Microfabricated Cell Analysis Device

Personnel
R.A. Braff and J. Voldman (M.L. Gray, M.A. Schmidt, and M. Toner)

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Microfabrication technology has the unique capability of producing arrays of devices as well as devices that are of the dimensions of biological cells. In this project we are exploring methods for cell capture and release that leverage these capabilities and could be productively deployed in a miniature biological instrument for discovering basic biological processes. Two approaches are being investigated for cell capture and release.

The first uses DiElectroPhoretic (DEP) forces. DEP forces can be used to create non-contact traps for capturing single particles such as cells. We have developed modeling tools with which we can design high-performance traps that can capture and hold cells under strong flows. These high-performance traps employ a novel three-dimensional extruded geometry. With these traps we can capture, hold, and electrically release single cells with single-trap control. We plan to now use arrays of these traps to perform biological assays.

The second uses hydraulic forces generated by MEMS actuators for cell manipulation. Thin film platinum heaters are used to form water vapor bubbles that serve as the means of actuation. We are currently studying microbubble formation and developing ways by which the bubbles can be more controllable and predictable. Bubble nucleation sites are etched in the center of platinum line heaters in order to precisely control bubble formation location, and decrease the amount of heat necessary to form a bubble. We have also used this microbubble technology in a bioparticle actuator. Single bioparticles are trapped in wells using a small backflow, then can be held there until a bubble is formed in the chamber below to release the particle.

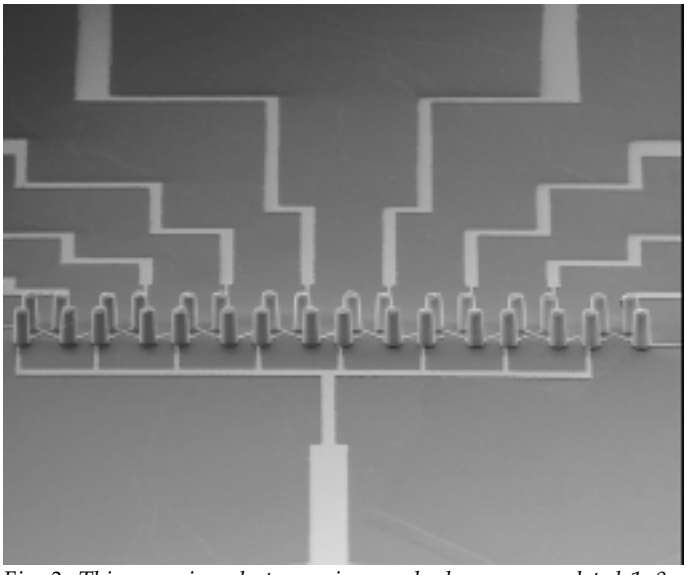

Fig. 2: This scanning electron micrograph shows a completed 1x8 array of cell traps. Each trap consists of four extruded gold electrodes fabricated by electroplating.

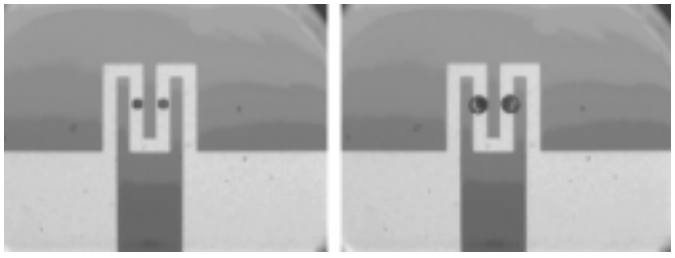

Fig. 3: A platinum heater with machined bubble nucleation sites, before and after bubbles are formed.

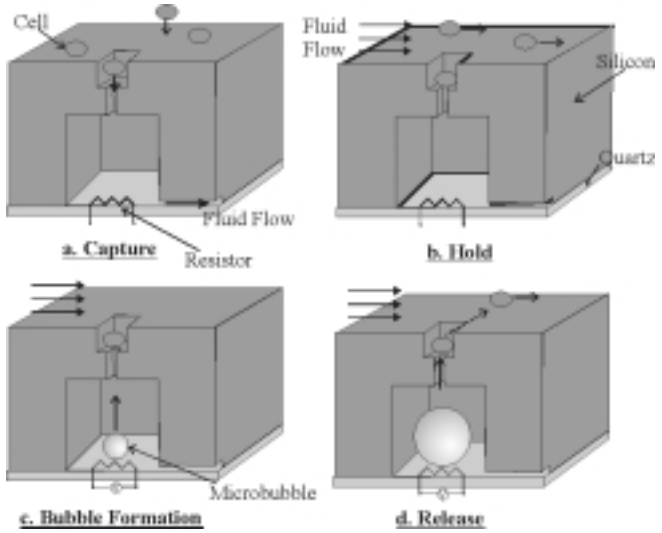

Fig. 4: Schematic of microbubble bioparticle actuator. a) A small back-flow draws particle into capture well. b) A bulk flow sweeps uncaptured particles away. c) The platinum heater is turned on and a vapor bubble begins to form in the bubble chamber. d) The volume expansion of the bubble creates a jet of fluid that releases the particle from the capture chamber and is entrained in the bulk flow.

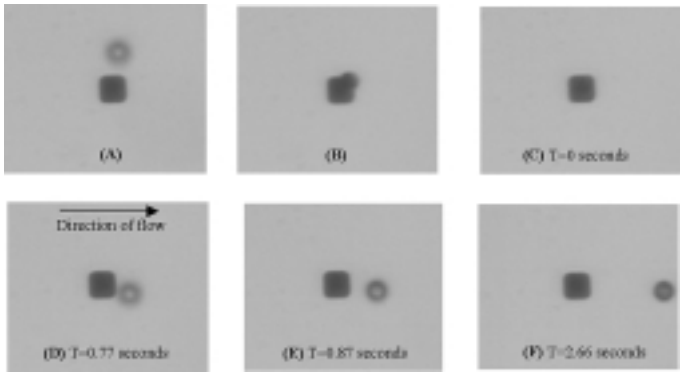

Fig. 5: Microbubble bioparticle actuator in operation. In A and B a 10µm polystyrene bead is drawn into the capture well, where it is held against a bulk flow in C. In D the bead is released by a jet created by a bubble in the chamber below, and in E and F the bead is entrained in the bulk flow.