Electric Field Actuated Microflows

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Abstract

The current work examines three flow actuation techniques for different flow systems namely: 1. Electrowetting of partially wetting thin liquid films, 2. Dielectrophoretic (DEP) actuation of sessile drops and 3. Electro hydrodynamic (EHD) pumping of oil in water emulsions. The aim of the first section is to assess electrowetting as a means to enhance wetting and to explore its potential in micro-cooling applications. A curved liquid meniscus of SDS solution over a silicon substrate (wafer) covered with a native silicon dioxide film (about 30 A thick) is subjected to a constant heat input and incremental voltages (0-8V). The meniscus shape is measured accurately using a non-intrusive image analyzing interferometric technique. The results clearly demonstrate that electrowetting effectively counters the meniscus retraction due to the heat, thereby increasing the suction of the coolant towards the hot spot. The aim of second section is to explore dielectrophoresis as a means to actuate discrete drops using a novel line electrode configuration. A merging scheme is demonstrated by applying AC fields to two sessile, de-ionized (DI) water drops placed horizontally apart on indium-tin oxide (ITO) coated glass through a common horizontal electrode. The motion of the drop is characterized and explained in terms of a lumped capacitive model. The success of liquid-DEP at such scales is attributed to the weak dependence of DEP actuation force on the electrode spacing. The effects of frequency on the drop behavior are investigated through a parametric study which shows two distinct regimes - EWOD type behavior at low frequency and DEP at high frequency. The aim of the third section is to devise a method for pumping oil in water emulsions through microchannels using EHD flows. The technique involves subjecting the emulsion to AC electric fields across the channel walls. A plug flow of the emulsion is observed by tracking the path of the entrained drops. The transverse velocities are measured as function of applied voltage for different electrode

separations and frequencies. The phenomena are analyzed in terms of EHD theory, with appropriate validation of experimental results. The scheme is found to be superior to conventional electro-osmotic pumps.