Electronic Supplementary Material (ESI) for Lab on a Chip.

ELECTRONIC SUPPLEMENTARY INFORMATION (ESI)

A reconfigurable stick-n-play modular microfluidic system using magnetic interconnects

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Ring magnet assembly

In order to ensure that the ring magnet is not tilted after press-fitted into the recess of the module, a drill press setup is used (Fig. S1). The drill press setup consists of a bottom non-magnetic stainless steel plate, a top magnetic steel plate with an alignment pin inserted into the center and two non-magnetic stainless steel spacers. A level is used to confirm that the top magnetic steel plate and the bottom non-magnetic stainless steel plate are level and parallel to each other. For magnetic interconnects using Kapton polyimide adhesive tape (2 mil (~50 μm) thick Nulink™ Kapton Polyimide Heat High Temperature Resistant Adhesive Gold Tape, Amazon.com, Inc., Seattle, WA, USA) as the sealing gasket, the two non-magnetic stainless steel spacers will ensure that the module and the ring magnet will not be damaged during the assembly process and a small protrusion (approximately 0.2 mm) of the ring magnet extended out of the recess of the module after assembly. After placing the module, which has a double-sided pressure sensitive adhesive tape (Scotch® Double Sided Office Tape, 3M Center, St. Paul, MN, USA) adhered to its bottom surface, in the center of the bottom non-magnetic stainless steel plate, the top magnetic steel plate is slowly and carefully lowered by hand towards the module such that the alignment pin on the top magnetic steel plate is aligned with the inlet/outlet inside the recess of the module (Fig. S1a). The alignment pin will ensure that the ring magnet will be placed perfectly inside the recess of the module after assembly. After the alignment step, the module is

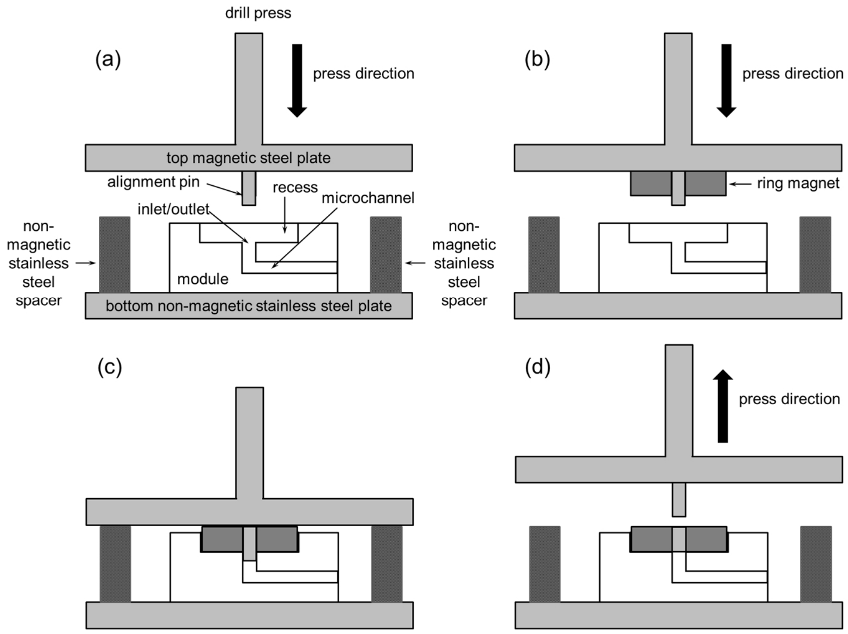

Fig. S1 Schematics of assembling a ring magnet into the recess of a module using a drill press setup. (a) Alignment pin on the top magnetic steel plate is aligned to the inlet/outlet inside the recess of the module that is adhered on the bottom non-magnetic stainless steel plate by a double-sided pressure sensitive adhesive tape. (b) Ring magnet with a biocompatible silicone adhesive added to its circular side wall is magnetically attached to the top magnetic steel plate with the alignment pin inserted through the inner hole of the ring magnet. (c) Ring magnet is press-fitted into the recess of the module. (d) The top magnetic steel plate is retracted to its original position after the ring magnet is press-fitted into the recess of the module.

then adhered to the bottom non-magnetic stainless steel plate by the double-sided pressure sensitive adhesive tape and the top magnetic steel plate is retracted to its original position. Next, a ring magnet is magnetically attached to the top magnetic steel plate with the alignment pin inserted through the inner hole of the ring magnet (Fig. S1b). Care should be taken to ensure that the correct pole of the ring magnet is facing upwards. A biocompatible silicone adhesive (Bio-PSA 7-4301 Silicone Adhesive, Dow Corning, Midland, MI, USA) is then carefully added to the circular side wall of the ring magnet. The biocompatible silicone adhesive will ensure that there will be no fluid leakage between the circular side wall of the ring magnet and the recess side wall of the module during fluid pumping. After attaching the ring magnet and adding the biocompatible silicone adhesive, the top magnetic steel plate is then slowly and carefully lowered by hand towards the bottom non-magnetic stainless steel plate to press-fit the ring magnet into the recess of the module (Fig. S1c). Finally, the top magnetic steel plate is retracted to its original position to complete the ring magnet assembly (Fig. S1d).

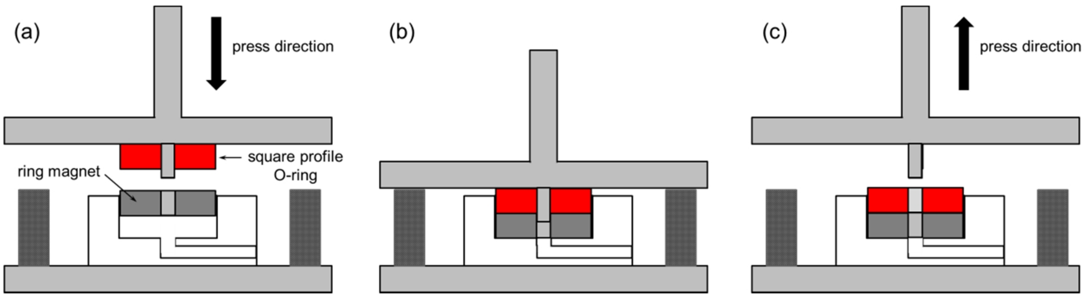

Fig. S2 Schematics of assembling a square profile O-ring into the recess of a module on top of the ring magnet using a drill press setup. (a) Square profile O-ring with a biocompatible silicone adhesive added to its circular side wall and its bottom surface is attached to the top magnetic steel plate with the alignment pin inserted through the inner hole of the O-ring. (b) O-ring is press-fitted into the recess of the module on top of the ring magnet. (c) The top magnetic steel plate is retracted to its original position after the O-ring is press-fitted into the recess of the module on top of the ring magnet.

For magnetic interconnects using square profile O-ring as the sealing gasket, after press-fitted the ring magnet into the recess of the module, a square profile O-ring is attached to the top magnetic steel plate with the alignment pin inserted through the inner hole of the O-ring (Fig. S2a). The biocompatible silicone adhesive is then carefully added to the circular side wall and the bottom surface of the O-ring. Again, the biocompatible silicone adhesive will ensure that there will be no fluid leakage between the circular side wall of the O-ring and the recess side wall of the module during fluid pumping. Next, the top magnetic steel plate is then slowly and carefully lowered by hand towards the bottom non-magnetic stainless steel plate to press-fit the O-ring into the recess of the module on top of the ring magnet, leaving a small protrusion (approximately 0.2 mm) of the O-ring extended out of the recess after assembly (Fig. S2b). Finally, the top magnetic steel plate is retracted to its original position to complete the O-ring (magnetic interconnect) assembly (Fig. S2c).

Fluid leakage test

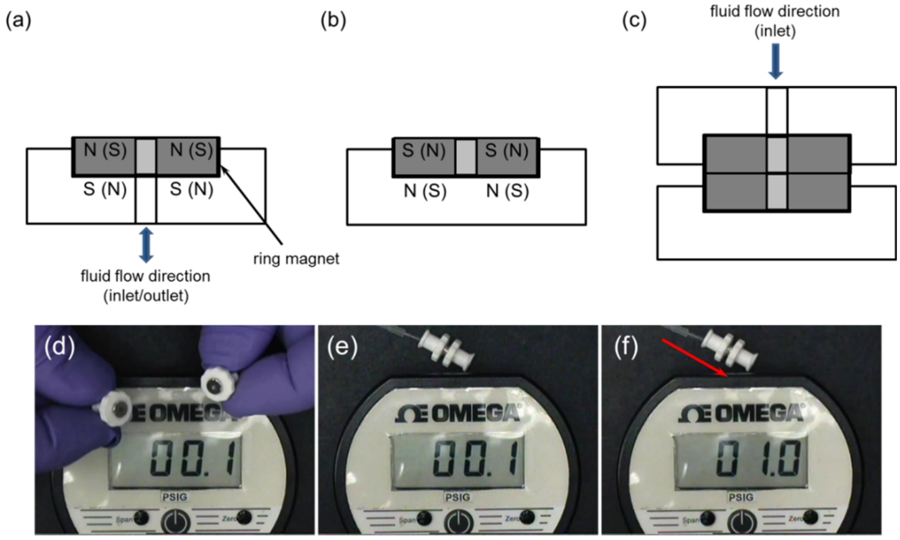

Fig. S3 Fluid pressure test for a pair of magnetic interconnects using an inlet/outlet module and a blocked module. Each magnetic interconnect comprised a nickel plated neodymium ring magnet (N52 5 mm OD × 1 mm ID × 1 mm thick magnetized through the thickness with an estimated pull force of 0.59 lb at zero distance) (The SuperMagnetMan, Pelham, AL, USA). Schematics of (a) the inlet/outlet module and (b) the blocked module with the magnetic interconnect, and (c) how they were connected. N and S represent the north and the south poles of each ring magnet, respectively. The two modules (d) were not and (e) were connected together without any fluid flow. (f) Maximum fluid pressure withstood by the magnetic interconnects before fluid leakage at the interface of the magnetic interconnects was first observed. Red arrow indicates the flow direction and the flow rate was 100 μl/min.

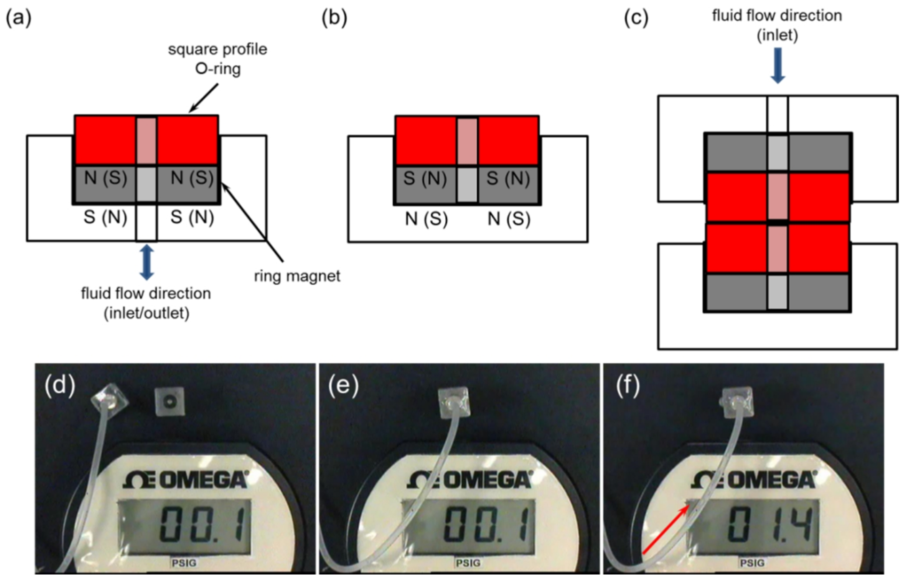

Fig. S4 Fluid pressure test for a pair of magnetic interconnects using an inlet/outlet module and a blocked module. Each magnetic interconnect comprised a nickel plated neodymium ring magnet (N52 5 mm OD × 1 mm ID × 1 mm thick magnetized through the thickness with an estimated pull force of 0.59 lb at zero distance) (The SuperMagnetMan) and a square profile O-ring (sealing gasket) (0.21"(~5.3 mm) OD × 0.07" (~1.8 mm) ID × 0.07"

(~1.8 mm) thick) (#1170N14, Square-Profile O-Ring, Chemical-Resistant Viton®, Dash Number 004, McMaster-Carr, Robbinsville, NJ, USA). Schematics of (a) the inlet/outlet module and (b) the blocked module with the magnetic interconnect, and (c) how they were connected. N and S represent the north and the south poles of each ring magnet. The two modules (d) were not and (e) were connected together without any fluid flow. (f) Maximum fluid pressure withstood by the magnetic interconnects before fluid leakage at the interface of the magnetic interconnects was first observed. Red arrow indicates the flow direction and the flow rate was 100 µl/min.

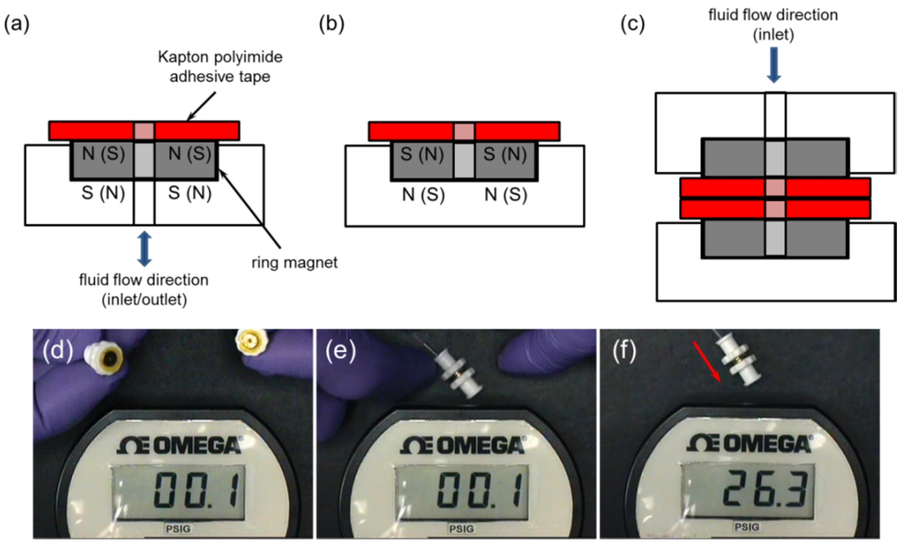

Fig. S5 Fluid pressure test for a pair of magnetic interconnects using an inlet/outlet module and a blocked module. Each magnetic interconnect comprised a nickel plated neodymium ring magnet (N52 5 mm OD × 1 mm ID × 1 mm thick magnetized through the thickness with an estimated pull force of 0.59 lb at zero distance) (The SuperMagnetMan) and a 2 mil (~50 µm) thick Kapton polyimide adhesive tape (sealing gasket) (8 mm OD × 1 mm ID) (Nulink™ Kapton Polyimide Heat High Temperature Resistant Adhesive Gold Tape, Amazon.com, Inc., Seattle, WA, USA). Schematics of (a) the inlet/outlet module and (b) the blocked module with the magnetic interconnect, and (c) how they were connected. N and S represent the north and the south poles of each ring magnet, respectively. The two modules (d) were not and (e) were connected together without any fluid flow. (f) Maximum fluid pressure withstood by the magnetic interconnects before fluid leakage at the interface of the magnetic interconnects was first observed. Red arrow indicates the flow direction and the flow rate was 100 µl/min.

Assembly of a serpentine channel base platform

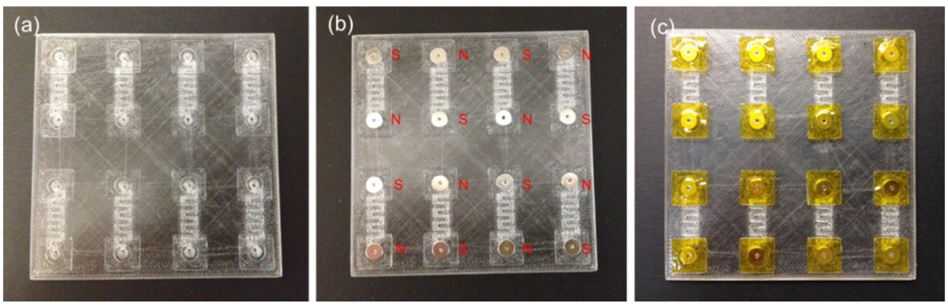

Fig. S6 Serpentine channel base platform.. (a) The serpentine channel base platform comprised eight 1 mm × 1 mm serpentine channels and 16 5 mm diameter × 0.8 mm tall inlet/outlet recesses. (b) A nickel plated neodymium ring magnet (N52 5 mm OD × 1 mm ID × 1 mm thick magnetized through the thickness with an estimated pull force of 0.59 lb at zero distance) (The SuperMagnetMan) was press fitted and glued into each recess. N and S represent the north and the south poles of each neodymium ring magnet, respectively. (c) Kapton polyimide adhesive tape (sealing gasket) (10 mm × 10 mm with a 1.5 mm diameter center hole) was adhered on top of each nickel plated neodymium ring magnet.

Another example of a reconfigurable modular microfluidic system

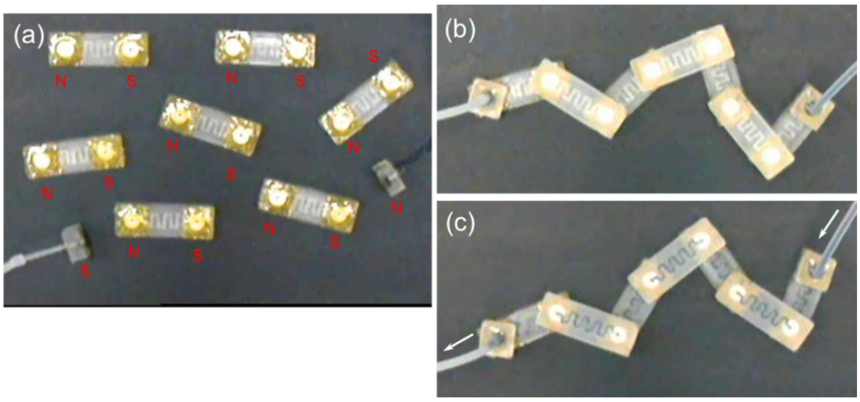

Fig. S7 Serpentine channel modular microfluidic system comprised seven serpentine channel modules and two inlet/outlet modules. N and S represent the north and the south poles of each magnetic interconnect, respectively. Kapton polyimide adhesive tape (10 mm × 10 mm with a 1.5 mm diameter center hole) was used as the sealing gasket in the magnetic interconnect. (a) Before and (b) after assembly of the modular microfluidic system. (c) The assembled modular microfluidic system was filled with a blue colored food dye solution by a syringe pump. The white arrows indicate the fluid flow direction. Fluid flow rate was 100 μl/min.