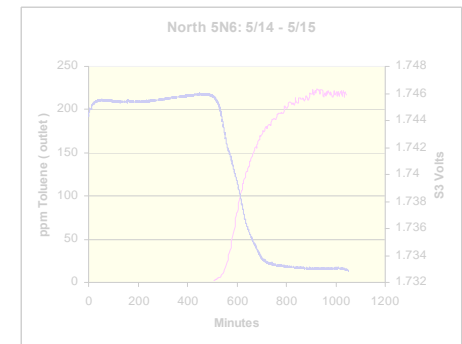


National Personal Protective Technology Laboratory

End-of-Service Life Program

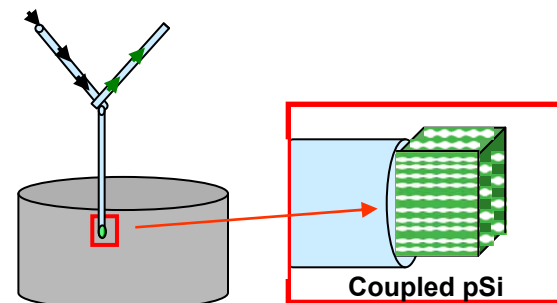
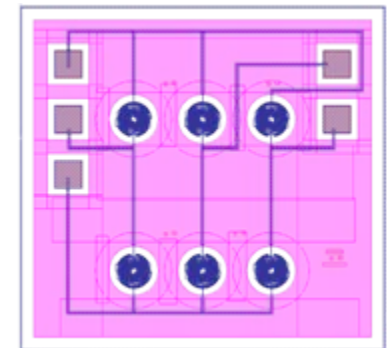
Jay Snyder



Contact Info

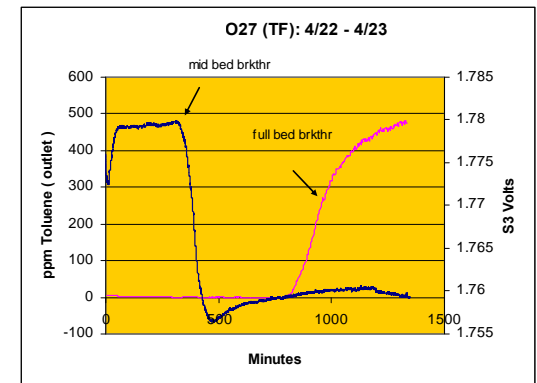
zpx5@cdc.gov

412-386-6775

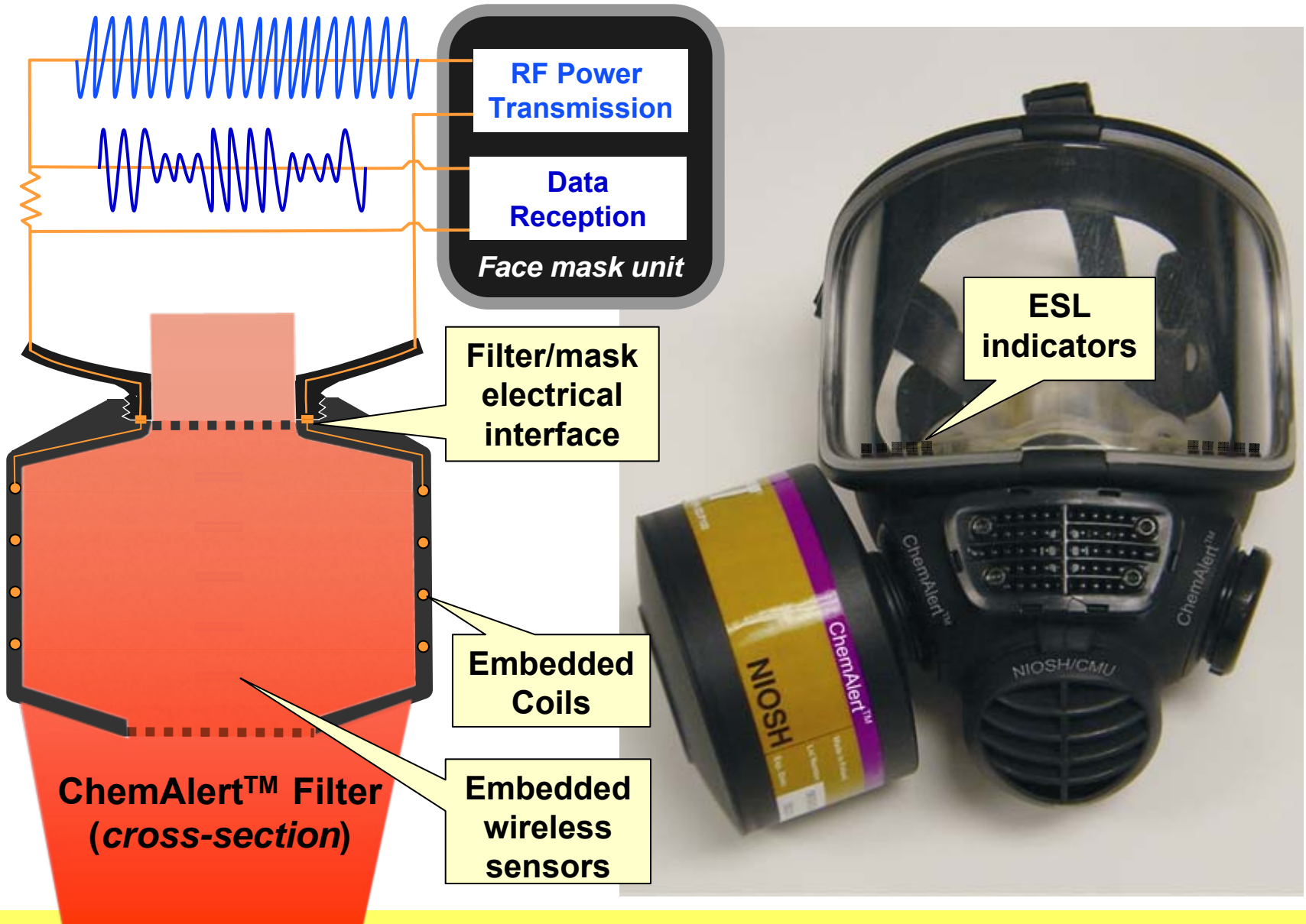


Presentation Outline

- **Present Work (electronic system)**
 - Cartridge-Sensor Integration/Testing/Evaluation
- **Future Work (electronic system)**
 - System Redesign
- **Optical System**
 - An Alternative to the Chemiresistor



End-of-Service Life Detection System



Collaboration with Respirator Manufacturers

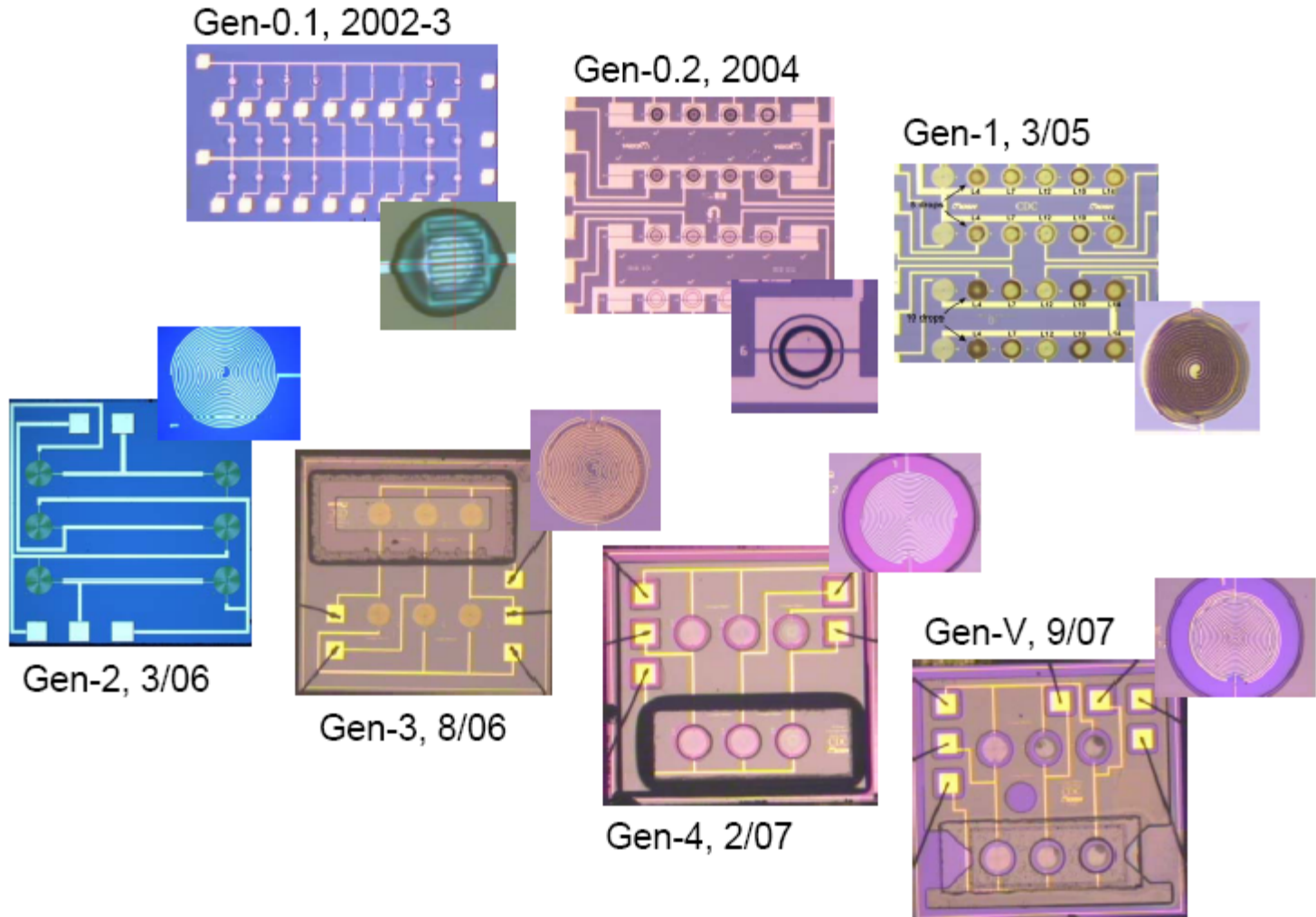
- Dräger
- MSA
- North Safety Products
- Scott Health & Safety
- Sundström Safety AB
- Survivair



Examples of Sensor Integrated Cartridges

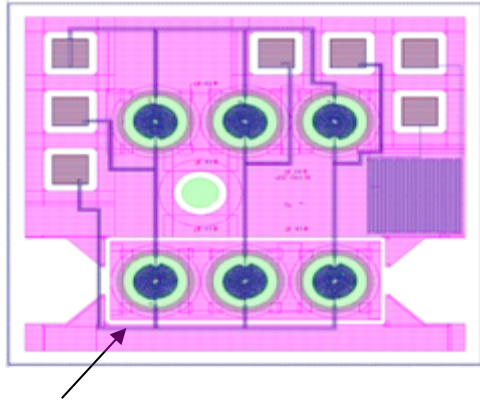


MEMS Sensor Generations

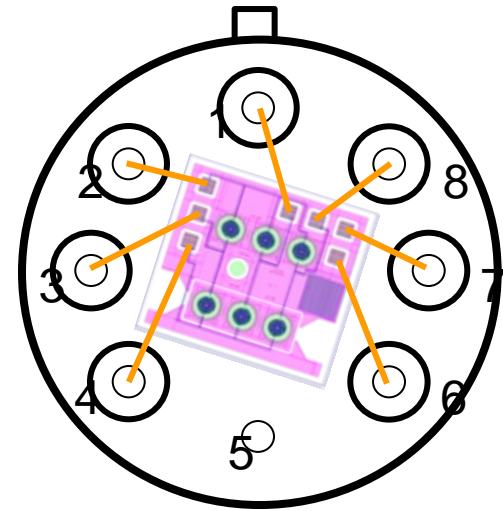


Sensor Assembly

Si chip

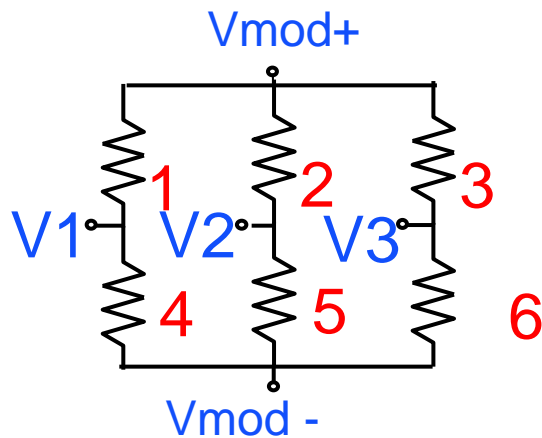


Cover glass



Sensor

Equivalent circuit



TO-5

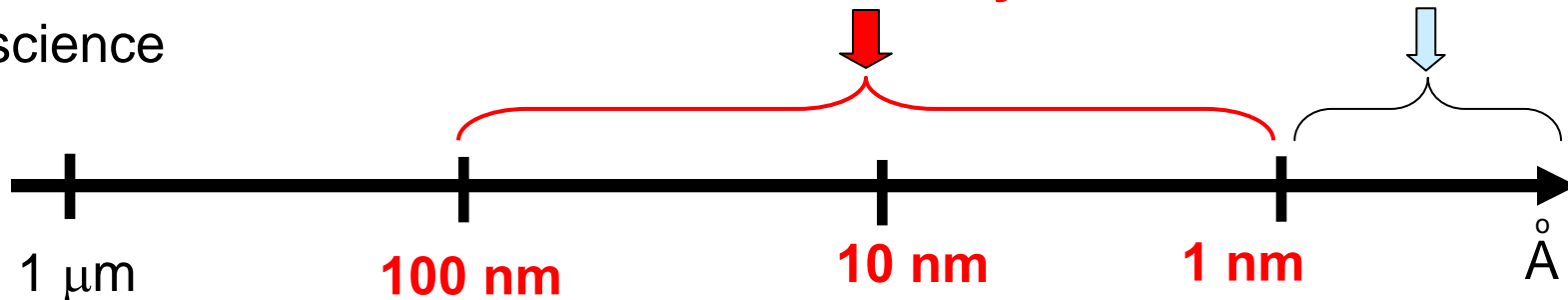


Small is Beautiful: From Bulk to Nano Scale

Solid state science

Nanochemistry

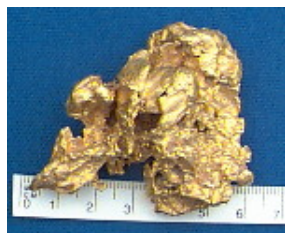
Molecular chemistry



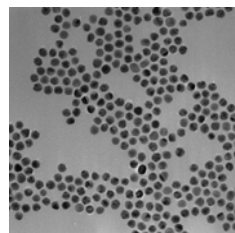
Bulk
($> 1\mu\text{m}$)

(crystalline nanoparticles, 1-100 nm)

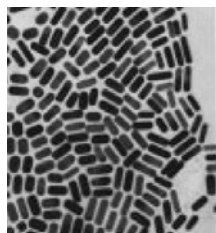
The bottom of nanoscale



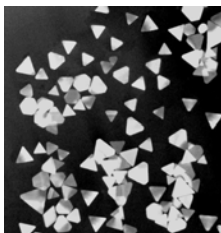
Gold nugget



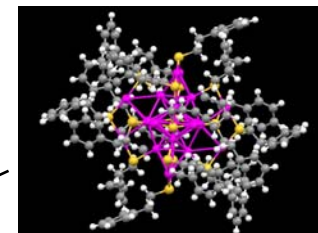
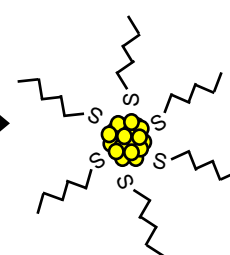
nanosphere



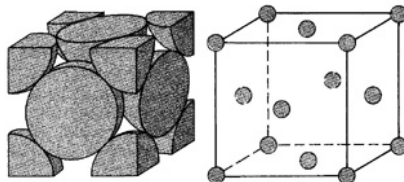
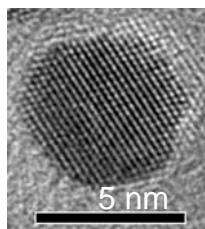
nanorods



nanoprisms

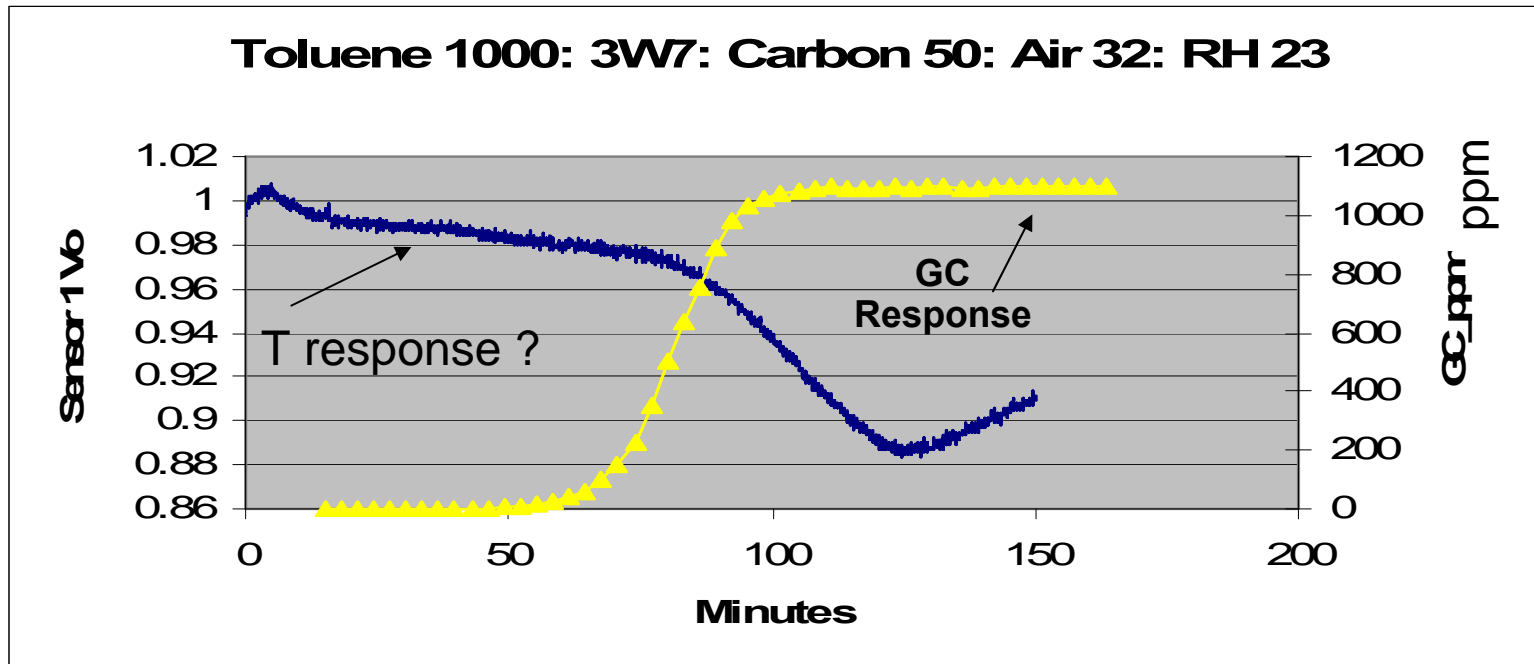
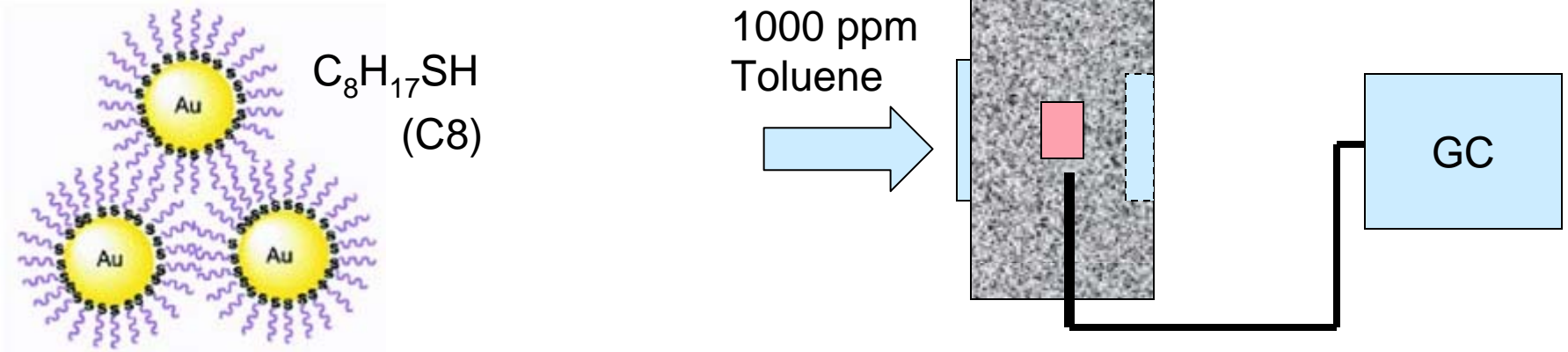


Au_n clusters



Used with permission from Carnegie Mellon University

Performance of a CGNP

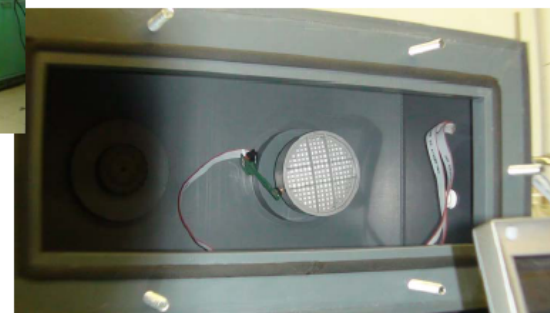


Properties

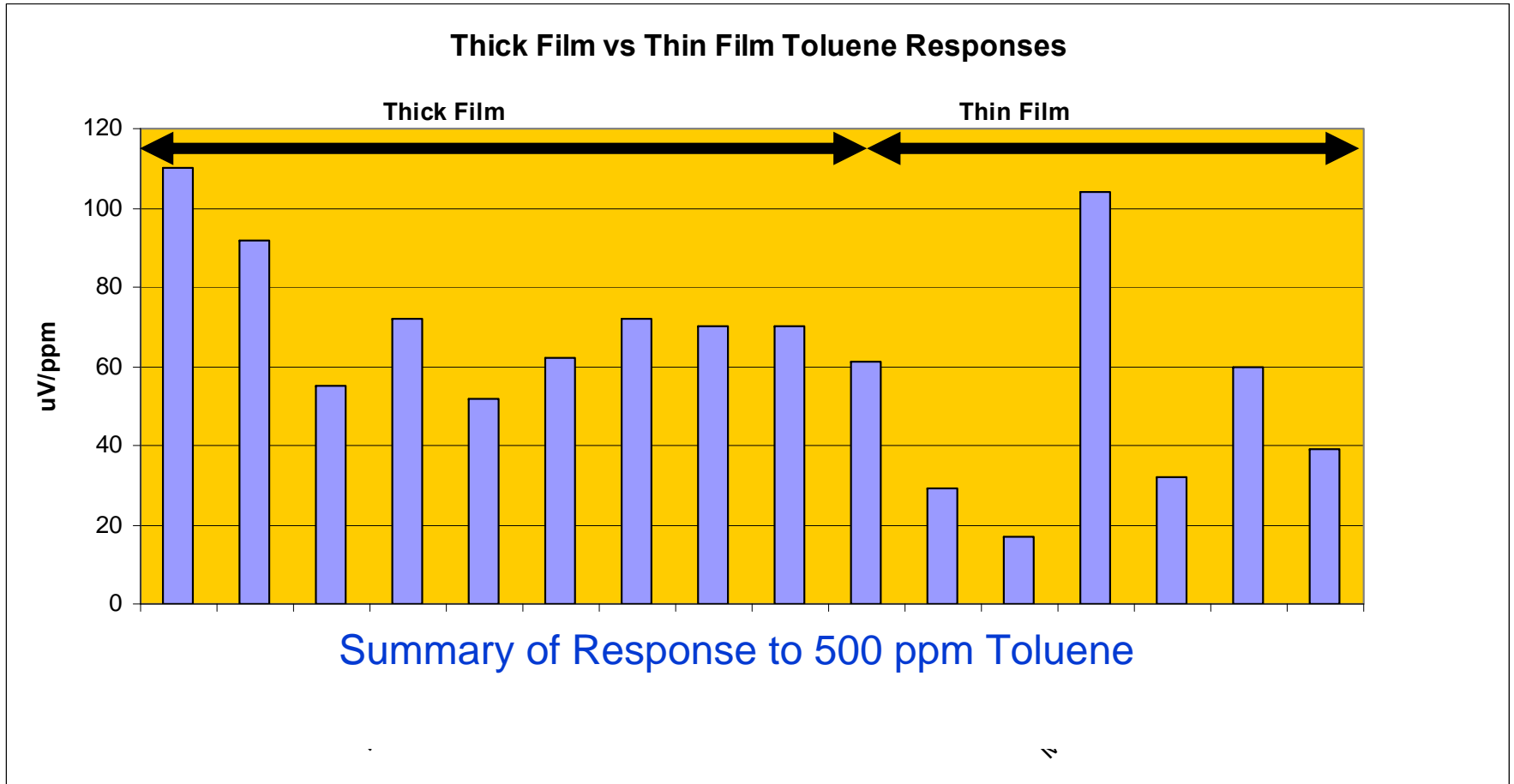
- **Easy to handle**
 - Air stable.
 - Soluble in organic solvents*.
 - Can be coated on substrates by ink-jetting, dipping, spinning and spraying.
- **Can be modified**
 - Size and shape.
 - Functional end groups of organic monolayer.
 - *Solubility determined by the nature of the monolayer.
- **Reusable**

Solvents and Test Setup

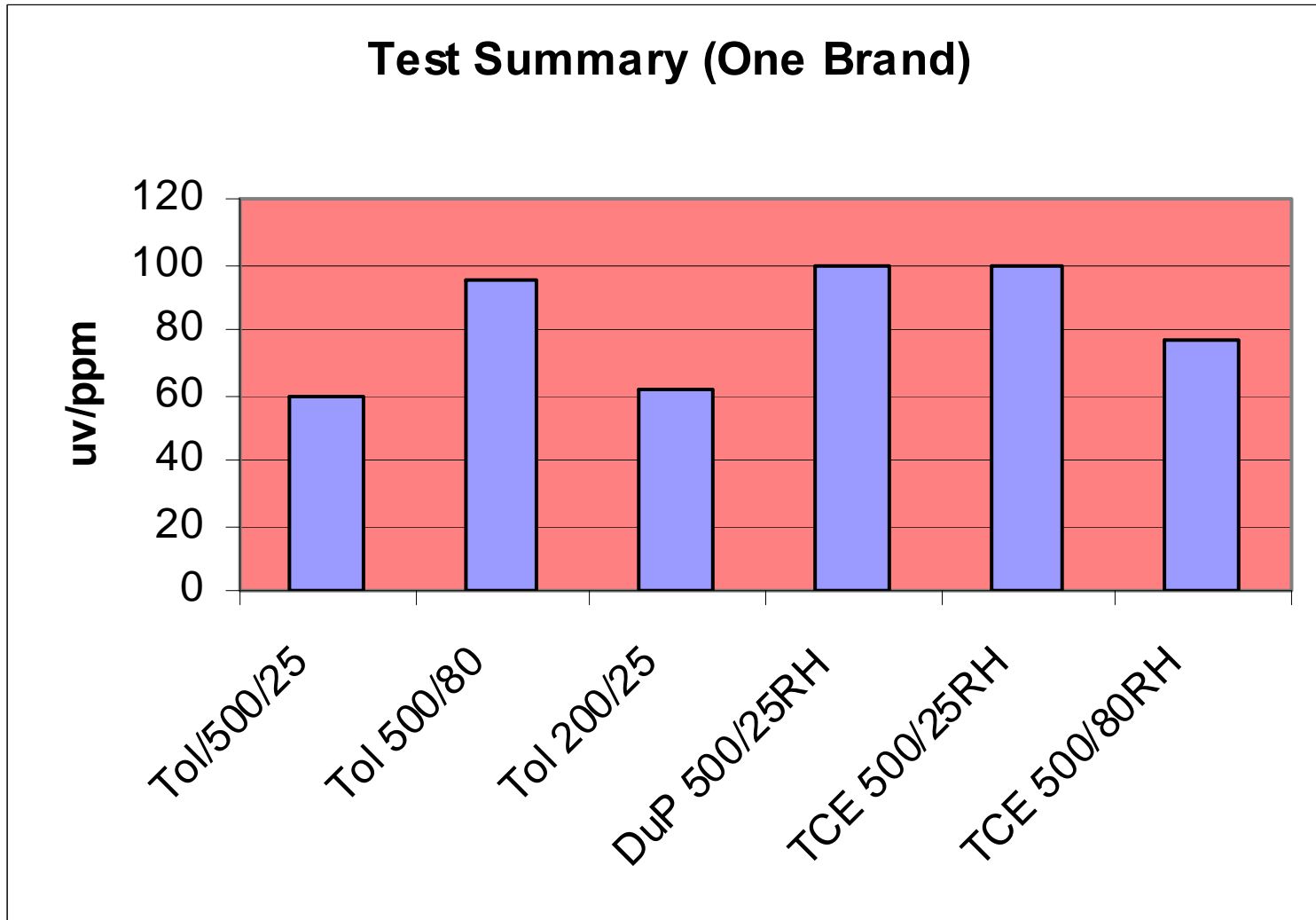
- Toluene (500 & 200 ppm)
- DuPont Enamel Reducer (500 ppm)
 - 19+ groups of compounds
- Trichloroethylene (500 ppm)
- 25 & 80 % RH
 - Custom chamber
 - 32 l/min flow
 - Controlled analyte and humidity



Thick/Thin Film Toluene Response



Test Results



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.
- No failures due handling and transportation?
- Did not observe aging effects.



Tasks for 2009

● **Materials task**

- develop new nanoparticle materials (gold nanocrystals and nanoclusters) for chemiresistive response to analytes of interest
- support generation of nanoparticle materials for chemiresistive device and system development
- test materials for chemiresistive response

● **Manufacturing task**

- jetting development of nanoparticle inks
- inkjetting support for chemical sensor device and system development

● **Sensor task**

- integrated gravimetric sensor characterization to analytes
- integrated capacitive humidity sensor characterization and refinement
- chemiresistor device design support

Tasks for 2009

• System Integration task

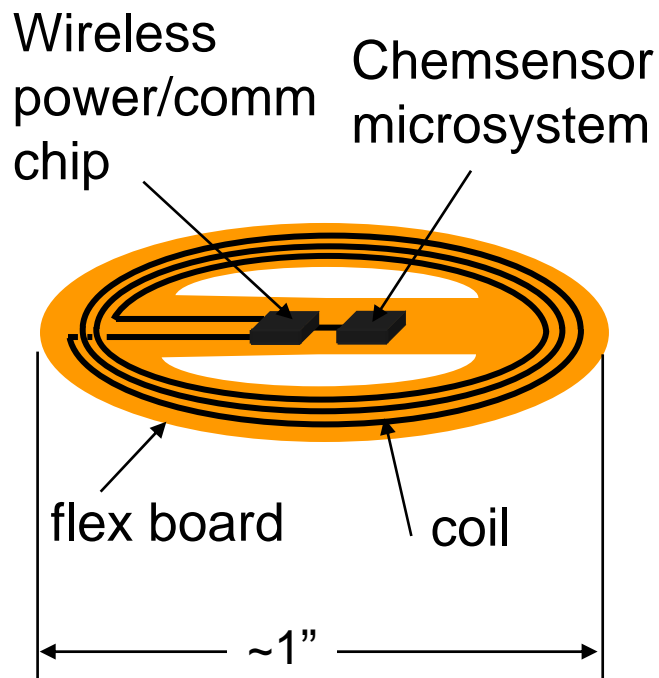
- preconcentrator design and implementation
- chip bonding of preconcentrator onto passive chip system incorporating chemiresistors
- testing with analytes of passive chip system
- incorporation of chemiresistors, humidity sensor and gravimetric sensor onto integrated chip platform with active circuitry

• Wireless task

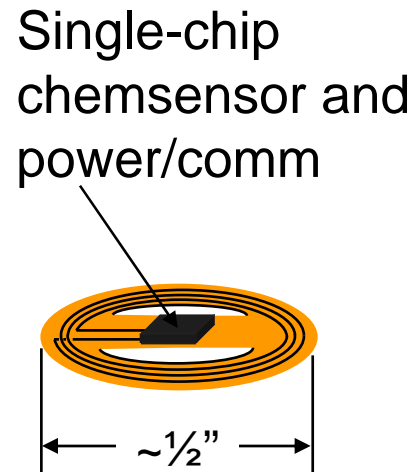
- system power estimation
- design and on-chip implementation of wireless power conditioning circuitry
- near-field antenna design for power transfer
- design of output communication circuits

Wireless Power and Communication

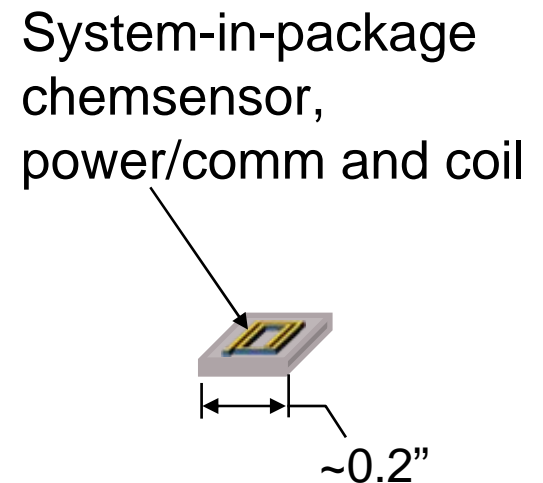
Phased Implementation



1-2 years



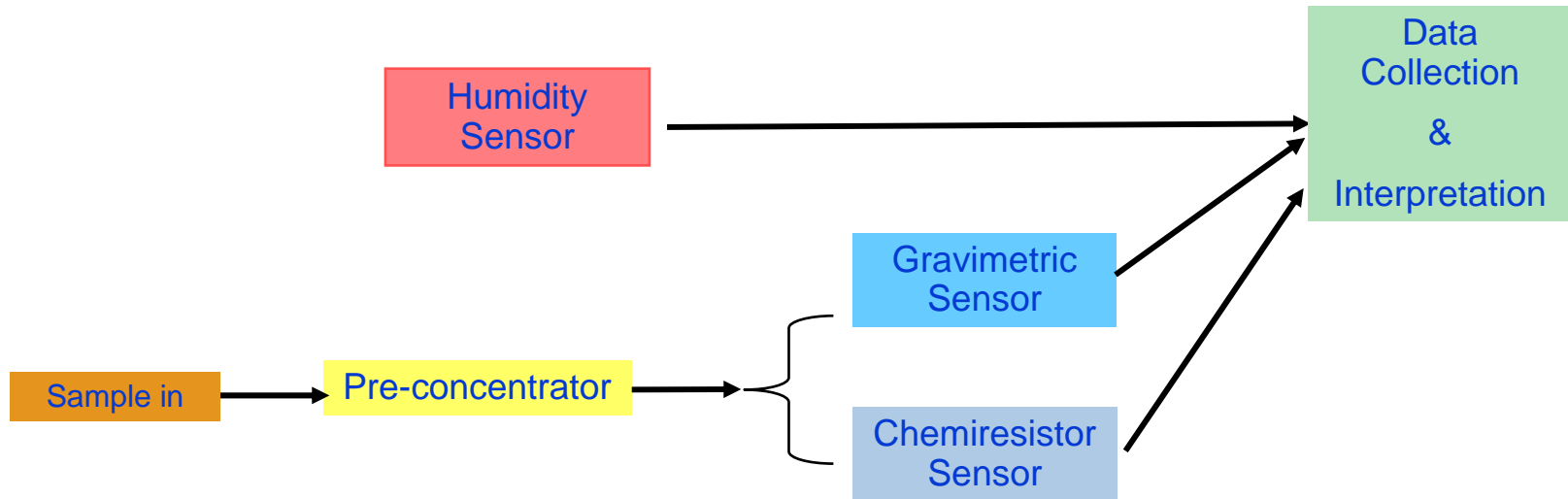
2-3 years



3-4 years

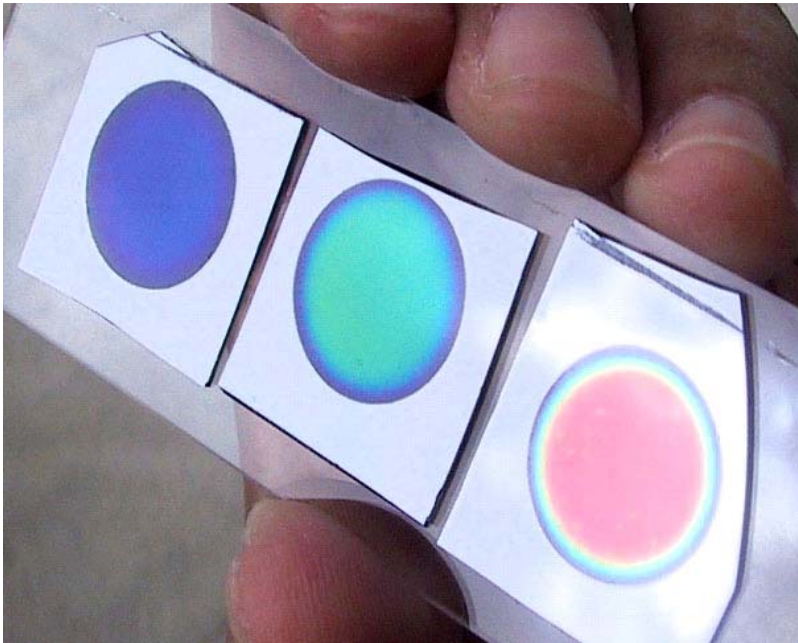
Gen Six Configuration

Next Generation MEMS Device



Nanosensors from Porous Si

- Low Power
- Mass produced, low cost
- Tunable Optics
- Sensitivity: high surface area
- Surface easily modified
- Impervious to electrical interference



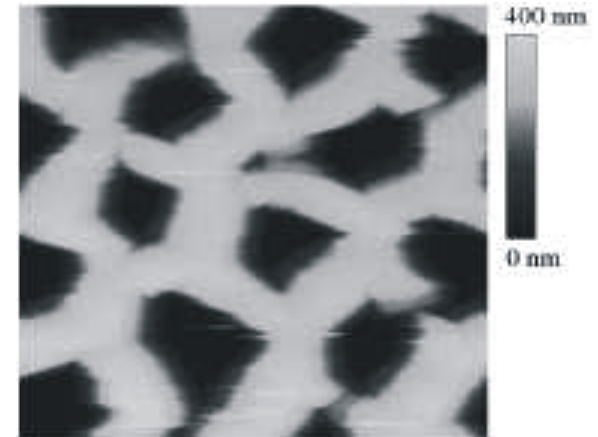
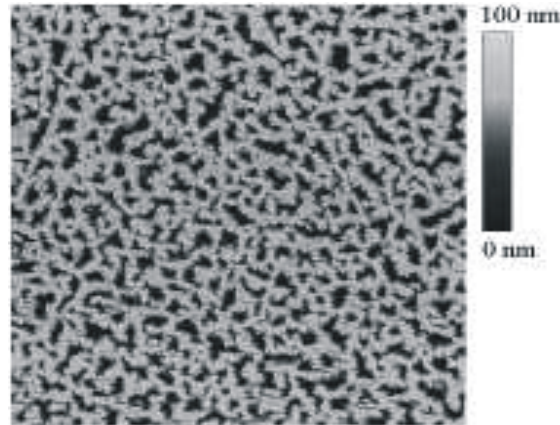
Plan View

Wide range of pore sizes possible

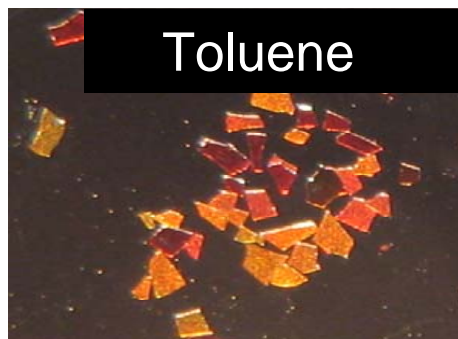
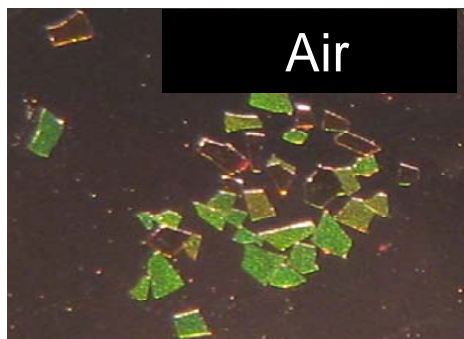
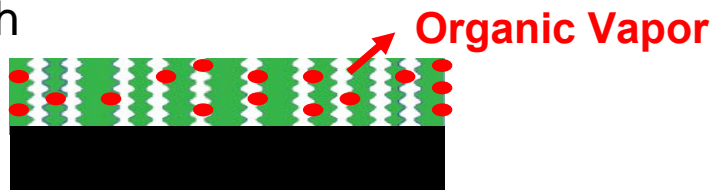
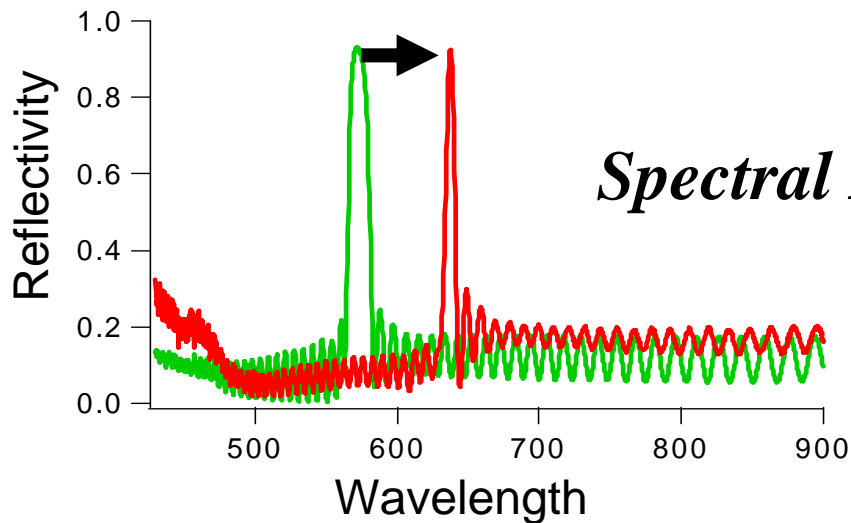
10nm

100nm

1 μ m

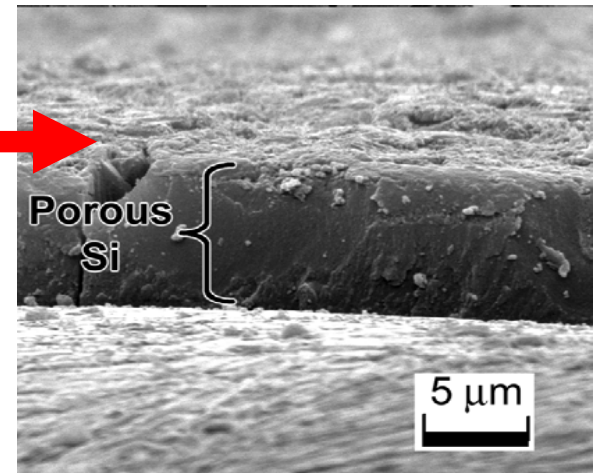
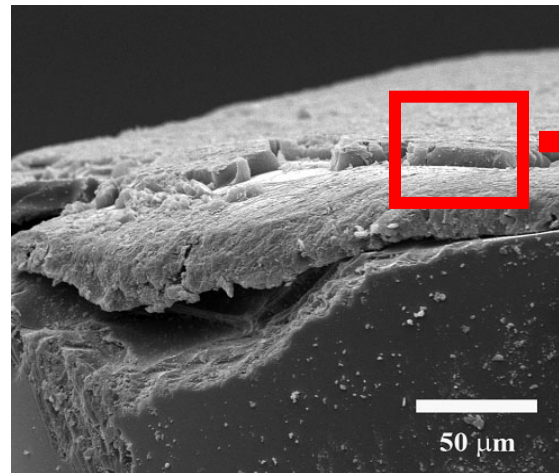
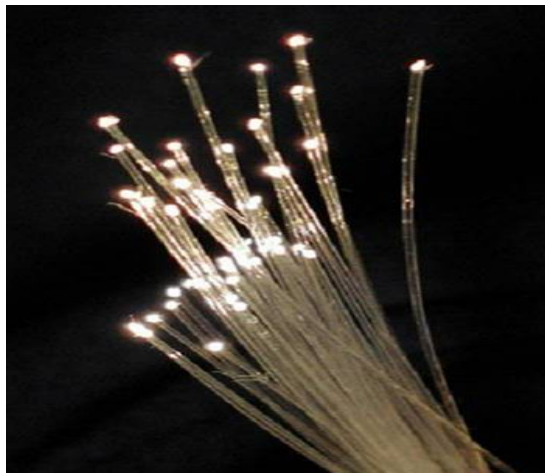
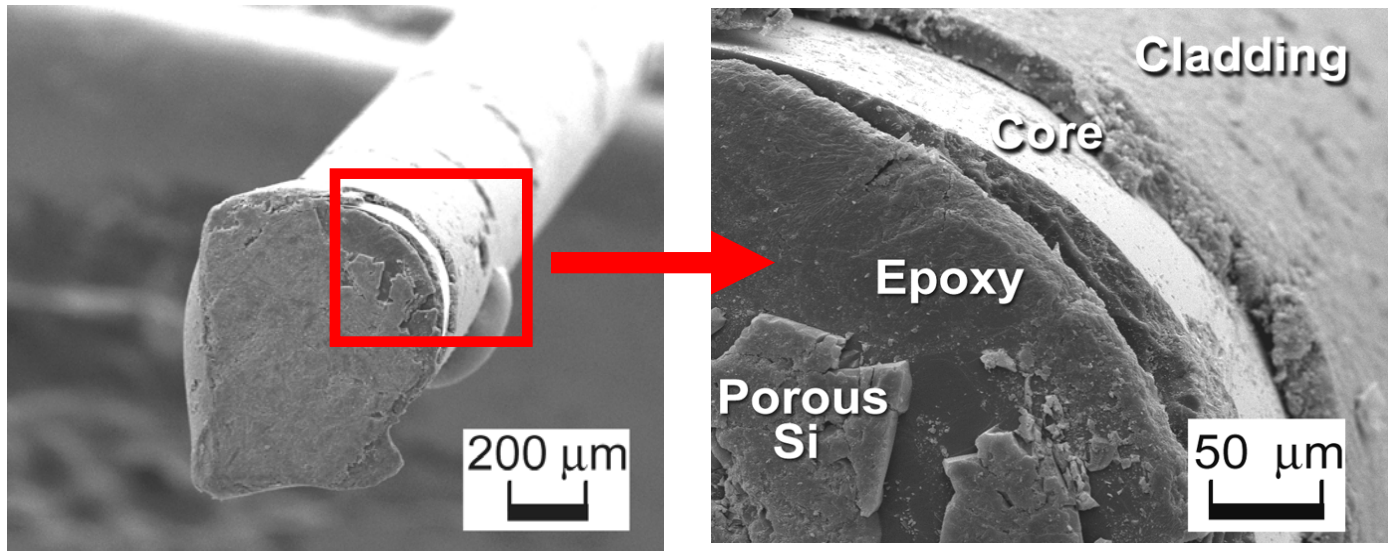


General Sensing Scheme

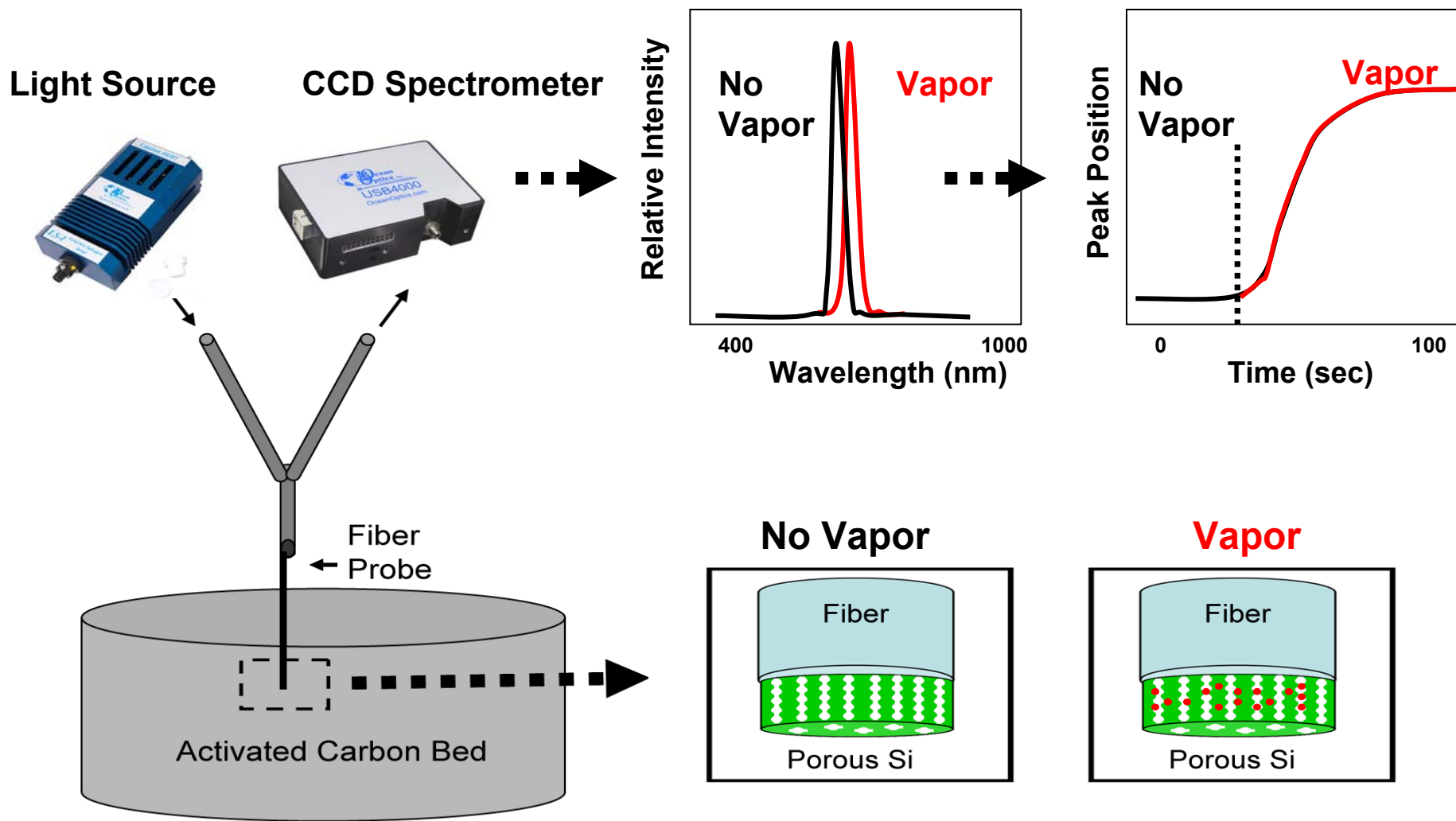


Vapors:
ppm to ppb
sensitivity

Attachment to Optical Fiber



Optical Fiber Sensing Scheme

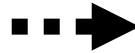


Optical Fiber Sensing Scheme

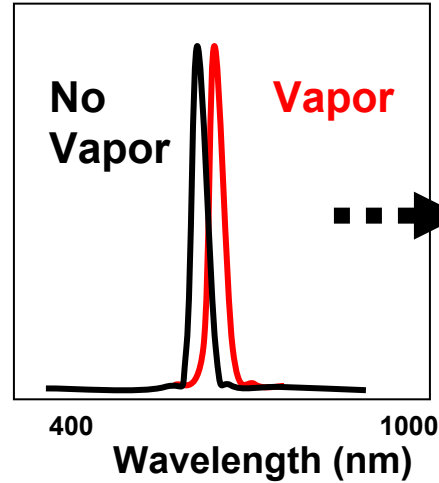
Narrowband LED Source



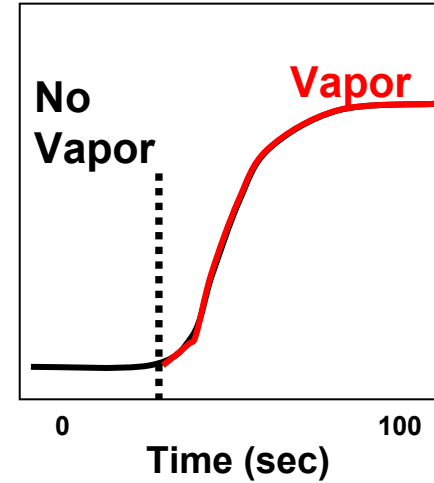
Photodiode Detector



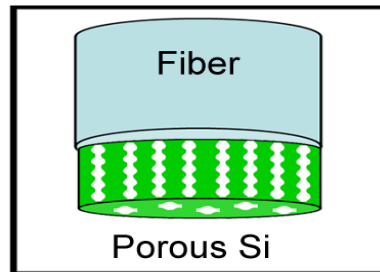
Relative Intensity



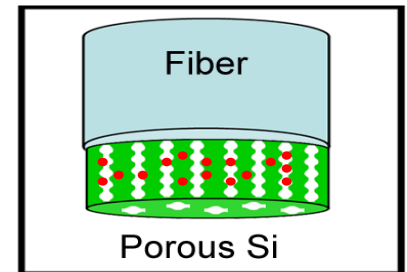
Peak Position



No Vapor



Vapor



Carnegie Mellon Team, Past and Present

- ***MEMS and system:*** Gary Fedder
 - Sarah Bedair, Kristen Dorsey, Nathan Lazarus, Suresh Santhanam, John Wu
- ***Nanoparticles:*** Rongchao Jin
 - Niti Garg
- ***Polymer characterization:*** Tomek Kowalewski
 - Rui Zhang
- ***Sensors:*** David Lambeth
 - Greg Barchard, Bo Li
- ***Polythiophenes:*** Richard McCullough
 - Jessica Cooper, Mihaela Iovu, Genevieve Sauv e
- ***Wireless:*** Jeyanandh Paramesh
- ***Jetting:*** Lee Weiss, Larry Schultz

Collaborators

- **Tony Rozzi, EG&G**
- **Michael Sailor, UCSD**
- **Anne Ruminski, UCSD**
- **Brian King, UCSD**
- **Jay Snyder, NIOSH**

Contributory Programs

- **CDC/NIOSH**
- **USAF Multidisciplinary University Research Initiative**
- **Sensors for a Safer America**
- **University of California Research Funds**



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Thank you