High-throughput Continuous Acoustofluidic Isolation of Vertically Focused Particles via Upward Migration

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In this study, we have demonstrated for the first time the vertical hydrodynamic focusing and a continuous acoustofluidic separation of particles inside a microchannel by uniquely taking advantage of the vertical component of acoustic radiation force (ARF). Surface acoustic wave (SAW) based acoustofluidic separation devices, using low power densities, offer a non-contact and label-free sorting capabilities using differences in mechanical properties (density, compressibility) or sizes of the micro-objects. SAW-based acoustofluidic device utilize an ARF for separation of particles when a traveling wave leaks at Rayleigh angle into a fluid flowing inside a microchannel at an angle of ~22° (in systems comprising water and a lithium niobate substrate). The ARF acting on a particle can be resolved into a horizontal and a vertical component, where the latter being ~2.5 times greater than the former. To date, most of the SAW-based microfluidic devices employ horizontal component of the ARF to deflect the pre-aligned particles laterally across the microchannel width. Fabrication limitations and complications in particle focusing in the vertical plane limits the use of the vertical component of ARF for particle separation. In the present work, a simple acoustofluidic device with straight PDMS microchannel loosely positioned on top of an interdigital transducer (IDT) is used to produce high frequency (140MHz) TSAWs to induce the ARF on the particles. Contrary to the previously used two sheath flows for particle focusing in SAW devices, a single sheath flow is used to pinch the particles close to the bottom of the microchannel. The particles mixture is uniquely focused in the vertical direction before continuously isolating the larger particles (4.8 µm) from the smaller ones (3.2µm or 2.0 µm) by the ARF. The horizontal component of ARF slowed down the selected particles while the stronger vertical component pushed the particles in the upward direction to realize continuous particle separation. The proposed particle separation device due to the utilization of principal component of ARF offers high-throughput operation (maximum tested flow rate up to 1.3 mL/min) with purity > 97% and recovery rate > 99%.