Ultracompliant Thermal Probes For High Throughput Thermal Imaging, Patterning, and Fluidic Actuation

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(A) Doublet flow on the surface of a thin-water film, driven by a thermal probe suspended just above it. (B) 4800 µm/sec flow in an 80 µm-thick water layer. (C) Toroidal flow generation in oil using the same technique. (D) 25 µm pollen in a 140 µm-think mineral oil layer is trapped in the probe-driven flow.

This project explores the use of microfabricated thermal probes and thermal probe arrays for 1) microscale manipulation of fluids, 2) high-throughput, high-resolution thermal imaging, and 3) thermal patterning of thin films. A thermal probe is a thin-film cantilever with a sharp metal tip, heat source, and temperature monitor integrated near the far end. When suspended <200 µm above a thin film of water or oil, heat transferred from the probe to the liquid surface results in surface-tension-driven convective flow patterns, with flow speeds approaching 5000 µm/sec. Another use of the probes is scanning thermal microscopy (SThM), a thermal analysis technique which profiles nanoscale gradients in temperature and thermal conductivity. The high-mechanical compliance of this probe design removes the need for the costly force feedback mechanism typically required of scanning probe systems. Lastly, the localized heat provided by the probes can be used to pattern thermally sensitive films in a maskless lithography process, also without force feedback, and with submicron resolution. These projects were supported by the National Science Foundation, the University of Michigan, and the Whitaker Foundation.