

Simple optimization of single-level particle trapping flow-through microfluidic devices using oblique hydrodynamic flow

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With the aim to monitor physico-chemical or biological processes, a strong effort has been put these last years to develop microfluidic devices [1,2] for the control of the spatial positioning of small objects such as cells or droplets [3,4], to allow their analysis over various timescales, at the single object level, alone or in interaction with other cells [5] or particles.

Over the wide range of hydrodynamic devices that have been developed so far, flow-through microsystems can be composed of auxiliary channels regularly spaced perpendicularly to a serpentine main channel [6], or arrays of half-circular [7] or U-shaped [3] trapping pocket. In this latter case, trap arrays were fabricated by single layer soft lithography [8], and could be improved in terms of efficiency, by making standing traps from double layer lithography [9,10], or in terms of selectivity, using reverse flow loading to immobilize multiple similar or different objects [4,10] together. Despite their simple fabrication process, single-level trapping arrays are generally less efficient than their double-level counterparts, since both the amount and the velocity of the fluid carrier entering the traps and escaping from their backside openings is much smaller than for the main flow, thus diminishing the probability for a trap to capture a particle.

In this work, we address this issue by showing that, contrary to the existing examples of single-level trapping devices from the literature that uses hydrodynamic flows parallel to the trap array, skewing the main direction of this flow increases both the efficiency and the spatial homogeneity of trapping at the full chip level. After a brief description of the fabrication process of the microfluidic traps and both the straight and skewed devices, we quantify and compare the trapping kinetics and homogeneity using model particles having sizes comparable to cells. Then, we show that mammalian cells can be efficiently immobilized using the skewed configuration. Finally, using simple simulations we will try to qualitatively explain the striking difference between the behavior of the straight and skewed configuration.

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