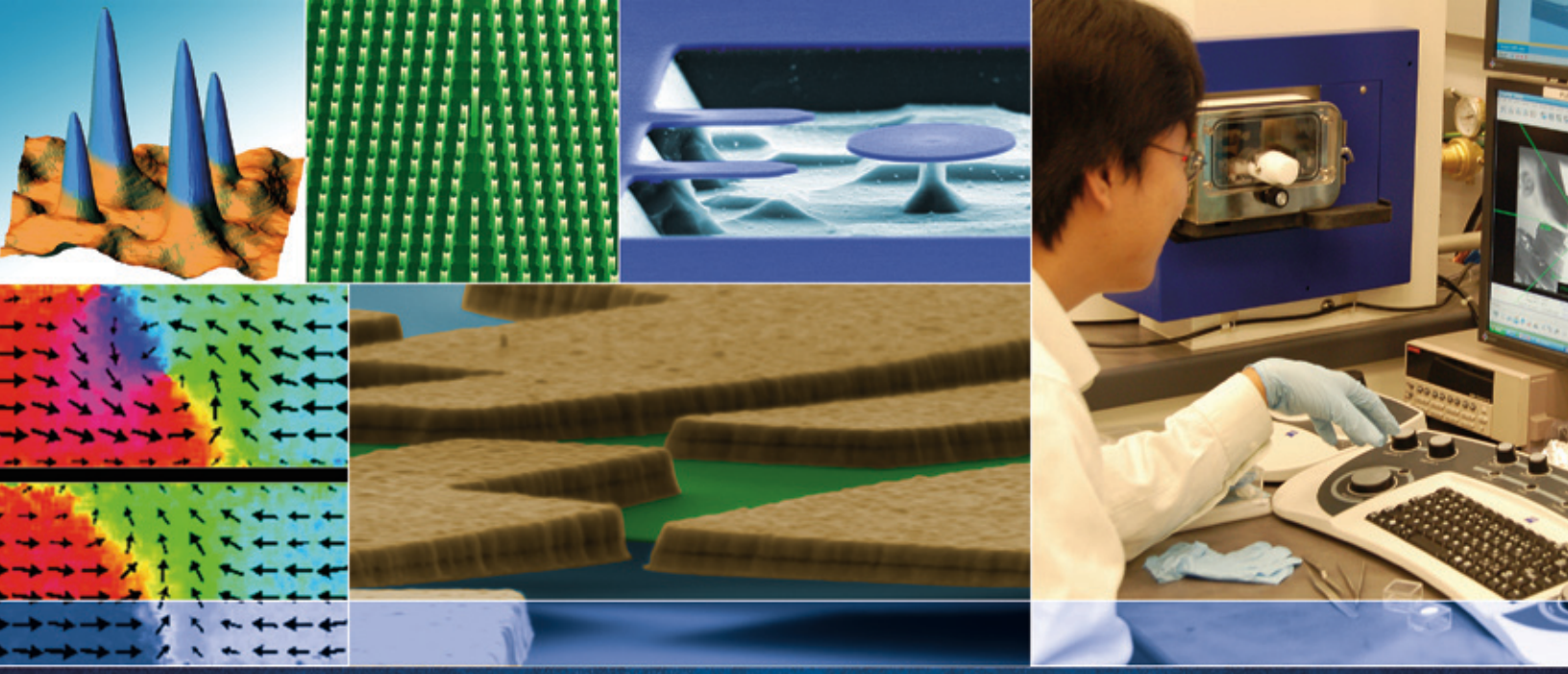
CNST Center for Nanoscale Science & Technology

Supporting the development of nanotechnology

from discovery to production.

NIST
National Institute of Standards and Technology
U.S. Department of Commerce



THE CNST AT A GLANCE

What We Do

The Center for Nanoscale Science and Technology supports the development of nanotechnology through research on measurement and fabrication methods, standards and technology and by operating a state-of-the-art nanofabrication facility, the NanoFab. The Center promotes innovation by using a multidisciplinary approach to research, maintaining a staff of the highest caliber and leveraging our efforts by collaborating with others.

The CNST was established in May 2007 in Gaithersburg, Maryland with the overarching goal of increasing the competitiveness of the U.S. nanotechnology enterprise. The Center supports nanotechnology development *from discovery to production* through its **two complementary components:** an agile, multidisciplinary **Research Program** and a state of the art **NanoFab facility**.

The **Research Program** is creating the next generation of nanoscale measurement instruments, which are made available through collaboration with CNST scientists.

The **NanoFab** is a shared-use facility operated on a cost-reimbursement basis, and is accessible through a simple application process. It provides researchers from industry, government and academia rapid access to a comprehensive suite of world-class tools and processes for nanofabrication.

Resources (FY 2010)

- $23.5 million annual budget (est.)
- 82 staff (72 technical)

Current Research Areas

- Future Electronics
- Nanofabrication and Nanomanufacturing
- Energy

NanoFab: Key Capabilities

Suite of advanced nanolithography tools and processes, including

- Large class 100 cleanroom
- Two high resolution, large area electron beam lithography systems
- High resolution laser pattern generator for on-site patterning and mask generation
- Nano-imprint lithography system
- Reactive ion etching and atomic layer deposition systems

All tools and processes are supported by expert staff and hands-on user training.

www.nist.gov/cnst

Research Groups

The CNST Research Program is agile and highly interactive by design, with significant contributions from a rotating cadre of postdoctoral researchers and CNST Visiting Fellows, and many collaborative projects both with NIST scientists and with others from across the US and abroad.

The Electron Physics Group

The Electron Physics Group conducts wide ranging, interdisciplinary research focusing on innovative measurement science in nanotechnology with an emphasis on applications for future electronics. Current programs are focused on the development of new paradigms in nanoelectronics, examining such areas as transport in novel electronic materials (e.g. graphene), spintronic and other nanomagnetic data storage and processing devices, and focused ion beam imaging and fabrication. The Group has broad expertise in scanning probe microscopy and spectroscopy, nanoscale magnetic imaging and dynamics, the theory of magnetism and electronic structure, and laser-based atom manipulation. This expertise is built on a rich history of world-leading research and instrumentation development in spin-polarized electron microscopy, electron-surface interactions, electron-atom scattering, electron optics, and scanning tunneling microscopy and spectroscopy.

Jabez McClelland
Group Leader

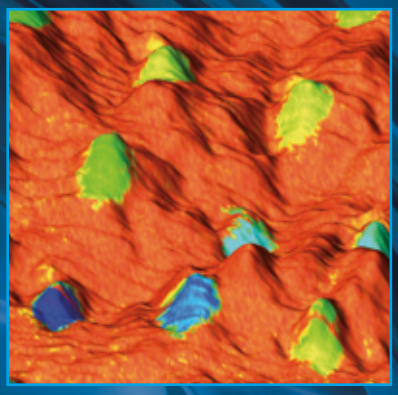
The Nanofabrication Research Group

The Nanofabrication Research Group develops novel nanofabrication and nanomanufacturing techniques and the enabling measurement methods. The Group uses a combination of theory, simulation and experiment to measure the fundamental processes underlying both top-down and bottom-up nanofabrication, and to thereby work towards feasible approaches for high-volume nanomanufacturing. Experts in plasmonics, photonics and metamaterials are creating new ways of controlling light far below the diffraction limit for observing and manipulating nanostructures. Micro- and nano-electromechanical systems are being developed as multi-probe platforms for rapid nanofabrication and multi-mode characterization of materials and devices. Stochastic processes — ubiquitous at the nanoscale — are being harnessed for precise and accurate control of nanostructure position and orientation during bottom-up assembly processes. And an environmental cell scanning/transmission electron microscopy system is being developed that will combine atomic-scale resolution with dynamic chemical analysis of nanostructures.

J. Alexander Liddle
Group Leader

The Energy Research Group

The newest Group in the CNST develops instruments designed to reveal the nanoscale physical and chemical processes and properties critical to advances in energy conversion, transport and storage. The Group's research includes nanoscale characterization of light-matter interaction, charge and energy transfer processes, catalytic activity and interfacial structure in energy-related materials and devices. The current focus is on the creation of instrumentation for nanoscale characterization of photovoltaic and thermoelectric materials and devices, nanostructures in electrochemical energy storage and conversion systems, and computational models of energy and charge transfer dynamics.



Nikolai Zhitenev
Group Leader

The CNST NanoFab – A National, Shared-Use Nanofabrication Facility

The NanoFab provides researchers from industry, government and academia rapid access to a comprehensive suite of tools and processes for nanofabrication. This world-class, 5600 m^2 (60,000 square foot) facility is a unique national resource, combining easy access, tool and process development, and training, while providing researchers from across the nation access to NIST-wide expertise in nanoscience and nanotechnology.

Infrastructure

- 1,800 m^2 (19,000 square foot) cleanroom, including 750 m^2 (8,000 square feet) at class 100
- Over 65 fabrication and processing tools in the cleanroom, including electron beam-, photo- and nanoimprint-lithography, laser writing and mask generation, field emission scanning electron microscopy, metal deposition, plasma etching, chemical vapor deposition, atomic layer deposition and silicon micro/nano-machining
- Additional tools outside the cleanroom, including a dual beam FIB system and an atomic force microscope

Key Attributes

- **Rapid Access**
  The streamlined project application process is designed to get researchers working in the cleanroom in a few weeks.
- **Process Support and Development**
  The facility is operated by a professional staff of process engineers and technicians with over 200 years of collective experience. The NanoFab offers a broad catalogue of established processes, along with assistance in the development of new processes.
- **Training and Education**
  The customer-oriented NanoFab staff members are available for expert consultation and hands-on training for all tools and processes.
- **Shared Expertise**
  As a shared-use facility open to all, the NanoFab brings NIST scientists together with industry, government and academic researchers from across the spectrum of nanotechnology applications, enabling the rapid exchange of ideas.

For a complete list of NanoFab tools, see our web site at
www.cnst.nist.gov/nanofab/nanofab.html

One of two electron beam lithography systems in the NanoFab. One resides in the class 100 cleanroom, the other in a high-performance laboratory outside the cleanroom.

The NanoFab's lithography suite features a laser pattern generator targeted for low volume mask making and direct writing. The system can write directly to mask sizes from 25 mm x 25 mm to 150 mm x 150 mm, and to wafers from 50 mm to 200 mm in diameter.

The NanoFab's atomic layer deposition system — one of five different deposition systems available — can deposit conformal, single atomic layers utilizing both thermal and plasma processes. The pictured system can deposit conformal layers of SiO_2, Al_2O_3, HfO_2, AlN, TiN and Ru.

Research Expertise

The CNST Research Program focuses on solving key interdisciplinary measurement and fabrication problems in nanoscience and nanotechnology. The Center's Project Leaders address these problems collaboratively by applying a broad range of expertise.

Atomic-scale Characterization and Manipulation

Contact: Joseph Stroscio, joseph.stroscio@nist.gov

Measurement of the geometric and electronic structure of surfaces and nanostructures, including those created by atom manipulation, using innovative ultra-high vacuum, cryogenic/high-magnetic-field scanning probe microscopy systems.

Electro-fluidic Control of Nanoparticles

Contact: Ben Shapiro, benjamin.shapiro@nist.gov

Feedback control-based techniques using electrically-driven fluid flows for controlling the position and orientation of nanoparticles.

Environmental Transmission Electron Microscopy

Contact: Renu Sharma, renu.sharma@nist.gov

Development of environmental cell scanning/transmission electron microscopy systems, combining atomic-scale resolution with dynamic chemical analysis, and its application to characterizing nanostructures and nanostructured materials, including catalysts.

Laser-atom Manipulation

Contact: Jabez McClelland, jabez.mcclelland@nist.gov

Laser control of atomic motion and its application to new nanofabrication and nanoscale measurement methods.

Modeling and Simulation of Nanofabrication

Contact: Gregg Gallatin, gregg.gallatin@nist.gov

Modeling, simulation and analysis of the physics and metrology of both lithographic and self-assembly based nanofabrication methods.

Nanofabrication

Contact: J. Alexander Liddle, alex.liddle@nist.gov

Methods to create and characterize processes underlying both top-down and bottom-up nanofabrication, from high-fidelity resists, to template-driven self-assembly.

Nanomagnetic Dynamics

Contact: Robert McMichael, robert.mcmichael@nist.gov

Dynamic measurement methods and supporting modeling for characterization of magnetic properties and spin polarized transport in magnetic nanostructures.

Nanomagnetic Imaging

Contact: John Unguris, john.unguris@nist.gov

Development and application of scanning electron microscopy with polarization analysis (SEMPA) for correlating material and magnetic structure across millimeter to nanometer length scales.

Nanomaterials for Energy Storage and Conversion

Contact: Alec Talin, alec.talin@nist.gov

Characterization of charge and matter transport in electrochemical energy storage and conversion devices based on novel nanomaterials and nanostructures.

Nanophotonics

Contact: Kartik Srinivasan, kartik.srinivasan@nist.gov

Fabrication of optical nanostructures that confine light to wavelength-scale dimensions, and the development of near-field probes and micro-photoluminescence systems to measure light-matter interactions in such structures.

Nanoplasmonics

Contact: Henri Lezec, henri.lezec@nist.gov

Design and fabrication of plasmonic systems that confine and control light at the nanoscale for deep sub-wavelength metrology, spectroscopy, lithography and future information processing.

Nanoscale Electronic and Ionic Transport

Contact: Nikolai Zhitenev, nikolai.zhitenev@nist.gov

Development of novel probes for characterizing light-matter interaction and charge and energy transfer processes at the nanoscale, and their application to determining the electronic and ionic transport properties of thin films and nanostructures.

Fluctuations and Nanoscale Control

Contact: Andrew Berglund, andrew.berglund@nist.gov

Methods for characterizing and controlling fluctuations in nanoscale systems, focusing on real-time measurement and feedback control for single-particle tracking and spectroscopy in liquid environments.

Nanotribology and Nanomanufacturing

Contact: Rachel Cannara, rachel.cannara@nist.gov

Techniques to quantify nanoscale frictional energy dissipation and to tailor interactions between nanoscale objects, and their use in the design of nanomanufacturing devices and systems.

Optical Micro/Nanoelectromechanical Systems

Contact: Vladimir Aksyuk, vladimir.aksyuk@nist.gov

Integrated optical micro electro mechanical systems (MEMS) with nano-scale elements (NEMS) for novel imaging, metrology, manipulation and assembly techniques.

Theory, Modeling and Simulation of Nanostructures

Contact: Mark Stiles, mark.stiles@nist.gov

Fundamental calculations that broadly elucidate the properties of nanostructures, ranging from magnetic materials and devices, to superconductors, to graphene.

Thermoelectrics and Photovoltaics

Contact: Fred Sharifi, fred.sharifi@nist.gov

Characterization of charge and phonon transport in reduced-dimension and nanostructured thermoelectric systems, and the impact of defects on transport and conversion efficiencies in inorganic photovoltaics.

About NIST

Founded in 1901, the National Institute of Standards and Technology is a non-regulatory federal agency within the U.S. Department of Commerce. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards and technology in ways that enhance economic security and improve our quality of life. NIST's estimated FY 2010 resources total $1 billion. The agency operates in two locations: Gaithersburg, Maryland (headquarters) and Boulder, Colorado. NIST employs about 2,900 scientists, engineers, technicians and support and administrative personnel, and hosts about 2,600 associates and facility users from academia, industry and other government agencies. See *www.nist.gov*.

CNST Center for Nanoscale Science & Technology

For administrative or technical inquiries contact:

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Lloyd Whitman, Deputy Director	lloyd.whitman@nist.gov

To discuss collaborative research opportunities contact our Group Leaders:

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J. Alexander Liddle, Nanofabrication Research Group	alex.liddle@nist.gov
Nikolai Zhitenev, Energy Research Group	nikolai.zhitenev@nist.gov

To discuss potential projects at the CNST NanoFab contact:

Vincent Luciani, NanoFab Manager		vincent.luciani@nist.gov
	or call:	1-877-NANO-US1
	or browse:	*www.cnst.nist.gov/nanofab/nanofab.html*

Employment Information:

The CNST has ongoing opportunities for Project Leaders, Postdoctoral and Student Researchers, Visiting Fellows and Process Engineers and Technicians. The CNST offers a dynamic, multidisciplinary environment for scientists at all career stages — from high school interns, through senior researchers seeking a highly productive sabbatical visit. Visit our web site for additional information and *www.USAJOBS.gov* for current vacancy announcements.

Travel Award Program:

A NIST-University of Maryland Cooperative Program competitively awards travel grants to participate in research at the CNST, including the NanoFab. See *www.nanocenter.umd.edu/travel*.

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