Optimal Design of Silicon-based Chips for Piezo-induced Ultrasound Resonances in Embedded Microchannels - DTU Orbit (24/12/2018)

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We present a variational formulation of the governing equations and introduce global indicators to describe the behavior of acoustofluidic devices driven at resonance frequencies by means of a piezoelectric transducer. The individuation of the correct Lagrangian densities for the different parts constituting the device (the piezo transducer, the silicon walls, the fluid-filled microchannel, and the glass lid) allows for the introduction of the weak formulation used in the finite element discretization of the equations describing the system in its oscillatory regime. Additionally, the knowledge of the Lagrangian density leads to the derivation of the correct structure of the Hamiltonian density, i.e. the energy density, which is important for the quantification of the energy content of the whole system and its individual parts. Specifically, the energy content of the embedded microchannel is quantified by means of the acoustofluidic yield \( \eta \) defined as the ratio between the energy in the channel and the total energy. From the standpoint of acoustophoretic application, the introduction of the acoustophoretic mean orientation allows us to identify the frequencies for which an acoustophoretic effect, i.e. the lateral motion of particle dragged by the axial main flow, is particularly strong. Finally, the connection between the mechanical and electrical degrees of freedom of the system is addressed. This is important for proper determination of the dissipated power, and it may lead to the detection of resonance states by means of purely electrical measurements. Numerical simulations and preliminary experimental results show some features of the model introduced.

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