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Abstract

Concept and Proof of Principle of an Acoustofluidic Single-Particle Sorting Device Using a Spatially Confined Acoustic Active Region †

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Abstract: We present the concept and a proof-of-principle experiment for an acoustofluidic single-particle sorter. In a microfluidic channel, a flow profile with the following three parallel fluid domains is generated: buffer fluid in the center and buffer plus particles in the lateral domains. Due to the laminar flow regime present in microfluidics, the particles essentially follow the stream line(s) along the channel. In the spatially confined sorting and detection region, by switching on the standing acoustic wave, particles of interest (POIs) are pushed into the center fluid domain, thus leaving the chip at the center outlet. For particles of non-interest (PONIs), the acoustic region remains silent, so PONIs are not centered and follow their path to the side outlet.

Keywords: microfluidics; acoustofluidics; single particle sorting; bulk acoustic waves

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1. Introduction

For the acoustofluidic sorting of single particles, usually, so-called surface acoustic wave (SAW) devices [1] are used. For easier-to-fabricate and easier-to-handle bulk acoustic (BAW) devices, only one publication was found in which a detection zone and a spatially confined sorting zone were used [2]. Our concept (Figure 1) is also a bulk acoustic device and is verified in a proof-of-principle experiment (Figure 2).

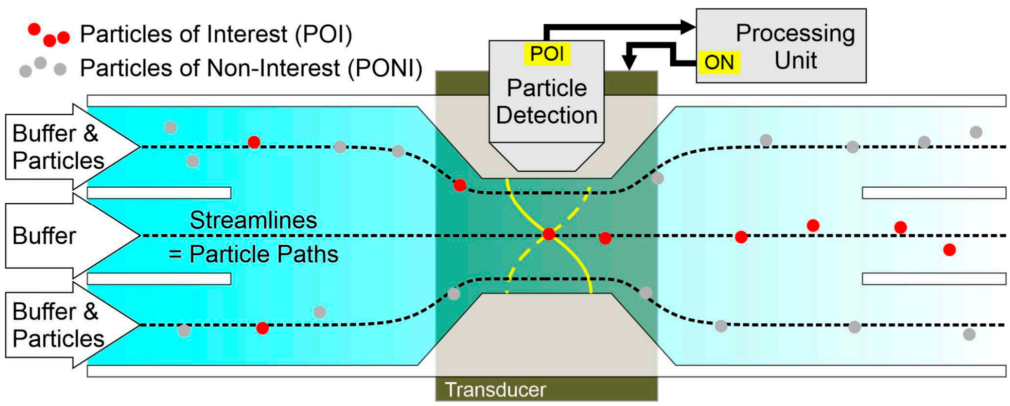
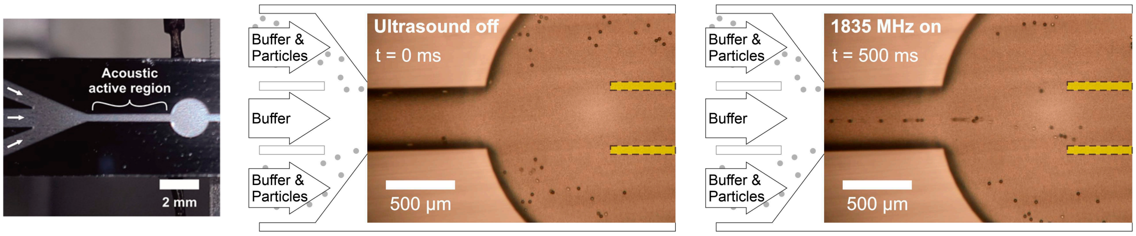


Figure 1. Concept of the acoustofluidic single-particle sorter. A flow profile with three fluid domains is generated in a microfluidic channel with only the lateral domains carrying particles. After detection,

POIs are pushed into the center stream in the acoustic sorting region and leave the chip through the center outlet, whereas PONIs stay on their path towards the side outlets.



(**a**) (**b**) (**c**)

Figure 2. Proof-of-principle experiment for the acoustic particle sorter. (**a**) Photograph of the silicon/glass device, which features trifurcation, a narrow region and a wider cavity, but lacks the three outlets on the right side, which in the following are indicated by yellow drawings. (**b**) As long as the ultrasound transducer is off, due to the laminar flow regime, polystyrene tracer particles that are introduced through the side inlets would leave through virtual side outlets. (**c**) When the transducer is switched on (1835 MHz), acoustic particle focusing only takes place in the narrow (400 µm) region, where the resonance condition is met. Particles that are in the wide region are not affected. Only the focused particles would leave through a virtual center outlet.

2. Materials and Methods

We use a microfabricated microfluidic chip made of silicon and glass that is externally actuated by a piezoelectric plate transducer. The acoustic active region is defined geometrically by narrowing in the channel width, so that the resonance condition for a standing sound half-wave is fulfilled only there. Aside from the sorting area, the width is chosen to not equal an integer multiple of the sound half-wavelength; thus, no standing wave can develop here. Detection takes place using a suitable method, e.g., fluorescence detection using a CCD camera.

3. Discussion

In contrast to the BAW sorting device in [2], our BAW concept contains a symmetric flow profile, which is expected to exhibit the easier and more stable adjustment of flow ratios between the inlets. Adjusting the dimensions of the acoustic active region facilitates the sorting of single particles and also smaller particles. For single-particle sorting, the fluid must be sparsely populated by particles, so our high-performance particle-focusing device from previous work [3] could be used for subsequent particle enrichment.

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