Abstract Submitted
for the MAR06 Meeting of
The American Physical Society

Experiments on Nonlinear Electrokinetic Pumps in Microfluidics[1]

JOHN PAUL URBANSKI, TODD THORSEN, Department of Mechanical Engineering, MIT, JEREMY A. LEVITAN, MARTIN Z. BAZANT, Department of Mathematics, MIT — Nonlinear electrokinetic pumps are attractive in the development of portable and flexible microfluidic analysis systems, since they operate without moving parts using low (battery powered) alternating potentials. Since the discovery of AC electro-osmosis (ACEO) in the late 1990s, there has been much work in designing and building two-dimensional, periodic micro-electrode geometries, which exploit broken symmetry to rectify AC forcing and produce steaming flow over a surface. Building on this work, we exploit more general principles of induced-charge electro-osmosis (ICEO) in three-dimensional electrode geometries to enhance pumping in microfluidic devices. Our fabrication efforts are guided by theoretical analysis and simulations using the standard low-voltage theory, which, in some cases, predict flow rates faster than existing planar ACEO pumps by an order of magnitude (for the same voltage and feature size). We test various microfabricated pump geometries in a microfluidic loop following the methodology of Studer et al (2004). We are also measuring the strong effect of solution chemistry (e.g. ion valence and concentration) on ICEO flow to guide further developments in the theory of nonlinear electrokinetics.

[1]Supported by the US Army through the Institute for Soldier Nanotechnologies.

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Date submitted: 30 Nov 2005 Electronic form version 1.4