► Particle Manipulation Using Ultrasonic Fields
► Integrated Micro Devices for Biological Applications
► Microfabrication Techniques
► Microturbines

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Ultrasonic Material Removal

► Ultrasonic Machining

Ultrasonic Particle Manipulation

► Particle Manipulation Using Ultrasonic Fields

Ultrasonic Pumps

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Synonyms

Acoustic streaming pumps

Definition

Ultrasonic pumps are pumps that use acoustic streaming to create a fluid motion inside microchannels. Acoustic streaming is the time-averaged flow induced by an ultrasonic wave (periodic pressure oscillation). Attenuation of the acoustic energy (via reflection and other distortion) generates a body force within the fluid and converts acoustic energy into kinetic energy of the fluid [1].

Overview

Ultrasonic pumps are very useful for microscale applications due to their simplicity, robustness and scaling advantages. Moreover, they are insensitive to the chemical state of the fluid and the wall material unlike electroosmotic and magnetic pumps. By using acoustic streaming as a pumping mechanism, noncontact fluid control is achievable since no contact is needed between the acoustic source and the fluid; and no valves are required [2].

Acoustic streaming flow fields depend on acoustic beam characteristics, fluid properties and the presence and the geometry of solid boundaries or particles. Depending on these factors, laminar, transitional or turbulent flow with jets and vortices can be generated. Acoustic streaming is proportional to the sound pressure level of the acoustic beam and the square of the frequency of the acoustic wave [1]. However, excessive heating – since most of the acoustic energy becomes heat – and bubble formation set an upper limit for high intensities [2].

An ultrasonic transducer is an integrated component of acoustic pumps. The transducers that generate ultrasonic energy with megahertz frequency for ultrasonic pumps make use of the piezoelectric (PZT) effect. A PZT layer is the vital component of the ultrasonic transducer and provides the oscillatory motion that ultimately produces the acoustic beam.

Rife et al. [3] developed a fluidic pumping circuit powered by an acoustic frequency of 50 MHz, and generated fluid flow with velocities of the order of mm/s. They used ultrasonic PZT transducers for their pump to generate the acoustic waves. The intensity of the waves was low enough to produce negligible heating; however, even if the heating could be tolerated, dielectric breakdown in the PZT thin film limited the maximum intensity. They also discussed bubble formation, and concluded that for frequencies above a few megahertz, the technique was safe to use for degassed liquids without any cavitation problem.

Nguyen and White [4] presented a numerical study of a flexural plate wave (FPW) micropump. Their simulated device consisted of a channel with a thin PZT membrane, whose thickness was 1 – 3 μm attached to a bottom wall. This membrane generated a high-intensity acous-

tic filed in the vicinity of the fluid inducing the motion of a fast-moving layer near the membrane. They investigated the pumping performance with different parameters such as the wave amplitude, channel height and back pressure. They concluded that micropumps with a height of a few micrometers had a good performance due to their high flow rate and high hydraulic impedance against back pressure.

Cross References

- ► Electrical Pumps
- ► Magnetic Pumps
- ► Thermocapillary Pumping

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Ultrasonic Separation

- ► Particle Manipulation Using Ultrasonic Fields

Unbalanced AC field

Synonyms

Aperiodic AC field

Definition

A periodic alternating-current (AC) electric field is called unbalanced, if its first moment has zero time average ($\langle E \rangle = 0$), but at least one of its higher moments does not (e. g. $\langle E^3 \rangle \neq 0$).

Cross References

- ► Aperiodic Electrophoresis
- ► Electrokinetic Motion of Polarizable Particles
- ► Nonlinear Electrokinetic Phenomena

Unimorph

Definition

A structure composed of one active layers and one or more passive layers. Typically the active layers work through either thermal expansion, hygrothermal expansion, or piezoelectric expansion via an externally-applied electrical field. Such devices are asymmetric about their neutral axis, and so may generate axial stretching or contraction along with bending.

Cross References

- ► Bimorph
- ► Piezoelectric Valves

Unit Impulse Function

- ► Dirac Delta Function

Unmanned Rotorcraft

- ► Microrotorcraft

Unmixing

- ► Demixing

UV-LIGA

- ► LIGA-Like Techniques