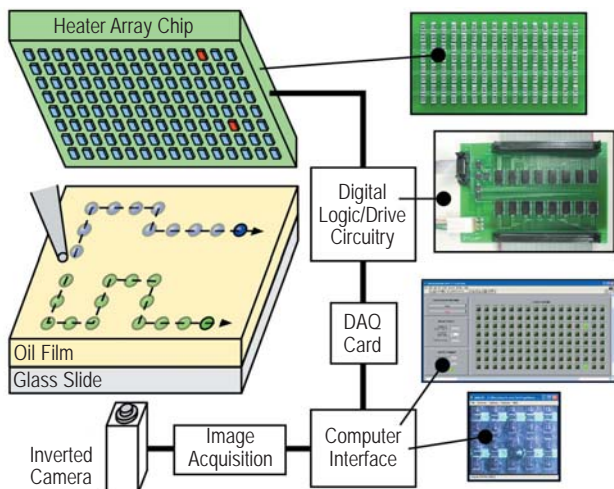


# Digital Microfluidics With Marangoni Flows—A Contact-Free Technique for Manipulating Microdroplets for Microscale Bioanalytical Systems

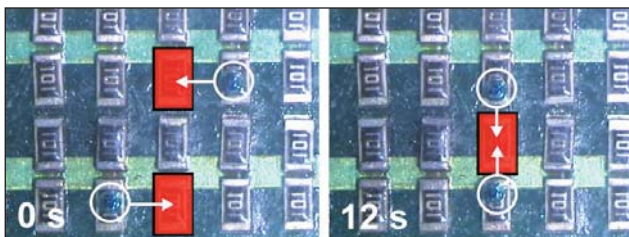
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Microdroplets are an emerging trend in microscale biological and chemical analysis systems. Rather than the traditional approach of guiding reagents in microfluidic channels, samples and reagents are instead dispersed as droplets in a continuous oil phase. With volumes in the range of pico- and femtoliters, microdroplets can provide low reagent consumption, fast reaction times, and high throughput for biochemical analyses. The concept of digital microfluidics uses a PFP (Programmable Fluidic Processors) to manipulate droplets real-time; however, the difficulty with many PFPs is that they rely upon droplet interactions with surface electrodes, which results in contamination, sample loss, and limited reusability.



**Figure 1 – The complete system for programmable, contact-free droplet actuation based on Marangoni flows, including a 128-pixel array of resistive heaters suspended above the oil layer, control circuitry, and a graphical user interface.**

Ongoing work at the Center has resulted in a PFP that allows for contact-free manipulation of droplets. Marangoni flows, driven by gradients in surface tension, are used to transport droplets without physical contact to the oil or the samples. The flows are localized and programmatically controlled by an array of heaters suspended above the oil layer. This project has developed and tested a 128-pixel system, which can manipulate and merge microdroplets with volumes  $<800\text{nL}$  at speeds up to  $200\mu\text{m/s}$ . Supporting simulation models show that the Marangoni effect scales favorably to smaller dimensions, providing  $>1\text{mm/s}$  flow velocities with  $<5$  degree change in surface temperature. ■



**Figure 2 – Droplet merging.**