

## Induced-Charge Electro-Osmotic Pumps and Mixers for Portable or Implantable Microfluidics

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Sponsorship: Institute for Soldier Nanotechnologies, MIT-France Program

Microfluidic technology offers great promise in diverse fields such as bioinformatics, drug delivery, and analytical chemistry. In spite of involving microchannels, however, current lab-on-chip technologies are mostly limited to bench-top analysis due to various bulky external elements. For example, peristaltic pumping in soft-polymer channels requires complicated tubing and flow meters, and capillary electro-osmosis requires a high-voltage power supply. Miniaturizing and integrating the power source is a crucial next step toward portable or implantable devices for medical diagnostics, localized drug delivery, artificial organs, or pressure control to treat diseases such as glaucoma.

We are developing new kinds of pumps and mixers exploiting “induced-charge electro-osmosis” (ICEO) [1], as a potential platform for portable microfluidics. ICEO refers to the slip of a liquid electrolyte at a polarizable (metal or dielectric) solid surface, driven by an electric field acting on its own induced

surface (double-layer) charge. Unlike classical (fixed-charge) electro-osmosis, which requires large DC voltages ( $>100V$ ) applied down a channel, ICEO can be driven locally by small AC voltages ( $<10V$ ). It is sensitive to the geometry, ionic strength, and driving frequency and scales with the square of the applied voltage. The effect generalizes “AC electro-osmosis” at planar electrode arrays [2] and offers some more flexibility.

We originally demonstrated ICEO flow in dilute KCl around a platinum wire by comparing flow profiles from micro-particle-image velocimetry ( $\mu$ PIV) to our theory [3]. We have also fabricated many devices involving electroplated gold structures on glass in PDMS microchannels, which exhibit mm/sec flow rates in 100 V/cm fields at kHz AC, and further optimization is underway. As a first application, we are developing a portable ICEO-powered biochip to detect blood exposure to toxic warfare agents by lysing cells and amplifying and detecting target genes.

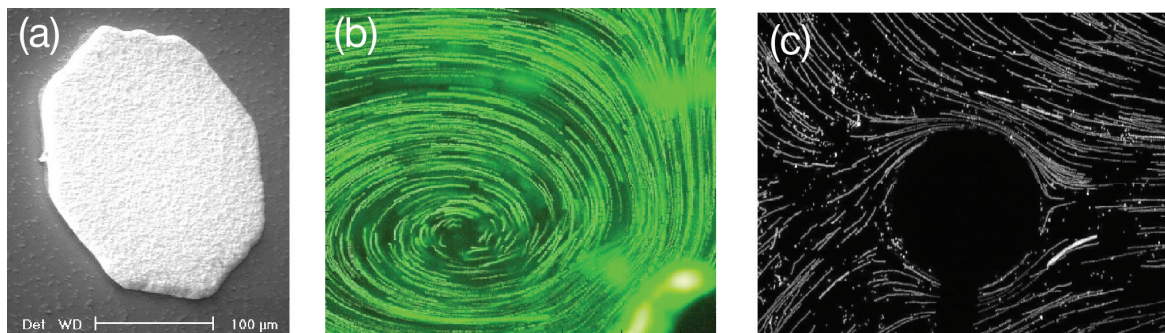


Figure 1: (a) SEM image of an electroplated gold post ( $12\mu\text{m} \times 150\mu\text{m}$ ). (b) ICEO convection around the post, visualized by streaks of fluorescent tracers used  $\mu$ PIV. (c) faster ICEO flow past a post held at fixed potential.

### REFERENCES:

- [1] Bazant, M.Z., T. M. Squires, “Induced-charge electrokinetic phenomena: Theory and microfluidic applications,” *Physical Review Letters*, vol. 92, art. no. 066101 (2004).
- [2] Ramos, A., H. Morgan, N.G. Green, A. Castellanos, “AC electric-field induced flow in microelectrodes,” *Journal of Colloid and Interface Science*, vol 217 (2), pp. 420-422 (1999).
- [3] Levitan, J.A., S. Devasenathipathy, V. Studer, Y. Ben, T. Thorsen, T.M. Squires, M.Z. Bazant, “Experimental observation of induced-charge electro-osmosis around a metal wire in a microchannel,” *Colloids and Surfaces A*, in press (2005).