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The Nanofluidic Field-Effect in Electrically Actuated Nanopores[1]

ZHIJUN JIANG, DEREK STEIN, Physics Dept., Brown University — We employed high-resolution milling techniques to create solid-state nanopores with integrated electrodes for exerting field-effect control over the transport of ions and single DNA molecules in solution. An embedded, annular gate electrode was used to voltage gate the ionic conductance through a nanopore. An absence of leakage currents confirms the electrostatic origin of this effect. The measurements also reveal strong dependencies on the pH and on the ionic strength of the fluid. These results reflect the crucial difference between the modulation of charge at a solid-liquid interface where surface chemistry plays an important role, versus at a chemically inert semiconductor interface. An electrochemical model of electro-fluidic gating that captures the gate-field-induced shift in the chemical equilibrium of the ionizable surface groups describes our measurements quantitatively. We seek to electrostatically control the translocation of DNA through such gated nanopores, and thereby mimic the single-molecule regulatory capabilities of biological transmembrane channels.

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