High pressure inertial focusing; integration in parallel and series

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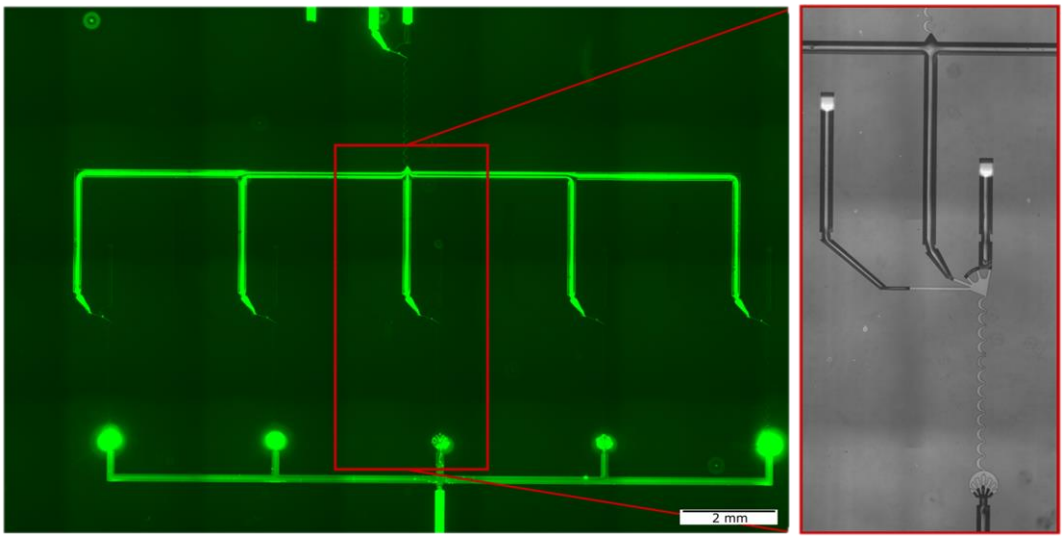
Inertial focusing is a phenomenon where particles are forced to migrate inside microchannels. With adequate conditions, microparticles align at equilibrium positions that depend on their size and geometry, enabling their separation and concentration at very high throughputs and recovery. The forces in play are extremely size dependent; *i.e.* the lift force (which normally plays the major role) relates to the size of the particle to the power of four ($F_L \propto a^4$). Therefore, to succeed in the alignment when targeting small particles, one must tailor the microchannel dimensions, its geometry and flow rate to compensate for the size. The smaller the particle targeted, the more pressure is needed; we used tens of bars and showed alignment of 1 µm particles in a spiral microchannel with the proper dimensions[1]. Others have shown it to work for 1 µm particles in a horse-shoe design at high pressure too[2].

In this abstract we present the results obtained in a chip with horse-shoe design that integrates five units in parallel (multiplying the though-put) and one in series (multiplying the concentration factor), Fig 1. Once the sample passes the parallel units, the concentrated outlets are recombined and go through the series unit where they are re-aligned and fractionated once more. In order to recombine the outlets we went out of plane; the channels were on both sides of a silicon wafer.

We built this system in silicon and glass to handle the high pressure. Especial attention was paid to the hydraulic resistance of the outlets; the particles should be centered in the outlet of interest to maximize the recovery.

[1] J. Cruz, S. Hooshmand, T. Graells, M. Andersson, J. Malmström, Z.G. Wu, and K. Hjort, J. Micromech. Microeng. 27, 084001 (2017).

[2] L. Wang, D.S. Dandy, Adv. Sci. 4, 1700153 (2017)



Left: Microfluidic chip with five units in parallel and one coupled in series concentrating 1 µm fluorescent particles. The recovery was 97% at a concentration factor of 35 with at a throughput of 200 µl/min and a pressure drop of 60 bar. Right: Single unit. It consists of a shallow horse shoe channel with deep and wide interconnects.