4.1.2 *CAD* — computer aided design

4.1.3 *COB* — chip-on-board

4.1.4 *EFIC* — electrofluidic integrated circuit

4.1.5 *LOC* — lab-on-a-chip

4.1.6 *PCB* — printed circuit board