Abstract Submitted
for the MAR06 Meeting of
The American Physical Society

Field Effect Modulation of Ion Transport in Single Nanotubes

RONG FAN, PEIDONG YANG, Department of Chemistry, University of California at Berkeley — Field effect control in metal-oxide semiconductor field effect transistors (MOSFETs) has revolutionized how information is processed and stored, and created the modern digital age. Introducing field effect in fluidic systems would enable the manipulation of ionic and molecular species at a similar level and even logic operation. Due to strong Debye screening, field effect control in ionic solutions has to be occurring in nanoscale. Here we present the integration of chemically synthesized inorganic nanotubes into metal-oxide-solution field effect transistors (MOSolFETs), and demonstrated a rapid field effect modulation of ionic conductance. Surface modification, functioning as doping in semiconductors, alters the nanofluidic transistors from p-type field effect transistors, to ambipolar FETs, and n-type field effect transistors. Ambipolar behavior is of special interests in this gapless transport system. Possion-Boltzmann model has been employed to extract two key physical parameters – zeta potential and surface charge density. Furthermore, transient study was conducted, leading to the first kinetic model of field effect in ionic solutions. Nanofluidic FETs would be the key elements in sub-femtoliter analytical techniques and the integration of large-scale nanofluidic circuits.

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Date submitted: 03 Dec 2005 Electronic form version 1.4