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# Microfluidic micromixing by micropost-based acoustic microstreaming

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## I. Introduction

Microfluidic mixing is important in many applications, including biology, chemistry, and drug delivery. Passive techniques utilize features of the channel geometry to increase mixing and typically suffer from low diffusion which leads to low mixing efficiencies. Active methods, however, are more effective, as external forces help create additional mixing interfaces. Acoustic microstreaming-based microfluidic mixing is a promising technique but has so far been limited due to high costs and low mixing efficiency[1]. Existing acoustic microstreaming-based microfluidic mixing relies on trapped bubbles and sharp edges on channel walls to trigger microstreaming. Our work is differentiated by the use of stop-flow lithography to create a wide variety of micropillars in the microfluidic device. Specifically, our micromixer uses microposts that can be tuned in terms of size, shape, and stiffness to enable fine tuning of the acoustic mixing profile. This novel approach can potentially enable adjustable mixing indexes suitable for a wide range of biomedical applications including nanoparticle synthesis with higher uniformity

## II. Materials and methods

We employ acoustic excitation to disturb and thereby mix fluids in a microfluidic device. The microfluidic device is fabricated by soft lithography, and a transducer is attached to the glass substrate of the device to enable acoustic excitation [1]. We create micropillars inside the microchannel using stop-flow lithography. The transducer actuation leads to the vibration of the glass substrate, which in turn, vibrates the posts inside the microfluidic channel such that microstreaming flows are generated around each pillar. The microstreaming flow significantly enhances the fluid mixing inside the channel [2].

## III. Results

We have created a robust protocol to examine mixing performance quantitively by designing a setup to avoid flow fluctuations over time and monitor mixing using an inverted microscope. We use Equation 1 below to evaluate mixing performance by measuring the grayscale value in microscopy images along a line that spans the channel width at the end of the channel. Parameters in Equation (1) are as follows: MI: mixing index; n: the number of pixels along the selected line; $I_i$: point gray scale value; $I_m$: mean grayscale value along the line. Complete mixing is reported for $MI \geq 90\%$ [1,3].

$$\mathrm{MI} = 1 - \frac{\sqrt{1/n \sum_{i=1}^{n} (I_i - I_m)^2}}{I_m} \qquad (1)$$

We investigate different parameters in the micropillar-fabrication stop flow lithography process to create various shapes and stiffness microposts. Finally, we also evaluate the resulting mixing performance from these parameter changes. We perform parameter sweeps for transducer power, micropost geometry and stiffness, and microchannel geometry to optimize the microfluidic acoustic micromixing platform.

## IV. Conclusion

Microfluidic mixing using microposts can lead to mixing in high aspect ratio channels. Achieving the goal of optimizing mixing performance will lead to benefits in applications in biology, chemistry, and other fields.

## References

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