Investigations on the propulsion of droplets induced by surface acoustic waves

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I hereby declare that I have authored this dissertation independently and that I have acknowledged all sources and means of assistance.

I declare that I have not finally failed in either the ongoing doctoral examination or in another similar one.

Coburg, 17.Dec.2013

Wei Liang

Abstract

A model for the numerical simulation of the movement of liquid droplets excited by Lamb waves propagating on non-piezoelectric substrates was developed and the results of simulation calculations based on this model were compared with experimental observations. In the experiments, antisymmetrical zero-order Lamb waves with 1 MHz center frequency were excited on a 1-mm thick glass substrate by piezoelectric single-phase transducers, which caused the propulsion of microliter water droplets. The acoustic streaming within the droplet was calculated by solving the incompressible Navier-Stokes equations with an inhomogeneous acoustic streaming force field. These calculations were validated by optical measurements of the streaming effects in the droplet and by measurements of the displacement amplitudes of the Lamb waves with a laser-Doppler-vibrometer. Another part of the numerical simulations was related to the transient motion of acoustically driven droplets by solving the incompressible Navier-Stokes equations using the moving mesh application mode of the COMSOL software including a weak formulation for the calculation of the surface tension. The corresponding measurements with a high-speed camera revealed a silkworm-like movement of the droplet resulting from the interaction with acoustic force, surface tension, gravity and inertial force, which was reproduced by the numerical simulations.

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