



Microsensors and Sensored Microsystems

An overview of Sensor Efforts in Sandia's Microsystems ST&C Center

ORGANIZATION, CUSTOMERS, & PROGRAMS

MESA: Top Facilities and Equipment For Microsystems Design, Fab and Test

- Microfabrication
- Si Micromachining
- Photonics
- BiV Semiconductors
- Inotechnology
- 3-D design, medium
- Adv. computation
- Packaging and qualification

#1400M including 50% equipment and classroom

600 people 380,000 sq ft

Primary Departments Focused on Local Sensing

- Activities in chem, bio, radiation, nuclear and explosives detection (CBRNE) in addition to physical sensing
 - Biosensors and Nanomaterials - Steve Casaravovo
 - Hand-held portable bio-identification
 - Micro-Total Analytical Systems - Larry Stotts
 - Portable chemical identification
- Advanced Sensor Technologies - Richard Cemosek
 - Chemical and physical detection
- Photonics Microsystems Technology - Jim Hudgens
 - Transduction to optical signal
- MEM Technologies - Keith Ortiz
 - Microfluidics and microsensors

Development of prototype autonomous and handheld CBRNE and physical detection systems.

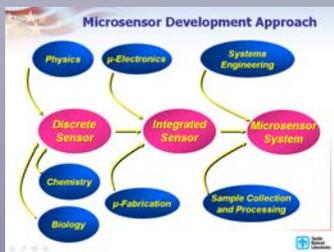
Microsystems Sensor Customers

- Programs support internal SMUs:
 - NW weapon systems surveillance (DSMA; chemical/bio/rad sensors for intelligence gathering)
 - ERIN: chemical/physical sensing
 - HSD: Facility Monitoring (Boston subway demonstration...)
- Deploying capabilities to industry and GFL:
 - Water sampling
 - Hydrogen sensors
 - Commercialized through HSCAN
 - Physical/Chemical Sensing
 - Chemical/biological detection for Intelligence Agencies
 - Demonstrated CO detection for EPC

Programs Supporting Technology Discovery and Maturation

- LEED program supports discovery and development:
 - ST&C LEED: Innovative concepts
 - Microfluidics research
 - Grand Challenge: Integrated concepts and prototypes
 - Microfluidics
 - 3D printed microfluidics
 - SMU: Mature technology to address customer needs to enhance work flow
- NW program funding for sensor maturation (Enhanced Surveillance Embedded Evaluation...)
- No ITS analogy to NW program funding
- Programs/Customers mature, demonstrate and deploy technology, include implementation
- Complex/Kansas City produces limited special products

CORE CAPABILITIES



Integrated Sensor Strategy

- Building on and extending micro-chem/bi GC/LDRD concepts for chem, bio and rad
 - Collection/concentration
 - Adsorptive hot plates
 - Polymers, beads
 - Acoustic streaming
 - Dielectrophoresis
 - Separation/selection
 - GC Columns
 - Lines
 - Fiber cytometry
 - Detection
 - SAW
 - Electrochemical - Organosensitizers
 - Optical detection

Chemical and Biological Assay Development

- Catalytic nanoparticles for reagentless BSA detection
- Protein assembly for improved antibodies and enzymes
- Functionalized nanoparticles for CVA sensing
- Biomimetic Molecules
- Catalytic deoxyribose molecular beacons to eliminate need for PCR
- Supramolecular self-assembly with dynamic shift in fluorescence

MESA Provides Enabling Technologies

- Flexible Fabrication
- Photonics
- Si CMOS
- Compound Semiconductor
- Advanced Packaging
- Si Bulk Micromachining
- Si Surface Micromachining

APPLICATIONS

Integrated Microsensors for Persistent Surveillance & Condition Monitoring

- Supporting:
 - Nuclear weapons
 - Military vehicle FHM
 - Industrial machines
- Self test
- State-of-health
- Environmental sensing
- Joint Test Assembly (JTA) components

MEMS passive shock sensors

Assembly Test Chip: CMOS-integrated temp, stress, E, corrosion sensors

MEMS piezoelectric sensors

qualified ODS components where appropriate

fiber-optic & Si integrated gas monitors

sensor modules for mixed-signal Memory structured ASICs

RadFETs built into hardened CMOS

MicroChemLab - Handheld Chemical Analysis

- Detects CWA, TICs, TMs
- Micromachined components enable miniaturization and rapid, low power response
- System has been assembled into a user-friendly hand-held unit
- ppb detection levels
- 2 minute analysis time
- Live agent tests at ECBC
- Field tests at subways and airports
- Specialized systems fielded by government agencies.

SnifferSTAR™ - Chemical Sensor for micro & mini-UAVs

Developed in conjunction with Lockheed Martin

System parameters:

- light weight - 14 grams
- low power consumption - 0.5 W
- 15 to 20 processing time
- severe & faster agents

Silver Nanoparticles

- nanoparticles
- high surface area
- highly porous
- highly reactive
- highly sensitive
- highly selective
- highly stable
- highly durable
- highly reliable
- highly accurate
- highly precise
- highly sensitive
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- highly stable
- highly durable
- highly reliable
- highly accurate
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2003 RAD 100 Award

Micro-Gas Analyzer - DARPA

Program Structure:

- Phase I is \$3.2M, Phase 2 is \$5M
- Phase III award \$8.5M including subcontracts with Caltech, LDR UCUC, Honeywell, Northrop-Grumman
- 18-month Phase II engineering PDR, hardware deliveries in 12 mos, live agent testing in 18 mos.

Deliverables:

- Chemical warfare agent detection: High speed (>1 sec), low power, small volume, low detection limit and false alarms
- Goal of gas detection
- Gas microvalves (fast injection)
- H₂ Carrier (fast separation)
- 2 Columns (reduce false positives, increase selectivity)
- Nanoparticle chemisorber (increase sensitivity, lower power)
- Modeling of pre-concentrator adsorption/desorption to shorten design cycle

An Electrochemical Microarray Sampling System for Multiple Biological Agent Detection

Application: Simultaneous detection of multiple pathogens (Es. coli, anthrax, etc.) using a single detection agent.

Process: Integrated Electrochemical & Biochemical Systems

Benefits:

- Simultaneous detection of multiple agents in parallel
- Highly sensitive and specific detection
- Low power consumption
- Small form factor
- Highly accurate and precise
- Highly reliable
- Highly accurate
- Highly precise

Technology to detect multiple CBRNE threats simultaneously

Quantum dot tagged magnetic bead-based detection

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- Highly sensitive and specific detection
- Low power consumption
- Small form factor
- Highly accurate and precise
- Highly reliable
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ElectroNed™ Biomedical Sensor Array

ElectroNed™ Sensor Array (SA) is a 4 x 4 x 10 x 10 array of individually addressable ElectroNeds™ (EN) for biosensing, medical diagnosis, and (3) a single ElectroNed™, allowing for portable electronic health, testing the electrical response of the cells.

- Microfabricated array of biosensors for real-time, point-of-care medical diagnostics
- Impacts emergency and third-world healthcare
- Sensor patch, pressed against skin, provides minimally invasive biomarker measurement
- Technology initially developed through Bio Micro Fuel Cell GC/LDRD
- Electrochemical detection minimizes system size and improves portability

2003 RAD 100 Award

Summary

- Novel microsensor technologies are being developed and deployed
- Emphasis placed on handheld and autonomous technology
- Nationally recognized with significant activities for Federal Agencies and Industry
- Sandia's microsystems capability is addressing national security needs in CBRNE and physical sensing

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