Integrated plastic micropumps with magnetic actuation

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Keywords: Ferrofluid, microfluidic chip, PMMA, powder blasting, rapid prototyping.

Introduction:

We have developed an efficient and low cost pumping device for biochemical analysis systems, based on magnetic actuation. A rapid prototyping technology is presented to realize two different types of externally actuated plastic micropumps: (i) an external magnet displaces a ferrofluid liquid plug that plays the role of a piston in a channel; (ii) an external coil actuates an integrated magnetic membrane, consisting of NdFeB magnetic powder in a polydimethylsiloxane (PDMS) matrix.

Fabrication technology:

A low-cost method for the fast prototyping of plastic microfluidic chips has been developed. The microfluidic chip is a stack of polymethylmethacrylate (PMMA) layers. Powder blasting is used to realize microchannels, while complex structures are machined with standard milling tools.
In a first step, a metallic mask is realised by laser cuting and applied on top of a 250 µm thick PMMA sheet. The micropatterning is obtained by the action of accelerated alumina (Al_2O_3) particles. The minimum channel dimensions obtained with this rapid prototyping method is in the 100 µm range. A silicone membrane (Ø7 mm) has been integrated to realize a check-valve. Such valve requires the presence of a PMMA pillar structure in a cavity, which is machined using standard milling tools. The integration of this valve has enabled the realization of two different types of magnetic micropumps.

Practical applications:

- *Ferrofluid Micropump:*

A ferrofluid is a stable colloidal suspension of nano-sized magnetic particles in a liquid carrier. In the presence of an external magnetic field, the whole fluid responds as a homogeneous magnetic liquid. The basic idea of the ferrofluid micropump is to generate magnetically a pressure to pump liquids [1].

- *Magnetic Membrane Micropump:*

A diaphragm micropump with 2 check-valves (the same as for the ferrofluid micropump) has been integrated in a microfluidic plastic chip. The oscillating membrane is made of a polymer magnet and is actuated with an external coil.

Conclusion:

Thanks to a rapid prototyping technology, we have integrated low cost micropumps in plastic microfluid chips. An external magnetic actuation has been chosen to control the pump. The developed micropumps are designed for lab-on-a-chip applications.

References:

[1] C. Yamahata, M. Chastellain, H. Hofmann, M.A.M. Gijs, “Ferrofluid Micropump for Lab-on-a-chip Applications”, in Proc. Eurosensors XVII, Guimarães, Portugal, Sept. 21-24, 2003.

Figure 1 : Ferrofluid micropump (dimensions: 36 x 22 x 5 mm, 8 layers).

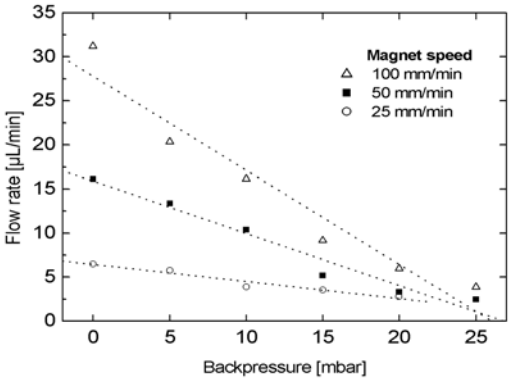

Figure 2 : Flow rate characteristic of the ferrofluid micropump for different backpressures.

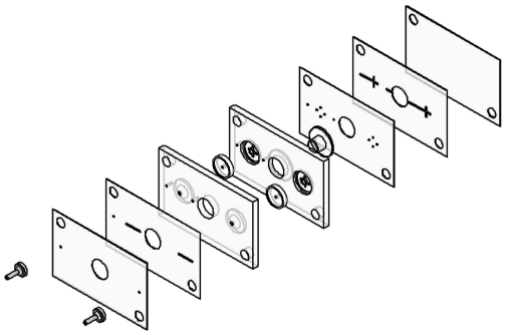

Figure 3 : Burst view of the membrane micropump.

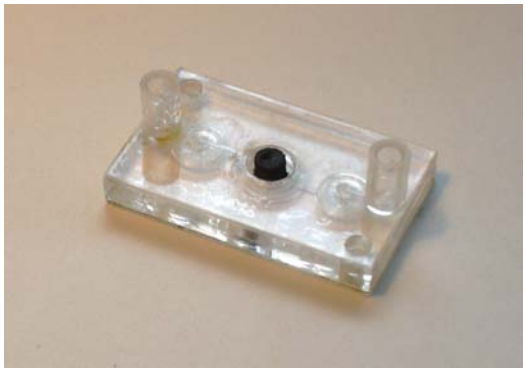

Figure 4 : Electromagnetic membrane micropump with 2 check-valves (dimensions: 36 x 22 x 5 mm, 7 layers).

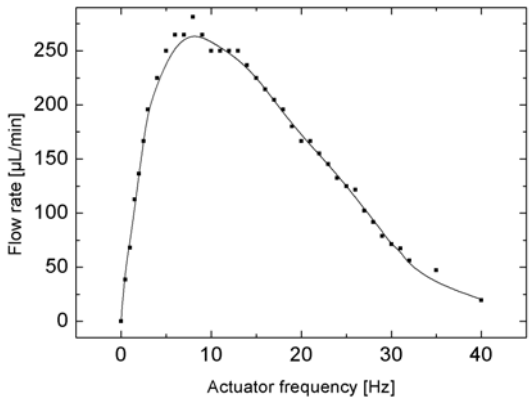

Figure 5 : Flow rate characteristic of the electromagnetically actuated plastic micropump having two silicone check-valves for different actuation frequencies.

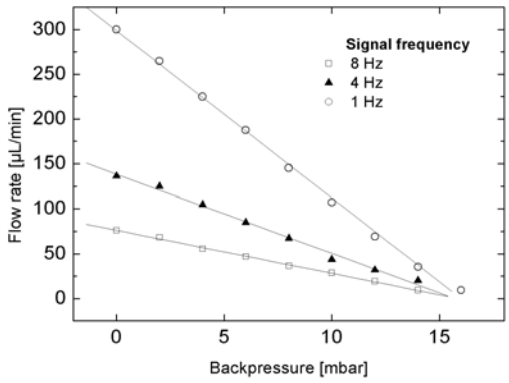

Figure 6 : Flow rate characteristic of the electromagnetically actuated plastic micropump for different backpressures.