Highly Selective Nano-MEMS Low Temperature Sensor

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AMPAC, Mechanical Materials Aerospace Eng (MMAE)
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Start Date = 2002, Planned Completion = 2006

Research Goals and Objectives

- Detecting H_2 at Room Temperature with High Sensitivity (S=100-1000). √
- Detecting H_2 with High Selectivity Over Other Gases such as CO, CO_2, NH_3, H_2S. √
- Detecting H_2 at Room Temperature in He Atmosphere. √
- Detecting H_2 at Room Temperature with Reduced Response and Recovery Time (< 60 sec).
- Detecting H_2 Under the Atmospheric Conditions Existing on the Moon/Mars Surface.
- Providing NASA a Prototype H_2 Sensor Device.

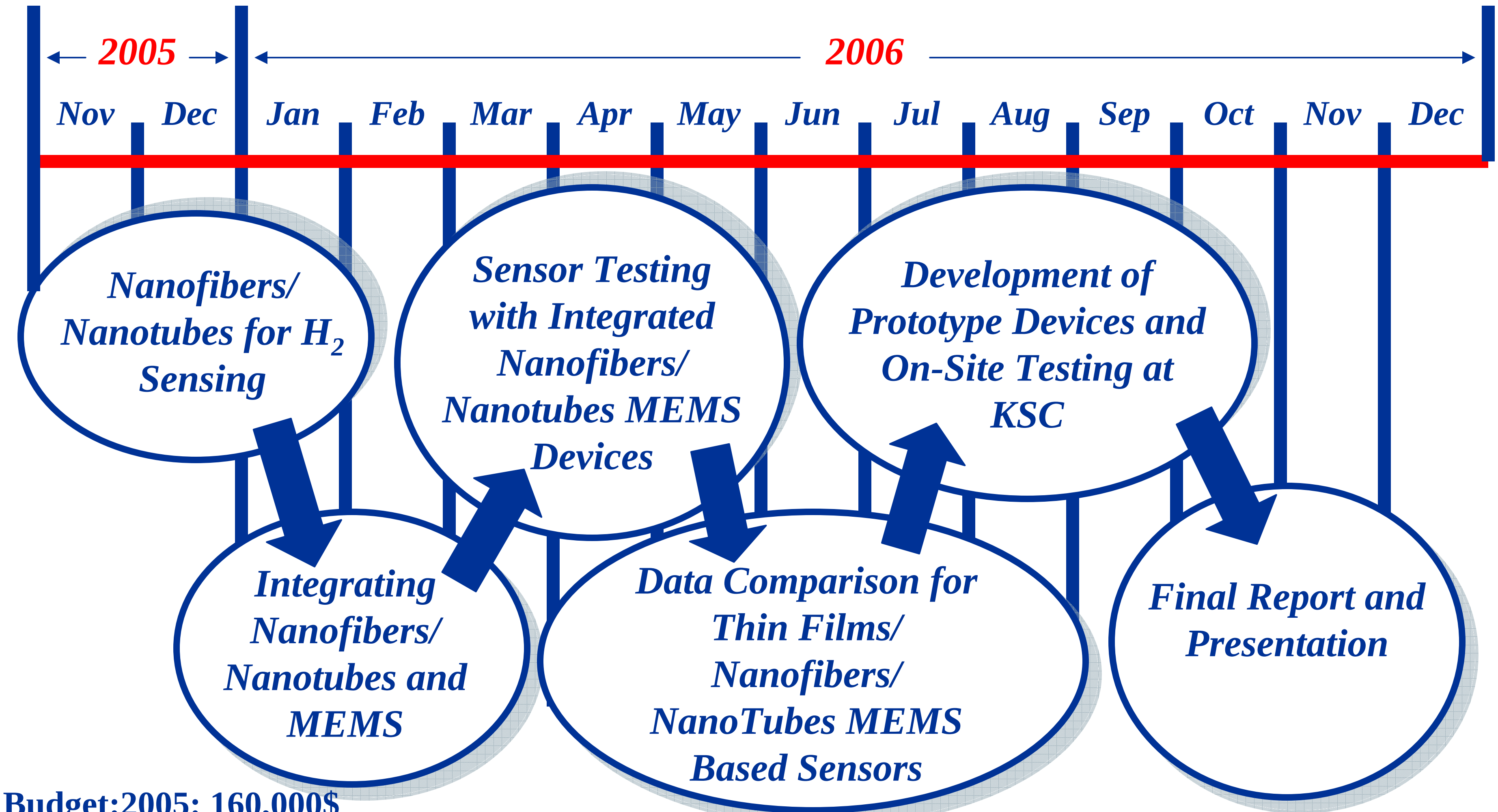
Relevance to Current State-of-the-Art

- Development of Novel Nanostructures (Thin Films/Porous Fibrous Network/Nanotubes) for H_2 Sensing Application Using Different Innovative Processing Techniques.
- Improved H_2 Sensitivity and Detection Time at Room Temperature.
- Development of Miniaturized Prototype H_2 Sensor, Working Under Normal Atmospheric Conditions, Using the MEMS Fabrication and Nano Technologies.

Relevance to NASA

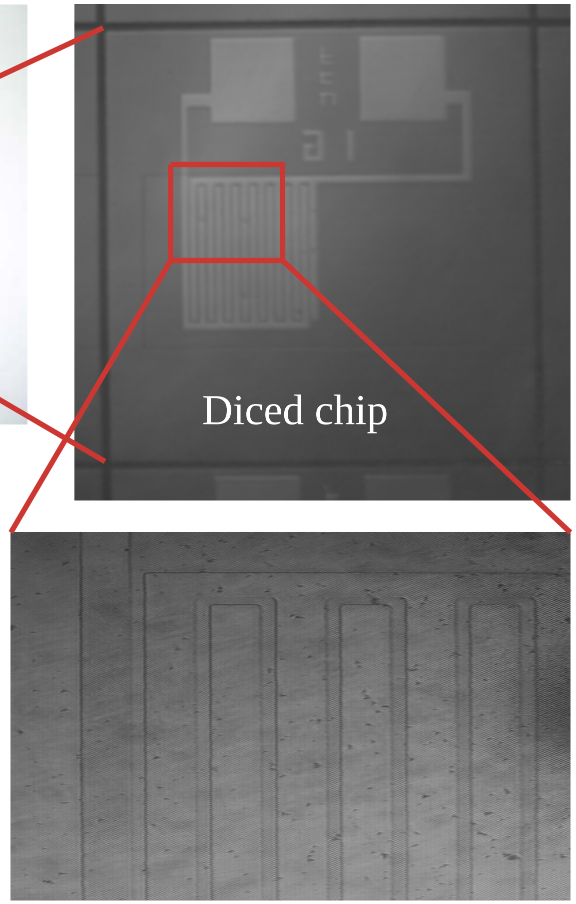
- Room Temperature, Fast Operating, Highly Sensitive and Selective, Self-Cleaning, Robust and Cheaper H_2 Detector.
- Suitable for H_2 Leak Detection in Transportation Vehicles, Storage Devices, and Pipelines Utilized during the Shuttle Launch Program.
- Useful to Sense H_2 Under Different Planetary Conditions.

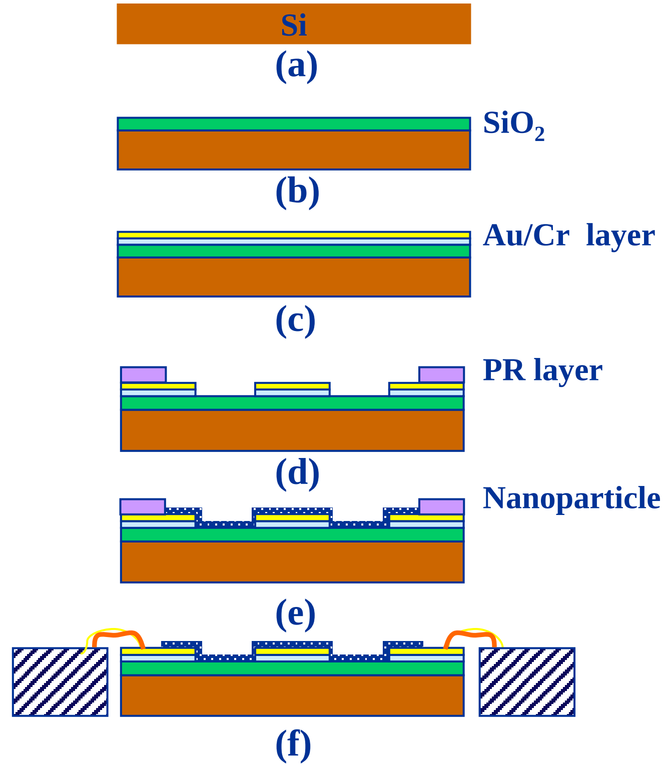
Budget, Schedule and Deliverables



Budget:2005: 160,000$

Anticipated Technology

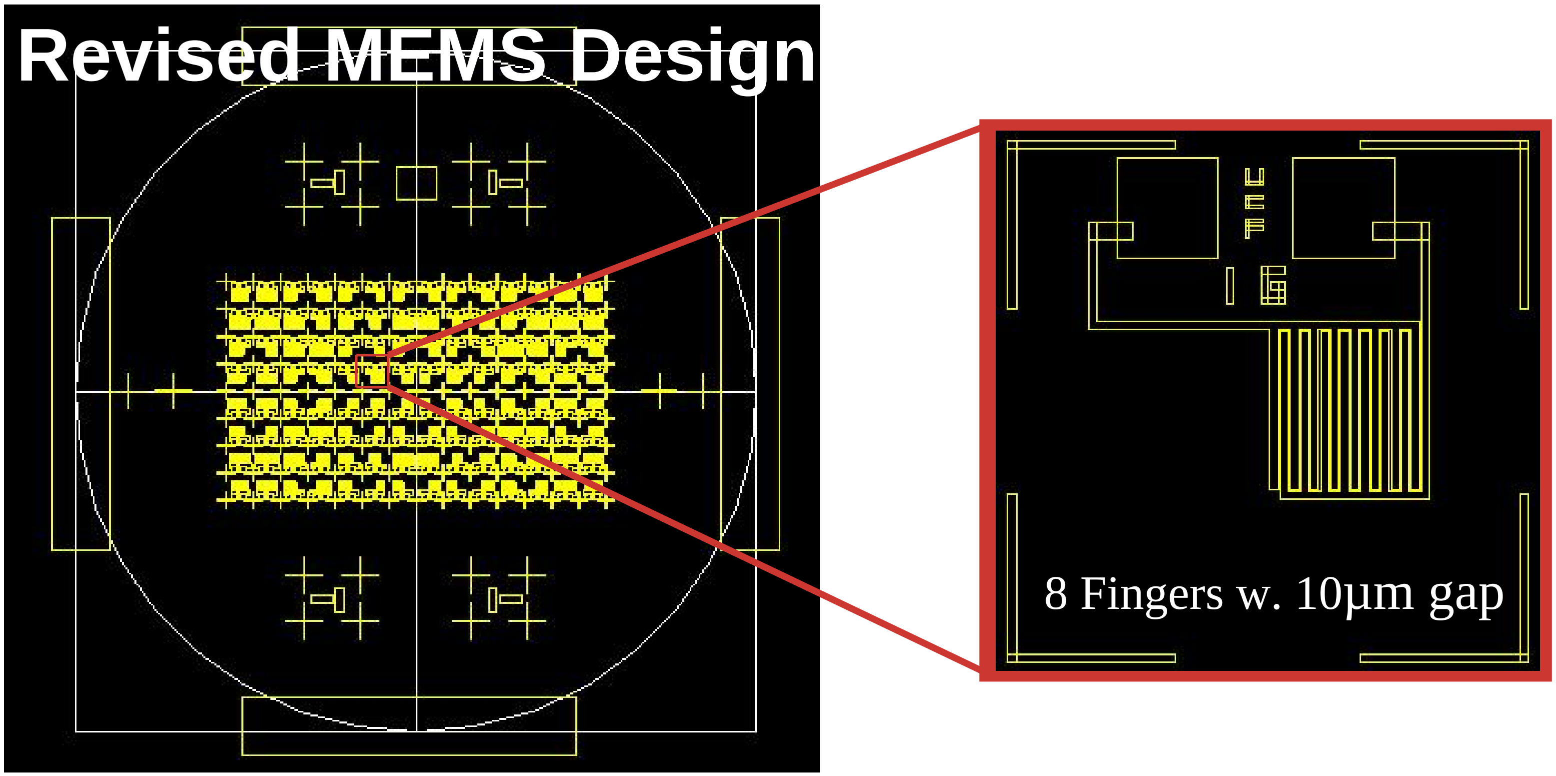




Fabrication steps:

(a) cleaning;
(b) thermal oxidation;
(c) metallic film deposition;
(d) photolithography and chemical etching;
(e) sol-gel dip coating and lift off
(f) packaging

Anticipated Technology

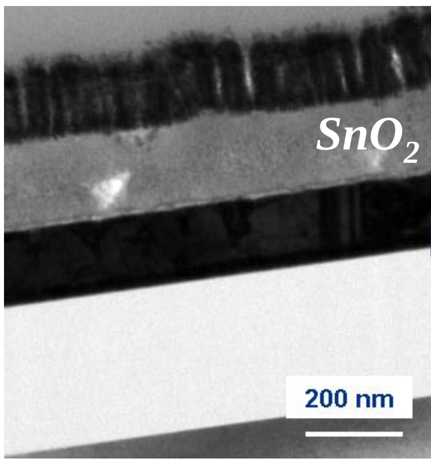


Sensors Electrode Parameters:

- **Number of Interdigitated Fingers: 8-20**
- **Electrode Spacing: 10-50µm**

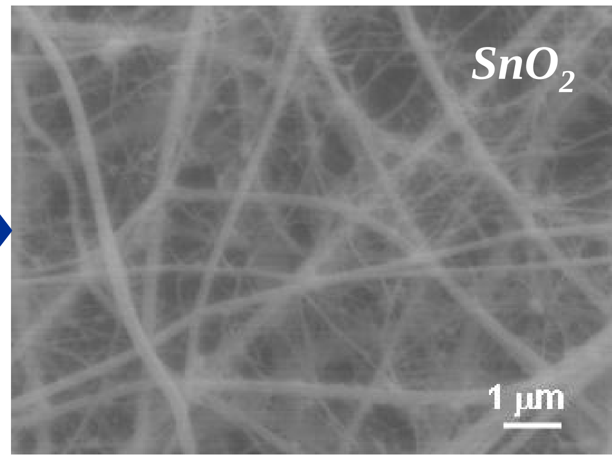
Our Trend In Morphological Change for Enhancing Sensor Performance

Thin Film



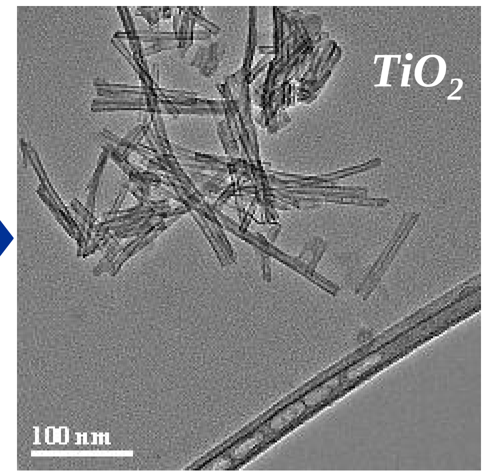
Sol-Gel

Nano/Submicron Fibrous Network

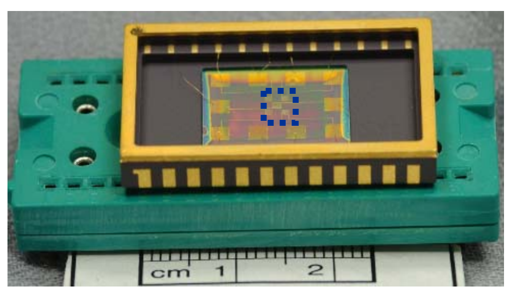


Electrospinning

Nanotubes

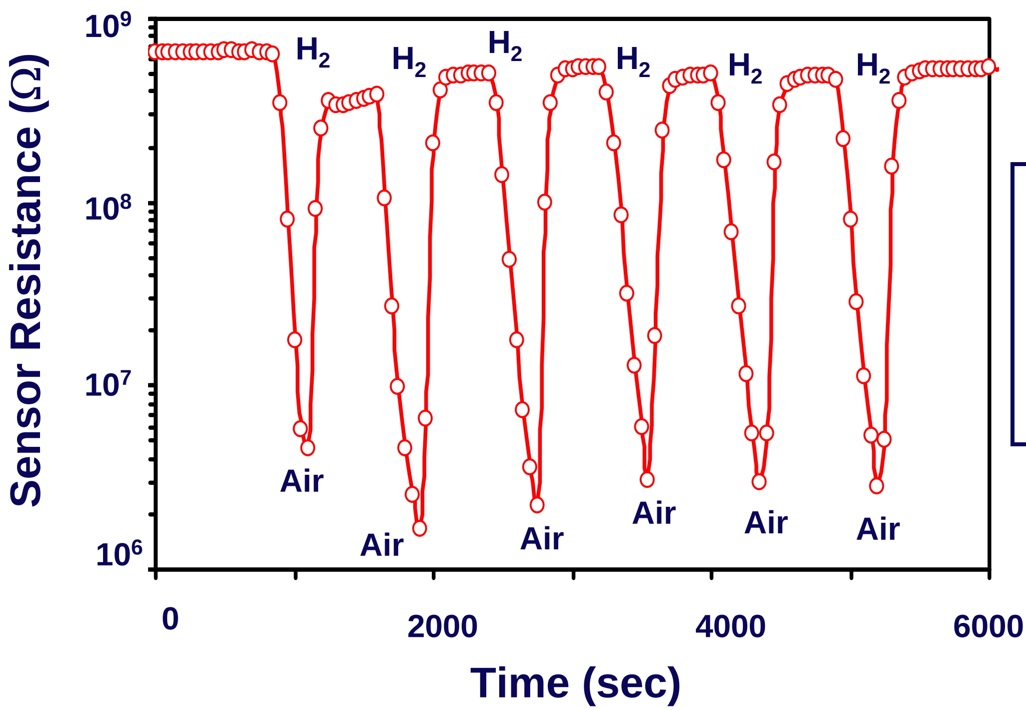


Hydrothermal



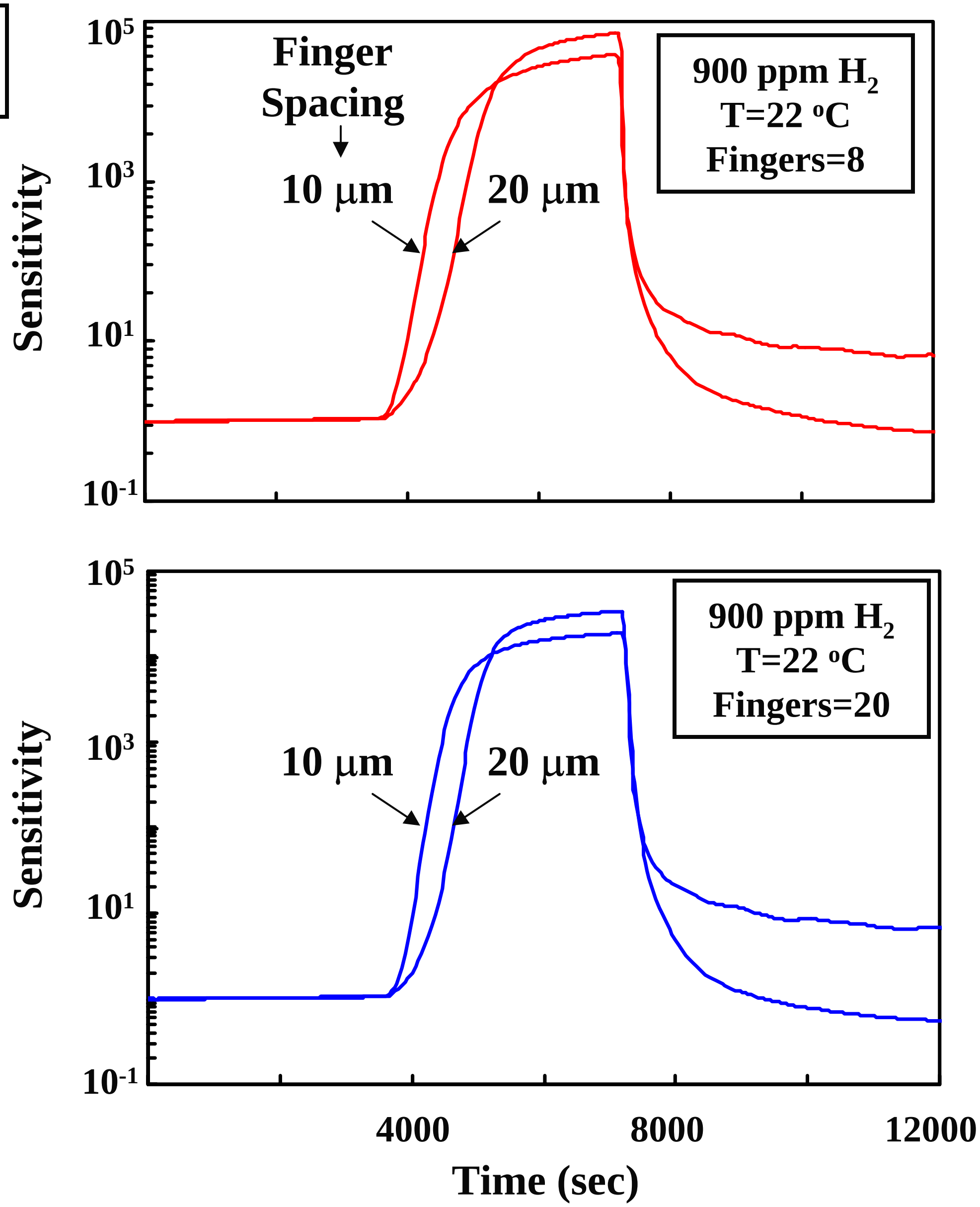
Accomplishments and New Results

Fast Room Temperature Sensor Response



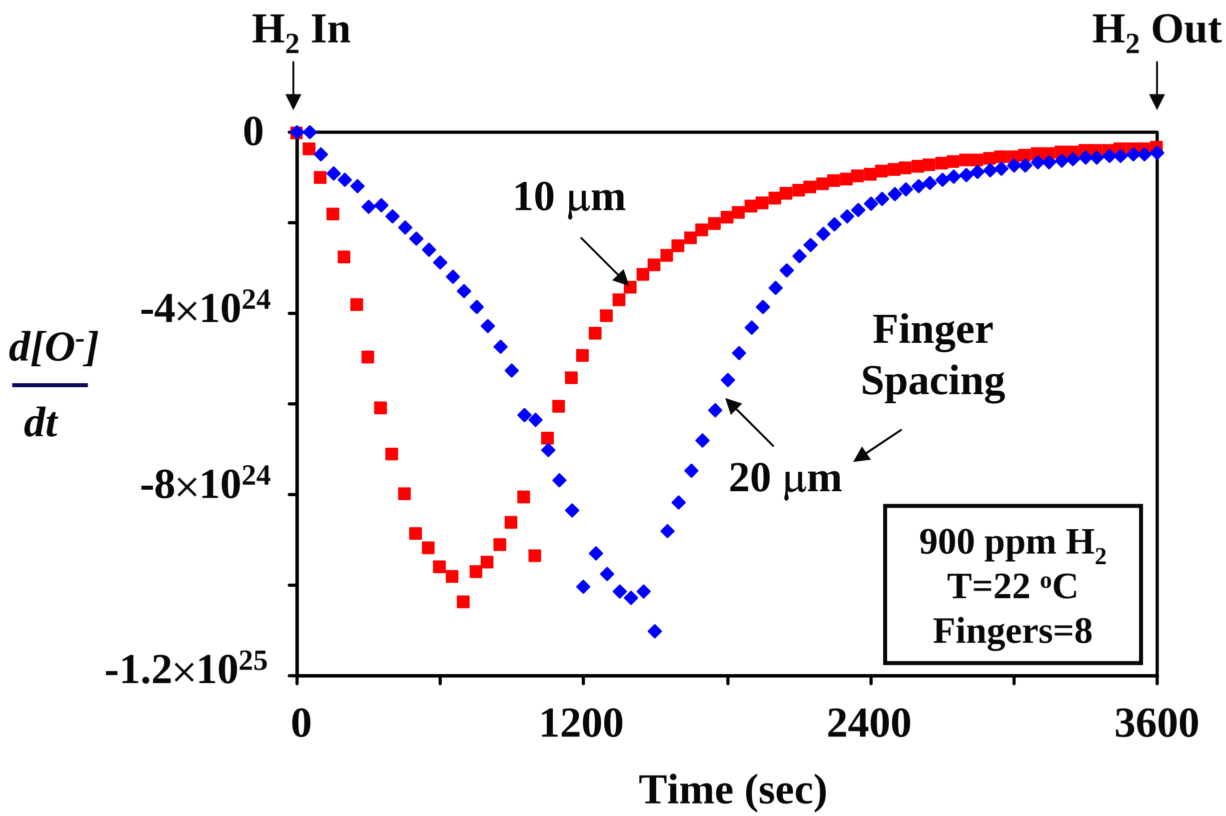
900 ppm H_2
T=22ºC
P=50 Torr
Fingers=4
Spacing=20 μm

Accomplishments and New Results



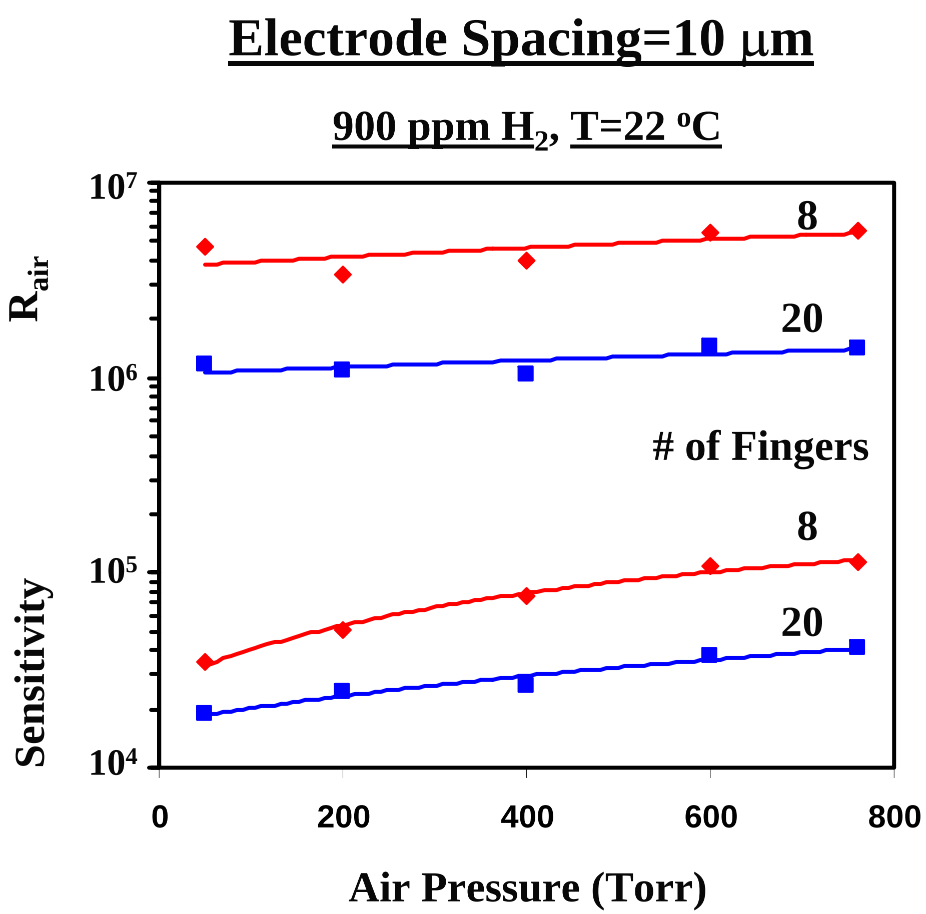
Accomplishments and New Results

Calculated Rate of Change in Surface Oxygen Concentration in H_2



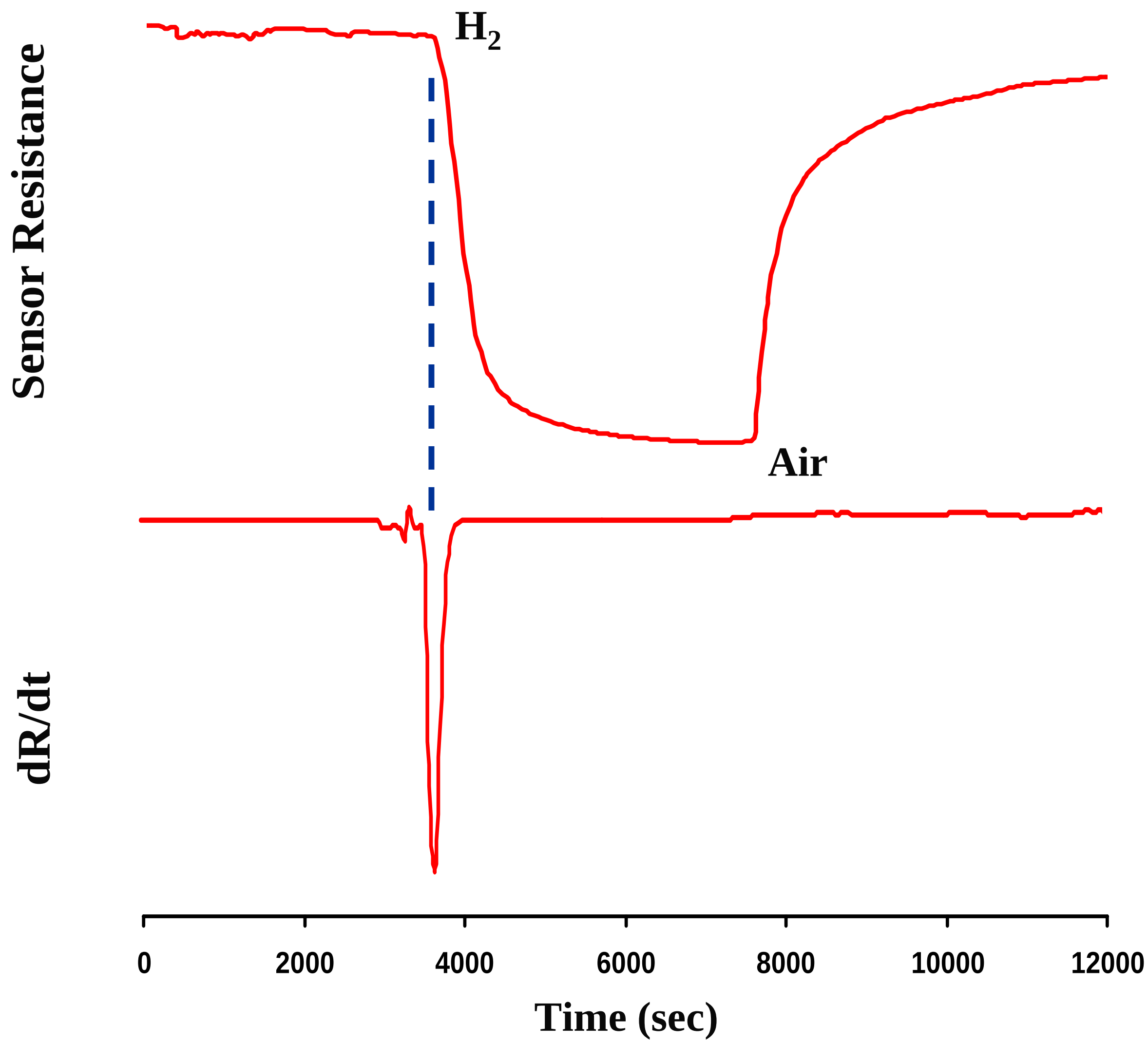
Accomplishments and New Results

H_2 Sensitivity: Number of Fingers as Variable



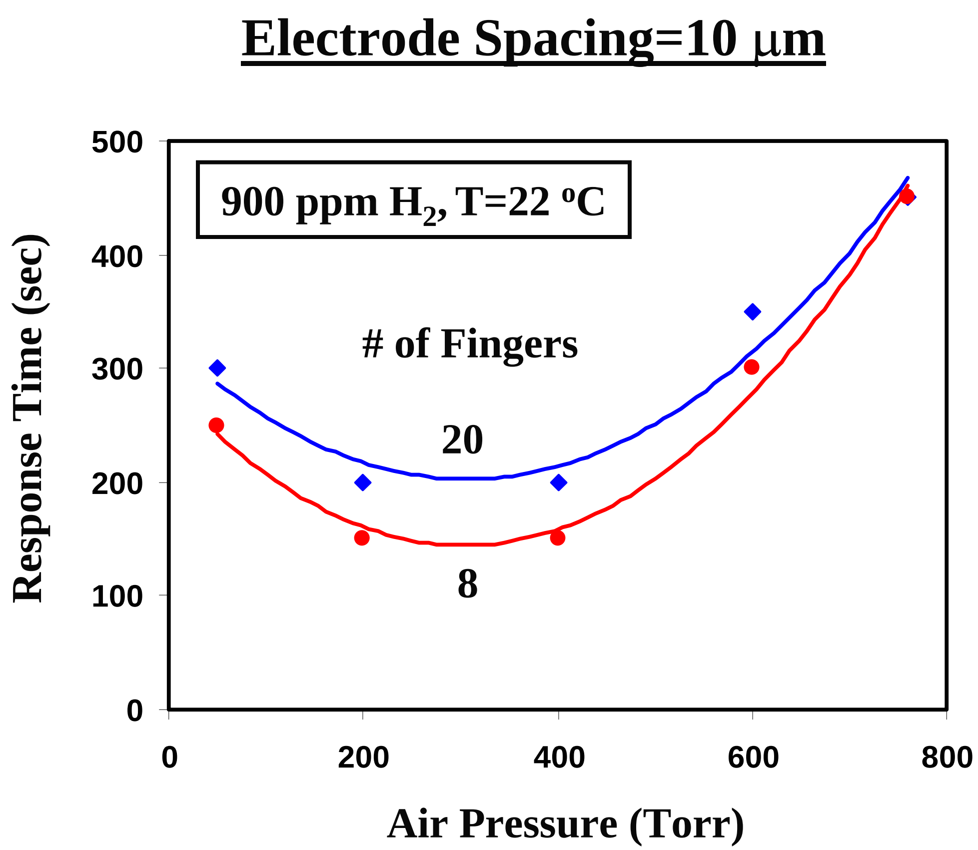
Accomplishments and New Results

Data Processing for Reducing Response Time



Accomplishments and New Results

Response Time: Number of Fingers as Variable



Various methods: 65% of S_{max}, Tangent method, S(10), dR/dT for determining Response time

Accomplishments and New Results

FTIR Facility

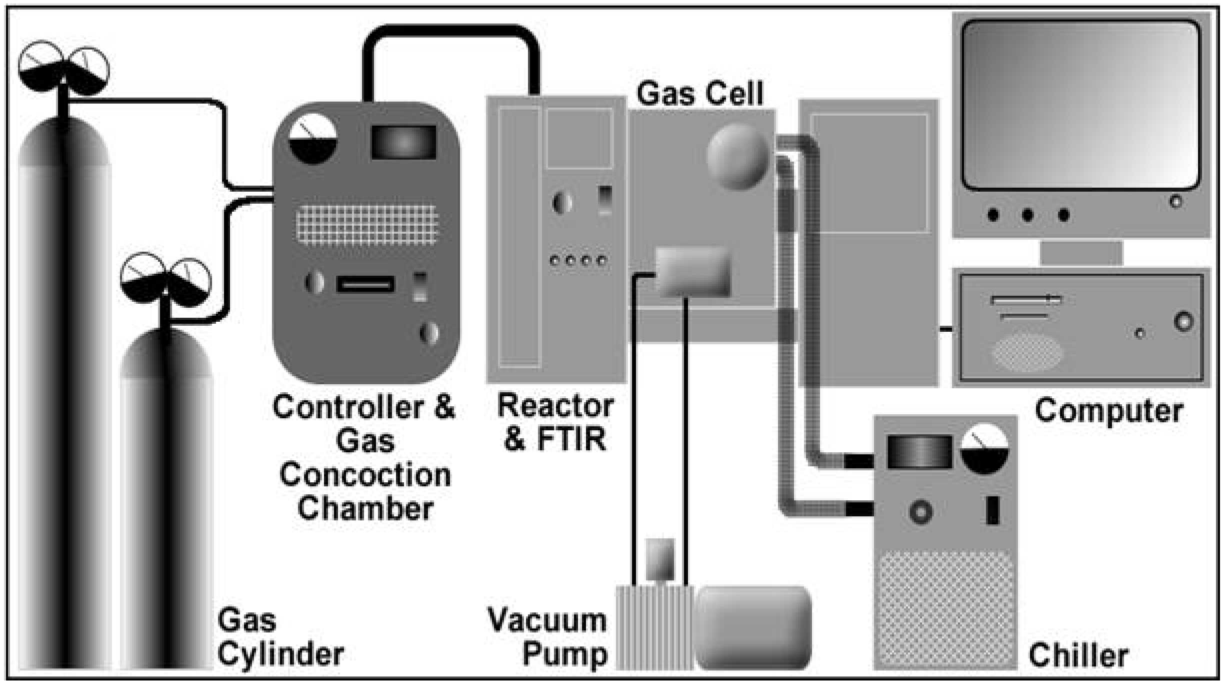
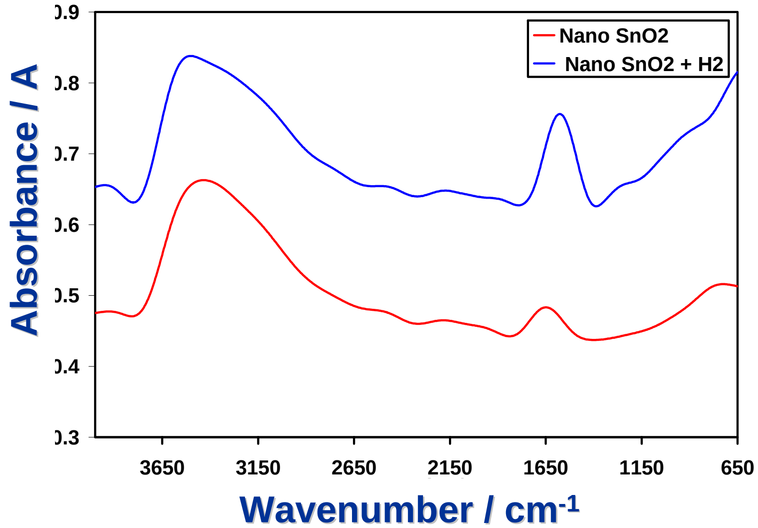


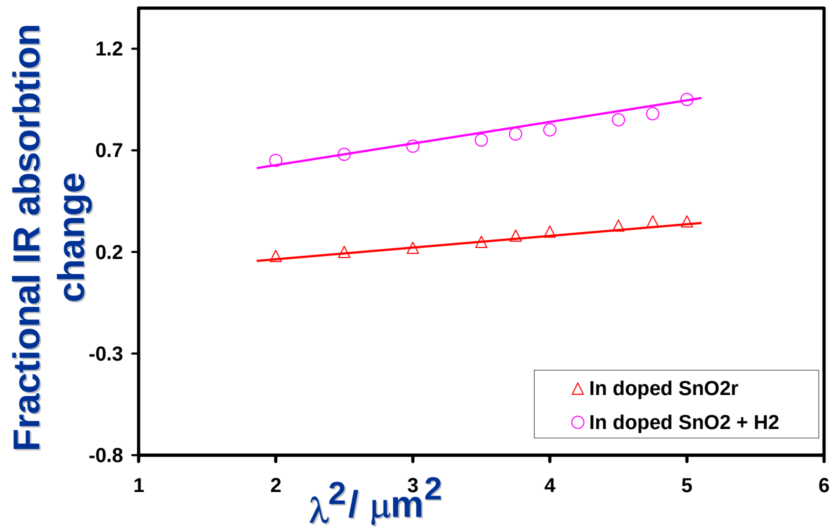
Figure 1: (a) Cartoon diagram of State of the art set up build at SNF lab for testing Nano-materials as sensor materials.

Electrochemical Society Meeting (ECS) 2005: 2nd Place: Poster Session

Accomplishments and New Results

Sensor Material Screening

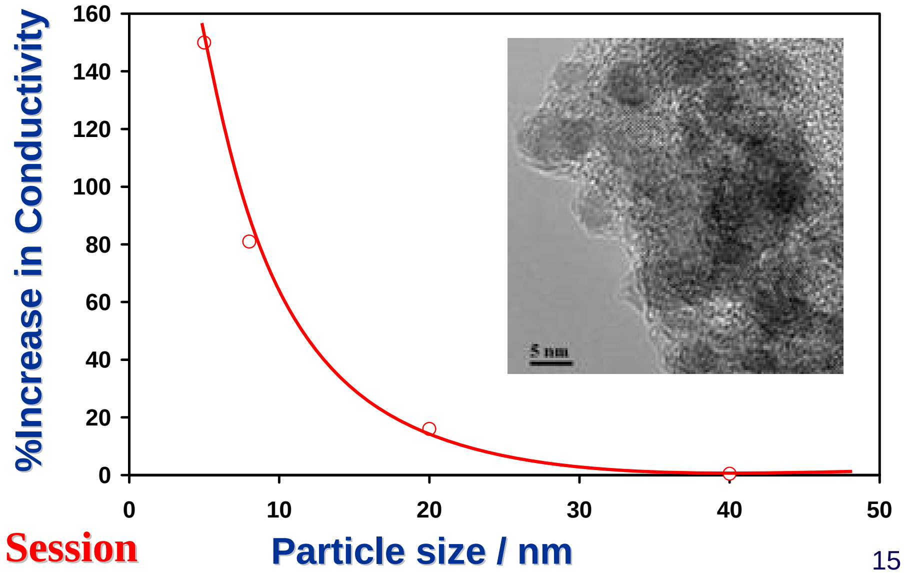




Drude – Zenner Theory

$$K = \frac{1}{\varepsilon_o c_o n} \bullet \frac{\sigma^2 q^2}{\omega^2 m^2 \mu^2} = \lambda_o{}^2 \bullet \frac{\sqrt{\mu_o}}{\sqrt{\varepsilon_o}} \bullet \frac{N q^3}{4\pi^2 n m^2 c_o{}^2 \mu}$$

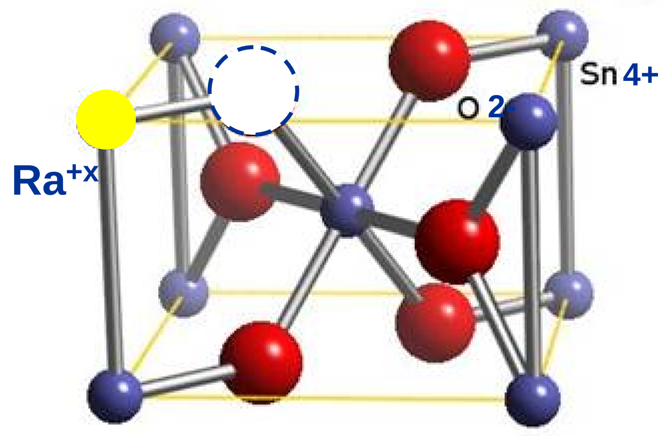
FTIR is a viable way to investigate electrical properties as well as account for quantum effects at the nanometer scale

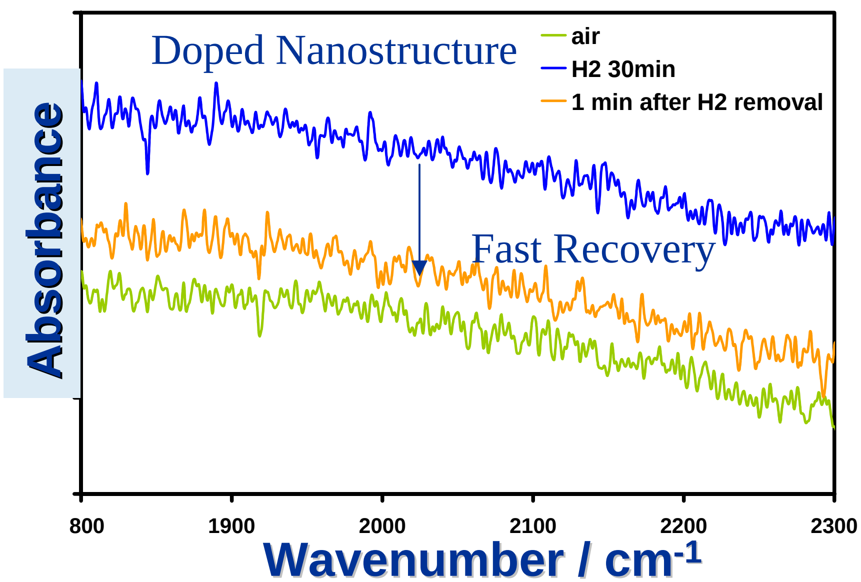


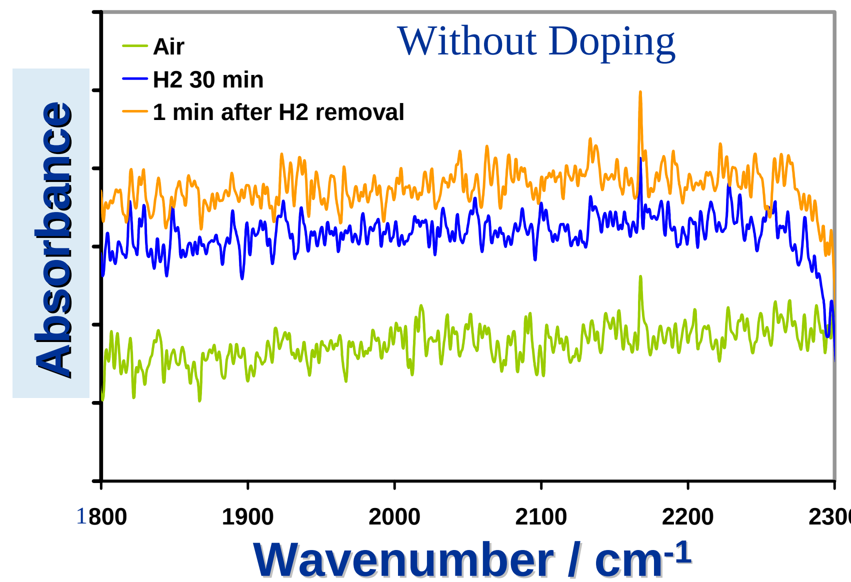
ECS 2005: 2nd Place: Poster Session

Accomplishments and New Results

Novel Material-Fast Recovery



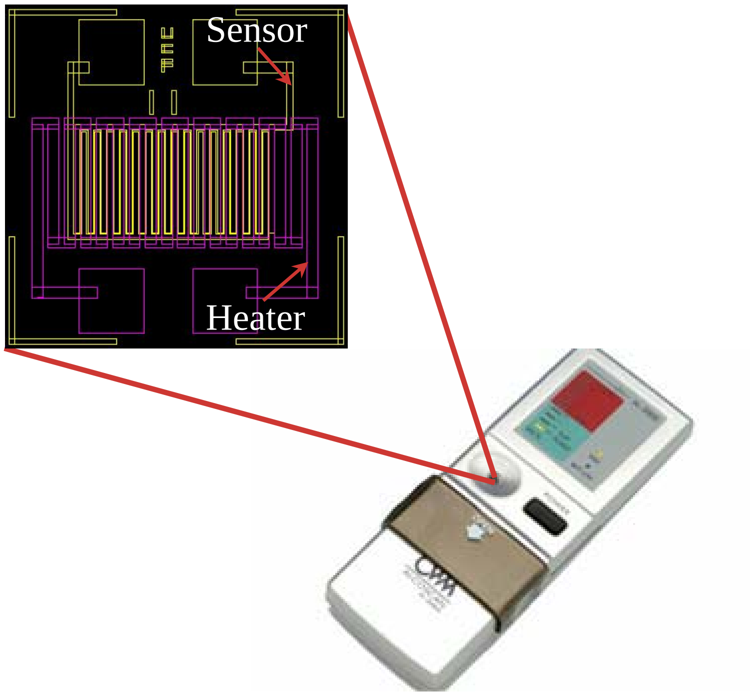


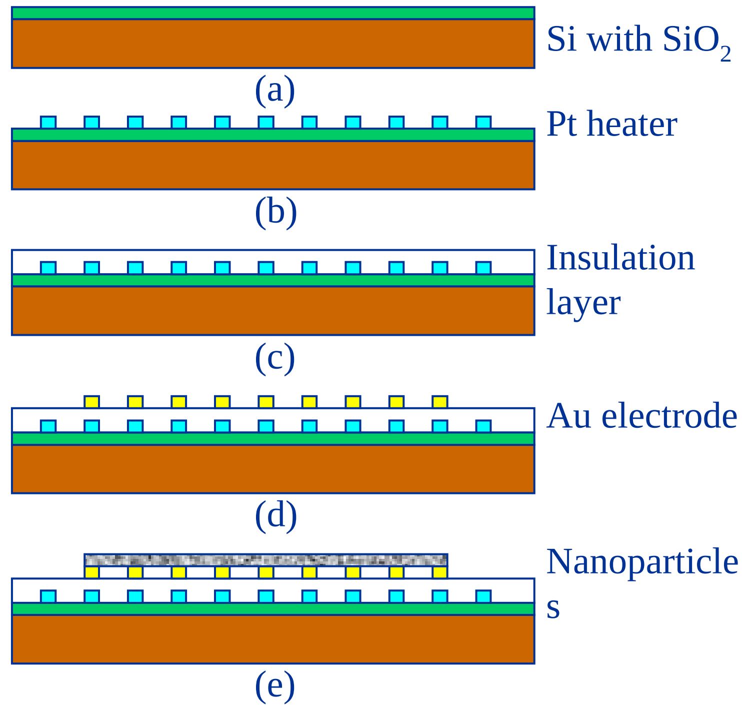


Future Plans

- **Optimizing MEMS Design continued...**
- **Integrating Nanofibers and 1-D nanostructures with MEMS continued….**
- **Integrate hybrid nanostructure for fast recovery with or without air**
- **Manufacturing Prototype H_2 Sensor Device.**
- **On-Site Testing at KSC.**

Future Plan: Prototype





- **Heater integration**
- **Optimum parameter study**
- **Portable sensor instrument**

Fabrication steps:
(a) cleaning and thermal oxidation;
(b) Pt film deposition and patterning;
(c) using spin-on glass as the insulation layer
(d) gold electrodes patterning
(e) coating

Acknowledgements

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