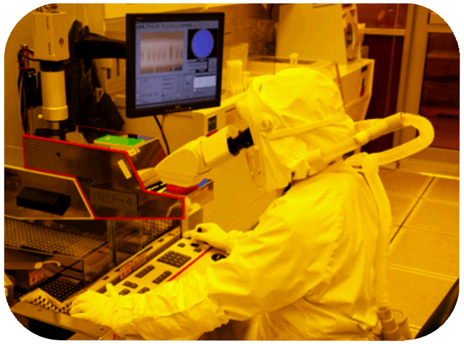
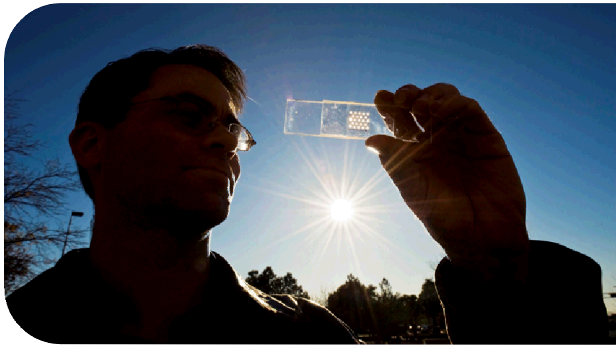
SAND2013-6901C

Exceptional service in the national interest

Sandia National Laboratories





Sandia's MESA Facility: Products for Today, Innovating for the Future

Gilbert V. Herrera

Director, Microsystems Science &Technology

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Roots in the Manhattan Project

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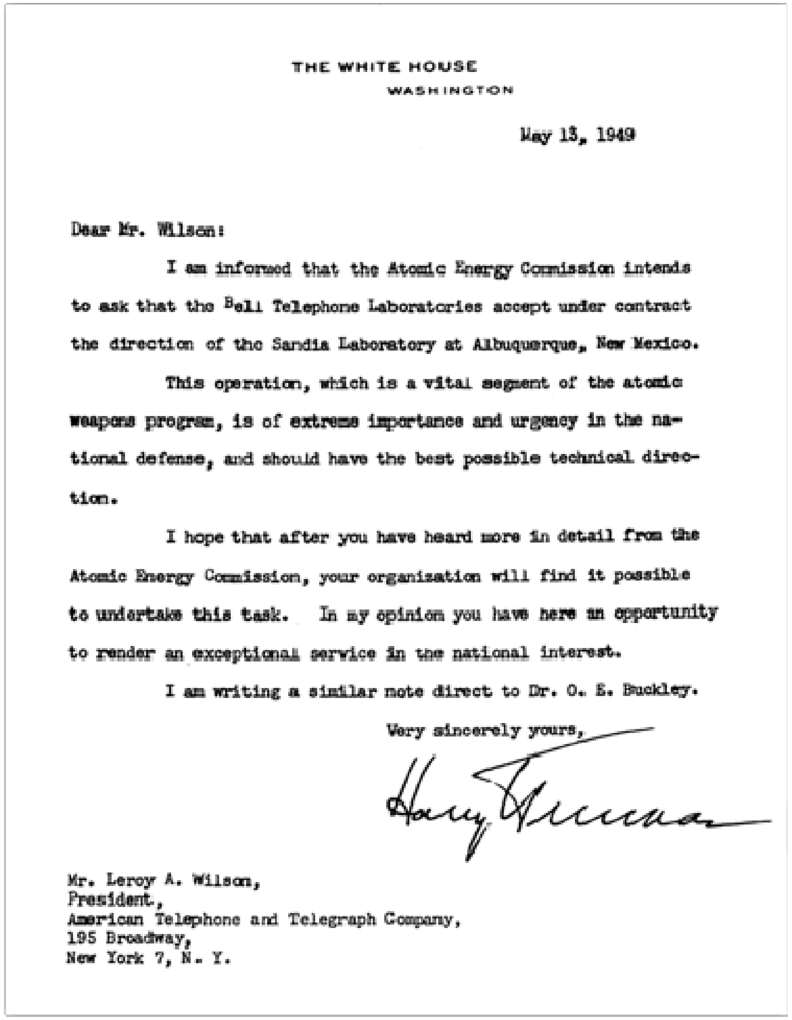


THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

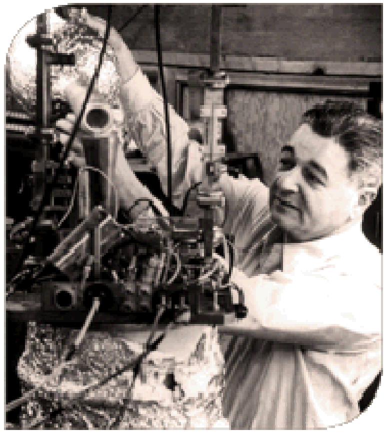
I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.



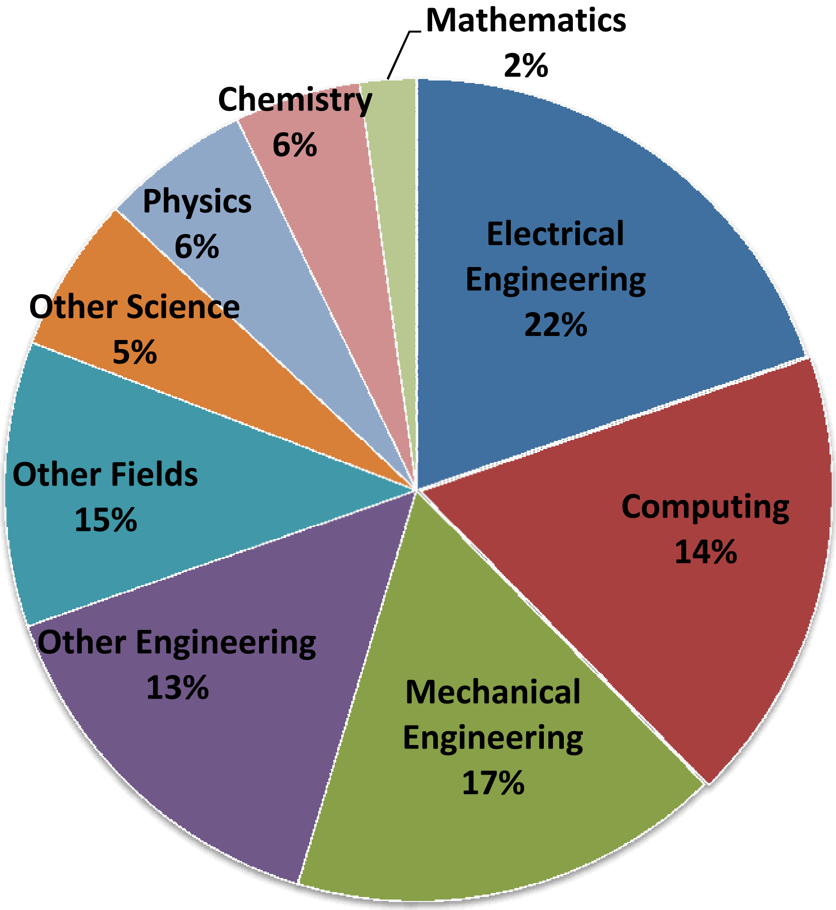
Sandia National Laboratories

Our Workforce

- On-site workforce: 11,711
- Regular employees: 9,494
- Gross payroll: ~$1.046 billion

Data as of April 12, 2013

R&D staff (4,799) by discipline

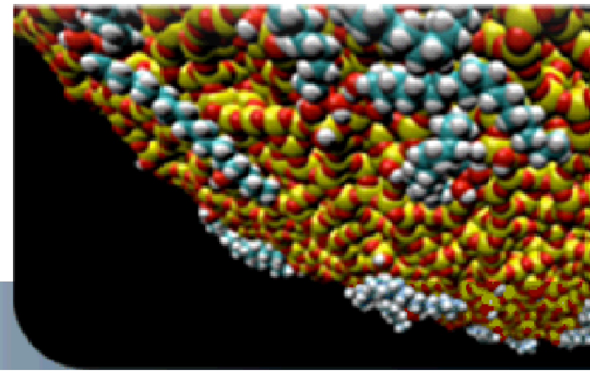


Foundations in Science and Engineering

Sandia National Laboratories

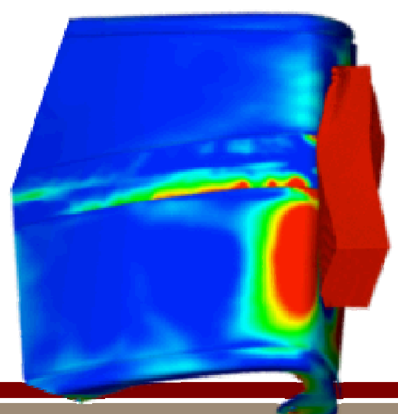
Computing and information science

Materials science

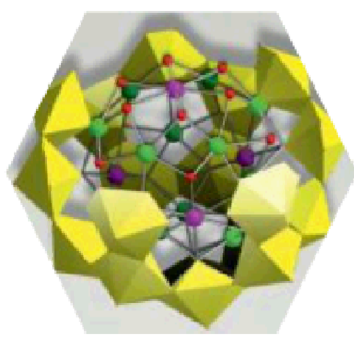


Nanodevices and microsystems

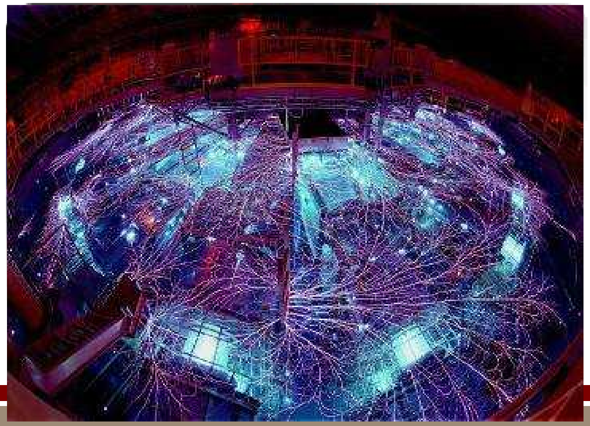
Engineering sciences



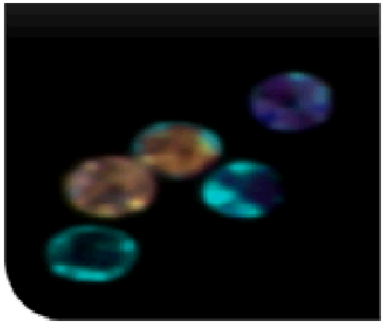
Geoscience



Radiation effects and high-energy density science



Bioscience



Microsystems Science, Technology, and Components Center

We are a research, development and production capability that converts concepts into working hardware.

- **We steward key infrastructure**
- **We conduct leading edge research**
- **We design, develop, fabricate, and qualify**
- **We partner with industry, universities, and government laboratories to rapidly convert the most advanced concepts into hardware.**

285 Patents - 42 R&D 100 Awards

MESA's Trusted Foundry: Supplying Hi–Rel Rad Hard Microelectronics while supporting the Research Community

MESA Silicon Fab

- Radiation Hardened CMOS Process
  - 350nm, 3.3V, Radiation Hardened, Silicon on Insulator Digital and Mixed Signal Technology
  - 5-Level MEMS Technology
- Custom Technologies
  - Ion Traps
  - Chem/Bio Detection Technologies
  - Si Photonics
  - GaN Resonators
  - 3-D Integration
- Part of the US Govt Trusted Supplier Network DoD Category 1A Trusted Supplier Certification

MESA Micro Fab

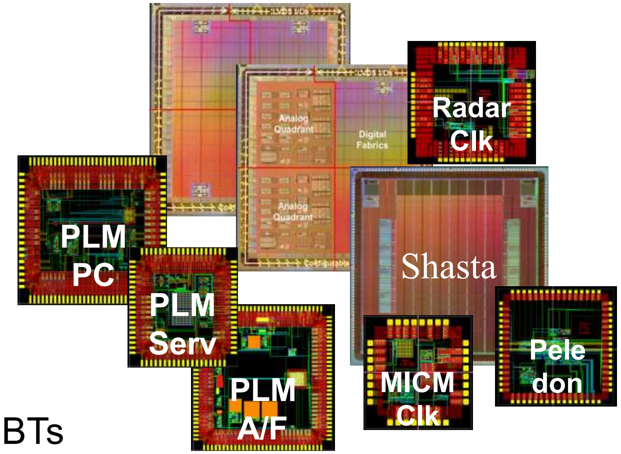
- III-V Compound Semiconductor Fabrication
- Compound Semiconductor Epitaxial Growth
- Compound Semiconductor Discretes, IC's and Optoelectronics

125 Light Laboratories Support and Extract Value from the MESA Fabs

NW Production

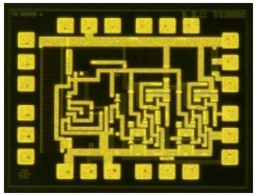
Develop, qualify, produce, survey and assess radiation hardened electronic and microelectronic nuclear weapon components.

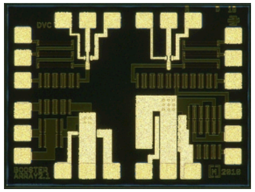
- Lifecycle Responsibility for NW Electronic Components
  - COTS cables/connectors, passive electronics and discrete semiconductors
  - Sandia External Production of specialty components
  - MESA production of ASICs and HBTs
- Fundamental Understanding from Underlying Physics through Packaged Devices
  - Electronic, optical, and mechanical properties
  - Failure mechanisms
  - Normal/abnormal/hostile performance
  - Radiation hardening
- Draws Upon All Division & Many Other SNL Capabilities
- Nuclear Enterprise Assurance



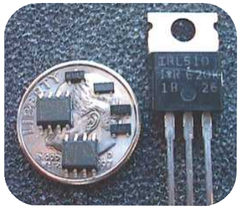
Silicon ASICs

HBTs





COTS & SEP

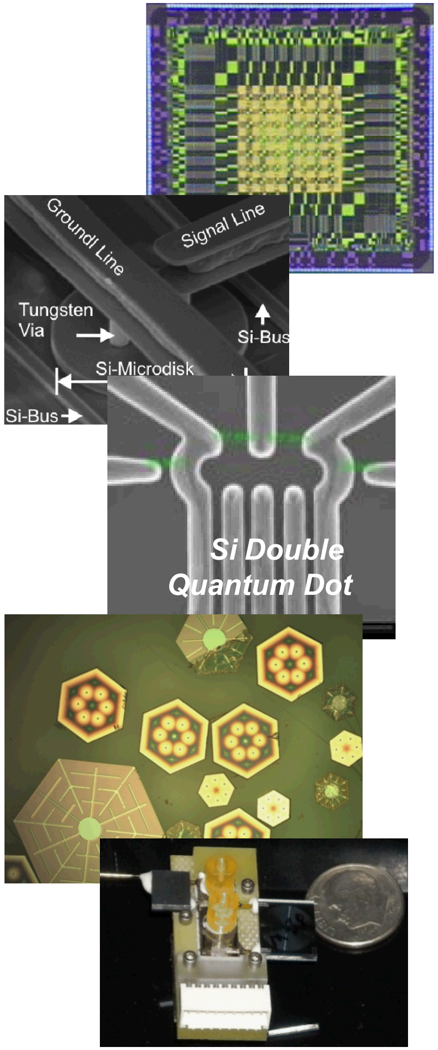


Nanodevices and Microsystems RF Focus

Sandia National Laboratories

Creating Enabling Opportunities for all of Sandia's SMUs

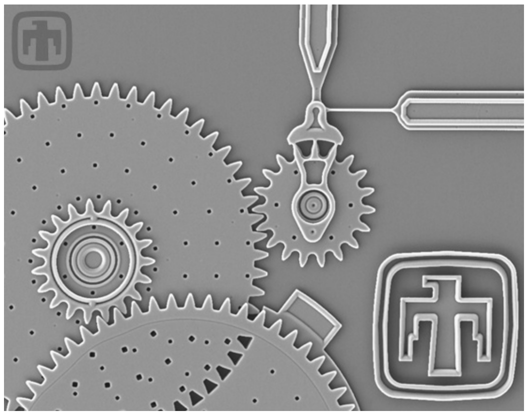
- **Trusted Radiation-Hardened Microelectronics:**
  - The development of concepts, devices and tools that enable the understanding and creation of fielded radiation-hardened microelectronics which are impervious to subversion.
- **Beyond Moore Technologies:**
  - The development of nanoscale and microscale concepts, devices, tools and systems that continue performance improvements beyond Moore's Law.
- **Optoelectronics of the Future:**
  - The discovery and creation of advanced optoelectronics, at the nanoscale and microscale, which provide new functionality.
- **Ultraportable Multi-function Sensor Systems:**
  - The development of nanoscale and microscale concepts, devices and systems that enable portable physical, chemical, biological, radiation, nuclear materials, and explosives detection that exceed current limitations in selectivity, sensitivity, and robustness.
- **Nanoscale and Microscale Enabled Performance:**
  - Discover and exploit new functionality that results from phenomena that are unique to the nanoscale and microscale.

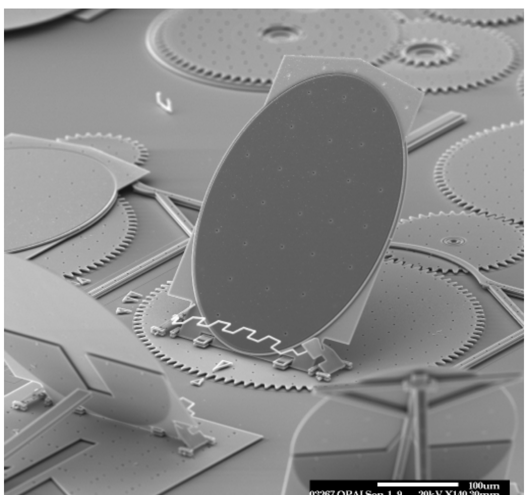


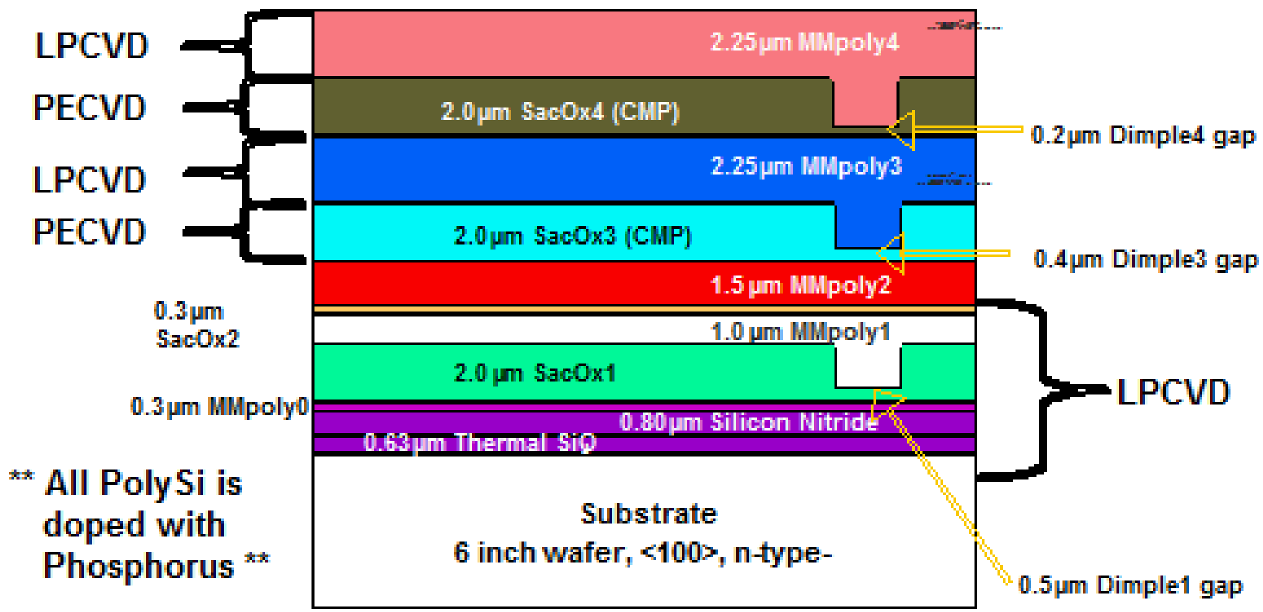
A Unique Capability: SUMMiT V™

Sandia
National
Laboratories

Sandia Ultraplanar, Multilevel MEMS Technology with 5 polysilicon layers

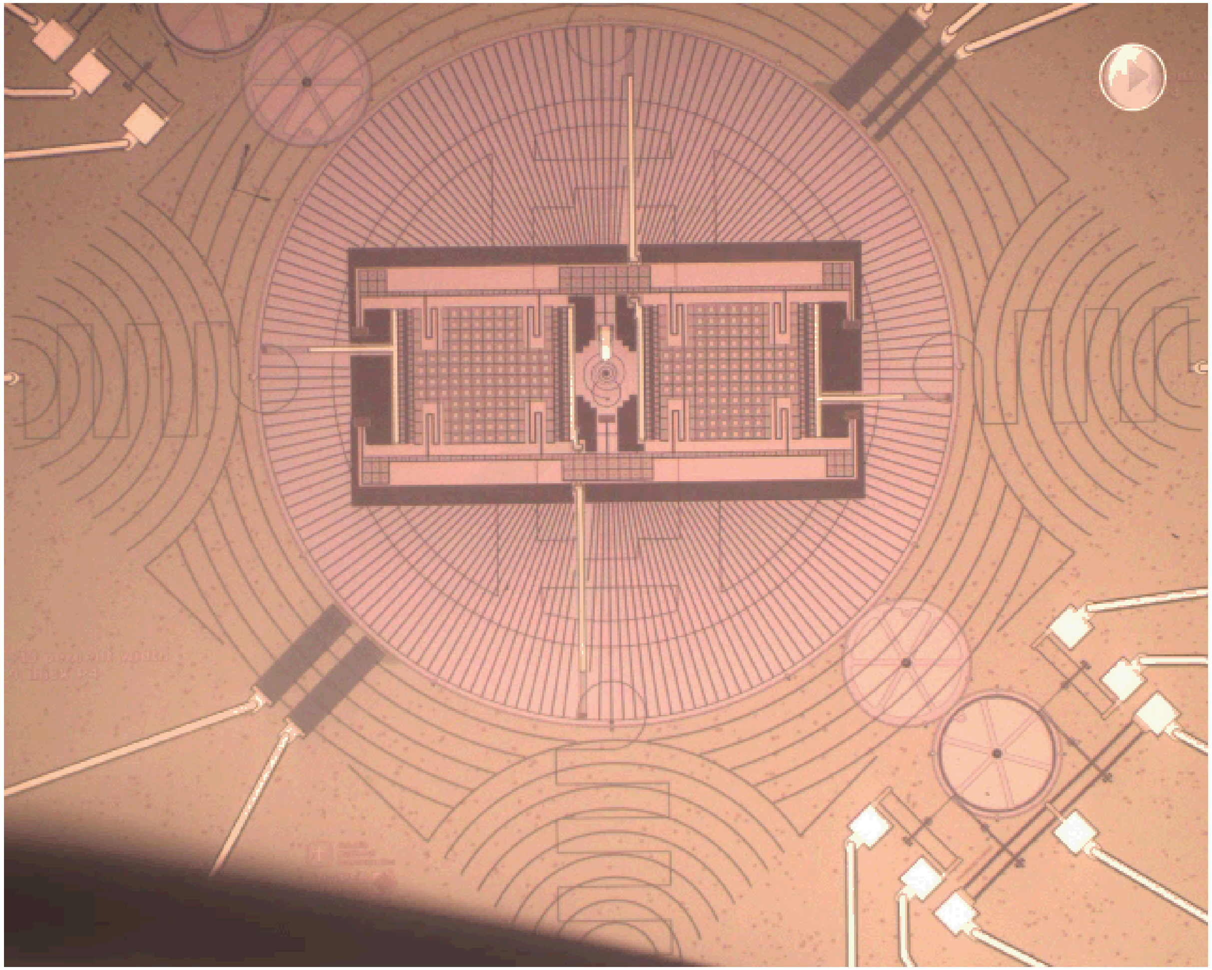






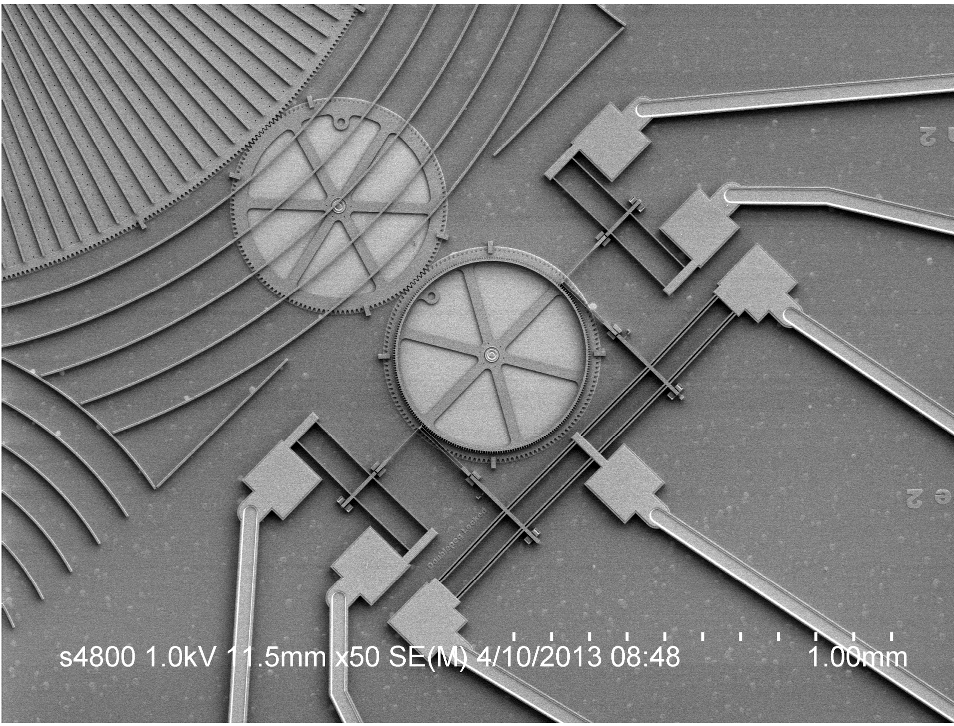
PASCAL Details

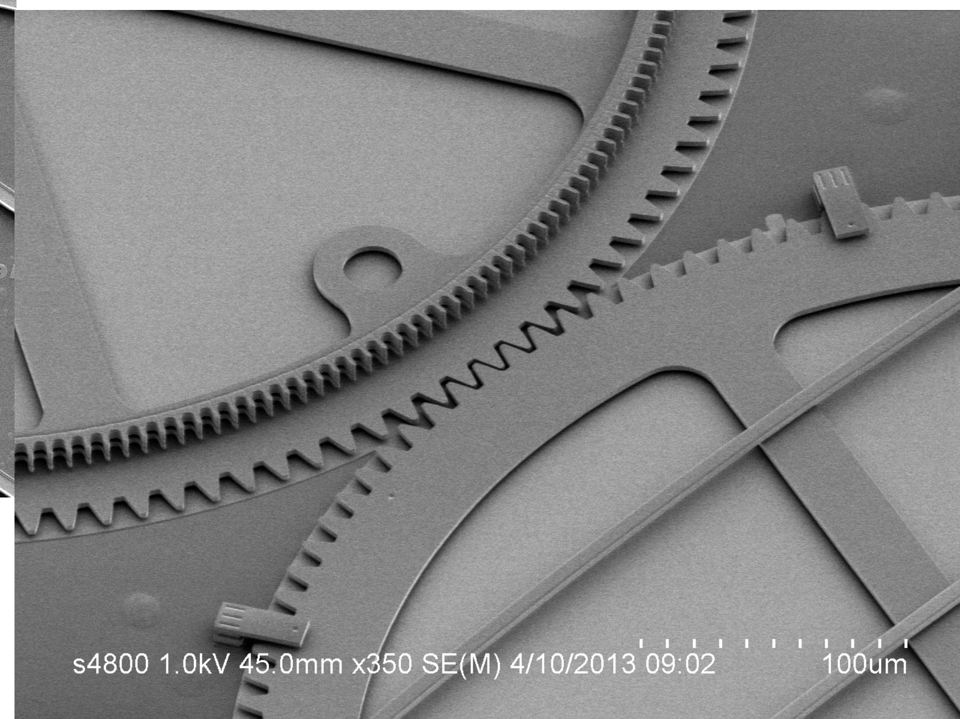
Bias reduction and scale factor calibration achieved by "carouselling" of rotating stage.



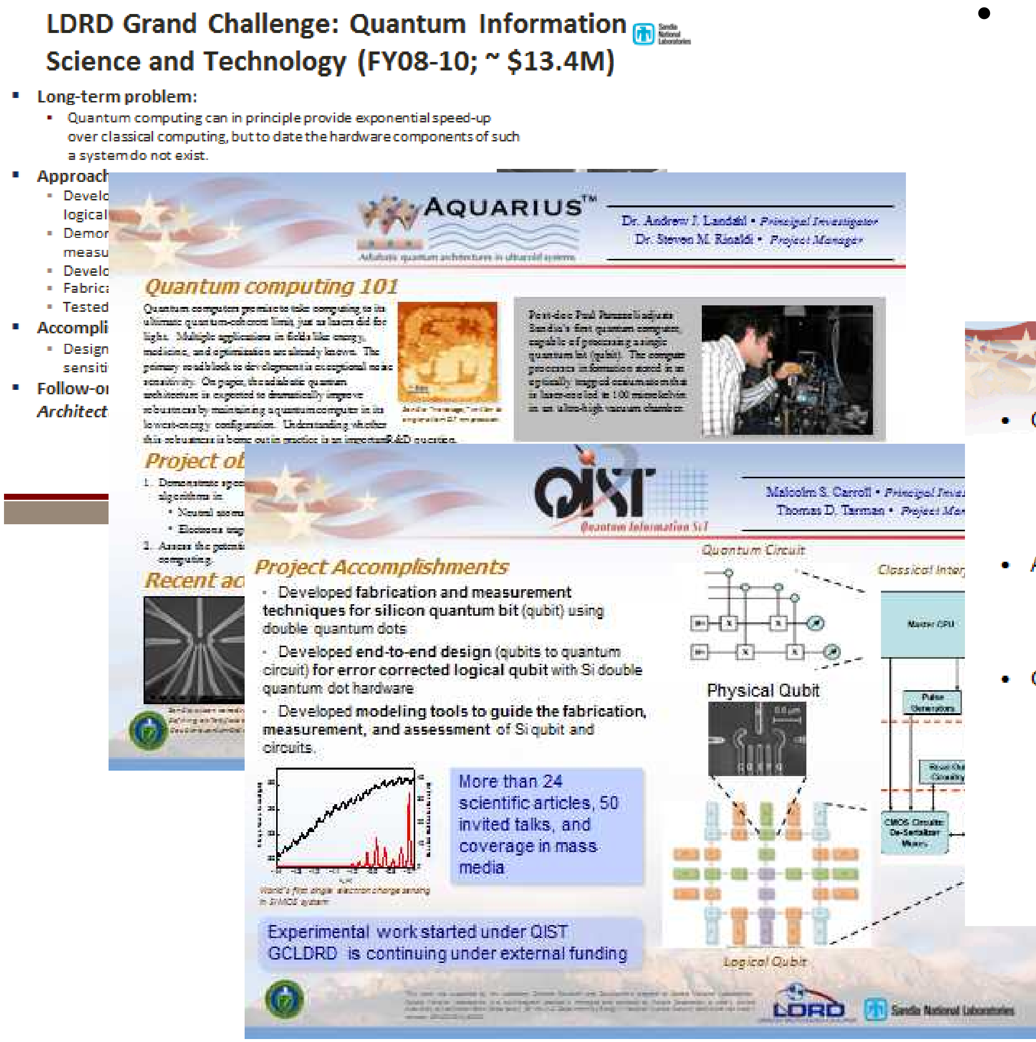
PASCAL Details

Bidirectional motion of rotating stage driven by thermal actuators and gears.

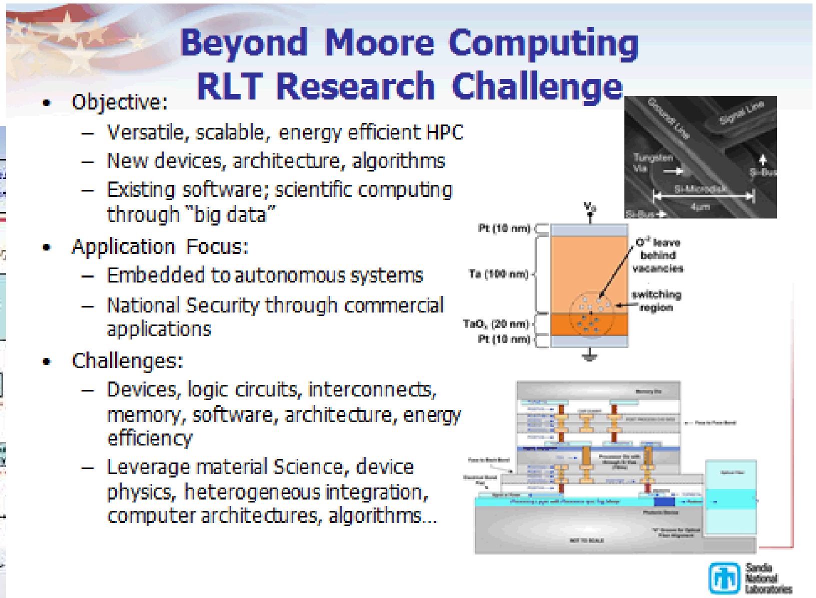




Quantum Information Processing Over $30M of investments at Sandia

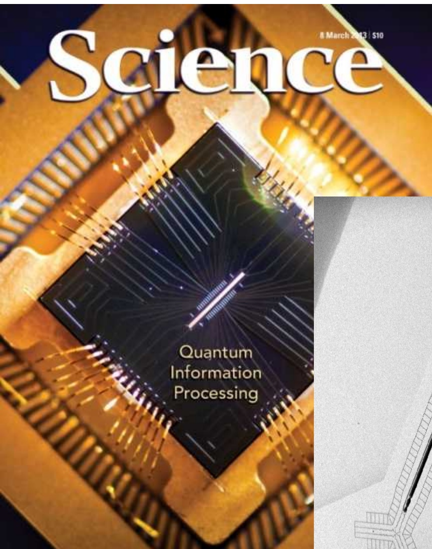


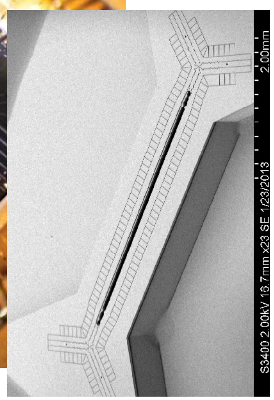
- Quantum Information Processing at Sandia enabled by 2 GC LDRDs



Quantum technologies and applications

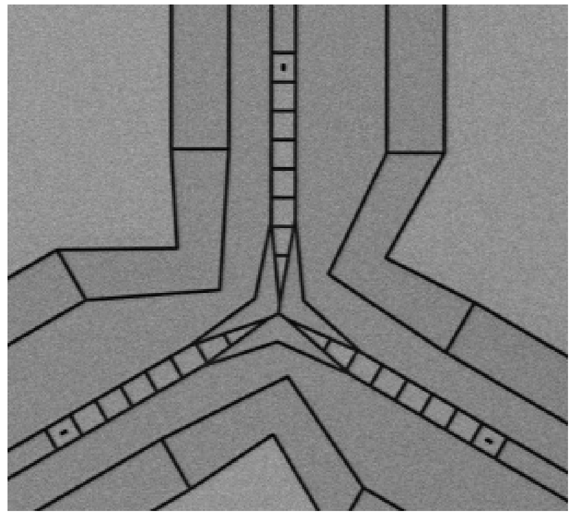
Quantum Information Processing





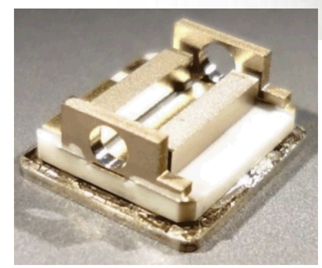
- 2008: Sandia's 1st "workhorse" trap
  - Used worldwide
  - Quantum operations
- 2013: Sandia's latest surface ion trap
  - Bowtie shape enables improved control of ions & quantum operations

Advanced surface ion trap concepts



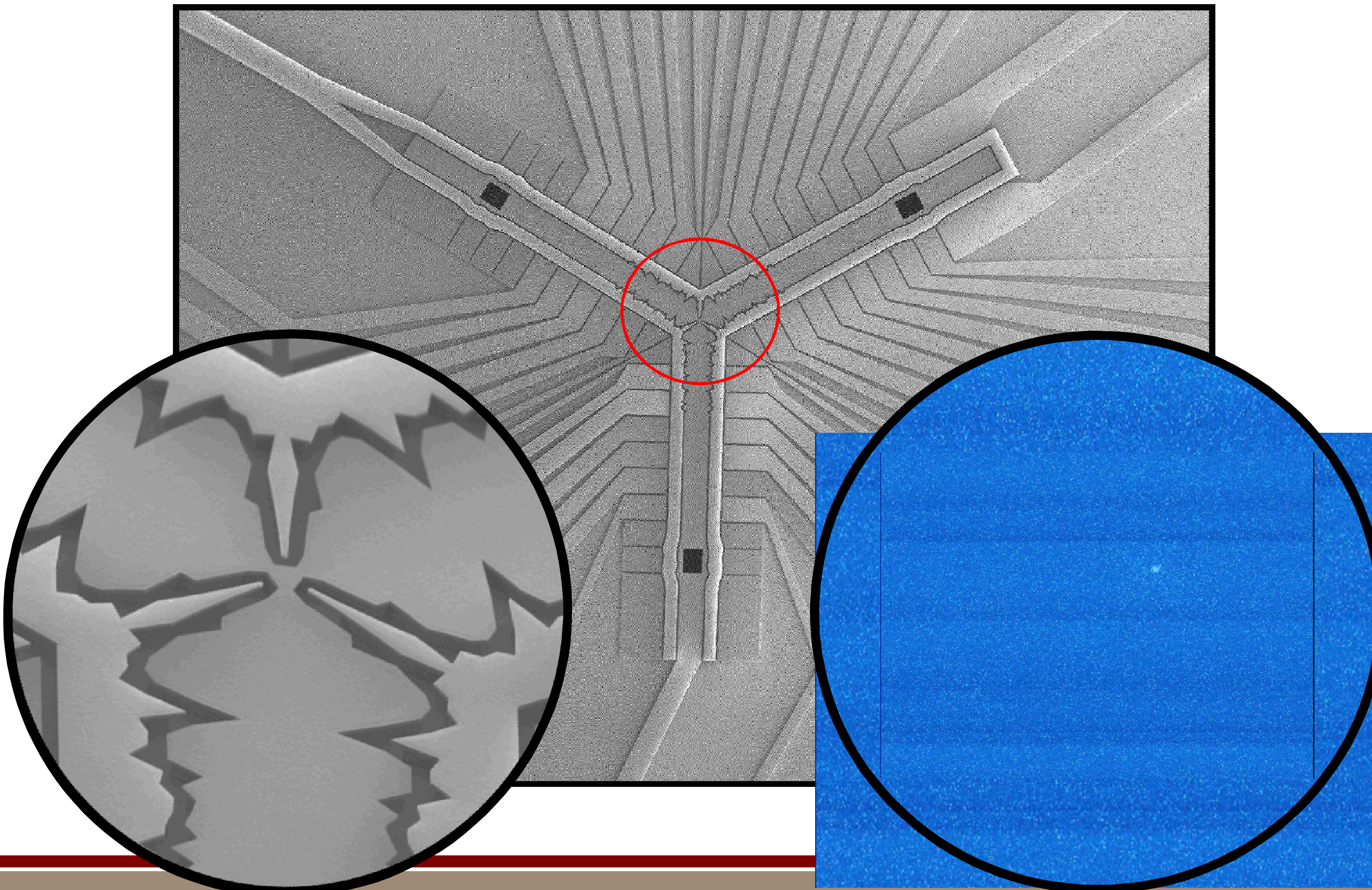
The world's most advanced Y-junction trap:
- "Railroad switch" for ions
- Designed for reordering of ions with minimal disturbance
- Made for David Wineland at NIST/Boulder

Accurate time-keeping with ions



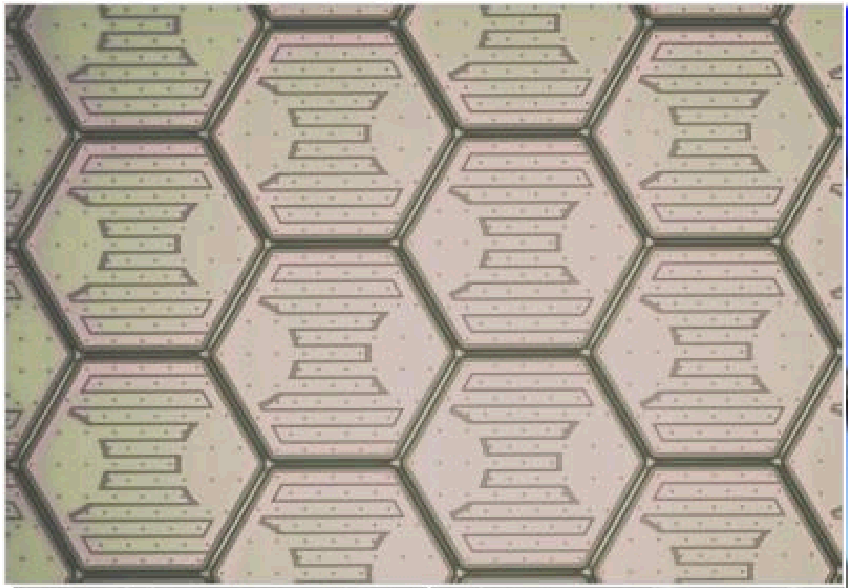
Tiny trapped-ion clock:
- Small size (5 cc) and low power (50 mW)
- Excellent long term stability (loses 32 ns in 1 month)
- Clock prototype passed demanding testing at NIST for 49 days

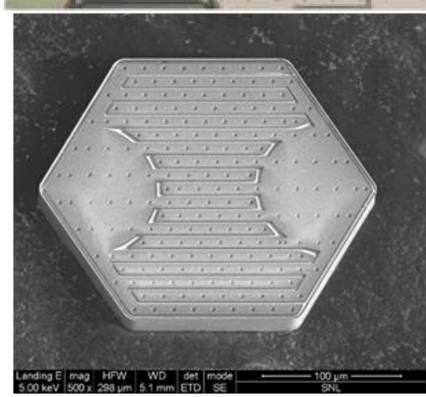
Y-Junction Microfabricated Ion Trap

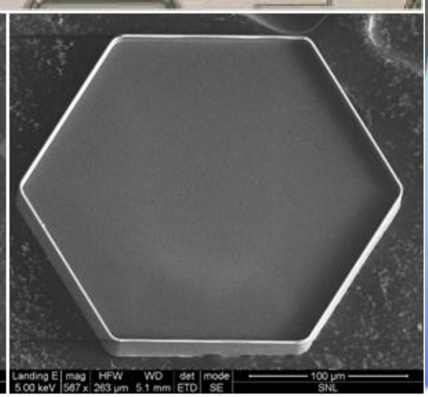


Microsystems Enabled Photovoltaic Cells

Create micro-PV cells then release them from Si or III-V substrate reuse substrate.

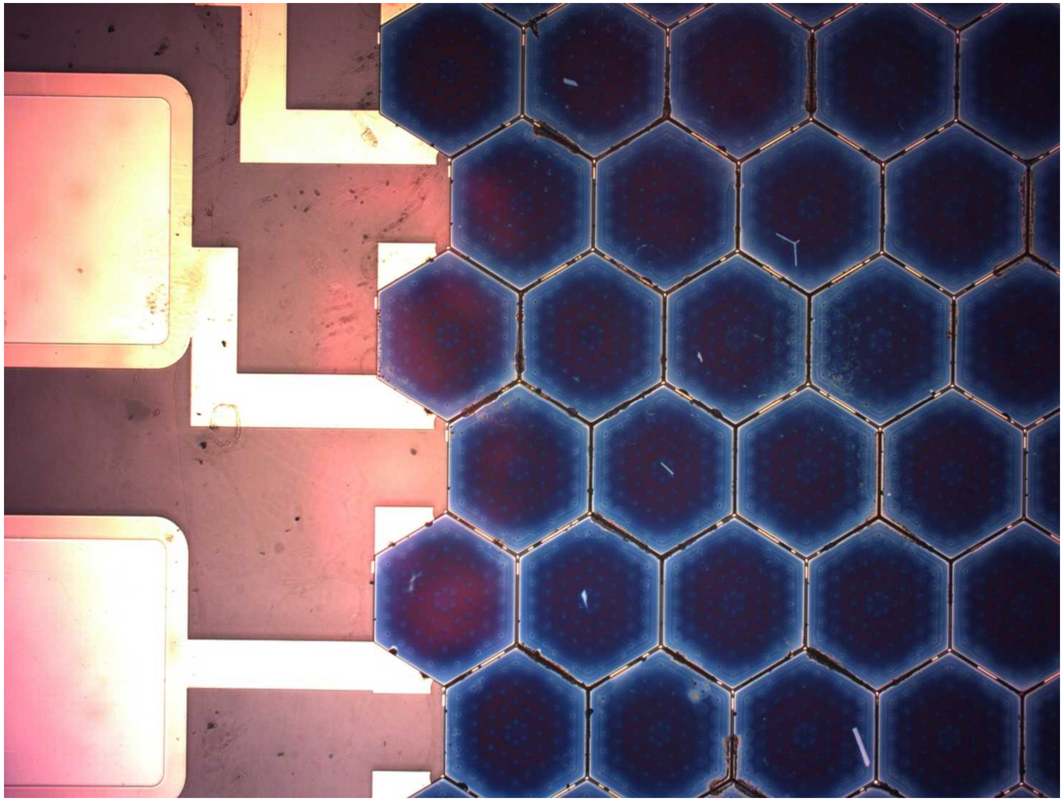


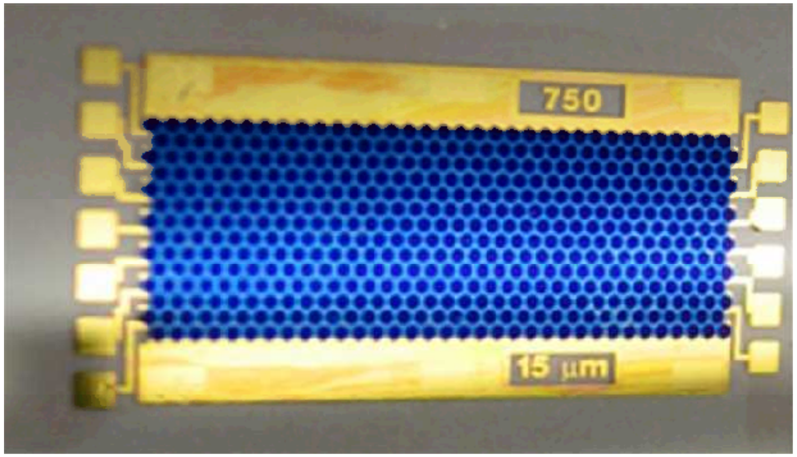




New Manufacturing Paradim

Reassemble cells using standard electronics manufacturing tooling.





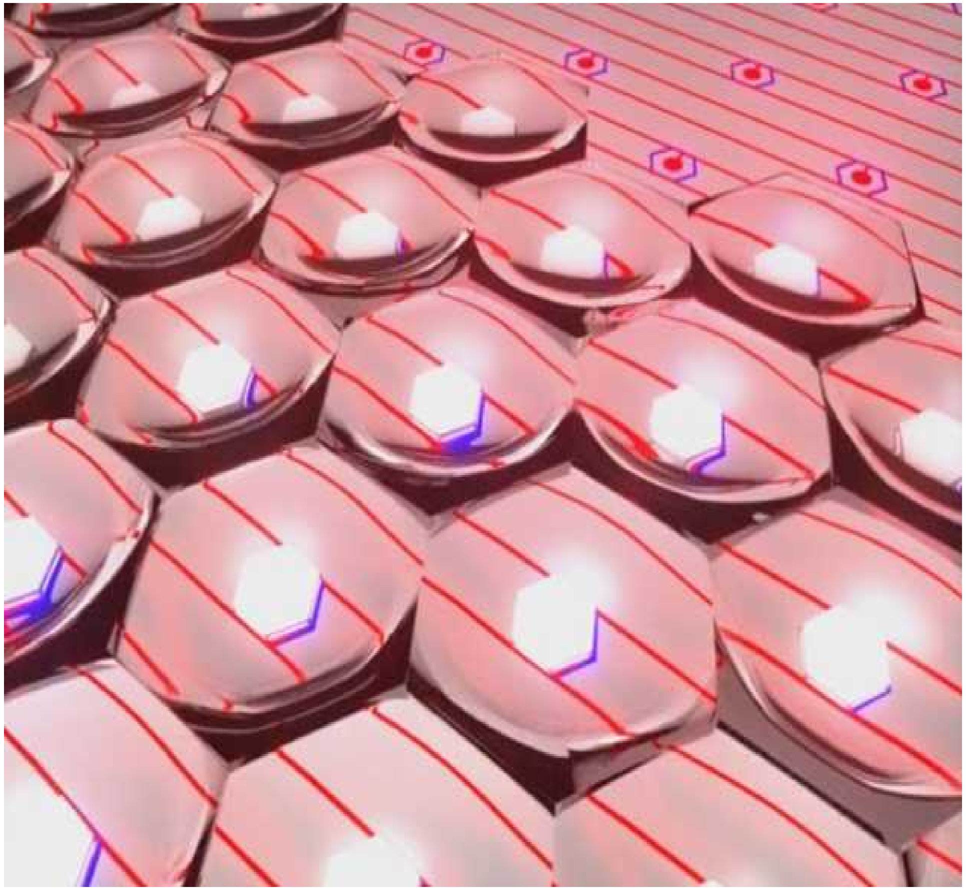
Flexible and Lightweight Arrays

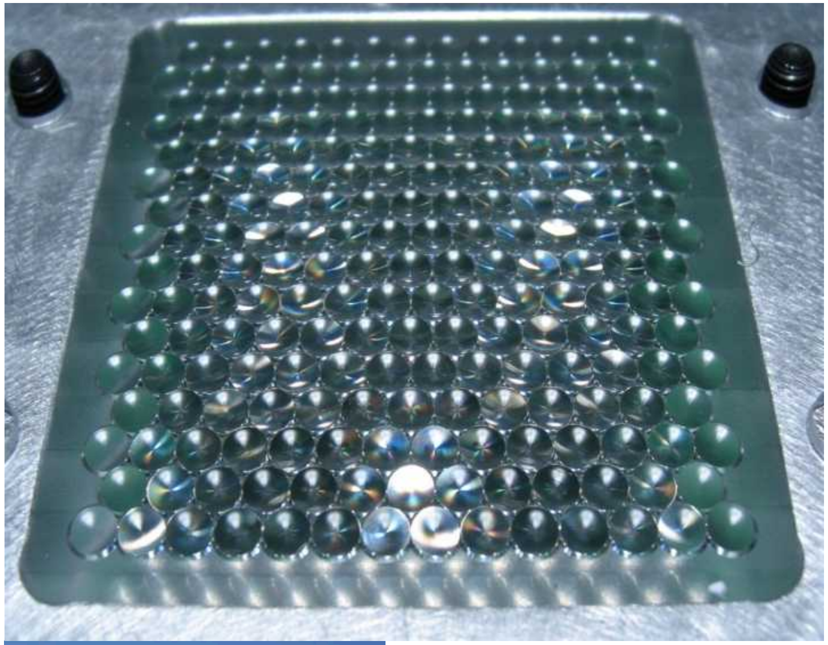
These cells are wired in series and parallel on a flexible substrate.

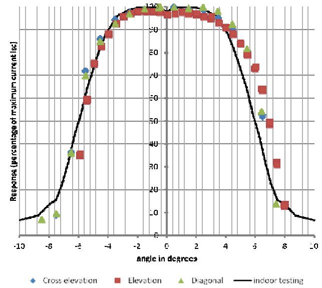
Concentrated PV with Micro-Optics

Sandia National Laboratories

Concentrating optics scale down with size of PV cell making them smaller and lighter.

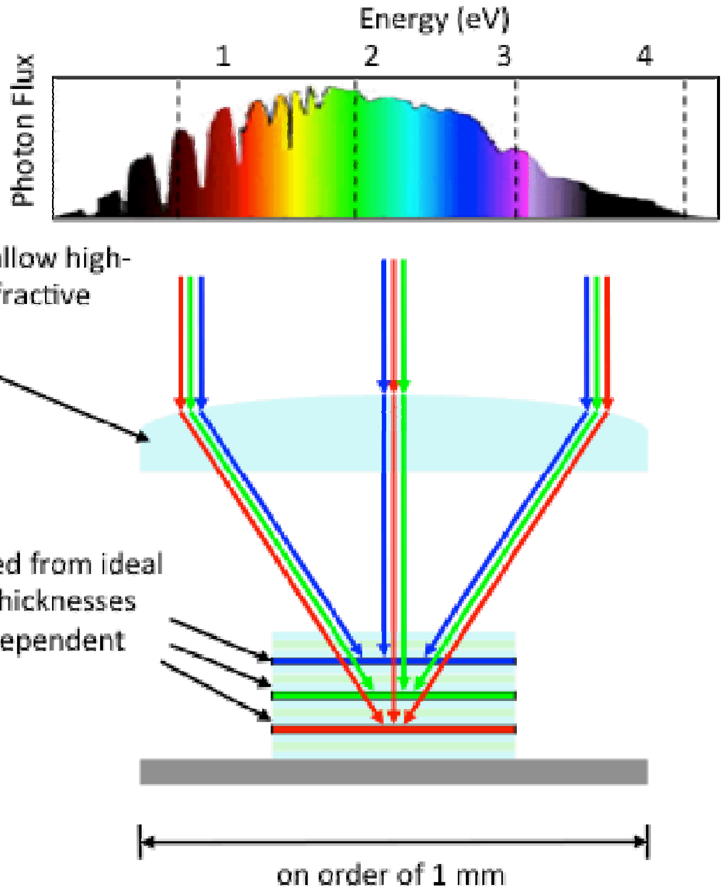






Multi-Junction Cell Stacks

Multi-junction cells can manufactured separately and independently wired.

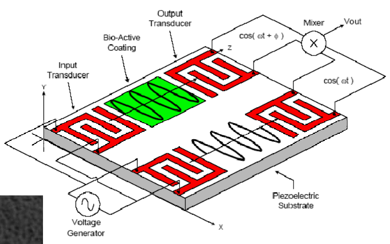


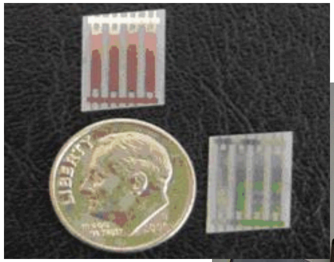
Material	Bandgap
InGaN	*2.5*
InGaP	*1.85*
GaAs	*1.4*
Si	*1.1*
InGaAsP	0.9
InGaAs	0.6

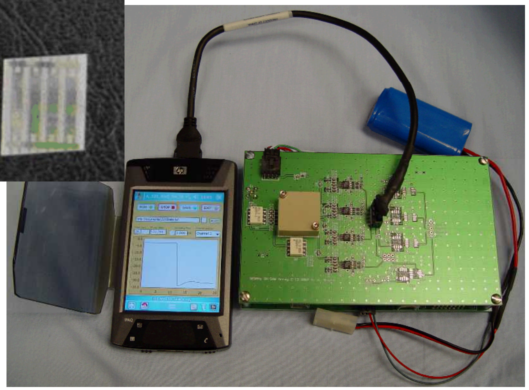
Triple junction Si/GaAs/InGaP cell

SH-SAW Biosensor Array

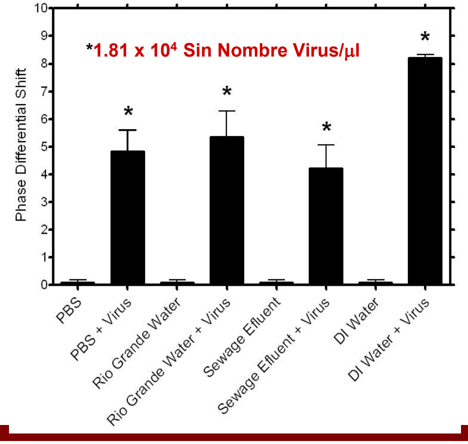
- Microfabricated acoustic delay line detector sensitive to small mass changes on surface
- Specific and sensitive identification of bioagents in environment – protein toxins, bacterial spores, and viruses
- Phase detection monitors 4 channels simultaneously
- Demonstrated detection in real-world samples
- Funding from NIH for biomedical applications
- Developed in collaboration with UNM Med School
- Technology licensed to commercialization partner
- Winner of 2010 R&D 100 Award



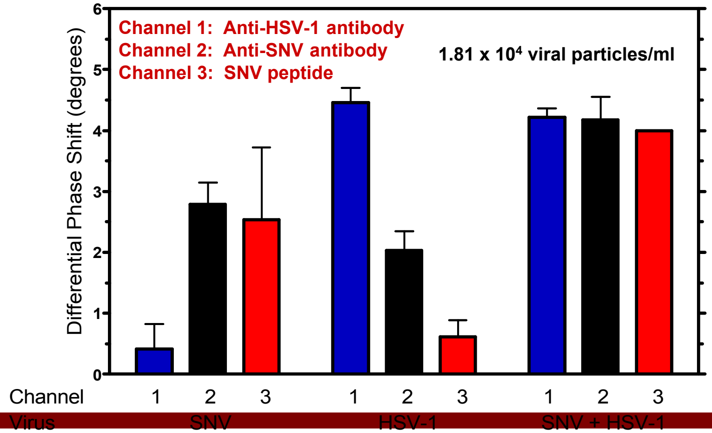




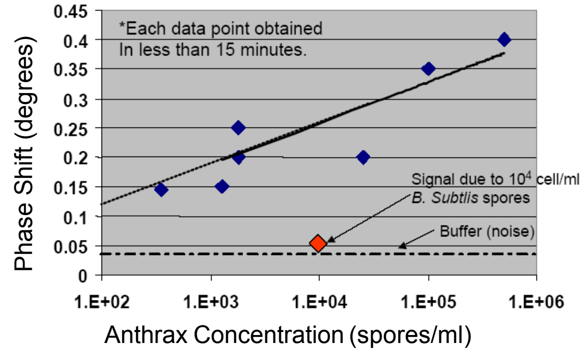
Virus Detection In Complex Samples



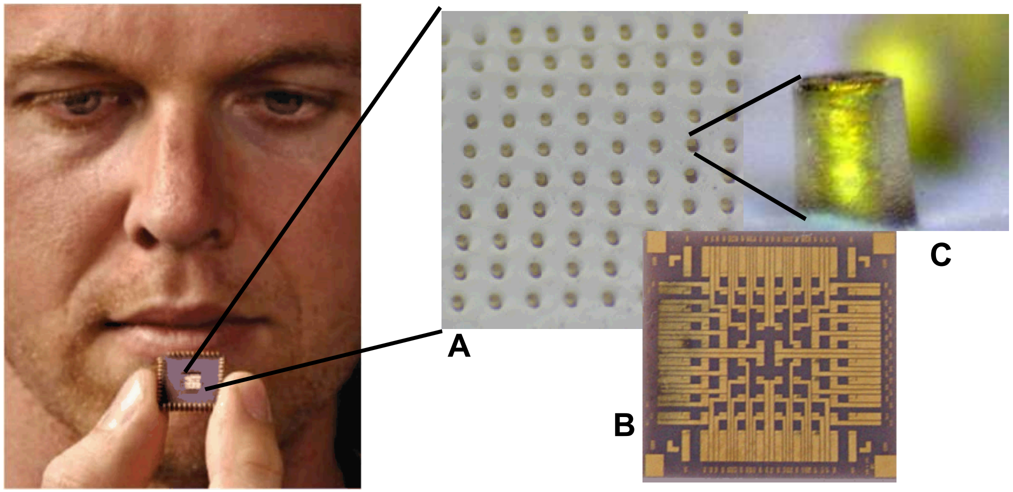
Multiplex Virus Detection



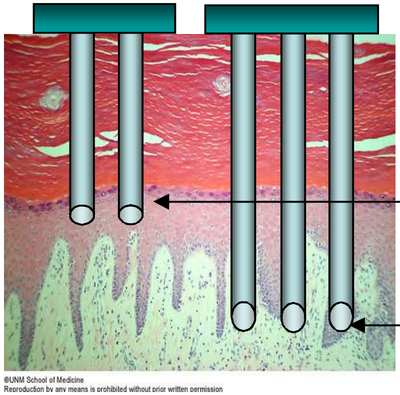
B. *thuringiensis* with B. *subtilis* Background



ElectroNeedle Medical Diagnostic Sensor Array



ElectroNeedle™ Sensor Array: (A) a 1 cm^2, 10 x 10 array of individually addressable ElectroNeedles; (B) the backside electrical contacts; and (C) a single Electro-Needle, showing the protective dielectric sheath, leaving the electrode exposed only at the very tip.

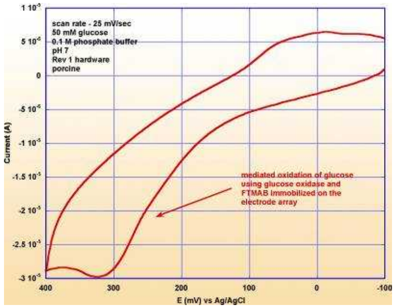


Tailor ElectroNeedle height to access various analytes

Epidermis: glucose, ionic conductivity

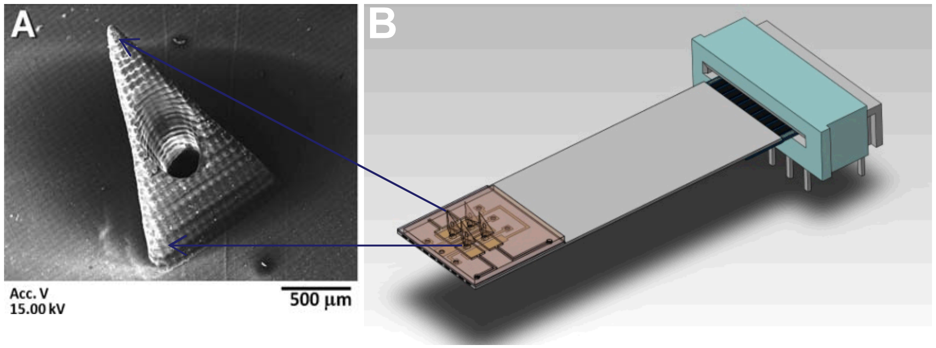
Dermis: antibodies, proteins, enzymes

Cross section of skin

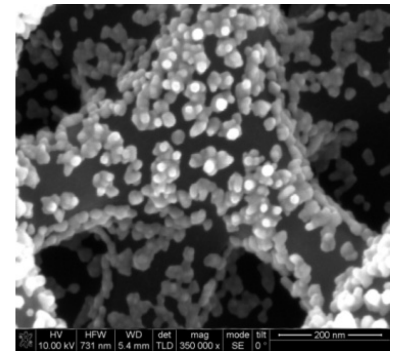


In Vitro Glucose Detection through Pig Skin

- Microfabricated array of biosensors for real-time, point-of-care medical diagnostics.
- Sensor patch, pressed against skin, provides minimally invasive biomarker measurement.
- Electrochemical detection minimizes system size and improves portability.
- Novel electrochemical assays and surface chemistry provide reagentless and label-free detection.
- Impacts emergency and third-world healthcare.
- Technology initially developed through Bio Micro Fuel Cell Project.

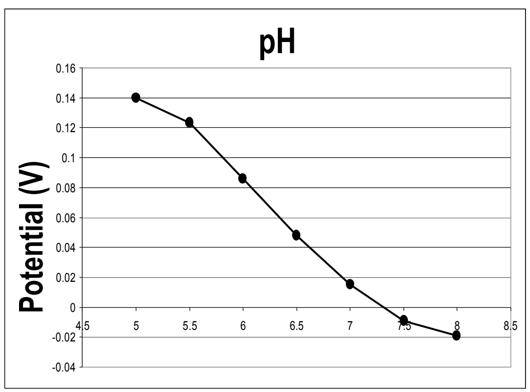


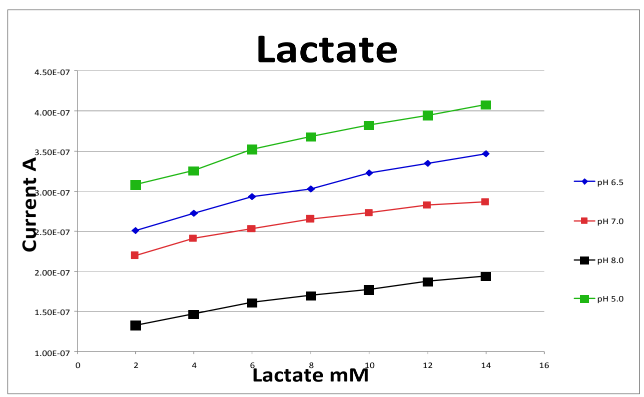
On-chip microneedle sensor: SEM of single hollow microneedle (A), assembled on-chip.

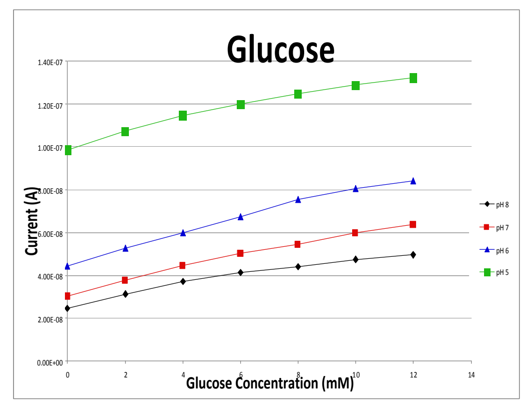


Electrochemically deposited nanoparticles for peroxide and glucose detection

Multiplexed detection of pH, Lactate, Ammonia, Hydrogen Peroxide, Ascorbic Acid, & Glucose

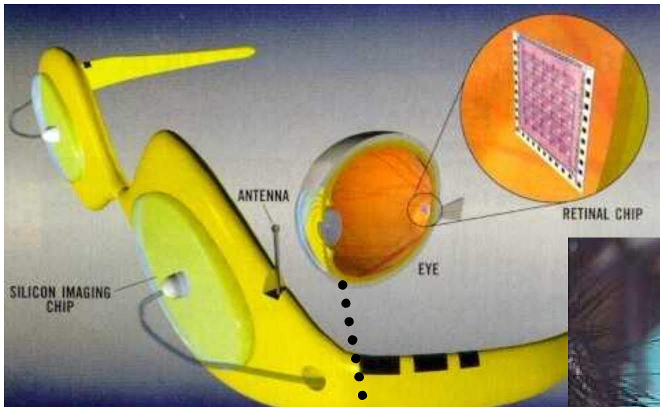




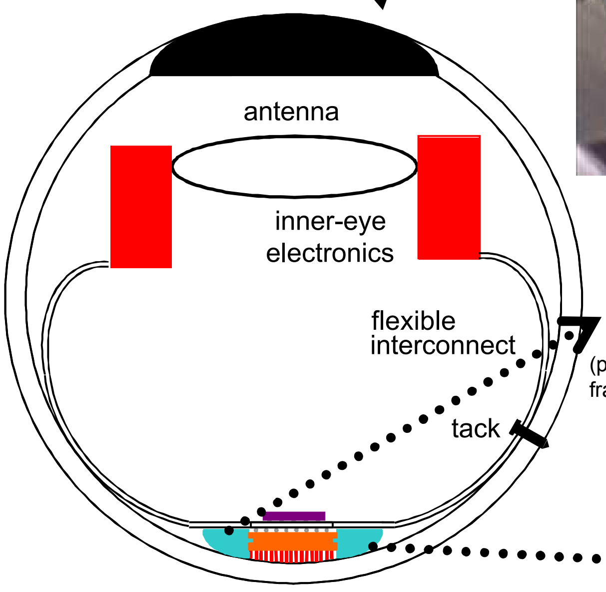


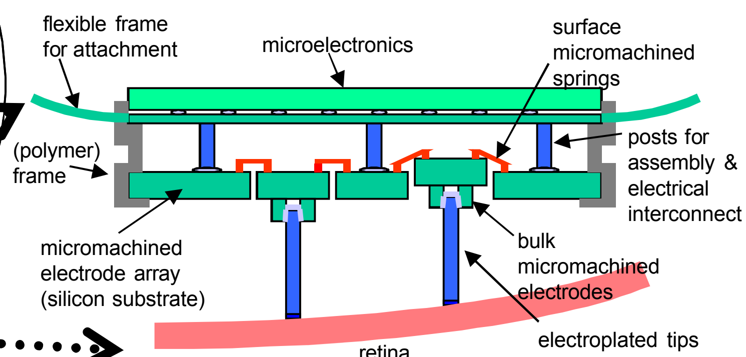
Anodic peak potential to phosphate buffer (A) and chronoamperometric response to lactate (B) and glucose (C) over a range of physiologically relevant pH

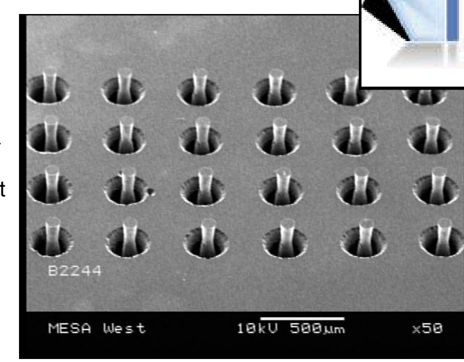
Retinal Implant



- Electrical stimulation of retinal neurons after light sensitive cells (photoreceptors) are lost.
  - Micromachined conformal electrode array provides positive controlled contact with tissue (retina), accommodating overall and local curvature.
  - Integrated electronics essential for high electrode count system (on-chip mux/demux for 100+).
  - Mechanical test modules in animal tests.

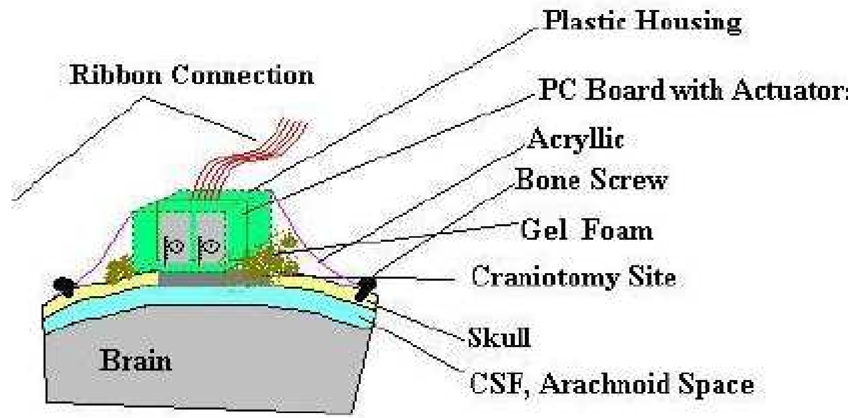




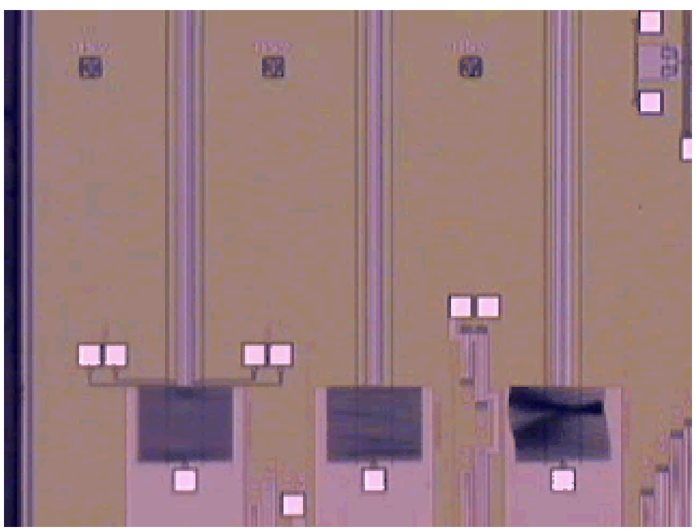


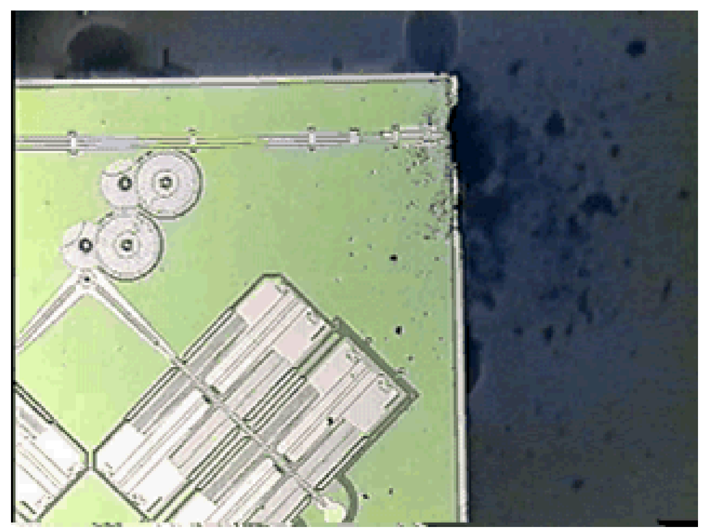
Micromachined Neural Probes

- First off-chip coupling to the external world (4mm extension)
- Testing under way at Arizona State University
- New designs have higher force, longer throw and better functionality with ratcheting thermal actuators



Current design using thermal actuation





First probe design using electrostatic actuation

Engineered Neural Circuits

- Provides a sensitive platform to test the efficacy of vaccines and countermeasures against chemical and biological agents
- Model biological system to study circuitry for advanced computing architectures