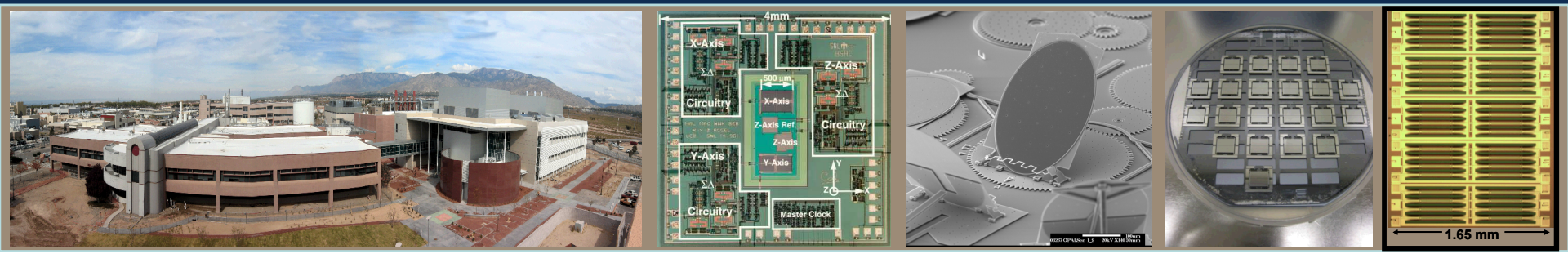
SAND2012-10015P

*Exceptional service in the national interest*

Sandia National Laboratories




# MEMS at Sandia National Laboratories

November 2012

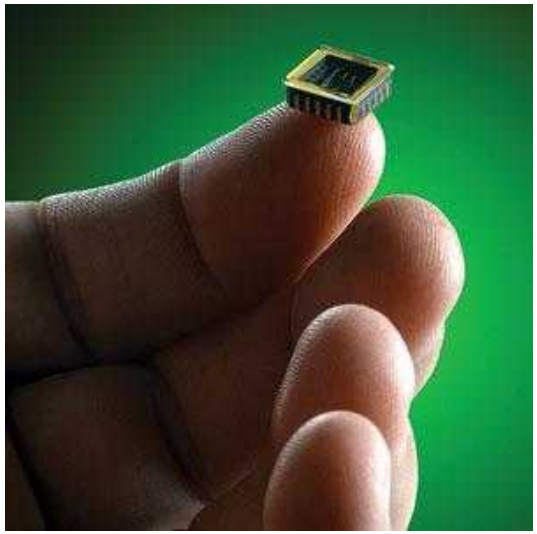
U.S. DEPARTMENT OF ENERGY | NNSA Nuclear Security Administration

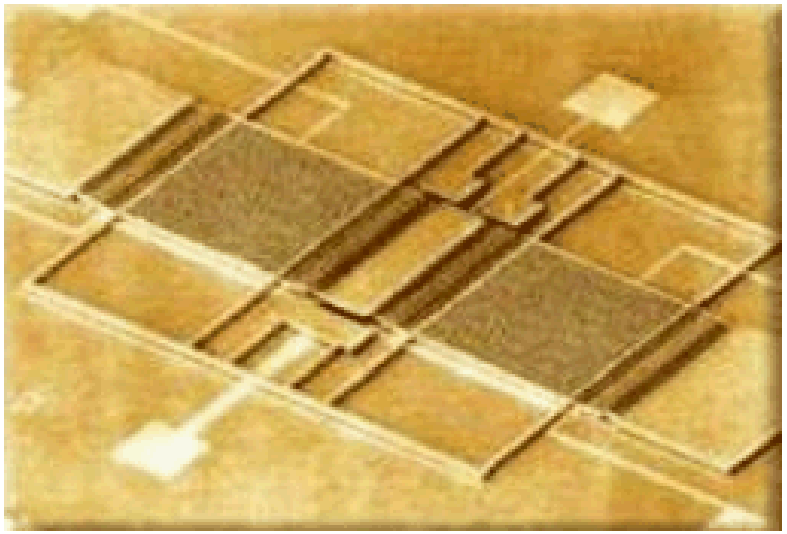
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

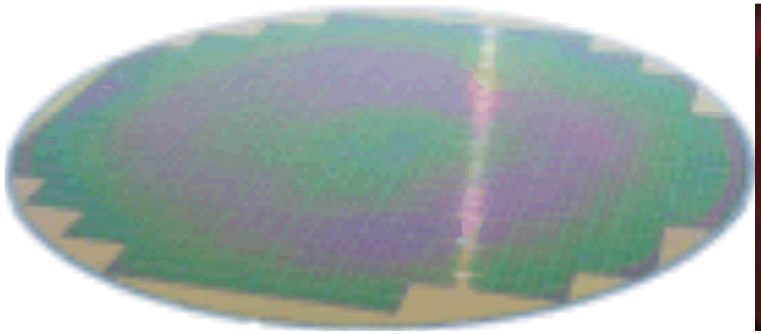
# MEMS are "MicroElectroMechanical Systems"

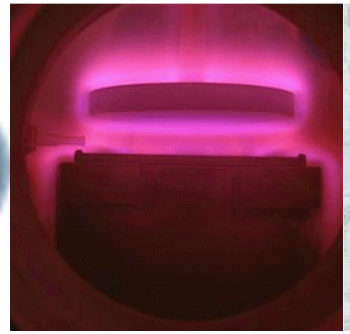
Sandia National Laboratories

***Also known as "microsystems"***









# The MEMS Technologies Department

*Pushing the MEMS technology envelope for national security*

## R&D for Advanced MEMS

- Mechanisms
- Pressure Sensors
- Inertial Sensors
- Fluidic Components
- Electrical Switches
- RF Switches
- RF Filters
- Mirrors
- Planar Light Wave Circuits
- Solar Cells
- Radiation Detectors

## Prototype Development and Limited Production

## Core Fabrication Processes

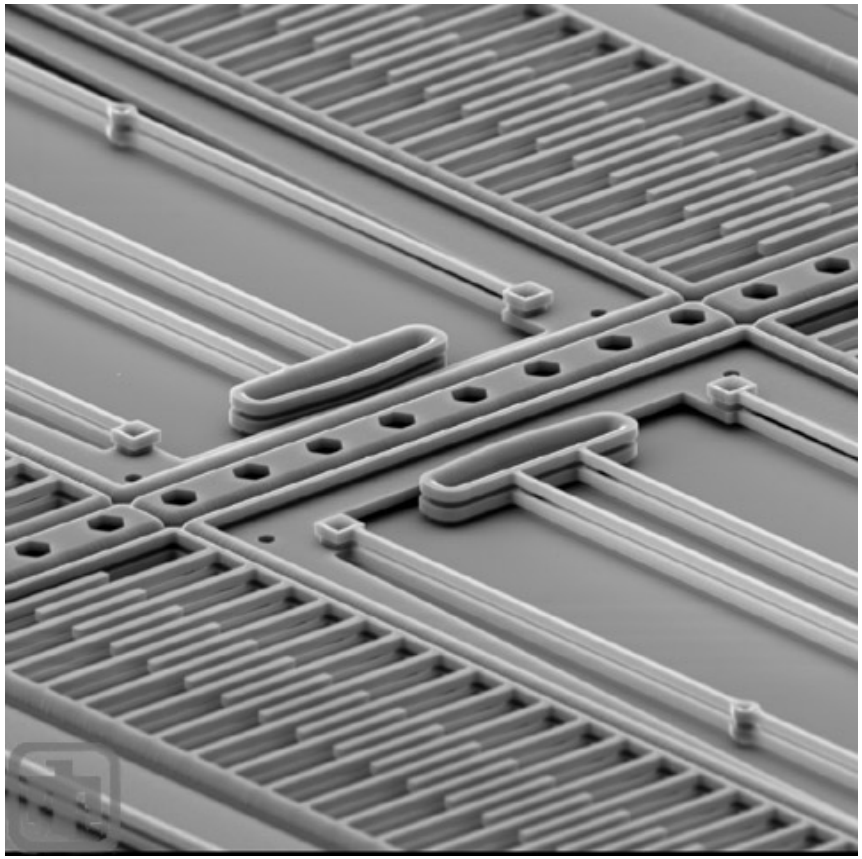
- SUMMiT V™, Baseline plus
  - Silicon Nitride
  - DRIE
  - SOI
  - SFET
- Molded Tungsten
- Aluminum Nitride

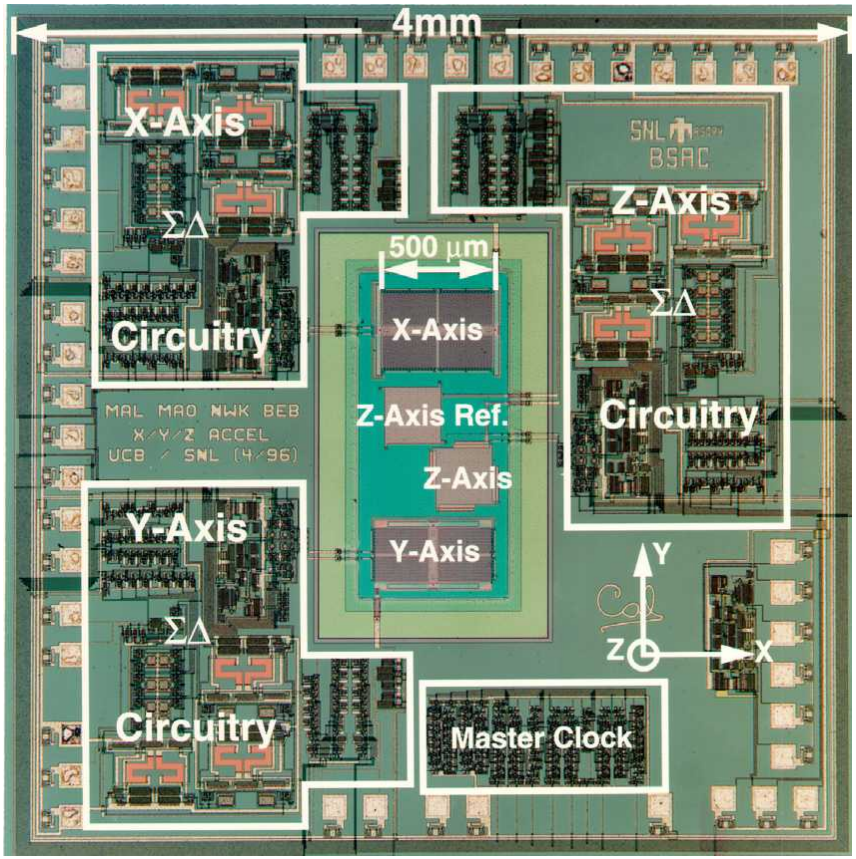
## Core Technologies

- Design, Layout and Analysis
- Device Testing/Characterization
- Reliability Science and Testing
- Failure Analysis

# Sandia's Efforts Started in 1990s

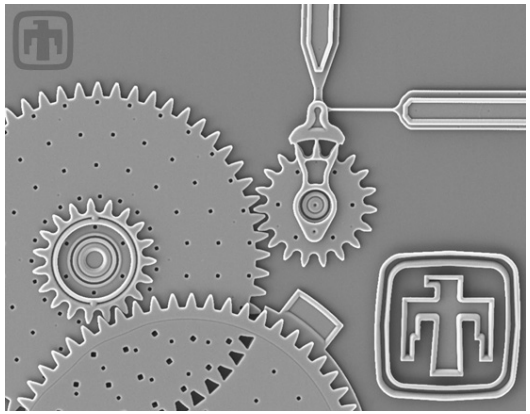
***Collaboration between semiconductor fab and mechanical designers***

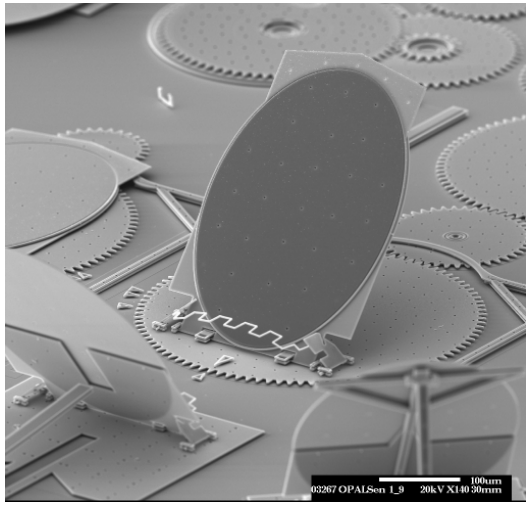


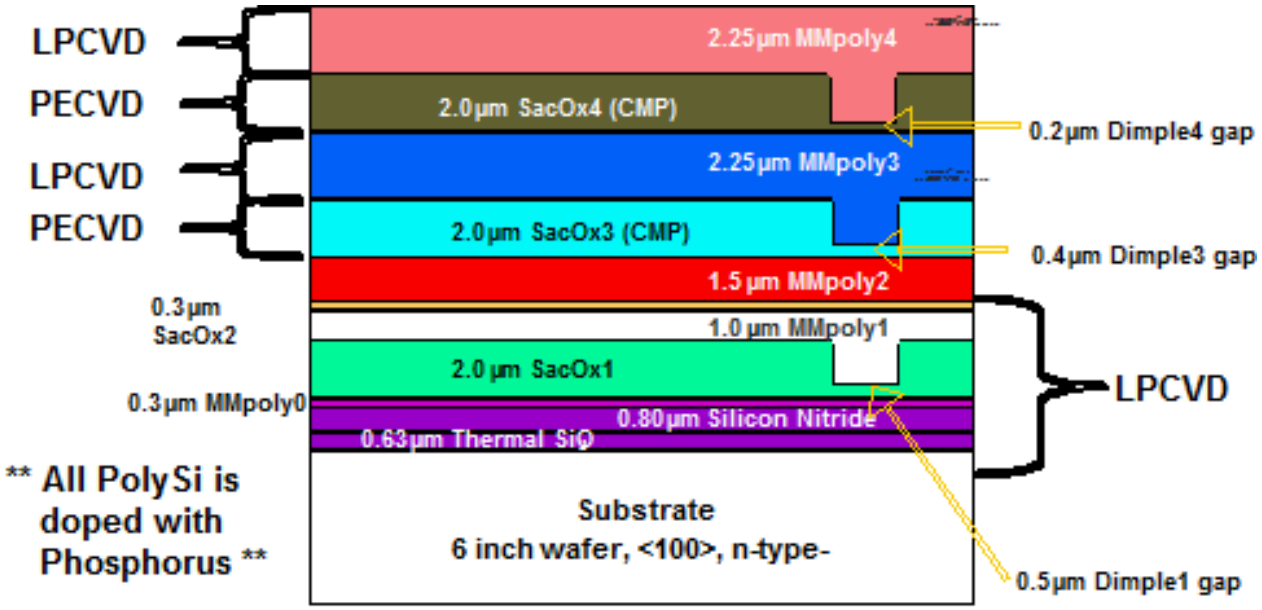


# SUMMiT V™: A Unique Capability

***Sandia Ultraplanar, Multilevel MEMS Technology with 5 polysilicon layers***



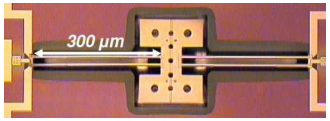


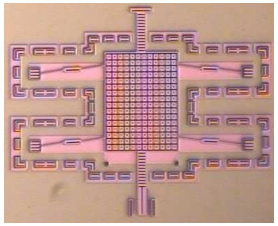


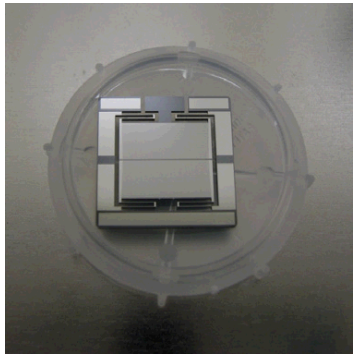
# Sandia's Portfolio Today

***Exploratory research and advanced development for MEMS technologies, devices, and systems for national security.***

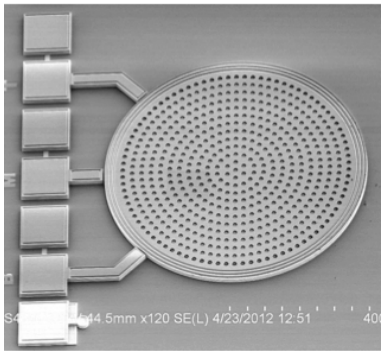
**Inertial Sensors**



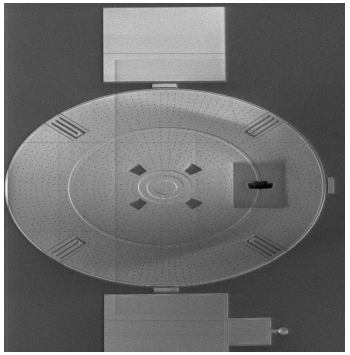





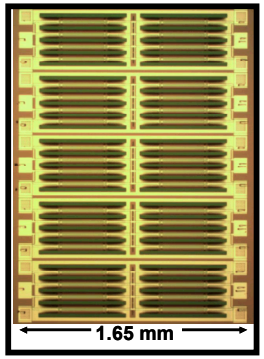
**Pressure Sensors**



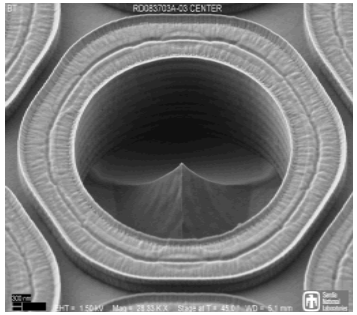
**Microfluidic Actuators**



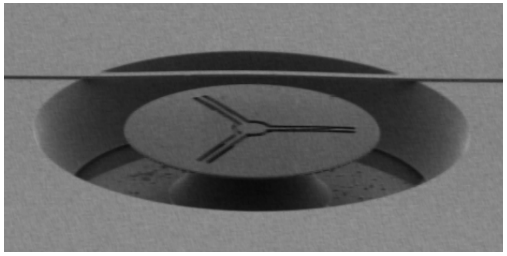
**Electronics**




**Vacuum Electronics**



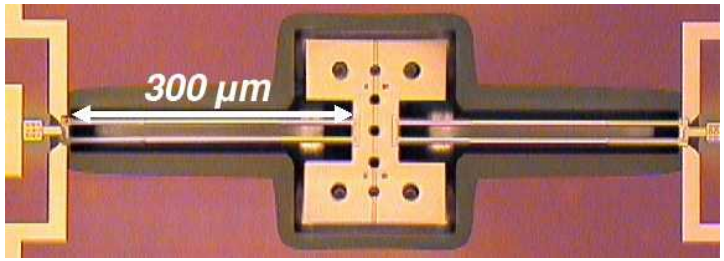
**Photonics and Waveguides**

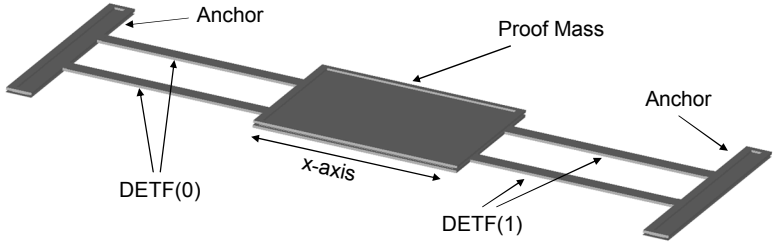


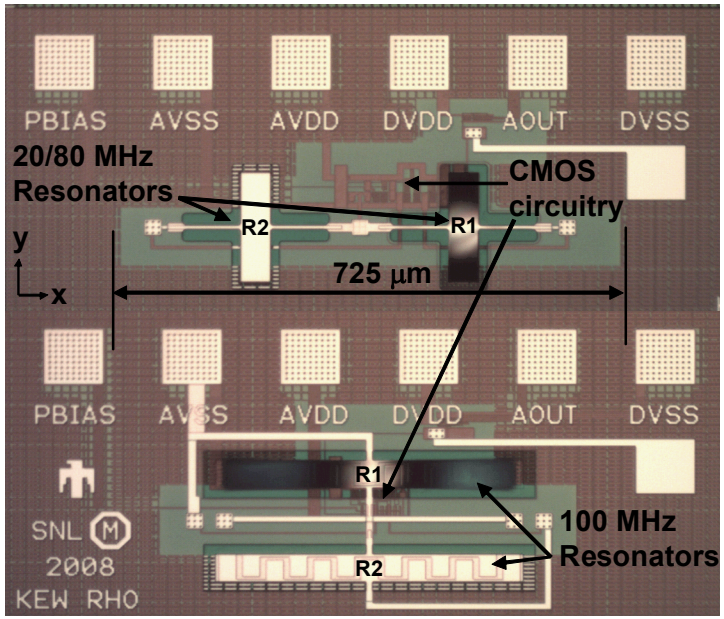
**Photovoltaic Cells**

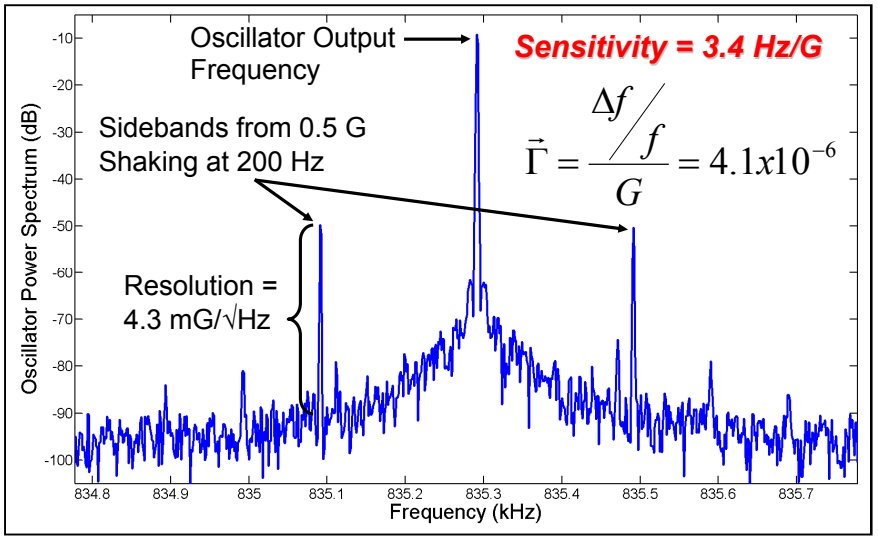
# Inertial Sensors: Radiation-Hard

***Supporting the core nuclear weapons mission***



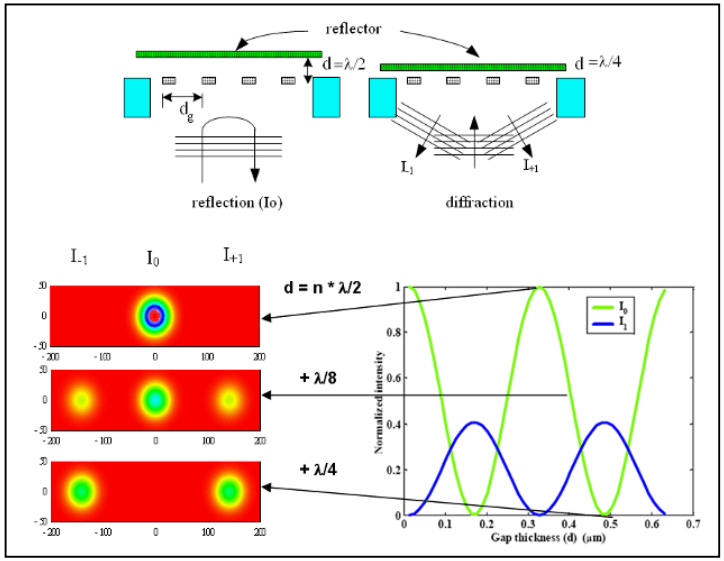



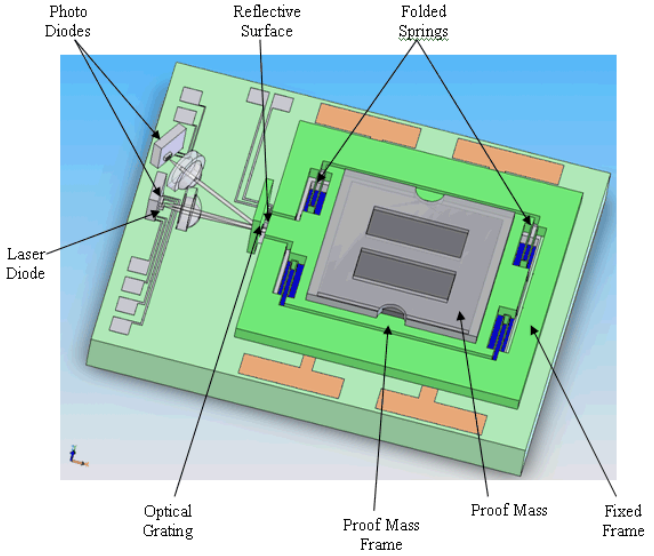



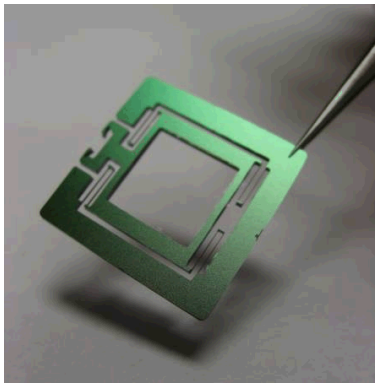



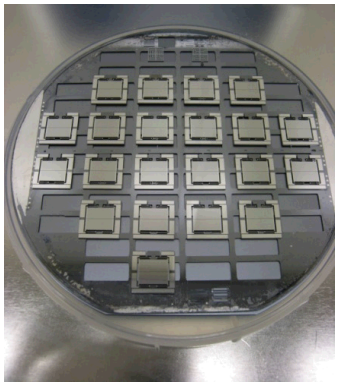
# Inertial Sensors: High Performance

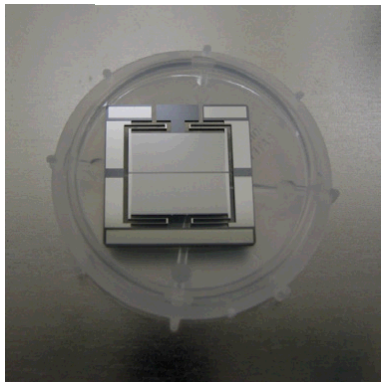
***Complex fabrication, uneconomical for commercial applications***

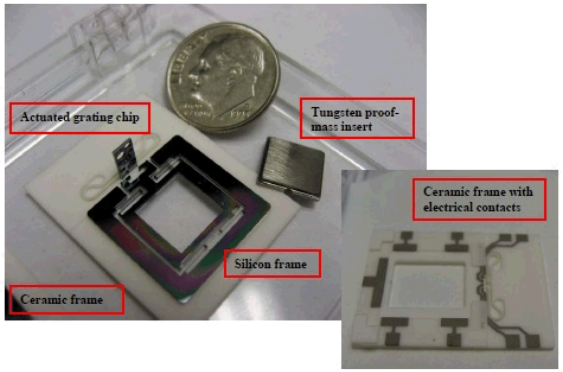


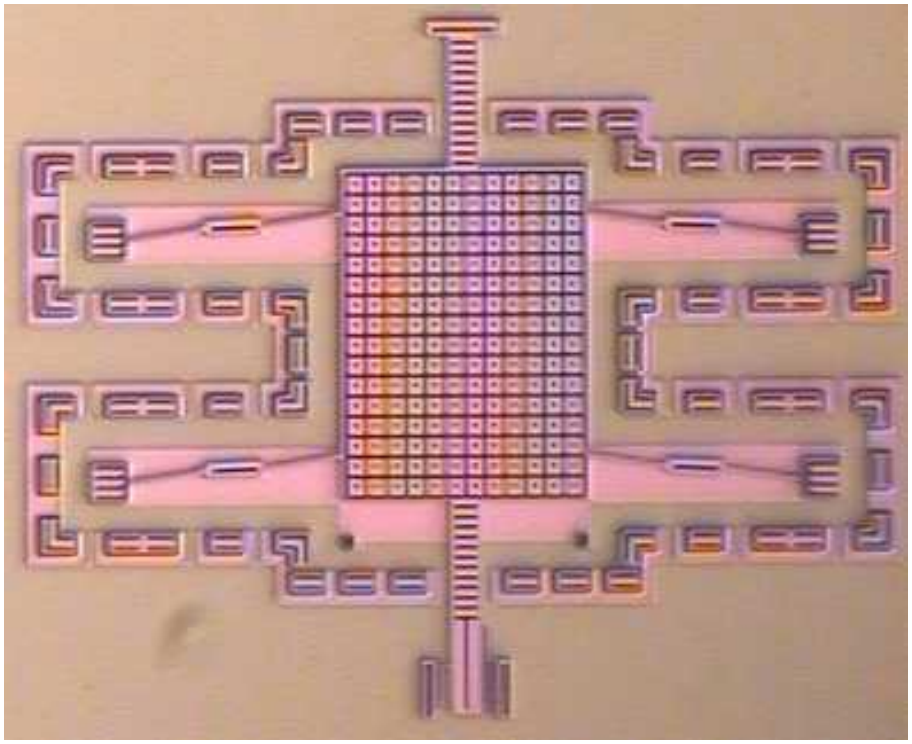


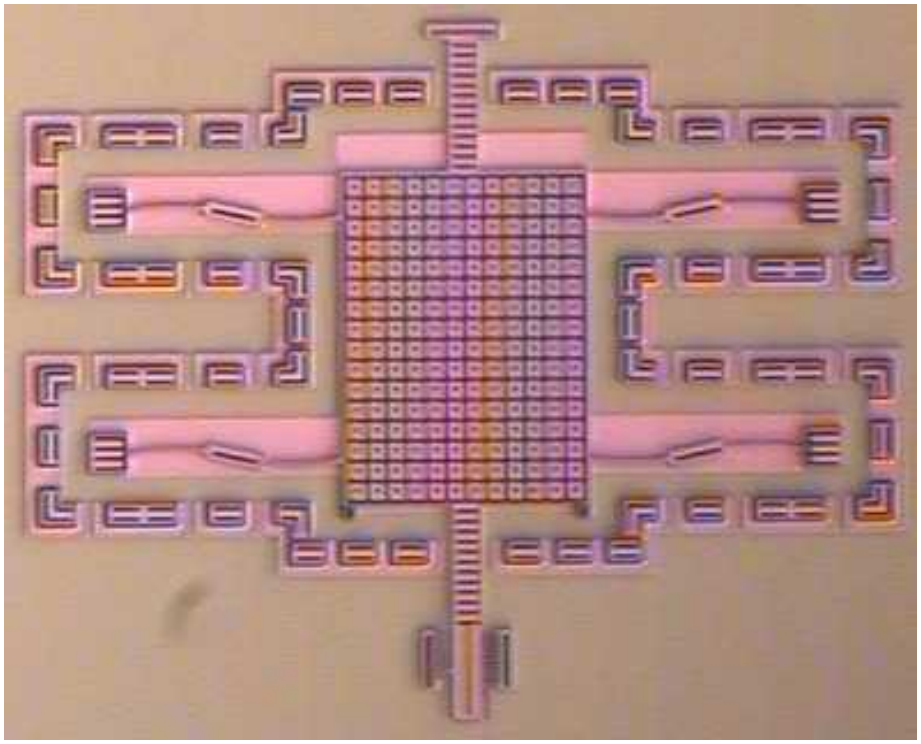




# Inertial Sensors: Novel Devices

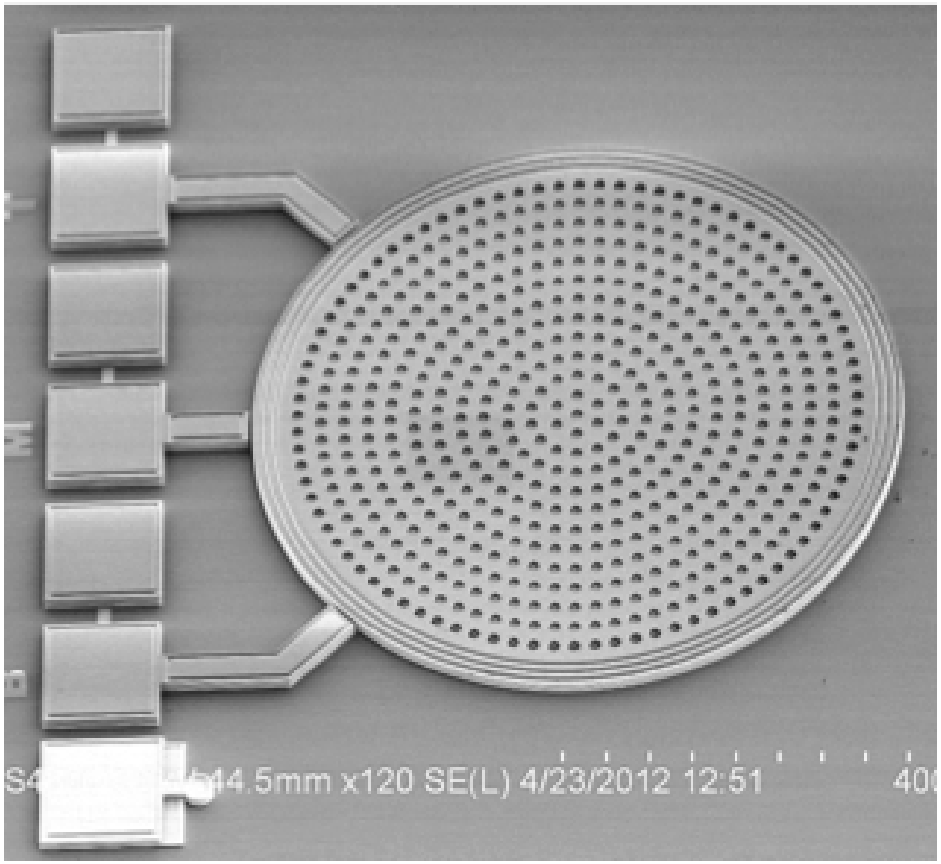
***Sensing unique inertial environments***

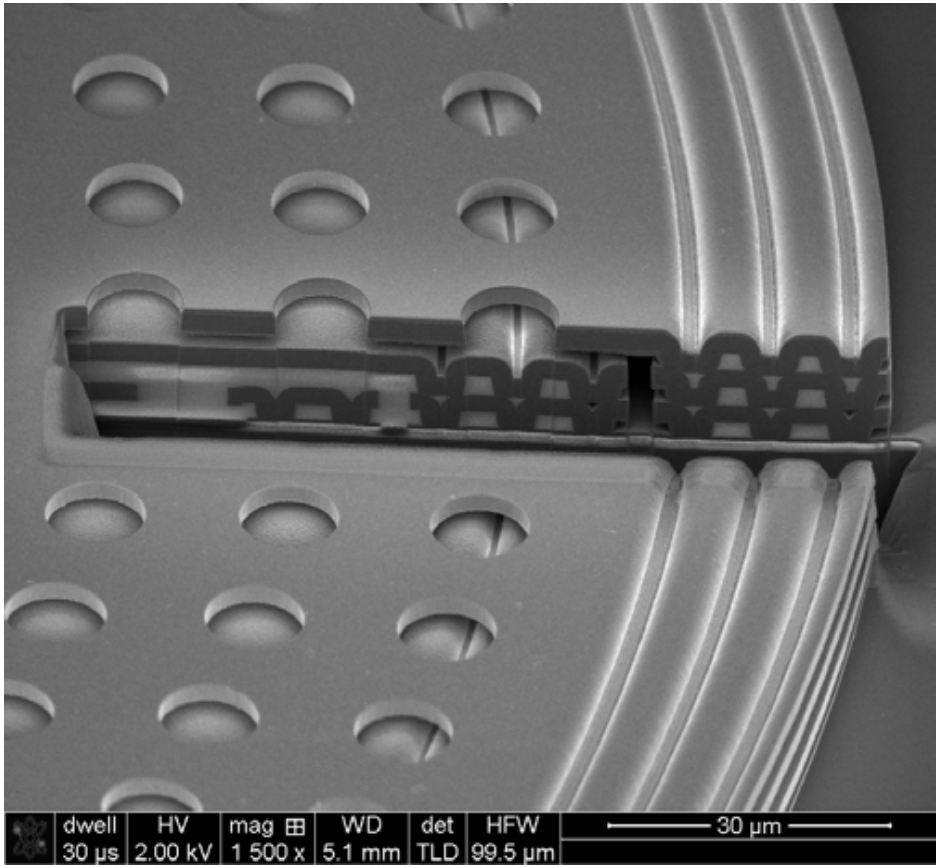




# Pressure Sensors

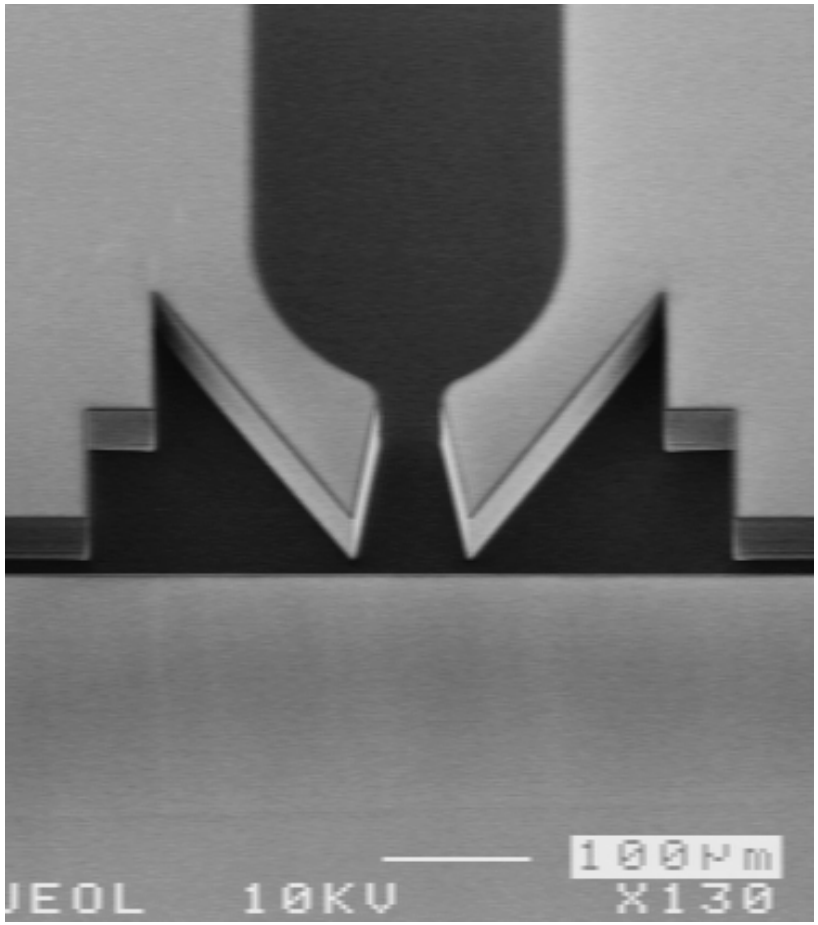
***And other moving membrane sensors, e.g., microphones***

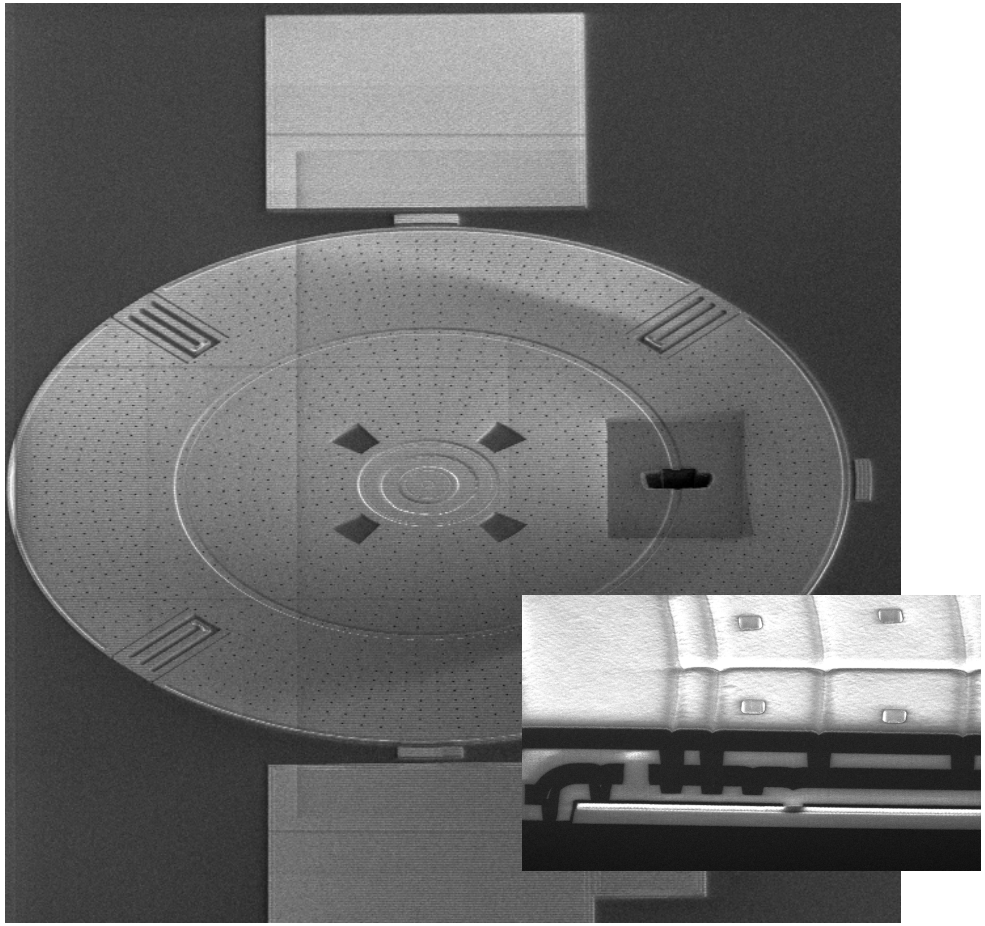


# Microfluidic Actuators

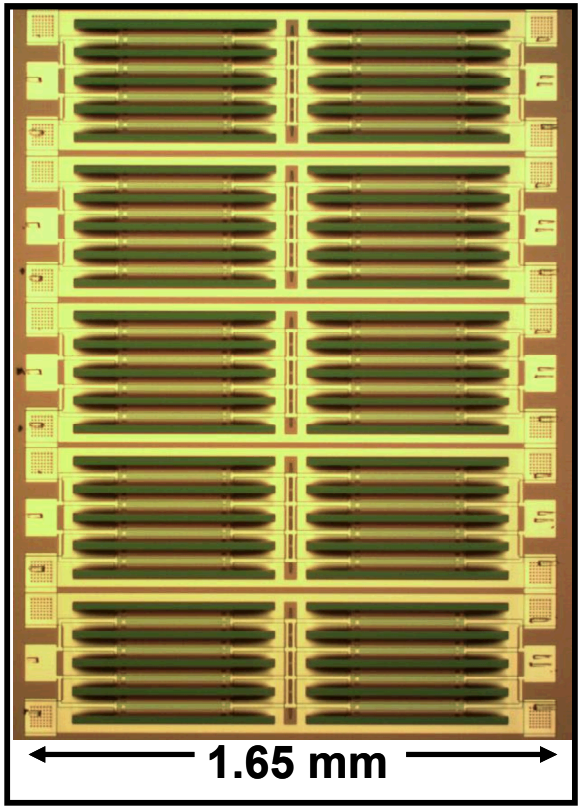
***Jet nozzles, active and passive valves, flow channels, and more***

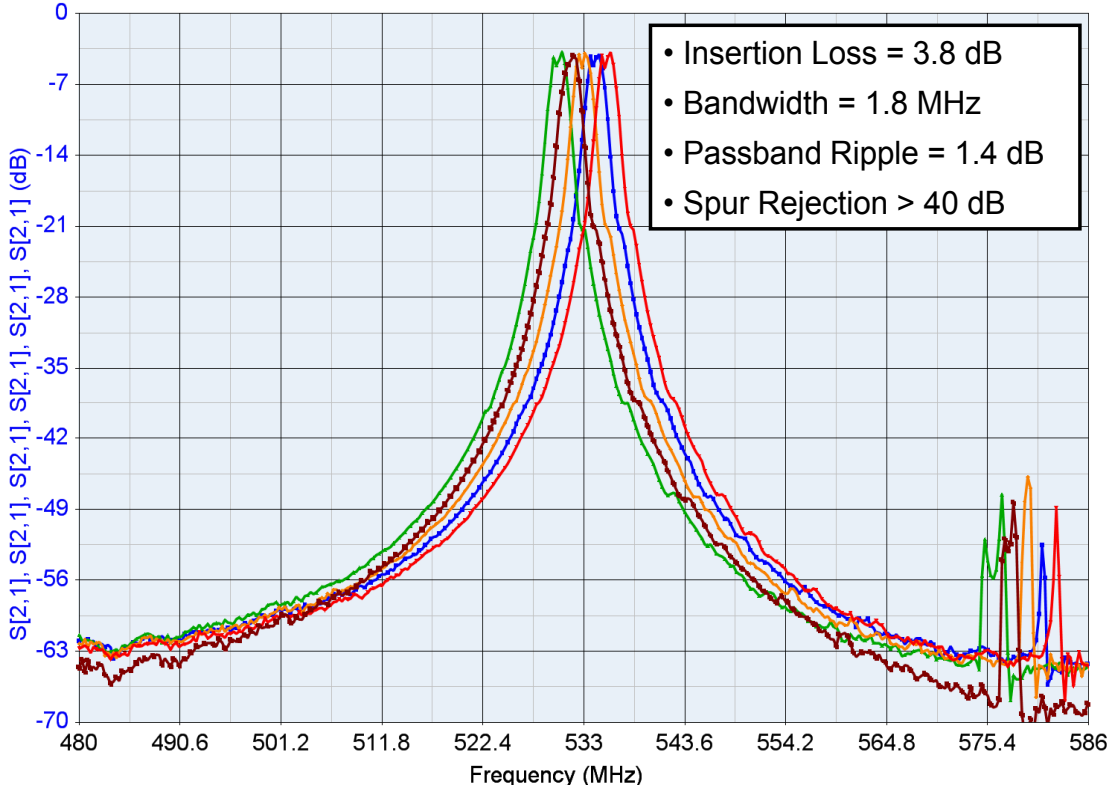


# Electronics: RF Filters and Oscillators

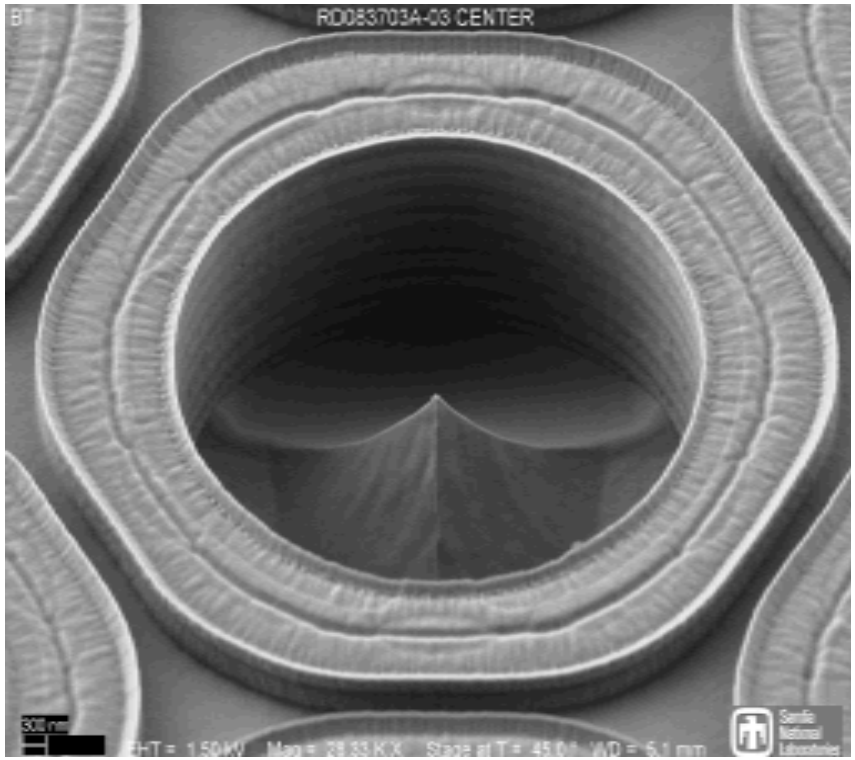
***Filter frequency defined by lithography; multiple filters on a chip***

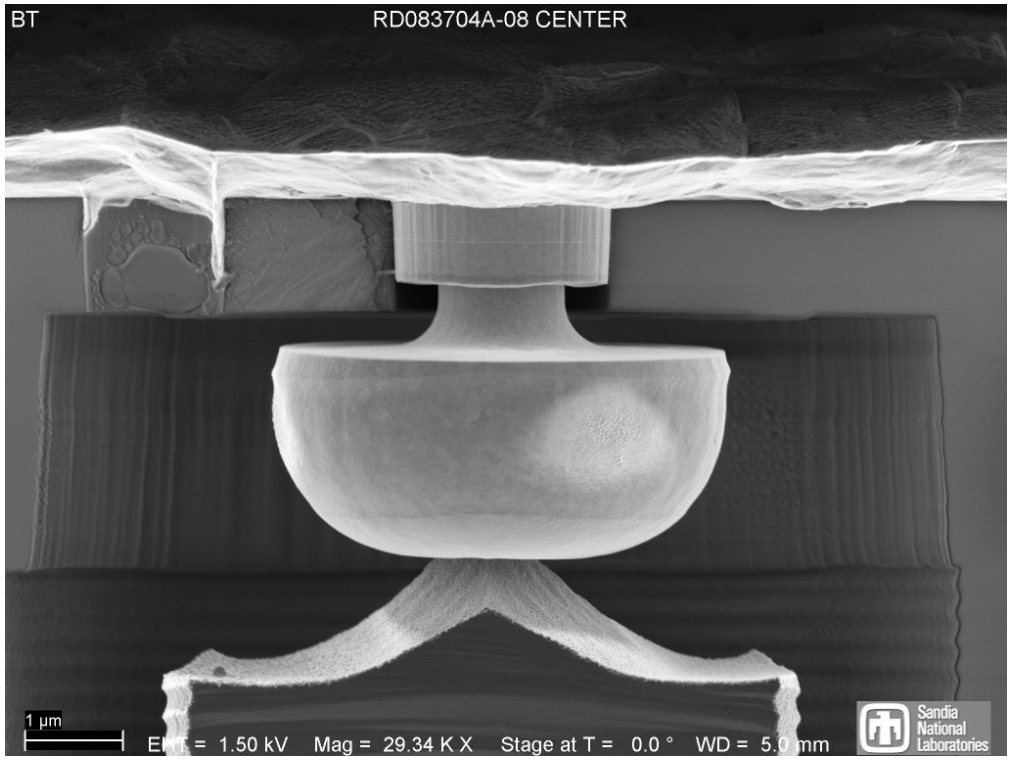


# Vacuum Electronics

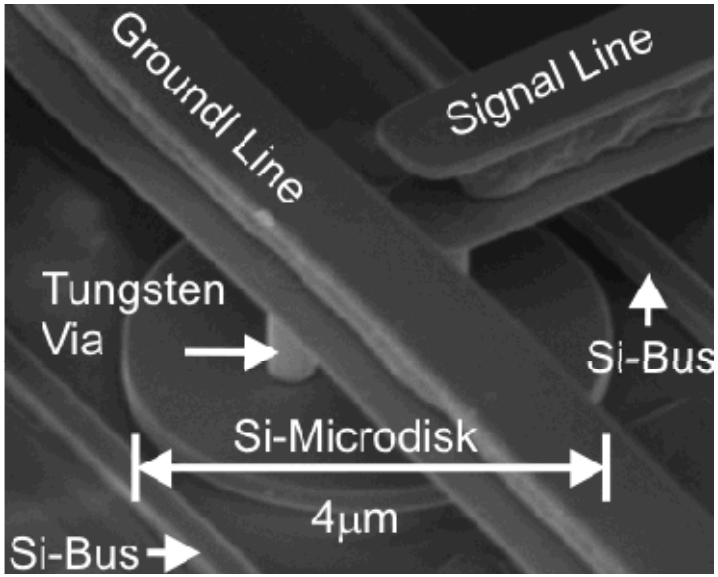
***Monolithically fabricated vacuum devices, e.g., diode***

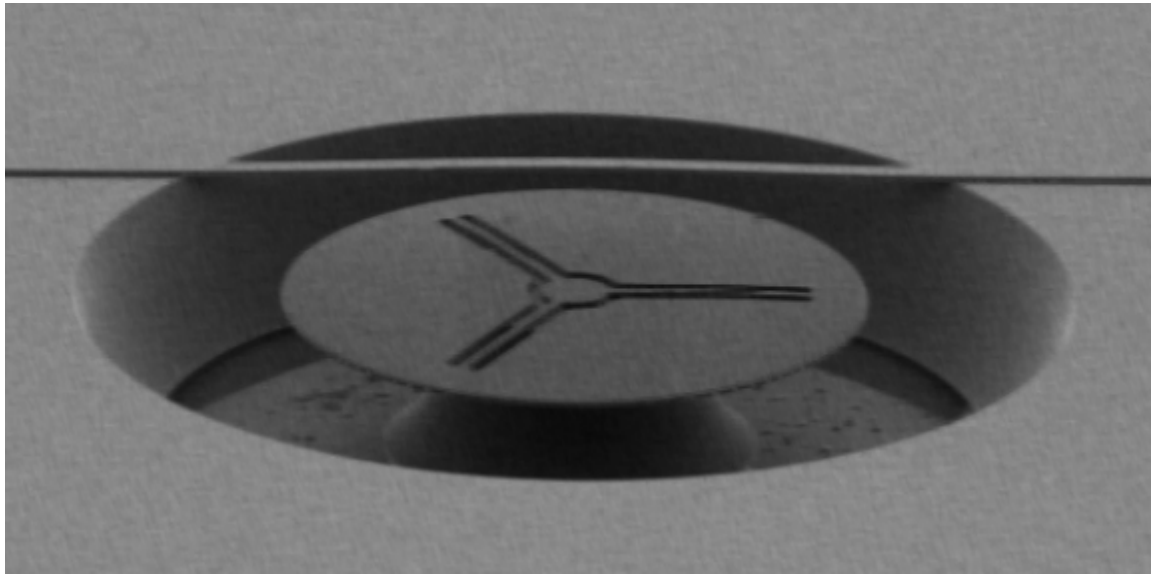


# Photonics and Waveguides

***Low loss waveguides and ring resonators for optical signal processing***

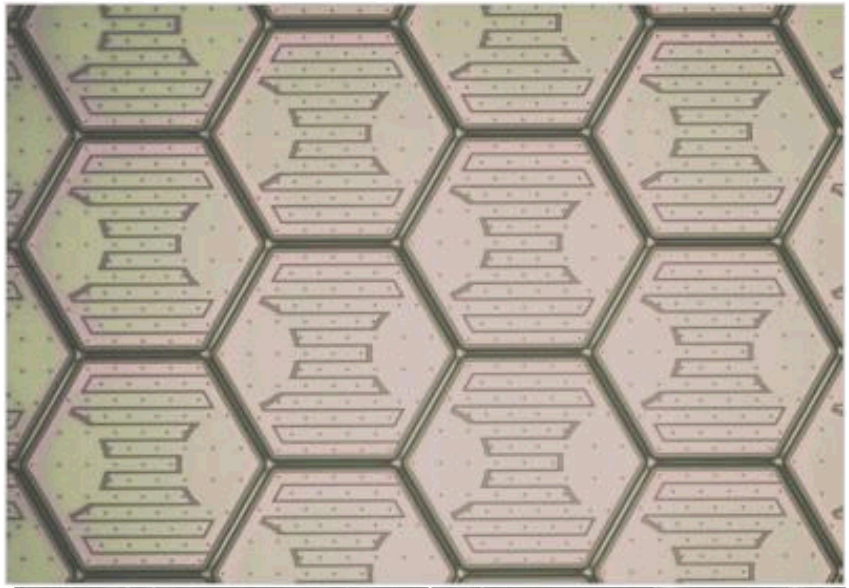


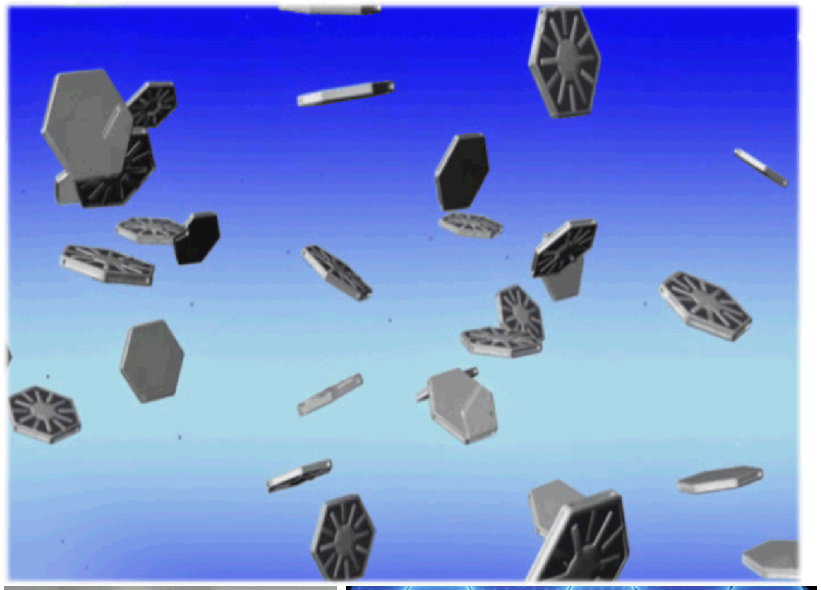



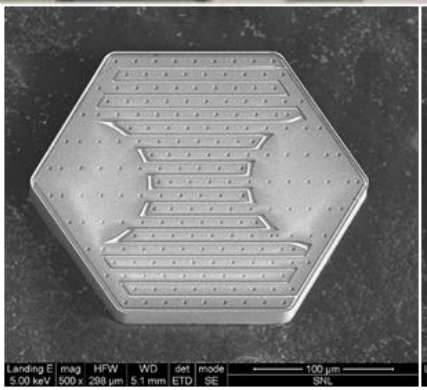
# Microsystems Enabled Photovoltaic Cells (MEPV)

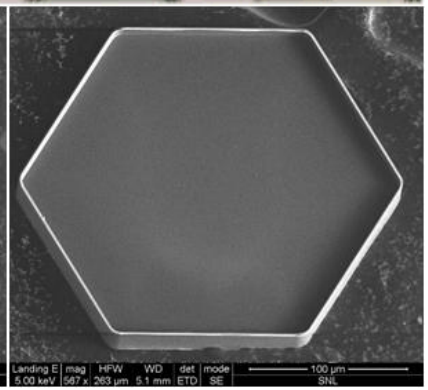
Sandia National Laboratories

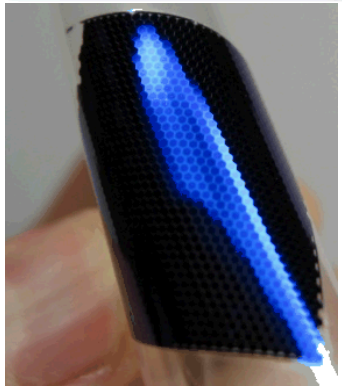
***Microsystems technologies are creating disruptive change in PV***

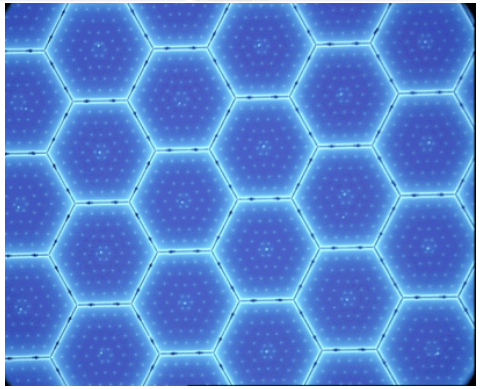












# Contact Information

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(505) 844-2072

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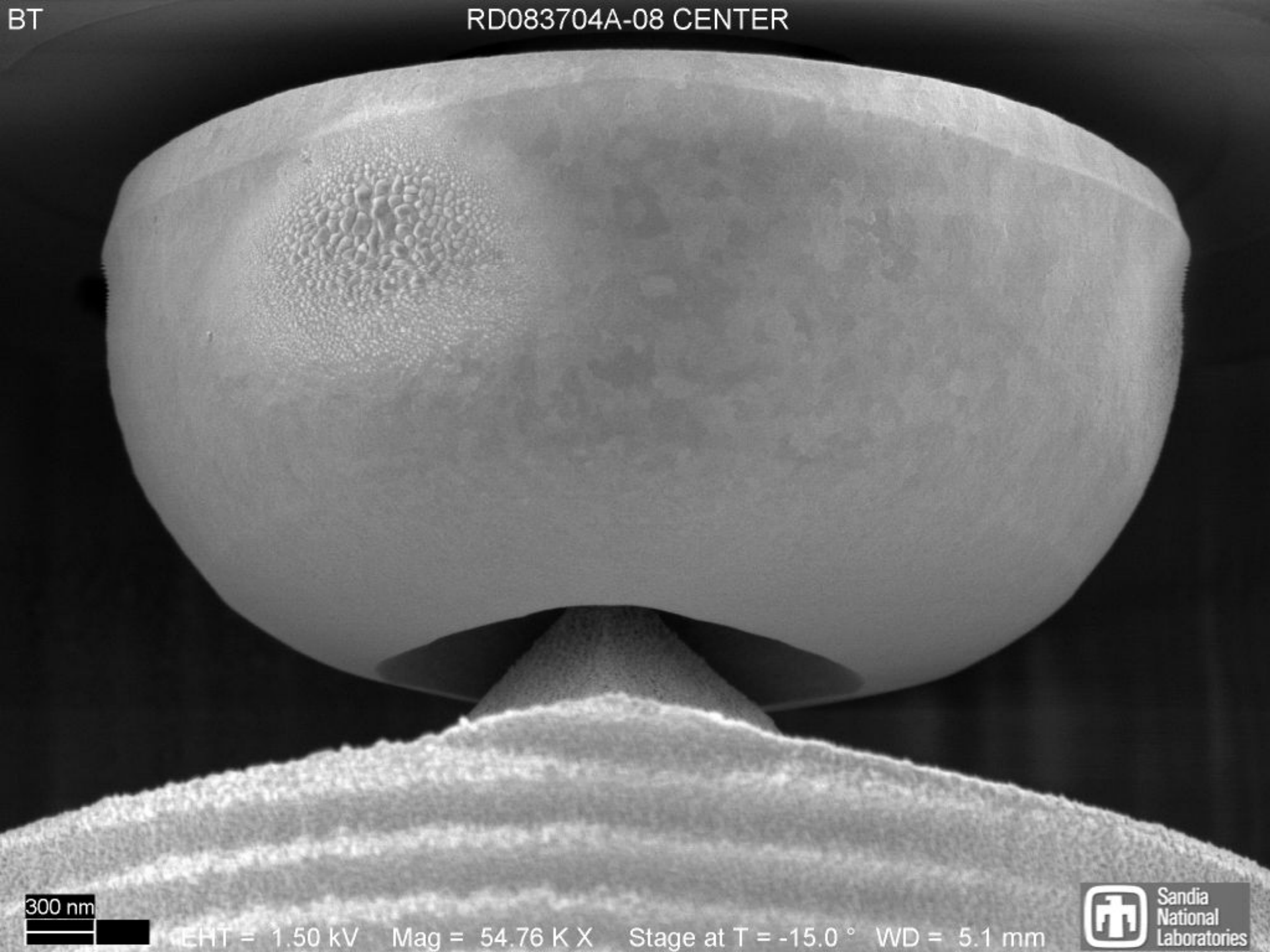
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RD083704A-08 CENTER
300 nm
EHT = 1.50 kV
Mag = 54.76 K X
Stage at T = -15.0 °
WD = 5.1 mm
Sandia National Laboratories