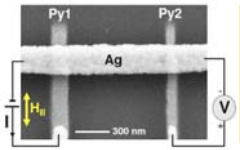
ELECTRONICS

Smart Systems

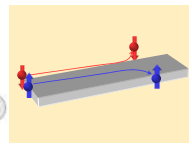
Microsystems and discrete electronic devices can provide functionality including logic, sensing, communication, control and power scavenging.

Pure Spin Currents

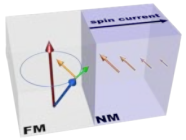
As miniaturization of electronic devices continues to ever-smaller dimensions the concomitant increasing dissipated power density becomes a formidable challenge. One possible way to address this dilemma is to utilize pure spin currents, which do not require dissipative charge displacement, but can be dominated by weakly damped exchange interactions. The main challenge is to find efficient ways for generating, manipulating, and detection of these pure spin currents.



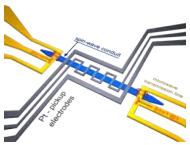
Non-local lateral spin valve. The two dimensional geometry allows to separate spin from charge flow and enables to study electrical spin injection and spin relaxation.



Spin Hall effects allow to detect and generate spin currents without the need of integrating ferromagnetic materials into the devices.



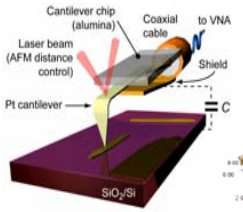
Spin pumping generates spin currents without the need for electrical charge currents. Mag-netization dynamics in a ferro-magnet give rise to spin diffusion in an adjacent normal conductor.



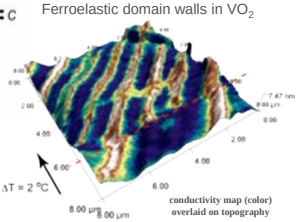
Spin Hall effects and spin pumping allow to connect spin waves in insulating ferromagnetic micro-wave conduits to electrical signals.

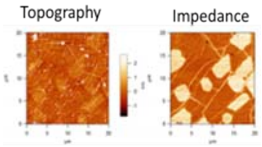
Scanning Near-Field Microwave Microscopy

- Imaging and local measurements of dielectric constant and conductivity
- Sub 100 nm resolution; f= 1-20 GHz
- Characterization of strongly correlated oxides (VO_2) and 2-D electron systems (graphene)

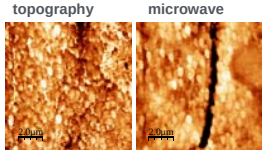


Ferroelastic domain walls in VO_2





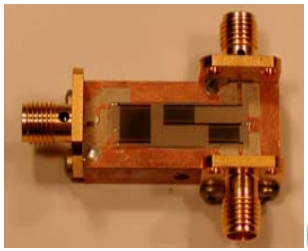
ZnO ceramic



Surface Acoustic Wave (SAW) Based Wireless Sensor.

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

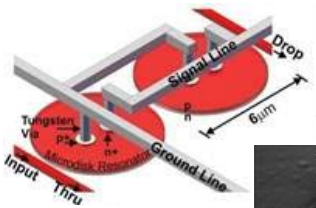
The acoustic path for the fixed load is visually shorter than the sensor path so the return calibration signal will arrive a few microseconds before the signal to be recorded. A chip sized package could be designed and optimized for a particular application.

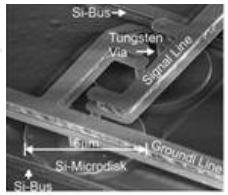


Smart Outlet

- 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.

Silicon Photonics

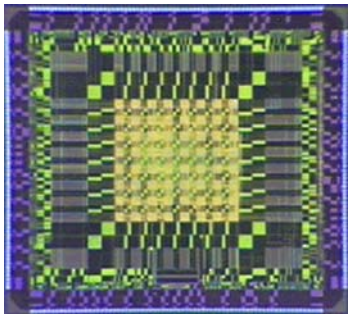




Development of silicon photonics ring modulators to permit direct modulation of optical signals for high-speed low-power optical communication.

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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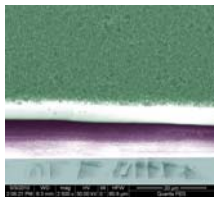
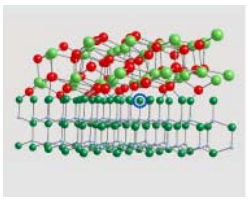
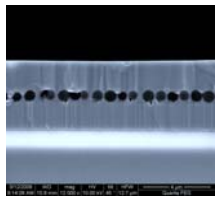
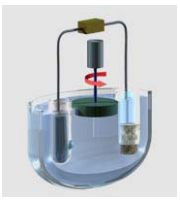
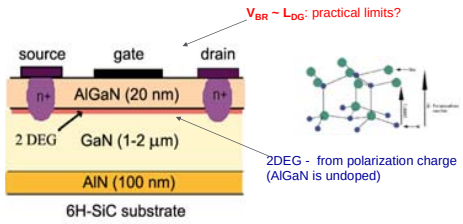
ELECTRONICS

Power Systems

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

Lateral polarization charge HEMT: GaN/AlGaN

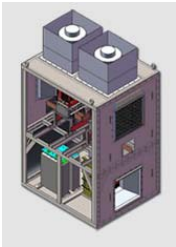


GaN/AlGaN High Electron Mobility Transistors for Power Electronics

- 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.
- MESA provides capabilities to characterize the performance and reliability of silicon and post-silicon power electronics.

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.



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.

Wide-bandgap Semiconductor Materials

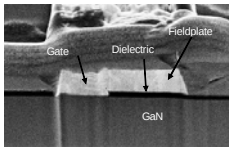
Wide-bandgap semiconductor materials such as SiC and GaN have the potential to revolutionize the field of power electronics.

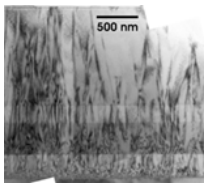
•Material properties including the wide bandgap itself, as well as high breakdown electric field and high thermal conductivity, make these materials well suited for demanding power environments where switching devices are subjected to high voltage, current, and temperature.

•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.

FIB FET Cross Section





Cross-section of AlGaN on sapphire.

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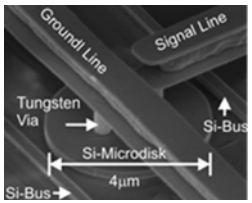
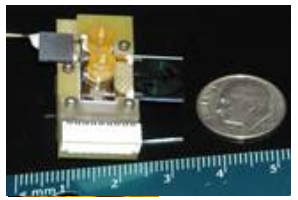
EXPLORE AND COLLABORATE
AMERICAN INDUSTRY AND AMERICA'S NATIONAL LABS
MATERIALS FOR ENERGY APPLICATIONS

ELECTRONICS

Facilities

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





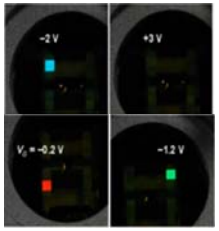
Captions
1.Inside the MESA fab.
2.Resonant optical modulator/filter
3.Micro-gas analyzer chemical sensor:

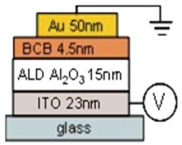
Center for Nanophase Materials Sciences

(Oak Ridge National Laboratory)

Atomic Layer Deposition (ALD)

- High performance sub 5 nm gate dielectrics and functional films for smart systems
- Highly conformal and uniform coatings
- Thickness control at the atomic level
- Wide range of precursors and resulting materials: Al_2O_3, SiO_2, TiO_2, HfO_2, AlN, HfN, V_xO_y, Fe_3O_4, ZnO





ALD Al_2O_3 Enable Low-Voltage Low-Power Organic Light Emitting Transistors

Science 332, (2011), 570

- The light is emitted through the transparent nanotube source electrode in each of the 3 primary colors
- Transparent 15 nm thick alumina films are pinhole free with leakage current density below 10^{-6} A/cm^2 and up to 6 MV/cm electrical field strength
- Lower current density improve device longevity
- Operation at industrially relevant gate voltages

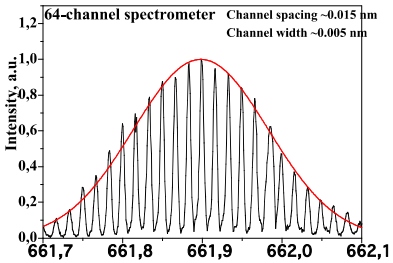
The Molecular Foundry

(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.

aBeam Technologies, Inc. and The Molecular Foundry develop a novel type of ultra-miniaturized spectrometer system with spectral resolution up to 10e5. Devices are based on planar holograms and promise to revolution the area of spectroscopy. First targeted application is Laser-Induced Breakdown Spectroscopy for metal inspection.

Novel type of miniaturized, ultra-high resolution spectrometer

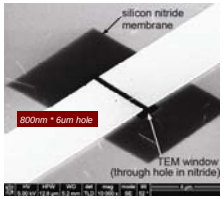


Center for Integrated Nanotechnologies

(Sandia National Laboratories)

CINT is a user facility that permits the R&D and integration of nanoscale inspired products including advanced lithium batteries, magnetic materials, and nanoelectronics.

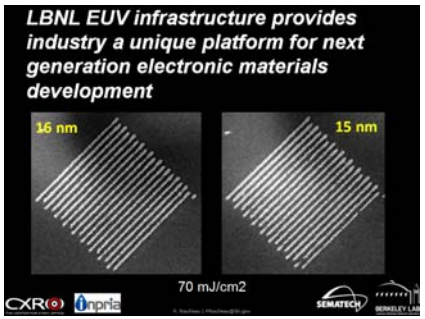
The facility permits the development, synthesis and characterization of nanoscale-structured materials for multiple applications including electronics, sensors and power devices.



Hybrid Nanofabrication Platform for in-situ TEM

Advanced Light Source

(Lawrence Berkeley National Laboratory)



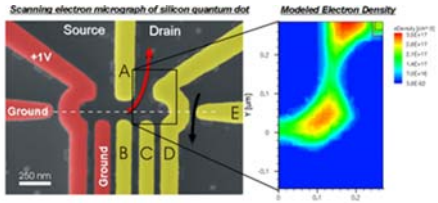
The Microsystems & Engineering Sciences Applications (MESA) Complex

(Sandia National Laboratories)

The MESA Fab at Sandia National Labs includes a Si fab and a compound semiconductor fab that permit the research, development, prototyping and limited production of multi-technology products including CMOS electronics, silicon MEMS, photonics, and power electronics, among others.

MESA has provided, to government agencies and industry, diverse solutions including the following: portable, autonomous sensors (CBRNE, physical and optical); diodes, lasers and detectors from the IR to the UV; rad-hard CMOS microelectronics; power electronics; and diverse integrated multi-function microsystems.

Current research focus areas include, among others, solid state lighting, advanced optoelectronics, quantum systems, nanoelectronics, diverse high sensitivity/selectivity sensors, power electronics and multi-junction integrated microsale-enabled PV.



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