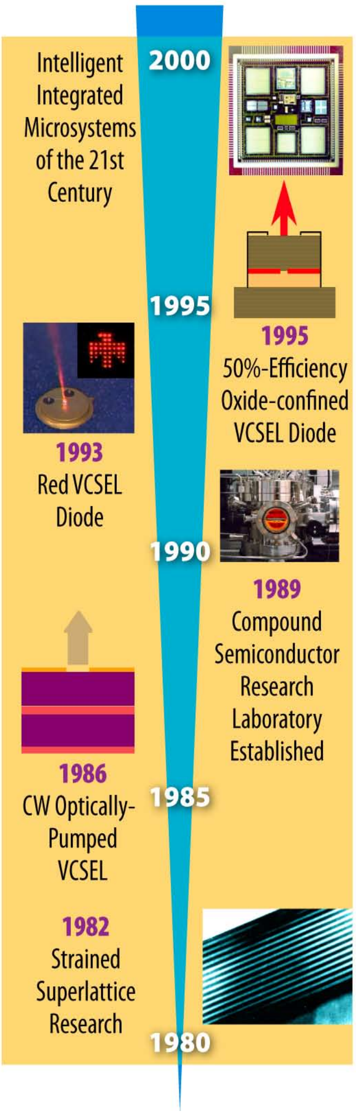
Innovation at the Interface of Science and Engineering: The Capability Advantage

SANDIA NATIONAL LABORATORIES
Nanoscience and Nanotechnology

Integration is the key to unlocking the promise of nanotechnology

Sustained Investment



Sandia's prowess in microsystems and microelectronics builds on sustained investment over several decades. The Discovery Platforms™ described here are some of the fruit of that investment. Realizing the promise of nanotechnology will require similar long-term commitment.

http://cint.lanl.gov/

Center for Integrated Nanotechnologies (CINT)

CINT, a partnership between Los Alamos and Sandia National Laboratories, is a focal point for Sandia's current research in nanoscience and nanotechnology. CINT is a Department of Energy/Office of Science Nanoscale Science Research Center operating as a national user facility devoted to establishing 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. Integration itself is key to the exploitation of nanomaterials, and the scientific challenges that it poses are at the heart of CINT's mission.

Sandia has Performed Nanoscience Research Longer Than the Word "Nanotechnology" has Been Around

Nanotechnology refers to the manipulation or assembly of individual atoms, molecules, or molecular clusters into structures with dimensions in the 1-to 100-nanometer range to create materials and devices with new. For comparison, a human hair is about 10,000 nanometers thick.

Sandia's work in nanoscience and nanotechnology dates back more than 20 years, as evidenced by our leadership in nanoscience and nanotechnology of compound semiconductors involving nanowires and quantum dots, nanoscale structures for optimizing light extraction from semiconductor-based devices, and nanoscale control of materials for quantum computing and fundamental studies of highly correlated electron systems.

Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND 2007-6814P

NNSA National Nuclear Security Administration

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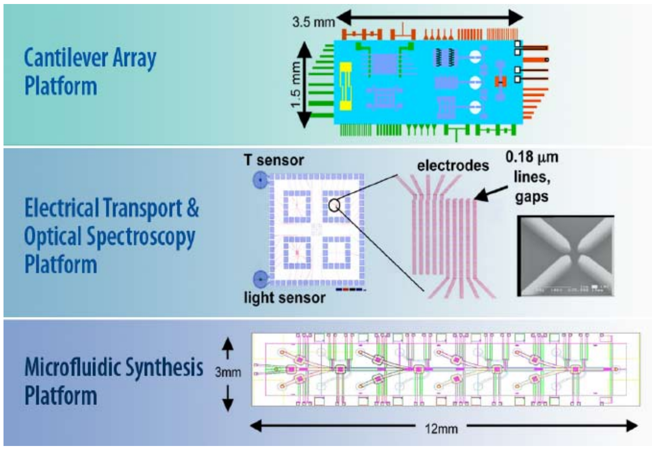
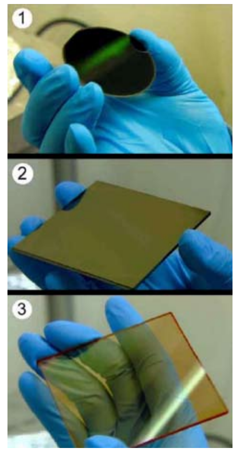


CINT's Discovery Platforms™



Examples of various nanoparticle thin films.
(1) A gold nanoparticle film on 2×2″ silicon wafer.
(2) A magnetic nanoparticle film on acrylic plate.
(3) A semiconductor nanoparticle film on acrylic plate.

Impacts on the Nanoscale

Discovery Platforms

CINT's Discovery Platforms™ are microlabs for nanoscience exploration, and they provide platforms for user-inspired problems in areas such as mechanics, optics, electronics, and fluidics. They stimulate, interrogate, and exploit nanoscale materials in a microsystem environment. The Discovery Platforms™ (shown in the figure above) have been fabricated and are undergoing in-house testing, characterization, and integration.

Nanotechology Simulations

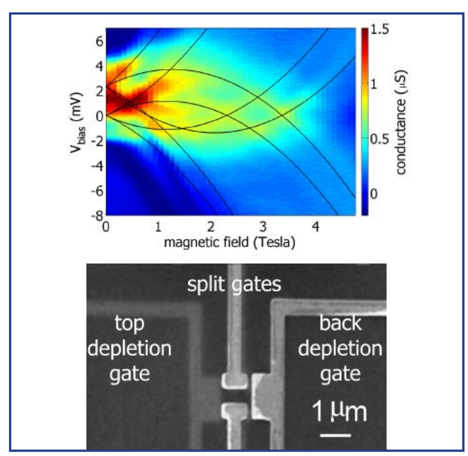
Researchers at Sandia have discovered that nanotechnology simulations provide researchers with more detailed results than experiments used alone. For example, one simulation demonstrated that a tiny but significant amount of material had transferred onto the tip of an atomic force microscope as it probed the self-assembled monolayer coating on a microsystem. Researchers discovered that the probe tip changed something infinitesimally small on the surface of the material, and it was almost not noticeable. But the property of the coating became very different. Laboratory observation could not identify the cause of the property change, but computer simulations explained the results.

Self-Assemby Process Fabricating Tailored Thin Films

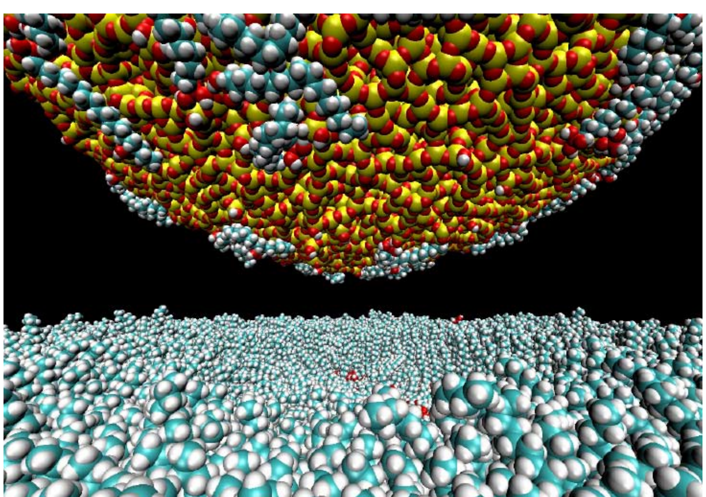
Many of today's technologies and products, including semiconductor devices, consumer electronics, and high-performance optical coatings, depend on the ability to produce high-quality thin films. Researchers at Sandia developed a wet-solution-based process employing self-assembly as a new method to produce optical and electrical thin films. This simple, economical nanotechnology driven coating process enables the development of thin films with nanoscale architectures and unique properties unattainable by any other processing method. Elegant, simple, and with more options for development and manufacturing than conventional coating processes such as chemical vapor deposition or sputtering, Sandia's technology involves chemical synthesis of mono-disperse nanoparticles with controlled chemical composition, particle size, shape, and their further assembly into engineered nanoparticle composite films.

Quantum Electron Transport

Quantum mechanical phenomena become observable only at the nanoscale but are of significant interest in the pursuit of quantum computing. Sandia scientists have combined the growth of GaAs/AlGaAs heterostructures of world-class structural and compositional purity with nanoscale fabrication techniques to fabricate two quantum wires separated by a mere 7.5 nm. Measurements on these wires reveal details about how electrons tunnel from one wire to the other and provide a significant test of theories of such systems.



Tunneling between independently contacted quantum wires provides information about energy and momentum of electrons traveling through one-dimensional systems.



"People view modeling and simulation as a critical component of nanoscience."
Eliot Fang

Left: Rendering of Sandia simulations by Michael Chandross demonstrates significant transfer of material to the probe tip of an atomic force microscope.