SAND2007-3893P

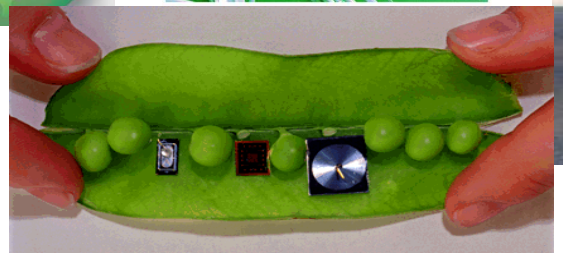
Enabling Science & Technology for National Security Applications

Dr. Mark F. Smith
Senior Manager
Advanced Manufacturing Science & Technology
Sandia National Laboratories*
Albuquerque, NM







*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000

Some Global Issues that can Affect US National Security

Energy Security

Terrorism

Political Instability

Waste

Energy Disruption

Climate

Water

Proliferation of SNM and Weapons Expertise

National Nuclear Security Administration

Sandia National Laboratories

Sandia is a National Security Science and Engineering Laboratory

- **Historical mission has been non-nuclear components in nuclear weapons and nuclear weapons security**
- **Today, broader mission in science & engineering for national security**

"We work on technologies at a scientific lab, but we must emphasize that science is not an end. The end is solving problems for the nation. Science is perhaps the best tool to achieve that end." *C. Paul Robinson, SNL President & Director 1995-2005*

NNSA National Nuclear Security Administration

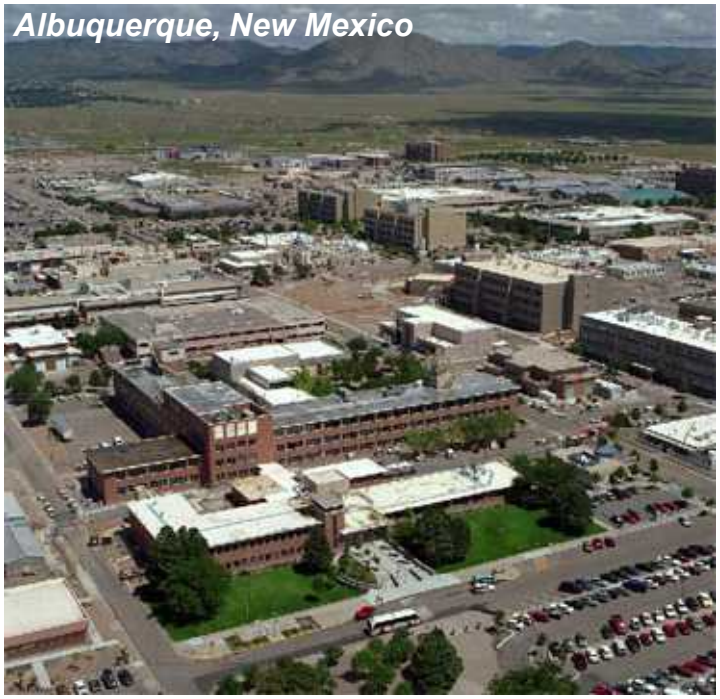
Sandia National Laboratories

Sandia National Laboratories Sites


Pantex, Texas

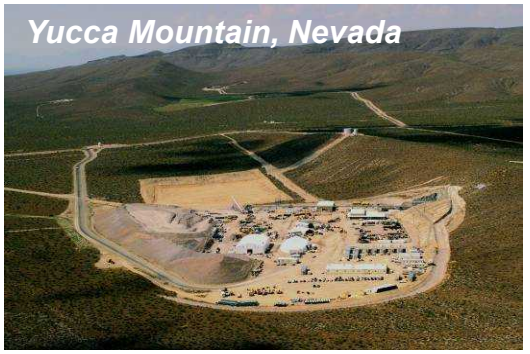

Tonopah, Nevada


Kauai, Hawaii


Albuquerque, New Mexico


Livermore, California

WIPP, New Mexico


Yucca Mountain, Nevada

NNSA
National Nuclear Security Administration

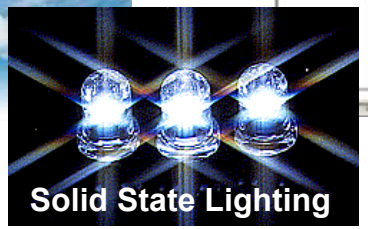
Sandia National Laboratories

Sandia's National Security Missions

- Nuclear Weapons
- Non-Proliferation
- Defense Systems & Assessments
- Energy & Infrastructure Assurance
- Homeland Security

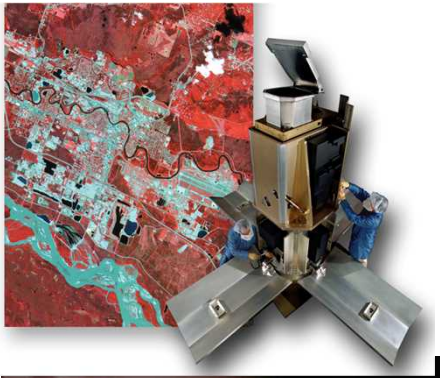
Air Launch Cruise

Radiation Monitoring

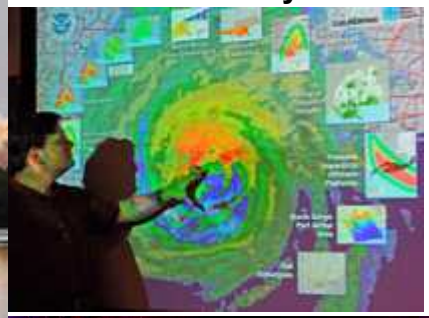


Support for Shuttle Return to Flight

Satellite Imagery

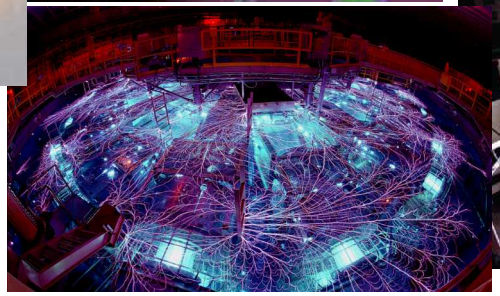


Katrina Analyses



Drugs/Explosives Detection

Infrastructure Vulnerability Assessment



Energy R&D

Chem-Bio Threats

"Helping to Secure a Peaceful and Free World Through Technology"

National Nuclear Security Administration

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Nuclear Weapons

- **Responsible for all non-nuclear components (> 90% of total weapon parts)**
- ***Mission includes "Surety" (Safety & Reliability) of the Nuclear Stockpile***
- ***A lot of functionality in small, rugged packages with very high reliability***

W88 SLBM
Arming, Fuzing, & Firing System

Radars
Impact fuzes
Shock absorbers
Casing
Detonators
Firing sets
Transverters
Capacitors
Switches
Switch tubes
Rectifiers
Programmers
Neutron generators
Reservoirs
Stronglinks
Batteries
Timers
Spin generators
Parachutes
Ejector systems
PAL controllers

B83 Strategic Bomb

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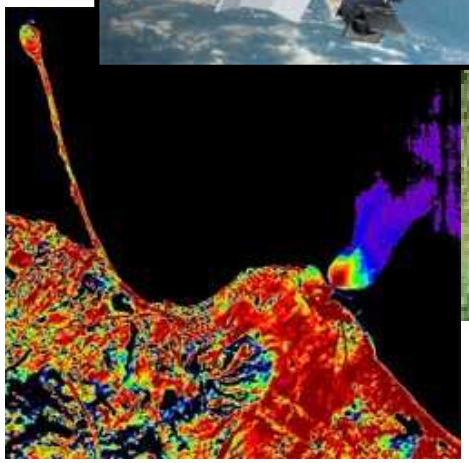
Nonproliferation

Monitoring & Verification



Neglected Russian Nuclear Facilities

SNL International Programs Bldg.

Soviet "String & Wax" Security System

FSU Personnel Redeployment

"We must keep the most dangerous weapons in the world out of the hands of the most dangerous people in the world" George W. Bush

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Defense Systems & Assessments

- Remote Sensing and Verification
- Surveillance, and Reconnaissance
- Integrated Military Systems

"RSVP"

(Remote Sensing & Verification Program)

Future Combat System
Integrated Support Team

TACMS-P
(Tactical Missile System – Penetrator)

Shuttle Heat Shield Inspection

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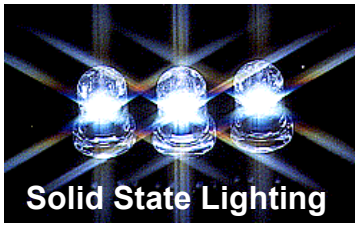
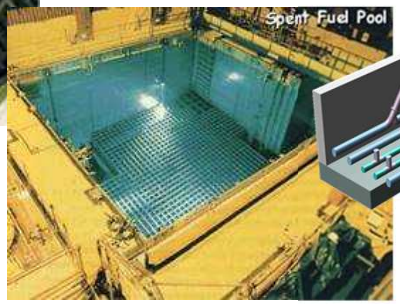
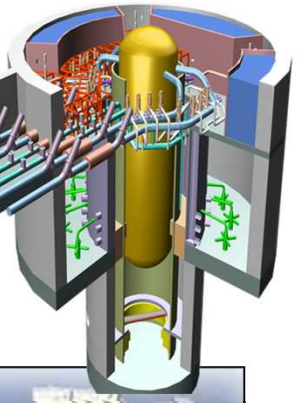
Energy & Infrastructure Assurance

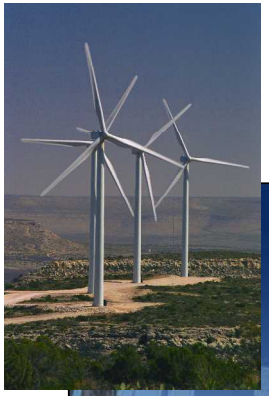
- Secure energy supplies for national security
- Clean, abundant and affordable energy
- Water research
- Infrastructure protection



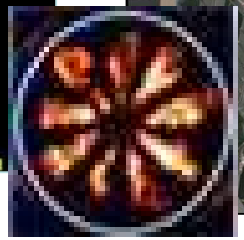
Nuclear Energy

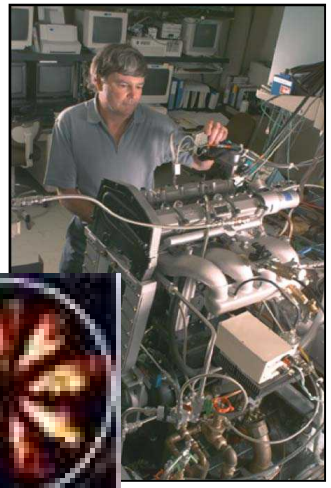






Solar/Wind Energy





Water Desalination

Combustion Research

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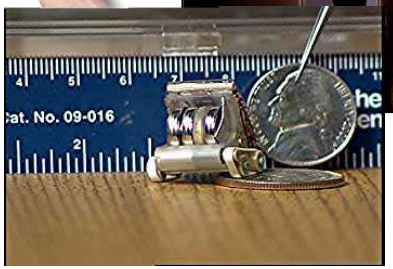
Homeland Security

- Homeland Defense & Force Protection
- Risk Management & Infrastructure Protection
- Catastrophic Event Mitigation

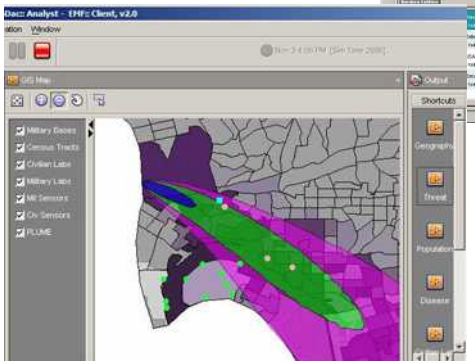
Force Protection

Bomb Disablement

Chem/Bio Neutralization



Rad/Chem/Bio Detection & Analysis



Threat & Vulnerability Assessments

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*Explosives Detection Portal**

Need:

- Rapid scanning of personnel who may be carrying or who may have been handling explosives
- For use at airports, government buildings, sports arenas, etc.

Technical Approach:

- Walk through system that uses Sandia patented technology to collect and concentrate vapor and particles from air that flows around person.
- Different versions use either a commercial ion mobility spectrometer or a mass spectrometer to identify trace amounts of a variety of explosives.
- Can also be configured to detect illegal drugs

*Funding provided by FAA, TSA, and DOE Office of Security

Miniaturization with Novel Materials Technologies

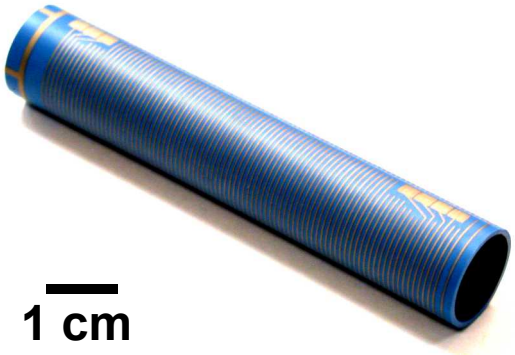
Need:

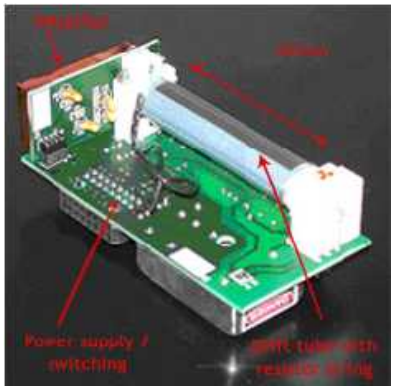
- Low cost handheld unit to screen suspicious packages, vehicles, or even people for traces of explosives, illegal drugs, etc.

Technical Approach:

- Hound™ – mated Sandia collection/pre-concentration technology to commercial IMS.
- MicroHound™ – developed miniature IMS drift tube using novel materials and processing technologies including LTCC, screen printing, and LIGA.
- Detect explosives, drugs, & chem/bio weapon agents

Hound™





MicroHound™

"There are not enough good things I can say about this tool." Jaime Garza, South Texas Specialized Crimes & Narcotics Task Force

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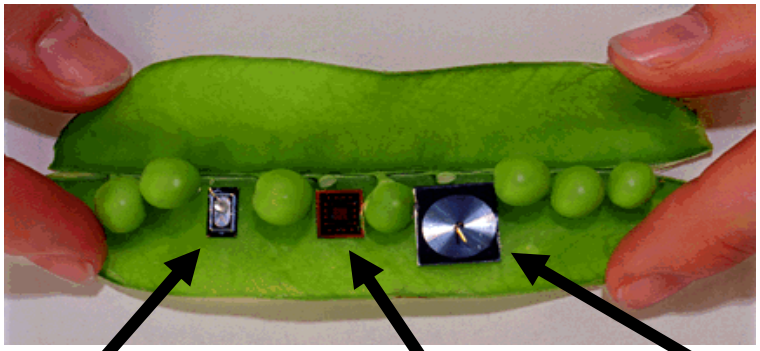
μChemLab™

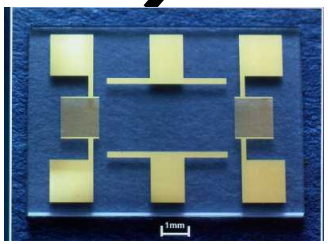
Need:

- Small, inexpensive, handheld analyzer for military, first responders, and other applications.

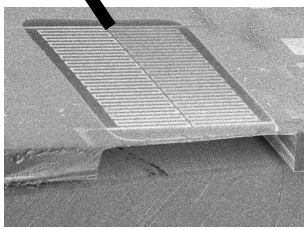
Technical Approach:

- Use surface micromachining to create Micro Electro Mechanical System (MEMS).
- Use Gas Chromatography (GC) column together with selective-surface sensors instead of IMS.

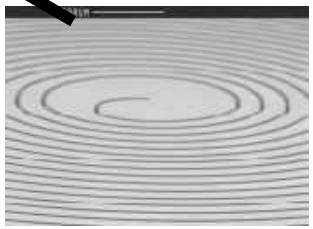




Chemically-Selective Detectors (SAW sensor)



Preconcentrator



~1 Meter Gas Chromatograph Column

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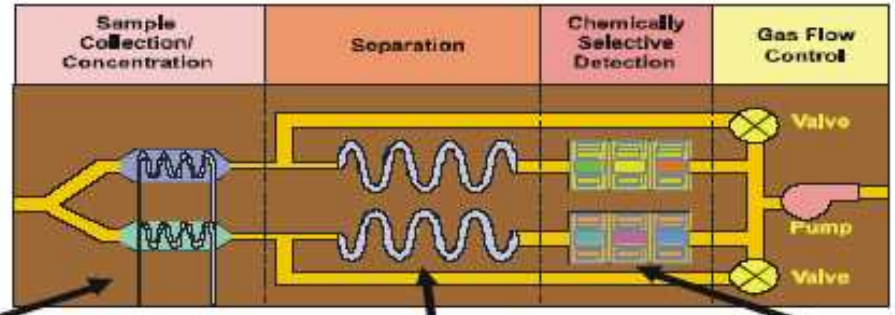
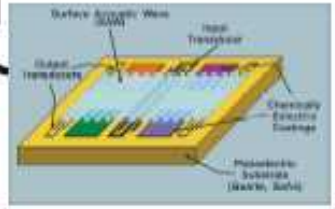
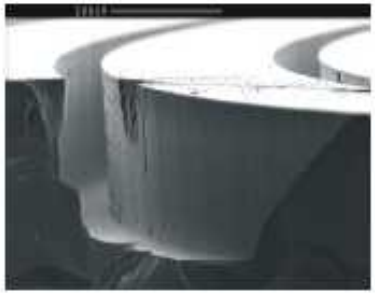
μChemLab™ Schematic/Components



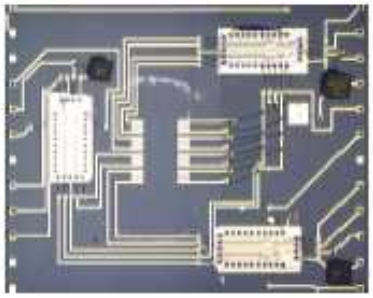


Gas Chromatograph separates species in time

Preconcentrator accumulates species of interest



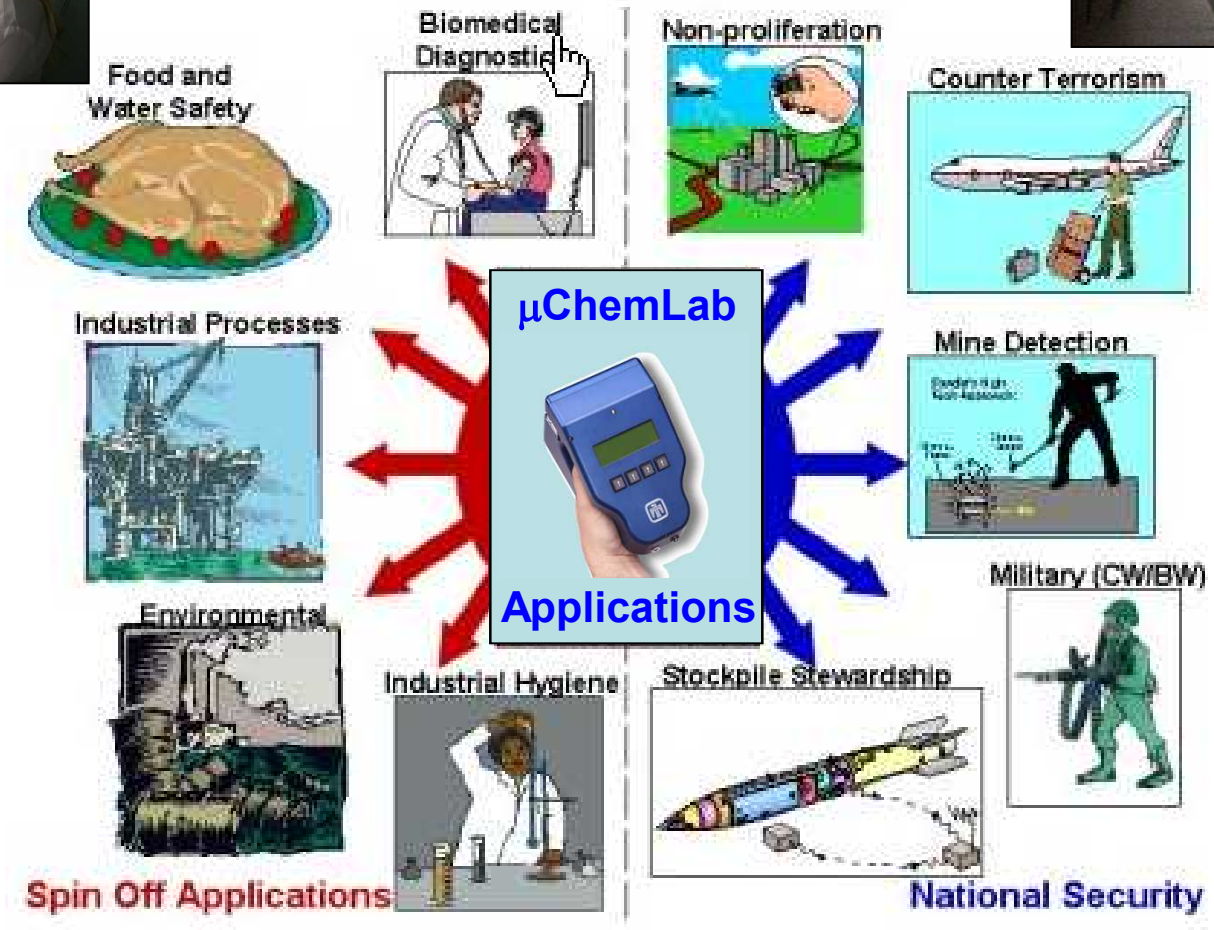
Acoustic Sensors provide sensitive detection



Many Current & Potential Applications

NOAA Project to Detect Toxins in Harmful Algal Blooms (HABs)

Monitoring Subway Stations



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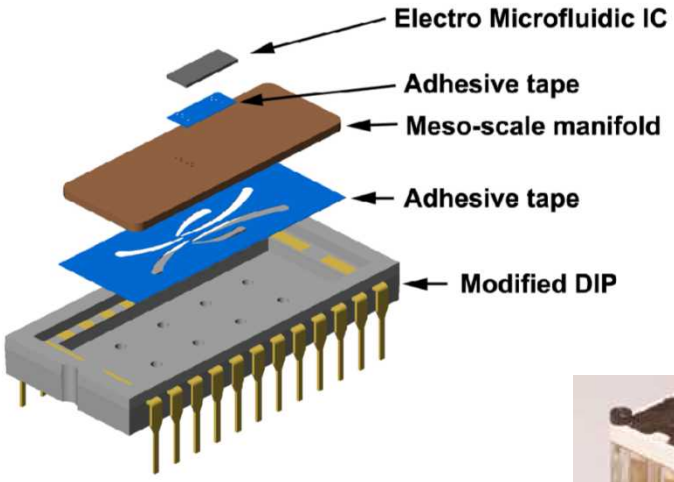
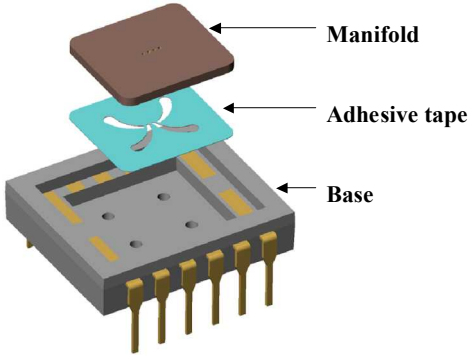
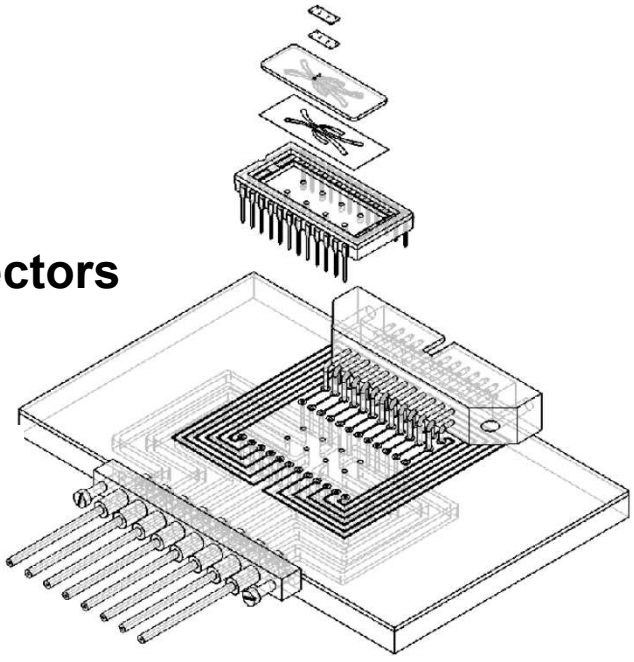
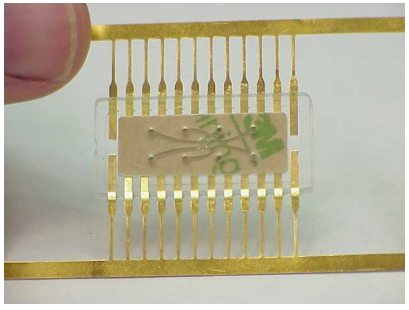
Electro-Microfluidic Devices

- Device and board level packages
- Standard interface
- Chemical sensors, biological sensors, drop ejectors

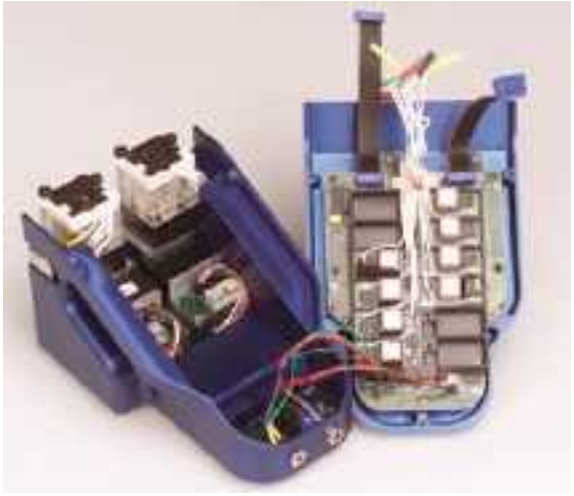








Liquid Phase μChemLab™ for Fluid Analysis



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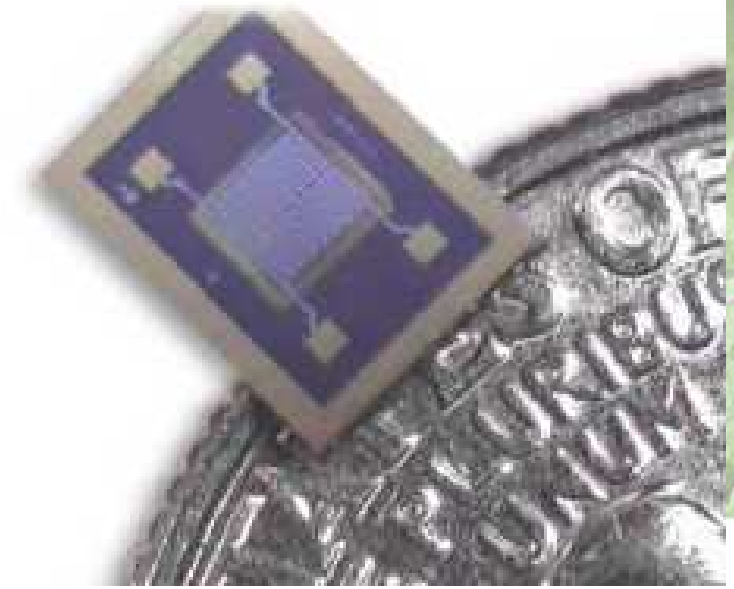
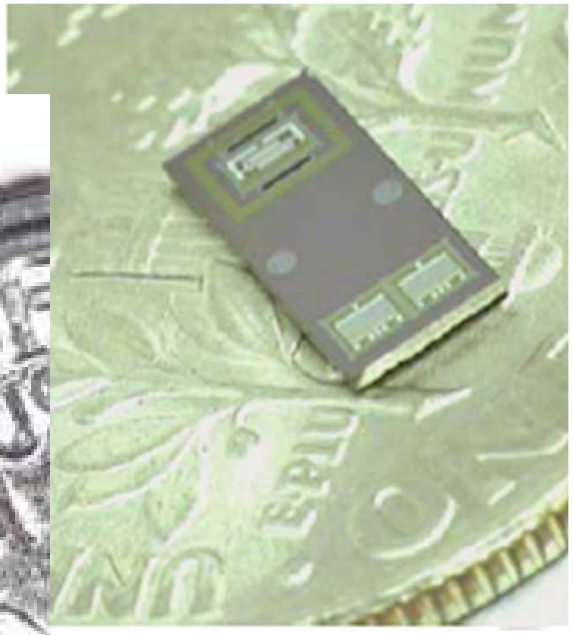
Further μChemLab™ Refinements In-Progress

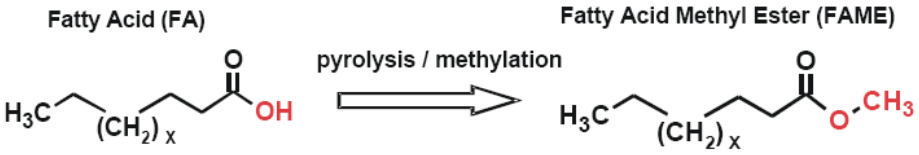
Micropyrolyzer atop a dime





Monolithic all-Si μChemLab™ with Preconcentrator, GC column & Pivot Plate Resonator detectors on a dime

used for Fatty Acid Methyl Esther (FAME) identification of micro-organisms (bacteria, anthrax, other pathogens



Full-up Monolithic Analysis System on a Sandia Micro-robot

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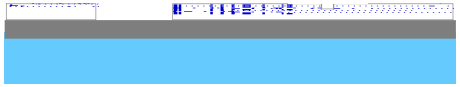
Sandia National Laboratories

Micro Electro-Mechanical Systems (MEMS)

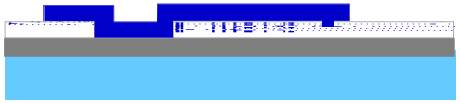
Deposit Ground Plane Layer

Deposit Sacrificial Oxide

Pattern Sacrificial Oxide

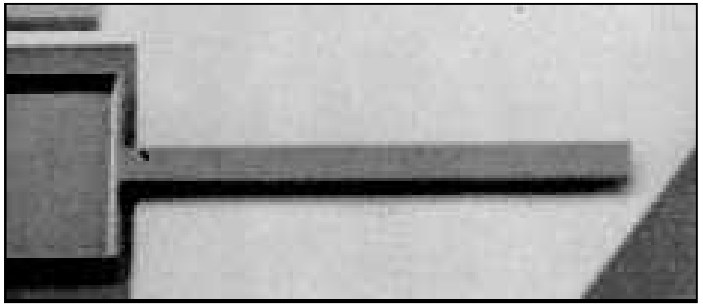


Deposit Poly-Si Layer

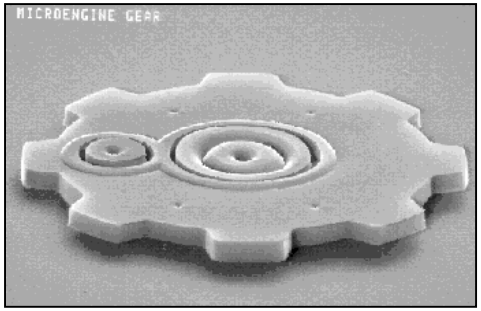


Remove Sacrificial Oxide to Release

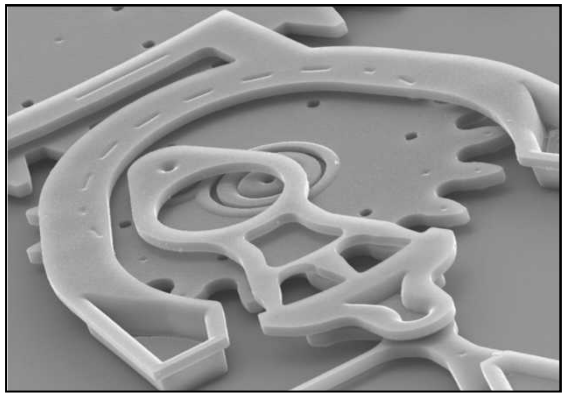
2 levels



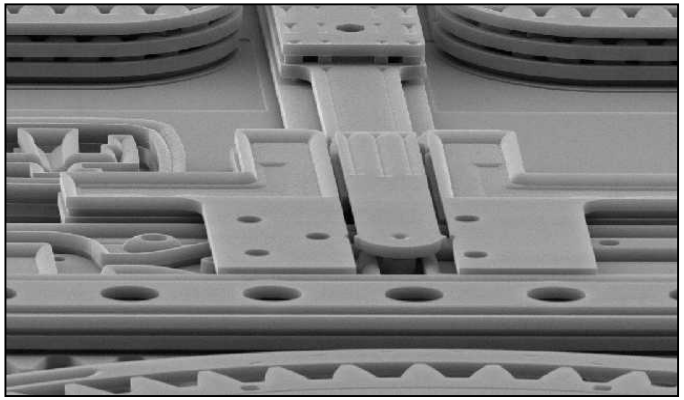
3 levels



4 levels



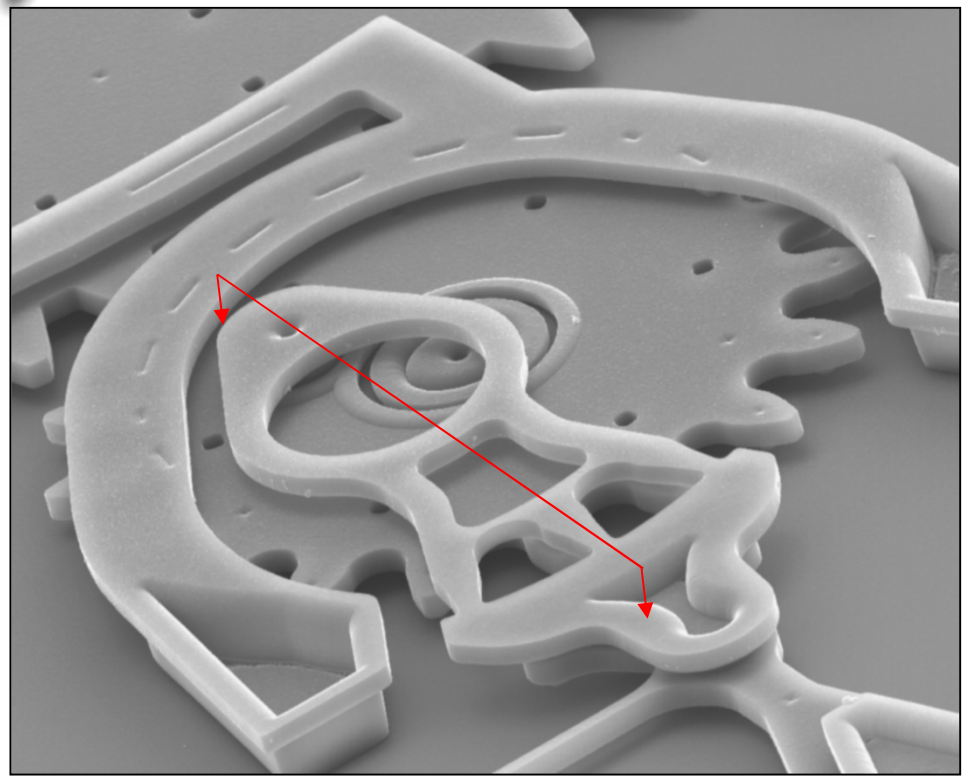
5 levels



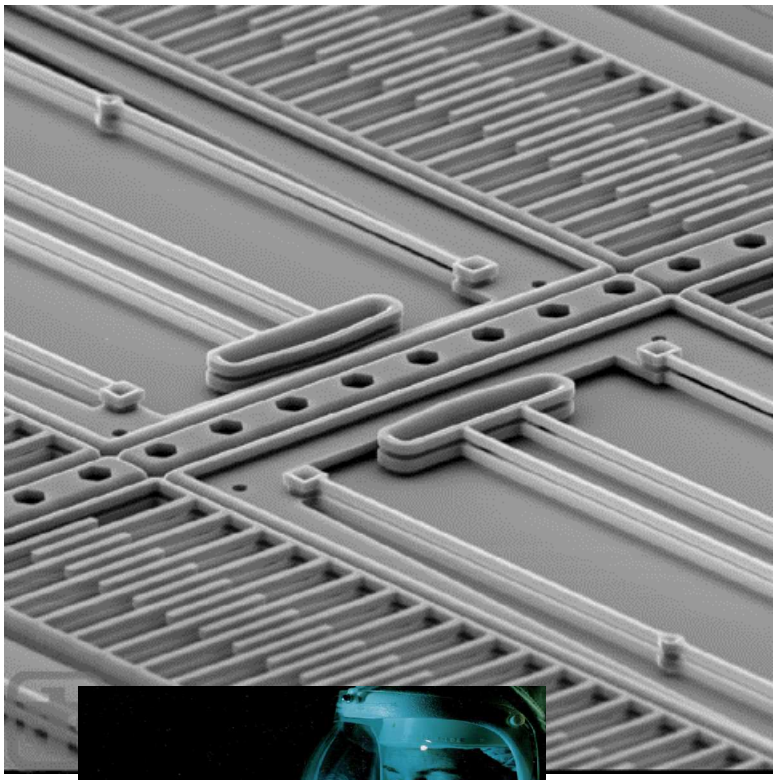
SUMMiT™ Process

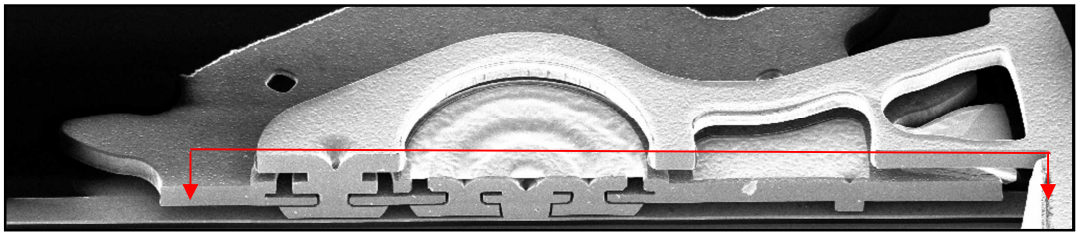
(Sandia Ultra-planar Multi-level MEMS Technology)

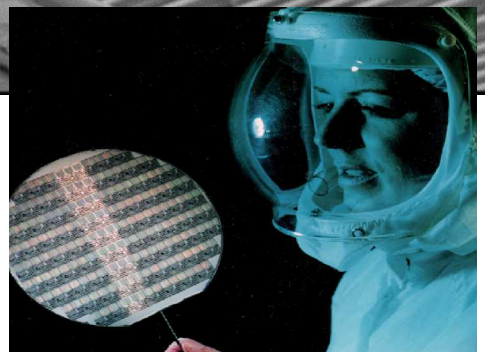
Gear Assembly



Comb Drive







There is no piece part assembly!

National Nuclear Security Administration

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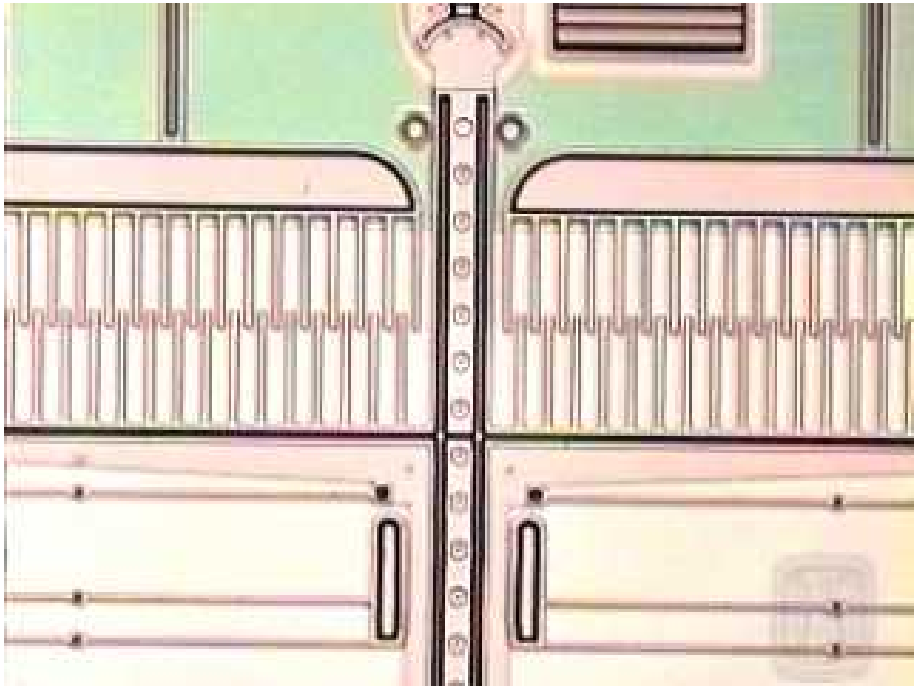
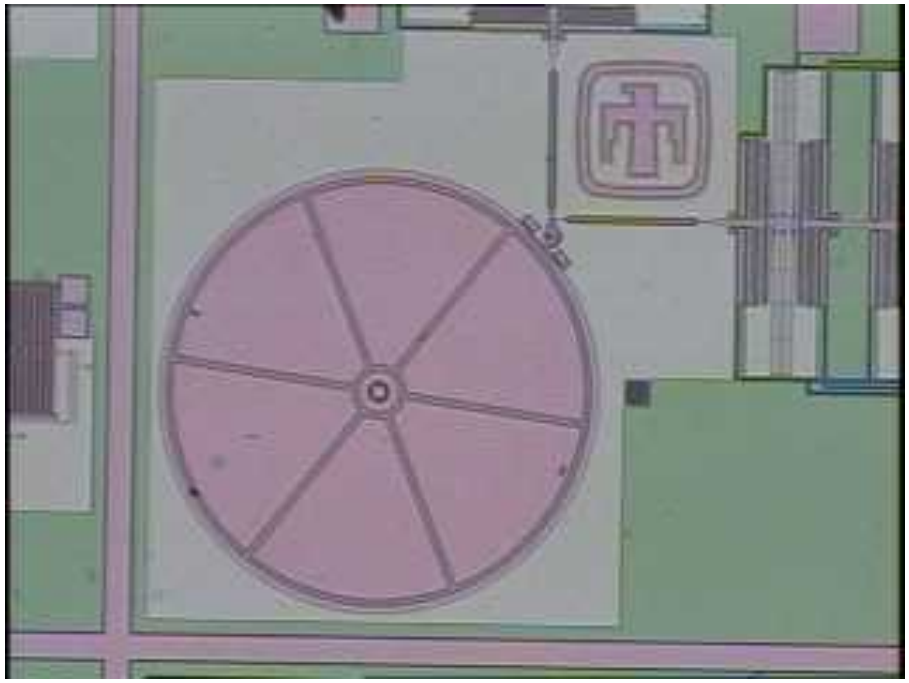
MEMS Drives in Action





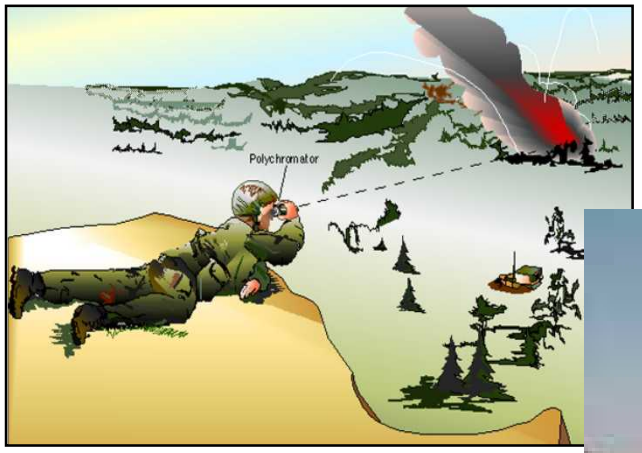
Remote Chemical Analysis

Need:

- *Remote and rapid field analysis* of unknown chemical species
- Useful for war fighters, first responders, fire fighters, env. monitoring, ...

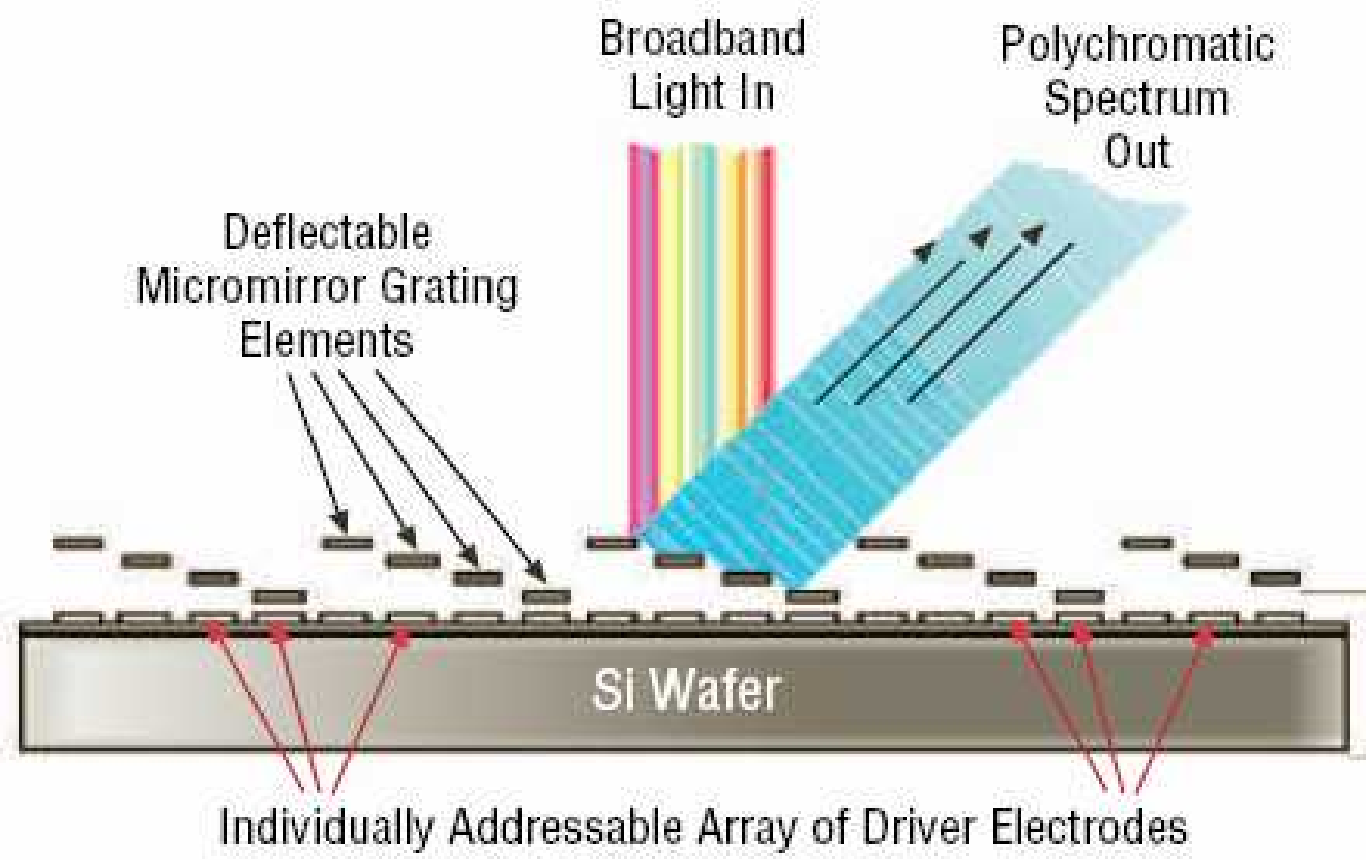
Technical Approach:

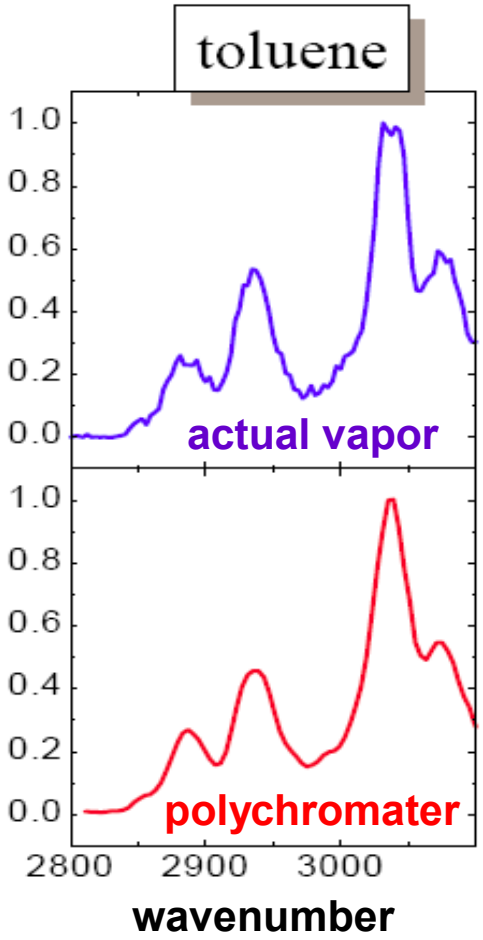
- MEMS programmable optical diffraction grating replaces the reference cell in a correlation IR spectrometer
- MEMS grating creates synthetic polychromatic reference spectra of target species, providing high selectivity & sensitivity



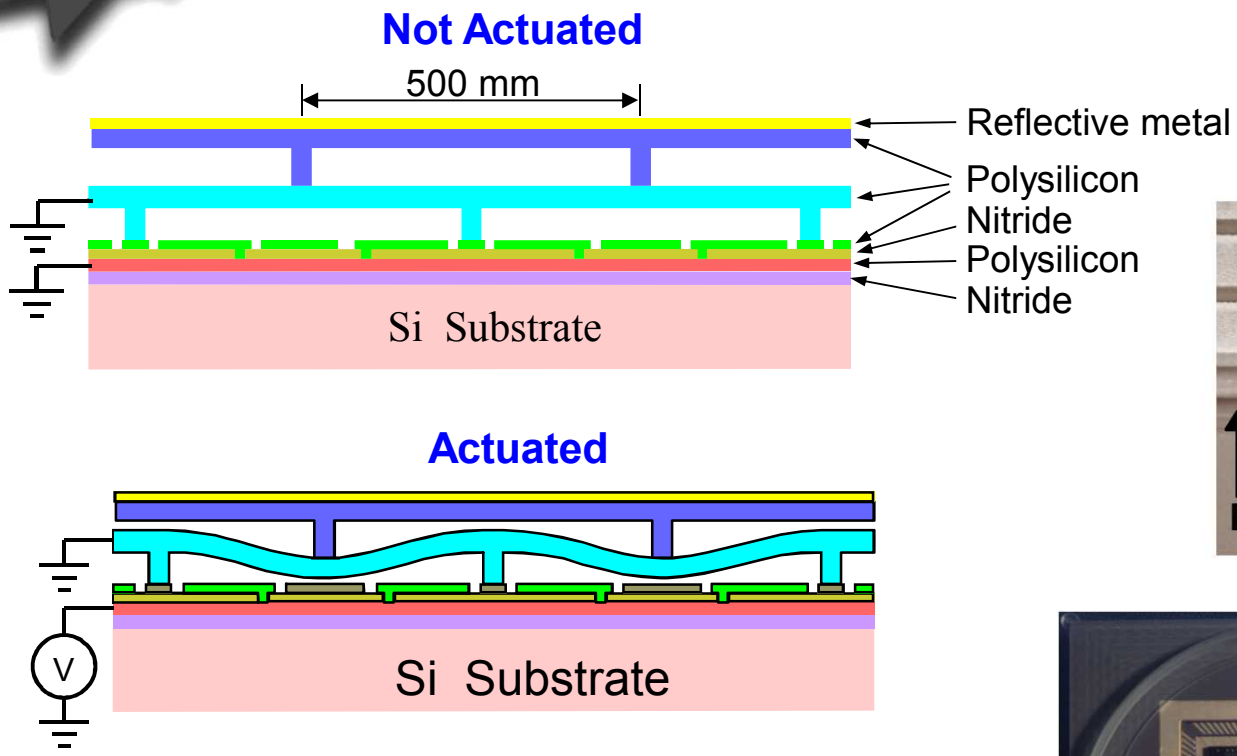
MEMS Polychromator

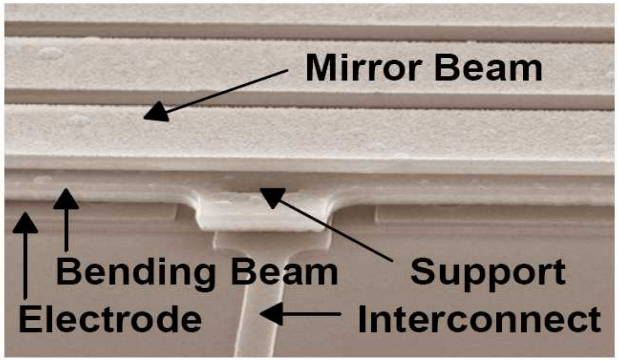
(Sandia/MIT/Honeywell/DARPA)





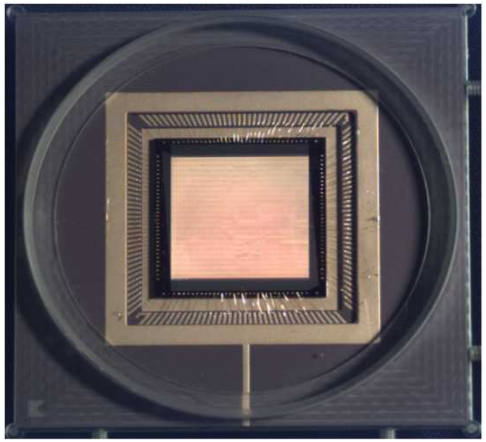
Actuation Principle: Leveraged Bending





Fabricated at Honeywell

- Overall size: 1 cm by 1 cm
- Micromirror length: 1 cm
- Micromirror width: 10 μm
- Vertical travel: 2 μm

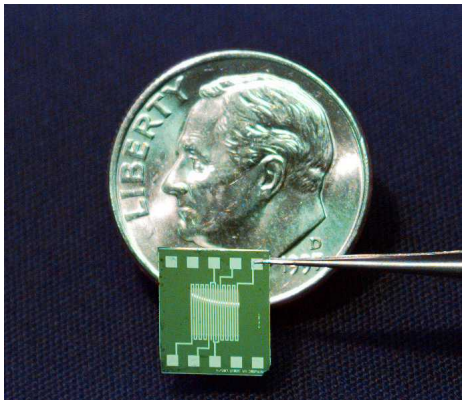


1024 Grating Element Polychromator Array

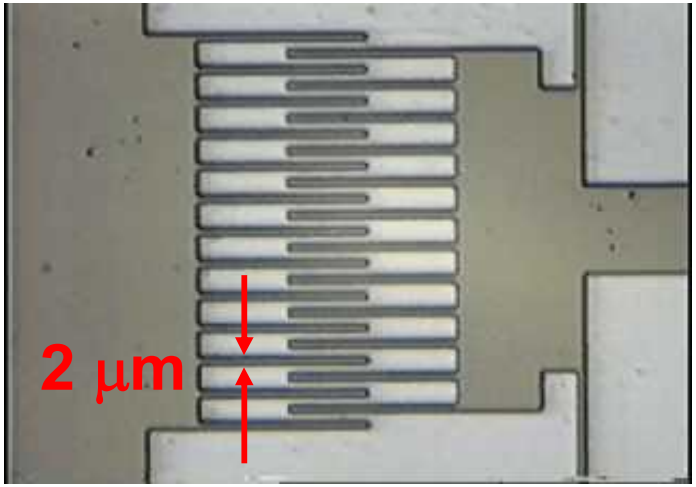
Amorphous Diamond (aD): Enables High Performance MEMS and Sensors

Stress-Free aD

- Deposited by pulsed laser deposition
- Room temperature growth
- Stress state can be tailored
- Hard, wear resistant
- Water-repelling (prevents stiction)
- High strength (enables thin membranes)
- Chemically resistant (can operate in harsh environments)
- Biocompatible (enables bio-sensors and bio-MEMS)
- Compatible with conventional lithographic processing

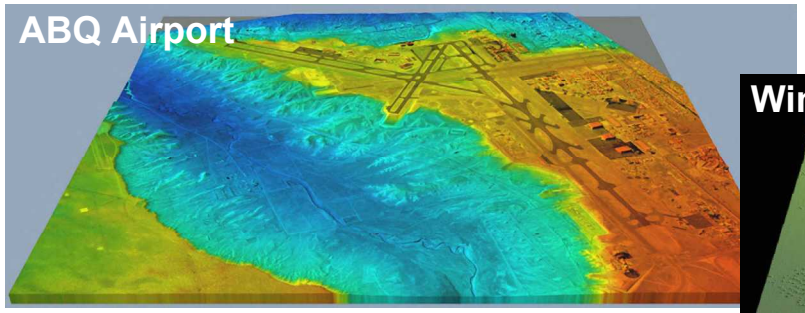


aD Flexural Plate Wave Sensor
(environmental, chemical and biological sensing)

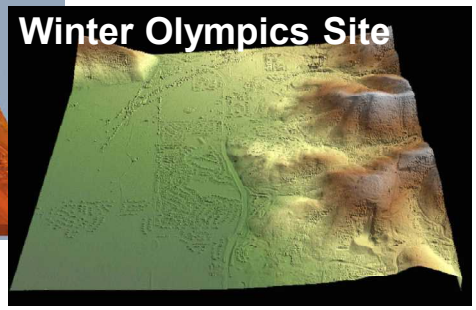


First demonstration of an aD MEMs device

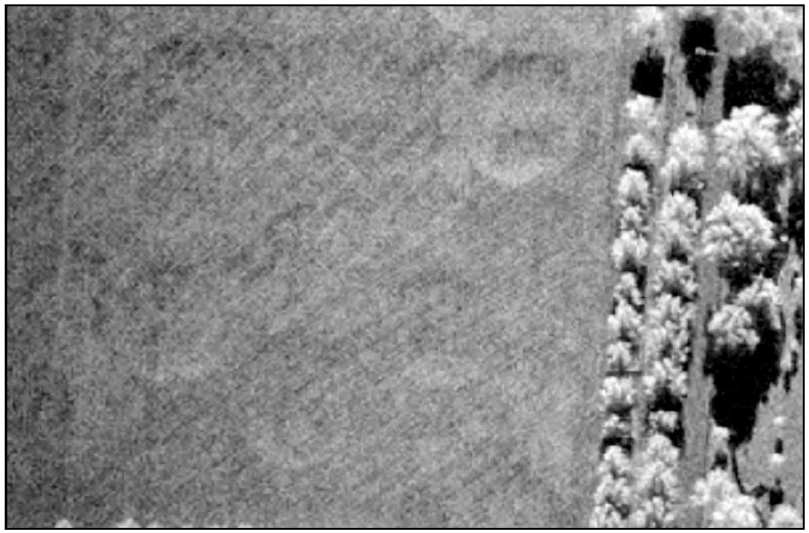
Ultra Hi-Res Imaging with Synthetic Aperture Radar

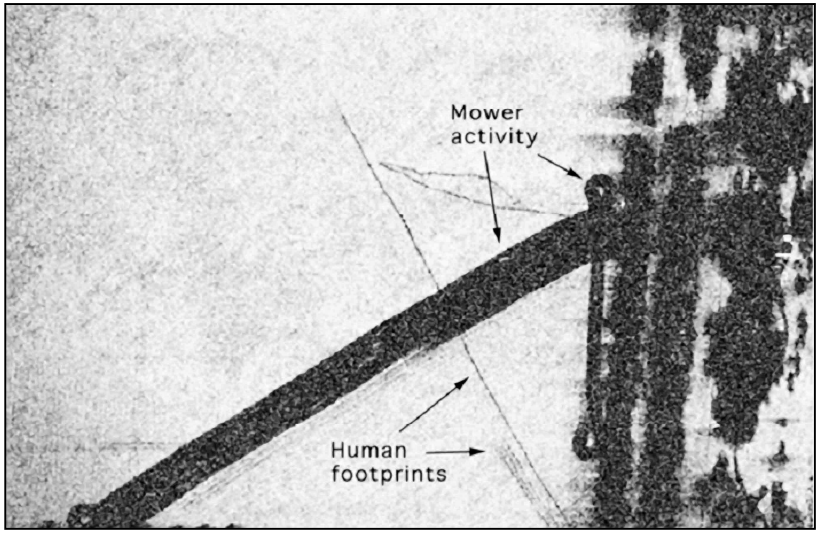


Rapid Terrain Visualization



- **Provides hi-res photographic-like images through clouds, rain, and fog during the day or at night up to 50 miles away.**
- **New Mini-SAR relies heavily upon RF MEMS and solid state GaN power supplies.**



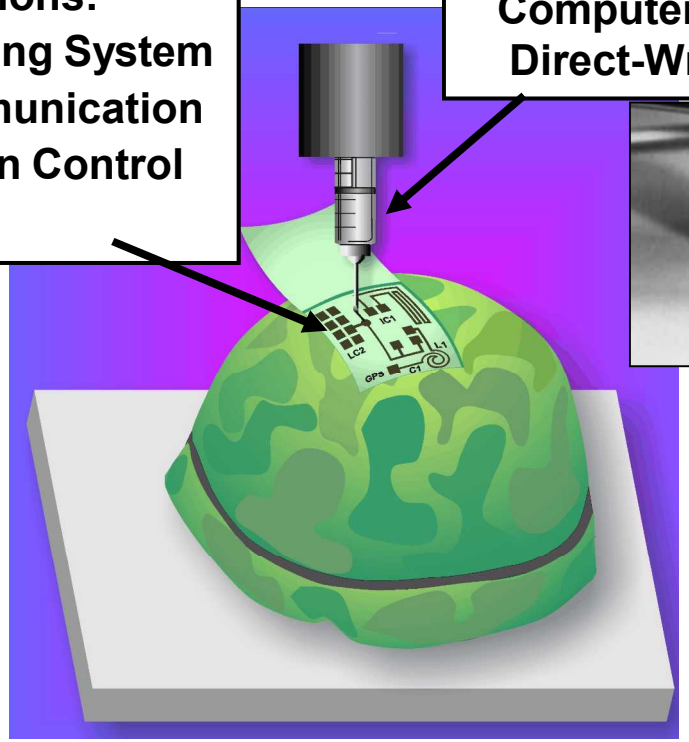


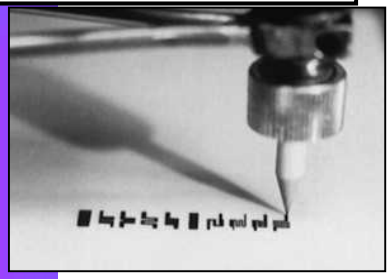
Coherent Change Detection

3-D Direct Write Conformal Electronics

MICE
DARPA
DSO

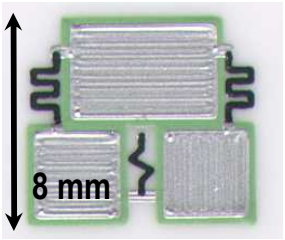
Possible Applications:
- Global Positioning System
- 2-Way RF Communication
- Remote Weapon Control
- Sensor array





Transformer

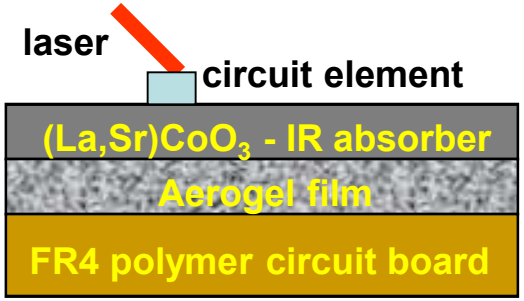
RF filter



Aerogels -- the world's lightest solid!

- Combination of low density (≤ 5%) and small cell size (< 20 nm) confer unique properties to aerogels.
- Aerogels have 3x lower thermal conductivity than ceramic fiber insulation

Aerogel insulation & rapid thermal processing used to reduce thermal impact on substrate -
⇒ processing reduced from min to sec



NNSA National Nuclear Security Administration

Mesoscopic Integrated Conformal Electronics

Sandia National Laboratories

Chemical and Biological Remediation

Need:

- Quickly, safely, economically decontaminate areas containing chem/bio hazards.
- Safely neutralize legacy chemical weapons in an environmentally friendly manner.

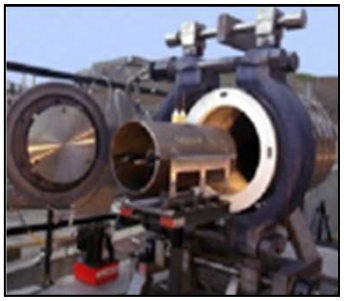
Technical Approach:

- Surfactant/oxidizer decontamination foam that is effective, safe, & inexpensive.
- Use shape charges to open munition inside a special containment vessel, then render hazardous agent harmless with caustic chemicals inside the vessel.

Decon Foam

- Effective against all typical chem/bio hazards
- Non-toxic, non-corrosive foam, fog, or mist.
- Successfully neutralize anthrax in Congressional office bldgs & commercial bldgs. in NY.
- Commercially licensed, used by US military.

Explosive Destruction System (EDS)



- Designed for WWI/WWII vintage CW materiel.
- Portable system obviates need to transport potentially unsafe legacy weapons.
- >100 legacy weapons neutralized to-date.
- Possibly >100 buried munition sites in US.

Bomb Disablement

Sandia PAN Disruptor was used to disable Unabomber and Shoe Bomber devices.

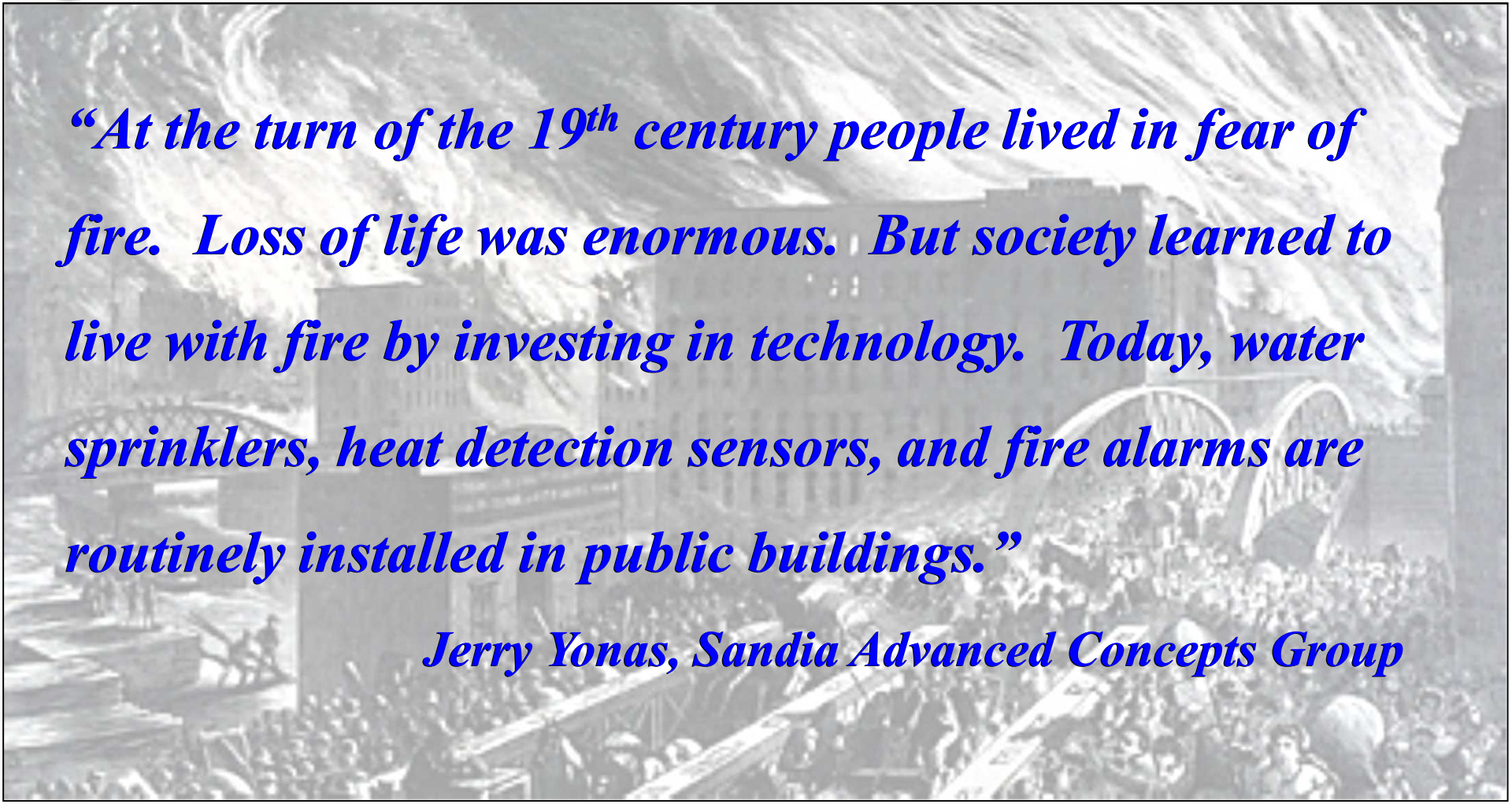
- Safe, non-explosive disablement saves lives and preserves critical evidence.
- Since 1994 Sandia has held an ongoing series of regional bomb disposal workshops.
- PAN commercially licensed in 1995.
- Sandia PAN Disruptor is now the primary bomb disablement tool for bomb squads across US.

NNSA National Nuclear Security Administration

NNSA National Nuclear Security Administration

Sandia National Laboratories

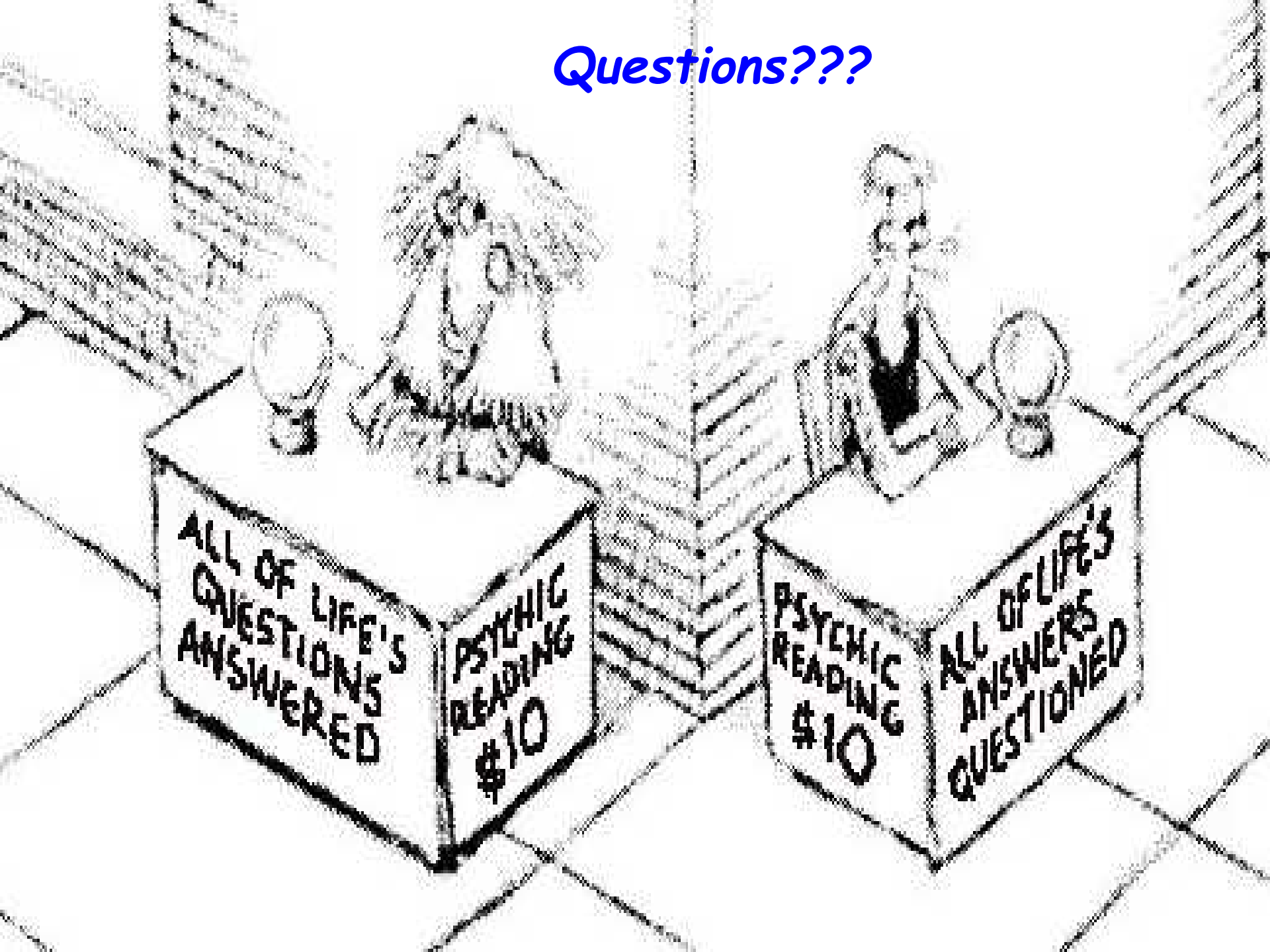
Fear of Fire



"At the turn of the 19th century people lived in fear of fire. Loss of life was enormous. But society learned to live with fire by investing in technology. Today, water sprinklers, heat detection sensors, and fire alarms are routinely installed in public buildings."

Jerry Yonas, Sandia Advanced Concepts Group

Questions???


ALL OF LIFE'S QUESTIONS ANSWERED
PSYCHIC READING $10
PSYCHIC READING $10
ALL OF LIFE'S ANSWERS QUESTIONED

"Helping to Secure
a Peaceful and Free World
Through Technology"