



Future Technologies Conference II

Session Introduction

Future Trends in Analysis & Characterization:
Session 5 – Embedded Sensors

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Cernosek 10/12/06



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Session Schedule

Track 4: Future Trends in Analysis and Characterization: *Embedded Sensors*
Moderator: Richard Cernosek, Sandia National Laboratories

- *Session Introduction*
Richard Cernosek, Sandia National Laboratories
- *Air Force Needs for Embedded Sensors*
James Blackshire, Air Force Research Laboratory
- *Reshaping the Stockpile – Persistent Surveillance Through Advanced Embedded Sensing Technologies*
Anthony Lavietes, Lawrence Livermore National Laboratory
- *Time Deterministic Wireless Smart Sensor Network in Harsh, Airborne Environments*
Wayne Manges, Oak Ridge National Laboratory



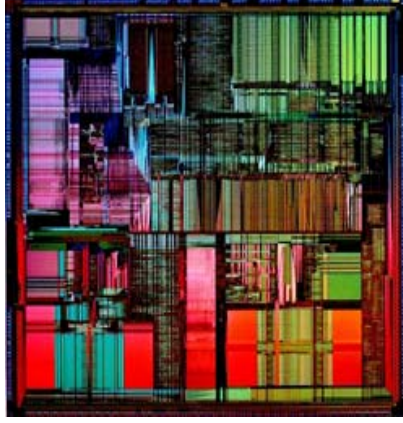
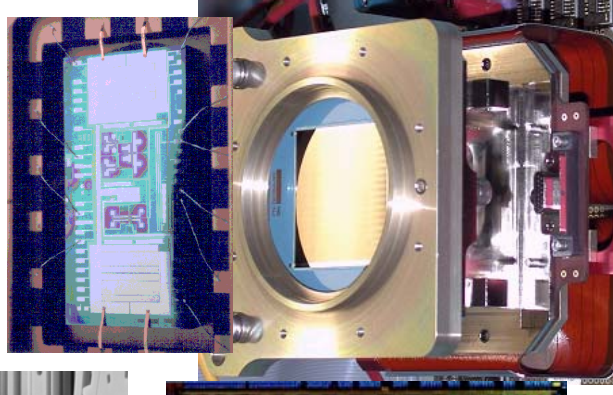
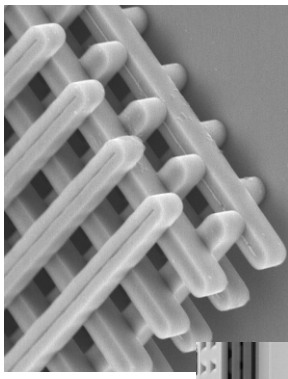
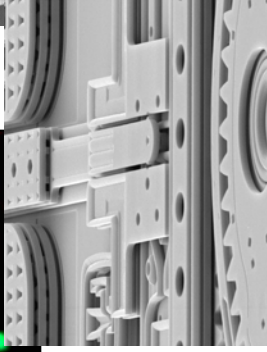
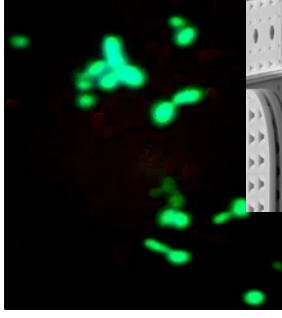
Embedded Sensors – Is There a Definition?

- Does one include: sensors, detectors, monitors, diagnostics, and analyzers?
- Is it the interface (material), the transducer, the transducer/electronic subassembly, or the packaged system? Maybe a larger integrated instrument?
- Does embedded mean integrated into a system, microfabricated with electronics, or located close to the information source?
- Does embedded imply many parallel channels? Wireless interfaces and comm?
- How to classify stand-off detectors in comparison to point or *in situ* sensors?



Embedded Sensors – Characteristic Trends

- Following the Micro-, Nano-, Bio-technologies
- Miniature or microfabricated and highly integrated
- Inserted where needed; distributed throughout
- Able to communicate; wired and wireless, including optical
- Part of *Smart* systems and networks





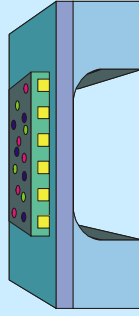
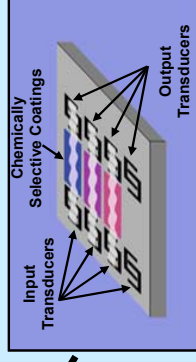
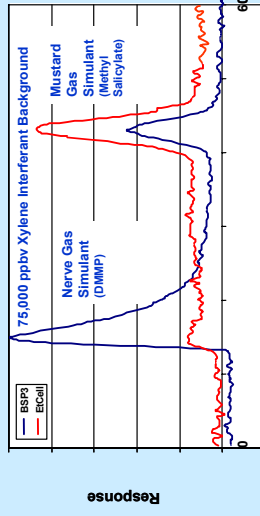
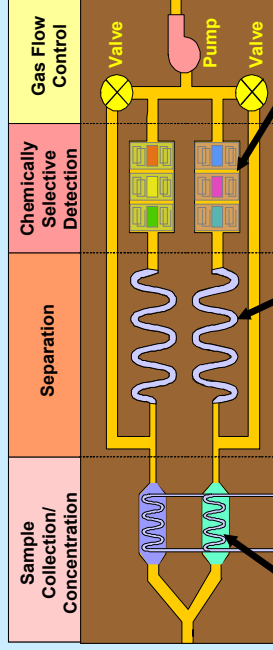
Miniature Analytical Instruments

Sandia Gas-Phase μ ChemLab™

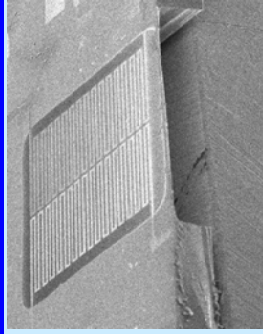
Hand-held chemical analysis system that uses three microfabricated stages.



- 8"x4"x2"
- 2 min. analysis
- 4W max. power



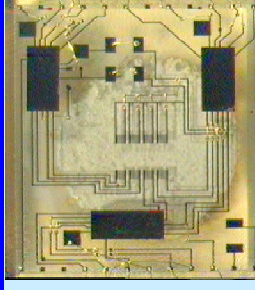
Preconcentrator accumulates species of interest



Gas Chromatograph separates species in time



Acoustic Sensors provide sensitive detection

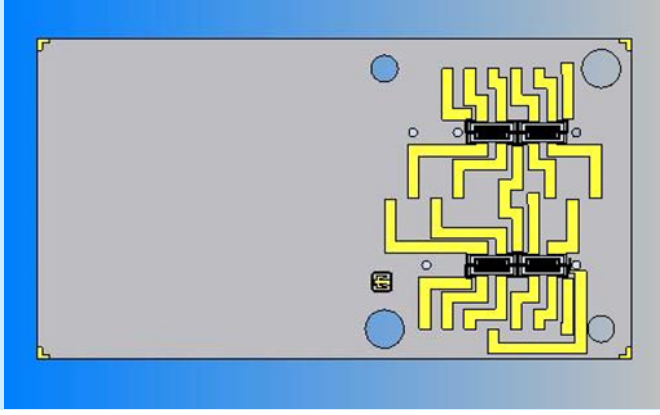




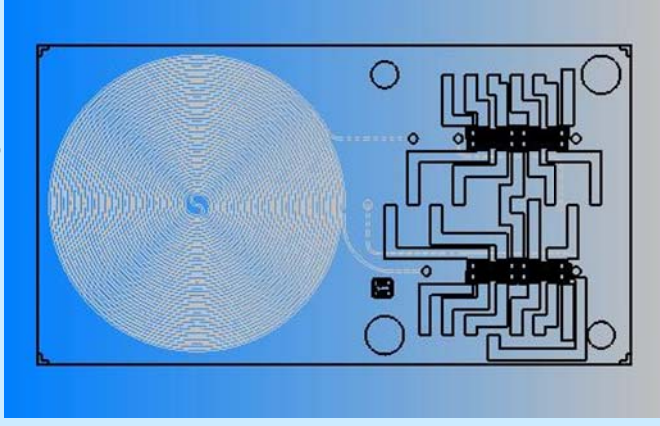
...Toward Integrated Sensored Microsystems

Version 4 Monolithically Integrated System

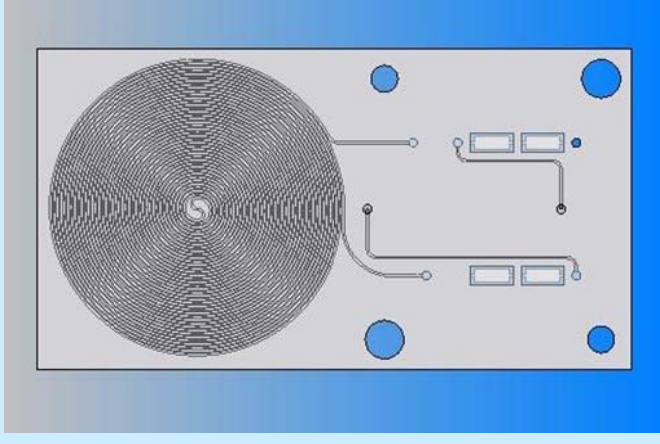
Front



Through



Back



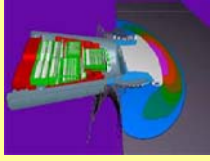
- PPRs as PC and sensors
- SOI wafer
- Fluidics in/out and electronics on opposite sides of wafer
- Standard (86cm) long GC



DOE/NNSA Investment in Integrated Microsystems

MESA Provides Top Facilities, Equipment, and Personnel For Microsystems Design, Fabrication and Test

**\$400M including
> 50% equipment
and cleanrooms**

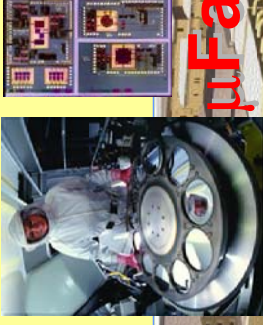


**adv.
computation**



**packaging and
qualification**

Microfabrication



Si Micromachining



Photonics

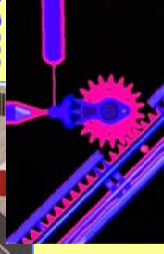
**III-V
Semiconductors**



nanotechnology



**3-d design,
modeling/simul**



**650 people
380,000 sq ft**



**μFab
μLab**

WIF



Air Force Needs ...

Blackshire

Condition Based Maintenance +

Paradigm shift from reactive/preventive maintenance to predictive/intelligent logistics and maintenance

- **CBM+ enables:**
 - Anticipatory, reliability-centered maintenance
 - Reduced logistics footprint and ownership costs
 - Increased operational availability and mission capability

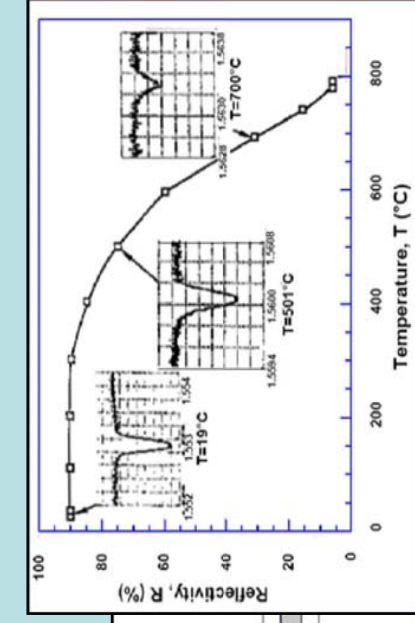
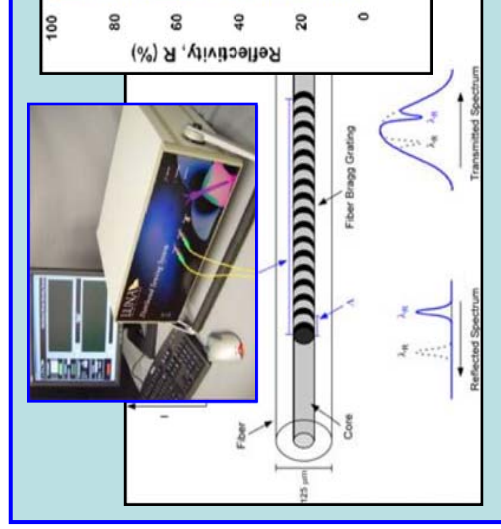
*Integrated System Health Maintenance &
Real Time State Awareness*



Air Force Needs ...

Blackshire

Sensor Development

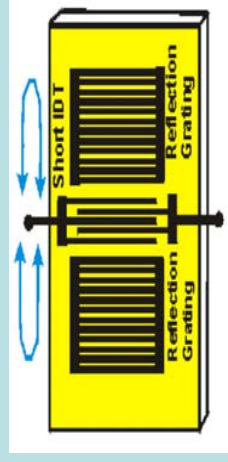


- Distributed Fiber Bragg Systems
- Fiber-Optic sensors are very sensitive to a broad range of environmental stimuli
 - Extreme long life stability requirements
 - High vibration environment

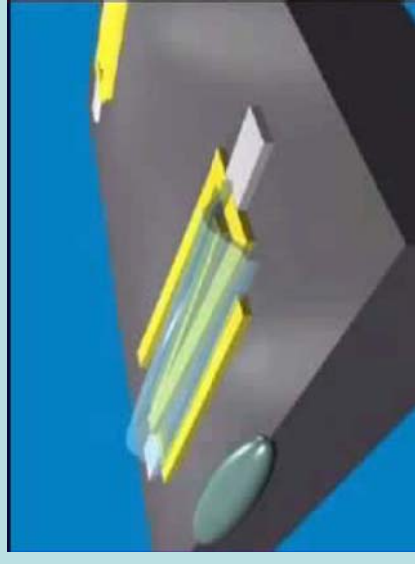
Extreme Environment MEMS

- Survivability of the sensor and packaging materials at 1,000°C
- Sensor / Substrate bonding interface degradation during extended test demo

Delay-Line SAW



Resonator SAW



Manges

- Don't forget ZigBee, Bluetooth, and Wireless USB!***



NNSA
National Nuclear Security Administration

Time Deterministic Wireless ... Manges



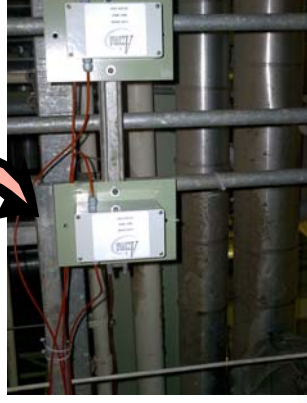
BOEING Flight Test Instrumentation: Case Study

- Five to Seven Miles of Wire
- 2500 to 4000 analog measurements plus thousands of measurements taken from production sensors
- Sensors are located **inside and outside the pressure vessel** and in remote locations of the airplane
- Wire run process requires significant **lead time**
- Sensors are sometimes located on rotating parts

Wireless Is Now – Some Applications Can't Afford to Wait



Wireless Vibration Sensor





Embedded Sensors – Challenges at Hand

- Not just developing appropriate sensors & monitors,
But.....
- Certifying sensor reliability for critical National
Security applications over extended lifetimes & in
extreme environments.
- Maintaining sensor calibration in such applications