

**MICROFLUIDIC DEVICES****CROSS REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit of the priority dates of U.S. application Ser. No. 11/229,065, filed Sep. 15, 2005, which claims the benefit of U.S. provisional application No. 60/609,970, filed Sep. 15, 2004, the disclosures of all of which are incorporated herein by reference in their entirety.

**STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT**

This invention was made with government support under Grant No. 5R01HG003583-01 awarded by the NIH; Project No. W911SR-04-P-0047 awarded by the Department of Defense; Contract No. NBCHC050133 awarded by HSARPA, and Agreement No. W81XWH-04-9-0012 (Order No. TTA-1-0014) awarded by the Department of Defense. The government has certain rights in the invention.

**BACKGROUND**

A wide variety of microfluidic devices of disparate, and often incompatible, design have been developed over the past 10-20 years, often with the goal of reducing sample volume requirements in bioanalytical methods. In the absence of standards controlling external dimensional form factors, the nature of the upstream and downstream external interface, and the length, cross-sectional geometry, and diameter of the internal microfluidic pathways, such microfluidic devices often prove incompatible with one another and with existing upstream purification and downstream analytical devices.

Despite advances in microfabrication, making possible analysis at microliter, even nanoliter or picoliter, scale, many biological and environmental samples are first acquired in volumes far greater than, and incompatible with, the scale of existing microfluidic analytical devices.

There is thus a need in the art for modular microfluidic components that can be used as components of integrated fluidic systems, and that can interface microfluidic components having different external dimensional form factors, external interfaces, and/or internal fluidic geometries, into effective fluidic communication, and that can interface preparative modules, or methods, that operate at larger scale with microfluidic preparative and/or analytical components.

**SUMMARY**

The present invention solves these and other needs in the art.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The skilled artisan will understand that the drawings, described below, are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

FIG. 1 illustrates an embodiment of a sample capture and purification module (SCPM) and bioprocessor module (BPM) workflow.

FIG. 2 illustrates an embodiment of a toxin assay workflow.

FIG. 3 illustrates an embodiment of a sample capture and purification module (SCPM) integrated with a bioprocessor module (BPM).

FIG. 4 illustrates an embodiment of an off-chip flow-through cartridge.

FIG. 5 illustrates an embodiment of a traveling wave flowthrough bead beater.

FIG. 6 illustrates an embodiment of flowthrough sonication in which a probe is inserted directly into a collector effluent.

FIG. 7 illustrates an embodiment of a nucleic acid purification module.

FIG. 8 illustrates an embodiment of a nanobioprocessor modular system that can be used for biodefense applications comprising an air sampler, sample concentration module, and a microfluidic sample amplification and analysis module.

FIG. 9 illustrates an embodiment of a MOV™ valve.

FIG. 10 illustrates an embodiment of a microfabricated pump.

FIG. 11 illustrates an embodiment of a microfabricated router.

FIG. 12 illustrates an embodiment in cross-section of three dimension connection service channel supplying sample cleanup matrix.

FIG. 13 illustrates an embodiment of a fluidic circuit for adding one or more reactants to a reaction chamber.

FIG. 14 illustrates an embodiment of a cycle sequencing module (CSM) repeat unit.

FIG. 15 illustrates an embodiment of a single bioprocessor unit.

FIG. 16 illustrates an embodiment of a microchip cartridge using externally actuated MOV valves and pumps.

FIG. 17 illustrates an embodiment of a 12 unit bioprocessor cartridge.

FIG. 18 illustrates an embodiment of a nonbioprocessor unit and microchip layout.

FIG. 19 illustrates microchip embodiment MBI-11. Panel A shows the mask design which shows the fluidic layer in blue and the actuation layer in red. Panel B shows the sub-assembly which has two each input and output reservoirs, a reaction chamber and an archive chamber, and a three-way router. The eight pneumatic control lines for the valves terminate in a standard connector to the pneumatics. Panel C shows an etched microfluidic wafer. Panel D shows an assembled MBI-11 three layer microchip with a lab marking pen shown for scale.

FIG. 20 illustrates microchip embodiment MBI-12 with nanofluidic structures for microcapillary electrophoresis (μCAE) integrated with sample preparation. Fluidic channels are shown in blue and MOV actuation channels in red.

FIG. 21 illustrates an embodiment of a dual paired-end read affinity capture sample cleanup with dual analysis channels. The dark layer is microfluidic, gray lines are the service layer. Valve actuation layer is not shown. The light dashed box defines the DNA Analysis repeat unit.

FIG. 22 illustrates an embodiment of integrated sample, preparation, cleanup, and analysis MINDS microchip repeat unit.

FIG. 23 illustrates an embodiment of a 16-channel 200 nL cycle sequencing module microchip.

FIG. 24 illustrates an embodiment of a microbead-feed integrated sample, preparation, cleanup, and analysis MINDS microchip repeat unit. A 25 nL sample preparation chamber is shown with two affinity capture and separation channels.

FIG. 25 illustrates an embodiment of a microchip that is designed as a disposable cartridge which includes on-board reagents, the nucleic acid purification, and the toxin module.

FIG. 26 illustrates an embodiment of instrument control of a microchip interface device.