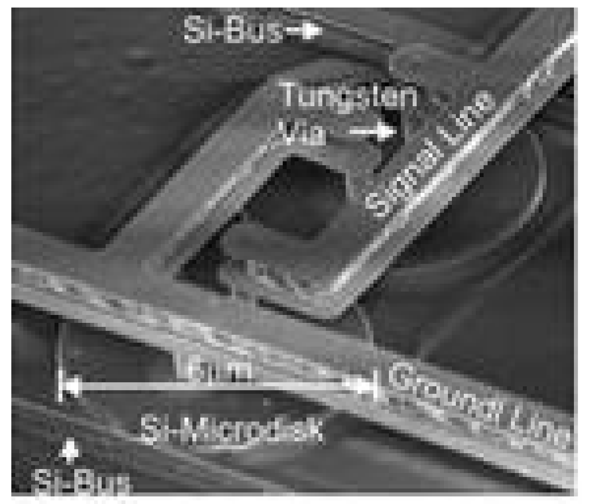
EXPLORE AND COLLABORATE
AMERICAN INDUSTRY AND AMERICA'S NATIONAL LABS
MATERIALS FOR ENERGY APPLICATIONS

ELECTRONICS

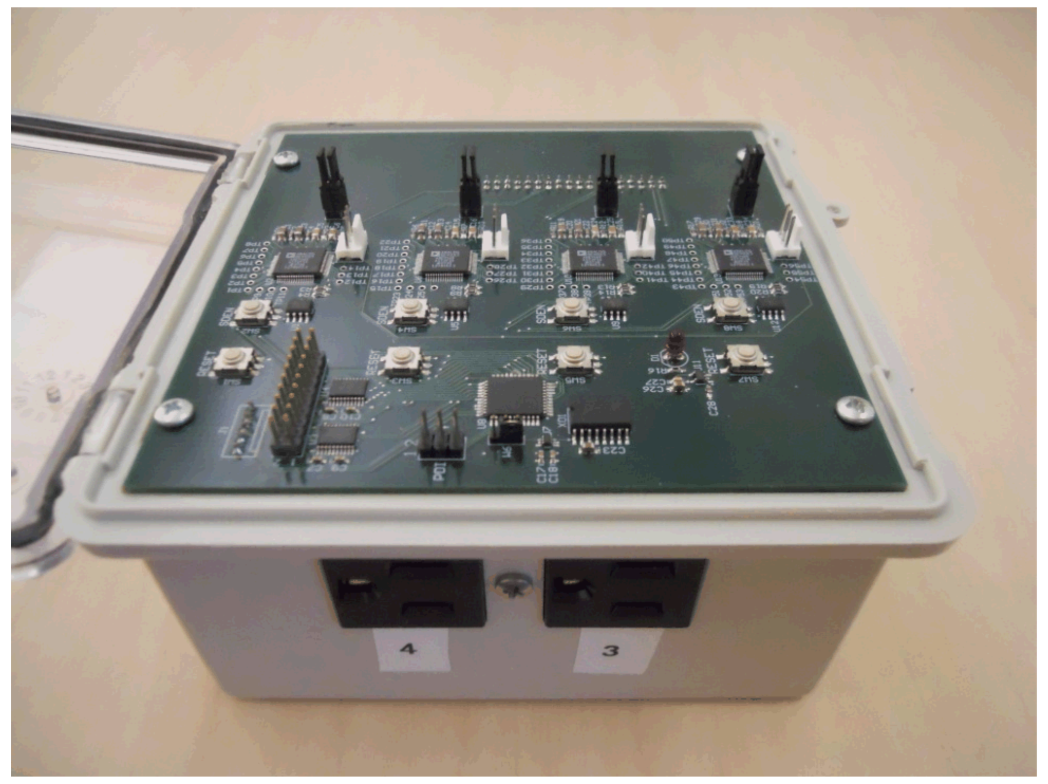
Smart Systems

Microsystems and discrete electronic devices can provide functionality including logic, sensing, communication, control and power scavenging.



Smart Outlet

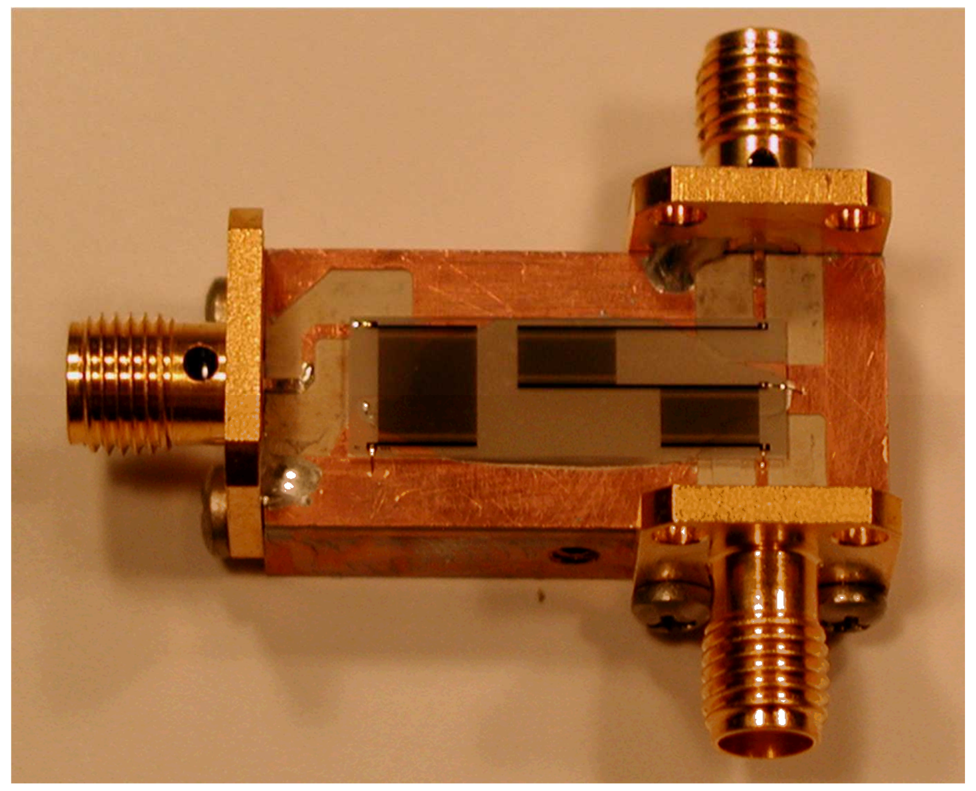
- The smart outlet platform performs sensing, actuation, processing, and communications for autonomous load control in response to variations in generation supply without a central computer or human making the decisions.
- This distributed control approach may be amenable to scaling to large numbers of loads and suited to distributed micro-grid applications where there is no central utility.



Surface Acoustic Wave (SAW) Based Wireless Sensor.

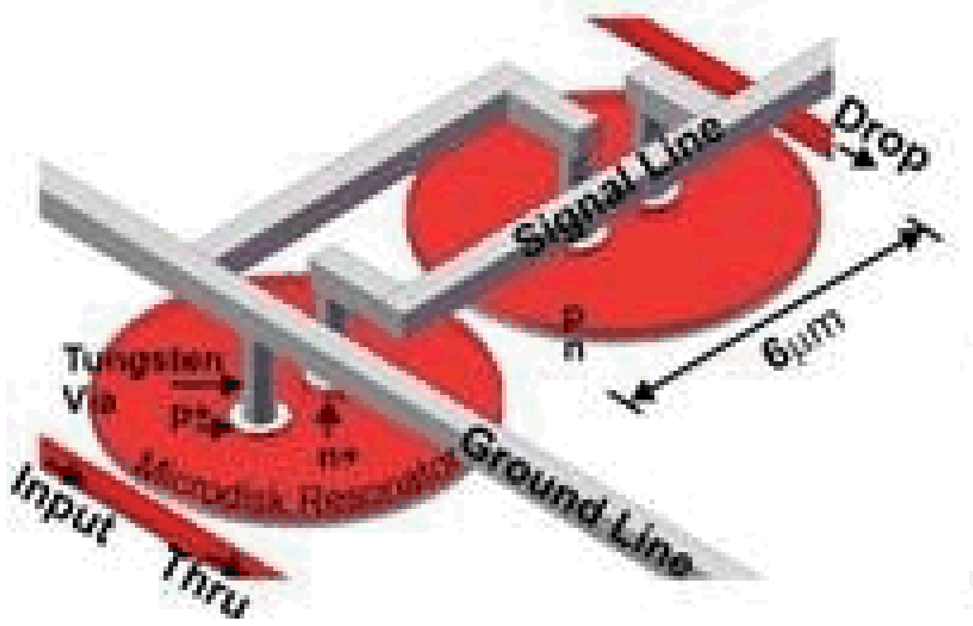
Remotely interrogate a sensor to permit a wireless measurement of the sensor signal.

The acoustic path for the fixed load is visually shorter than the sensor path so the return calibration signal will arrive a few microseconds before the signal to be recorded. A chip sized package could be designed and optimized for a particular application.



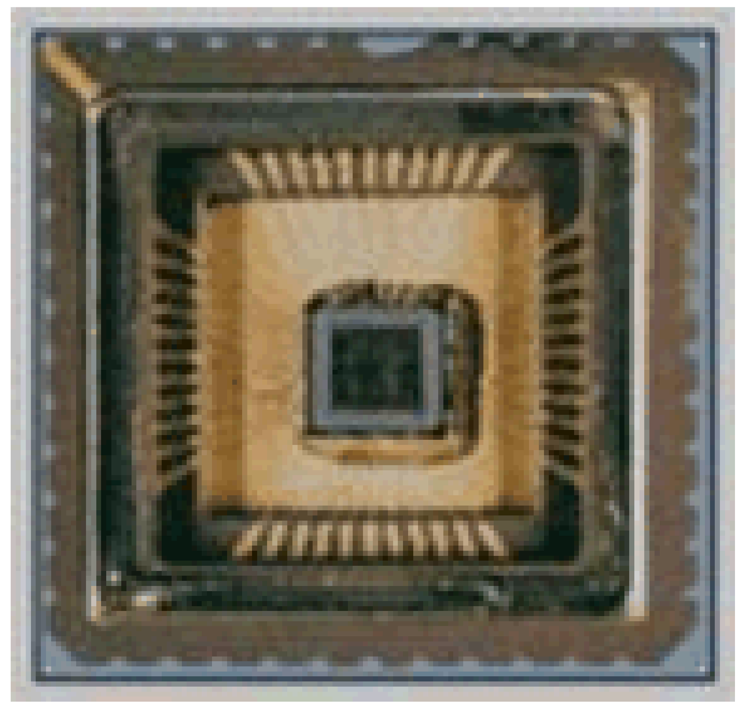
Silicon Photonics

Development of silicon photonics ring modulators to permit direct modulation of optical signals to permit high-speed low-power optical communication.



CMOS Application Specific Integrated Circuit (ASIC) Chip

CMOS ASICs design, development and fabrication to enable logic and control of energy systems.



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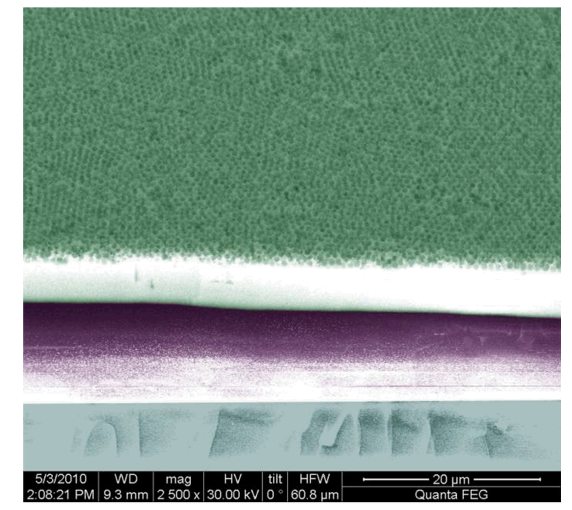
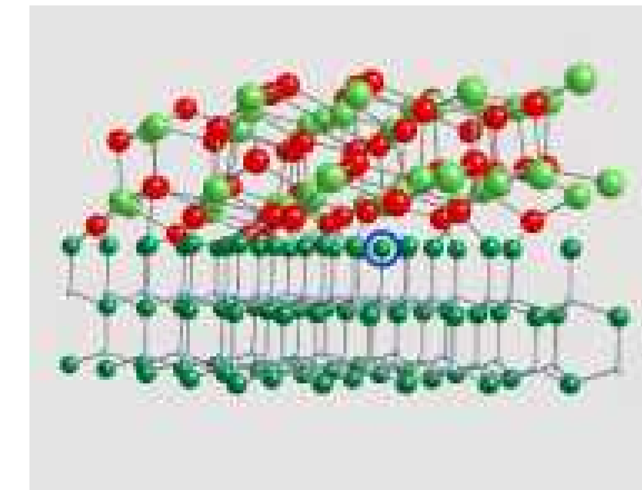
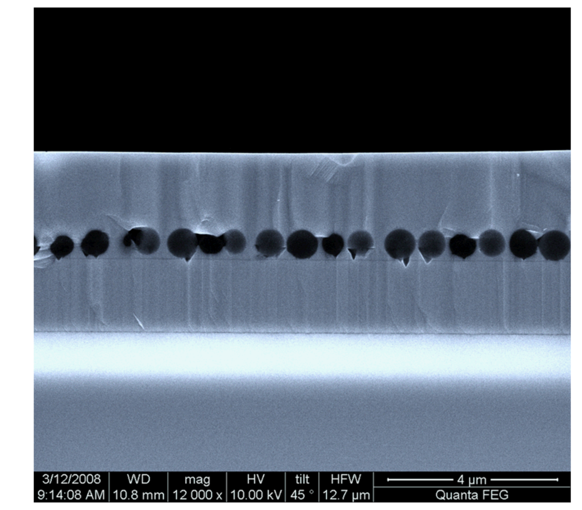
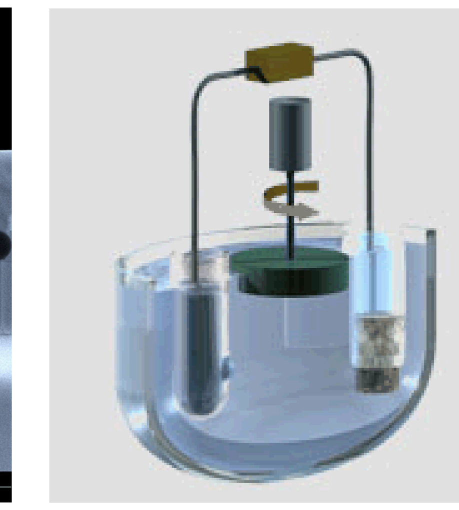
Power Systems

Electronics and materials that enable power generation, power conditioning and high-voltage switching.

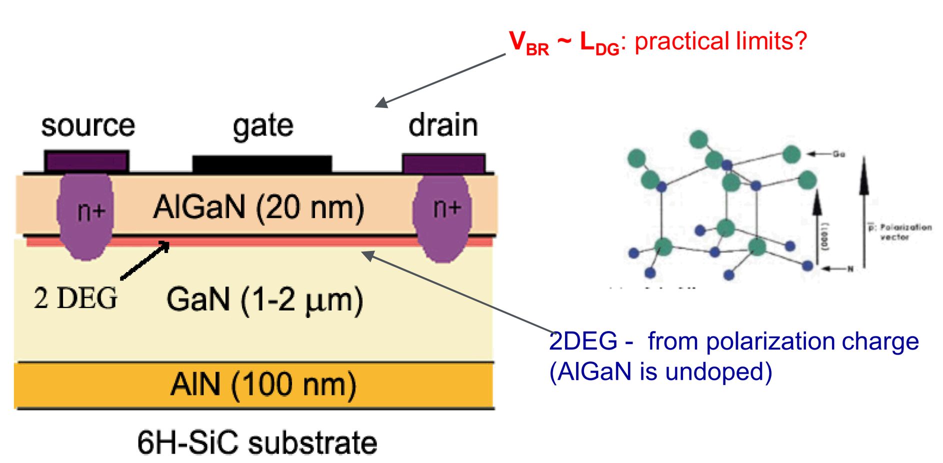





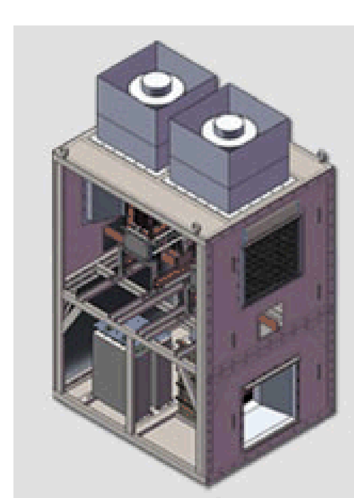
Spintronics and Photonics

GaN/AlGaN High Electron Mobility Transistors for Power Electronics

- Sandia is conducting materials research to develop high power transistors that have high voltage breakdown standoff and low resistance in the on state. To achieve this objective, they are leveraging low defect GaN and AlGaN to enable high voltage between the gate and drain of a power electronic device.
- GaN/AlGaN transistor cross section, focusing on the gate to drain region in order to increase the breakdown voltage of a lateral transistor. This particular transistor uses no intentional doping on this region, the conduction charge comes from polarization effects.

Lateral polarization charge HEMT: GaN/AlGaN





Power Conversion System:

The PCS is a vital part of all energy storage systems. It interfaces energy storage, the energy-storage device, and the load (the end-user). PCS costs are significant and can be greater than 25% of the overall storage system. PCS costs range from $100/kW for uninterruptible power supply (UPS) markets to $1200/kW for standalone markets.

Wide-bandgap Semiconductor Materials

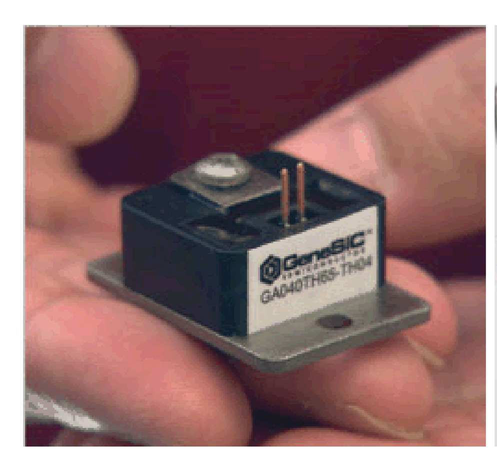
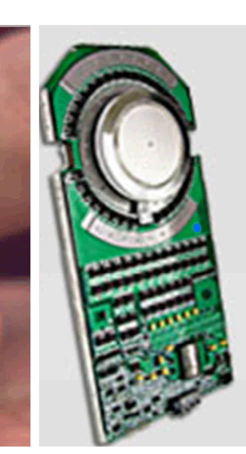
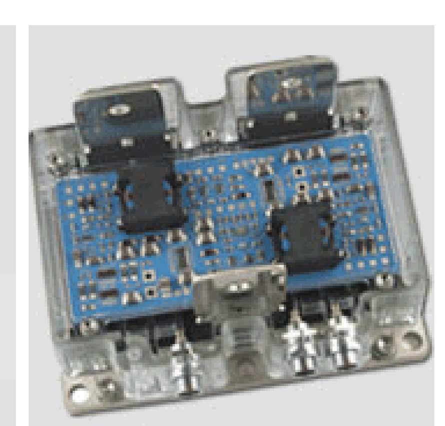
Wide-bandgap semiconductor materials such as SiC and GaN have the potential to revolutionize the field of power electronics.

- Material properties including the wide bandgap itself, as well as high breakdown electric field and high thermal conductivity, make these materials well suited for demanding power environments where switching devices are subjected to high voltage, current, and temperature.
- In order for devices fabricated from these materials to be competitive with well-established Si technology, many questions must be answered including long-term reliability.
- Understanding of these mechanisms is especially critical due to the high cost of these emerging devices compared to Si devices, especially in cost-sensitive applications such as renewable energy generation and energy storage.

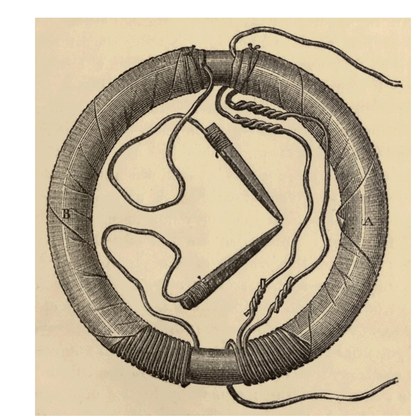
SiC Thyristors

Sandia's SiC-based Thyristors can reduce next-generation Smart Grid power electronics system size and weight by up to an order or magnitude over existing technologies by offering 10 times higher voltage, 100 times faster switching frequencies, and higher-temperature operation when compared to conventional Si-based Thyristors.

Sandia's high-temperature SiC-based half bridge power electronics module with an integrated gate driver is designed for driving electric vehicle motors and converting DC power supplied by solar arrays.

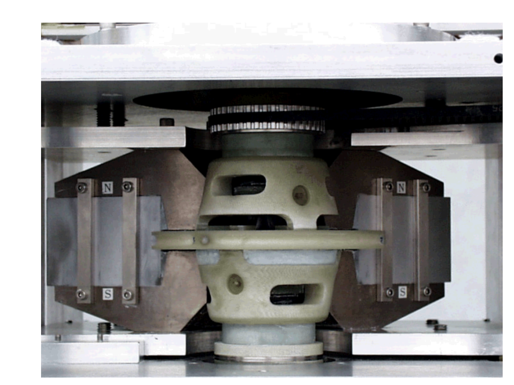




Nanocomposites for Transformer Cores



Composites based on superparamagnetic nanoparticles make an ideal candidate for transformer cores due to their high susceptibility and absence of hysteresis or eddy current losses. The basic design is for single-domain magnetic nanoparticles in a rigid insulating matrix.
Initial targets include cost-insensitive applications like pulsed power, but we foresee additional impact in grid and consumer transformers.

Nanoparticles for Magnetic Refrigeration



- Refrigeration is estimated to consume 10-30% of domestic electricity, leaving room for significant energy savings.
- Magnetic refrigeration can achieve 30% improvements in efficiency when compared to conventional refrigeration.
- Magnetic nanoparticles with rationally designed properties are being developed for rare earth-free magnetic cooling materials.
- The dependence on expensive rare earth materials remains a barrier to commercialization.

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U.S. DEPARTMENT OF ENERGY
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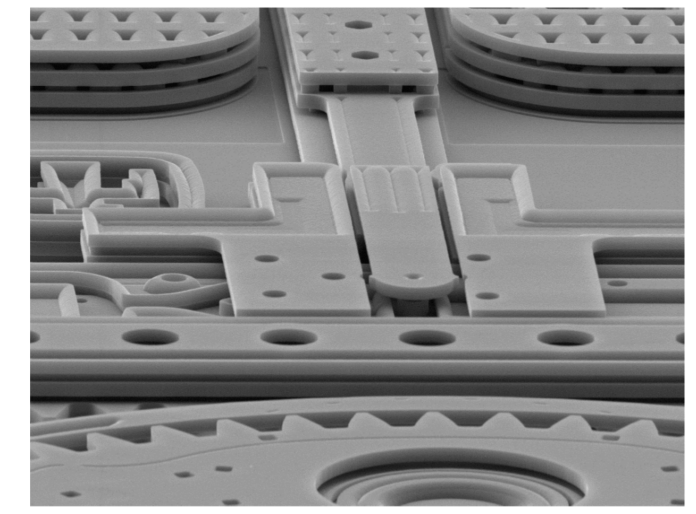
Facilities

With capabilities ranging from R&D to Production, National Lab facilities can assist industry by providing technology, product/process development and maturation expertise.



Captions:

Advanced Photon Source

(Argonne National Laboratory)

The APS is one of the most technologically complex machines in the world. This premier national research facility provides the brightest x-ray beams in the Western Hemisphere to more than 5,000 (and growing) scientists from around the United States and the world.

Our users bring with them ideas for new discoveries in nearly every scientific discipline, from materials science to biology, chemistry, environmental and planetary science, and fundamental physics. They bring their ideas to the APS because our x-ray beams let them collect data in unprecedented detail and in amazingly short time frames. The knowledge our users gain here promises to have real and positive impact on our technologies, our health, our economy, and our fundamental understanding of the materials that make up our world.

The Molecular Foundry

(Lawrence Berkeley National Laboratory)

The Molecular Foundry is a Department of Energy-funded program providing support to researchers from around the world whose work can benefit from or contribute to nanoscience. Through unparalleled access to state-of-the-art instruments, materials, technical expertise and training, the Foundry provides researchers with the tools to enhance the development and understanding of the synthesis, characterization and theory of nanoscale materials.

Center for Integrated Nanotechnologies

(Sandia National Laboratories)

- Our vision is to become a world leader in nanoscale science by developing the scientific principles that govern the design, performance, and integration of nanoscale materials.
- The distinguishing characteristic of CINT is its emphasis on exploring the path from scientific discovery to the integration of nanostructures into the micro and macro worlds.
- Work at CINT includes Nanoscale Electronics and Mechanics: Control of electronic transport and wavefunctions, and mechanical coupling and properties using nanomaterials and integrated nanosystems.

Advanced Light Source

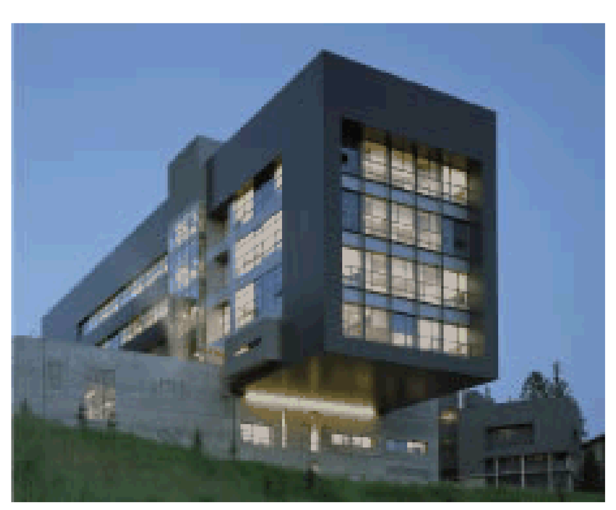
(Lawrence Berkeley National Laboratory)

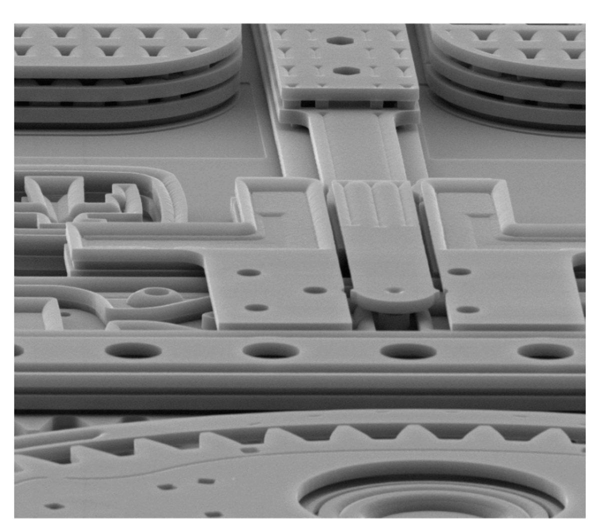
The Advanced Light Source (ALS) is located in Berkeley, California. The original building, situated in the East Bay hills overlooking San Francisco Bay, was completed in 1942. Designed by Arthur Brown, Jr. (designer of the Coit Tower in San Francisco), the domed structure was built to house Berkeley Lab's namesake E. O. Lawrence's 184-inch cyclotron, an advanced version of his first cyclotron for which he received the Nobel Prize in Physics in 1939. Today, the expanded building houses the ALS, a third-generation synchrotron and national user facility that attracts scientists from around the world.

The Microsystems & Engineering Sciences Applications (MESA) Complex

(Sandia National Laboratories)

- The Microsystems & Engineering Sciences Applications (MESA) Complex represents the essential facilities and equipment to design, develop, manufacture, integrate, and qualify microsystems for the nation's national security needs that cannot or should not be made in industry—either because the low volumes required for these applications are not profitable for the private sector or because of stringent security requirements for such high-consequence systems as nuclear warheads.
- Microsystems extend the information processing of silicon integrated circuits to add functions such as sensing, actuation, and communication—all integrated within a single package. The MESA Complex integrates the numerous scientific, engineering, and computational disciplines necessary to produce functional, robust, integrated microsystems at the center of Sandia's investment in microsystems research, development, and prototyping activities. This suite of facilities encompasses approximately 400,000 square feet and includes clean- room facilities, laboratories, and offices.





Captions: