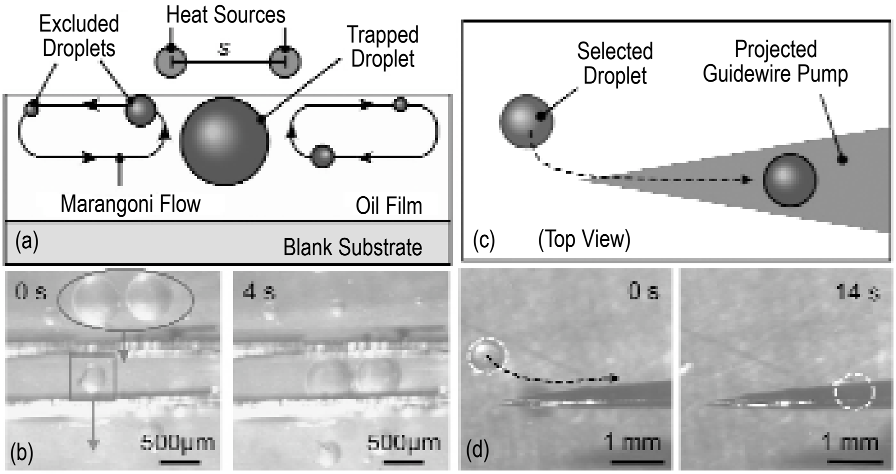
Virtual Microfluidic Components for Droplet Manipulation Using Marangoni Flows

Amar S. Basu and Yogesh B. Gianchandani



(a) Cross-section of a droplet trapped in a virtual channel. (b) Micrographs showing size-selectivity of the channel. (c) Guidewire pump emulated by a triangular heat flux. (d) Droplets are pulled along the length of the guidewire as a result of Marangoni flows.

Microdroplet systems use small droplets of aqueous reagents submerged in an immiscible oil phase as compartmentalized reactors. Techniques for manipulating droplets, including electrowetting and dielectrophoresis, require physical contact between the droplet and a solid surface, which greatly increases the likelihood of device contamination and sample loss. This project explores the use of Marangoni flows to transport, trap, and manipulate droplets. Local flows are generated by microscale heat sources placed near the surface of the oil layer that do not contact the droplets or the oil. A variety of flows, engineered through the geometric design of the heat source, can emulate common microfluidic components such as filters, traps, and pumps. Size-selective droplet channels, emulated by parallel line heat sources, demonstrate nearly 100% selectivity based on droplet diameter. A droplet pump, emulated by a triangular heat flux on the liquid surface or with a linear gradient in surface temperature, is capable of moving droplets 400–1000μm diameter at speeds up to 200μm/s. Simulations indicate that at small length scales, only small changes in surface temperature (<5°C) are needed to generate Marangoni flows. This work has been supported by NSF, NIH, the University of Michigan, and a Whitaker Foundation fellowship (AB).