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Lamb-Wave Mode-Conversion Based Neurostimulation Device

We present a simple, and cost-effective ultrasound device for in-vitro neurostimulation to facilitate fundamental and advanced research in the field. The effect of ultrasound on excitable biological tissue has been studied since 1920s but the exact mechanisms of the phenomenon are not fully discovered or understood yet. Previous and current approaches using focused, or planar ultrasound transducers inevitably experience attenuation of plane waves in a coupling medium and are bulky and complicated to be coupled with high-resolution imaging/recording techniques.
We developed new type of ultrasound neurostimulation device using lamb-wave mode-conversion principle to improve the delivery of ultrasound and reduce the complexity of the in-vitro and ex-vivo experimental setup. The device consists of a piezoelectric cylinder, a 250 μm thick glass coverslip as a specimen stage, and surrounding glass wall. Working in radial mode vibration, the piezoelectric cylinder induces lamb-waves in the glass coverslip and the antisymmetric mode lamb-waves below approximately 1 MHz, which have phase velocities slower than that of the biological solution or water in the specimen stage. These propagate through the glass coverslip, converge at the center, and then leak into the biological specimen. These improved propagation conditions minimize loss and improve spatial resolution of the delivered ultrasound wave. Notably, the piezoelectric cylinder can be frequency tuned for different tissue types making this useful for neuromodulation devices as well as high-resolution live-cell and tissue imaging techniques.

Stage of Research

- Prototype

Applications

- Ultrasound neuromodulation devices

- Microscope add-on

Advantages

- Improved spatial resolution and minimized loss of delivered ultrasound wave
- Higher acoustic impedance for better propagation conditions
- Thin geometry glass coverslip as a waveguide path

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