

Design and build your own integrated microfluidic systems using magnetic interconnects

Microfluidic technology involves the miniaturization and integration of complex systems that enable low volumes (microliters, μL ; $1\ \mu\text{L} = 1 \times 10^{-6}$ liter, L) of fluids to be manipulated and controlled in micron-sized (1 micron/micrometer, $\mu\text{m} = 0.001\ \text{mm}$) channels (microchannel) for biological and chemical applications. It is a multidisciplinary field that intersects engineering, material sciences, physics, chemistry, biology and nanotechnology, and has generated tremendous interest and excitement over the past two decades.

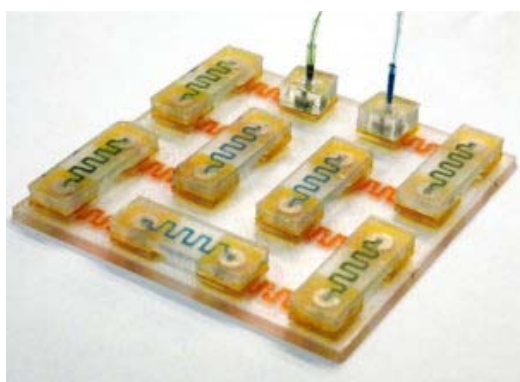


Fig. 1. A reconfigurable stick-n-play modular microfluidic system composed of seven serpentine channel modules, two inlet/outlet modules and a serpentine channel base platform.

In order to develop a multi-function microfluidic technology-based system that could perform complex multiple functions, significant time, effort and expertise are required. A slight modification of this multi-function microfluidic system frequently requires rebuilding the entire system, which will result in a long development time and incur substantial costs. One of the proven approaches to address this integration problem is the modular design approach or modular architecture that involves designing and optimizing each module separately before connecting them together to form a larger system. In the modular design approach, the critical component is the module-to-module fluidic connectors (interconnections) that can effectively provide leak-free fluidic communication between connected modules after their assembly. These module-to-module fluidic interconnects should be reversible, simple to use (ideally, in a single step), easy to manufacture and, most importantly, consistent and reliable in their performance after repeated assembly and disassembly. Also, in order to provide fluidic communication between the pumping system and the inlet(s) and outlet(s) of the modular system (world-to-module/chip fluidic interconnects), simple and easy to use world-to-module fluidic interconnects should be included in the modular systems.

Over the years, the modular design approach has been utilized in developing “plug-n-play”, reconfigurable LEGO® concept-based modular microfluidic systems that could be assembled, disassembled, reconfigured and assembled again. There are also plug-n-play modular microfluidic kits available on the market for building modular microfluidic systems. In addition, plug-n-play

world-to-module fluidic interconnects have also been developed for modular microfluidic systems both in academia and industry. However, all these modular systems are either non-manufacturing friendly or not reliable in their performance after repeated assembly and disassembly. Thus, a reconfigurable “stick-n-play” modular microfluidic system using magnetic interconnects (connectors using ring magnets) is presented (Fig. 1). Although magnets had been used previously in world-to-module fluidic connectors for microfluidic devices, they have not been envisioned, demonstrated or utilized in any module-to-module fluidic interconnects for reconfigurable modular microfluidic systems. In this study, magnetic interconnects, comprising ring magnets and sealing gaskets, are integrated into each microfluidic module’s inlet(s) and outlet(s) for both world-to-module and module-to-module interconnects to reversibly “stick” each individual microfluidic module together by magnetic forces and to provide leak-free fluidic communication between connected microfluidic modules in order to form a larger integrated microfluidic system (Fig. 2). Another advantage of the magnetic interconnects is that using recess adapters, the magnetic interconnects can be easily integrated onto any pre-fabricated microfluidic devices to convert the pre-fabricated microfluidic devices into a stick-n-play modular system.

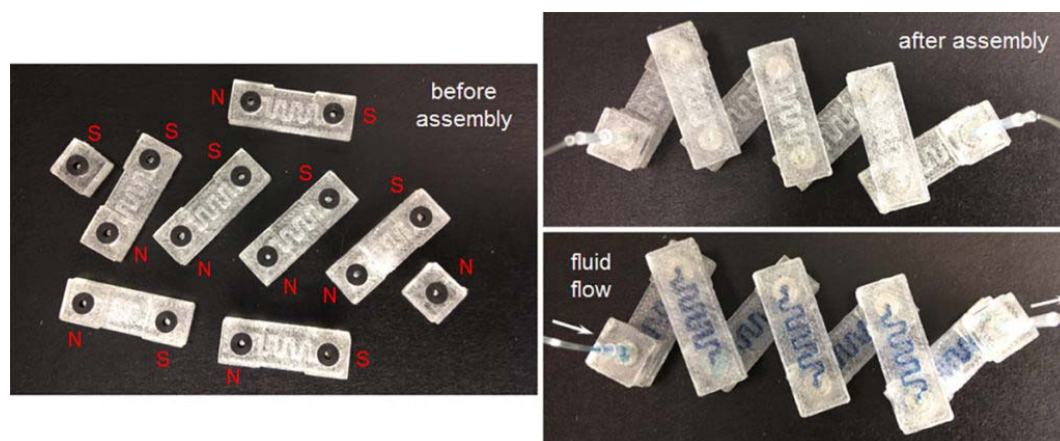


Fig. 2. A 7-serpentine channel modular microfluidic system using seven serpentine channel modules and two inlet/outlet modules. N and S represent the north and the south poles of each magnetic interconnect, respectively.

Because of the magnetic interconnects, microfluidic modules can be easily connected, disconnected, reconfigured and connected again, allowing flexible design changes and their optimization. Rapid customization of modules can be achieved with three-dimensional (3D) printing using 3D computer-aided design (CAD) models and software, and then integrated with the magnetic interconnects. Thus, module design change and optimization can be easily performed by simply modifying the 3D CAD model and then 3D printed with little effort. Other than real world applications, a reconfigurable stick-n-play modular microfluidic system with basic microfluidic technology could be a very useful tool in teaching laboratories with limited resources for expensive and high technology equipment and will lower the barriers for new entrants to the field of micro-scale devices and systems.

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