

The National Nanofabrication Users Network (NNUN)

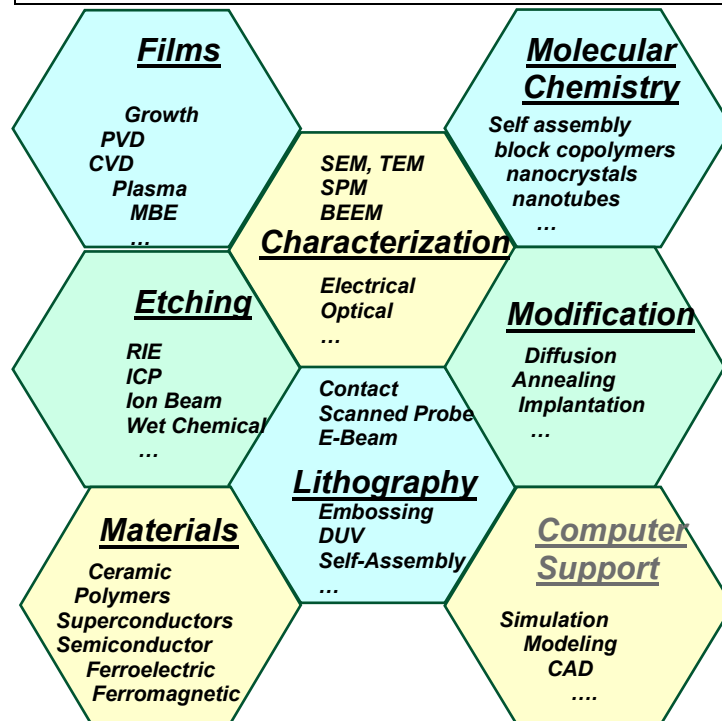
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The National Nanofabrication Users Network (NNUN)'s mission is to enable rapid advancements in science and engineering of the nano-scale through efficient access to nanotechnology infrastructure. This infrastructure, consisting of tools in NNUN participant facilities, technical staff, and extensive web-based knowledge resource, provides on-site and remote support so that experimental research and technology tasks requiring advanced one-of-kind instruments and skill in usage, and complex process integration employing a large number of tools can be accomplished with ease. Thus, efforts across the broad range of physical and life-science subjects where experimental research employs small dimensions benefit from the access to the network: examples of these efforts vary from use of nanotubes as probes for sensing, transport measurement across single molecule placed between electric probes, nanocrystals as chip-based fluorescent tags or low power embedded electronic memory elements, structures for measurements on cell membranes, spin-valves as magnetic memory elements, new technologies of three-dimensional integration for information processing, to complex systems built around the use of the unique effects of the nano-scale. The key contribution of National Nanofabrication Users Network (NNUN) to nanotechnology is in providing effective and efficient access to advanced integrated nanofabrication and synthesis equipment and expertise to make the research experiments and applications possible. Research work conducted in NNUN typically depends on the integration of complex chemical and physical nanotechnology processes conducted over a large number of tools. So, self-assembly and chemical synthesis accompany electron-beam lithography and more traditional tools such as stepper lithography or high density plasma etching, or implantation or chemical-mechanical polishing in order to make projects successful on a larger scale.

During fiscal 2003, NNUN researchers included, >1050 graduate students, >250 undergraduate students, and >250 post-doctoral and other senior researchers. Industrial users (~350 including from 158 start-up companies), foreign institutions, federal laboratories also employed the resources of NNUN. The users of NNUN come from 33 of the states of the country. Over the last many years research from NNUN has spawned nearly 25 companies.

Figure 1: Integrated nanotechnology resources from NNUN.

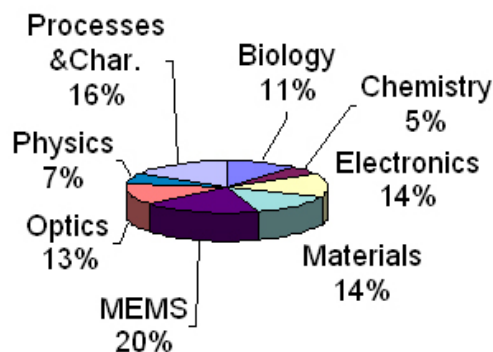


NNUN is a service network, and its success depends critically on providing networked resources; education through workshops and courses; web-based information and tools for project preparation; integrated tools and instruments for synthesis and fabrication; strong on-site training; and strong project support and technical assistance through a highly skilled staff. NNUN consists of two hub facilities on the east and west coasts at Cornell University and Stanford University, and three additional sites at Howard University, the Pennsylvania State University and the University of California at Santa Barbara, each offering expertise in overlapping general purpose and specialized complementary areas.

Research and Usage at NNUN:

NNUN evaluates its research and usage through a variety of measures. A sampling of research¹ conducted at NNUN is published annually in the first quarter of the year and is available on the web. Individual sites also provide information related to projects conducted² with representative projects from across various disciplines. For quantitative purposes, we separate these categories as biology; chemistry; electronics; materials, physics, processes and characterization; mechanics and microelectromechanical systems (MEMS); and optics. The usage across these disciplines is broad and a number of significant accomplishments in research employed NNUN resources. We invite you to visit our web-site <http://www.nnun.org> to see our latest reports and to watch technical events.

Figure 2: Technical area distribution of NNUN users during fiscal 2003.



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Three examples of work conducted by researchers during the year 2003 across these disciplines are provided in Figure 3. Multiple publications are also available from <http://www.nnun.org>.

Education and Outreach: Technical training, encouragement of careers in science and engineering, and broad dissemination of information are also important directions of NNUN's efforts. Our web-site provides important links to these activities and resources. Some examples of these are:

Introduction to NNUN:³ An introduction to the network and its resources. Available as a CD and as a movie on the web.

Nanotechnology Courses:⁴ Available since 1999 on the web and updated yearly from the on-site courses that are offered at Cornell Nanofabrication Facility, these courses introduce the practice of nanotechnology and its usage across disciplines.

Process Libraries:⁵ Available since 1998, the search engine provides a wide variety of information on tools and techniques for specific technical steps across disciplines as practiced in NNUN.

¹ See e.g. reports available at <http://www.nnun.org>

² For example, <http://www.cnf.cornell.edu/2003cnfra/2003cnfra.html>, <http://www.msce.howard.edu/%7Enanonet/PROJECT.HTM>, <http://www.nanofab.psu.edu/research/default.htm>, <http://snf.stanford.edu/About/Research/Research.html>, <http://www.nanotech.ucsb.edu/research/research.html>,

³ <http://www.nnun.org/Multimedia/Multimedia.html>

⁴ <http://www.cnf.cornell.edu/nanocourses/nanocourse.html>

Live Technical Sessions:⁶ A recent addition has been live broadcasting of web-sessions that are lively interchanges of specific projects and possible methods of implementations.

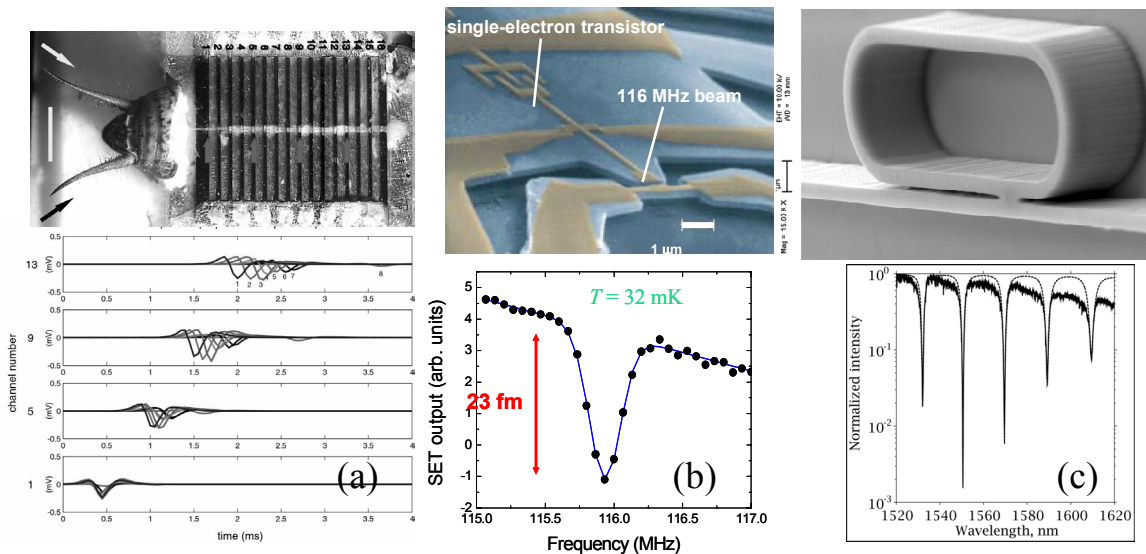
Workshops: NNUN organizes workshops throughout the year which emphasize detailed practice of specific techniques, or provide a broader forum for discussing advances in a field. During this year, the network hosted a number of workshops including a US-Japan Symposium on Tools and Metrology for Nanotechnology. Proceedings of the workshops are also available on the web-site.

High-School and Community Colleges: NNUN hosts a variety of events that specifically address technical training and educational needs. These include chip-camps organized at Penn-State, visits to our laboratories for a day by community colleges, and visits to local schools, etc.

Research Experience for Undergraduates: NNUN hosts 42 undergraduate students that focuses on carefully screened faculty and staff-sponsored hands-on research that can be completed in 10 weeks with a real-world experience of publications⁷ and conference.

Major Conferences: NNUN has multiple booths, posters, CDs, and other material that it continuously develops and deploys in order to broaden the accessibility of nanotechnology to researchers. During 2003, NNUN has been present at APS, AVS, ECS and numerous other meetings.

Figure 3: Some recent examples of experimental results that utilized the resources of NNUN. (a) simultaneous recording in the cricket ventral nerve cord during a burst of activity by Spence et al., (b) near quantum-limit displacement sensing using single-electron transistor by Knobel et al., and (c) ultra sensitive notch filters using micro-resonators with bias tenability of resonance by Grover et al.



Summary: NNUN is a network that helps users implement ideas requiring fabrication, synthesis and integration of nano-scale and larger structures, devices, and systems. We are easily accessible, our focus is on user support, and our extensive infrastructure of equipment, staff, and knowledge provides a convenient path for implementation. A large community (~2000) of academic and non-academic researchers employ these resources either on-site or remotely.

⁵ accessed via <http://www.nnun.org> and see for example, <http://snf.stanford.edu//SiteMap/SiteSearch.html> and <http://www.cnf.cornell.edu/>

⁶ <http://www.cnf.cornell.edu/live.html>

⁷ <http://www.nnun.org/Reu/REU.html>