A FERROFLUID MICROPUMP FOR BIOCHEMICAL APPLICATIONS

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INTRODUCTION:

The objective of this project is to develop an efficient and low cost pumping device for biochemical analysis systems, using the magnetic actuation of a ferrofluid. A rapid prototyping technology based on the powder blasting microstructuration of polymethylmethacrylate (PMMA) is used to realize the micropump.

METHODS:

The water based ferrofluid used in the experiments is synthesized in-house. The magnetization curve of the ferrofluid (figure 1) is obtained by subjecting the sample to a magnetic field cycle ranging between 800 kA/m and - 800 kA/m.

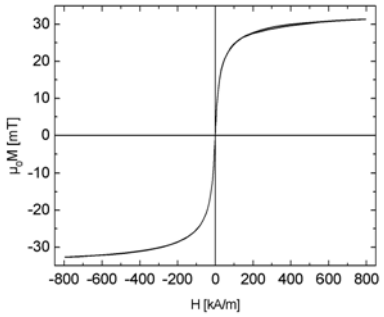

Fig. 1 : Magnetization curve at 300 K of the ferrofluid used in the piston micropump. The saturation magnetization is about 32 mT.

RESULTS: The magnetic pressure that a ferrofluid plug can withstand in a microchannel is determinated with the ferrofhydrodynamic Bernoulli equation [1]:

$$\Delta P = \mu_0 \int_0^{H\max} M dH \qquad (1)$$

where ΔP is the static magnetic pressure of the ferrofluid plug, and $H_{\max}$ is the highest value of the field applied to the ferrofluid seal. The area under the magnetization curve (figure 1) is integrated from 0 to $H_{\max}$ to evaluate the burst pressure of the ferrofluid seal. Values are compared to experimental results in figure 2.

The ferrofluid micropump is fabricated thanks to our rapid prototyping method of PMMA microfluidic chip [2]. Two passive check-valves are integrated in the microfluidic chip and the ferrofluid plug plays the role of a piston externally actuated by a motorized magnet.

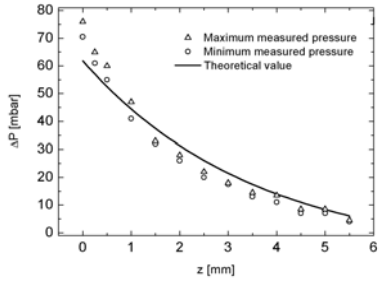

Fig. 2 : The theoretical and measured static burst pressures of the ferrofluid seal are in good agreement.

The Pressure-Flow rate characteristic of the micropump is reported in figure 3.

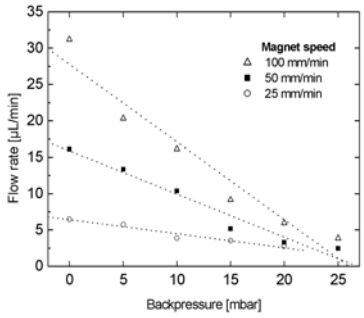

Fig. 3 : Pressure-flow characteristics of water for different speeds of the rare-earth magnet.

DISCUSSION & CONCLUSIONS: We have presented a plastic micropump based on the magnetic actuation of an in-house synthesized ferrofluid. The maximum backpressure of the micropump is in good agreement with the measured burst pressure of a ferrofluid seal.

REFERENCES: [1] R.E. Rosensweig (1985), *Ferrohydrodynamics*, Cambridge monographs on mechanics and applied mathematics, New York, pp 144-148. [2] C. Yamahata, M. Chastellain, H. Hofmann, and M.A.M. Gijs (2003), "Ferrofluid Micropump for Lab-on-a-chip Applications", *in Proc. Eurosensors XVII*, Guimarães, Portugal, Sept. 21-24, 2003.

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