Liquid Dynamics in Dielectrophoretic Actuation

by

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ABSTRACT

Electrostatic actuation of liquids has become a viable means for moving small volumes of liquid in microscale applications. This work explores the actuation of liquids by an electrostatic force using a phenomenon known as liquid dielectrophoresis (LDEP or just DEP). Due to scaling properties, LDEP can function as an effective means for moving liquid in microsystems. For potential integration of this actuation method into microsystems, a reliable model is needed to predict how the dynamic response of liquid behaves during actuation. To develop such a model, theory that incorporated five independent forces acting on an infinitesimal segment of liquid was applied, followed by experimental testing. The forces were dependent upon system parameters as well as liquid height and/or liquid velocity. The net effect due to these forces was then quantified in a non-linear differential equation. Matlab was used to solve this equation with respect to time. For experimentation a potential difference is applied across two transparent capacitor plates, and an electric field is created through a microchannel, which creates an electrostatic force that enables the liquid to rise against gravity. The microchannel for liquid actuation was roughly 2mm by 130um by 7.5 cm, and the voltage used was 300 V for water and 470 V for silicone oil. The dynamics of this process were then analyzed and the theoretical model's results were compared to experimental results.

Experiments were run to validate the model. Experiments yielded maximum actuation heights of about 30 mm for water and 6 mm for silicone oil. Maximum velocities demonstrated were 80 mm/s for water and .5 mm/s for silicone oil. After analyzing the results, the theoretical model was proven to be accurate for relatively high-speed actuation. The model deviated from experimental results in that it predicted further liquid advancement over a longer time period. A possible explanation for this disparity could be attributed to liquid stiction, which was not considered in the model.