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# AN INTEGRATED MAGNETIC PLANAR ACTUATOR REDEFINING MULTILEVEL (3D) MICROFLUIDIC STRATEGIES

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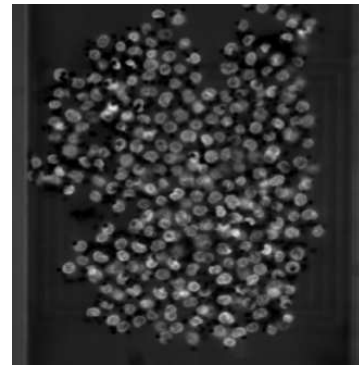
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Super-paramagnetic micro particles (SMPs) are broadly used in medical and biological applications (from cellular to genomic scales), but the handling tools for those particles remain mostly non-integrated. Since a decade, a few solutions for integrated actuation have been proposed and paved the way to the micro-scale control of SMPs. So far, spiral planar coils showed the best compromises between the available magnetic force and the actuator footprint. Albeit the technology to integrate this type of coils with microfluidic structures exists, it is hard to find examples of dual architectures using those two aspects for concrete applications.

As a matter of fact, the fluidic structures of such an actuator should be designed so as to take advantage of the high impact of the magnetic force component developed on the orthogonal axis of a spiral planar micro-coil, which is impossible given the lack of simple fabrication techniques for 3D microfluidics.

We therefore developed a SU-8 dry film lamination technique, which can be used with standard micro technology processes. It allows us to combine a good resolution (the height and width of the coil turns are 5 $\mu$ m) and 3D structures, can be carried out on silicon, glass or flexible substrates, and is compatible with other commercially available low cost dry films for the microfluidic architecture. Our approach was then to place planar coils under two superposed channels, the top one containing a sample with magnetically targeted cells, and the bottom one a buffer to recover the magnetic beads an attached cells.

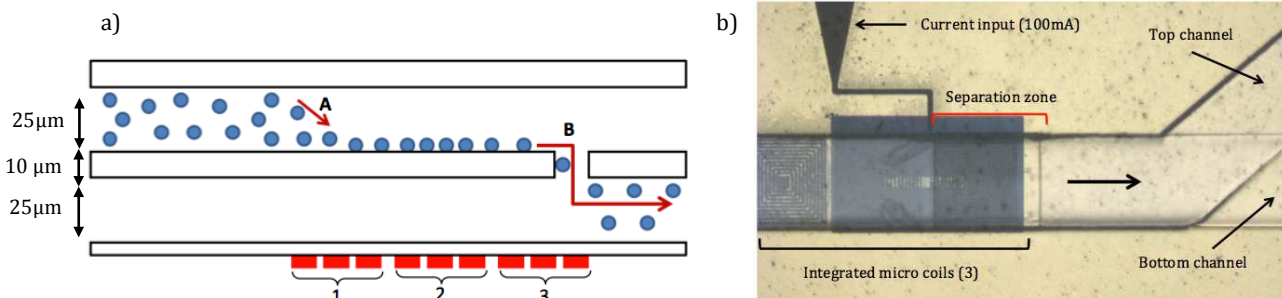


**Figure1:** THP1 Monocytes (about 15 $\mu$ m diameter) trapped on a planar microcoil.

The devices were then tested with a setup including a current source (100mA injected in each coil, the coils being wired in three series of three), a Fluigent pressure controller, and a bright field microscope. In a first step (A), the magnetic particles (5 $\mu$ m diameter from Invitrogen) are vertically focused using the first six coils. Once the beads have reached the separation level, they are attracted towards the bottom channel with the last three actuators.

Using that system, we achieved to separate a solution of SMPs with an 80% efficiency at a 2.5  $\mu$ L/min flow rate (4.6 mm/s). It is also possible to perform trapping (all the beads stay on the coils) at lower flow rate: trapping is observed simultaneously with separation (with a 100% yield) at 1 $\mu$ L/min (1.8 mm/s). We showed also that trapping of monocytes was possible on this coil design.

Currently we are working on the system characterization with a biological application. This type of systems is particularly suited to integrated detection techniques, and a next important step would be the conception of a fully coupled magnetic actuation and electrical detection microfluidic chip.



**Figure 2:** a) Scheme of the integrated magneto-fluidic actuator. SMPs are separated from the top channel to be released in the bottom channel, due to the magnetic attraction of nine microcoils. b) Top view photography of the microfluidic chip.