DOI: 10.1017/S14319276034411305
Microsc Microanal 9(Suppl 2), 2003


# Micromachined Platforms for Microscopic Measurements

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Whether they are simple cantilever beams or complicated machines fused with microfluidic channels, surface micromachined platforms with cellular-scale feature sizes can be manufactured by the thousands. Cutting-edge efforts now aim to develop individual platforms that integrate sample manipulation, signal transduction, feedback circuitry, and readout in a single package. Ideally, extended platform arrays would collect statistically significant amounts of data with single event resolution.

At the single cell level, our efforts have centered on sample manipulation. We have demonstrated both mechanical and electrophoretic pumps that move microliter volumes with picoliter resolution. We have also demonstrated selective dielectrophoretic trapping of DNA, yeast cells, and latex particles using monolithic microfluidic devices [1]. Because the electrodes are closely spaced (see Figure 1), the electric field strengths needed for trapping can be generated using potentials of ~10 V.

We are also experimenting with devices that interact with cells by direct contact. The “cell masher” (Figure 2) is designed to disrupt the cell membrane [1,2], and the device in Figure 3 will hold cells, administer reagents, and electrically probe the cellular response [1]. Finally, the neural probe shown in Figure 4 is designed to penetrate a cell and measure action potentials [3].

Arrays of micromachined devices can also be used to probe tissues. As a part of the DOE Retinal Implant project, we are developing a MEMS based conformal electrode array that will allow intimate coupling of the electrode array to the retina while accommodating the curvature and topography of the retina.

These successes are early, and many challenges still exist. Ultimately, advancements must be made in areas such as biocompatibility, on-chip electronics, sensing, and advanced packaging. Even so, the expanding interest in this field highlights the great potential of micromachined platforms for microscopic measurements.

References:

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[2] M. Okandan, P. Galambos, S. Mani, J. Jakubczak, Proceedings of the Micro Total Analysis Systems, Oct 21-25 (2000), 305.

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[4] Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000. We gratefully acknowledge collaborations with many members of the Sandia Microsystems Center, Prof. Boris Khusid at the New Jersey Institute of Technology, Prof. Jit Muthuswamy at Arizona State University, and members of the DOE Retinal Implant project (LAB 01-14), which include Doheny Eye Institute (Keck School of Medicine) USC, Oak Ridge National Laboratory, NCSU, Argonne National Laboratory, Lawrence Livermore Laboratory, Los Alamos National Laboratory, Sandia National Laboratories.

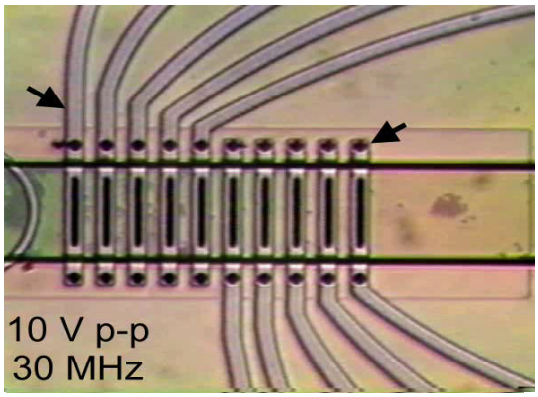


Fig. 1: Latex beads (white circle) are dielectrophoretically trapped by applying 10 V between the first and last electrode (black arrows - 90 μm separation).

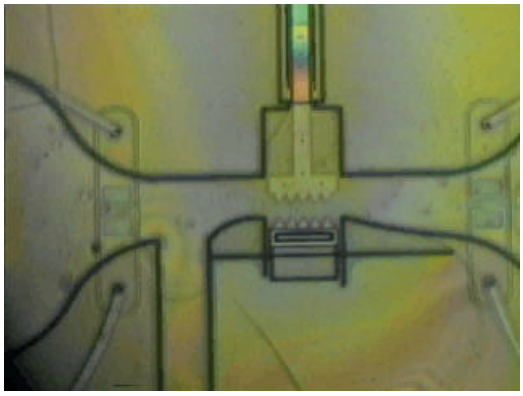

Fig. 2: Cells that pass through the channel are mashed between the fixed lower teeth and the vertically moving upper teeth. The shaft on the upper teeth is 10 μm wide.

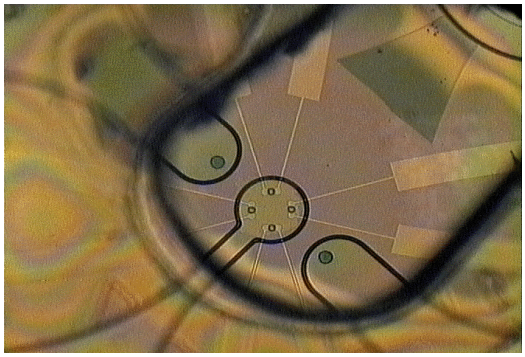

Fig. 3: Cells are trapped on one of four holes (3 μm dia.) in the center of the image. Electrical measurements are made between the contact pairs that extend from each hole.

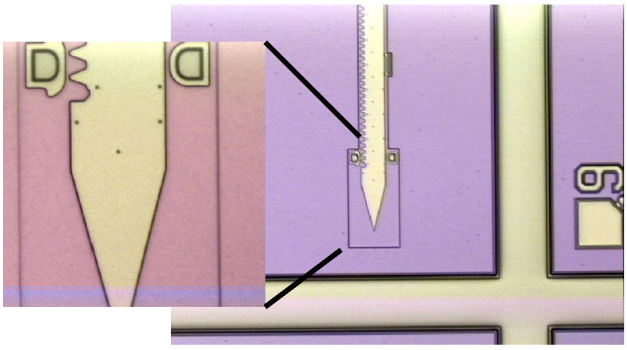

Fig. 4: The pointed probe is driven off the edge of the silicon substrate and into a cell by a rack and pinion system. The probe is 100 μm wide.

https://doi.org/10.1017/S1431927603441305 Published online by Cambridge University Press