

Welcoming KAFB OCD to Sandia's Micro- and Nano-technology!

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Sandia is a Multiprogram Laboratory Operated by Sandia Corporation,
a Lockheed Martin Company, for the United States Department of Energy
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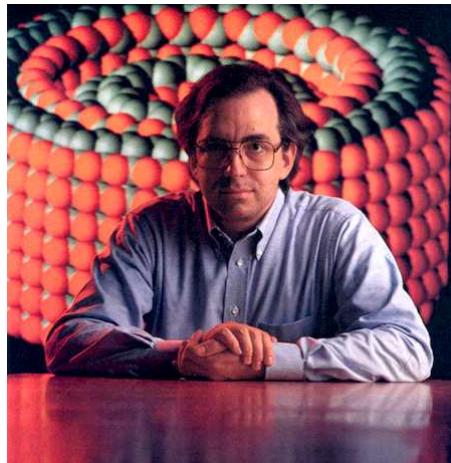


The future could be scary!

*“Nanotechnology will alleviate world hunger, clean the environment, cure cancer, guarantee biblical life spans or concoct super weapons of untold horrors.”**



Nano-aliens fight human warfare



* Scientific American, Sept., 2001.

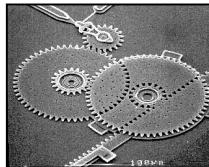
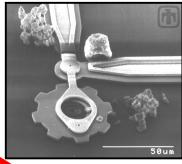
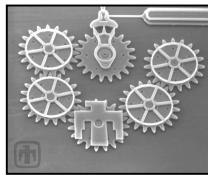
Nano-assemblers that will be able to copy and duplicate themselves, self-assemble into anything, including human body parts, in seconds. These nano-assemblers may take control of human race.



Trains and airplanes powered by nano-machines

This talk will steer you to where reality begins.

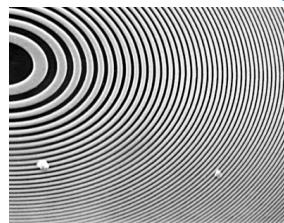
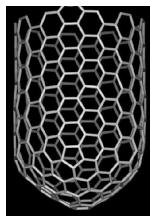
This talk focuses on micro and nano. Other talks cover macroscopic systems.



Head of a pin
1-2 mm

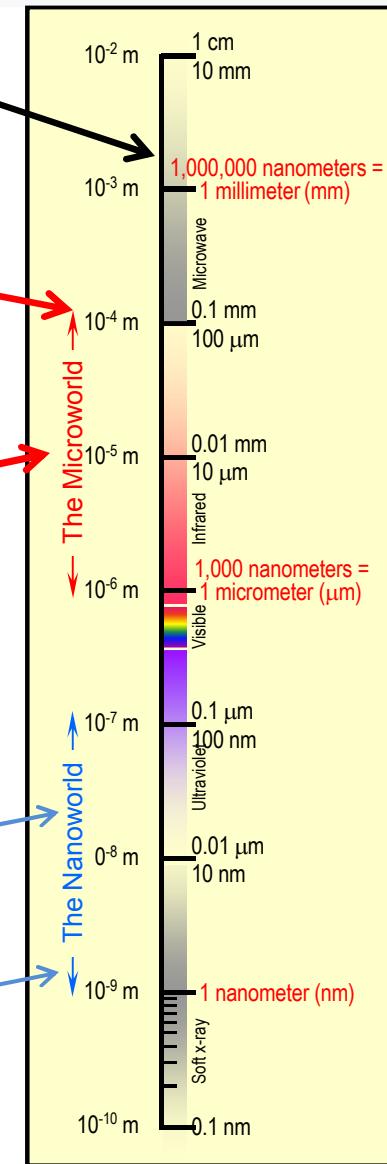
Micro-Machines
 $10 - 100 \mu\text{m}$ wide

Carbon nanotube
 $\sim 2 \text{ nm}$ diameter



X-ray "lens"
ring spacing $\sim 35 \text{ nm}$

In Greek, micro = "small", Nano = "dwarf"



10⁻³ meter

10⁻⁶ meter

10⁻⁹ meter



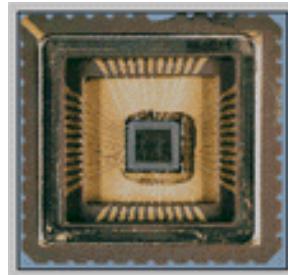
DOE sustains Sandia's mission in microelectronics and microsystems

We:

- assure the reliability of all stockpile electronics
- provide the most parts (make or buy) to the Nuclear Stockpile
- are the Nation's contingency for rad-hard Microelectronics



Reliability tester



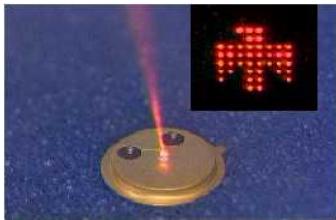
SA 3935 Digital ASIC



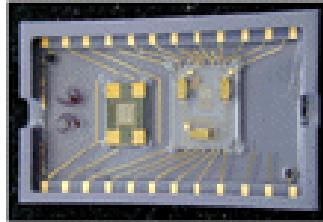
MESA Fabrication Facilities
HR105-271 page 87, SR105-44 page 102

- pioneer new technologies for Sandia and the Nation

- are leaders in developing intelligent, integrated microsystems



Visible VCSEL



MicroChemLab



Micro Gas Analysis Unit



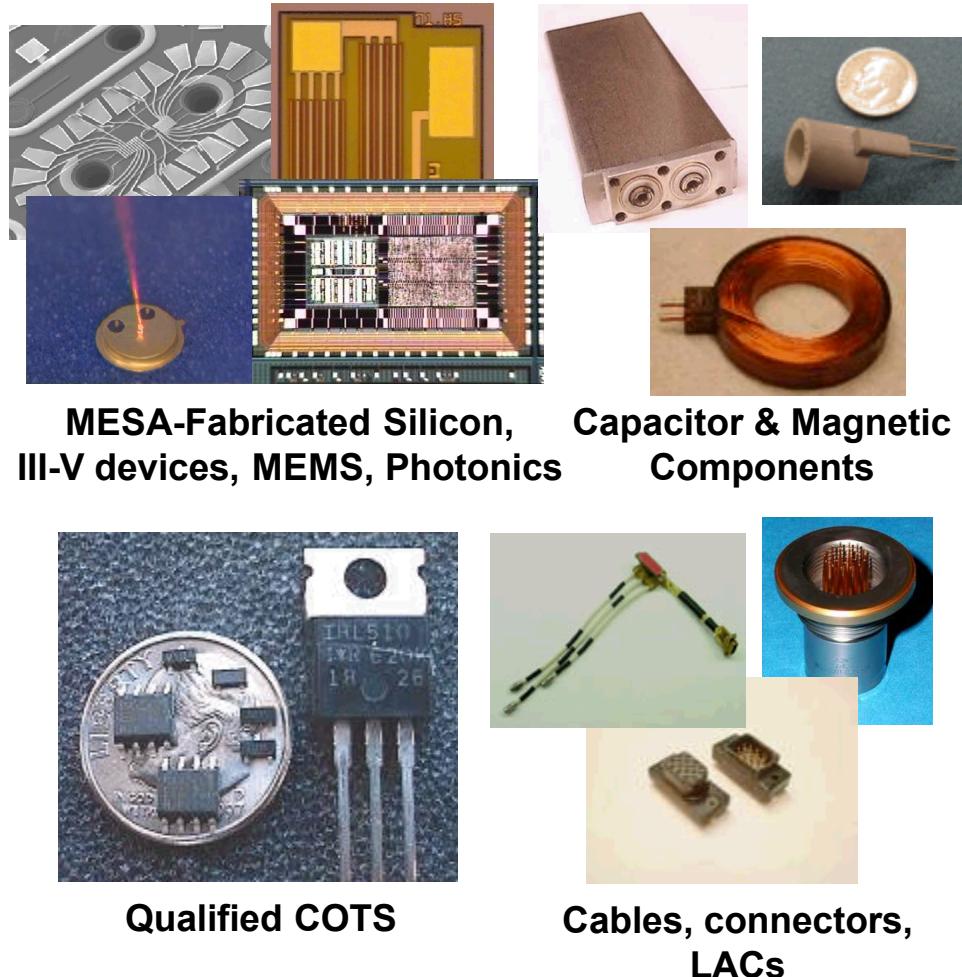
MEMS optical link

We've been doing it for over 50 years!

We'll be around as long as there's a nuclear stockpile.

Sandia supports the entire weapon life cycle through a buy/transfer/make strategy

- **Buy** standard commercial products *when they can be qualified* to meet mission requirements- including Trust
- Design custom components (silicon, III-V compounds, MEMS, photonics, custom magnetics, capacitors, radio-frequency components, interconnects, transducers, & clocks) for production in industry or at Sandia
 - First work with industry to supply components; **transfer** technology from Sandia when necessary
 - As appropriate, **supply** products from our MESA Facilities as the last resort.

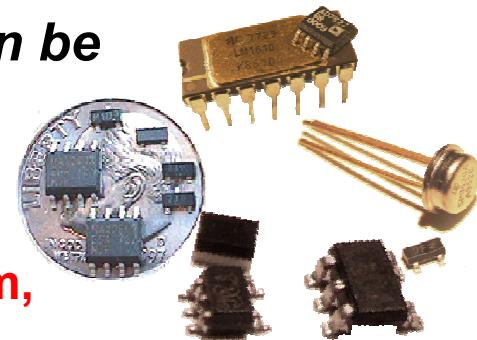


Systems are differentiated by functionalities not available to any other potential adversary. Let's focus on the transfer/supply approach

Sandia's Science and Technology base impacts each part of buy/transfer/make

Buy standard commercial products *when they can be qualified to meet mission requirements*

- **Issues:** Counterfeit parts, adversarial threats, new technologies/obsolescence
- **Essential support:** War-Reserve COTS, Trust Program, last-resort internal supply



Transfer technology from Sandia for industry production

- **Issue:** Intermittent, low-volume production is difficult for industry to sustain.
- **Essential support:** Technical assistance, quality oversight



Make as appropriate, **supply** products from our MESA Facilities as the last resort.

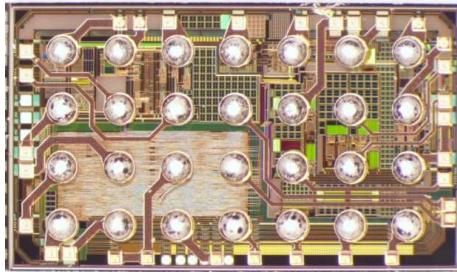
- **Issues:** Technology maturation, capability sustainment
- **Essential support:** Design, fabrication, test, packaging, reliability, failure analysis, Trust, radiation survivability, quality system



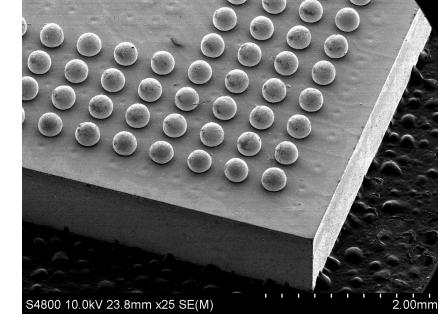
Sandia identified future challenges for COTS.

■ New Technologies

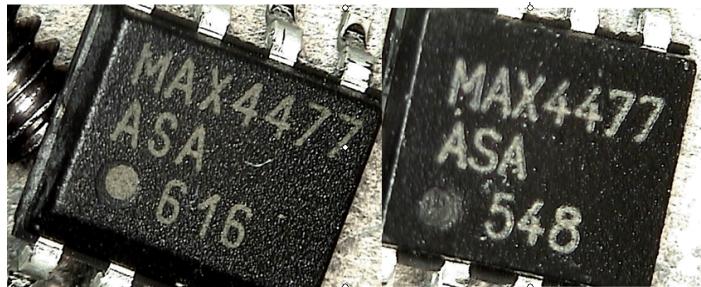
Chip Scale
Package
(CSP)



Fine Pitch Ball
Grid Array (BGA)



- Trusted COTS (adversarial threat)
- Counterfeit Part Threat

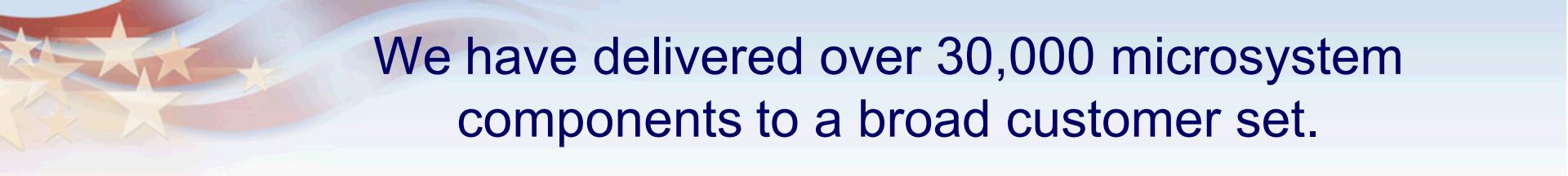


Genuine Counterfeit



Genuine Counterfeit

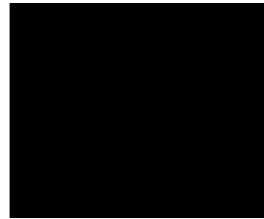
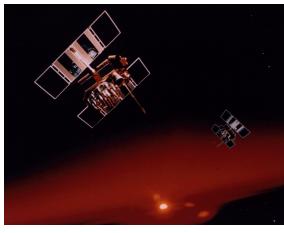
If you haven't found a counterfeit part in your system,
you haven't been looking hard enough.



We have delivered over 30,000 microsystem components to a broad customer set.

We deliver custom components when no one else will.

Our customer base includes



Nuclear Weapons
(NA10)

Non Proliferation
Payloads (NA20)

30 Classified
Customers

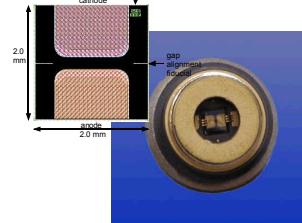


All deliveries were made on schedule
during the MESA retooling.

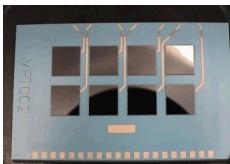
Our product deliveries include:



Neutron-immune
QASPR III-V
Transistors



III-V Switch Tube
Replacement



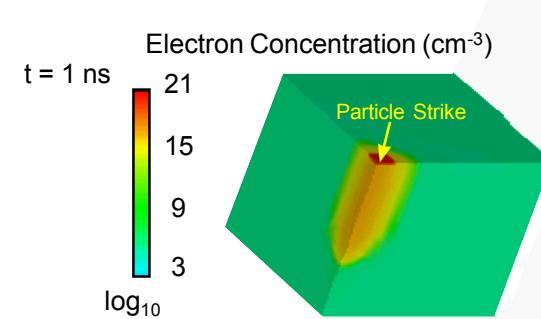
ASICs and multi-
chip modules



MicroChemLab-based
Sensor systems



Sensitive
Microsystems



Modeling and simulation saved 8 months
and \$1.5M in Permafrost technology
development.

Sandia's entire micro- and nano-technology capability designs, develops, and qualifies fully custom Trusted components.

Silicon Fab: Microelectronics

Unique custom and rad-hard process technologies

- TAPO-Certified Trusted Foundry
- Strategically rad-hard devices and circuits unavailable from other potential providers

Trusted Design:

Expertise in custom design of integrated circuits

- Secure microcontrollers
- Analog/Digital/RF
- IBM Trusted Foundry
- Tamper Resistant Features

Packaging & Qualification:

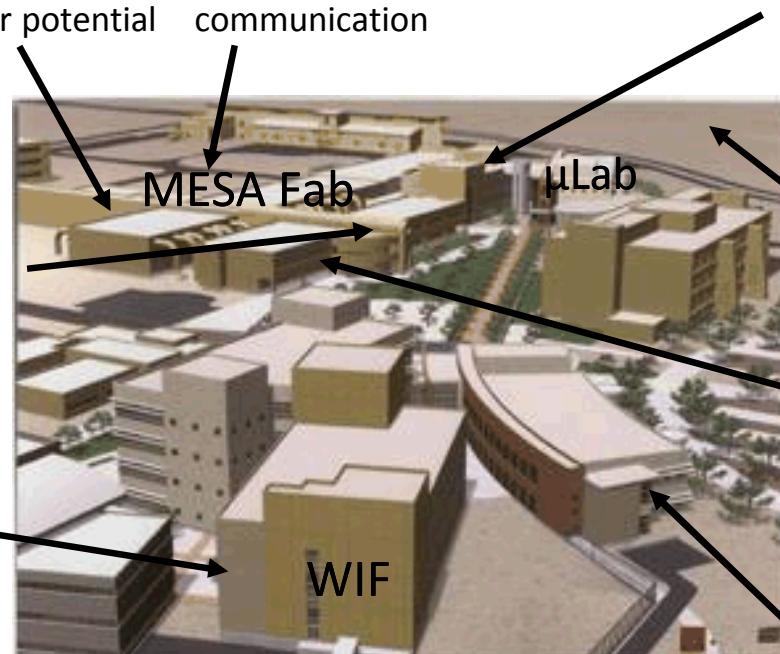
Custom packaging & COTS qualification

- Advanced packaging
- Custom components (cables, connectors, capacitors, frequency devices, magnetics)

Silicon Fab: Micromachining

Deposition, patterning reactive ion etching for micromachines.

- Surety components
- Embedded surveillance including communication



MicroLab:

Extensive growth and processing of III-V semiconductor devices

- Neutron-immune heterojunction bipolar transistors
- Rad-hard optical links
- Solid-state radio-frequency devices (radar and communications)

Nanotechnology:

Advanced sensors
Options for novel devices

Failure Analysis:

Microsystems reliability & failure analysis expertise

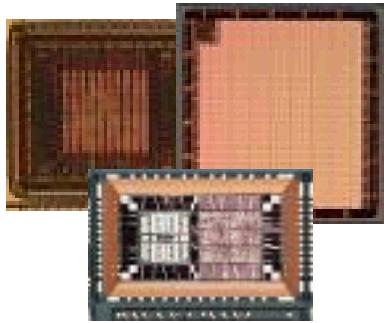
- Vulnerability analysis in NW systems

Design, Modeling, & Simulation:

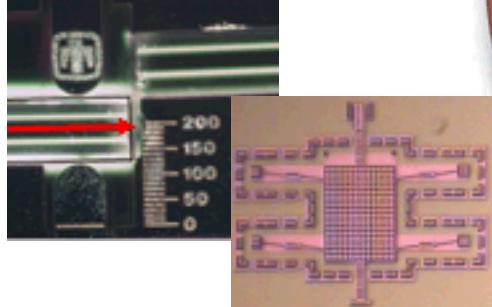
3-D system analysis



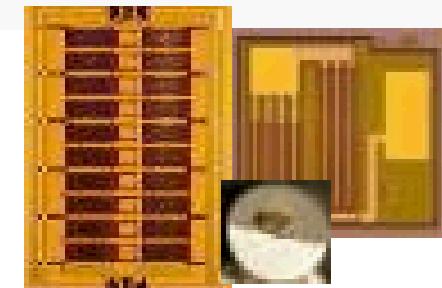
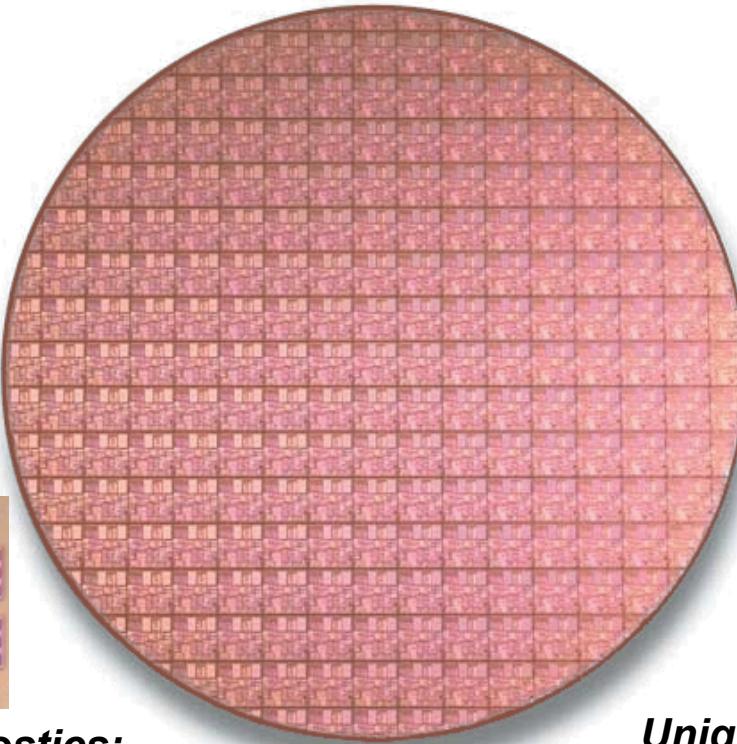
Sandia develops and delivers the non-commercial products required for National Security Systems.



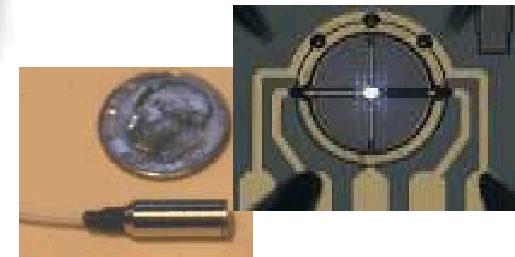
Key products: Rad-hard digital and analog Trusted ASICs



Nuclear Weapon diagnostics:
MEMS Shock Switch & Optical Switch

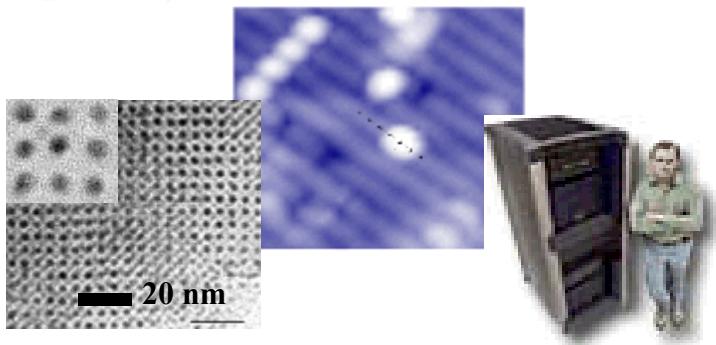


Unique requirements:
High-voltage and rad-hard HBT compound semiconductor devices in non-commercial form factors



Unique functionalities: Photo-Conducting Semiconductor Switch, Vertical Cavity Semiconductor Lasers, Optical Monitors

We draw on all the resources of a National Laboratory to support Sandia's mission areas



Synthesis, Characterization, & Theory

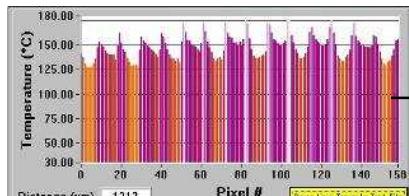
Atom-level Physical and Chemical Sciences

Quantum Dots

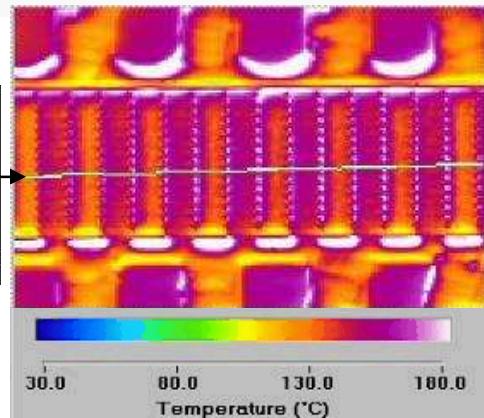


Test and Validation

Optical tweezers for macrophage cells in microfluidic devices



The Model



The Data

Advanced Computation

Thermal Modeling of GaN Power Amplifier Junction temperatures without heat spreaders

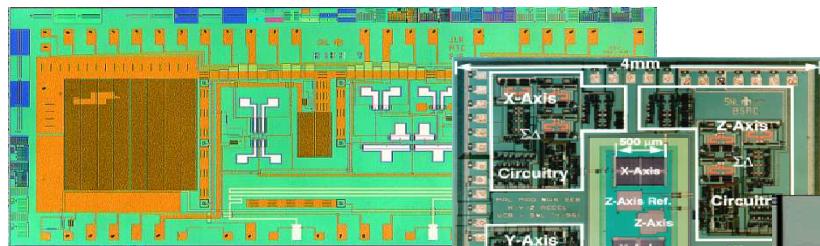


Engineering Complex Systems

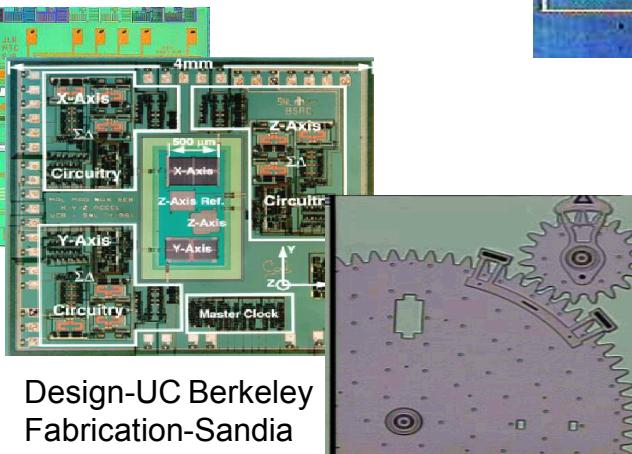
Sandia Multispectral Thermal Imager Satellite

Integrated Microsystems add functions instead of more transistors to a chip

- The next leap in function will involve more than just packing additional transistors on the chip
- It will involve the building of new microscopic structures along side the transistors, giving the chip the ability to:

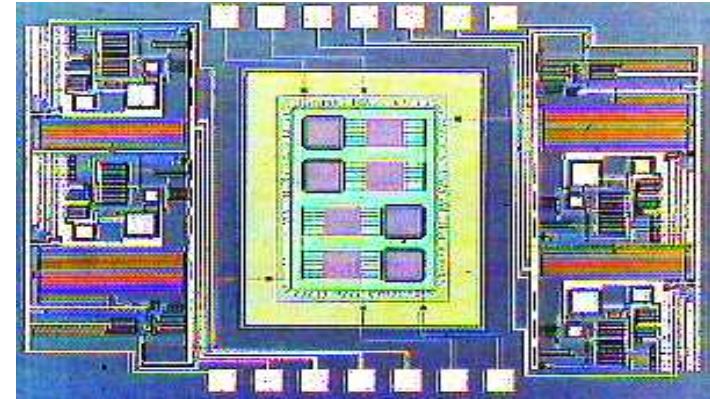


Sense

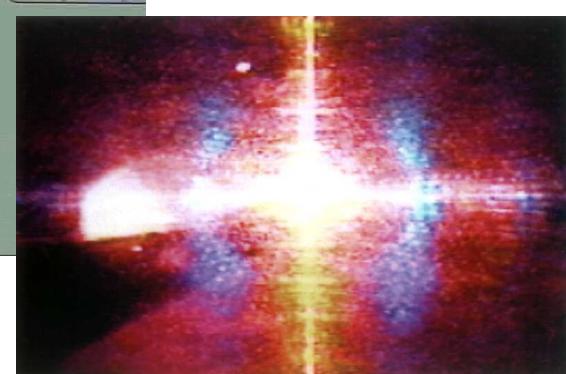


Design-UC Berkeley
Fabrication-Sandia

Think

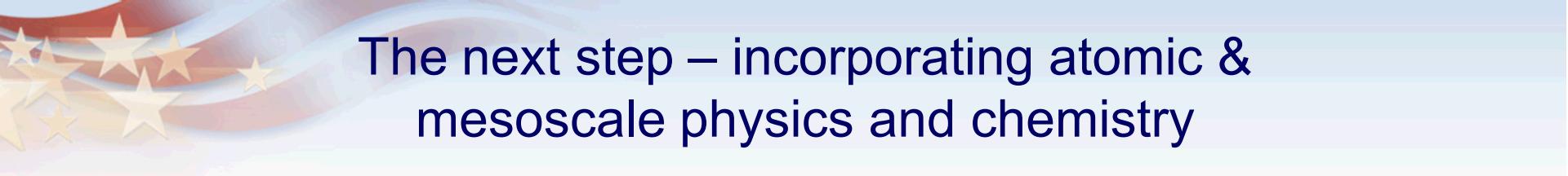


Act

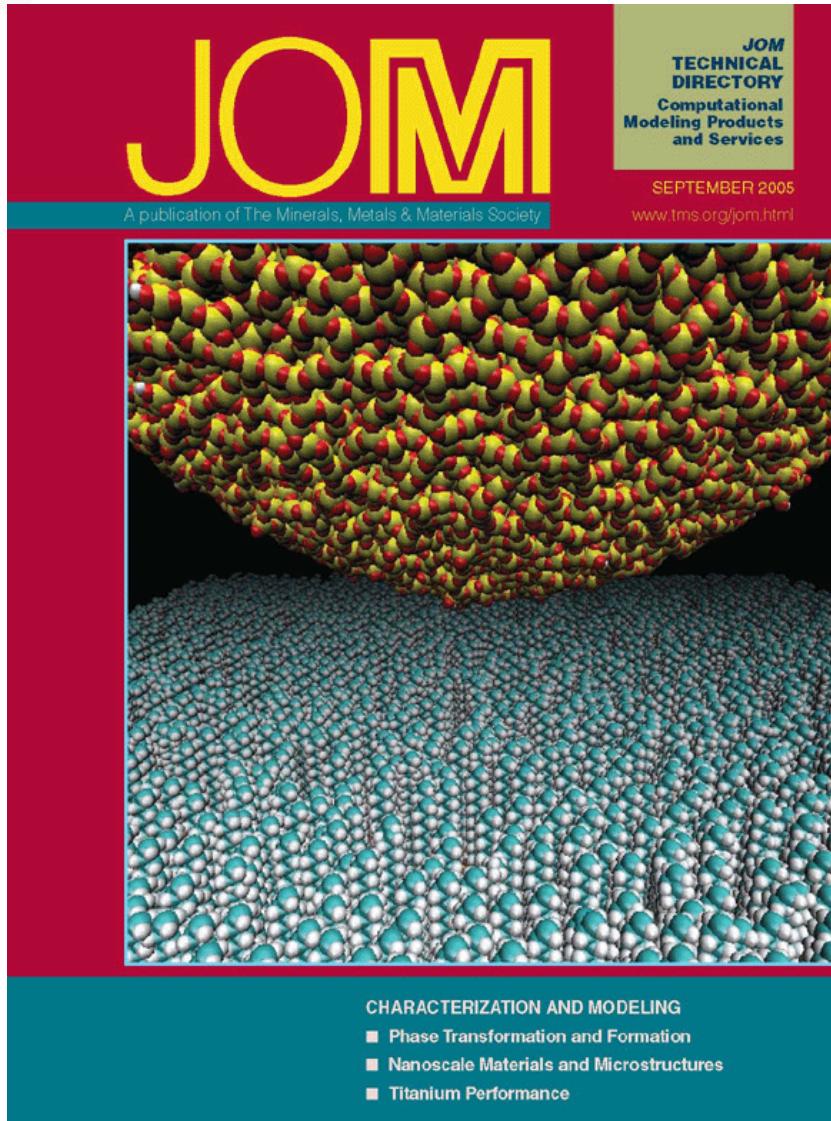


Communicate

All integrated within
a single package!



The next step – incorporating atomic & mesoscale physics and chemistry



Sandia is a world leader in materials modeling

The magazine cover article highlights Molecular Dynamics simulations of adhesion and friction to predict and improve performance and reliability



We develop integrated nanosystems using a nanosystem platform concept

Transform to modular approaches modeled on microsystems - adaptable & responsive



Modular Integrated Nanosystem Platforms

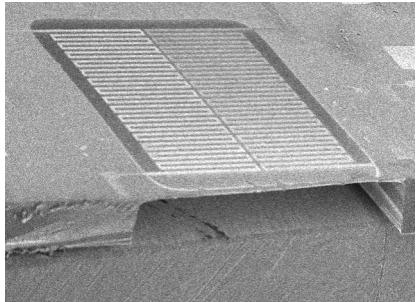
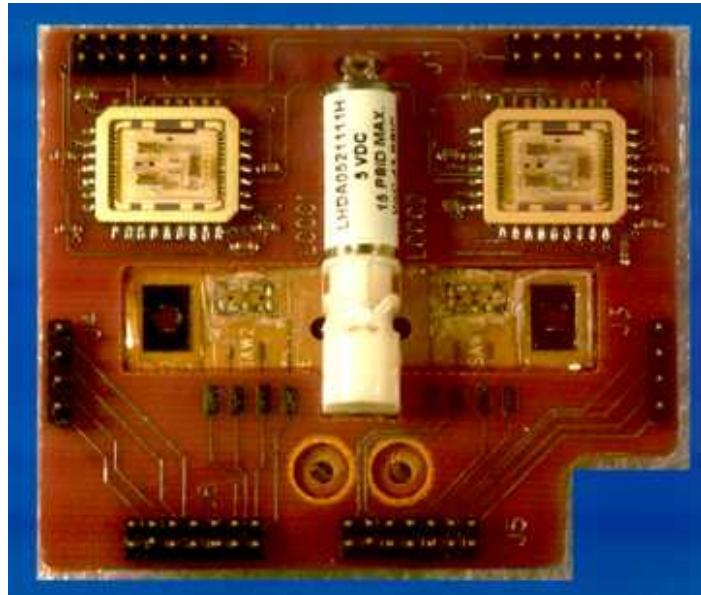
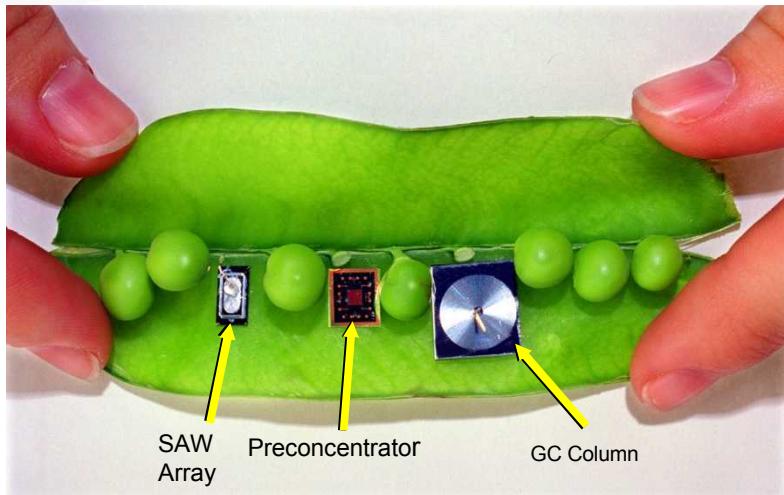
Smaller, lighter, new functionality (e.g., self-repairing)

Elements of Platforms:

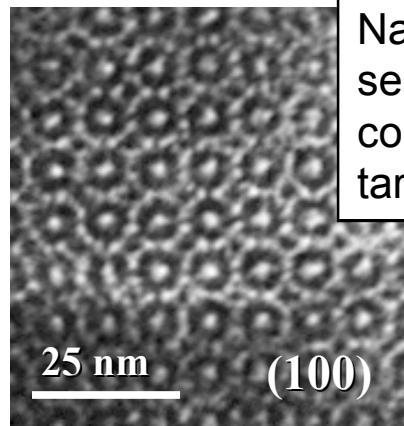
- Power/energy – energy generation, storage, conservation, efficiency, remote creation & harvesting
- Sensor systems – Chem-Bio-Nuclear threat detection, tagging, location and motion detection, activity detection, ...
- Communication & information processing – nanoelectronics & nanophotonics, memory, signal processing, quantum information processing
- System delivery/transportation

Integrated Systems – CINT Discovery Platforms™ – first step in this direction

One example: Sandia's Micro-ChemLab™ has nanotechnology inside



Micro-scale heater



Nanoporous film
selectively
concentrates
target analytes.



Two of Sandia's major capabilities help us realize fully custom functionalities.



MESA DoD-Certified Trusted Fabrication Facility Complex



Center for Integrated Nanotechnologies

*To learn more: www.NANO.GOV and
<http://www.sandia.gov/mstc/>*



In Summary

- Sandia is sustained by the Department of Energy to assure a supply of Trusted Components for nuclear weapons and nonproliferation satellites.
- Sandia investigates concepts, matures technologies, and when necessary delivers products that no one else will provide.
- To develop these custom products and systems, Sandia applies all the resources of a National Laboratory.
 - You'll get just a taste of these in the later talks.
- This is only the briefest of introductions. Come back again when you have more time for briefings in more detail.
 - And bring your friends!

Thank you for coming. We look forward to future interactions!