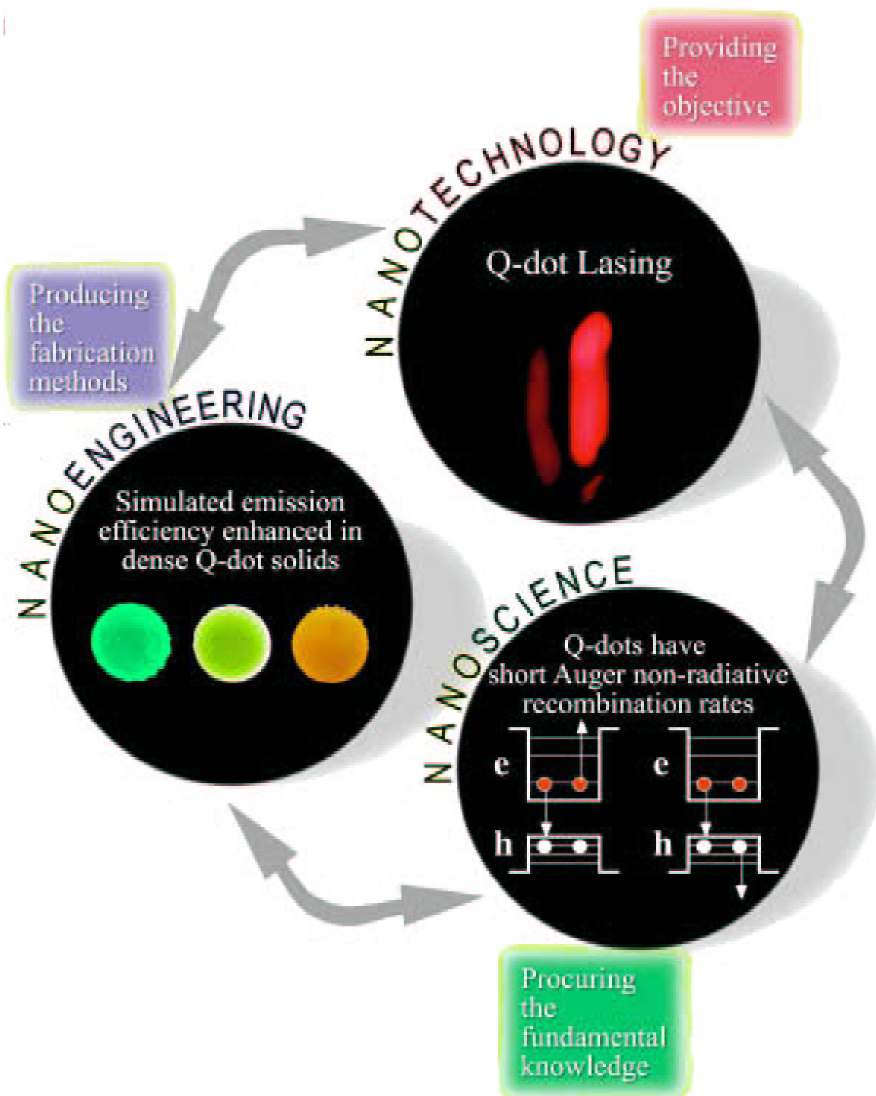
Nanoscience and Nanotechnology

There are spaces in the world too small to be seen with even the most powerful optical microscopes, where atoms and molecules are measured at the nanoscale level — lengths from 1 to 100 billionths of a meter. However, the development of sophisticated new laboratory techniques recently allowed scientists to monitor, measure, and manipulate matter at the nanoscale level. This ability to precisely control atoms and build molecules at extremely small length scales holds the promise for unprecedented breakthroughs in healthcare, manufacturing, agriculture, energy, and national security in what some are calling a nanoscience and nanotechology revolution.

Los Alamos is a leader in nanoscience and nanotechnology, developing some of the very theories and tools that have made the current revolution possible. For example, Los Alamos scientists recently constructed a novel device for “seeing” tiny metal nanoscale particles by combining sub-wavelength, near-field imaging with broadband interference spectroscopy that uses the high-intensity illumination produced by an ultrafast laser, that emits pulse durations lasting only of a few quadrillionths of a second. The technique could help scientists everywhere gain a deeper understanding of the largely unseen nanoscale world.



Los Alamos already is advancing the field of nanoscience through the discovery that nanocrystal quantum dots can provide the necessary performance for efficient emission of laser light. These tiny crystals perform over a range of temperatures, making them suitable for a variety of applications, and also can be “tuned” to emit at different wavelengths, or colors. The emission wavelength of a quantum dot is a function of its size, so by making dots of different sizes scientists can create light of different colors. This and other nanophotonics accomplishments could pave the way for new applications in computing, communications and remote sensing.

Laboratory researchers also have developed reusable nanosponges, polymer-based material with nanometer-sized pores that can absorb and trap organic contaminants in water. The sponges can be used for cleaning up oil, organic contaminants in industrial settings, organic explosives or organic chemical spills, especially in water, or for remediating underground water, all while decreasing cleanup costs associated with current technologies.

Using the new imaging technique, Los Alamos scientists have studied the collective oscillations of electrons in individual gold nanoparticles and their assemblies, which result in periodic modulations of surface charges, or surface plasmons. Understanding these oscillations and their interactions may have practical applications in the ultrasensitive detection of chemical and biological molecules.

Today, Los Alamos has five areas of focus in the field of nanoscience and nanotechnology: nano-bio-micro interfaces; nanophotonics and nanoelectronics; complex functional nanomaterials; nanomechanics; and theory and simulation.

In the future, at least some of the Los Alamos nanoscience research will take place under the auspices of the recently created Center for Integrated Nanotechnologies, a nanoscience collaboration with Sandia National Laboratories.

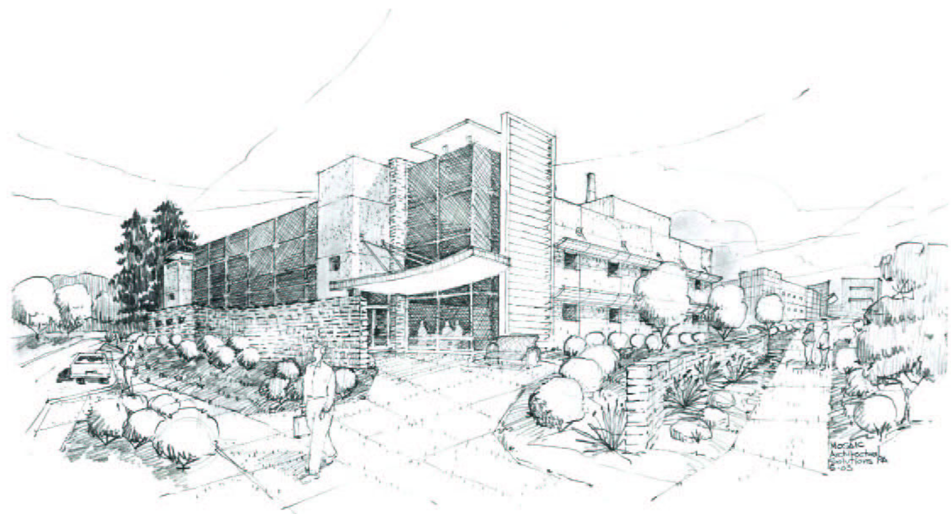
Center for Integrated Nanotechnologies

The Center for Integrated Nanotechnologies is one of five Nanoscale Science Research Centers being created by the U.S. Department of Energy's Office of Science.

A partnership between Los Alamos and Sandia National Laboratories, the center will operate as a national user facility devoted to establishing the scientific principles that govern the design, performance, and integration of nanoscale materials. Through its Core Facility at Sandia and Gateway building at Los Alamos, CINT will provide open access to tools and expertise to explore the continuum from scientific discovery to the integration of nanostructures into the micro and macro worlds.

To address the national grand challenges of nanoscience and technology, The Center for Integrated Nanotechnologies will support five scientific areas designed to serve as integrated synergistic building blocks. These areas include nano-bio-microinterfaces, which work to import biological principles and functions into artificial bio-mimetic nano- and microsystems; nanophotonics and nanoelectronics as an effort to develop the novel and unique properties necessary for the precise control of electronic and photonic wave functions; complex functional nanomaterials in order to promote complex and collective interactions between individual components in materials to yield emergent properties and functions; and nanomechanics as an attempt to increase our understanding of the underlying mechanisms of mechanical behavior of nanoscale materials and structures. In addition, CINT will provide theory and simulation research aimed at applying state-of-the-art computational resources to address complex, multiple length-scale problems. When fully operational, CINT will consist of a Core Facility in Albuquerque, two Gateway Facilities, one at Los Alamos and another at Sandia National Laboratories, and access to specialized capabilities within each laboratory. Prior to the completion of these new facilities, CINT activities will leverage existing laboratory capabilities. For example, at Los Alamos, the national user programs at the Los Alamos Neutron Science Center and the National High Magnetic Field Laboratory currently offer opportunities for CINT users to apply neutron scattering and high magnetic field techniques for nanoscale science research. In addition, Los Alamos' Bioscience Division provides expertise that spans biochemistry, soft materials, chemical synthesis, self-assembly, spectroscopy, and microscopy. At Sandia, the Compound Semiconductor Research Laboratory, the Microelectronics Development Laboratory, and the Integrated Materials Research Laboratory together provide an impressive array of state-of-the-art fabrication and characterization capabilities housed in research laboratories as well as approximately 100,000 square feet of clean room space.

Today CINT is a work in progress. The baseline budget is now set at $75.8M with a schedule for the beginning of facilities construction in March/April of 2004 and completion set for October/November 2005. Construction of the CINT Core Facility in Albuquerque and the CINT Gateway to Los Alamos Facility will occur in parallel with start and finish dates occurring within one month of each other.



Artist's concept of the new Center for Integrated Nanotechnologies Gateway at Los Alamos National Laboratory

Los Alamos NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the U.S. Department of Energy's National Nuclear Security Administration

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