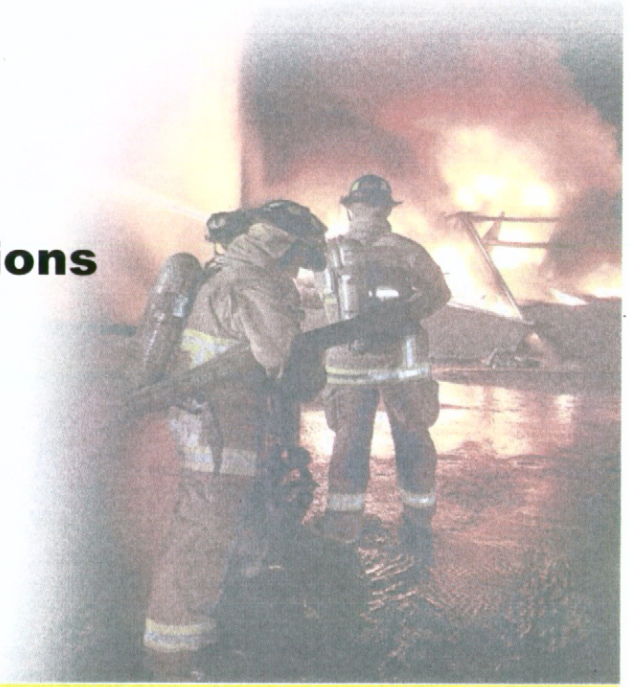
National Personal Protective Technology Laboratory

End-of Service Life Program for Personal Protective Equipment at NPPTL



A summary of past presentations

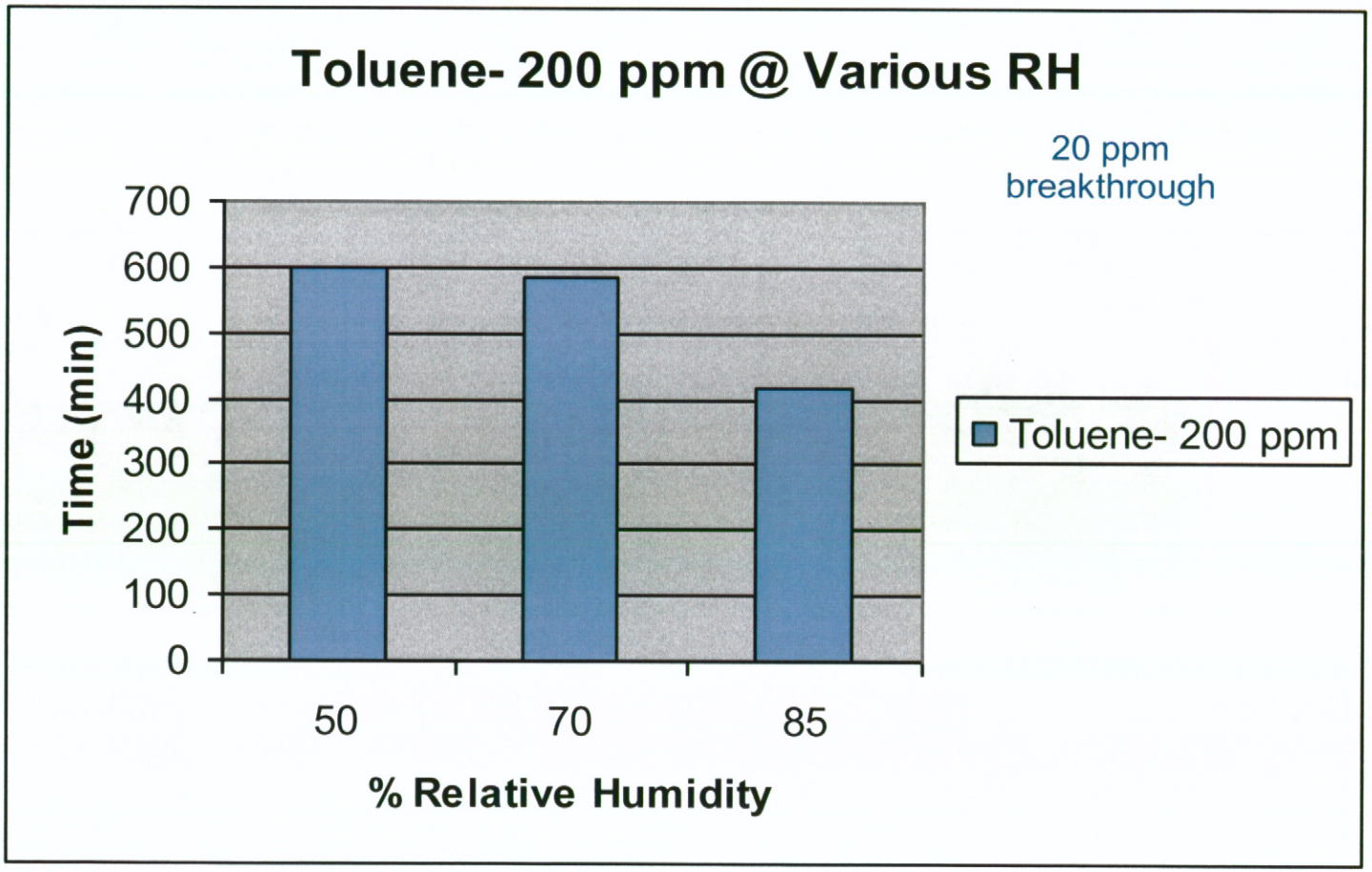
Jay Snyder, NIOSH

September 21, 2011

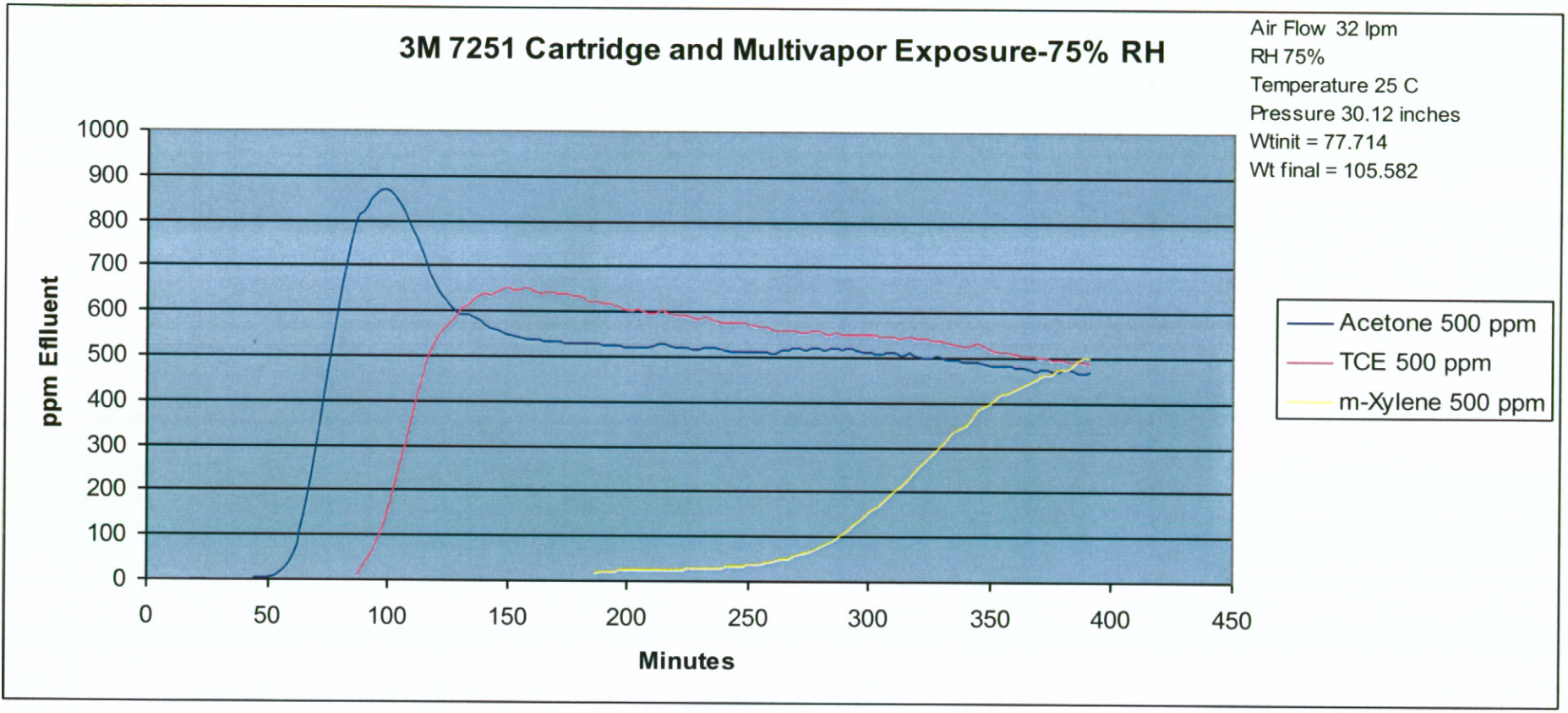
Presentation Overview

- NIOSH/NPPTL End-of-Service Life Program
  - Air Purifying Respirator Cartridge Modeling
  - Sensor Development Program

Effects of RH on Service Life

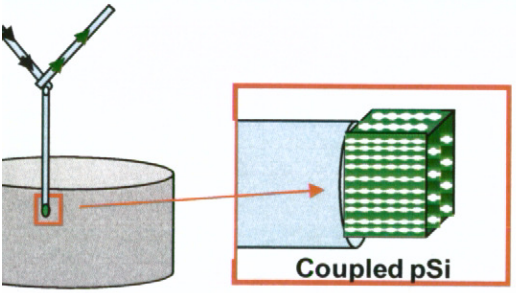


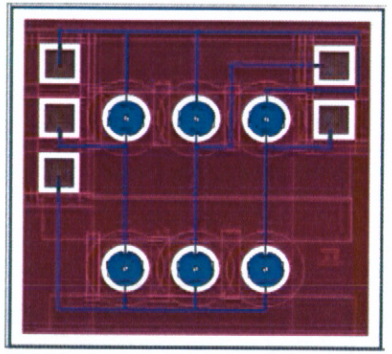
Multivapor at 75% RH



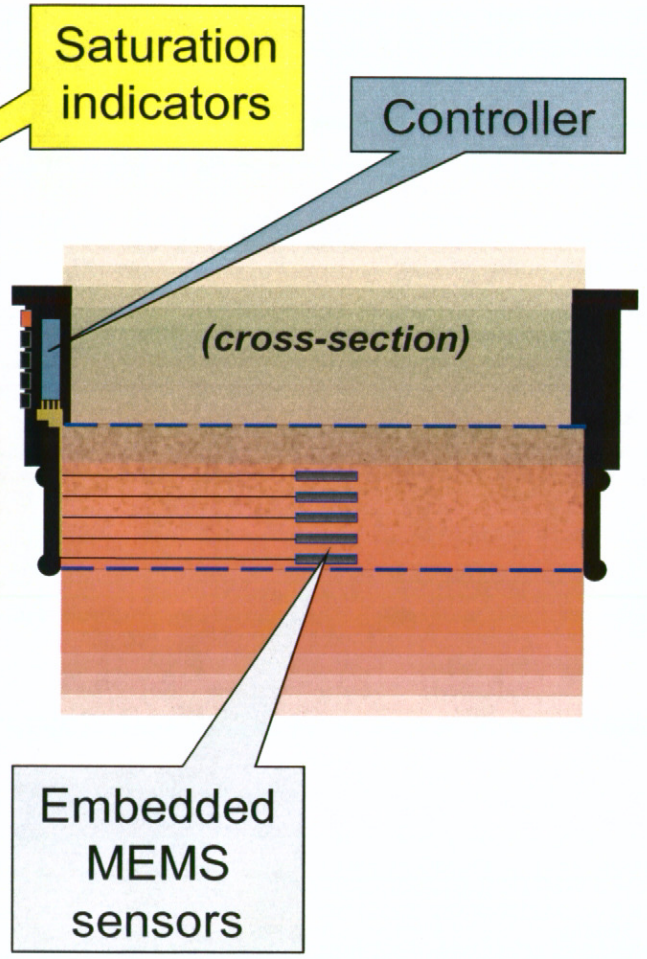
Sensor Development Program

- **Electronic System (chemo resistive devices)**
  - Collaboration with CMU (Fedder group)
- **Optical System**
  - Collaboration with UCSD (Sailor group)

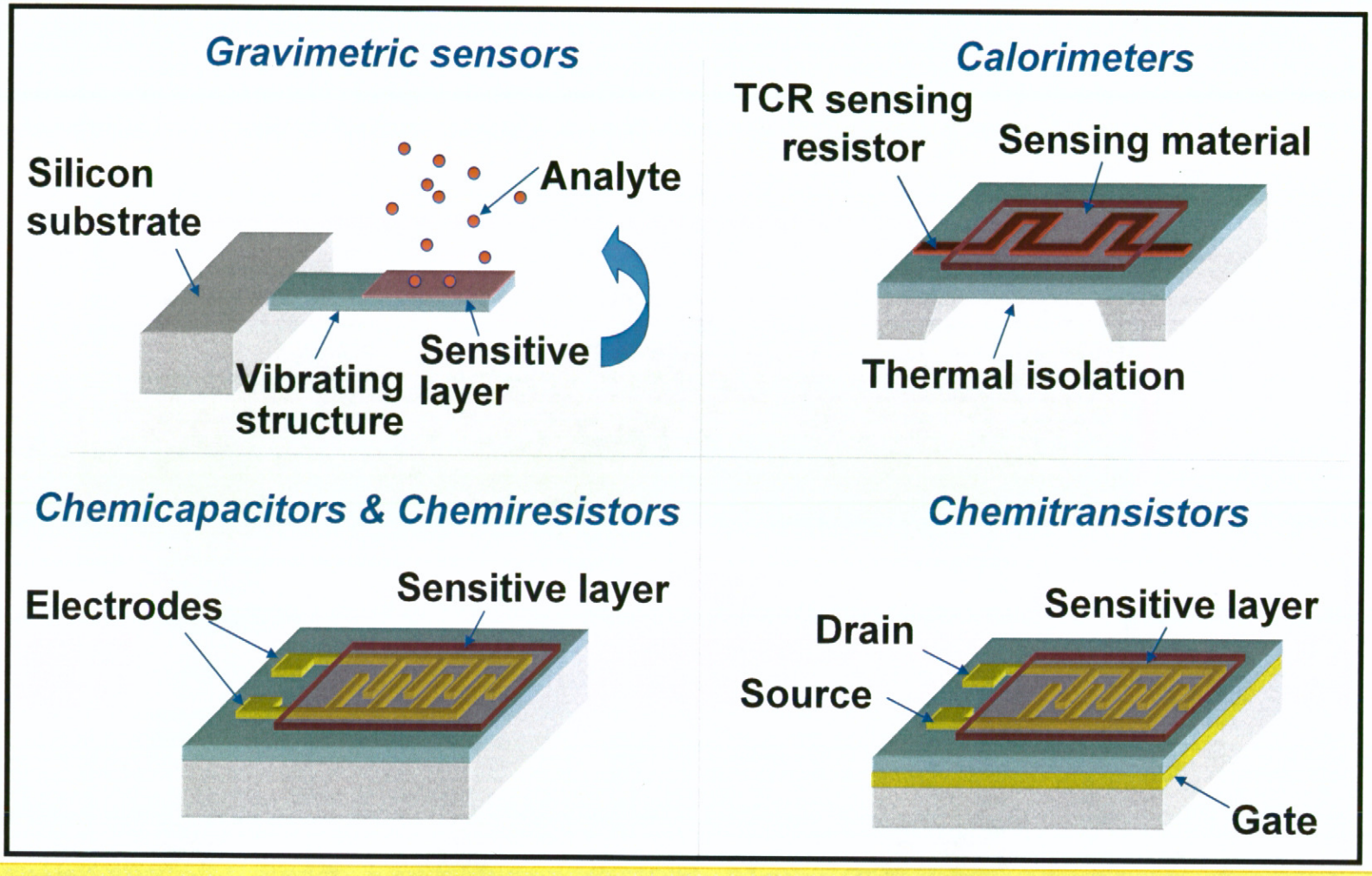




ESLI Sensor Concept

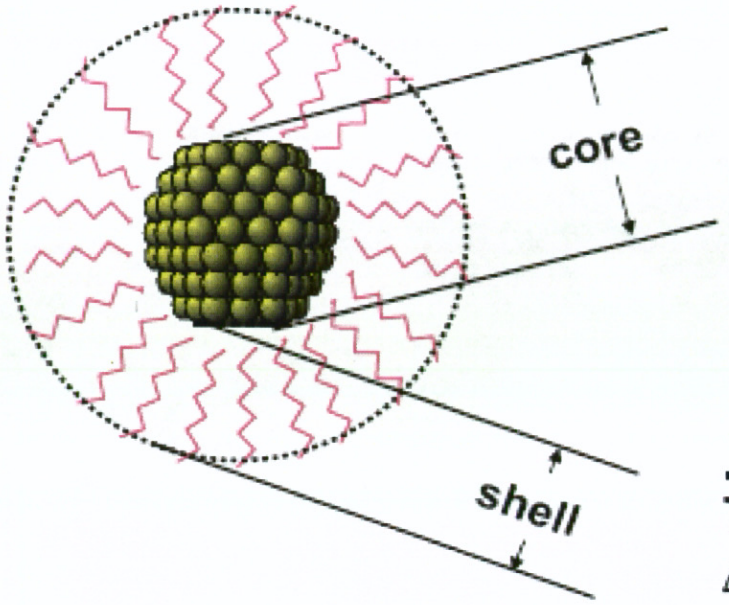


Possible Sensor Types



Coated Gold Nanoparticles (GNP)

N-Alkyl Thiols = RSH = $C_nH_{2n+1}SH$



Au:RSH Ratio = 1:3 → 8:1

diameter 1.5 → 6.0 nm

$\Delta\sigma$ (range) = + 10^4 $\Omega^{-1}cm^{-1}$

$C_4 \rightarrow C_{16}$

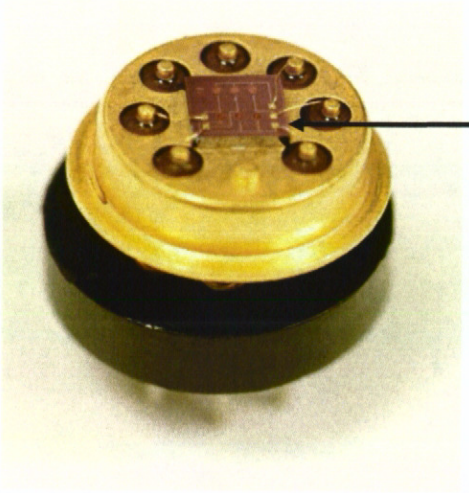
Thickness 0.4 → 2.0 nm

$\Delta\sigma$ (range) = - 10^7 $\Omega^{-1}cm^{-1}$

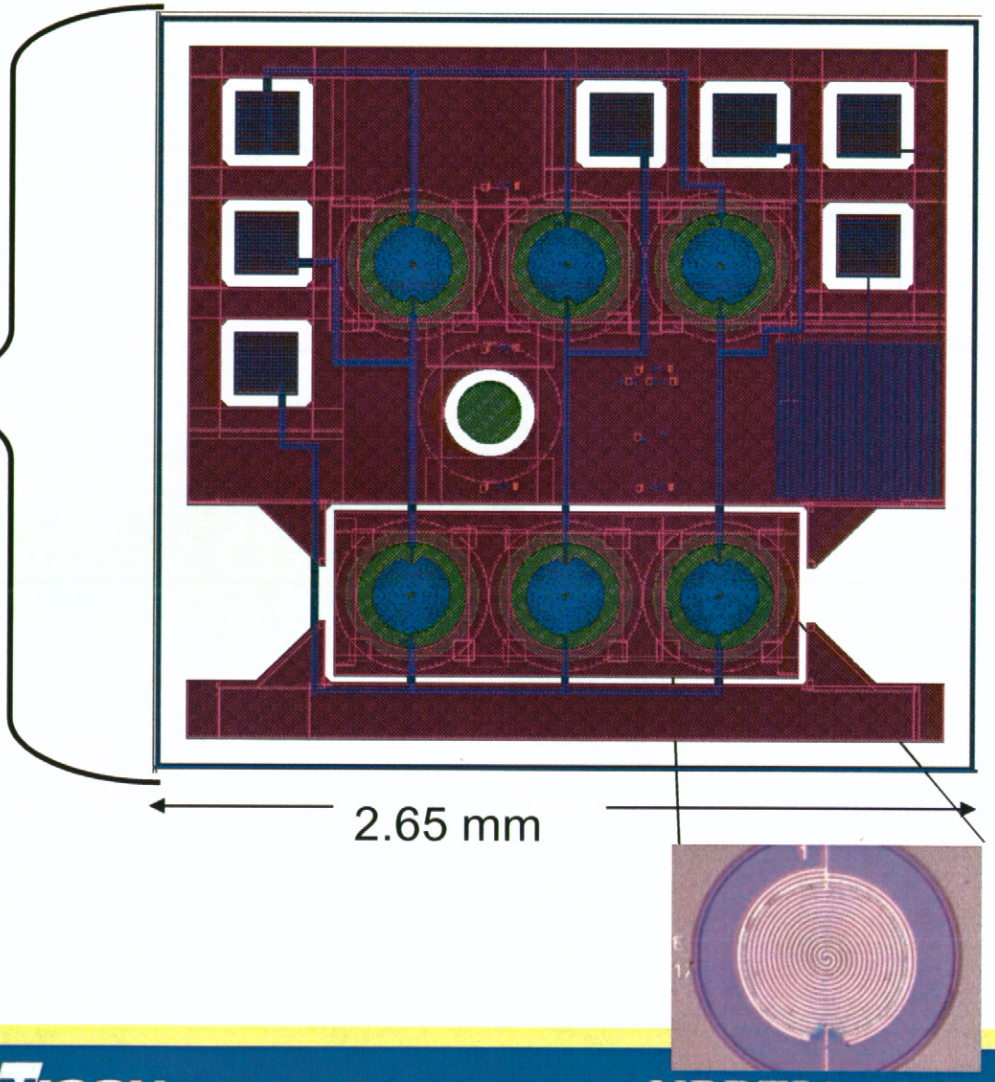
5th Gen CMU / NIOSH Sensor

TO-5 Package with Sensor Array

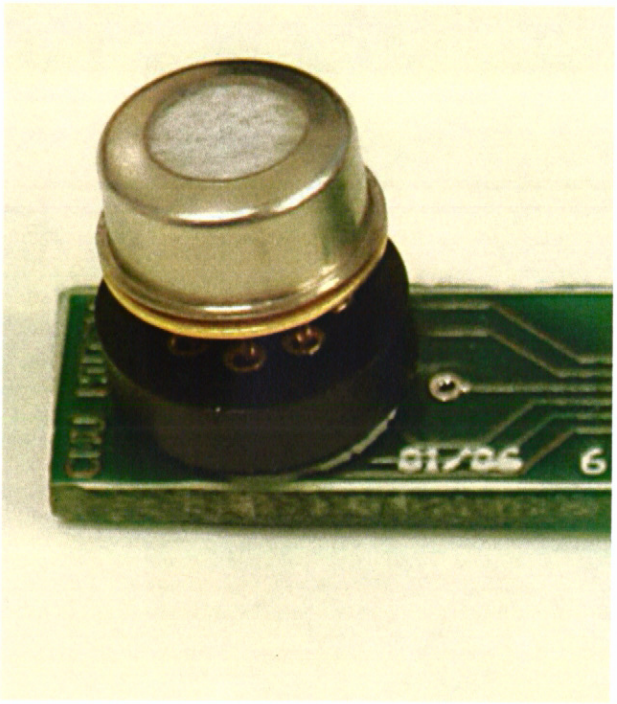
0.25 inches



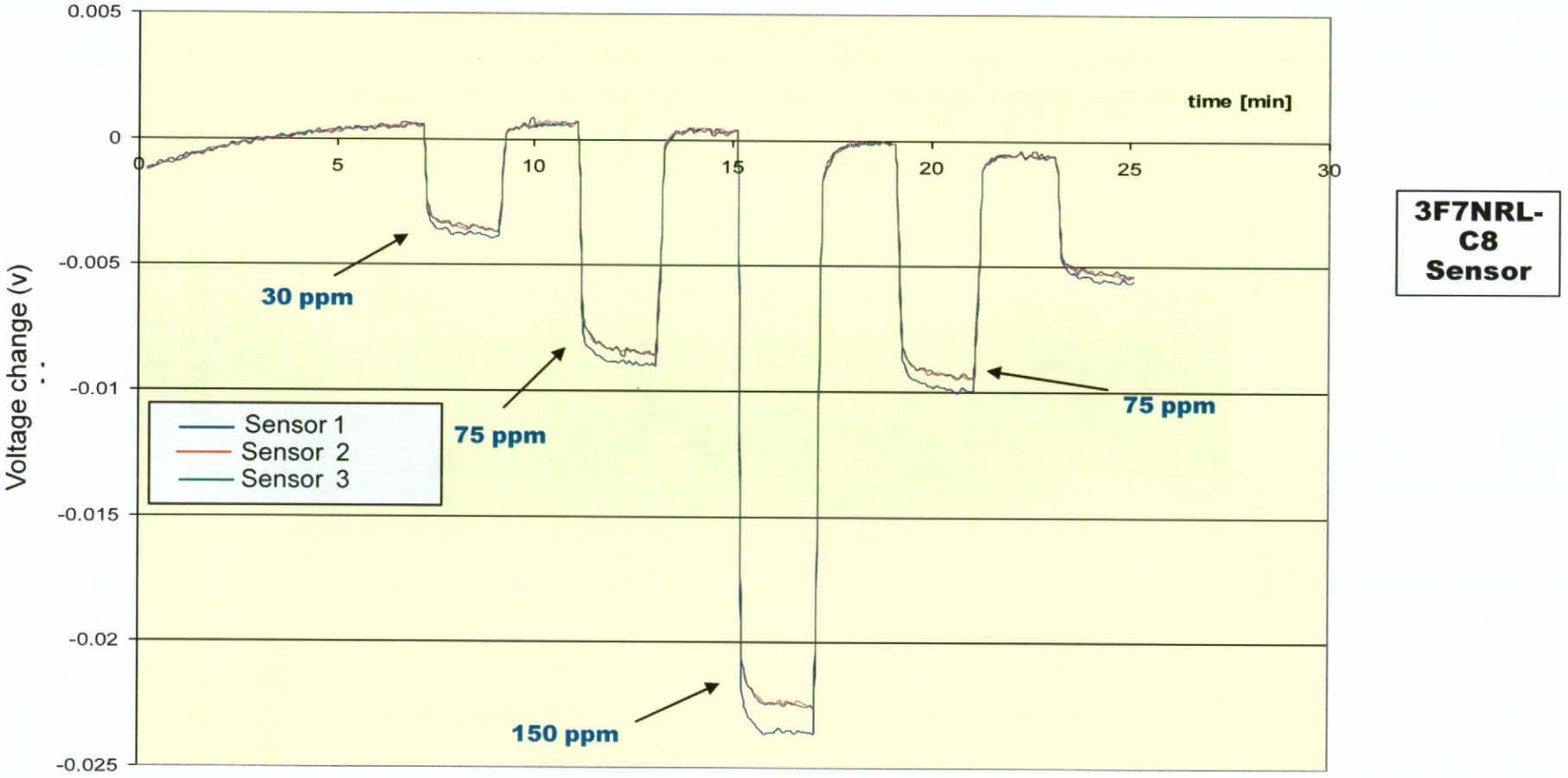
3-Sensor Array Design with RTD



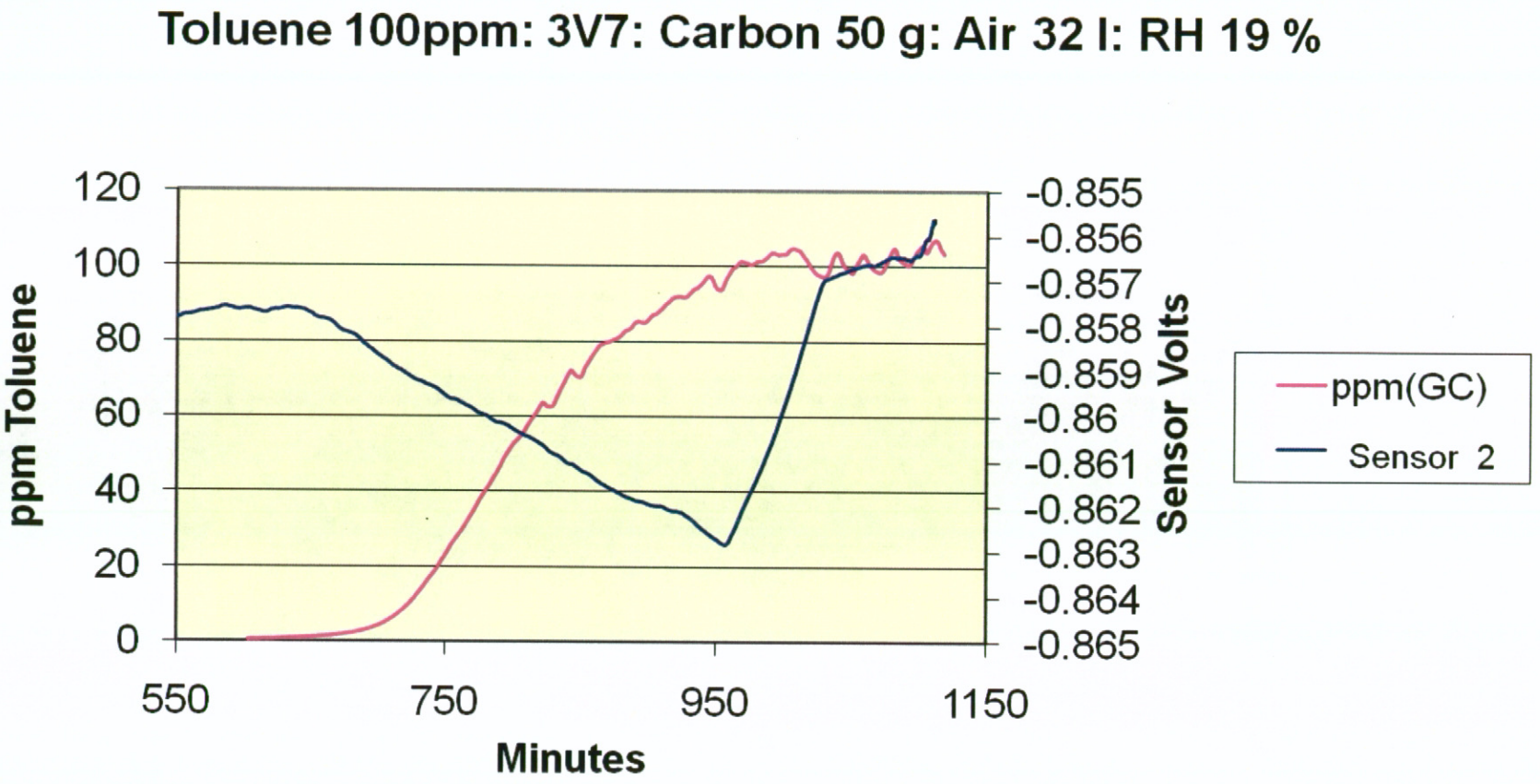
Complete TO-5 Package



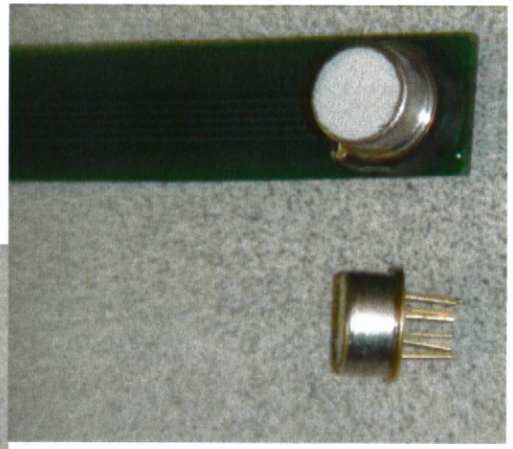
GNP Sensor Response to Toluene in Air

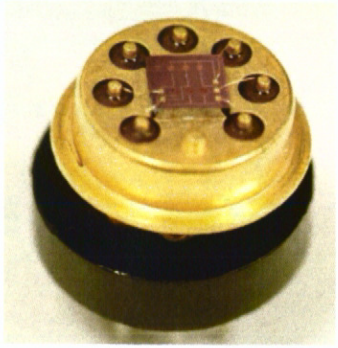


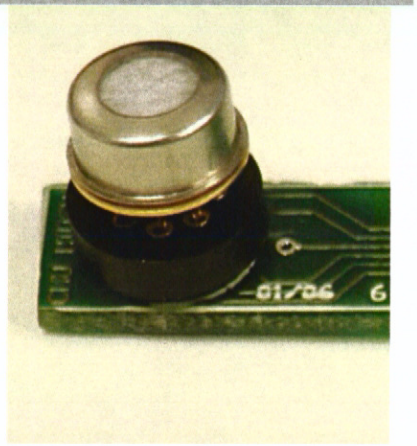
Sensor Response in a Carbon Bed



Sensor Options for Integration



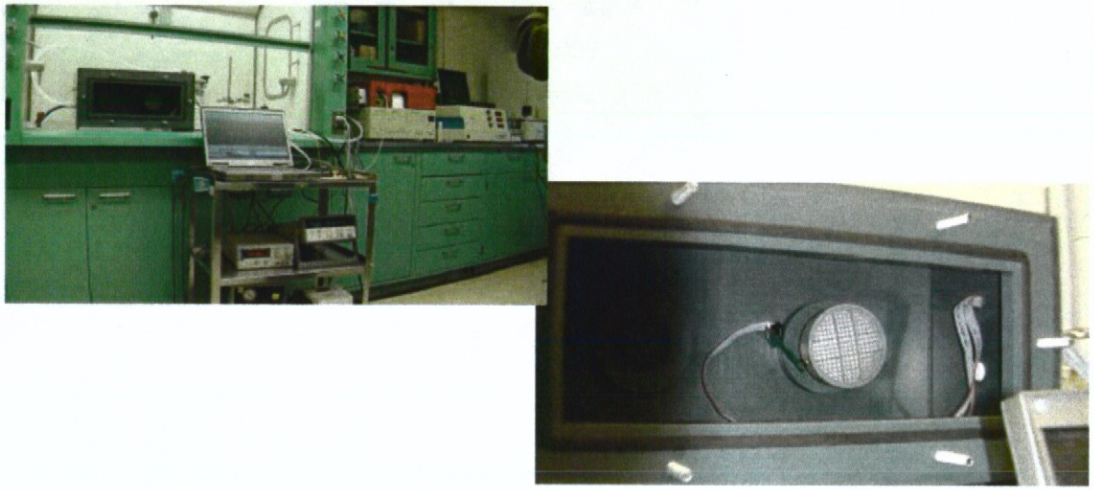




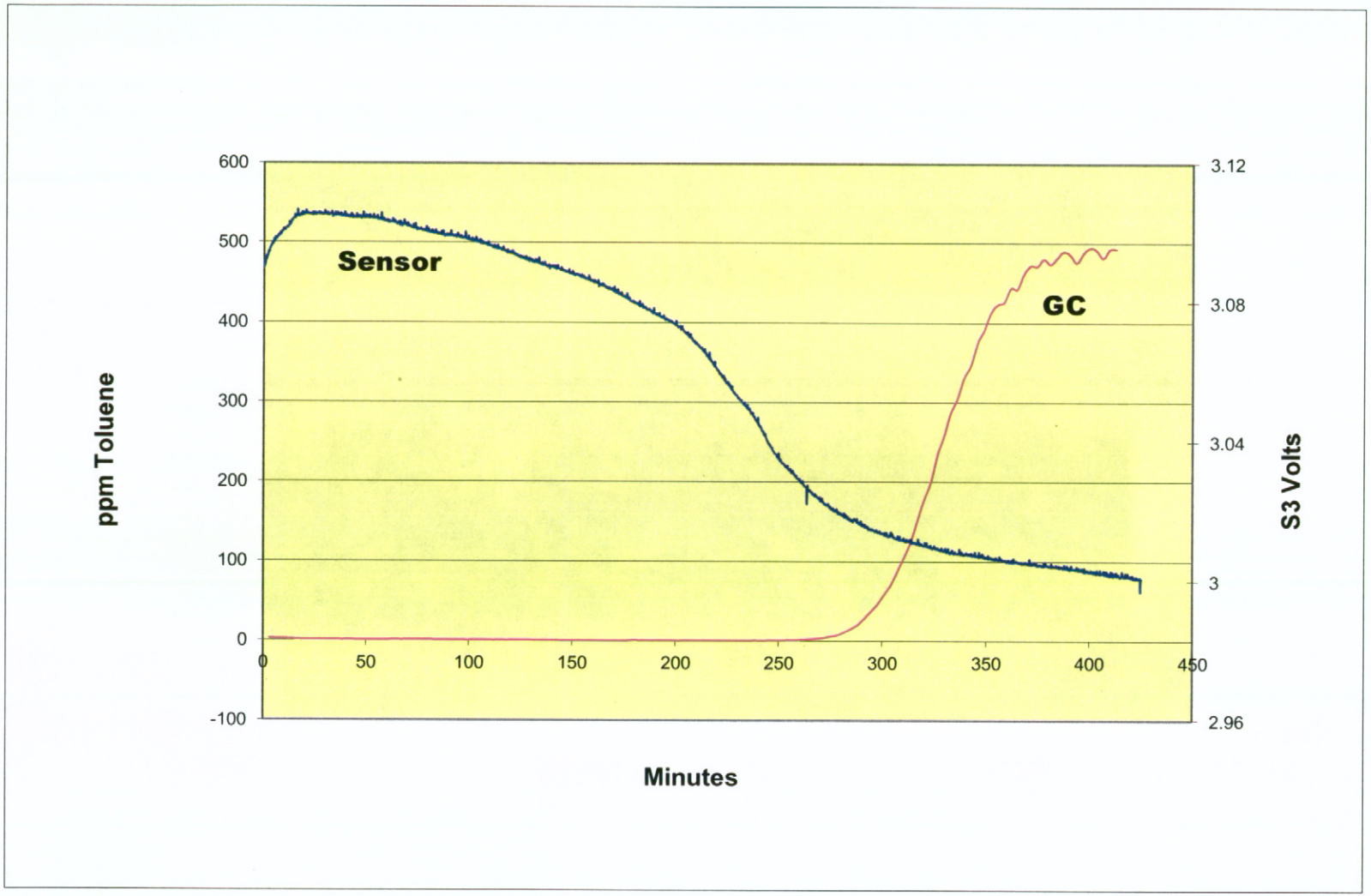
Solvents and Test Setup

- **Toluene**
- **DuPont Enamel Reducer**
  - 19+ compounds
- **Trichloroethylene**
- **25 & 80 % RH**

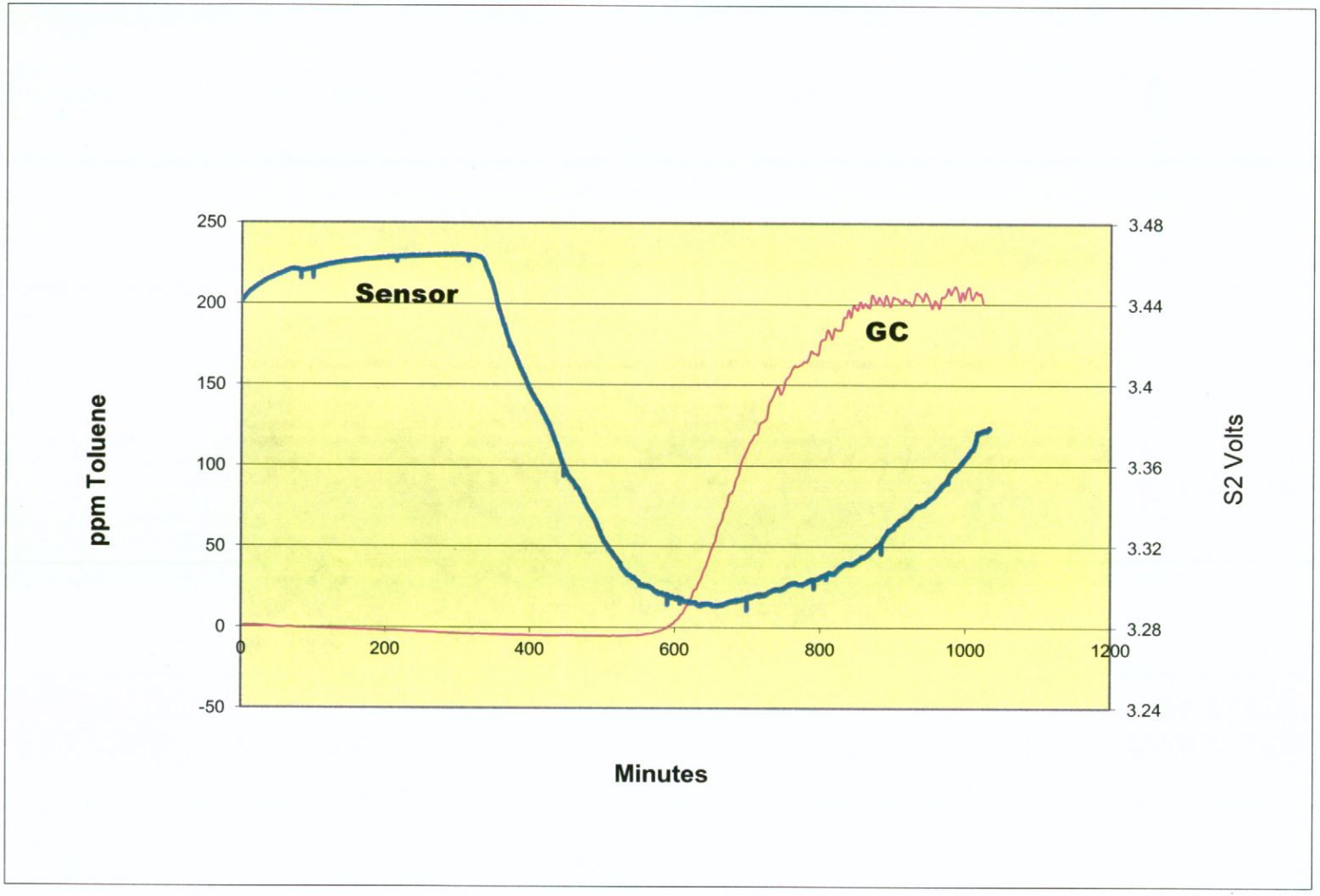
- Custom chamber
- 32 l/min flow
- Controlled analyte and humidity



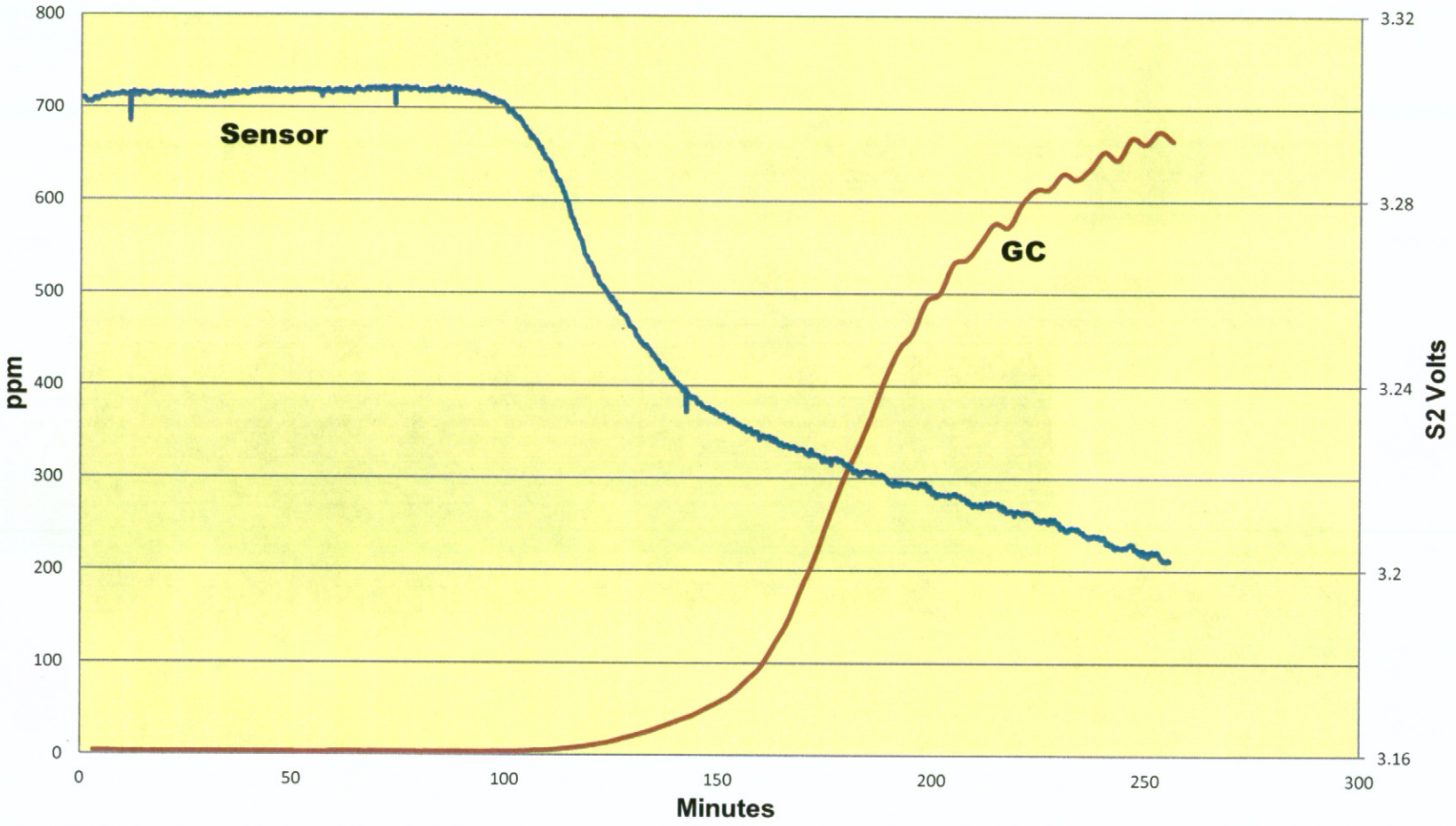
Toluene-500ppm-25%RH



Toluene-200ppm-25%RH



Enamel Reducer-500ppm-25%RH

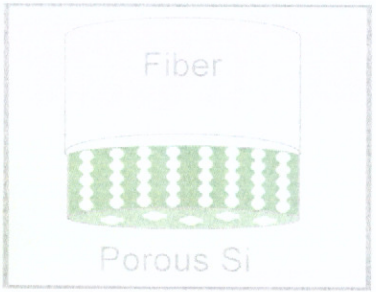


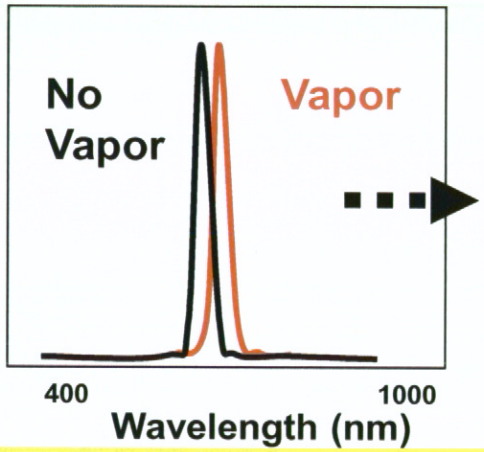
Preliminary Conclusions from Cartridge Testing

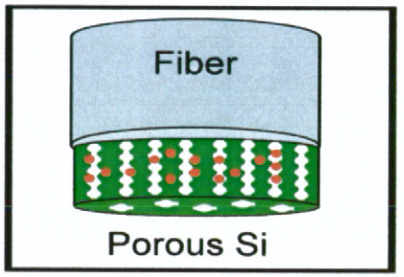
- Uniform film thickness devices were more sensitive than earlier device.
- Detection of contaminants at high RH levels was not acceptable.
- Sensor location (side vs center) made little difference.
- Inconsistent sensor performance.
- Failures on a few due to handling and transportation.
- Did not observe aging effects.

Optical Sensing System

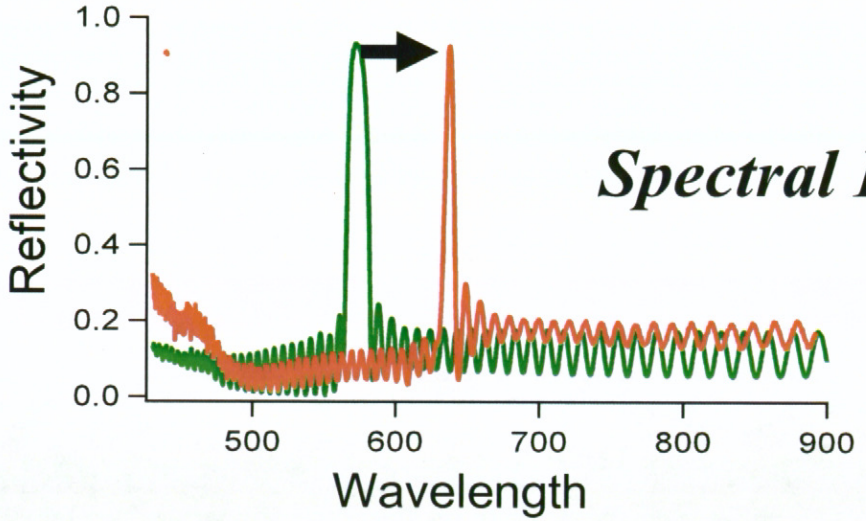
- Utilizes nano technology (photonic crystals) Porous Silicon (PSi)



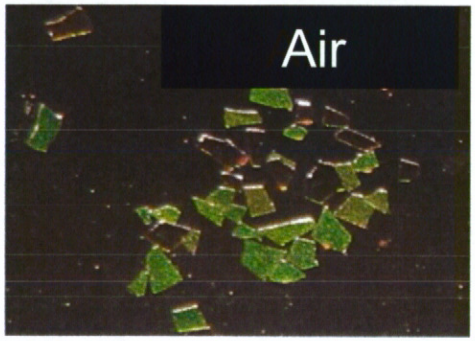


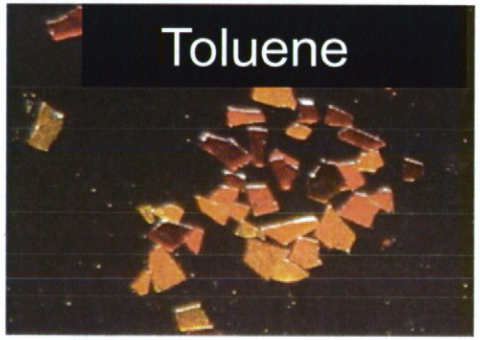


General Sensing Scheme



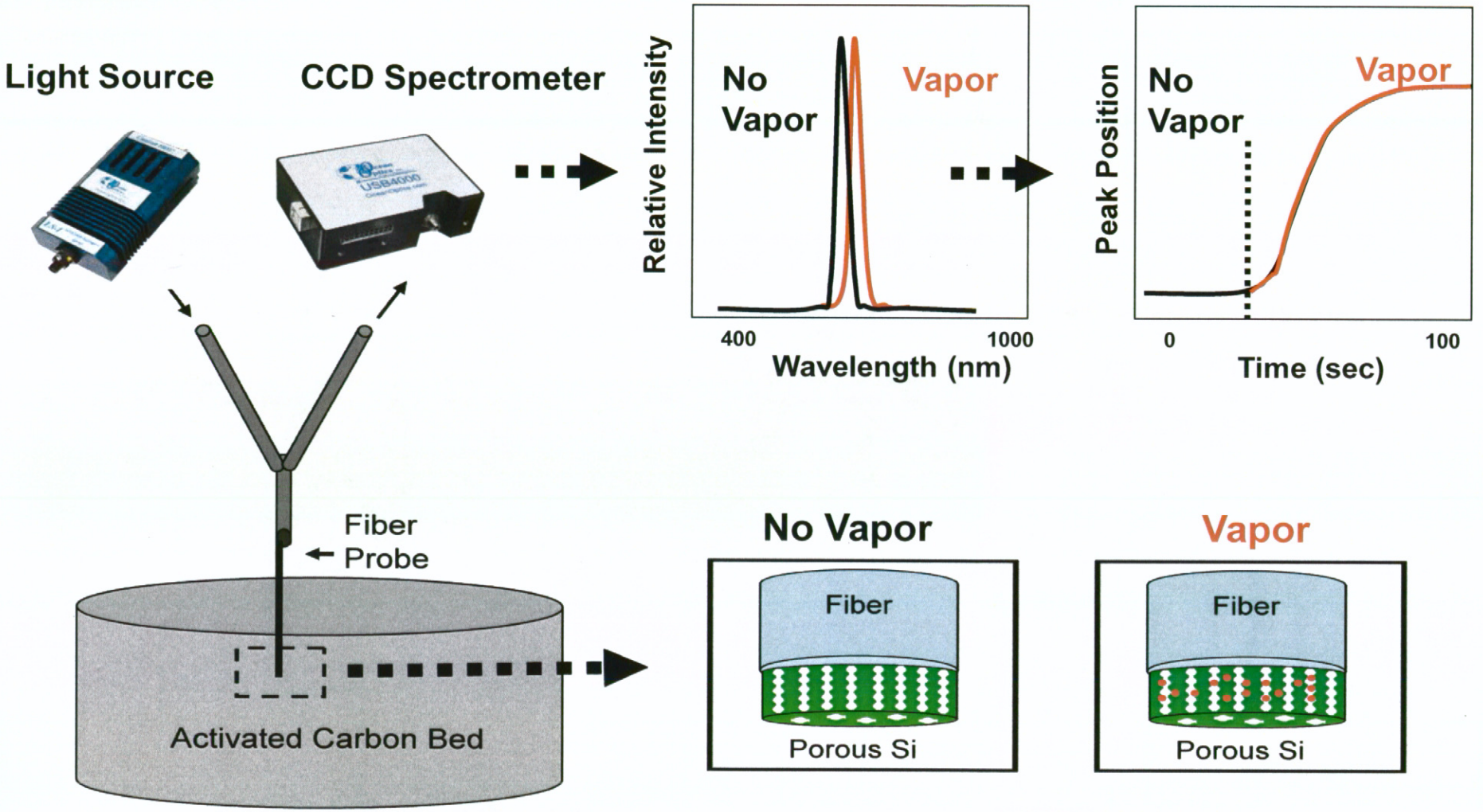
Spectral Band Shifts



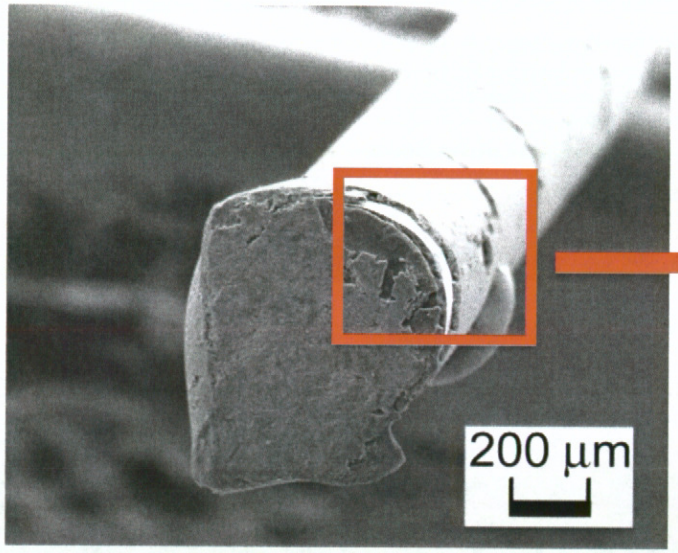


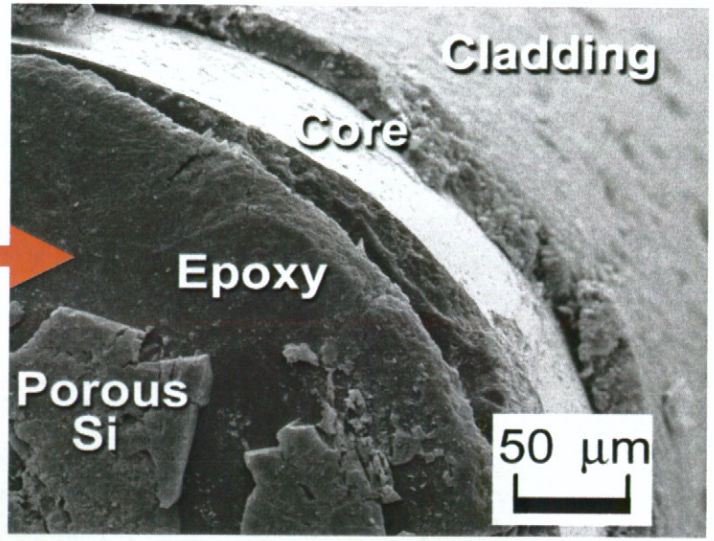
Vapors:
ppm to ppb
sensitivity

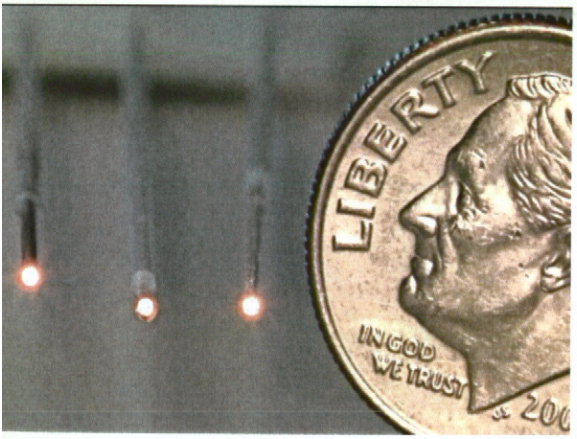
Optical Fiber Sensing Scheme

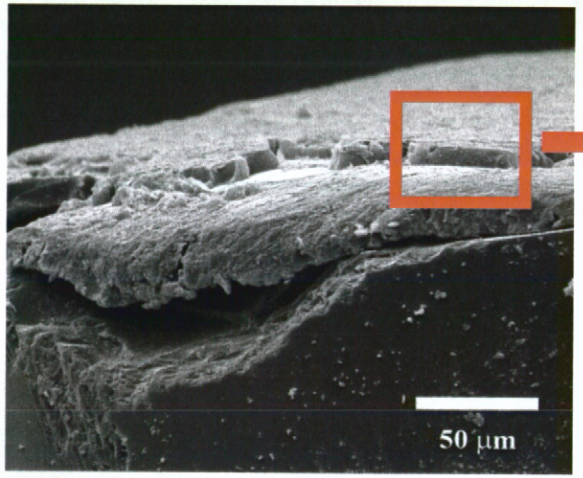


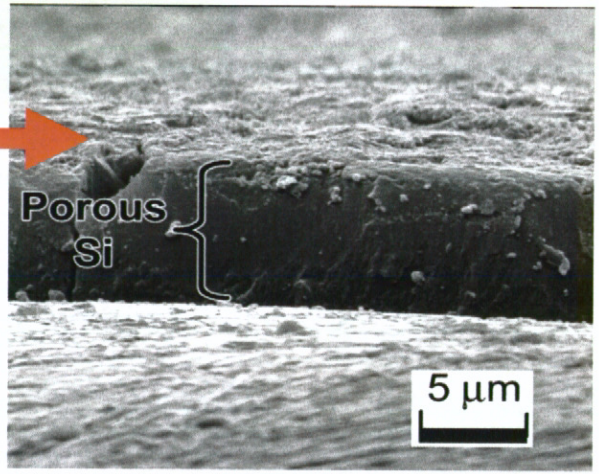
Attachment to Optical Fiber



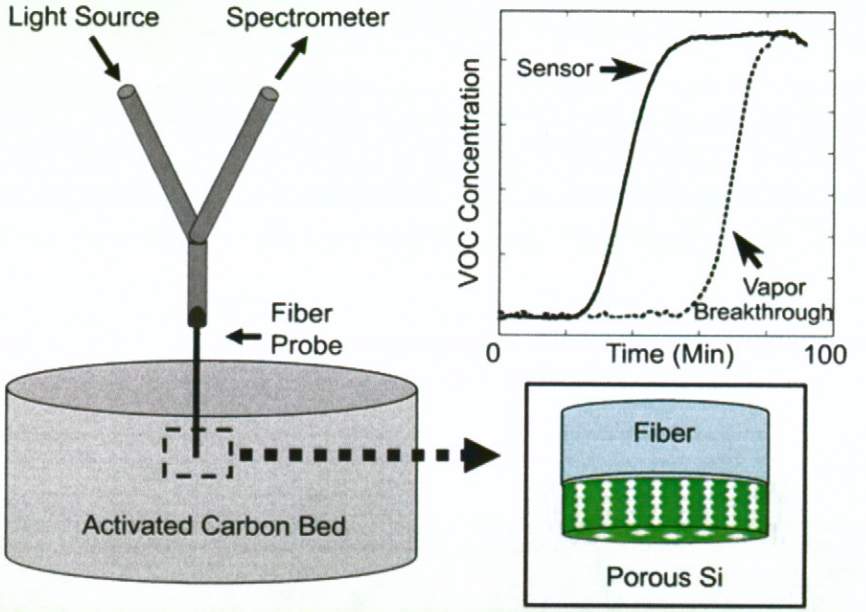


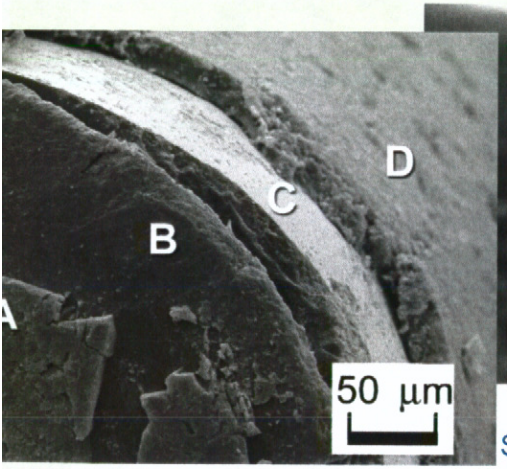


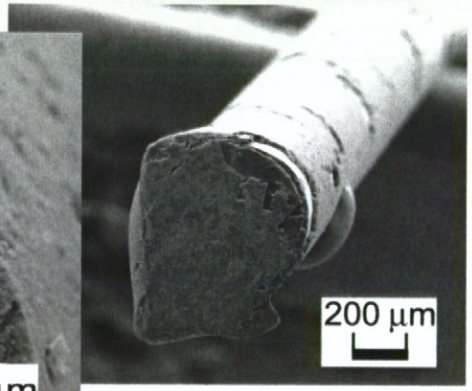




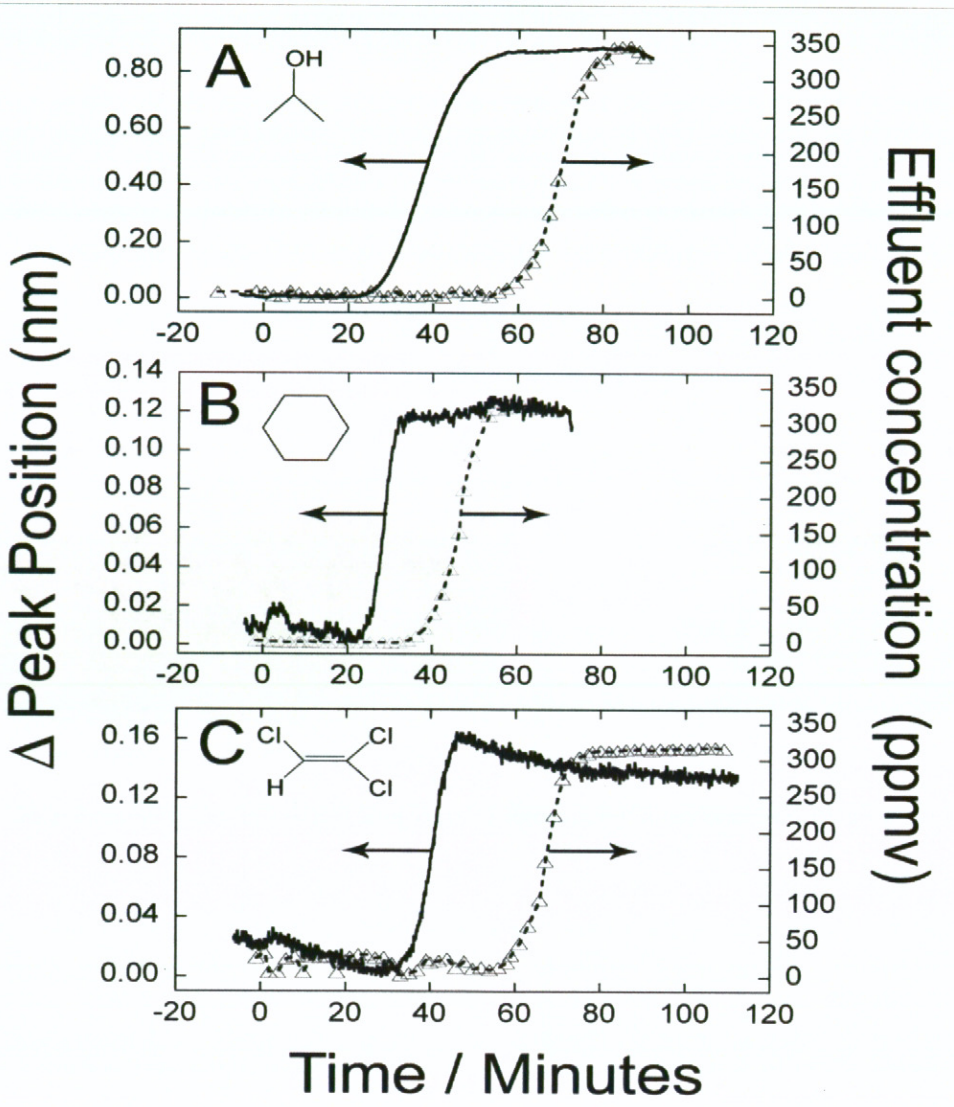
"Smart Dust" Sensor in Respirator Cartridge (simulator)



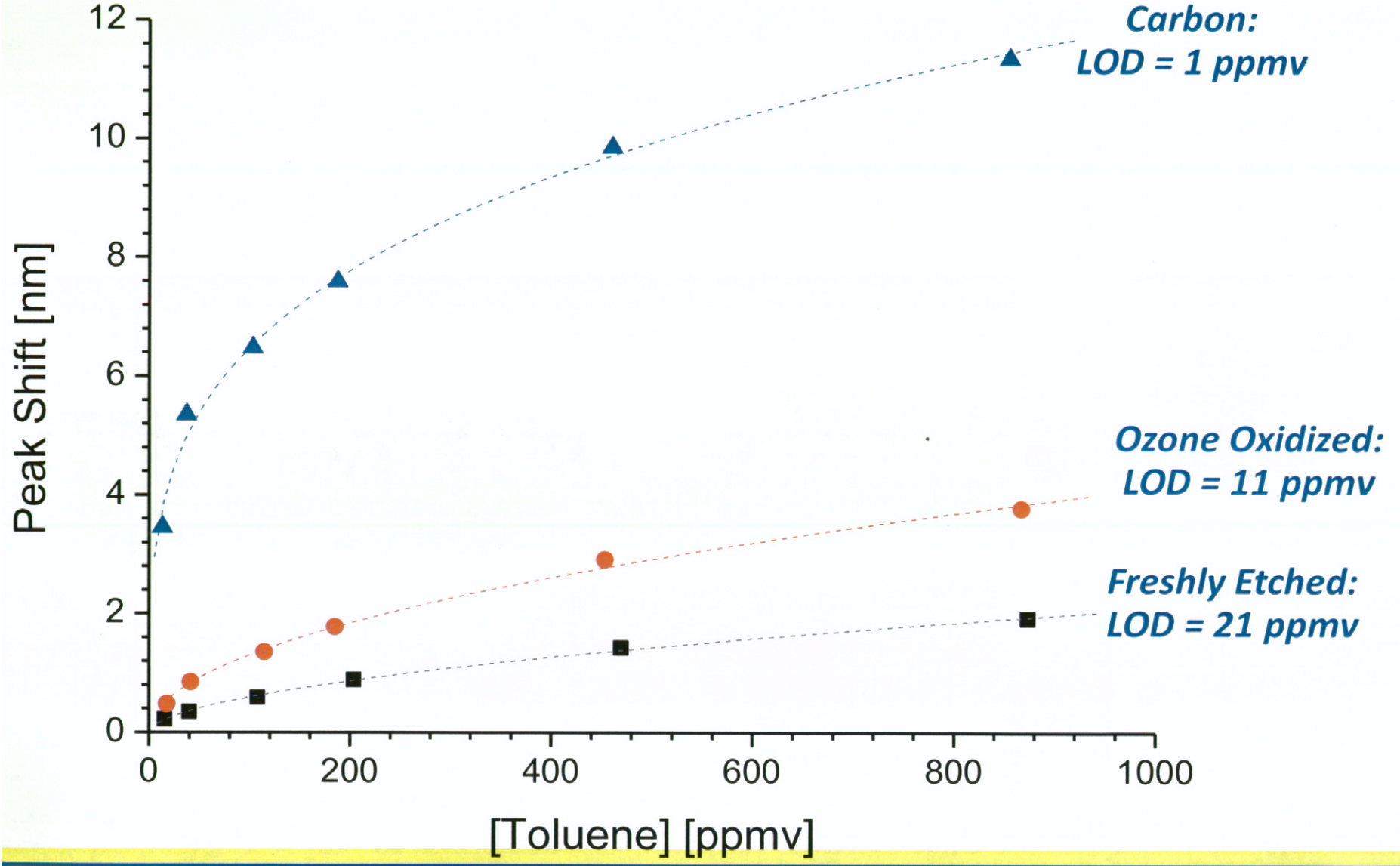




King, B. H.; Ruminski, A. M.; Snyder, J. L.; Sailor, M. J. *Adv. Mater.* **2007**, *19*, 4530 - 4534.



Toluene Calibration Curve



Disclaimer

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

Contact Info

JSnyder@cdc.gov

412-386-6775