Chapter 13
Locations of US Facilities

Description of Locations

The National Nanotechnology Coordinated Infrastructure (NNCI) consists of 16 primary sites distributed across the United States. Of these, two are specialized research facilities and the rest are open use facilities that welcome industry users.

On the west coast, the facilities are the University of Washington (with partner Oregon State University), Stanford University, and the University of California at San Diego.

In the western region, the facilities are Montana State University (with partner Carlton College), Arizona State University (with partners Maricopa County Community College and Science Foundation Arizona), University of Nebraska at Lincoln, and the University of Texas at Austin.

In the Midwestern region, the facility is the University of Minnesota at Twin Cities with partner North Dakota State University. There is also a specialized facility for soft and hybrid nanomaterials at Northwestern University with partner University of Chicago. Not part of NNCI, but also at Northwestern University, is the Nanotechnology Corporate Partners (NCP) Program, which collaborates with industry.

In the southern region, the facilities are the University of Louisville (with partner University of Kentucky) and Georgia Institute of Technology (with partners North Carolina A&T State University and University of North Carolina at Greensboro).

On the east coast, the facilities are Harvard University, Cornell University, the University of Pennsylvania, and North Carolina State University (with partners Duke University and University of North Carolina at Chapel Hill). There is also a specialized facility for Earth and environmental science at Virginia Tech (with partner Pacific Northwest National Laboratory [PNNL]).

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Tabulated List of Locations

Each site submitted an application with a detailed abstract. This information can be found at http://www.nnin.org/news-events/news/nnci-award and is summarized here by region with all of the key contact information. It is further tabulated in Table 13.1.

Table 13.1 Summary of NNCI facilities

NNCI facility name	Primary site	Location	NNCI site name	Facility website
West coast region				
Northwest Nanotechnology Infrastructure	University of Washington	Seattle, Washington	NNI	www.wnf.washington.edu
Nano@Stanford	Stanford University	Palo Alto, California	NanoStanford	nanolabs.staaford.edu
San Diego Nanotechnology Infrastructure	University of California at San Diego	La Jolla, California	SDNI	sdni.ucsd.edu
Western region				
Montana Nanotechnology Facility	Montana State University	Bozeman, Montana	MONT	www.nano.montana.edu
Nanotechnology Collaborative Infrastructure Southwest	Arizona State University	Tempe, Arizona	NCI-SW	ncisouthwest.org
Nebraska Nanoscale Facility	University of Nebraska at Lincoln	Lincoln, Nebraska	NNF	nanoscale.unl.edu
Texas Nanofabrication Facility	University of Texas at Austin	Austin, Texas	TNF	www.mrc.utexas.edu
Midwestern region				
Midwest Nano Infrastructure Corridor	University of Minnesota at Twin Cities	Minneapolis, Minnesota	MiNIC	minic.umn.edu
Soft and Hybrid Nanotechnology Experimental Resource	Northwestern University	Evanston, Illinois	SHyNE	www.shyne.northwestern.edu
Nanotechnology Corporate Partners (NCP) Program	Northwestern University	Evanston, Illinois	*Allows corporate partners	www.iinano.org/nanotech-nology-corporate-partners-program

(continued)

Table 13.1 (continued)

NNCI facility name	Primary site	Location	NNCI site name	Facility website
Southern Region				
Kentucky Multi-scale Manufacturing and Nano Integration Node	University of Louisville	Louisville, Kentucky	KY-MMNIN	www.kymultiscale.net
Southeastern Nanotechnology Infrastructure Corridor	Georgia Institute of Technology	Atlanta, Georgia	SENIC	senic.gatech.edu
Eastern Region				
Cornell Nanoscale Science and Technology Facility	Cornell University	Ithaca, New York	CNF	www.cnf.cornell.edu
Virginia Tech National Center for Earth and Environmental Nanotechnology	Virginia Polytechnic Institute and State University	Blacksburg, Virginia	NanoEarth	www.nanoearth.ictas.vt.edu
North Carolina Research Triangle Nanotechnology Network	North Carolina State University	Raleigh, North Carolina	RTNN	www.rtnn.ncsu.edu
East coast region				
Center for Nanoscale Systems	Harvard University	Cambridge, Massachusetts	CNS	cns1.rc.fas.harvard.edu
Mid-Atlantic Nanotechnology Hub	University of Pennsylvania	Philadelphia, Pennsylvania	MANTH	www.nano.upenn.edu

West Coast Region

Northwest Nanotechnology Infrastructure (NWNI)

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Abstract
The Northwest Nanotechnology Infrastructure (NWNI) as an NNCI site serves as the prime resource for nanotechnology researchers and engineers for a large geographical area from the Pacific Coast to Montana and from southern Oregon to the Canadian border and beyond. NWNI offers world-class facilities at the University of Washington (UW) in Seattle and Oregon State University (OSU) in Corvallis, complemented with unique capabilities at Pacific Northwest National Laboratory, a Department of Energy site, and the University of British Columbia in Vancouver, Canada. Anchored at the UW, this site provides critical workhorse tools, unique instruments, and key educational support to a large and distributed user base with particular attention to the clean energy and biotechnology fields.

The mission of NWNI consists of four core services that can be described by four Ms: make, measure, model, and mentor. The first three Ms form the physical foundation and the fourth serves to coordinate educational efforts with broad impact beyond the scientific community. The physical infrastructure consists of the Washington Nanofabrication Facility (WNF, Seattle) and the Microproducts Breakthrough Institute (MBI, Corvallis) for making, the Molecular Analysis Facility (MAF, Seattle) and the Materials Synthesis and Characterization Facility (MaSC, Oregon) for measuring and distributed computational resources for modeling in design and analysis. Mentoring is essential to NWNI. The site's integration with the region's vibrant biotech and start-up community implies immense diversity in users.

NWNI offers flexible access to its facilities, from comprehensive training of local users to operator-assisted tool access to remote execution of assignments. Whether novice or seasoned engineer or scientist, whether undergraduate, graduate, postdoc, or community college student or teacher, all users are offered support for their entire nanotechnology project from initial design to final analysis.

The NWNI serves as a broad-based nanotechnology resource, though three principal research focus areas are highlighted in which the site will provide leadership:

(i) Integrated photonics, which aims at enabling large-scale photonic networks, which are expected to overcome current limits in speed and bandwidth of electronic circuits. Beyond information processing, the miniaturization and integration of photonics in medical devices is facilitating the development of new, minimally invasive health diagnostics.
(ii) Advanced energy materials and devices, which aims at providing the scientific and engineering basis for clean energy solutions, including the creation of better batteries or scalable and environmentally benign materials for solar power.
(iii) Bio-nano interfaces and systems, which provides the infrastructure and expertise for inventing and demonstrating new devices for biomedical applications, enabling advances in protein modeling, drug delivery, sensors, bio-scaffolds, and bioelectronics. NWNI features capabilities in materials and devices including quantum dots, superabsorbers for solar cells, and oxide-base transistors for flexible electronics for sensors and displays, resulting in comprehensive infrastructure and expertise in nanotechnology that is considered unique within the field.

The site provides an array of educational activities geared toward a broad audience and designed to have a multiplier effect. Three signature residence programs are offered:

(i) Educators in residence gain hands-on laboratory skills for use in teaching their K-12 classes.
(ii) Entrepreneurs in residence, in coordination with UW Technology Transfer (CoMotion), work with nanotechnology inventors to explore start-up opportunities.
(iii) OSU Advantage connects businesses with faculty expertise, student talent, and world-class NWNI facilities to assist in bringing ideas to market.

In a collaboration with the University of British Columbia, online edX courses are supported that allow students across the country and around the world to build and test their own nanoscale photonic devices on multiproject wafers built with electron beam lithography at UW. Worldwide, UW participates in a network of 15 institutions in America, Asia, and Europe that offer joint summer schools on nanotechnology for future global engineers.

Stanford University—SNSF, SNF, MAF, EMF

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Abstract

The Stanford site of the National Nanotechnology Coordinated Infrastructure (NNCI) at Stanford University will provide open, cost-effective access to state-of-the-art nanofabrication and nanocharacterization facilities for scientists and engineers from academia, small and large companies, and government laboratories. Stanford will open the Stanford Nano Shared Facilities (SNSF), the Stanford Nanofabrication Facility (SNF), the Mineral Analysis Facility (MAF), and the Environmental Measurement Facility (EMF) more fully to external users.

Open access to these facilities will not only promote the progress of science but also accelerate the commercialization of nanotechnologies that can solve a broad array of societal problems related to energy, communication, water resources, agriculture, computing, clinical medicine, and environmental remediation. Stanford

will create and assemble a comprehensive online library of just-in-time educational materials that will enable users of shared nanofacilities at Stanford and elsewhere to acquire foundational knowledge independently and expeditiously before they receive personalized training from an expert staff member. Stanford staff members will also collaborate with two minority-serving institutions (California State University Los Angeles and California State University East Bay) to provide coursework, hands-on training, and nanofacility access to their students.

The Stanford site's shared nanofacilities will offer a comprehensive array of advanced nanofabrication and nanocharacterization tools, including resources that are not routinely available, such as an MOCVD laboratory that can deposit films of GaAs or GaN, a JEOL e-beam lithography tool that can inscribe 8-nm features on 200-mm wafers, a NanoSIMS, and a unique scanning SQUID microscope that detects magnetic fields with greater sensitivity than any other instrument.

The facilities occupy ~30,000 ft^2 of space, including 16,000 ft^2 of cleanrooms, 6000 ft^2 of which meet stringent specifications on the control of vibration, acoustics, light, cleanliness, and electromagnetic interference. The staff members who will support external users have acquired specialized expertise in fabricating photonic crystals, lasers, photodetectors, optical MEMS, inertial sensors, optical biosensors, electronic biosensors, cantilever probes, nano-FETs, new memories, batteries, and photovoltaics.

Stanford will endeavor to increase the number of users from nontraditional fields of nanoscience (e.g., life science, medicine, and Earth and environmental science) by creating a targeted formal curriculum, fabricating experimental nanostructures as a service, providing seed grants, and leading seminars and webinars.

San Diego Nanotechnology Infrastructure (SDNI)

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Abstract

The San Diego Nanotechnology Infrastructure (SDNI) site of the NNCI at the University of California at San Diego offers access to a broad spectrum of nanofabrication and characterization instrumentation and expertise that enable and accelerate cutting-edge scientific research, proof-of-concept demonstration, device and

system prototyping, product development, and technology translation. Nanotechnology is the cornerstone of many industry sectors and a rich source for scientific discoveries and innovations. Using nanotechnologies, scientists are likely to find solutions for the most important challenges in health, communications, energy, and environment.

Nanotechnology is multidisciplinary by nature and requires highly sophisticated tools and deep expertise, often unavailable or unaffordable by individual research labs and businesses. The SDNI site will offer state-of-the-art knowhow, tools, and services of nanotechnologies to all interested users across the nation in a user-friendly, timely, and cost-effective manner. The site will also become a nanotechnology provider to create and develop new nanotechnologies and bring them to its users.

The goals of the site are to serve a large number of academic, industrial, and government users, to transfer enabling nanotechnologies from research laboratories to the general user community, to educate and train future generations of scientists and engineers in nanotechnology, and to bring nanoscaled research experience to college students and K-12 students, especially underrepresented minority students, to prepare them for STEM careers.

The SDNI site will build upon the existing Nano3 user facility and leverage additional specialized resources and expertise at the University of California at San Diego. The SDNI site is committed to broadening and further diversifying its already substantial user base. The proposed strategic goals include:

(i) Providing infrastructure that enables transformative research and education through open, affordable access to the nanofabrication and nanocharacterization tools and an expert staff capable of working with users to adapt and develop new capabilities, with emphasis in the areas of nanobiomedicine, nanophotonics, and nanomagnetism
(ii) Accelerating the translation of discoveries and new nanotechnologies to the marketplace
(iii) Coordinating with other NNCI sites to provide uninterrupted service and creative solutions to meet evolving user needs

Significant growth is anticipated in the number and variety of local and regional users in the academic, government, and industrial sectors. Discoveries made by users of the SDNI site have the potential to create transformative change in fields as diverse as medicine, information technology, transportation, homeland security, and environmental science, leading to improved healthcare, faster communications, safer transit, and cleaner water and air.

To develop a more diverse and productive scientific workforce, the SDNI site will expand undergraduate and graduate training programs including REU opportunities to train 900 students over 5 years. Through an RET program and other activities, the site will work to increase the number of students from underrepresented minority groups who pursue studies and, ultimately, careers in STEM disciplines.

Western Region

The Montana Nanotechnology Facility (MONT)

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Abstract

Nanotechnology, which gives us the ability to manipulate and interrogate physical systems on a length scale of nanometers to microns, has become pervasive in many fields of scientific inquiry and engineering. Access to basic nanotechnology tools has therefore become increasingly important, not only for so-called nanotechnologists but for scientists and engineers from many academic disciplines and from industry.

The Montana Nanotechnology Facility (MONT), an NNCI site at Montana State University, promotes discovery, education, and outreach related to nanotechnology by providing access to shared-use instruments, expert training on their safe and effective use, and broad-based education about nanoscale science and technology for learners at all levels who come from diverse communities.

The MONT site serves both regional users in the northern Rocky Mountains and Great Plains and users from across the United States who need the specific expertise and equipment found at Montana State University. Those users are pursuing diverse objectives related to advances in healthcare diagnostics and surgical solutions, sources of clean energy, remediation strategies for contaminated soils, and technologies related to optical telecommunications, imaging systems, and advanced computing.

By enhancing our service to external users and building on its unique fabrication and characterization strengths, MONT will help to meet a national need for access to nanotechnology, for training of the workforce that will develop the nanotechnology of the future, and for education and outreach that engages and informs students and teachers from kindergarten to graduate school, industrial users, and the general public.

MONT helps meet the growing need faced by regional and national researchers for access to nanofabrication tools and processes at the interdisciplinary frontiers, with local expertise related to microelectromechanical systems (MEMS) and micro-opto-electromechanical systems (MOEMS); microfluidics; nanostructured materials with unique optical, mechanical, or thermal properties; ceramic materials; bio-inspired and bio-derived nanostructures; and bacteria or bacterial biofilms incorporated into micro- or nanoengineered substrates. The goals of the MONT site are as follows:

(i) To increase the number of external users served
(ii) To increase the collective research output of MONT users
(iii) To enhance the MONT site's capabilities in the areas of its research strengths through heavily leveraged capital investment
(iv) To create best-in-class educational opportunities for facility users, STEM educators, and the general public

These goals are accomplished through specific initiatives that will add laboratory personnel to enhance training, assistance, and advocacy for external users, establish a user grant program for external users to help address costs of facility use as well as local housing, invest in new tools and capabilities, and expand both on-site and web-based instructional and outreach activities related to nanofabrication, nano-characterization, and the ethics and societal impacts of nanotechnology.

The project specifically improves access to nanotechnology infrastructure in the northern Rockies/Great Plains region, and it promotes discovery, education, and outreach in emerging fields where nanotechnology is impacting the life sciences, healthcare, energy, the environment, and a number of important technology sectors.

Nanotechnology Collaborative Infrastructure Southwest (NCI-SW)

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Abstract
Arizona State University (ASU) will establish the Nanotechnology Collaborative Infrastructure Southwest (NCI-SW) as an NNCI site. The NCI-SW will support the advanced toolset, faculty expertise, and knowledgeable staff required by academic and industrial users performing research at the frontiers of nanoscience and engineering.

Its training programs will focus on workforce development and entrepreneurial initiatives for twenty-first century manufacturing industries. A partnership between ASU, Maricopa County Community College District (MCCCD), and Science Foundation Arizona (SFAz) will allow two-year colleges in metropolitan Phoenix and rural Arizona to deliver a STEM-based nanotechnology curriculum designed to meet the economic development needs of their communities.

Particular emphasis will be placed on programs in rural Arizona that support Hispanic and Native American students. Students in these programs will have access to advanced laboratory facilities either directly on the ASU campus or via remote access. Faculty and students from local high schools and community colleges will collaborate with ASU faculty on summer research programs at the frontiers of nanotechnology and develop lesson plans that convey the excitement of the latest discoveries back to their classrooms. Public outreach events at science fairs and at the Arizona Science Center will allow the wider community access to the latest breakthroughs in nanotechnology at ASU and from around the world.

The goals of the NCI-SW are to build a southwest regional infrastructure for nanotechnology discovery and innovation, to address societal needs through education and entrepreneurship, and to serve as a model site of the NNCI. The NCI-SW site will encompass six collaborative research facilities: the ASU NanoFab, the LeRoy Eyring Center for Solid State Science, the Flexible Electronics and Display Center (FEDC), the Peptide Array Core Facility, the Solar Power Laboratory (SPL), and the user facility for the social and ethical implications of nanotechnology.

The NCI-SW site will open the FEDC and SPL to the broader research community for the first time. The site will provide particular intellectual and infrastructural strengths in the life sciences, flexible electronics, renewable energy, and the societal impact of nanotechnology. ASU will collaborate with Maricopa County Community College District (MCCCD) and Science Foundation Arizona (SFAz) to develop STEM materials with a nanotechnology focus for AS and AAS students in communities throughout metropolitan Phoenix and rural Arizona. NCI-SW will provide entrepreneurship training for users who wish to commercialize nanotechnology in order to benefit society.

To facilitate the commercialization of research breakthroughs, the NCI-SW will support prototyping facilities and low-volume manufacturing pilot lines for solar cells, flexible electronics, and biomolecular arrays. The Science Outside the Lab summer program at the ASU Washington, DC, campus will allow users across the NNCI to explore the policy issue associated with nanotechnology.

A web portal hosted and maintained by MCCCD will provide seamless access to all the resources of the NCI-SW.

Nebraska Nanoscale Facility (NNF)

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Abstract
The Nebraska Nanoscale Facility (NNF) at the University of Nebraska will provide a regional center of excellence for instrumentation and service in nanoscience and nanotechnology to the NNCI. It will contribute to the US research and educational infrastructure for transformative advances in the fabrication, understanding, and utilization of novel nanostructures, materials, and devices.

These structures and devices play an increasingly critical role in contemporary technologies including ultraminiaturization in information processing, digital communications, energy processing, sensors for threat detection, and biomedicine. Special attention will be given to serving the nanotechnology needs of educational institutions and industry in the western region of the US Midwest.

NNF will significantly enhance economic development through industrial collaborations, spin-offs, materials analyses, and tech transfer to companies. National impact will result from interactions and collaborations with the newly developing Nebraska Innovation Campus and the National Security Research Institute at the University of Nebraska. A strong education-outreach program at NNF is focused on increasing diversity through summer research experiences for students and professor-student pairs, after-school middle-school programs, community college programs, minicourses, and others. In addition, education and outreach efforts will be pursued with Native Americans and tribal colleges in Nebraska associated with the Winnebago, Santee Dakota, and Omaha tribes.

NNF will build upon the established Central Facilities of the Nebraska Center for Materials and Nanoscience to strongly galvanize research and education in nanotechnology in Nebraska and the region. The Central and Shared Laboratory Facilities include: nanofabrication cleanroom, nanomaterial and thin-film preparation, nanoengineered materials and structures, electron microscopy, X-ray structural characterization, scanning probe and material characterization, low-dimensional nanostructure synthesis, and laser nanofabrication and characterization. Most of these facilities are housed in the 32,000 sq. ft. Voelte-Keegan Nanoscience Research Center that was completed in 2012 and funded by major grants from the National Institute for Standards and Technology and the University of Nebraska Foundation.

The research in NNF is bolstered by strong research groups in nanoscale electronics, magnetism, and materials and structures for energy. NNF in turn will reinforce several centers and focused research programs including the Nebraska NSF-MRSEC: Polarization and Spin Phenomena in Nanoferroic Structures, DOE-EERE Consortium on Magnetic Materials, SRC-NIST Center for Ferroic Devices, NSF-Center for Nanohybrid Materials, and others. These programs have many national and international collaborators that will add vitality to and provide a broad base of users for the NNF. Hundreds of graduate and undergraduate students, postdoctoral research associates, and visiting scientists and engineers from companies will benefit each year from the state-of-the-art facilities in NNF.

Texas Nanofabrication Facility (TNF)

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Abstract

Nanotechnology deals with man-made objects with sizes that are much smaller than everyday objects we deal with, but much larger than atoms or molecules. They can thus manifest novel and potentially useful properties that can have applications in diverse areas such as electronics, defense, and healthcare. Nanotechnology is projected to be a significant segment of the US and world economy in the twenty-first century.

However, since these objects are so tiny, fabricating them takes a tremendous investment in equipment and infrastructure and in personnel to maintain and train users in these tools. Often, these are beyond the resources of academic institutions and start-ups, and support from the federal government is critical.

The Texas Nanofabrication Facility (TNF), a National Nanotechnology Coordinated Infrastructure (NNCI) site at the University of Texas at Austin, builds upon a proven NSF-supported model and will help train the next generation of engineers and scientists in this nascent field, with a strong focus on recruiting minorities and women in these STEM fields.

It will also engender start-ups in nanotechnology and will lead to advances in areas such as faster computers that would consume less energy, lasers and photonic devices for faster communication, and a dazzling array of products for the consumer market and defense applications. This effort will also have an impact on healthcare and other major federal initiatives such as developing nanosensors for the Brain Initiative, better DNA and protein sequencing tools for personalized medicine, and nanostructures for targeted drug delivery.

The TNF will facilitate breakthroughs in nanoscience and technology, with applications in nanoelectronics/photonics, green energy, and healthcare in the southwest and in the nation, by providing state-of-the-art capability in nanodevice prototyping, metrology, and nanomanufacturing. The efforts in prototyping of nanoelectronic devices will be underpinned not only by tool-training-based approaches, as in the past, but also new holistic solution-based schemes.

Coupled with device fabrication, TNF will provide cutting-edge tools in nanoscale imaging and metrology at the atomic scale. The application of nano-in-healthcare will be bolstered by the recently established Dell Medical School at the University of Texas, one of very few new medical schools in recent decades and one that is committed to reinventing medical education.

The TNF will mentor and foster start-ups in nanotechnology and provide platforms for nanomanufacturing of prototypes at the NSF Engineering Research Center in Texas. It will establish educational activities in nanotechnology especially directed at underrepresented minorities and women while making social and ethical implications (SEI) of nanotechnology an integral component of every activity.

The growing Hispanic population in the southwest makes it crucial that this segment of the population is well represented in STEM fields. The TNF is located centrally in the so-called Texas Triangle, which encompasses most of the population and the high-technology activity in Texas. This is one of eleven mega-population centers in the nation and a key hub of nanotechnology in the United States. As such, this site should have a major impact on advancing nanoscience and technology in the twenty-first century in the United States.

Midwestern Region

Midwest Nano Infrastructure Corridor (MINIC)

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Abstract

Recent advances in technology allow the fabrication of very small structures with highly desirable capabilities. This enables new physical and chemical understanding (nanoscience) as well as new structures and devices that are of interest to many industries (nanotechnology). The Midwest Nano Infrastructure Corridor (MINIC) National Nanotechnology Coordinated Infrastructure (NNCI) site at the University of Minnesota will accelerate these advances by providing access to leading-edge micro- and nanofabrication capabilities for the research and development of nanoscience and technology.

The MINIC core facilities represent more than $50M in labs and equipment as well as more than 400 man-years of staff expertise. Academic researchers can use these capabilities on an equal basis with University of Minnesota faculty. Students will travel to MINIC facilities to gain valuable hands-on experience. Entrepreneurs will enjoy low-cost access to try new ideas without having to make long-term capital equipment commitments.

MINIC will support a broad spectrum of nano R&D; however, it will target researchers in two new areas: the application of two-dimensional materials and the use of nano in biology and medicine. By partnering with North Dakota State University, MINIC will also enable the packaging of nanodevices. This allows researchers to perform reliability testing and to incorporate these devices into complex electronic systems. MINIC will also reach out to underserved communities to increase their participation in this rapidly growing field. It will also support micro- and nanolaboratories at smaller schools throughout the Midwest to enable the development of nanotechnology over a broad geographic area.

MINIC will provide support to micro and nano researchers throughout the country. MINIC offers researchers access to multiple cleanrooms with a full suite of fabrication equipment including state-of-the-art electron beam lithography and extensive staff support to enable them to carry out difficult fabrication projects in a timely and cost-effective manner.

To better recruit and serve external users, MINIC will add three new process focus areas. The first will support the deposition of a broad variety of 2D thin films, beginning with graphene and the transition metal dichalcogenides. Users will be able to build devices on top of their own substrates without the low yield and variability associated with exfoliation. MINIC will also provide new modeling tools to support this area. The second focus area will be led by North Dakota State University's Packaging Center, which has long-standing expertise in the area. This will enable researchers in academia and industry to economically package nanoscale devices, including difficult applications such as RF devices, MEMS, power devices, and 3D multichips. MINIC's third focus area will support external users working in bionanotechnology by providing all the facilities and equipment needed to form nanoparticle suspensions, perform sizing and zeta potential measurements, use them to expose cell cultures in a BSL2 environment, and characterize the result with confocal and fluorescence microscopy. MINIC will also develop a novel outreach program to support nanoscience and technology labs throughout the upper Midwest.

Soft and Hybrid Nanotechnology Experimental (SHyNE)

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Abstract

The Soft and Hybrid Nanotechnology Experimental (SHyNE) Resource NNCI site is a collaborative venture between Northwestern University (NU) and the University of Chicago (UC), building upon each institution's long history of transforming the frontiers of science and engineering. Soft nanostructures are typically polymeric, biological, and fluidic in nature, while hybrid represents systems comprising soft-hard interfaces.

SHyNE facilities enable broad access to an extensive fabrication, characterization, and computational infrastructure with a multifaceted and interdisciplinary approach for transformative science and enabling technologies. In addition to traditional micro-/nanofabrication tools, SHyNE provides specialized capabilities for soft materials and soft-hard hybrid nanosystems. SHyNE enhances regional capabilities by providing users with on-site and remote open access to state-of-the-art laboratories and world-class technical expertise to help solve the challenging problems in nanotechnology research and development for nontraditional areas such as the agricultural, biomedical, chemical, food, geological, and environmental, among other industries.

A critical component of the SHyNE mission is scholarly outreach through secondary and postsecondary research experience and integration with curricula at both universities, as well as societal outreach through a novel nano-journalism project in collaboration with the Medill School of Journalism. SHyNE promotes active participation of underrepresented groups, including women and minorities, in sciences, and utilizes Chicago's public museums for broader outreach.

SHyNE leverages an exceptional depth of intellectual, academic, and facility resources to provide critical infrastructure in support of research, application development, and problem-solving in nanoscience and nanotechnology and integrates this transformative approach into the societal fabric of Chicago and the greater Midwest.

SHyNE is a solution-focused, open-access collaborative initiative operating under the umbrella of NU's International Institute for Nanotechnology (IIN), in partnership with UC's Institute for Molecular Engineering (IME). SHyNE's open-access user facilities bring together broad experience and capabilities in traditional soft nanomaterials such as biological, polymeric, or fluidic systems and hybrid systems combining soft/hard materials and interfaces.

Collectively, soft and hybrid nanostructures represent remarkable scientific and technological opportunities. However, given the sub-100-nm length scale and related complexities, advanced facilities are needed to harness their full potential. Such facilities require capabilities to pattern soft/hybrid nanostructures across large areas and tools/techniques to characterize them in their pristine states. These divergent yet integrated needs are met by SHyNE, as it coordinates NU's extensive cryo-bio, characterization, and soft-nanopatterning capabilities with the state-of-the-art cleanroom fabrication and expertise at UC's Pritzker Nanofabrication Facility (PNF).

SHyNE addresses emerging needs in synthesis/assembly of soft/biological structures and integration of classical cleanroom capabilities with soft-biological structures, providing expertise and instrumentation related to the synthesis, purification, and characterization of peptides and peptide-based materials. SHyNE coordinates

with Argonne National Lab facilities and leverages existing supercomputing and engineering expertise under the Center for Hierarchical Materials Design (CHiMaD) and Digital Manufacturing and Design Innovation Institute (DMDII), respectively.

An extensive array of innovative educational, industry, and societal outreach, such as nano-journalism, industry-focused workshop/symposia, and collaborations with Chicago area museums, provide for an integrated and comprehensive coverage of modern infrastructure for soft/hybrid systems for the next-generation researchers and the broader society.

Nanotechnology Corporate Partners (NCP) Program

Although also housed at Northwestern University, this is not part of NNCI; however, it has an advertised small business and industry partnership program, as found at https://www.iinano.org/nanotechnology-corporate-partners-program.

To find out more about the NCP program, please contact:

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Small Business Commercialization:
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Abstract
Corporate Partner Program

In today's competitive business environment, industry is finding it necessary to cut back on research endeavors. Yet the need to stay on the leading edge of technology is undiminished. University researchers and industry have critical resources to offer each other, but sometimes need a program that can help link them together.

The Nanotechnology Corporate Partners (NCP) Program at the IIN creates that link. NCP participants benefit from ongoing multilevel interaction with faculty, staff, and students, thereby strengthening their relationships with one of the world's leading centers for nanotechnology research. Partners gain exposure to a broad spectrum of research applications and interact with a pool of highly talented potential employees. As a member of the NCP program, your organization receives a mechanism for closer interaction between academic and corporate researchers to further mutual goals.

Small Business Commercialization

Academic exploration in the field of nanotechnology is often driven by federal and state investment with the hope that this investment will bear fruit in the marketplace.

The IIN's Small Business Entrepreneur's Evaluation (SBEE) program provides a platform for scientists and engineers to present their newly developed technologies and receive assistance in the development of viable business plans.

Through this program, faculty members are offered the opportunity to present their marketable technology to an audience of students from the NU Kellogg School of Management, who, then, may use this as a springboard for writing a complete business plan. The success of the SBEE program is evidenced by the formulation of 20 start-up companies since the inception of the IIN who have raised over $700 million in venture capital to date.

Southern Region

The Kentucky Multi-scale Manufacturing and Nano Integration Node (MMNIN)

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Abstract

The Kentucky Multi-scale Manufacturing and Nano Integration Node (MMNIN) is a collaboration between the University of Louisville and the University of Kentucky focused on integrating manufacturing technology over widely different length scales. With nanotechnology now integral to scientific discovery and engineering, there is a pressing need for infrastructure that supports the rapid and effective prototyping of nanoscale devices in macroscale systems.

The goal of the MMNIN is to combine micro-/nanofabrication processes with the latest in 3D additive manufacturing technology to allow researchers to explore nanotechnology solutions to real-life problems in healthcare, energy, the environment, communication, and security. In addition to having access to state-of-the-art tools and expertise, MMNIN participants will conduct novel research addressing multiscale manufacturing and integration challenges with a particular focus on the interfaces between different length scales, materials, and manufacturing processes.

The MMNIN's state-of-the-art multidisciplinary infrastructure will serve a growing user base whose home institutions include high schools, university laboratories, government facilities, start-up ventures, and Fortune 100 companies. Through new

educational and seed research programs, MMNIN will offer unique opportunities to users from traditionally underrepresented regions and groups, including the Appalachian region of the United States. MMNIN's unique focus and central location (60% of the US population within a day's drive) will greatly encourage external usage. Through these efforts MMNIN seeks to transform the interfaces between the nanoscale and the human scale and impact society by rapidly providing new multiscale technological solutions.

The MMNIN will be the first open user facility nationwide with a focus on 3D micro-/nanofabrication and true multiscale integration. Users will have access to design, simulation, and fabrication resources that span the nanometer to meter scales and the expertise to effectively integrate these processes. At the nanoscale, MMNIN will provide rapid prototyping capabilities based on electron- and ion-beam-induced processes and two-photon polymerization along with the expertise to convert the prototyped structures to functional devices.

At the microscale, users will have access to a variety of unique fabrication processes including stress engineered thin-film deposition for self-programmed 2D to 3D fabrication; 128-level grayscale lithography for rapid prototyping of complex 3D structures; micro aerosol jet 3D printing using conductive, resistive, dielectric, and biological materials; and a diversity of traditional semiconductor and MEMS fabrication processes using MMNIN's new class 100 $30M, 10,000 sq. ft. cleanroom facility.

At the meso-/macroscale, MMNIN offers automated roll-to-roll manufacturing processes and the latest in additive manufacturing tools for 3D printing custom structures and enclosures using metals and/or polymers. MMNIN also offers a variety of characterization techniques ranging from transmission electron microscopy to squid magnetometry. All of these efforts involve exciting research challenges, not only on the processes themselves, but also on the integration of these processes to make reliable electrical, mechanical, optical, and fluidic interfaces between the length scales.

As a result, users will be able to create systems such as nanoscale sensors in biocompatible enclosures, artificial crystalline optical filters with high-density interconnects, and nanoelectronics that expand from the substrate to interact with the external world. Ultimately, these capabilities, combined with the MMNIN faculty expertise in multiscale manufacturing and integration, will allow users to rapidly and economically produce products and solutions addressing society's pressing challenges.

Southeastern Nanotechnology Infrastructure Corridor (SENIC)

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Abstract

Development of nanoscale materials and devices, as well as incorporation of these components into full systems, has become an important part of addressing global challenges in energy, health, and the environment. However, nanoscale science and engineering often requires the use of complex and expensive tools and facilities for the fabrication and characterization of these materials and devices. This necessitates the support of shared national resources for both basic research in academic institutions and the translation of these discoveries into commercial products by small and large enterprises.

As part of the National Nanotechnology Coordinated Infrastructure (NNCI) program, the Southeastern Nanotechnology Infrastructure Corridor (SENIC) will create a partnership between the Institute for Electronics and Nanotechnology at the Georgia Institute of Technology and the Joint School of Nanoscience and Nanoengineering, an academic collaboration between North Carolina A&T State University (NCA&T) and the University of North Carolina at Greensboro (UNCG).

This national resource will provide open access to nanofabrication and characterization facilities and tools along with expert staff support to a growing user community across the southeastern United States. The SENIC infrastructure will strengthen and accelerate discovery in nanoscience and nanoengineering, benefiting both traditional disciplines, such as electronics and materials, and newer areas, such as biomedical and environmental sciences.

In addition, because societal and economic need requires a skilled workforce trained in the tools and techniques of nanotechnology, SENIC will implement a comprehensive education and outreach program, embedded with lessons in socially and ethically responsible development and use of nanotechnology, designed to reach a broad and diverse audience of students, teachers, and the public.

With access to more than 230 nanotechnology fabrication and characterization tools, SENIC's goal is to provide a one-stop-shop approach, covering both top-down approaches using nanoscale patterning and bottom-up approaches based on nanomaterial synthesis and additive processing. A particular strength of the partnership is the ability to connect nanomaterials and devices to full packaged systems. This helps transition nanoscale research achievements more quickly into high-impact applications in biomedical/health, energy, communication, smart transportation, textiles, and smart agriculture.

SENIC will operate with an interdisciplinary culture where engineers, scientists, physicians, educators, policy experts, and economic development professionals work together with shared access to facilities and tools and a deep understanding of industry opportunities and societal challenges to promote the accelerated translation of invention into innovation. Furthermore, the SENIC partners will work with undergraduate and graduate students, as well as partner with 2-year technical colleges, to produce science and engineering professionals from diverse backgrounds who are ready to meet the global workforce demands of the twenty-first century.

In tandem, the public outreach with hands-on classroom activities as well as interactive facility tours will encourage K-12 students to participate in the STEM pipeline and will help create an informed citizenry that supports the safe development of nanotechnology. Closely coupled with its education program, SENIC will have a

social and ethical implications program that educates on the challenges associated with the expectations that nanoscale science and engineering will contribute to the solution of societal, environmental, and economic problems, while anticipating and avoiding potential negative consequences.

Eastern Region

Cornell Nanoscale Science and Technology Facility (CNF)

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Abstract
The Cornell Nanoscale Science and Technology Facility (CNF) will provide the nation's researchers with rapid, affordable, hands-on shared access to advanced nanofabrication tools and associated staff expertise that are too expensive for individual universities or small companies to operate and maintain.

Under this National Nanotechnology Coordinated Infrastructure (NNCI) site award, hundreds of engineers and scientists nationwide, from throughout academia, industry, and government, will utilize CNF's unique toolset and technical staff. The new research and technology development that the CNF makes possible will transform many fields of engineering and science, spanning sensor and actuator arrays for probing how the brain works; improved photovoltaics, batteries, and fuel cells for economical renewable energy; new types of electronic devices that surmount limitations of silicon; fabrication of living tissues and organs; distributed measurement networks for geosciences; microbiome characterization and manipulation; on-chip signal processing with light; precision agriculture using new sensors; low-cost medical diagnoses; and improved quantum devices for utilizing entanglement, to name just a few.

The CNF will also organize education and outreach programs targeting a wide range of researchers, undergraduates, and K-12 students and their families, with the broader goals of providing a hands-on research education to a new generation of diverse engineering and science students, facilitating the commercialization of nanotechnology for societal benefit, extending the benefits of nanofabrication to less-traditional areas of research, and interesting more young students in technology and science.

The unique nanofabrication capabilities that the CNF will make available to the nation's researchers include world-leading electron beam lithography, advanced optical lithography, dedicated facilities for soft lithography, and direct-write tools for rapid prototype development, along with the flexibility to accommodate diverse projects through the ability to deposit and etch a very wide variety of materials.

In addition, CNF's experienced, expert technical staff will be solely dedicated to user support. Engineers and scientists from throughout academia, industry, and government will utilize CNF's resources to fabricate structures and systems ranging from the centimeter scale down to the nanometer scale. The new research that the CNF makes possible will advance research and development across many fields, spanning electronics, optics, magnetics, mechanical devices, thermal and energy systems, electrochemical devices, fluidics, and the life sciences and bioengineering.

Educational and outreach programs are designed to benefit several target audiences. CNF will teach new nanotechnology researchers to quickly operate at the research frontier through hands-on training on state-of-the-art tools, in-depth minicourses, and subject area workshops. Experienced nanotechnology researchers will benefit from advanced technical workshops in partnership with leading tool vendors. Undergraduate students will participate in blended courses with regional universities and unique summer research experiences. Young K-12 students and their families will be encouraged to become excited about technology and science through CNF's highly-popular Nanooze science magazine and a new partnership with 4-H.

Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure (VT NCE2NI)

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Abstract

The scientific and engineering investigations and understanding of ultrasmall objects, known as nanomaterials, is not only revolutionizing critical fields such as medicine, personal electronics, and national security, but it is also sharpening the understanding of how the Earth works. The air one breaths, the soil in which crops are planted, the metals from minerals that build industries, and the contaminants that can profoundly harm one (from arsenic to dangerous bacteria) are all related to and/or influenced by the vast store of nanomaterials that make up key portions of the planet.

These nanomaterials must be studied and understood, despite great difficulty due to their minute size, to safely and efficiently clean the air, purify water, and allow the responsible use of Earth's vast store of life-sustaining resources. The Virginia Tech National Center for Earth and Environmental Nanotechnology Infrastructure

(VT NCE2NI) will greatly accelerate the progress that Earth scientists and engineers have made in studying, understanding, explaining, and utilizing Earth for the well-being of all. In addition, new types of environmental sensors and detectors based on rapidly emerging nanotechnologies, for example, to detect harmful living and nonliving contaminants in air, water, and soil, will clearly be a major benefit to society. VT NCE2NI users will consist of far more than professional academics and their advanced research students. Users will also come from private and publicly held companies, as well as students from high schools, community colleges, liberal arts colleges, and key minority-serving universities.

VT NCE2NI provides an NNCI site to specifically support researchers who work with nanoscience- and nanotechnology-related aspects of the Earth and environmental sciences/engineering at local, regional, and global scales, including the land, atmospheric, water, and biological components of these fields. The national presence of VT NCE2NI is significantly enhanced by a close partnership with the Environmental Molecular Sciences Laboratory (EMSL) at Pacific Northwest National Laboratory (PNNL).

NNCI geo- and environmental science/engineering users have access to both the Virginia Tech and EMSL/PNNL sites depending on specific technical needs and geographic considerations. VT NCE2NI consists of (i) the 15,000 sq. ft. Nanoscale Characterization and Fabrication Laboratory (NCFL) that houses a broad array of high-end, state-of-the-art electron-, ion-, and X-ray-based characterization tools and sample preparation laboratories, as well as meeting space and ample office space for visitors and (ii) the 6300 sq. ft. Virginia Tech Center for Sustainable Nanotechnology (VT SuN) which contains extensive nanomaterial synthesis facilities and knowhow (in aqueous, soil/solid media, and atmospheric environments), characterization tools, and experimentation/reactor systems, plus meeting rooms and additional office space for visitors.

VT NCE2NI also provides broader impact initiatives including substantial funding for students from key minority-serving institutions and outreach programs with community colleges and four-year liberal arts colleges. The overall contribution of this NNCI site will be to accelerate the growth of a field that is revolutionizing the understanding of several broad aspects of Earth and environmental sciences and engineering.

North Carolina Research Triangle Nanotechnology Network (RTNN)

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Abstract

The Research Triangle Nanotechnology Network (RTNN) enables innovation and commercialization of new promising nanotechnologies and enables public education for the United States by providing technical leadership and open access to comprehensive and unique nanotechnology laboratories, equipment, and research expertise. The RTNN is anchored by three major research universities (North Carolina State University, Duke University, and University of North Carolina at Chapel Hill) that are clustered near one of the nation's major nanoscience and nanobiotechnology regional economies.

The RTNN focuses on pioneering, studying, and refining innovative methods to catalyze both traditional and emerging nanotechnology research areas, including those from biology, biomedical engineering, textile engineering, environmental engineering, agriculture, soil science, forest biomaterials, and plant and microbial biology. Since the barriers of distance, cost, and awareness often prevent facility usage by both traditional and nontraditional users, the RTNN will surmount these barriers using a variety of innovative programs.

The RTNN further leads research on the societal and ethical implications of nanotechnology, including issues of environmental health, safety, ethics, and equity, through a social and ethical implications of nanotechnology (SEIN) component that also assesses innovative program success. The RTNN will create a nanotechnology innovation ecosystem that spans grades 7–12, community colleges, universities, and industry. By translating program successes across the nation, the RTNN will become a national focal point for innovation and will serve as a guide for nanotechnology innovation ecosystems across the nation.

The RTNN brings together comprehensive shared user facilities and complementary faculty research programs at three major research universities. These resources will be used to dramatically increase the national impact of state-of-the-art fabrication and characterization facilities and research expertise in nanoscience and nanotechnology. RTNN technical capabilities span nanofabrication and nanocharacterization of traditional hard, dry materials (i.e., 2D and 3D nanomaterials, metamaterials, photonics, and heterogeneous integration) and emerging soft, wet materials (i.e., tissue, textile, plant, and animal nanomaterials).

Specific areas of capability include the environmental assessment of nanotechnology, atomic layer deposition, flexible integrated systems, and fluidic systems. The RTNN will enable emerging research areas by adding additional process flows and tools throughout the project that enable new ways of integrating and interfacing the nanoscale with the human scale. The RTNN will expand shared facilities usage by creating and assessing innovative programs and disseminating these programs across the nation.

These programs include graduate student peer-to-peer distance using Internet networking, summer undergraduate research internships with follow-on outreach to the student's school of origin, public engagement leveraging large-scale Internet courses, and outreach to grades K-12. A specific emphasis is on engaging users from underserved user groups, including women, minorities, and people who do not typically access shared university facilities. The aim of the RTNN is to create a comprehensive, integrated nanotechnology ecosystem that will provide a pipeline of STEM students for a strong, vibrant, and entrepreneurial next-generation workforce.

East Coast Region

The Center for Nanoscale System (CNS) at Harvard University

Investigator(s):	Robert Westervelt westervelt@seas.harvard.edu (principal investigator) William Wilson (co-principal investigator)
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Abstract
The goal of the Center for Nanoscale Systems (CNS) at Harvard University is to provide outstanding facilities and expertise to make, image, and understand nanoscale structures and systems. CNS provides a collaborative, multidisciplinary research environment that allows researchers from academia and industry to study and develop new structures, devices, systems, and technologies in fields ranging from biomedicine to nanoscale electronics and photonics.

CNS offers tools for nanofabrication, electron microscopy, and characterization of nanoscale systems, with technical expertise and assistance provided by its staff. CNS is one of the most active nanofabrication and imaging facilities in the world with more than 1500 users, and it is an important part of the high-technology boom in the northeast. With its diverse user base, well-established infrastructure, and outstanding facilities, CNS is well placed to continue as a technology leader.

In addition, CNS plays a key role training the nation's next generation of scientists and engineers. It has an established Research Experiences for Undergraduates (REU) program, as well as an annual summer nanotechnology seminar series. A new CNS Scholars Program will bring in underrepresented researchers, and an internship program will train US veterans in nanotechnology. As part of the NNCI, CNS will help make the transition from research on nanoscale devices to complex nanosystems engineering.

Since its creation in 2001, CNS has become a key nanotechnology resource for the nation. As part of the previous NNIN, CNS developed diverse and versatile facilities including multi-length-scale optical and electron beam lithography, focused ion beam (FIB) and reactive ion etch (RIE) systems to shape structures, and soft lithography expertise to enable fabrication of a wide variety of microfluidic systems. These tools allow users to push the frontiers of nanoscale electronics and photonics using nontraditional materials, and they enable the development of sensor systems for biomedicine.

CNS researchers pursue advanced topics including plasmonics, diamond photonics, nanoscale sensors, and atomic-layer devices. CNS has an outstanding suite of imaging and characterization tools including an aberration-corrected STEM, a high-resolution TEM, a CryoTEM, and an atom probe for 3D tomography, as well as scanned probe microscopes, and linear and nonlinear optical microscopes. Its characterization tools permit detailed analysis and assessment of materials, components, and systems, providing researchers with a comprehensive platform for nanotechnology research.

CNS focuses on the core missions of the National Nanotechnology Initiative (NNI): advancing world-class nanotechnology research, fostering the transfer of new technologies into products for commercial and public benefit, developing and sustaining educational resources to develop a skilled nanotechnology workforce, and supporting the evolving infrastructure and advanced tools needed to support excellence in nanotechnology research and development.

Mid-Atlantic Nanotechnology Hub (MANTH) for Research, Education, and Innovation

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Abstract

Nanotechnology, the exploitation of the science of the very small, has the potential to revolutionize lives—a few examples include faster electronics, smaller biomedical implants, better batteries, materials with high strength or the ability to self-clean, and small machines that can sense the physical world. Often, nanotechnology development requires access to a large fabrication and characterization infrastructure and the related scientific expertise to allow users to build and measure such nanomaterials and nanodevices.

This project establishes a Mid-Atlantic Nanotechnology Hub (MANTH) for research, education, and innovation at the University of Pennsylvania as an NNCI site. This site will allow users in the mid-Atlantic region, the nation's fifth largest economic area, to access the Singh Center for Nanotechnology, where they can perform nanofabrication and measurement tasks and interact with nanotechnology experts. The Singh Center is located at the University of Pennsylvania in downtown Philadelphia and is highly accessible to over 100 regional academic institutions and the industry-rich mid-Atlantic region.

The Singh Center will also host education programs to introduce high school students, college undergraduates, and the Philadelphia area community to nanotechnology. These potential future nanotechnologists will have the opportunity to participate in Nano Day and Summer Research Experiences for Undergraduates programs held on-site, view nanotechnology contributions to community outreach programs such as Philly Materials Day and the Philadelphia Science Festival, and participate in workforce training activities for nanotechnology technicians carried out in partnership with the Community College of Philadelphia.

MANTH will enable access to leading-edge research and development facilities and expertise for academic, government, and industry researchers conducting activities within all disciplines of nanoscale science, engineering, and technology. Examples of its capabilities include: electron beam, photo-, imprint, and soft lithographies, material deposition and etching, multiscale 3D printing, laser micromachining, electron and scanning probe microscopy, tip-based nanofabrication, and ion and electron beam milling.

This NNCI site will foster intellectual collaboration by assisting users in addressing their nanoscience and application needs, providing a forum for intellectual exchange between academic and industry users, and developing new fabrication processes that not only contribute to the users' end application but also further the fields of nanofabrication and nanomanufacturing. Users will also benefit from interaction with Penn faculty and staff, possessing significant expertise in nanofabrication; flexible/stretchable nanodevices; MEMS; microfluidics, photonics, and electronics; fabrication and exploitation of nanostructured soft materials systems; multiple low-dimensional materials; characterization and integration of beyond-silicon material systems; and investigations at the nano-bio interface, from medical devices to enabling the understanding of biological systems.

In addition to serving existing researchers, MANTH will engage potential future nanotechnologists through on-site research reviews, summer research experiences, and outreach to local Philadelphia high schools. By acting as a catalyst for growth of nanotechnology in this region, significant opportunities for nanotechnologists at all levels will be created, from technicians through a workforce development partnership with the Community College of Philadelphia to PhD researchers.