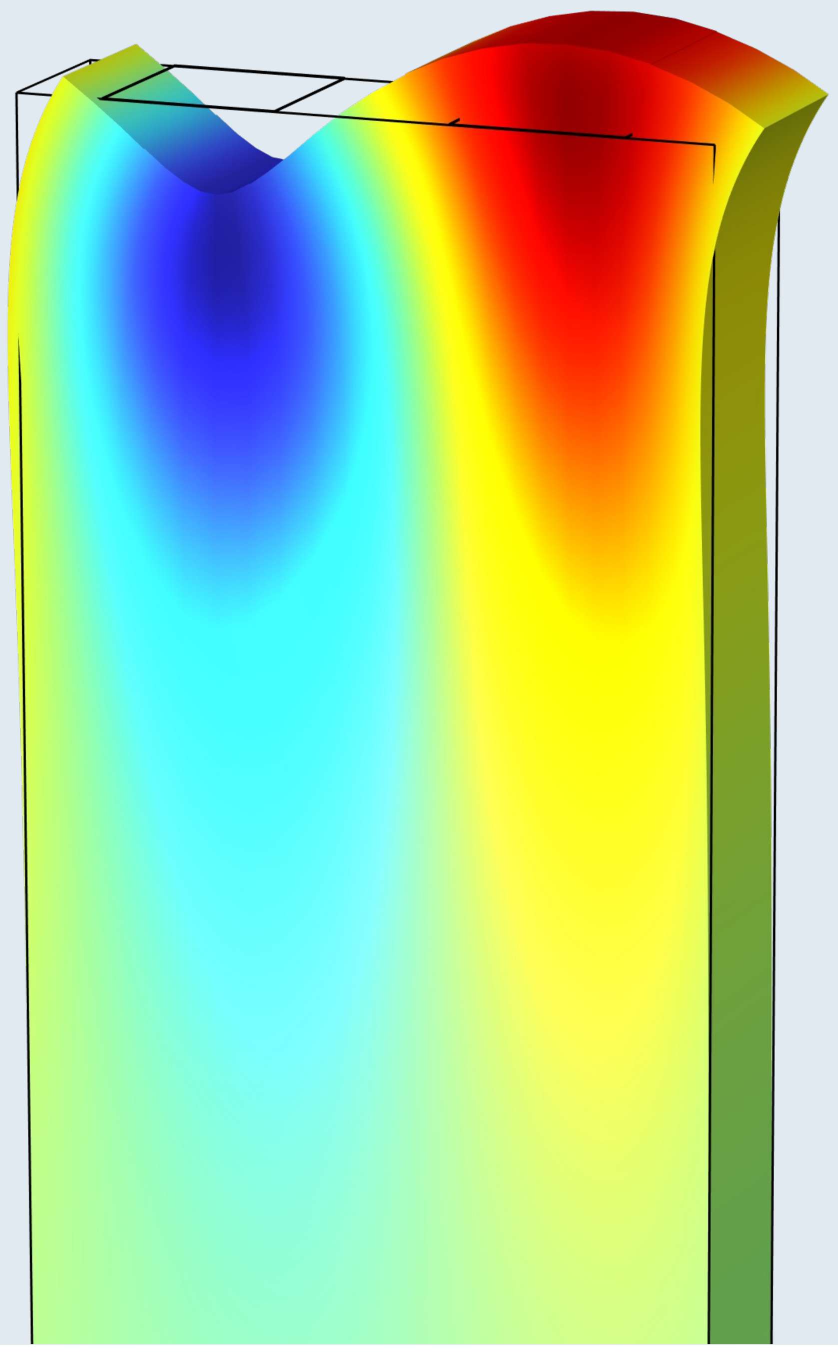

Design and Optimization of Piezoelectric Transducers for Rayleigh Wave Generation in Microfluidics

Surface acoustic waves (SAW) can be used in microfluidic devices to manipulate and sort particles based on their mechanical properties.

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Introduction and Goals

Microfluidic devices based on acoustophoresis are emerging as powerful tools for particle manipulation in biomedical and chemical analysis. Acoustophoresis leverages acoustic waves to separate particles based on their size, mass, and density.
This work focuses on optimizing a piezoelectric transducer device to generate standing Rayleigh waves, known for their high efficiency in coupling mechanical energy from piezoelectric substrates into fluids. COMSOL Multiphysics® was employed to simulate the device before fabrication, providing a cost-effective alternative to traditional trial-and-error methods. The objective is to enhance particle sorting efficiency by optimizing the geometry and operational parameters of the device.

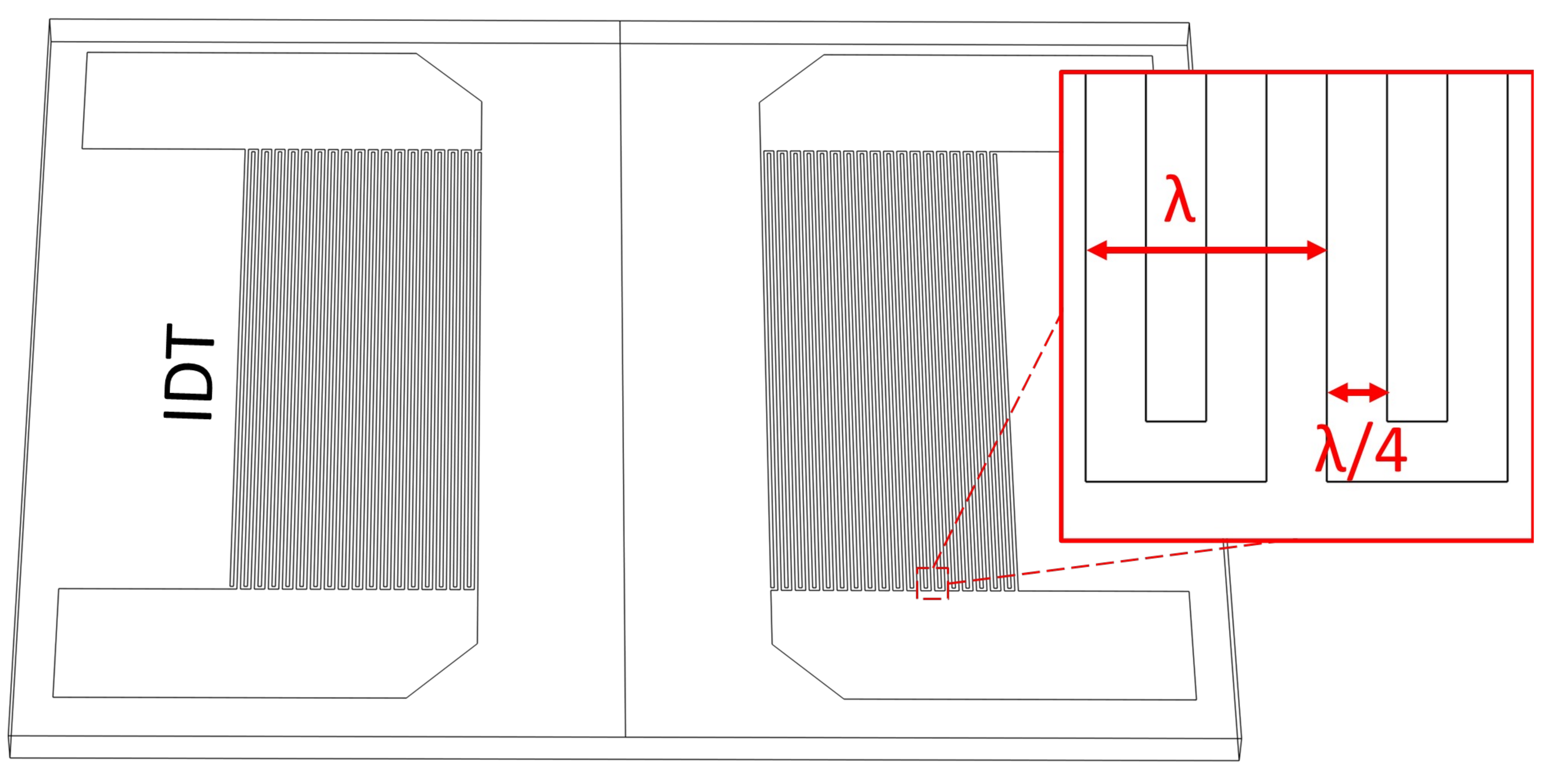

FIGURE 1. Design of the piezoelectric transducer device showing the two counterposing IDT electrodes on the lithium niobate substrate. The wavelength λ of the acoustic wave is 200 µm.

Methodology

The device design consists of two sets of aluminum IDTs placed on a lithium niobate substrate with a 128° YX cut. As preliminary step, a reduced unit domain of the device was simulated, based on its geometric periodicity of 200 µm. A modal analysis identified the resonance frequency of the Rayleigh waves, which was used for subsequent harmonic studies. Two sets of IDTs were excited at this frequency, and the resulting standing wave patterns were analyzed. The admittance of the device at the resonance frequency was also examined. A time-dependent analysis was performed to study the transient phase of wave generation before scaling up the model to the full device.

Results

The simulations showed the successful generation of standing Rayleigh waves between the two IDTs at the resonance frequency of 18.21 MHz. The mechanical energy was mostly confined between the IDTs, maximizing the efficiency of the transducer. The device's admittance peaked at the resonance frequency and the parametric study confirmed a linear response to excitation. The harmonic analysis of the full device validated the simulation by creating a digital twin ready-for-comparison with real-world data.
These findings suggest the device's strong potential for efficient particle manipulation in acoustofluidic applications.

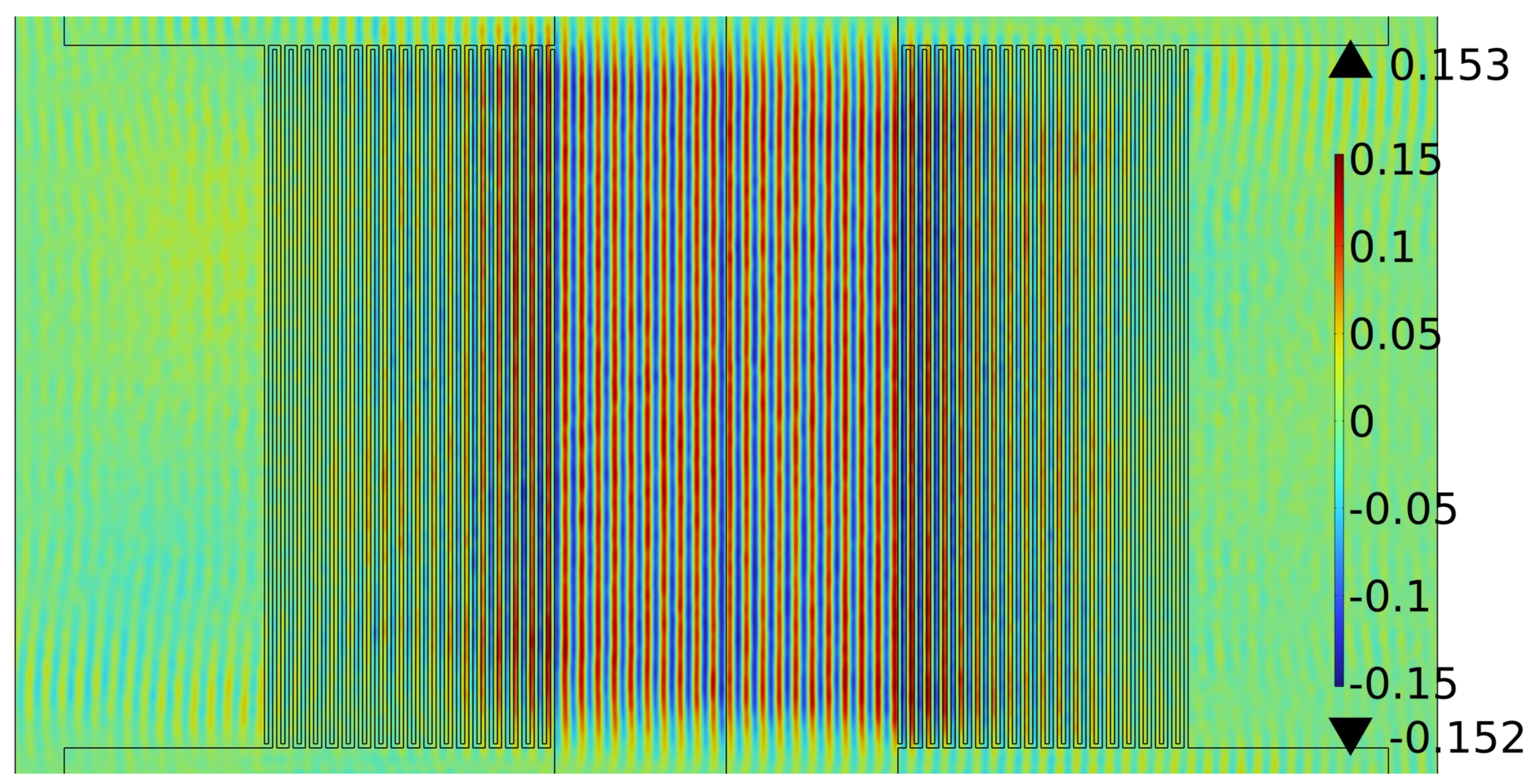

FIGURE 2. Vertical displacement field of the piezoelectric transducer digital twin. The standing surface acoustic wave (SSAW) pattern is confined to the region between the IDTs.

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