MICROFLUIDIC SUBSTRATE ASSEMBLY AND METHOD FOR MAKING SAME

CROSS-REFERENCED APPLICATIONS

[0001] This is a continuation of U.S. patent application Ser. No. 10/033,315, titled "Microfluidic Substrate Assembly and Method for Making Same", filed on Dec. 27, 2001, which is a continuation of International Application No. PCT/US01/31333, titled "Microfluidic Substrate Assembly and Method for Making Same," filed on Oct. 5, 2001, and to commonly assigned U.S. Patent Application No. 60/239,010 titled "Microfluidic Substrate Assembly and a Method for Making Same" and filed on Oct. 06, 2000, commonly assigned to U.S. Patent Application No. 60/239,063 titled "Liquid Separation Column Smart Cartridge" and filed on Oct. 06, 2000, commonly assigned U.S. Patent Application No. 60/238,805 titled "Liquid Separation Column Smart Cartridge with Encryption Capability" and filed on Oct. 06, 2000, commonly assigned U.S. Patent Application No. 60/238,390 titled "Microfluidic Substrate Assembly and a Method for Making Same" and filed on Oct. 06, 2000, the entire disclosure of each of which is hereby incorporated herein by reference for all purposes.

FIELD OF INVENTION

[0002] The present invention relates to fluid-handling substrate devices and more particularly to microfluidic substrate assemblies and to methods for making certain preferred embodiments of such microfluidic substrate assemblies.

BACKGROUND

[0003] Systems for biochemical, chemical, and molecular analysis can be miniaturized as substrates with multifunctional capabilities including, for example, chemical, optical, fluidic, electronic, acoustic, and/or mechanical functionality. Miniaturization of these systems offers several advantages, including increased portability and lower production cost. Such devices can be fabricated from a diverse ensemble of materials including, for example, plastics or polymers, metals, silicon, ceramics, paper, and composites of these and other materials. Typically, such substrates include fluid channels extending within them for the transport and/or analysis of fluids or components contained in the fluids. Additionally, the channels may contain fragile or environmentally sensitive structures, such as materials, architecture and/or devices used for analyzing the fluids or components contained therein. Mesoscale sample preparation devices for providing microvolume test samples are described in U.S. Pat. No. 5,928,880 to Wilding et al. Devices for analyzing a fluid sample, comprising a solid substrate microfabricated to define at least one sample inlet port and a mesoscale flow channel extending from the inlet port within the substrate for transport of a fluid sample are described in U.S. Pat. No. 5,304,487.

[0004] Currently known miniaturized fluid-handling devices have not met all of the needs of industry. Also, methods for assembling miniaturized fluid-handling substrates are inadequate in one or more respects. The microfabrication of solid substrates to produce mesoscale devices is not adequately suited to cost effective, flexible production of suitable fluid handling devices. Current thermal welding methods, for example, are unsuitable or ineffective for fluid-handling substrates having, i.e., incorporating or embodying, environmentally sensitive elements. More specifically, as noted above, the channels formed in substrates produced by thermally welding together pieces, layers, or the like may contain environmentally sensitive elements, such as microstructures or devices that could be damaged by exposure to high temperature or intense radiation. Thus, current methods used for welding plastic pieces together may require temperatures and/or pressures that can destroy such environmentally sensitive elements. It is possible that the temperature of a system being welded could reach over 600 degrees centigrade, a temperature that could easily destroy sensitive fluid analysis or detection components, such as a computer processor contained within the channels of a substrate, and could destroy the walls of miniaturized channels, e.g., channels formed by micro-machining in the plastic layers joined together to form a fluid-handling substrate.

[0005] Other methods of joining plastic or other substrate pieces together include solvent-based sealing, high pressure and temperature based sealing, and adhesive based sealing. Additional problems exist with these methods used to seal channels. Adhesives require time to cure, which slows manufacturing. Also, adhesives may require difficult control of pressure during assembly, since too little pressure may result in an inadequate seal and excessive pressure can squeeze the adhesive into the channels. Adhesives also must be applied carefully so as not to produce areas that are so thick as to alter the dimensions of the channel. Solvents and the chemicals in adhesives may contaminate the channels and/or otherwise damage the environmentally sensitive elements contained in the channels. Certain components within the solution might dissolve one ore more components in the adhesives which may result in potential interferences in detecting the components of interest in the solution.

[0006] Therefore, there exists a need in the art for improved fluid-handling substrates, and for methods for manufacturing fluid-handling substrates that avoid damage to substrate elements and/or heat-sensitive components contained within such substrates. It is a general object of the present invention to provide improved fluid-handling substrates, particularly micro-fluidic substrates, and improved methods of forming such fluid-handling substrates. These and other objects of the invention will be more fully understood from the following disclosure and detailed description of certain preferred embodiments of the invention.

SUMMARY

[0007] In accordance with a first aspect, fluid handling devices are provided, comprising a multi-layer laminated substrate defining at least one fluid inlet port and at least one microscale fluid flow channel (also referred to in some cases here as a microfluidic channel or a microchannel of the multi-layer laminated substrate) within the multi-layer substrate in fluid communication with the inlet port for transport of fluid to be tested, analyzed or operated on. Preferred embodiments of the devices can be utilized in a wide range of automated tests for the analysis of a fluid. As used here fluid refers to gases, liquids, supercritical fluids and the like, optionally containing dissolved species, solvated species and/or particulate matter. Testing or analysis of a fluid has a broad meaning, including any detection, measurement or other determination of the presence of a fluid or of a