Towards a multi-interdigital transducer configuration to combine focusing and trapping of microparticles within a microfluidic platform: a 3D numerical analysis

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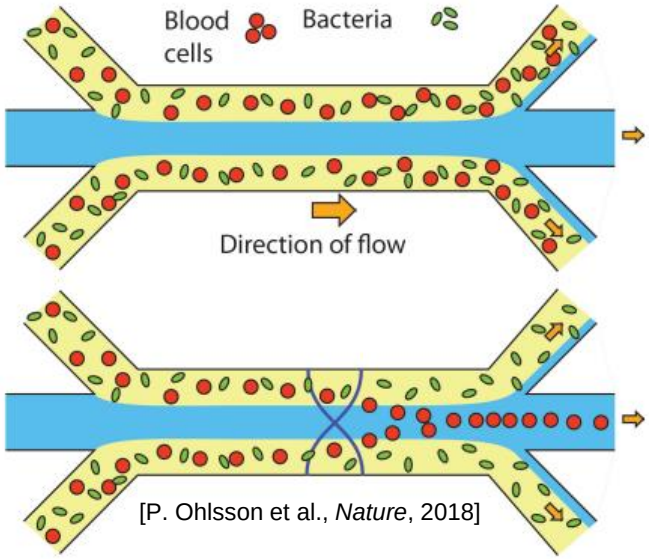
Introduction

Background:

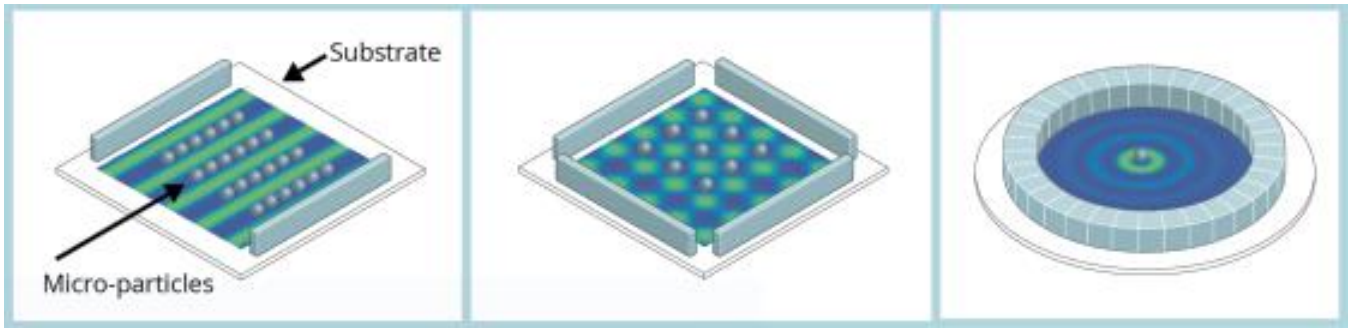
- Microfluidics and Lab-On-a-Chip (LOC) devices.
- Acoustic manipulation of microparticles through acoustophoresis.
- Surface acoustic waves (SAW)-based devices.

Aim:

- Analysis of a multi-interdigital transducer configuration to achieve a versatile and efficient acoustic manipulation of particles.

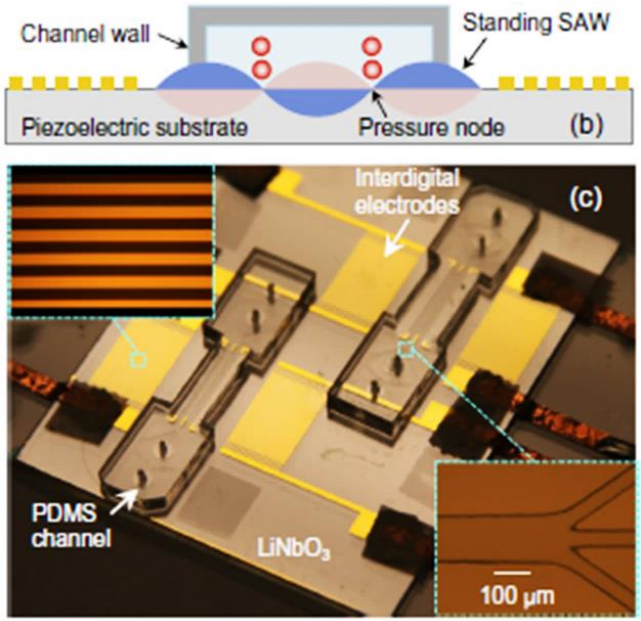


[P. Ohlsson et al., *Nature*, 2018]



[B.W. Drinkwater, *Lab on a chip*, 2016]

SAW-based devices



[J. Guo et al., *Journal of Colloidal and Interface Science*, 2015]

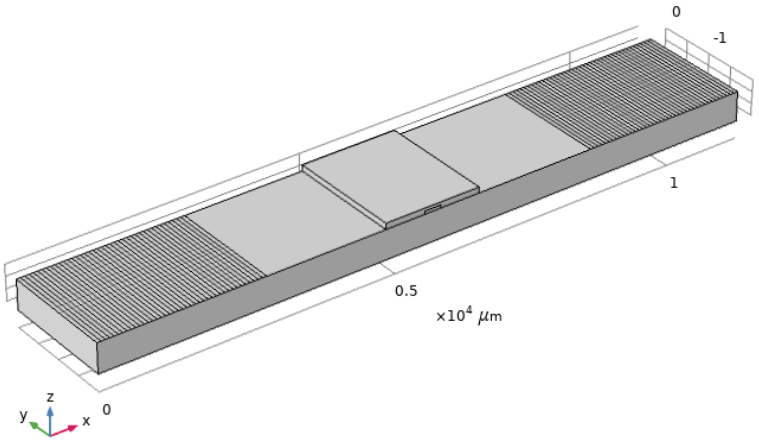
Device functioning:

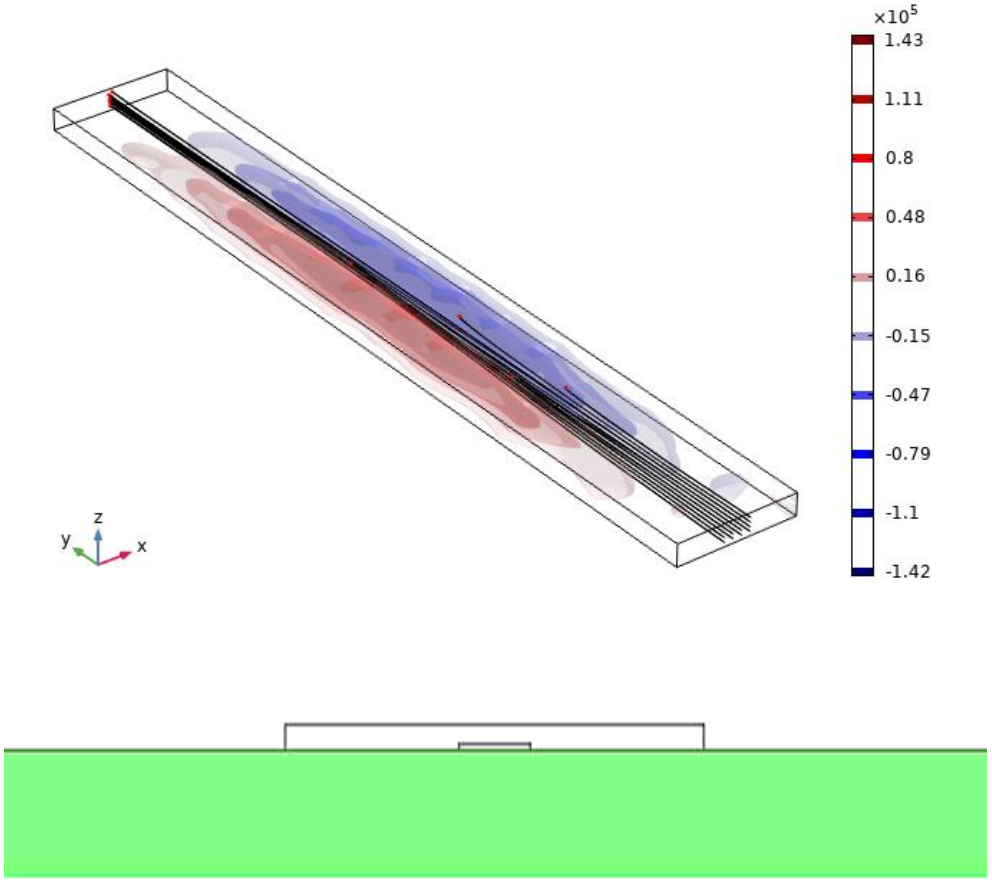
- AC voltage signal applied to IDTs deposited on the surface of a piezoelectric substrate;
- Converse piezoelectric effect generates travelling SAWs (TSAWs) on the surface of the substrate;
- Two or more counter-propagating waves interact developing a standing SAW (SSAW);
- The SSAW is transmitted to the fluid contained in a microchannel, in form of pressure waves;
- The standing pressure field can be exploited for acoustic manipulation of microparticles dispersed in the fluid.

Two-IDTs configuration

Model:

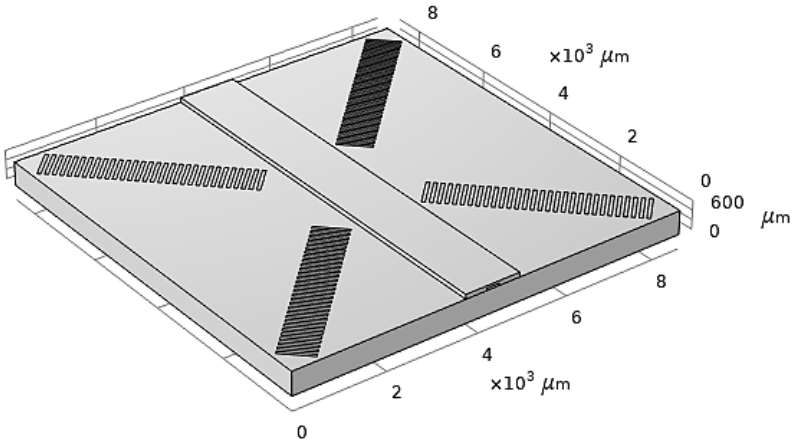
- Piezoelectric effect: coupling between mechanics and electrostatics (piezoelectric constitutive law).
- Acoustic pressure field: Helmholtz wave equation.
- Forces acting on particles: acoustic radiation force and fluid drag force.



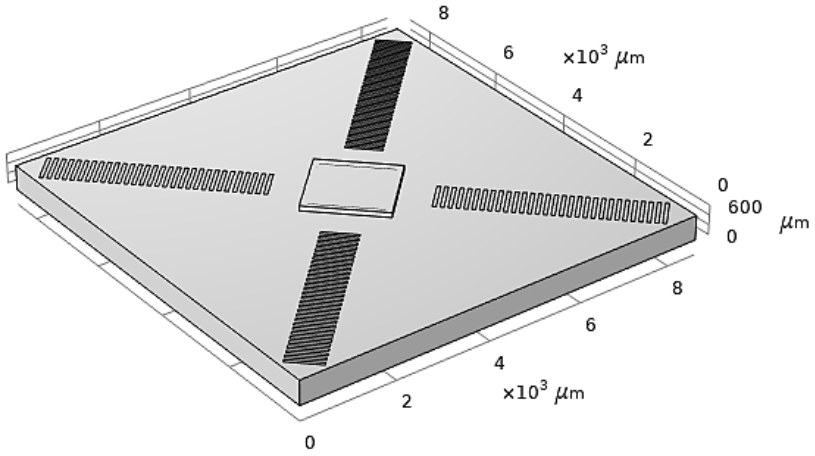


Multi-IDTs configuration - Geometry

	$LiNbO_3$ Substrate	PDMS Channel	Water Channel	PDMS Chamber	Water Chamber
Width	8627µm	1650µm	280µm	1650µm	1400µm
Length	8627µm	8627µm	8627µm	1650µm	1400µm
Thickness	500µm	100µm	50µm	100µm	50µm

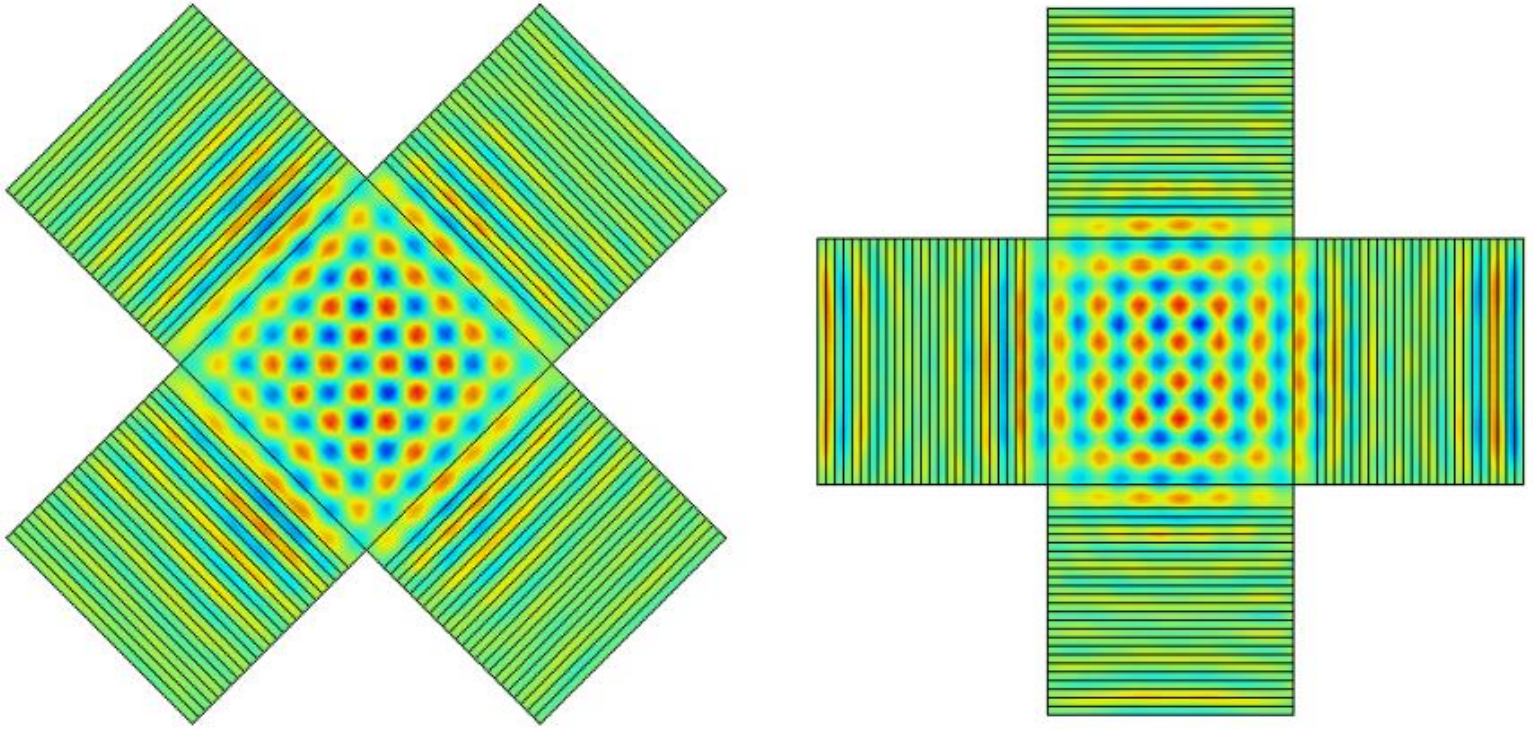


PDMS Microchannel



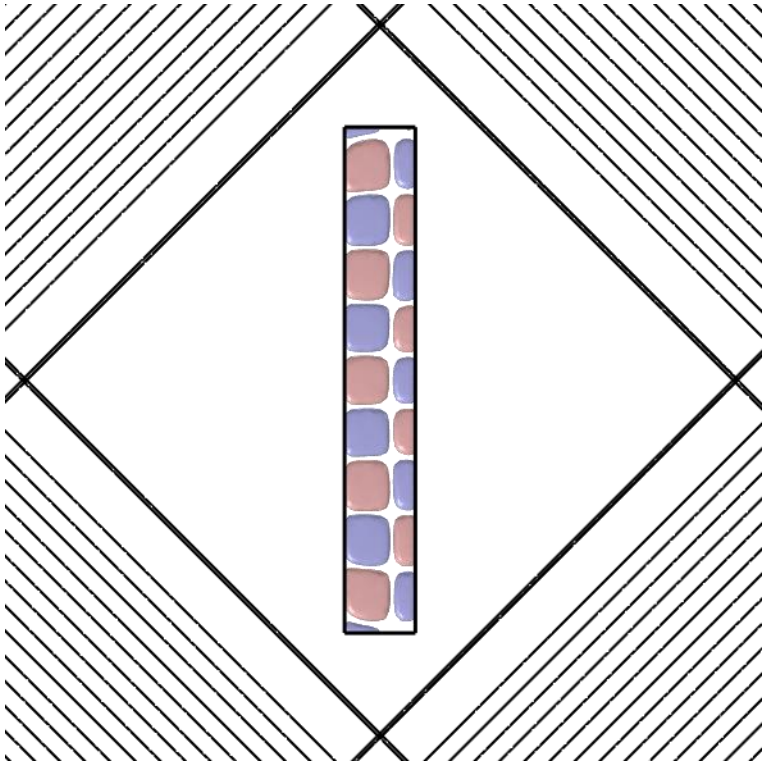
PDMS Chamber

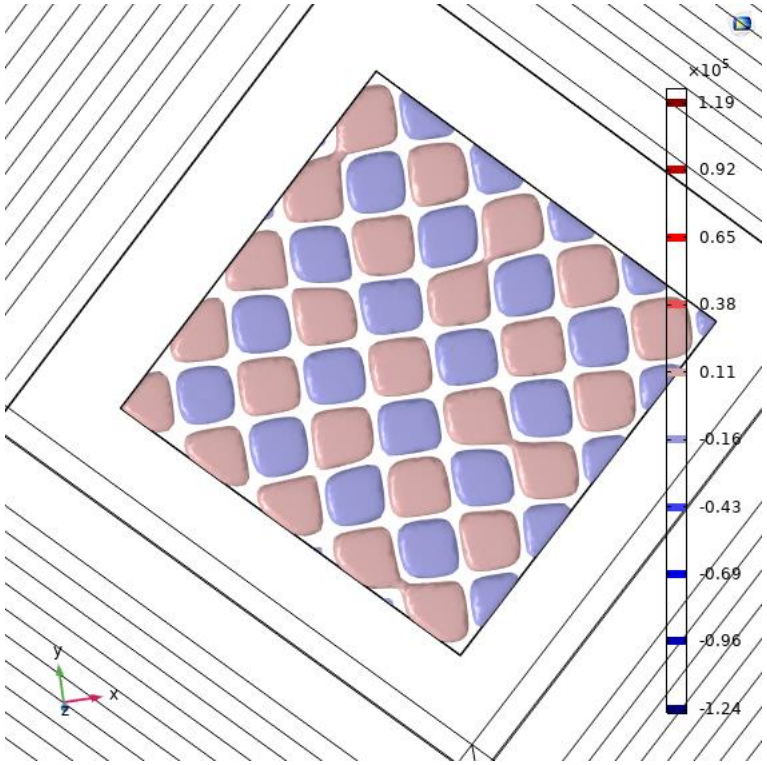
Multi-IDTs configuration - SSAW



SSAW distribution caused by four TSAWs interacting.

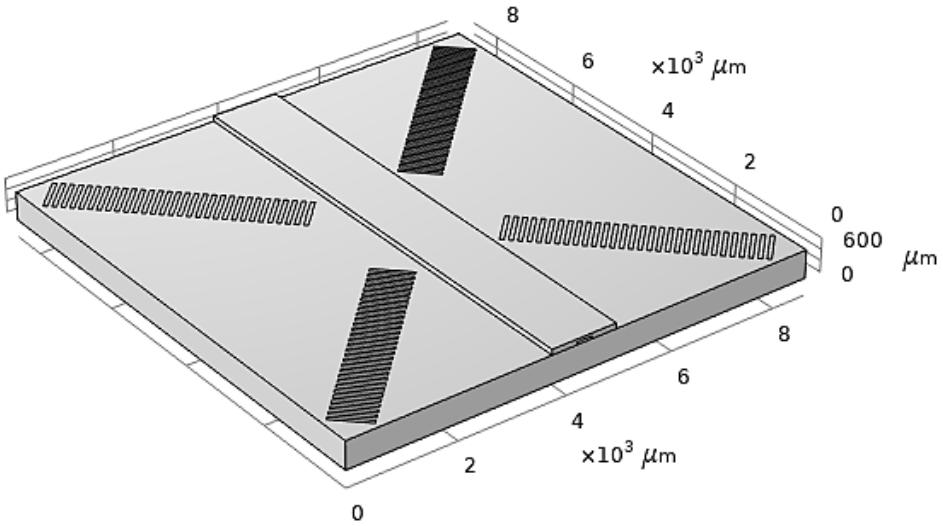
Multi-IDTs configuration – Standing pressure field

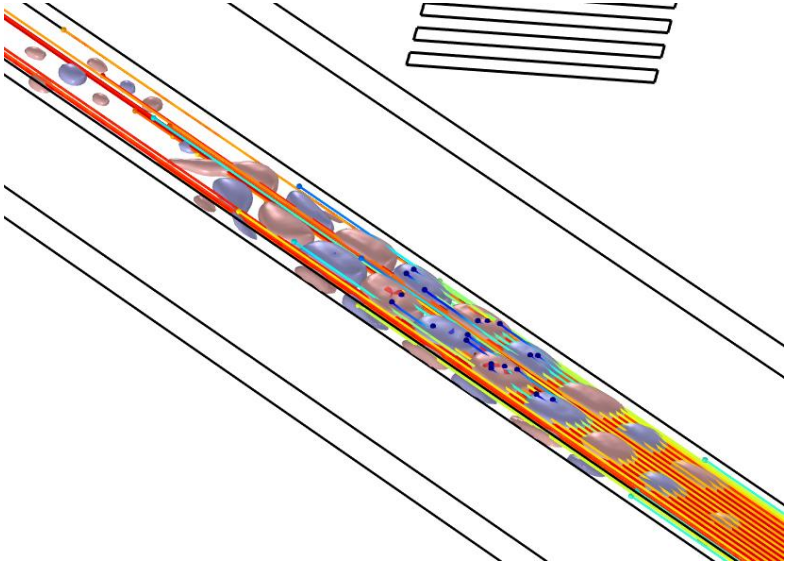




Standing pressure field within the fluid domain contained in the PDMS structures.

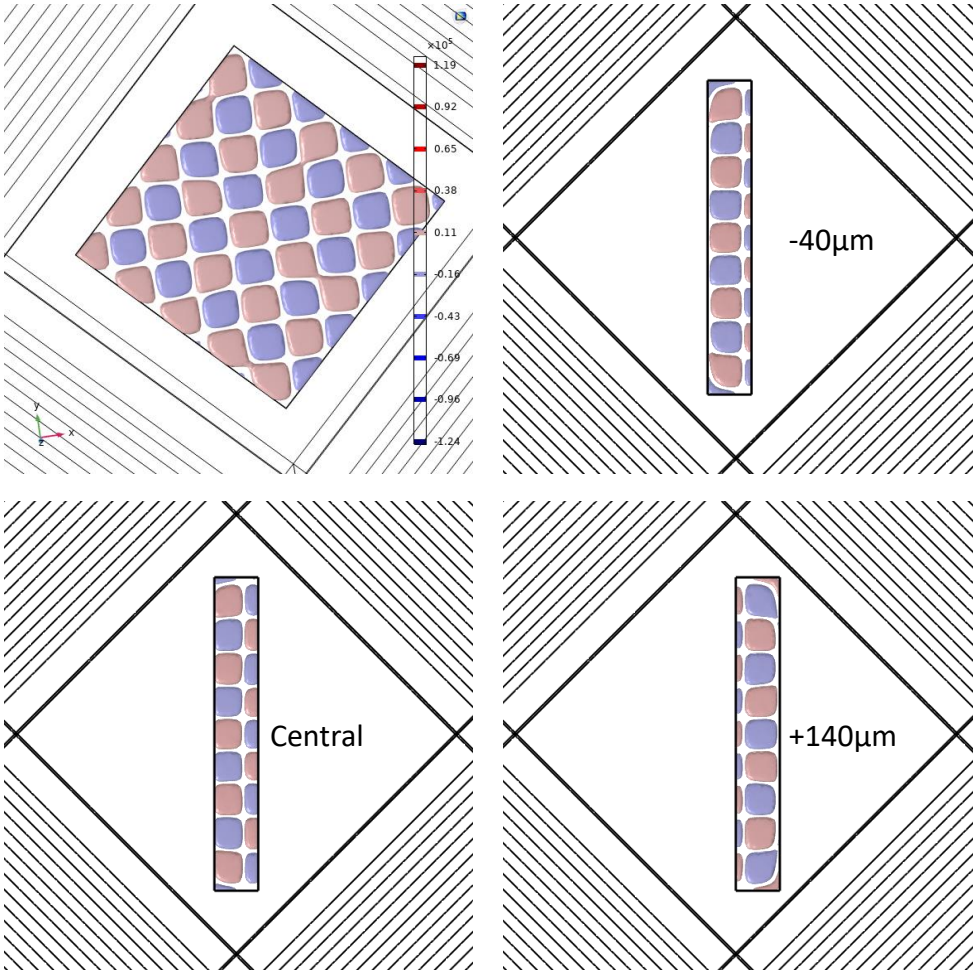
Multi-IDTs configuration - Focusing





Particles focused on the two pressure nodes.

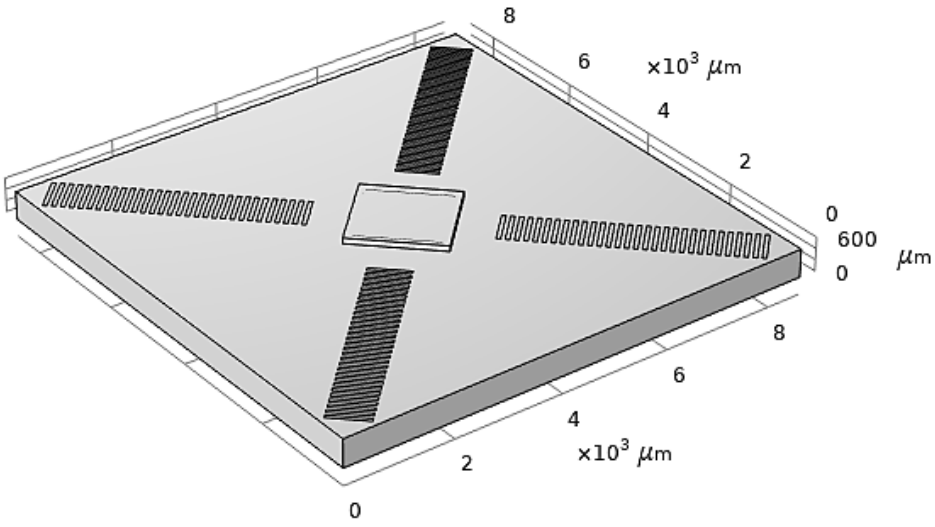
Multi-IDTs configuration - Versatility

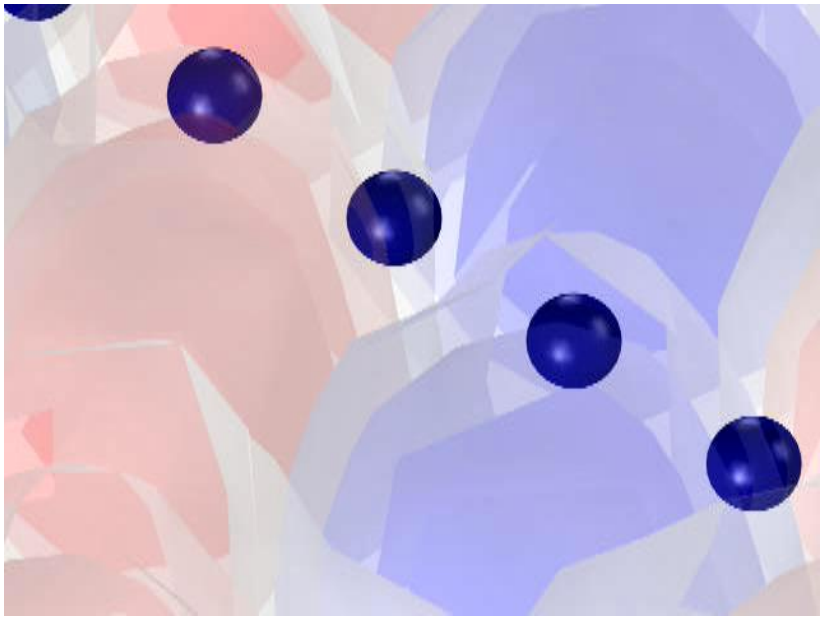


Versatility of the configuration:

- Design of the microstructure to generate a specific standing pressure field within the fluid domain (change position of the pressure nodes).
- Disposable PDMS microchannels can be used.

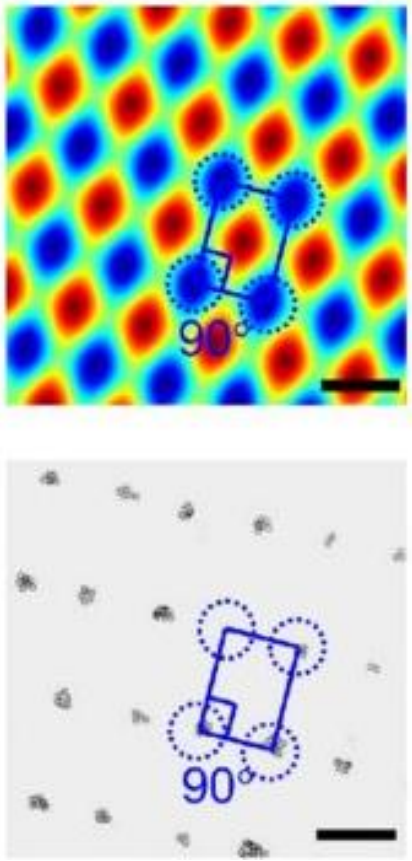
Multi-IDTs configuration – Trapping





One particle is trapped within the pressure node.

Conclusions



[Tian et al., *Sci. Adv.*, 2019]

Conclusions:

- Low-cost fabrication;
- Easy integration in Lab-On-a-Chip devices;
- Microparticle focusing, sorting and trapping can be achieved;
- Versatility of the platform depending on the design of the microchannels;
- Applications towards biological cell sorting, isolation, and assembling can be considered based on this principle.

Thank you for your attention!

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