Carbon Nanotube Based Aqueous Ion and pH Sensitive Biosensors

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MERIT FAIR
BIEN 2009

Introduction

- Carbon nanotube transistor based biosensors are versatile and can be used to detect
  - Nucleic acid hybridization
  - Anti-body/antigen binding
  - Peptides and proteins
  - Ionic concentration in electrolytes
  - pH of solutions
- Project Goals
  - To learn the chip fabrication process and the measurement system
  - To assess measurement repeatability and sensor reusability
  - To quantify our biosensor response to changes in ionic concentration introduced by
    - Varying concentration of Sodium Chloride (NaCl)
    - Varying pH values of buffer solutions
  - To study long-term behavior of the biosensors

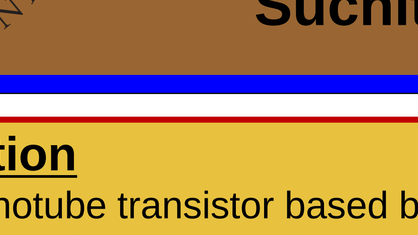

Figure 1: The Developed Biosensor Chip

The Sensor System

- 104 FETs on a chip
- Electrolyte of interest serves as the top gate
- Carrier transport occurs through carbon nanotube (CNT) channels

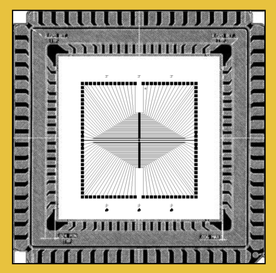

Figure 2: Sensor Chip Layout

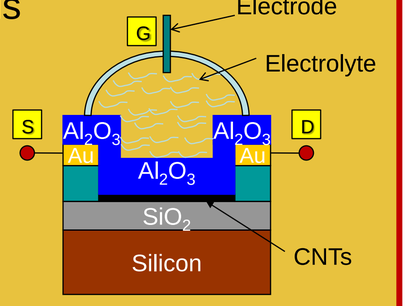

Figure 3: Carbon Nanotube Field Effect Transistor (FET)

Experiment

- Drain current (Id) vs. top gate bias (Vgs) collected for a CNT transistor

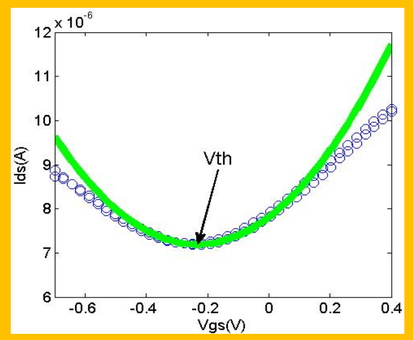

Figure 4: Typical FET Transfer Characteristics

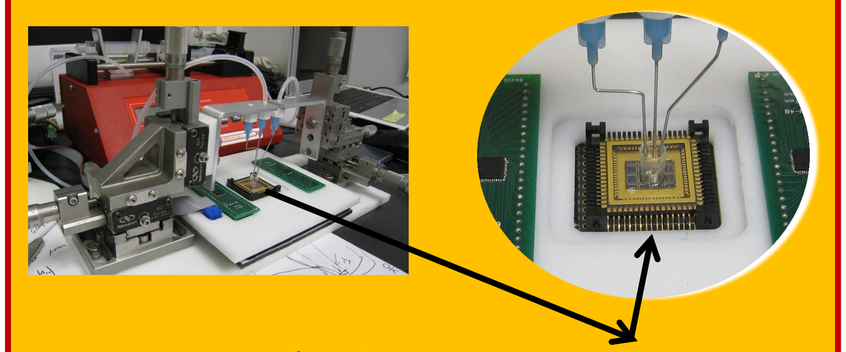

Figure 5: Measurement Setup

Results

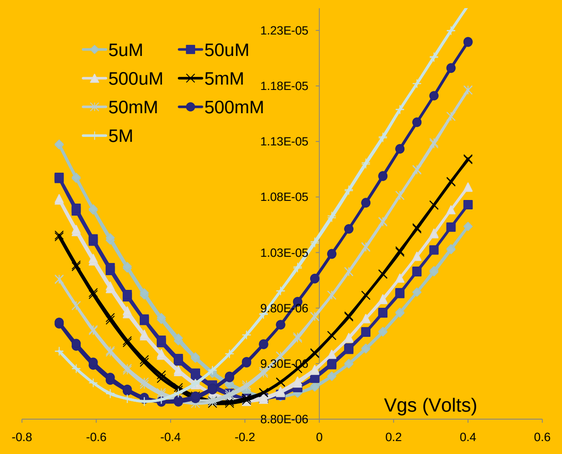

Figure 6: Representative Shifts in Transconductance Curves

- Sensitivity to NaCl
  - Relative <Vth> = Δ<Vth> from baseline [NaCl]
  - Chosen baseline [NaCl] = 5μM
- Sensitivity to pH
  - Slope of <Vth> vs. pH

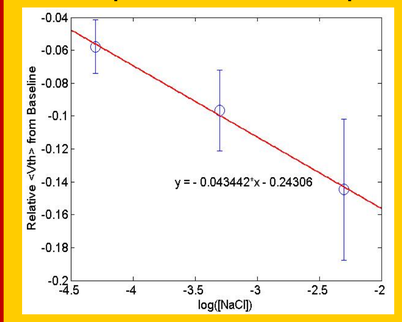

Figure 7: Sensitivity to NaCl, 64 FETs

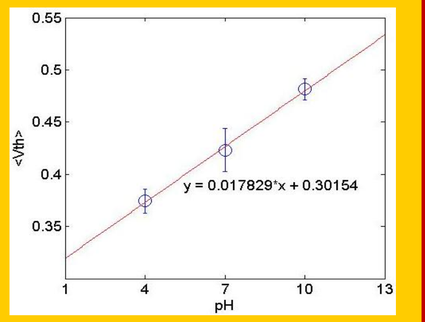

Figure 8: Sensitivity to pH, 1 FET

- Time dependence of Vth
  - 1 Trial = 4 minutes

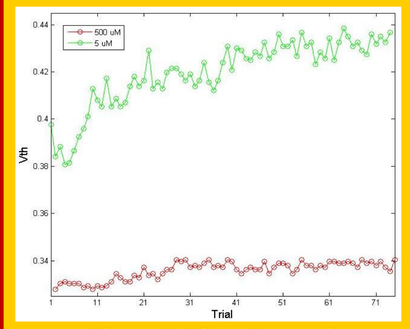

Figure 9: Time-Dependent Response to NaCl

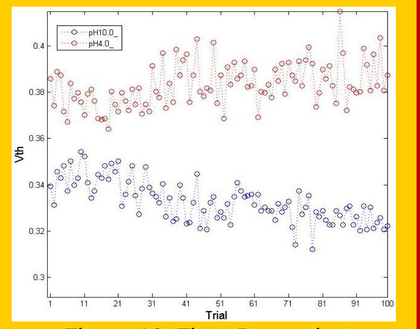

Figure 10: Time-Dependent Response to pH

⇒NaCl Sensitivity = **-43.44 mV/decade**

⇒pH Sensitivity = **17.83 mV/pH**

Conclusions

- Sensitivity of biosensors were experimentally determined for
  - NaCl experiments measured on all FETs on chip
  - pH experiment measured on 1 FET on chip

Future Work

- Rigorous error analysis of obtained results
- Experiments with a larger sample of pH values

Acknowledgements

- National Science Foundation CISE award #0755224