Low-cost organic gas sensors on plastic for distributed environmental sensing

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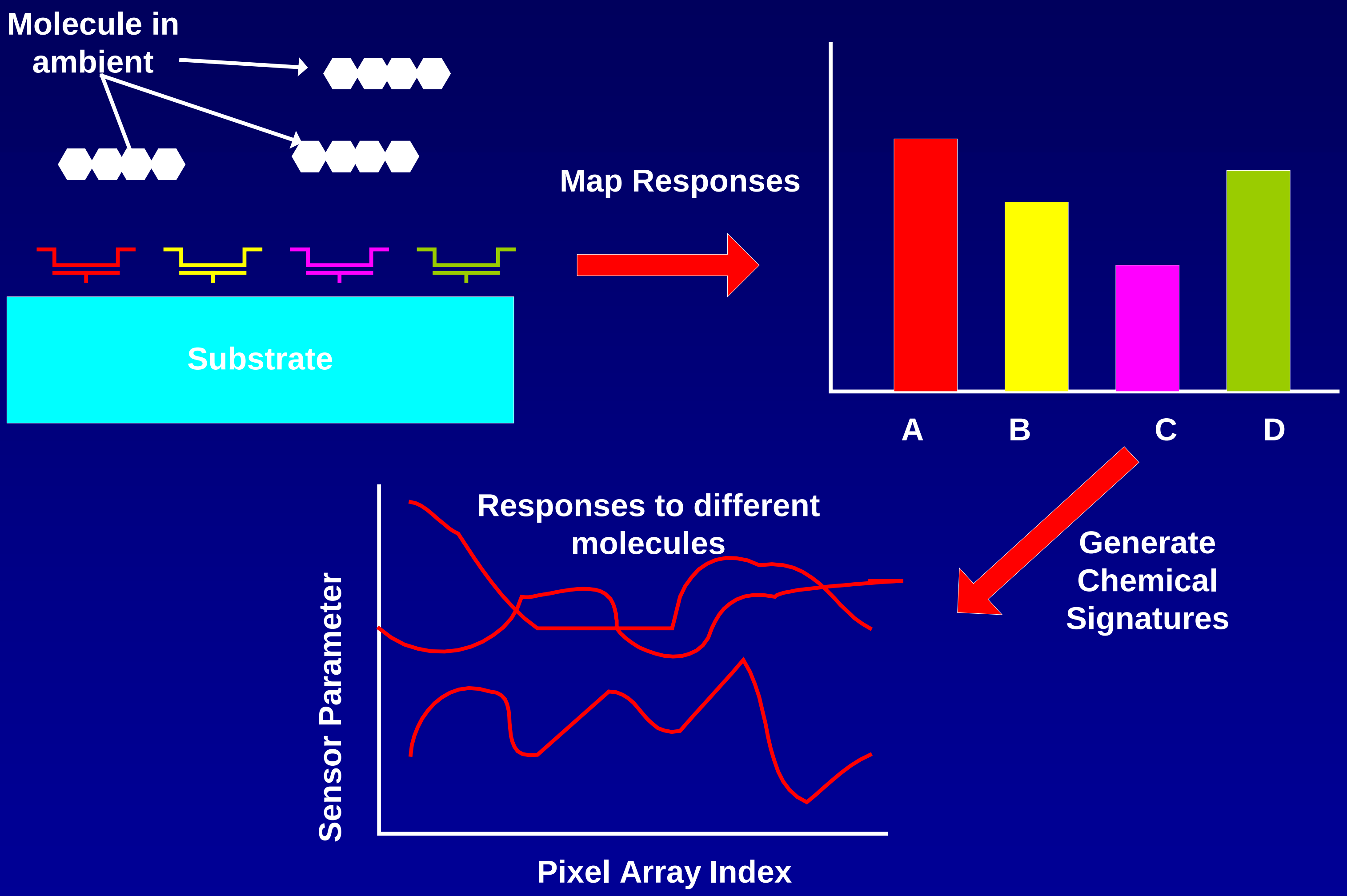
This research is funded by

U.S. EPA - Science To Achieve Results (STAR) Program

Grant # RD83089901

Arrayed Gas Sensors



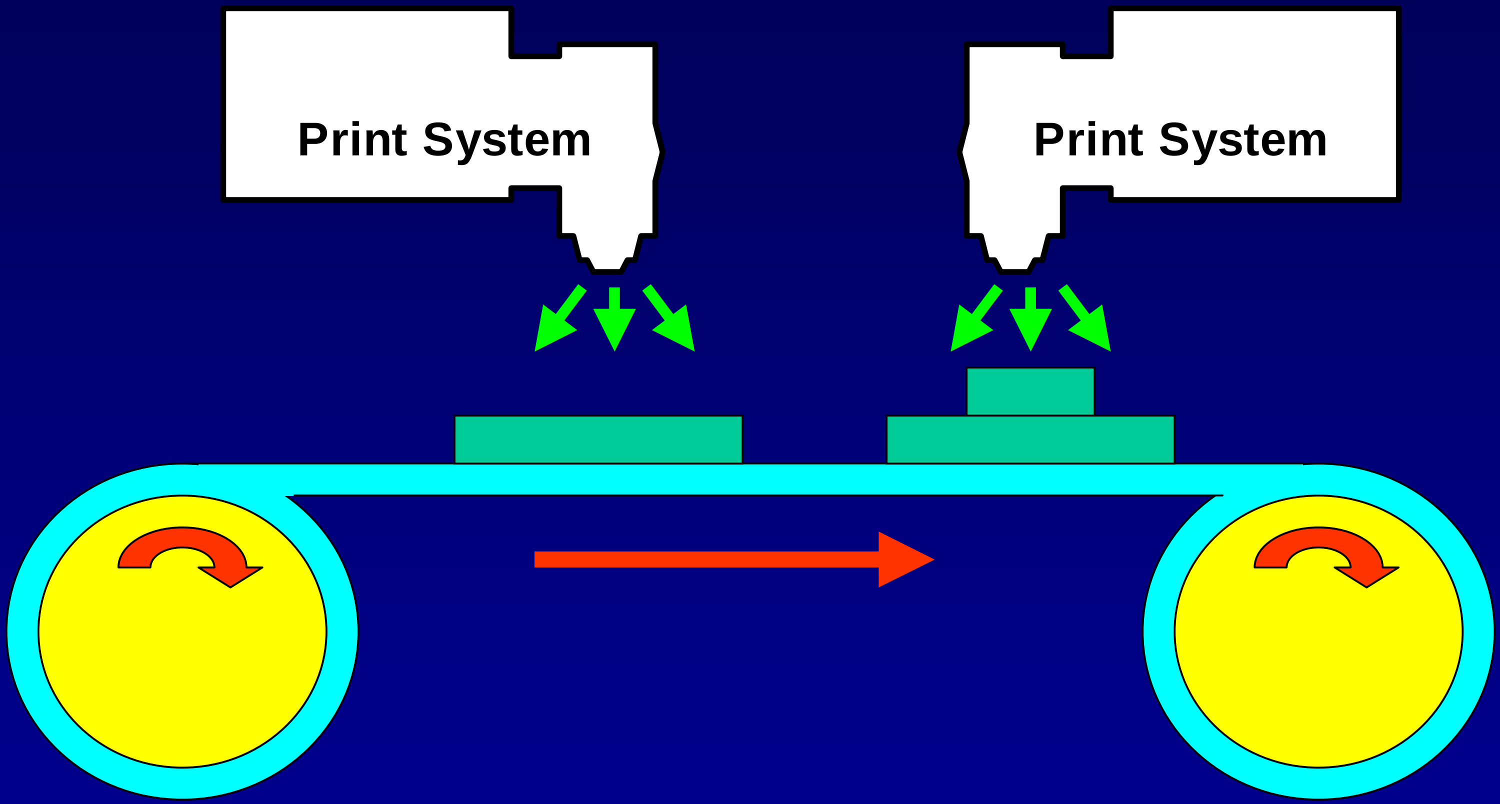
Distributed environmental monitoring

- Need for distributed monitoring
  - Identification of environmental hazards
  - Triggering of proactive action
  - Development of accurate environmental models

- Sensor Requirements
  - Ultra-low-cost
  - Ease of dispersal
  - Trainability / adaptability

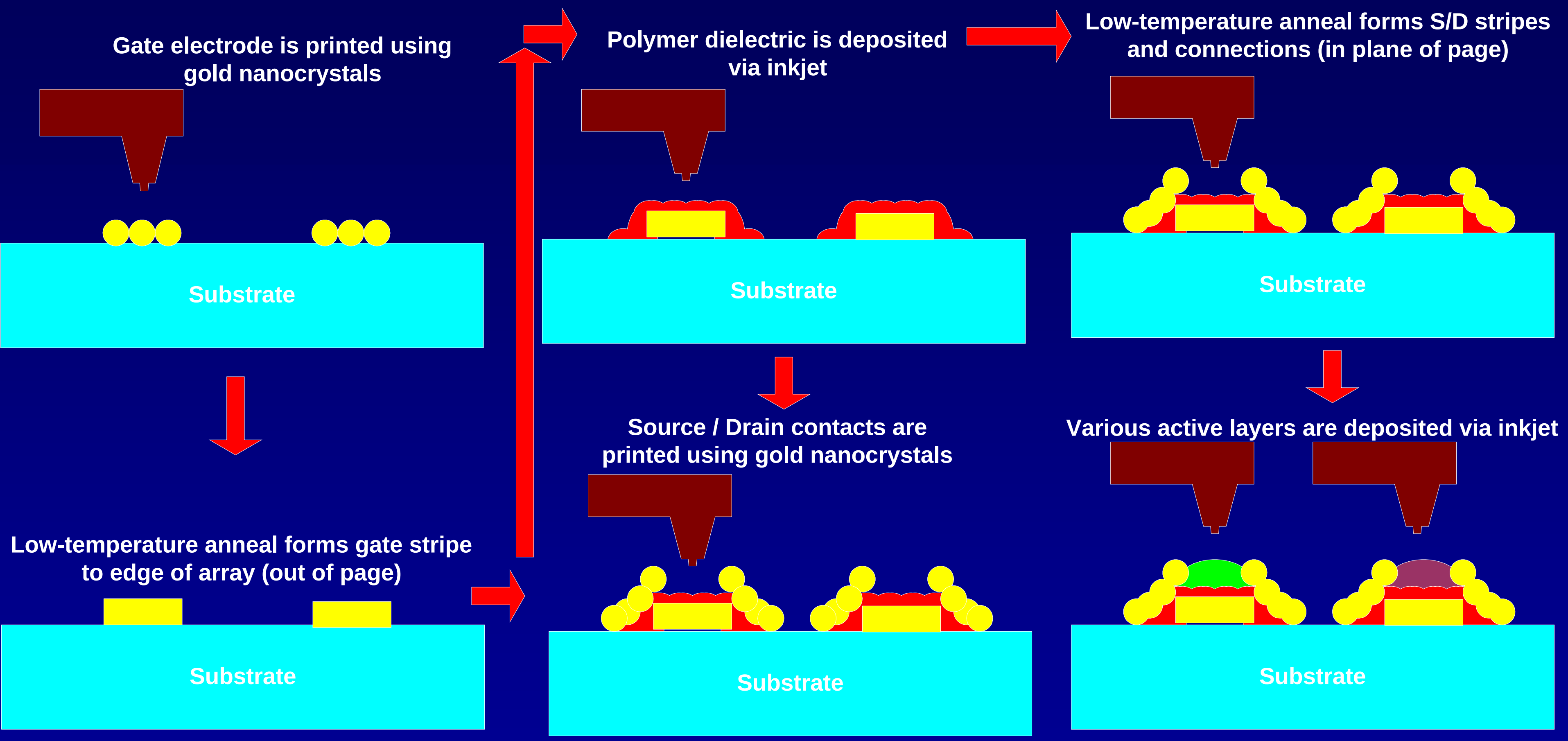
- Our Approach: Arrayed organic FETs
  - Easily arrayed at low-cost via printing
  - Flexible for easy dispersal
  - Trainable via electronic nose architecture

Printing: a pathway to low-cost



No lithography
No vacuum processing (CVD, PVD, Etch)
Reduced abatement costs
Cheap substrate handling
Reduced packaging costs

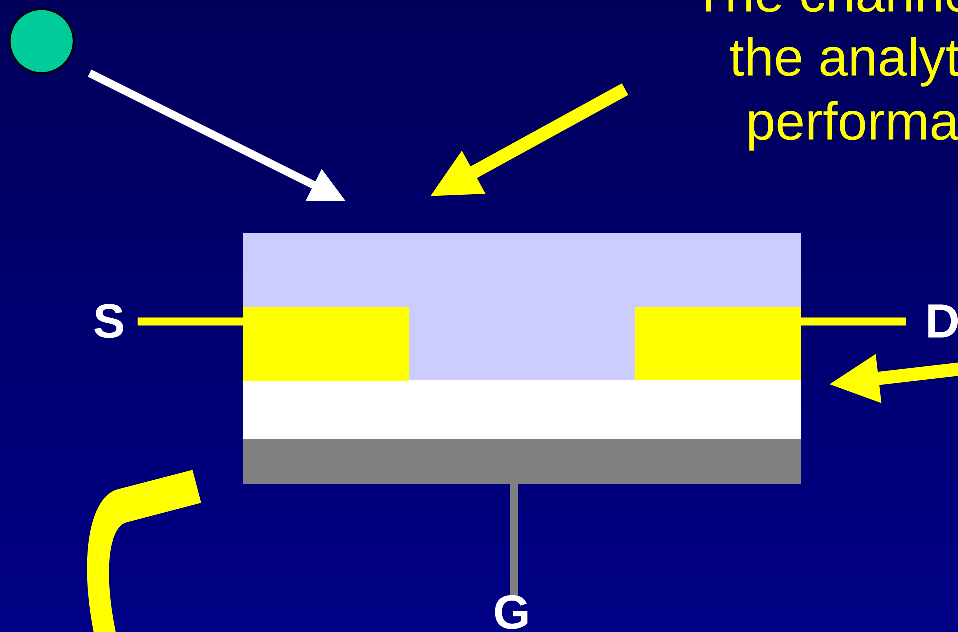
Printed Transistors



Plans & Current Status

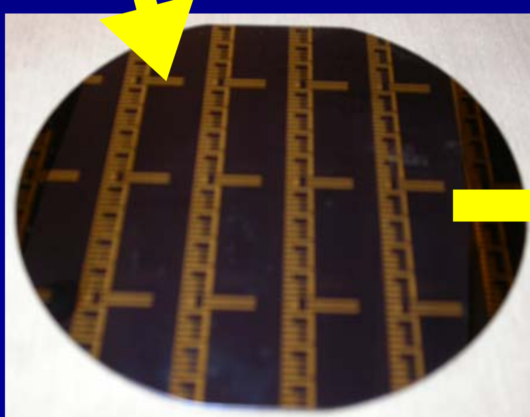
- Year 1:
  - Development of baseline arrayed sensor process
  - Sensor Characterization
  - Development of arrayable materials
- Year 2:
  - Array demonstration
  - Development of signature table for above arrayed sensor
  - Characterization of 2nd generation targets
- Year 3:
  - Optimization of arrayed sensors
  - Characterization of real-time monitoring
  - Characterization of fluid sensing using organic gas sensors
  - Optimization of derivatives for sensing applications.

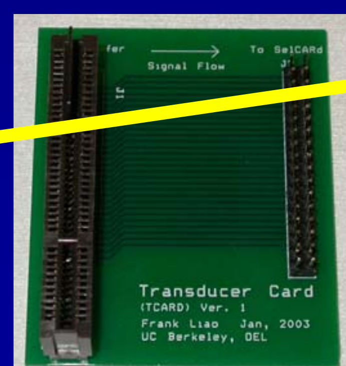
Baseline sensor screening process



The channel is exposed to the analyte, resulting in performance changes

Materials are characterized using a substrate-gated architecture (easy fabrication for rapid screening)

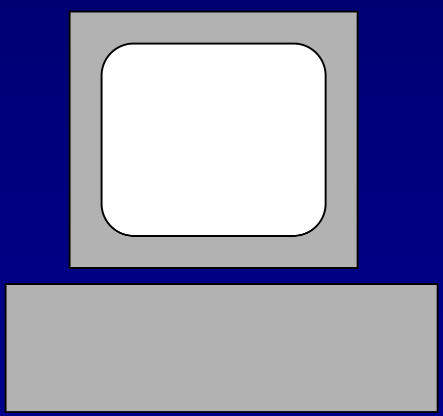




A silicon substrate enables easy I/O via an edge connector

Sensor Characterization

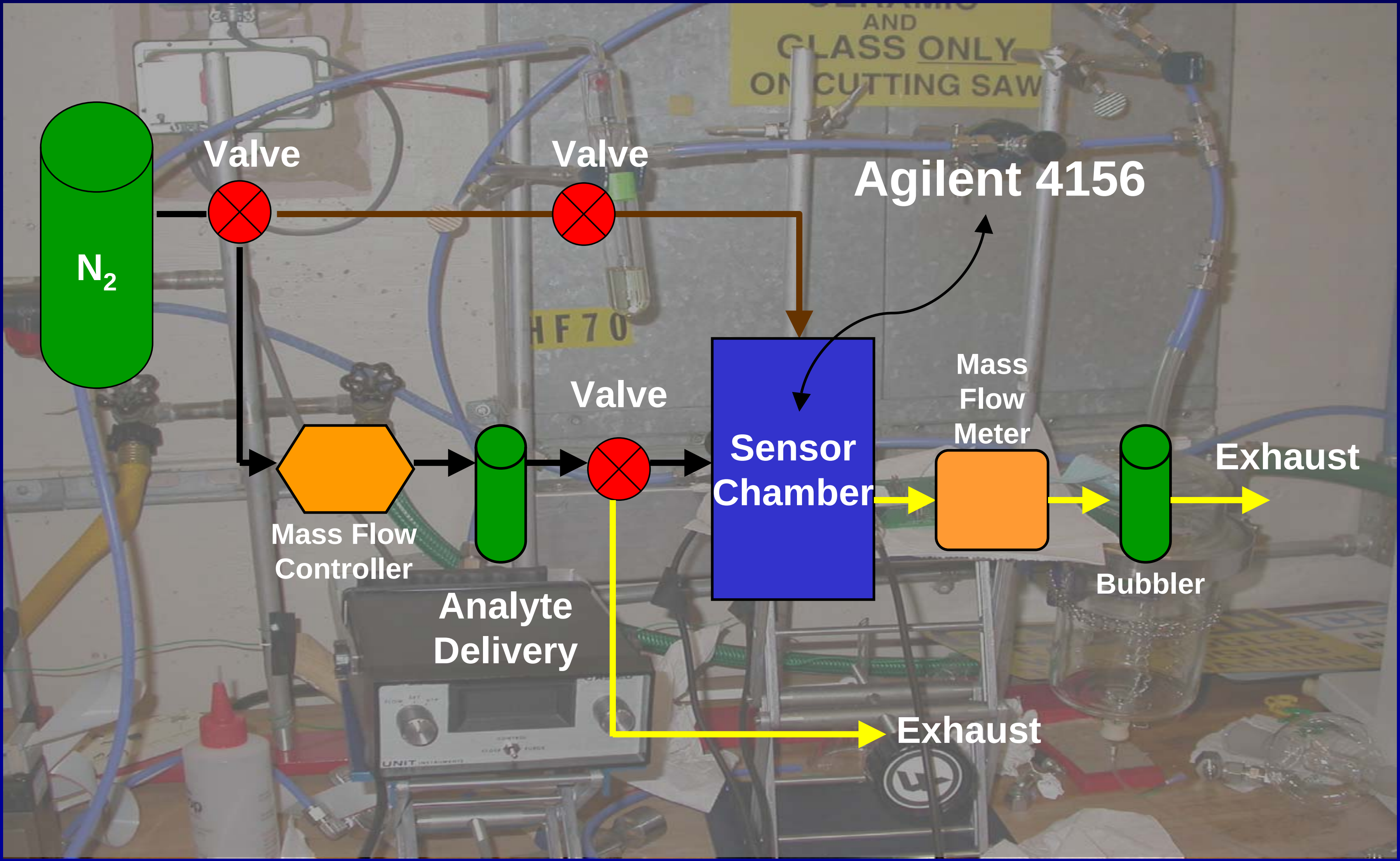
Switching between individual sensors is performed via a switch matrix PCB



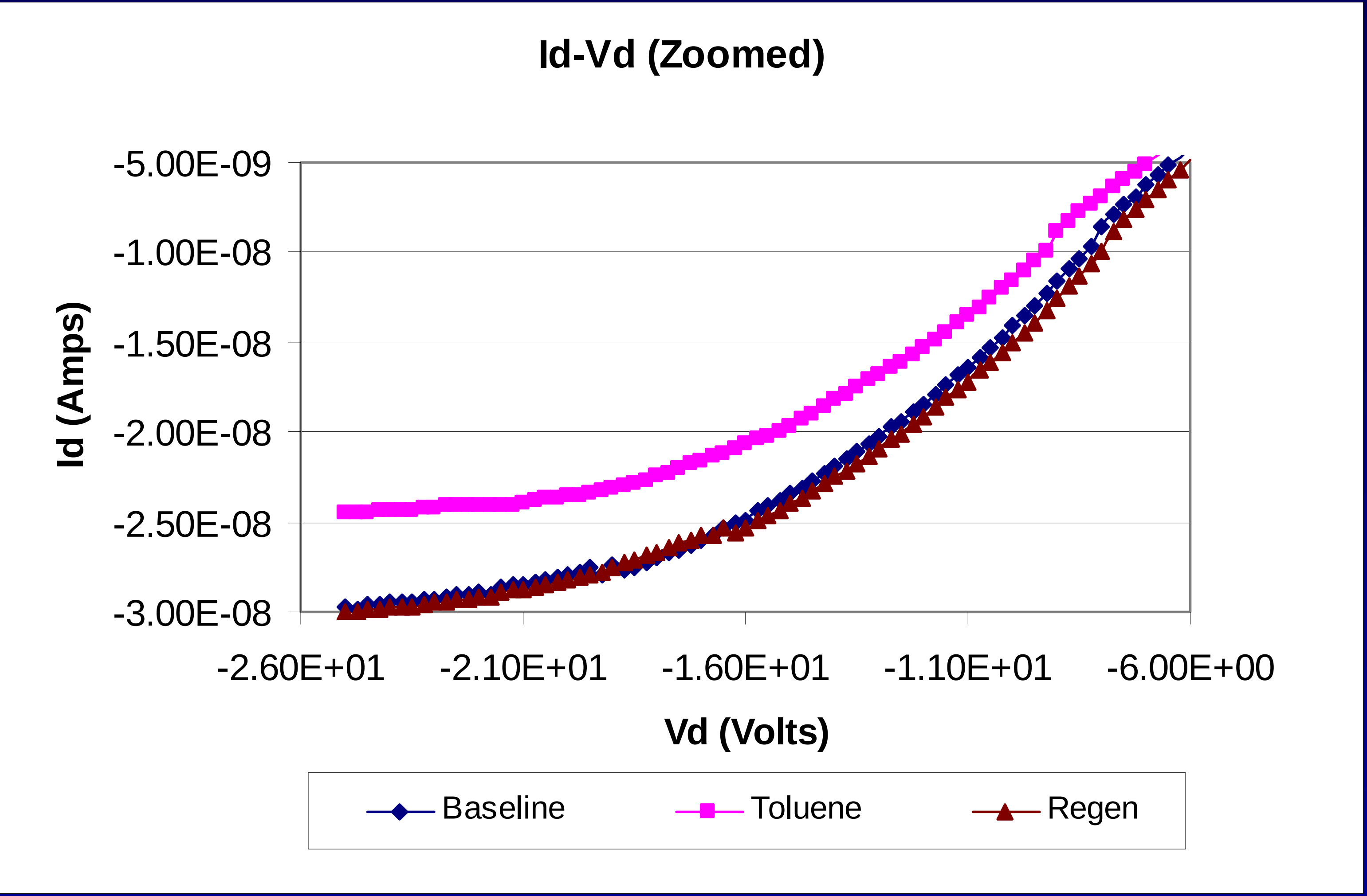
Agilent 4156

To ensure accuracy, measurements are performed with a calibrated precision semiconductor parameter analyzer.

Experimental Setup

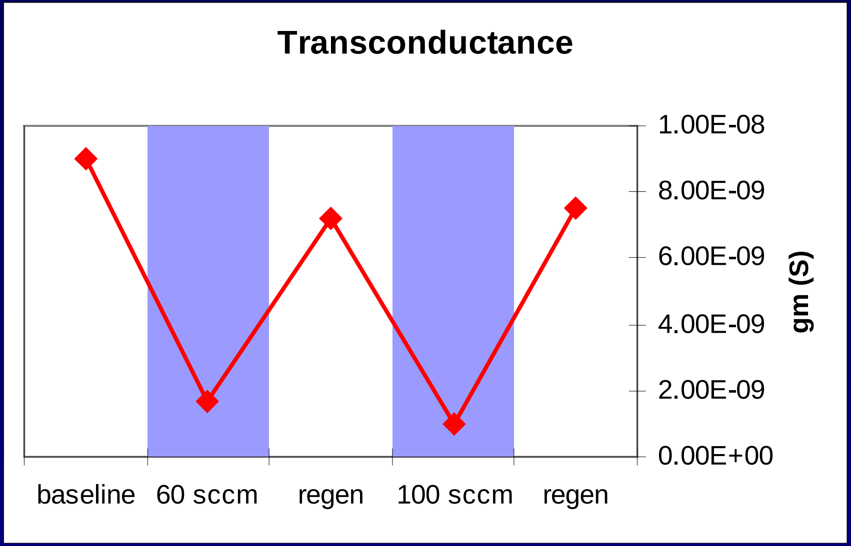


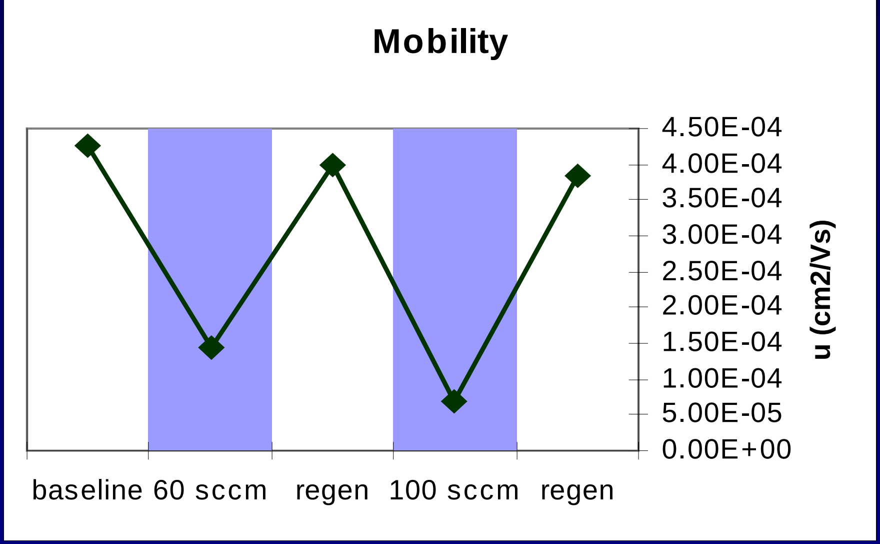
Sensor Repeatability

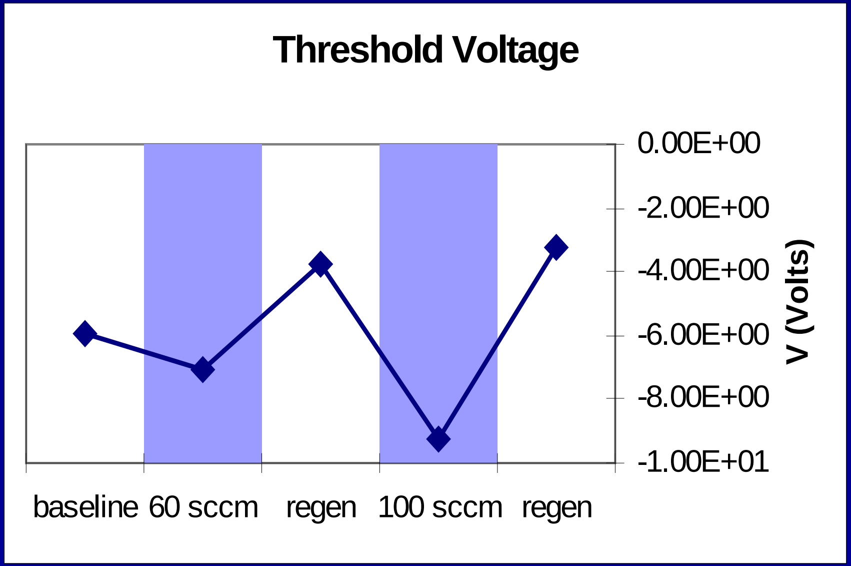


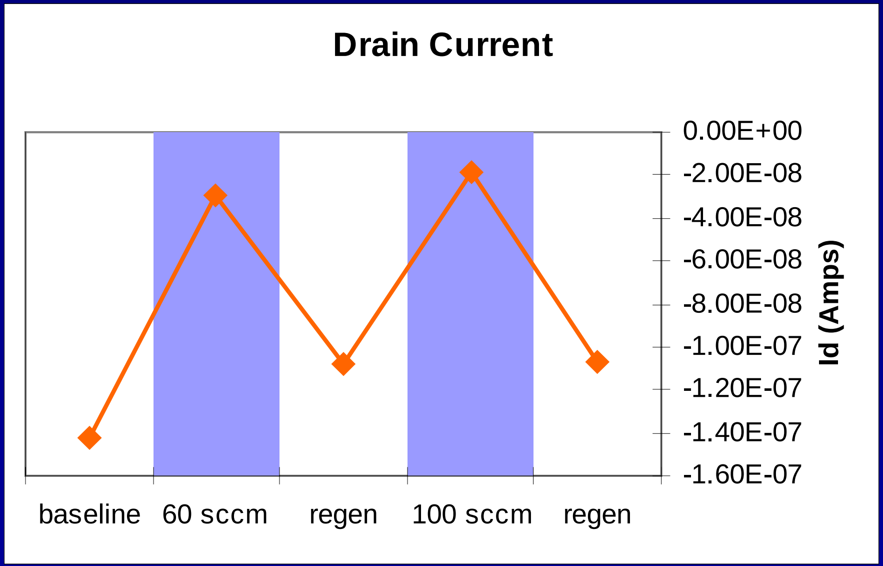
Multiple cycles can be performed with full regeneration

Multi-parameter sensing

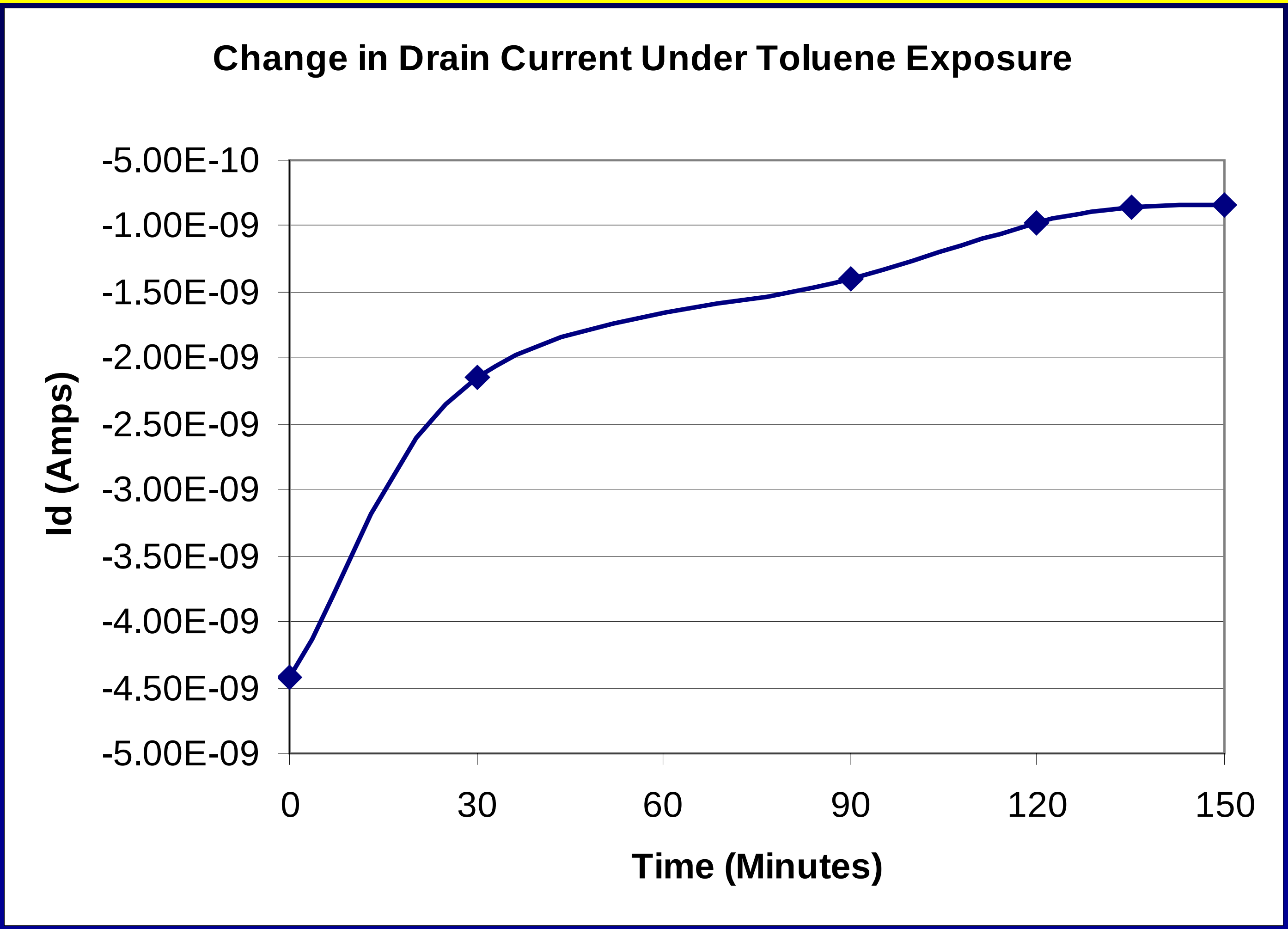






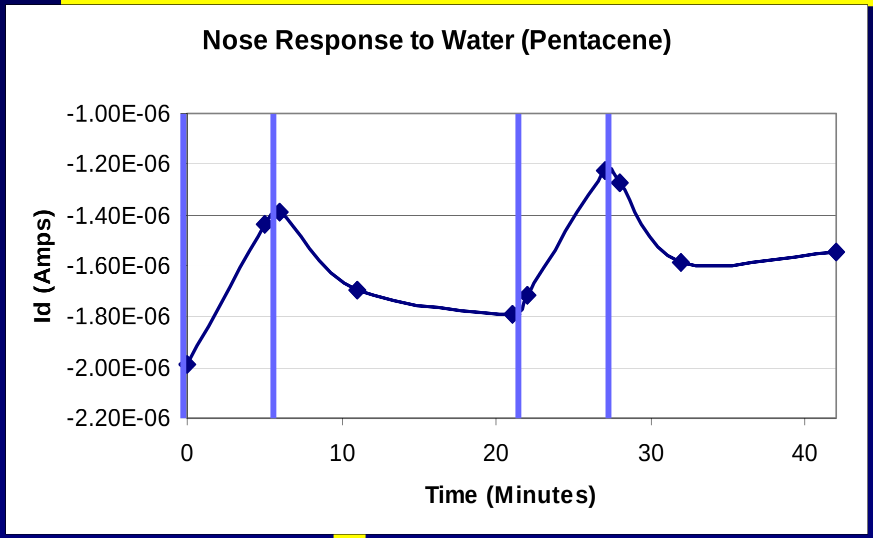


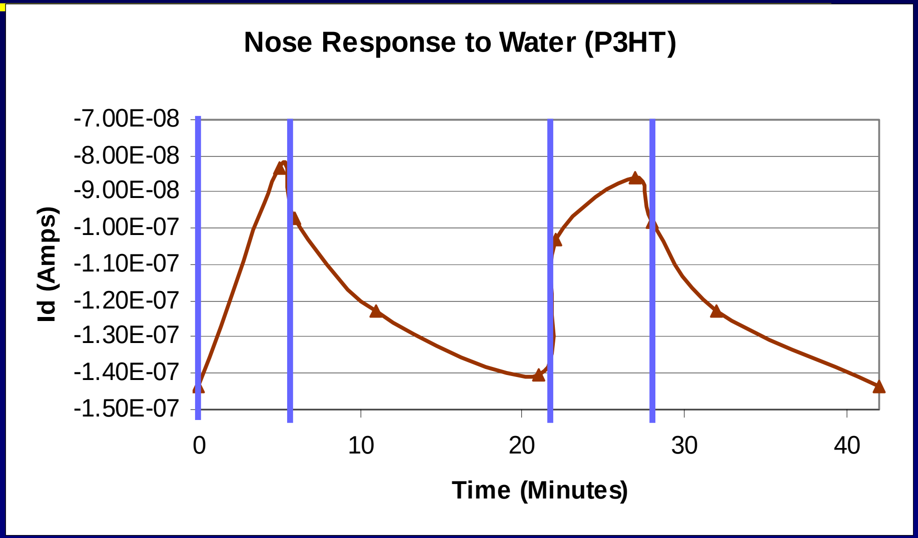
Sensor dynamics – transient response

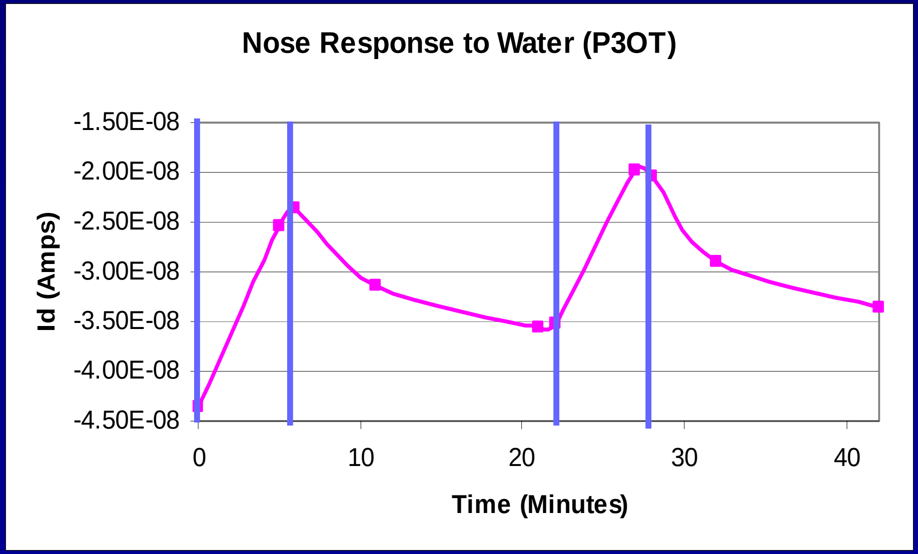


Sensor response can be very slow, due to slow analyte absorption.
Speed can be increased by reducing film thickness

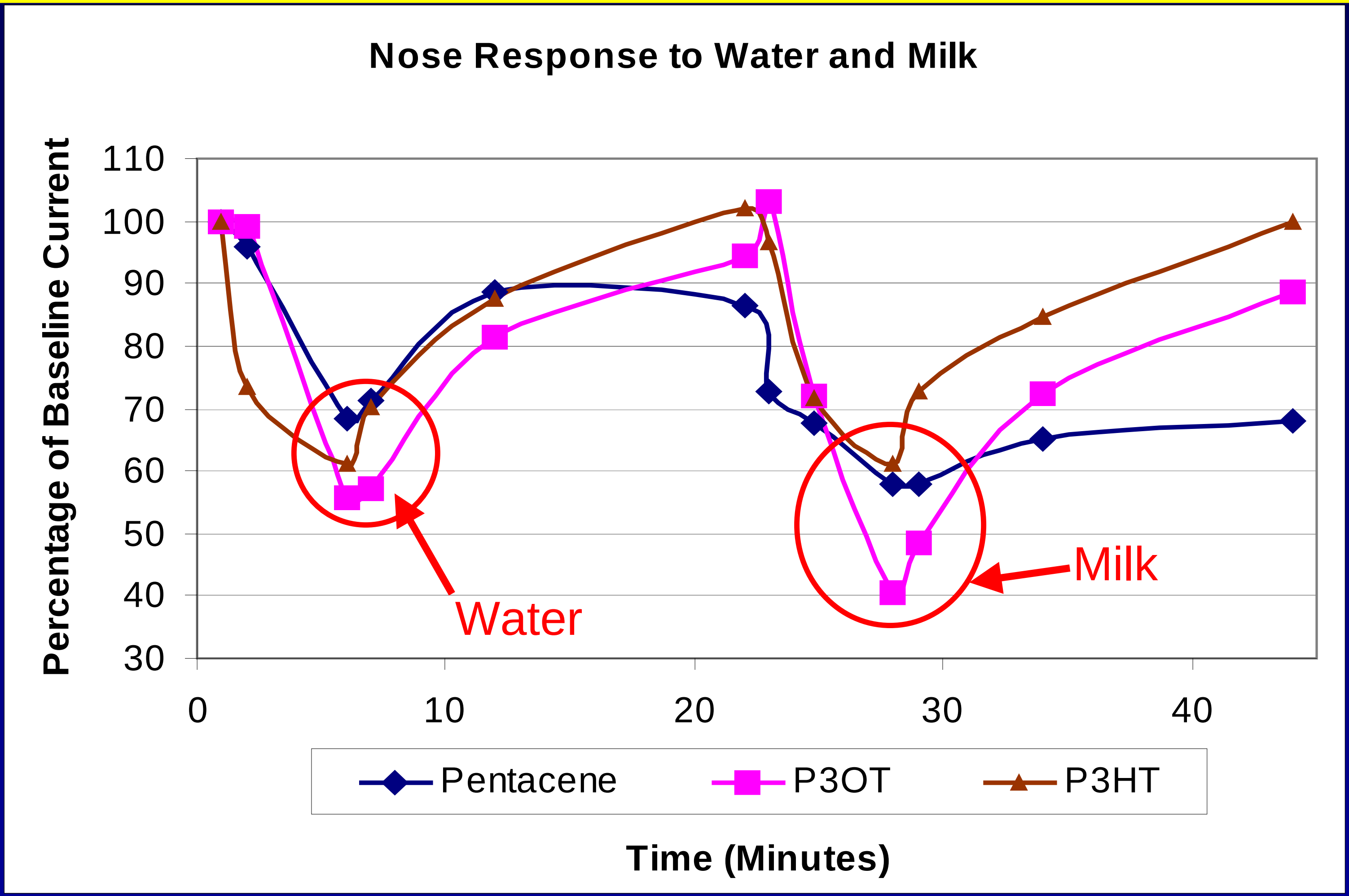
Differential sensitivity – pathway to an electronic nose?



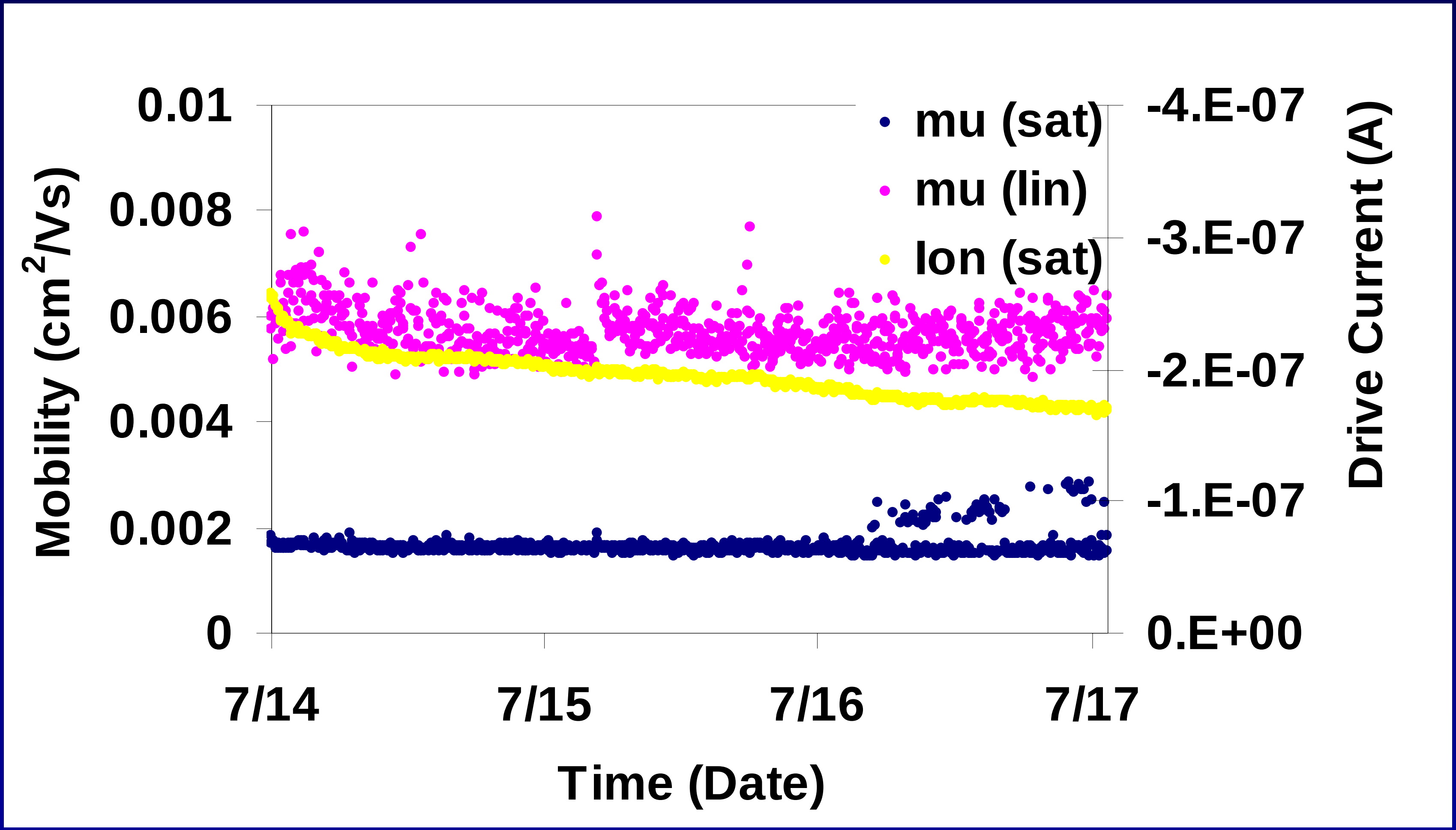




Demonstration of basic electronic nose functionality



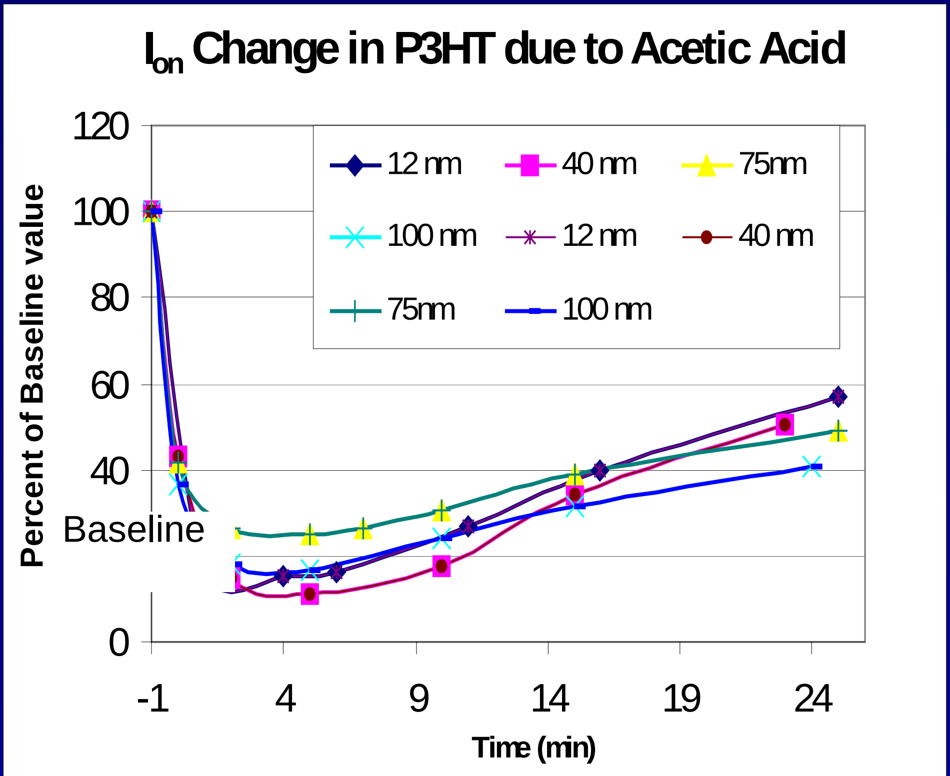
Organic Transistor Stability

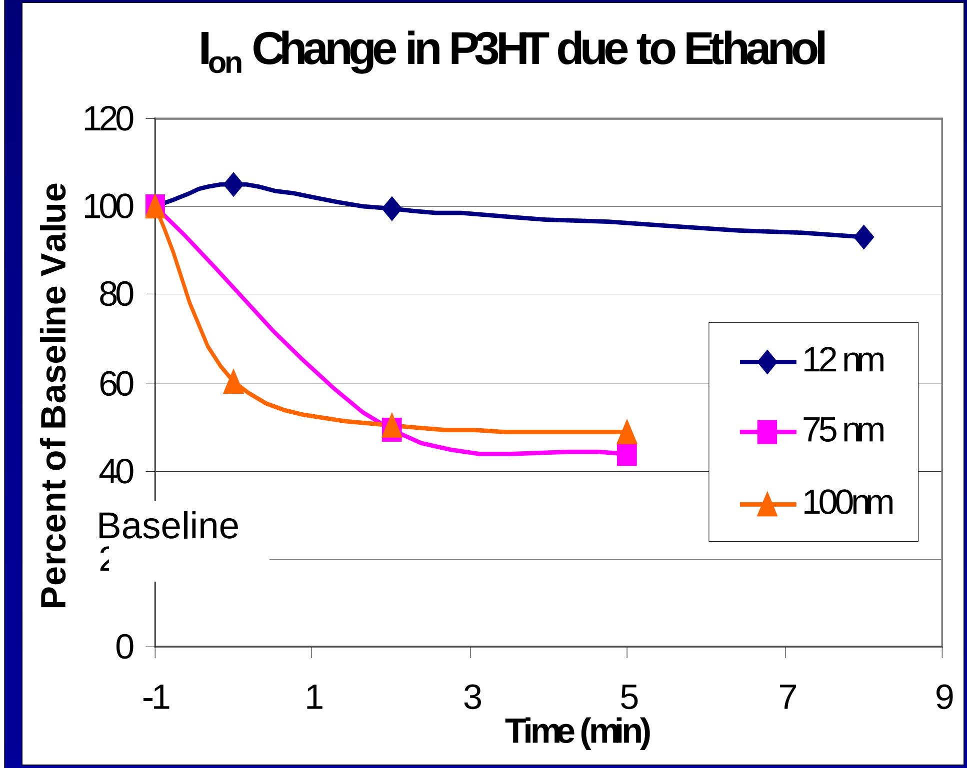


Implication: We must either improve dielectric interface or use V_T-insensitive differential sensing method

Interaction Mechanisms

- Sensors show a wide range of interactions, complicating analysis. Interactions include:
  - Polar group interactions
  - Chain / bulk interactions
  - Swelling





Conclusions & Future Work

- Organic FET-based sensors show promising responses, including transient behavior and cycle life

- Work remains to optimize structure and process flow, particularly in terms of stability and reliability

- Future Work:
  - Integration of latest sensing materials into printed device architecture
  - Deployment in testing of environmentally-relevant analytes
  - Enhancement of specificity through functionalization / doping