

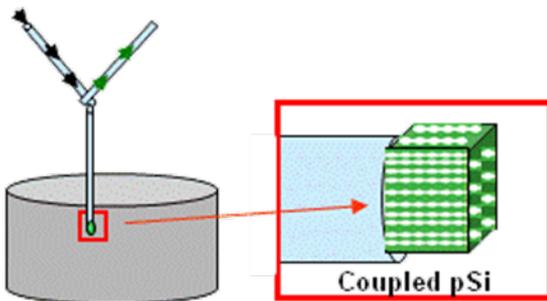
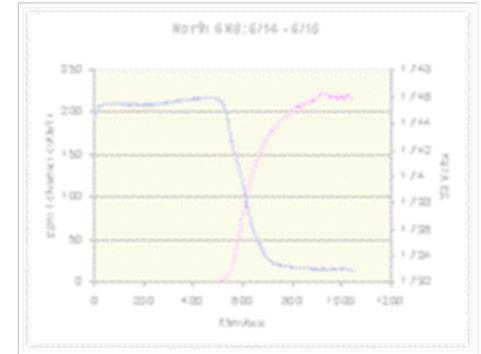
National Personal Protective Technology Laboratory

Sensor Development for ESLI

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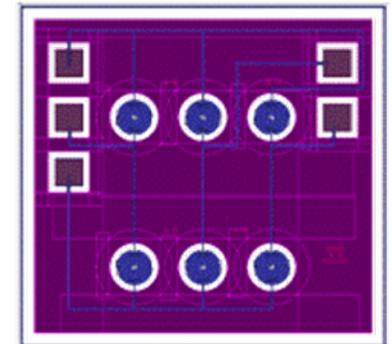
Application to Chemical
Detection

Jay Snyder- NIOSH



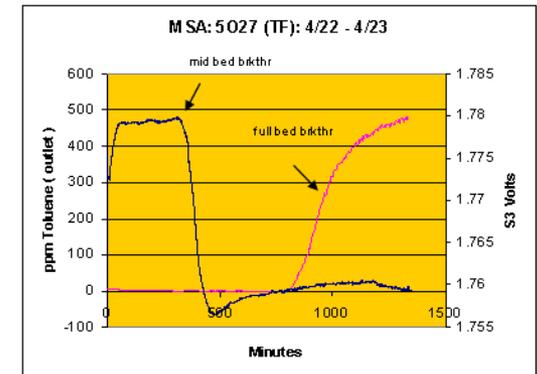
412-386-6775

JSnyder@cdc.gov

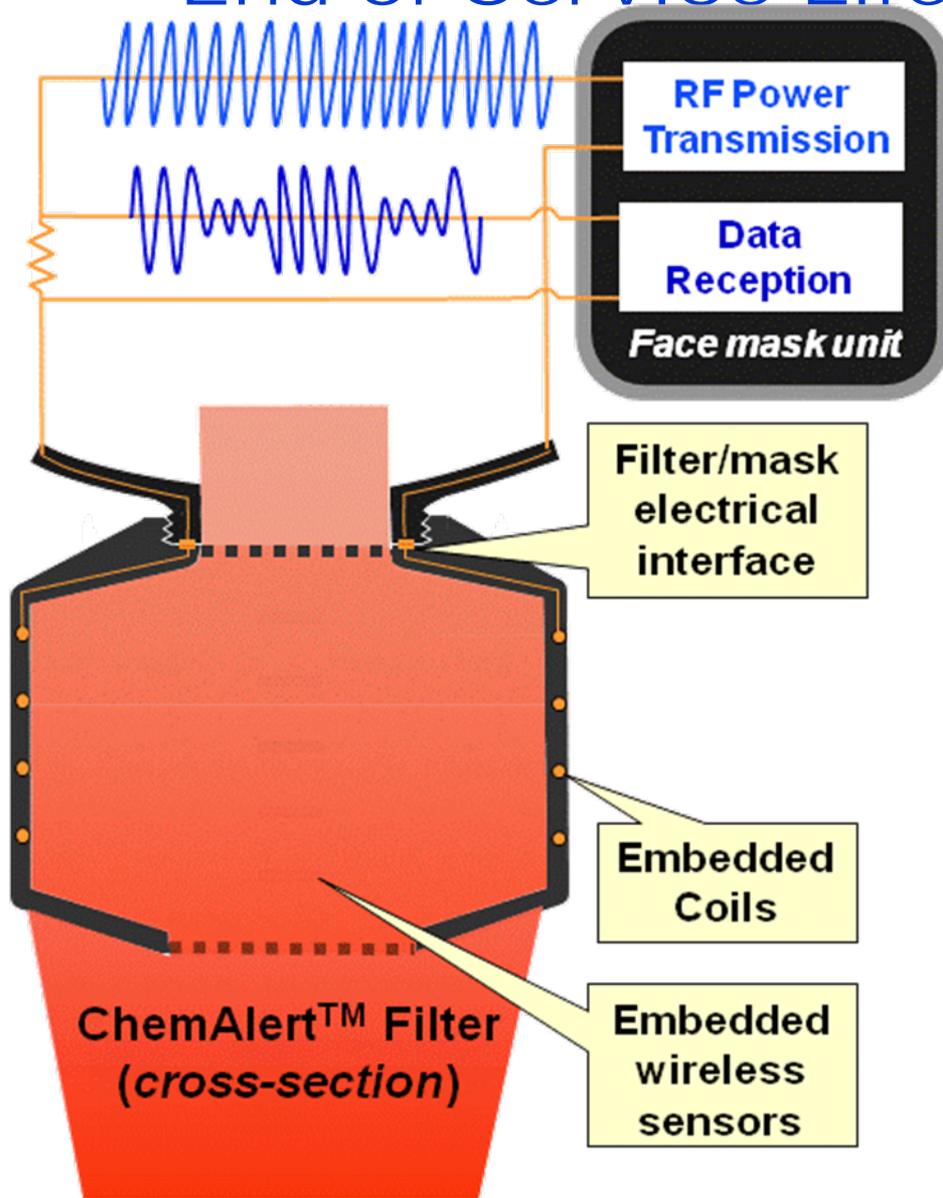


Presentation Outline

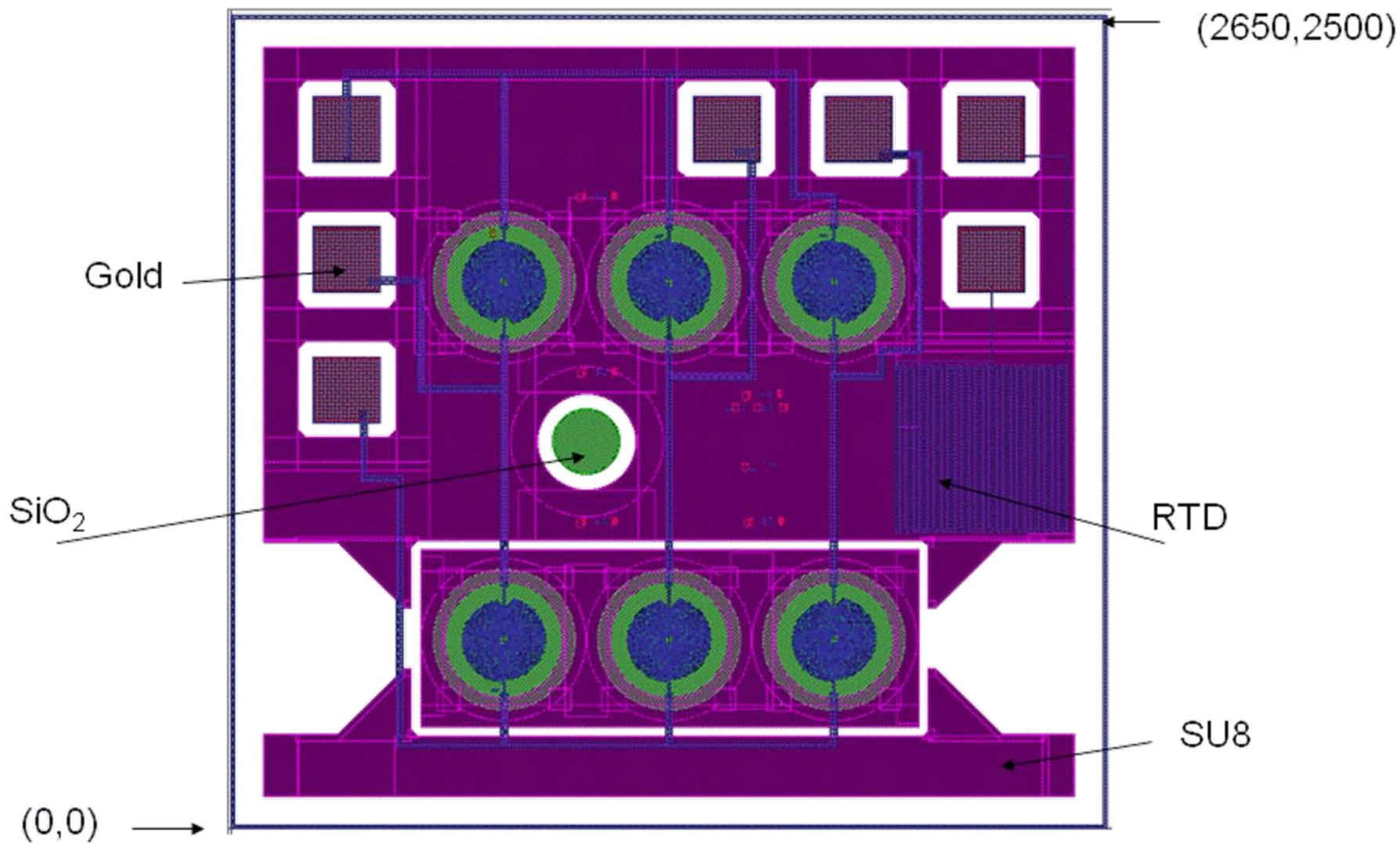
- **Current and Future Electronic System Work**
- **Current and Future Optical System Work**



End-of-Service Life Detection System



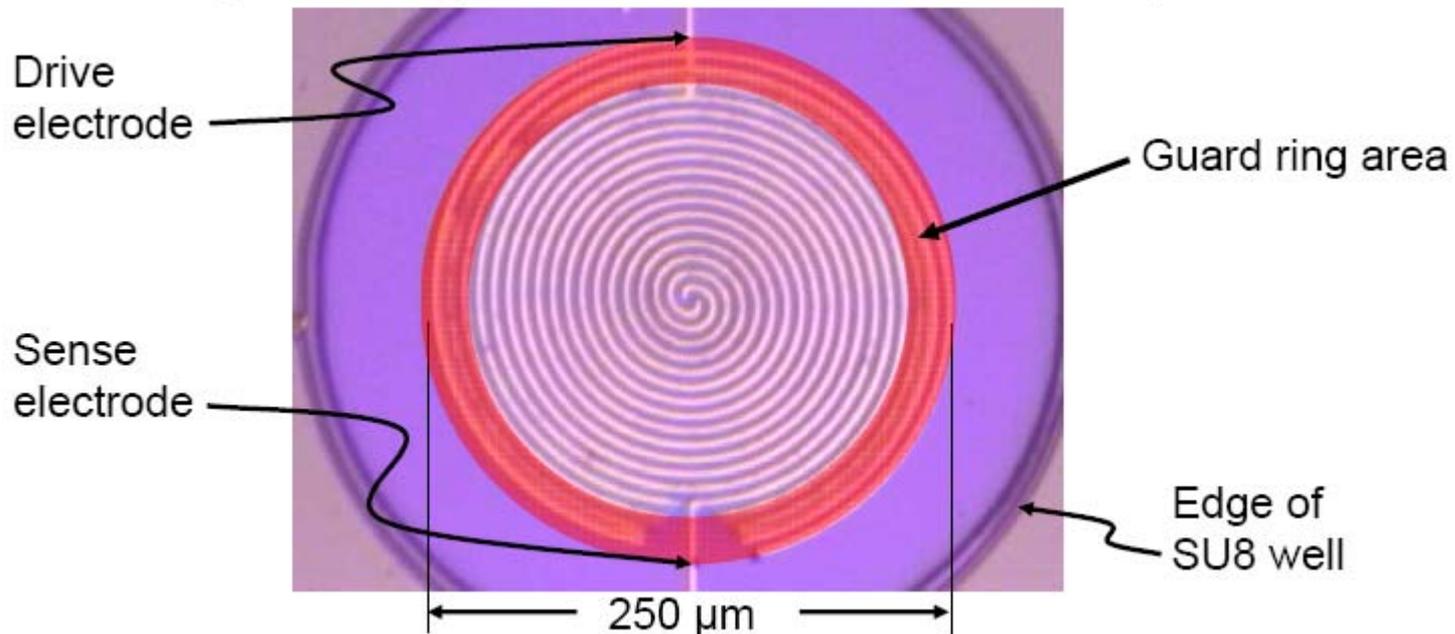
Generation V – Embedded T sensor.



GenV – May 29, 2007, rev July 12, 2007

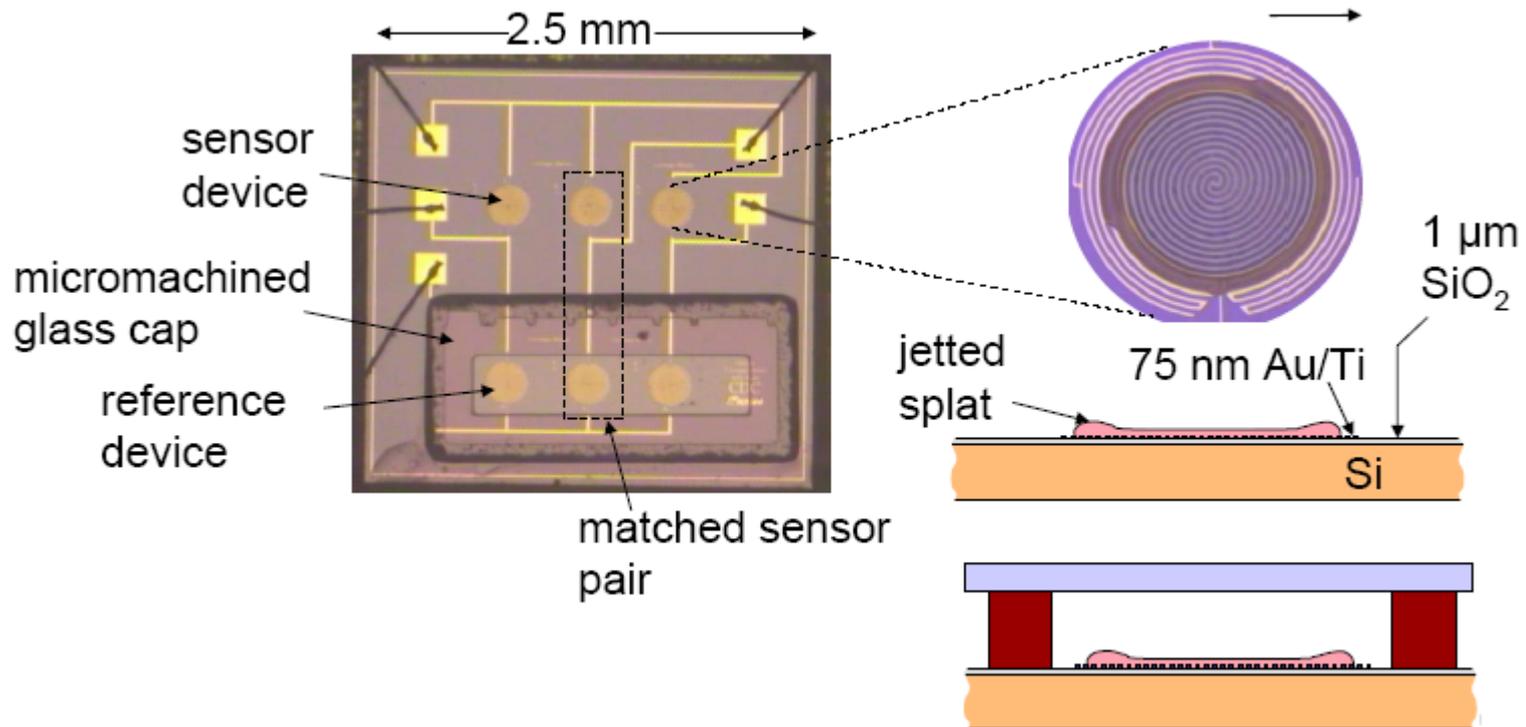
Electrode Design

- **Spiral interdigitated gold electrodes**
 - Symmetric coverage of jetted splat
 - 3 μm -wide traces, 4 μm spacing, 75 nm thick
- **Sized to accommodate 30 to 60 μm diameter nozzles**
- **Outer guard ring to achieve better uniformity**



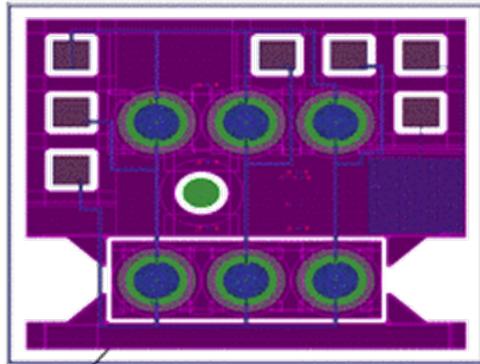
Sensor Circuit Chip

- 3 chemiresistive sensor circuits
- Reference devices capped with glass/SU8 epoxy cap
- Sealed with low outgassing arathane

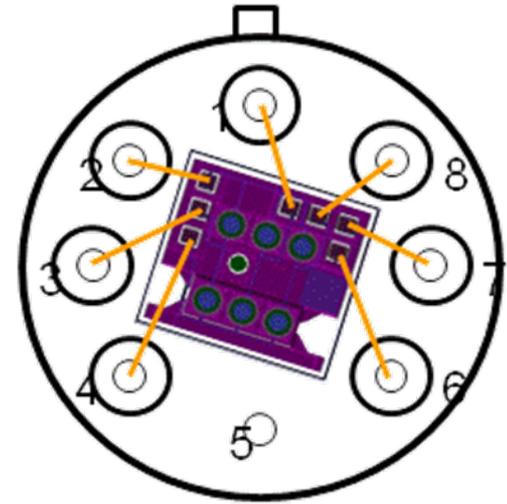


Sensor Assembly

Si chip

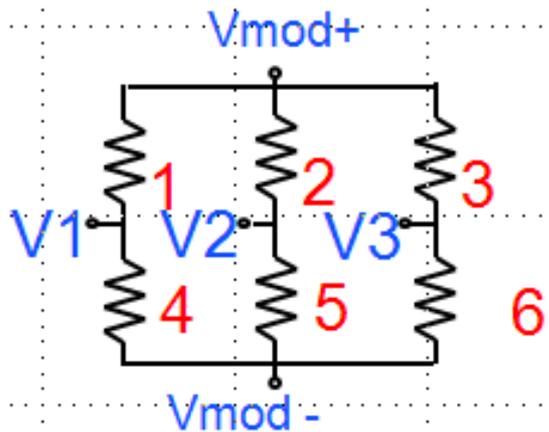


Cover glass



Sensor

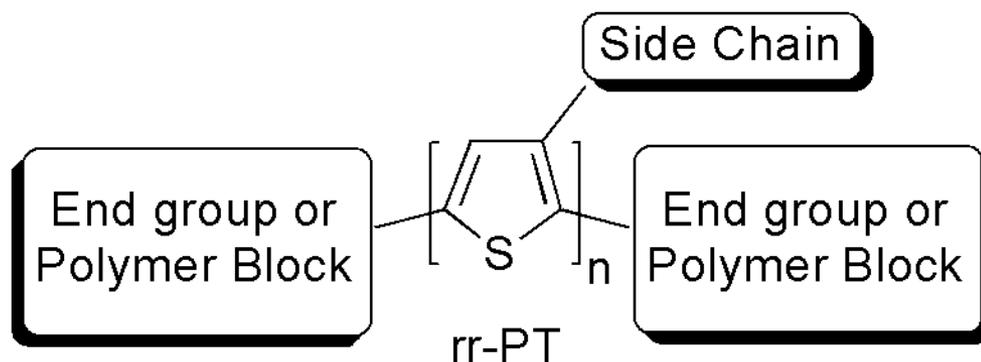
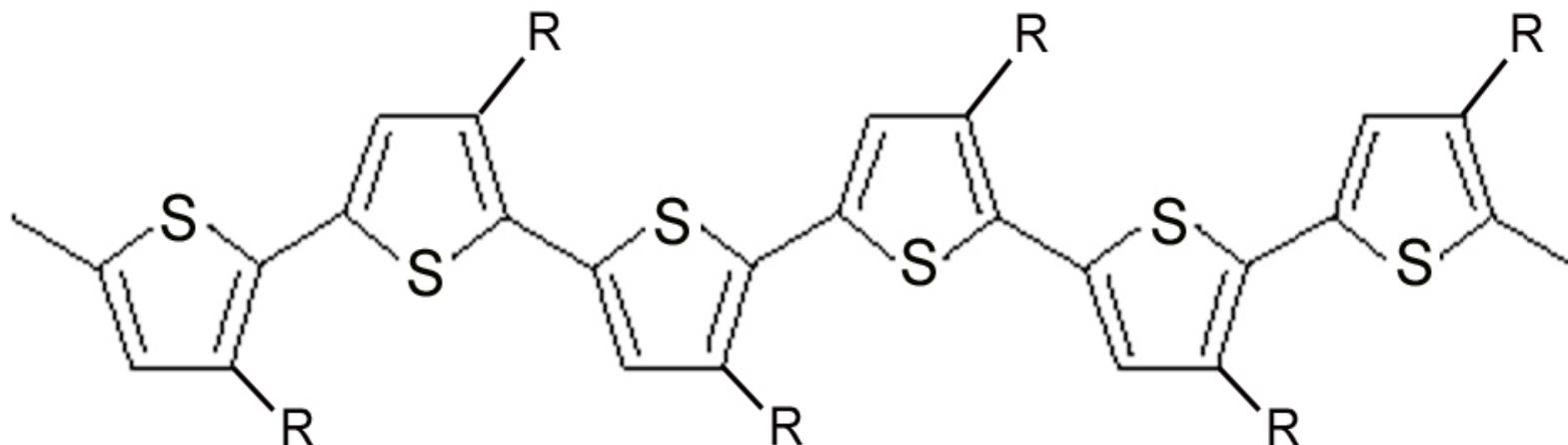
Equivalent circuit



TO-5

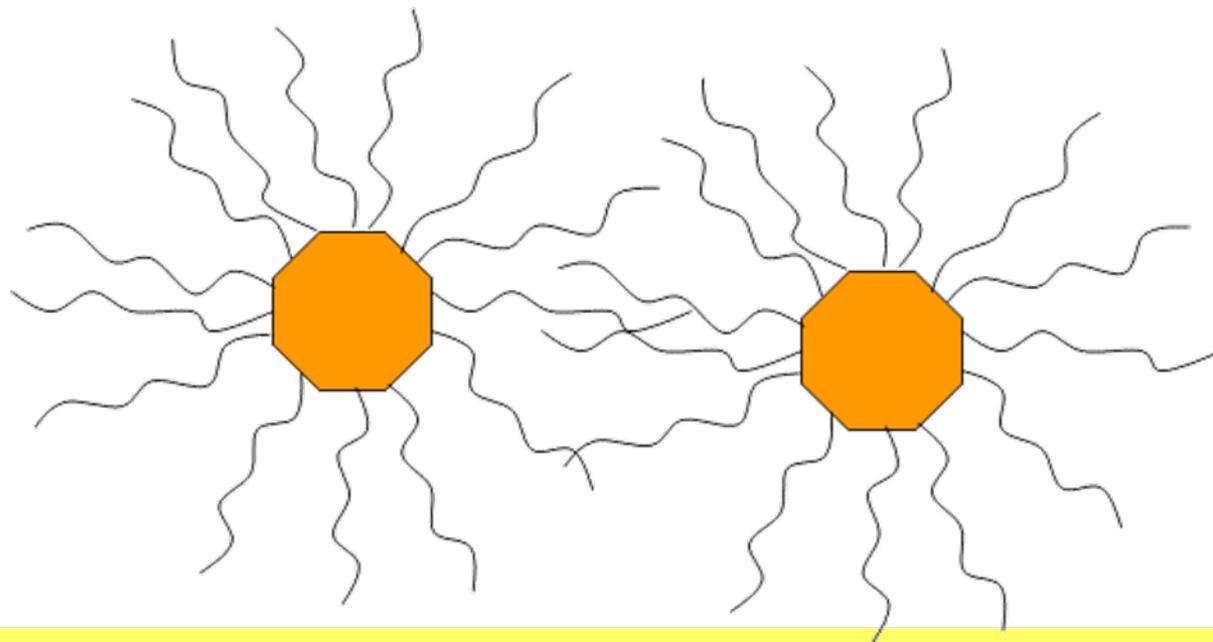


Regioregular poly(alkylthiophene)



What are Au-Monolayer Protected Clusters?

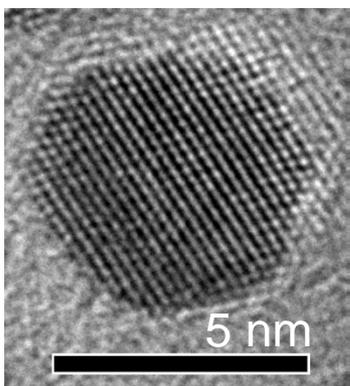
- **Composite material consisting of a cluster of gold atoms surrounded by a single layer of an organic molecule (thiol) bound to the metal through a sulfur atom:**



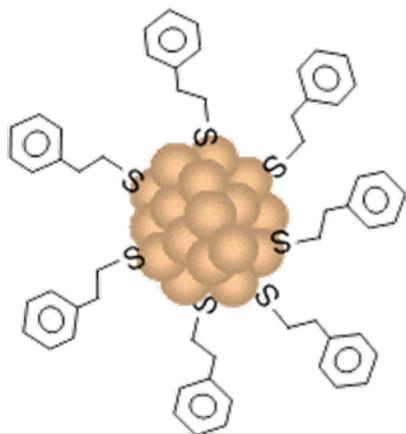
Nanoparticle Terminology

Nanoparticle:

- Solids in a size range of 1-100 nm in diameter (a general term).
- New phenomena not seen in atoms/molecules or bulk will emerge at this scale (**The exact size at which this happens depends both on the **system** and the **property** being considered*).

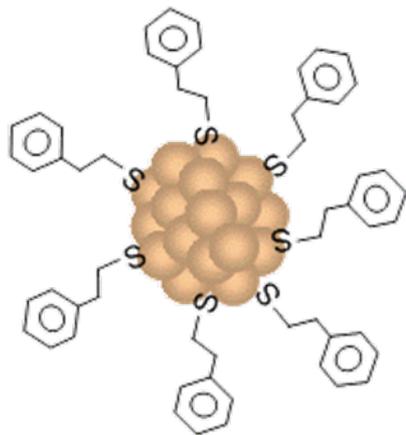


Nanocrystal: single crystalline nanoparticles (typically > 2nm to exhibit crystallinity (i.e. translational symmetry).



Nanocluster or cluster: individual molecular units that have **well-defined** structure (e.g. Au₁₁ and Au₂₅), but are too small to be true crystals, with sizes ranging from subnanometer to ~2 nm). They are closely akin to molecules in terms of transport and other properties.

Gold Nanoclusters for VOC sensing



A New Type of Ultrasmall Gold Nanoparticles:

- These particles have well-defined composition and structure (e.g. Au_n , n =the # of gold atoms);
- Too small to be true crystals (size ranging from subnanometer to 2 nm);
- New physiochemical properties that could benefit VOC sensing.

Synthetic Challenges:

1. How to achieve the ultrasmall size (< 2nm)?

— Ultrasmall size effects electron quantum confinement (semiconducting gold nanoparticles)

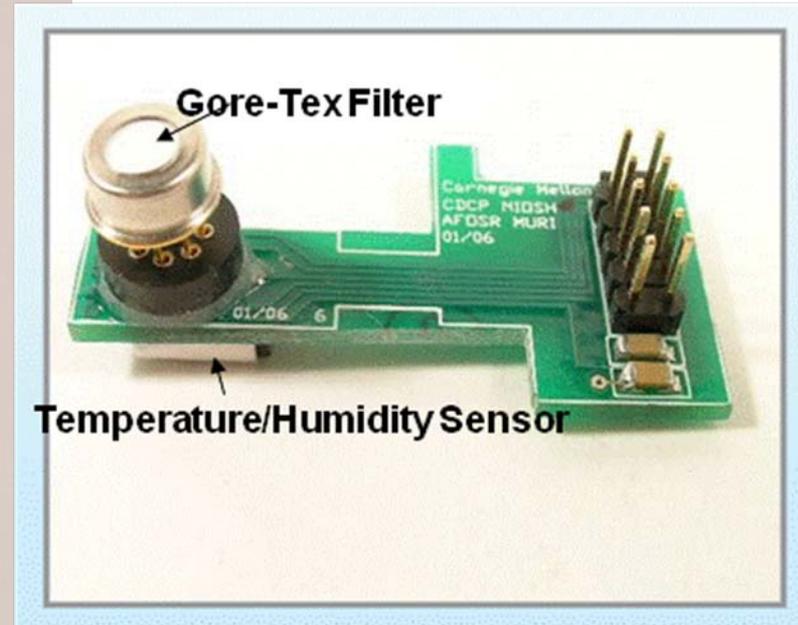
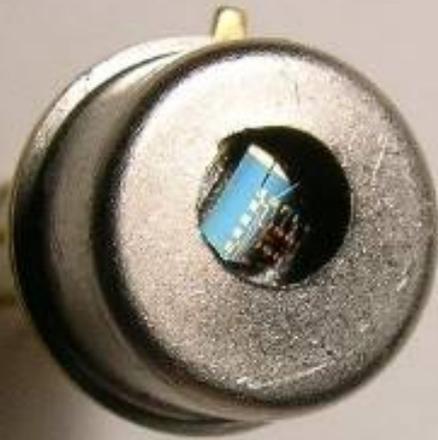
2. How to achieve atomic monodispersity?

— Controlling the # of atoms in a particle via kinetic control (atomically monodisperse: the ultimate)

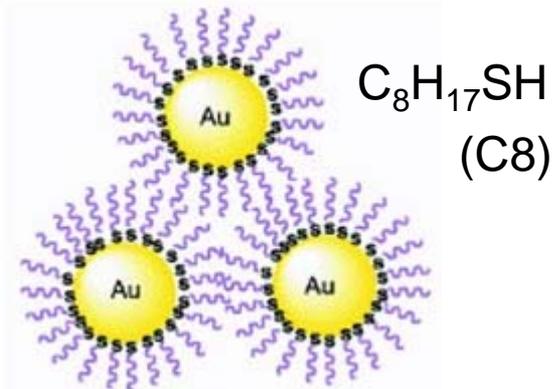
MPC Properties

- **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**

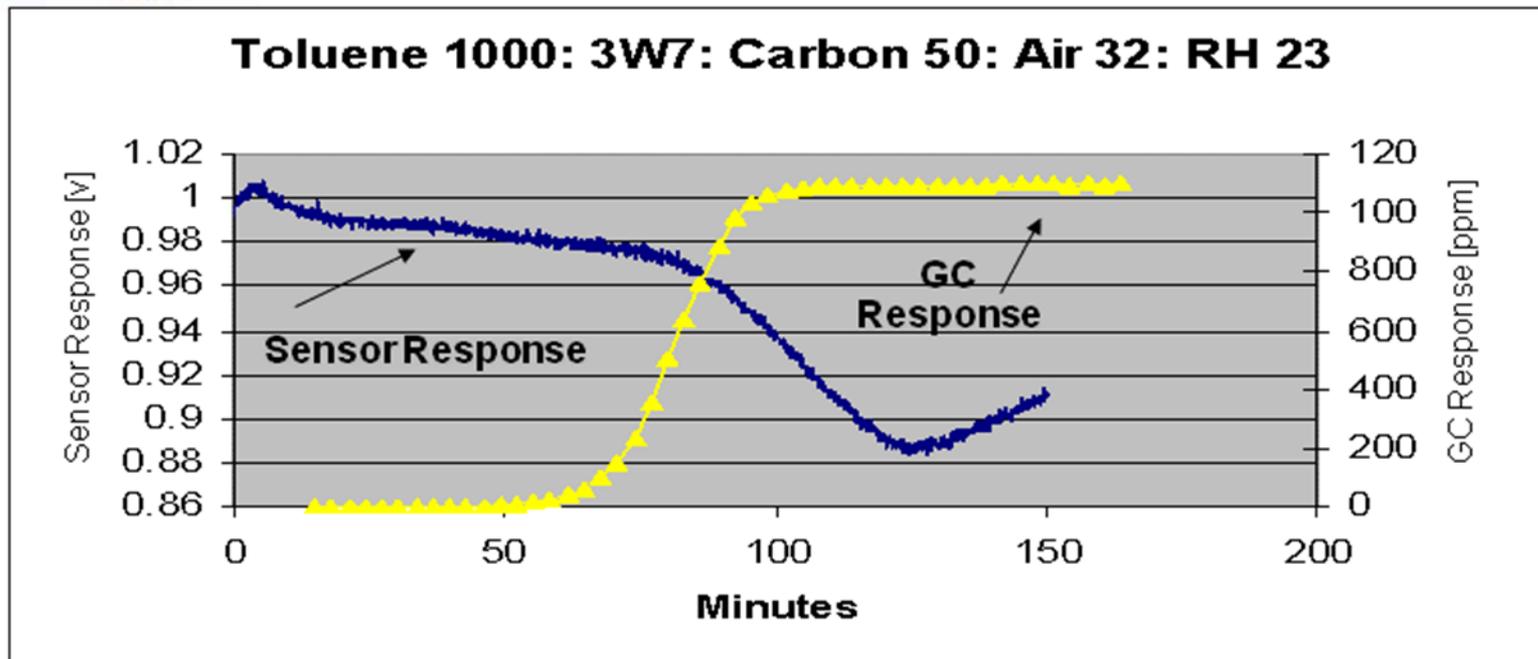
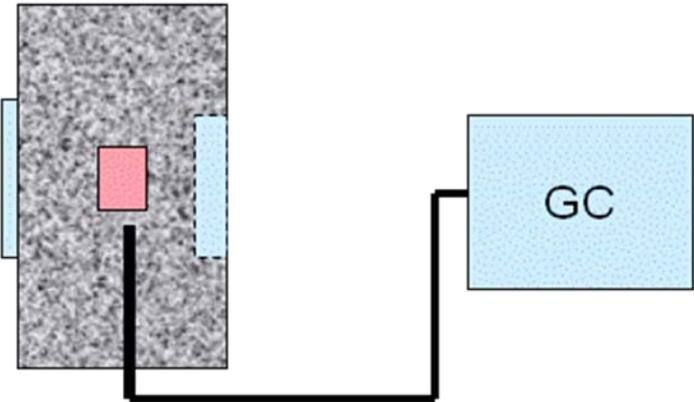
Complete TO-5 Package



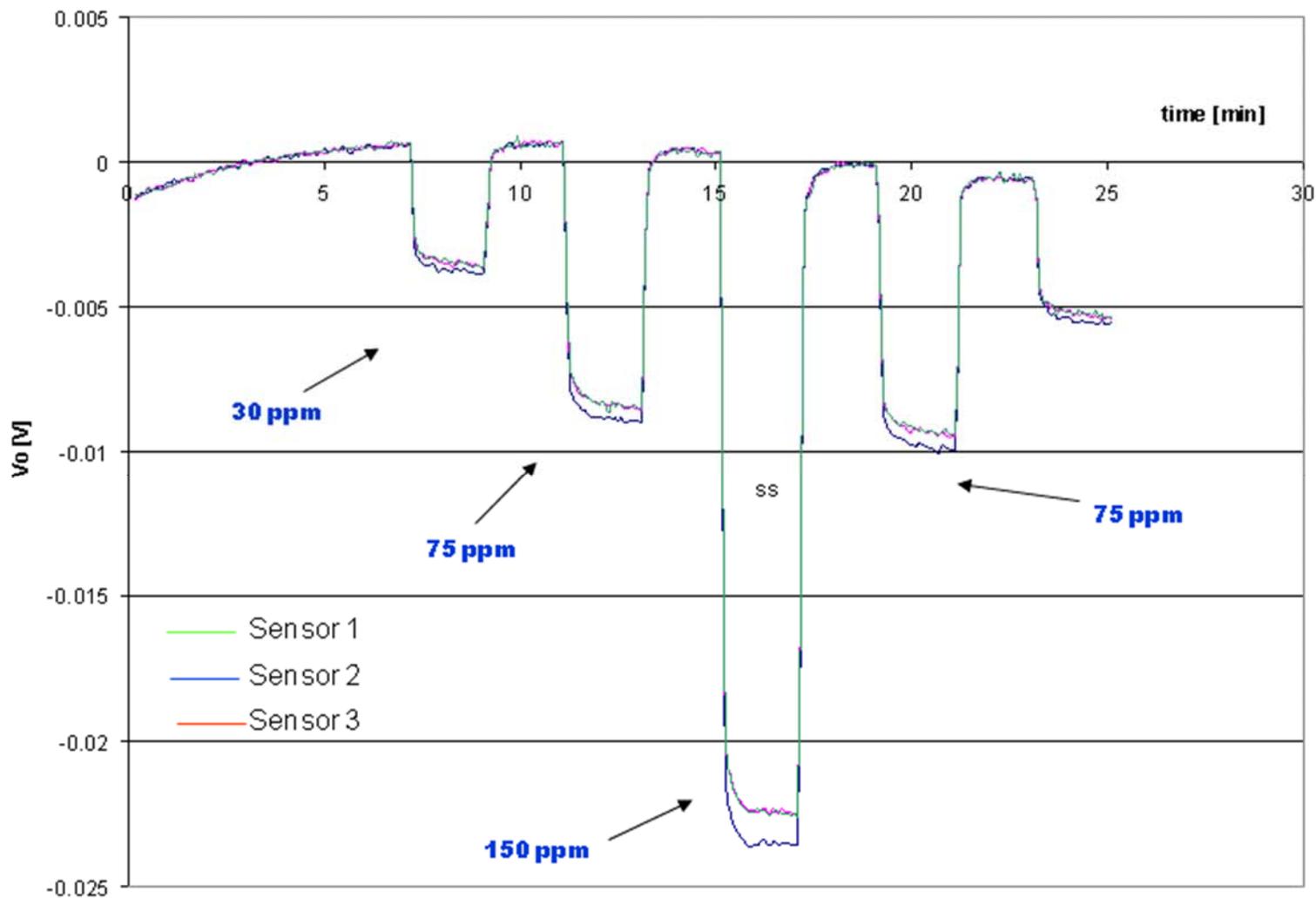
Performance of a MPC



1000 ppm
Toluene



MPC Sensor Response to Toluene in Air



**3F7NRL-
C8
Sensor**

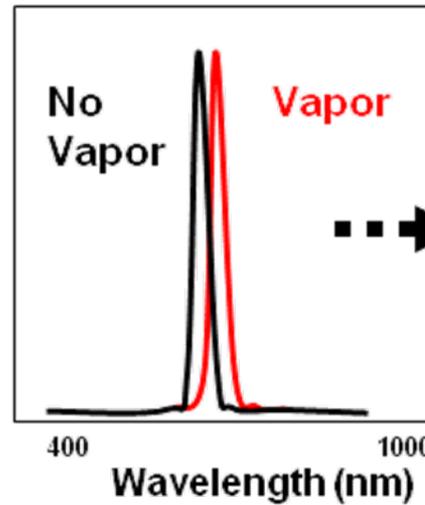
Optical Fiber Sensing Scheme

Light Source

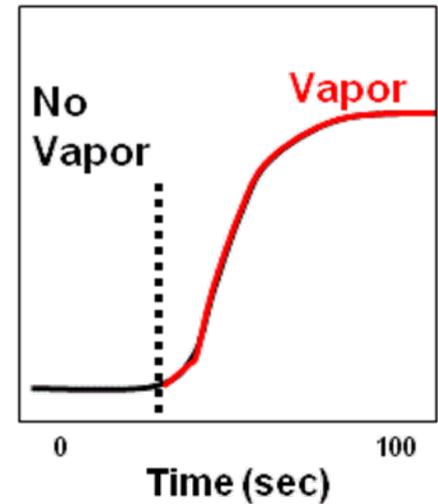
CCD Spectrometer



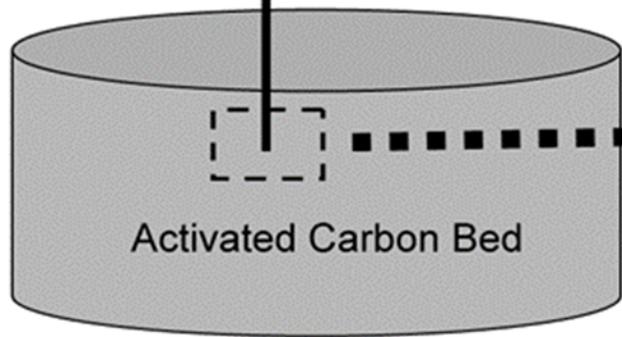
Relative Intensity



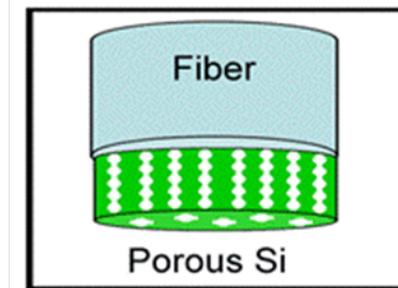
Peak Position



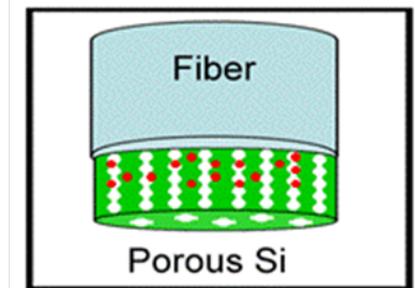
Fiber Probe



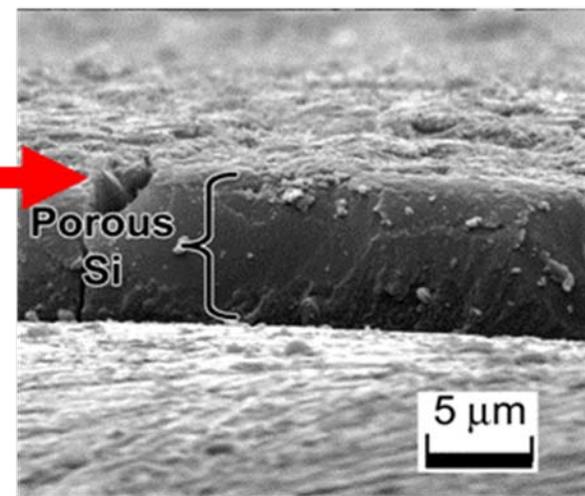
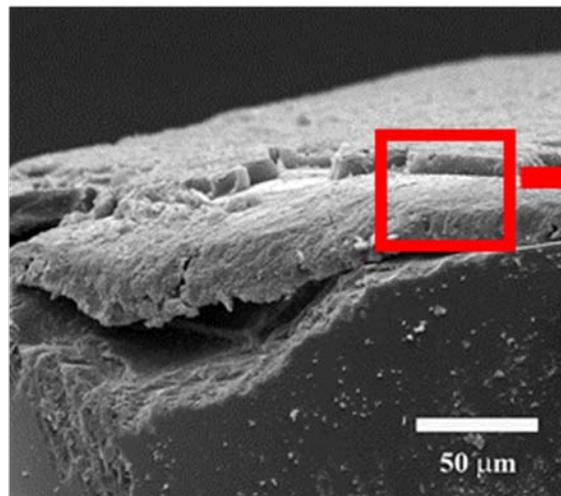
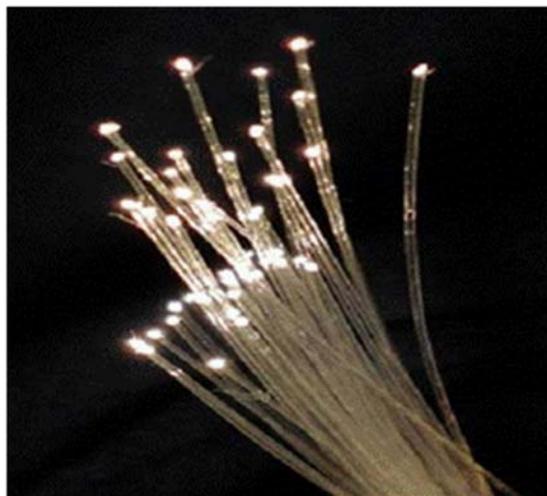
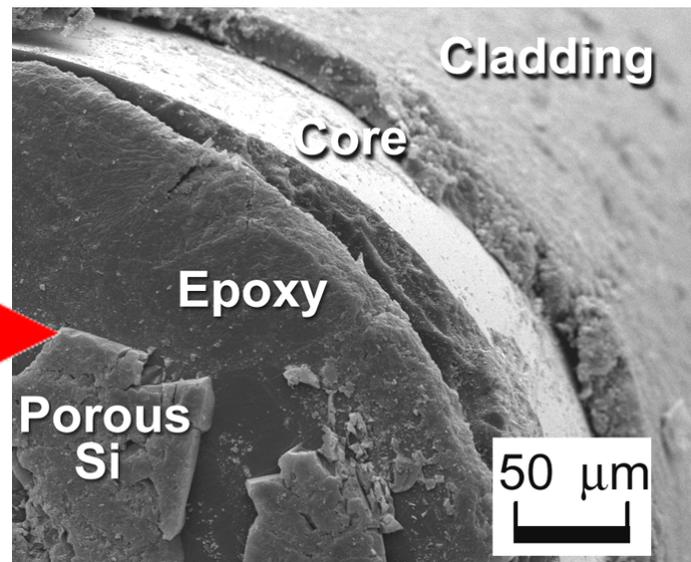
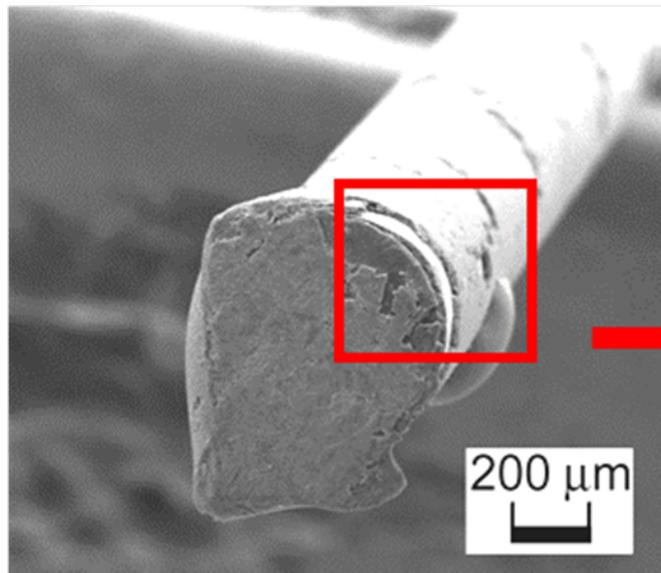
No Vapor



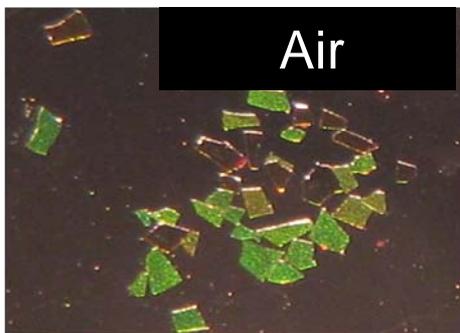
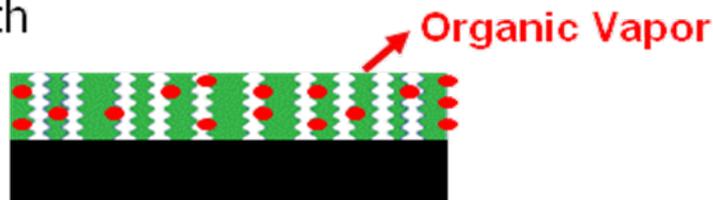
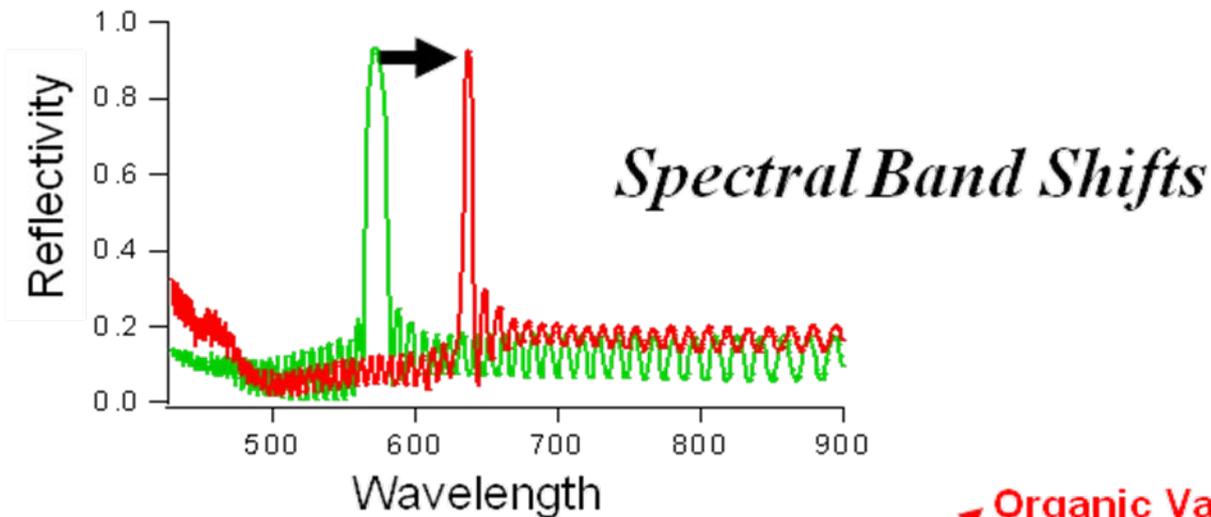
Vapor



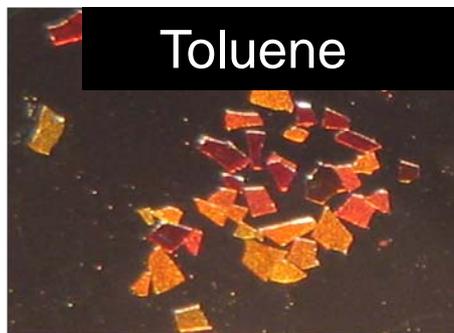
Attachment to Optical Fiber



General Sensing Scheme



Air



Toluene

Vapors:
ppm to ppb
sensitivity

Conclusions

- **NIOSH and its partners have made great progress toward ESLI for organic vapor respirator cartridges.**
- **Prototype electronic sensor systems have been inserted into commercially available cartridges.**
- **Optical based ESLI systems have completed proof of concept testing.**

Summary

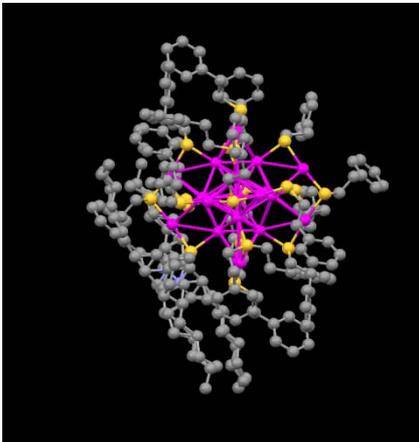
- **Many ESLI design parameters still need to be optimization and continued development is underway.**
- **Application to commercial chemical detection is possible.**

Disclaimer

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Disclaimer:

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Thank you

