REGIONAL, STATE, AND LOCAL INITIATIVES IN NANOTECHNOLOGY

Report of the National Nanotechnology Initiative Workshop
September 30–October 1, 2003

About the Nanoscale Science, Engineering, and Technology Subcommittee

The Nanoscale Science, Engineering, and Technology (NSET) Subcommittee is the interagency body responsible for coordinating, planning, implementing, and reviewing the National Nanotechnology Initiative (NNI). The NSET was established in 2000, replacing the Interagency Working Group on Nanoscience, Engineering, Technology (IWGN), which was formed in 1998. The NSET is a subcommittee of the Committee on Technology of the National Science and Technology Council (NSTC), which is one of the principal means by which the President coordinates science, space, and technology policies across the Federal Government. The National Nanotechnology Coordination Office (NNCO) provides technical and administrative support to the NSET Subcommittee and supports the subcommittee in the preparation of multi-agency planning, budget, and assessment documents, including this report.

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For more information on NNI, NSET and NNCO, see http://www.nano.gov.

About this document

This document is the report of a workshop held under the auspices of the NSET Subcommittee on September 30 and October 1, 2003, at the U.S. Department of Commerce in Washington, D.C. The primary purposes of the workshop were to enhance the effectiveness state, regional, and local economic development initiatives in nanotechnology and to collect resources and experiential perspectives for those considering the launch of similar initiatives. The meeting was jointly sponsored by the NSET Subcommittee, through the NNCO, and by the U.S. Department of Commerce, Technology Administration.

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Regional, State, and Local Initiatives in Nanotechnology

Report of the National Nanotechnology Initiative Workshop
September 30–October 1, 2003, Washington, D.C.

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PREFACE

This report, Regional, State, and Local Initiatives in Nanotechnology, is one of a series of reports resulting from workshops convened in 2003 and 2004 by the Nanoscale Science, Engineering and Technology (NSET) Subcommittee of the National Science and Technology Council's Committee on Technology. The workshops were organized as a part of a long-range planning effort for the National Nanotechnology Initiative (NNI), a multi-agency program aimed to ensure that the United States fully realizes the great promise of nanotechnology for the Nation's economy, national security, and quality of life through coordination of funding, research, and infrastructure development activities at individual agencies.

A key part of the NNI plan is to develop synergies between the activities of regional, state, and local nanotechnology initiatives and the Federal nanotechnology program. State and local efforts benefit from access to NNI research funding and Federal user facilities that have been established or are under development around the country. Similarly, the NNI benefits greatly from state and local government investments, particularly in research infrastructure.

The objectives of the Regional, State, and Local Initiatives in Nanotechnology workshop were to promote the continued success of both the NNI and the existing regional, state, and local nanotechnology initiatives; to identify mechanisms for improved technology transfer between researchers and industry; and to provide an opportunity for those who are planning new regional, state, and local initiatives to benefit from the knowledge of those who have already established them. This workshop report contains valuable information for the various communities that have interests in developing, maintaining, and improving regional, state, and local initiatives for economic development in nanotechnology and, undoubtedly, other fields as well.

On behalf of the NSET Subcommittee, we want to express our thanks to Phillip J. Bond, Under Secretary of Commerce for Technology, and Co-chair, Committee on Technology, NSTC, and to John Sargent and others in the Technology Administration, U.S. Department of Commerce, for their collaboration and hard work in making the workshop a success. We also extend our thanks to all the principal report editors, speakers, the session chairs, and participants for their time and efforts on behalf of the workshop and this workshop report.

Mihail C. Roco
Chair, Nanoscale Science, Engineering and Technology Subcommittee

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Executive Summary

Nanotechnology is poised to become a critical driver of economic growth and development for the early 21st century. Cities, states, and entire regions have quickly recognized the potential and have begun to take steps to create nanotechnology clusters—concentrations of interrelated businesses based upon a common manufacturing process, set of customers, or both.

Given the tremendous investments being made at the local, state, and Federal level, the U.S. Department of Commerce and the National Nanotechnology Coordination Office (NNCO), on behalf of the other member agencies of the Nanoscale Science, Engineering and Technology Subcommittee, convened the Workshop on Regional, State, and Local Initiatives in Nanotechnology. The primary aims of the workshop were to enhance the effectiveness of the efforts already underway and to collect resources and experiential perspectives for those considering the launch of similar initiatives. From the Federal Government perspective, the workshop also was convened as a forum to provide information about Federal programs relevant to such initiatives and to assist the Nanoscale Science, Engineering and Technology Subcommittee and the NNCO in collecting and disseminating information about regional, state, and local initiatives.

The workshop took place on September 30 and October 1, 2003, at the U.S. Department of Commerce in Washington, D.C., with representatives from over 20 initiatives participating. Uniformly, participants viewed the workshop as a critical first step for the success of both their individual efforts and those of the Nation.

This workshop facilitated coordination across the regional, state, and local initiatives. But participants felt that greater communication amongst and across these initiatives will be instrumental in accelerating the commercialization and realization of the economic development potential of nanotechnology. For example, an ongoing forum to discuss the chief obstacles to building a cluster would enable each of the initiatives to learn through others' mistakes rather than repeating them. Without this kind of channel and communication forum, many of our scarce state and local resources will be directed in inefficient and

Figure A.1. Plenary speakers (l to r) Dr. E. Clayton Teague, Director, NNCO; Hon. David A. Sampson, Assistant Secretary for Economic Development, U.S. Department of Commerce; Hon. Aris Melissaratos, Secretary, Maryland Department of Business and Economic Development; Hon. Phillip J. Bond, Under Secretary of Commerce for Technology, U.S. Department of Commerce; Dr. Mihail C. Roco, chair of the NSET and Senior Advisor, National Science Foundation (courtesy of Technology Administration, Department of Commerce).

ineffective ways—unnecessarily replicating research and commercialization infrastructure (e.g., user facilities), reinventing the wheel on workforce development and training programs, or delaying adoption of commercialization practices that are already well known or well understood in other regions.

Around the country, states, cities, and universities are aggressively pursuing nanotechnology-based economic development strategies. However, the resource commitments are a small fraction of the economies in which they are operating.

Investments are complicated at the state and local level by tremendous fiscal pressure. As a result, state and local governments lack sufficient funds to support robust nanotechnology development efforts and struggle even to fund the coordinating efforts of initiative principals, such as those who took part in this workshop. It is, therefore, imperative that state, local, and regional efforts be very focused and highly effective. If not, the regions making investments will be no closer to achieving their objectives.

The Nation's experience with the development of biotechnology clusters and the billions of dollars that have been poured into them has provided insight into the necessary ingredients for successful technology-based economic development strategies. Current thinking on economic development stresses the importance of systems orientation. No one dimension, whether it be research excellence, infrastructure, technical and management talent, risk capital, or an entrepreneurial culture, is likely to be sufficient to successfully build a nanotechnology cluster.

In reality, not every region will be able to develop a broad nanotechnology cluster on its own. The combination of research, infrastructure, talent, money, and conducive business environment requires enormous and sometimes prohibitive investments that make it unlikely that all but a few areas will be able to develop major nanotechnology clusters. However, with sufficient focus, local efforts may develop distinctive competencies and then leverage partnerships with others to catalyze more growth and development.

To enhance their efforts, workshop participants requested support in the following areas:

- establishing a more formal ongoing steering committee, possibly with representation from the major business development organizations from across the United States, to facilitate communication and provide an umbrella of credibility as the initiatives seek to engage a broader community of stakeholders
- establishing an online resource for launching and sustaining effective initiatives:
  - documenting and sharing best practices for initiative development and operation
  - developing a "tool kit" including "Nanotech 101," "Frequently Asked Questions," and common messages to key constituencies, possibly even communication templates
- forming partnerships and alliances across geographies, particularly for economically smaller regions without the scale to "go it alone"
- developing programmatic financial support for regional, local and state initiatives

Most of this report seeks to consolidate and summarize the presentations from the day-and-a-half-long event into a manageable overview. Additional material on infrastructure and commercialization is included to enhance the value of the report. The report does not seek to be a compendium or a census of all nanotechnology economic development activity, as the field is evolving too rapidly for a static report to effectively do so.

Representatives from several of the most advanced nanotechnology initiatives made presentations at the event, while others submitted abstracts that are included for reference in Appendix D. To be clear, the more detailed case studies presented here were chosen for their different approaches to economic development through nanotechnology—not because they are "better" than the others. Indeed, it is far too early

to know which regions will be successful, and even indicators of success would not establish a linkage or causal relationship between those measures and the characteristics of the model.

The body of this report is laid out in five brief sections:

1. Models and Considerations for Launching an Initiative
2. Workforce Development and Education
3. Research Infrastructure and Development
4. Economic Development and Commercialization
5. Lessons Learned

The four appendices that follow the main body of the report present the workshop agenda, list of participants, summaries of regional, state, and local nanotechnology initiatives, and a glossary.

1. Models and Considerations for Launching an Initiative

WHAT IS MEANT BY AN "INITIATIVE"?

Because the intrinsic assets and needs vary so substantially from one region to the next, we limit our definition of an initiative to its mission and intent rather than specific tactics or approach. For the purposes of this report, a nanotechnology state, regional, or local initiative is defined as "a focused effort to promote nanotechnology research and development for the purpose of economic development for a region or governmental entity."

WHAT ARE THE CRITICAL ISSUES WHEN LAUNCHING AN INITIATIVE?

Launching an initiative is, in many ways, like starting a business as an entrepreneur. Many of the challenges are the same. First, one must develop a compelling vision for the organization and rally stakeholders around it. Second, one must develop a clear and focused "organization plan" to guide activities and attract funding. Third, one must establish a robust organization model and execute flawlessly to maintain the growth trajectory.

Beyond the complexity associated with launching any new venture, there is another significant layer of complexity in launching an initiative of this nature. Economic development efforts are inherently multiparty, collaborative undertakings; success depends not only upon the principals within the organization, but also upon the engagement of all of the key stakeholders. Further, many of the key stakeholders may have a spotty history of collaboration or may view one another as competitors, as universities within a region often do. So, there are multiple agendas at play, and they rarely are perfectly aligned.

Finally, billions of dollars are being invested by the Federal Government and large corporations in nanotechnology research and infrastructure, but funding for the typical state and regional economic development initiative is well under $1 million annually. Thus, these initiatives tend to be "little fish" by way of comparison.

Clearly, a major challenge for any effort is to develop sufficient credibility to engage the primary players and marshal resources of these constituents to greater effect and shared benefit. Toward this end, initiatives must focus on engaging the stakeholders that control the majority of the resources and on developing top-level institutional support.

WHAT ARE THE DESIGN CONSIDERATIONS IN LAUNCHING AN INITIATIVE?

In order to provide structure to this discussion, initiative development is separated into two phases: (1) pre-initiative and planning and (2) launch.

Pre-Initiative

In the pre-initiative phase, the first design consideration revolves around the leadership team or steering committee for the planning process. Particularly in the planning phase, it is important to get input from a broad range of constituencies, including leaders from industry, academia, government, and the nonprofit and financial sectors. It is also important to get the right people involved at this point. Top-level participation from the institutions in the planning process can engender buy-in and limit future conflicts.

It is useful to limit the initial commitment to serving on the steering committee. This ensures that the committee makes judicious use of the leadership team's time. It also allows involvement of leaders who may have interest in catalyzing the initiative but not overseeing it into the future or serving on the future board.

The next key design parameter revolves around the development of a strategic roadmap with goals and milestones to facilitate planning and to evaluate progress. All initiatives seek to enhance economic development and to position their respective region as a leader. The strategic roadmap takes the first cut at defining what the initiative seeks to achieve and at outlining steps toward those achievements.

Proper development of the strategic roadmap can be exceptionally valuable toward facilitating development of a robust plan for the organization and buy-in with the key stakeholders of the region. To be meaningful, the strategic roadmap should consider both an "inside out" (what can the region do based upon evolving its current capabilities), as well as an "outside in" (where would the region like to be) perspective. This necessitates that the planners take an inventory of the region's capabilities to provide a fact base on the current situation. A large number of qualitative interviews with key stakeholders can provide valuable information to initiative planners. By examining the gaps between the "outside in" view of where the region would like to play and the "inside out" view of where it is well positioned to play, the steering committee can identify strategies to build additional but targeted capabilities and develop rough resource estimates of what would be required to do so.

Launch

In the launch phase, the central task is to transform strategy into action. The first issue to clarify is governance. Will the initiative be a stand-alone entity? Will it be part of an existing organization? Will it operate as a new formal organization with dedicated resources or instead draw upon existing assets and resources across multiple locations and entities to build momentum for a future organization? (The latter model is often known as a virtual organization.) There are trade-offs between the models. Functioning as part of an existing entity can minimize start-up costs and accelerate activity, but can also create political battles and disincentives for others to engage. The virtual approach has challenges in obtaining a consensus regarding agreements, operating procedures, and governance structure. Advantages are minimizing cost of entry and breadth of participants.

Other considerations are how large the governing board will be and how it will it be structured. Typically, nonprofits raise money through their boards, so a bigger board enables the organization to bring more people and institutions into the fold to help generate resources. But, it can also dramatically complicate decision making and "dilute" the impact that individual board members have, ultimately undermining the sense of commitment that motivates them. Thought should also be given to board renewal—how long will board terms be and how will continuity of leadership be maintained? One approach is to stagger board terms so no more than 50% of the board can change in any given year.

The next issue is tax structure. Will the organization function as an economic development charity or as a trade and advocacy group? The former can raise money from foundations and charities, while the latter can lobby to affect policy and drive a more conducive business climate. Generally, it is advantageous to be a 501(c)(3) charity because these organizations can seek tax-deductible, charitable contributions from individuals and foundations if the organization is not seeking to lobby. However, it can take six months or more to receive approval of tax-exempt status, so it is important to file the application with the IRS as soon as possible.

The next major consideration is scope. What geographical area will the initiative serve? What industries and technology will it focus upon and what are the highest priorities for future expansion and growth?

Once those issues have been settled, the management of the organization has to be identified. Will it be volunteer or full-time? If it needs to be volunteer due to resource constraints rather than design, when does it make the transition to permanent management?

Obviously, all of these decisions are constrained by funding. Therefore, it is critically important to have a launch plan that allows the initiative to bootstrap itself to greater things.

REPRESENTATIVE MODELS AND APPROACHES

While each of the initiatives described below reflect the uniqueness of the environment in which it operates, all have a strong focus on developing "linkages" to other parties. Each initiative is, at some level, adopting a network-centric and partnering approach rather than just seeking to build internal capabilities.

Again, the detailed case studies presented below were chosen for their different approaches to economic development through nanotechnology—not because they are "better" than the others. It is far too early to know which regions will be successful, and even indicators of success would not establish a linkage or causal relationship between those measures and the characteristics of the model.

Partnerships across sectors are evident in all four case studies presented here. Sponsorship is mixed in the initiatives: The Nanotechnology Institute in Pennsylvania has state, private, university, and regional economic development sponsorship; the Virginia Nanotechnology Initiative, is state sponsored; AtomWorks in Illinois has state and private sponsorship; and the Texas Nanotechnology Initiative is primarily funded through the private sector.

The Nanotechnology Institute

In March 2000, Ben Franklin Technology Partners of Southeastern Pennsylvania (BFTP/SEP), a state-funded economic development organization, organized a nanotechnology workshop. The response was so favorable that BFTP/SEP decided to explore developing a regional nanotechnology activity.

After subsequent meetings with individual university and company representatives, the University of Pennsylvania (Penn), Drexel University, and BFTP/SEP formed a team to outline the structure of what became the Nanotechnology Institute (NTI). The team identified the new Pennsylvania Technology Investment Authority (PTIA) as the appropriate funding source and initiated discussions with the Pennsylvania Department of Community and Economic Development, which administered PTIA.

This led to a meeting with state and Federal representatives in Spring 2000. At the meeting, BFTP/SEP and regional university and company representatives met with Dr. Joseph Bordogna, Deputy Director and Chief Operating Office of the National Science Foundation, and representatives from the Commonwealth of Pennsylvania's Department of Community and Economic Development to explore the role of nanotechnology as an engine for growth in southeast Pennsylvania. The value of a collaborative regional nanotechnology initiative was uniformly endorsed and the founding partners were encouraged to submit a proposal to PTIA. The principal investigators (PIs) on the proposal were professors at Drexel and Penn and the Executive Vice President of BFTP/SEP. Following the meeting, Drexel, Penn and BFTP/SEP developed and submitted to the Commonwealth of Pennsylvania a $10.5 million proposal to support formation of the Nanotechnology Institute (NTI), focused on bio/pharmaceutical applications of nanotechnology to leverage regional competencies. Funding was approved in September 2000.

The NTI was from its inception a complex undertaking. Each of its components required identification of the appropriate partners and participants. As an example, the research and development (R&D) effort began with a broadly disseminated Request for Interest (RFI) in which university faculty were asked to submit brief white papers describing their nanotechnology activity. The PIs, after close review of the RFIs,

then selected faculty whose research most closely met the goals of the NTI and formed four teams, comprising 40-plus faculty members. The PIs then chose team leaders at several formative team meetings. The challenge was to pick leaders with technical expertise and leadership ability, as well as the shared NTI vision of applications and commercial outcomes of the R&D.

The NTI mission is as follows:

> In contrast to typical academic research centers, the NTI will focus on the transfer of discoveries and intellectual knowledge from universities to industrial partners and the promotion of rapid application and commercialization.

The NTI is governed by an oversight committee consisting of a representative of each of the founding partners. BFTP/SEP is the fiscal agent and manages the grant. A research committee oversees the R&D effort and an economic development committee oversees the other components. Day-to-day operation is managed through the PIs, Team Leaders, and BFTP staff.

The NTI is currently a virtual model designed to be a focal point for nano-related efforts, building on the collective strengths of corporate interests, life and materials science assets, research institutions, and economic development organizations. The NTI's innovative model incorporates a "wrap-around" approach, represented by the alignment of six key components:

- Research & development: NTI provides a gateway to nine universities and medical schools, 41 faculty members, and more than 100 post-doctoral fellows and advanced students focused upon intelligent drug delivery systems, nano-biosensor development, nanotubular cellular probes, and nanofiber-based tissue engineering.
- Entrepreneurial development and commercialization: NTI provides a single point-of-contact system that provides financing and robust business development services and resources with uniform and streamlined IP and licensing processes.
- Risk capital: NTI provides limited seed capital and strives to stimulate the creation of longer-term financial resources to fuel the growth of the region's nanotechnology activities.
- Community of interest networks: NTI fosters growth of the region's nanotechnology community by facilitating dialogue and interaction among Federal agencies, university faculty, corporations, entrepreneurs, and economic partners. Further, NTI takes the lead in identifying and accessing potential national and international partners.
- Education and workforce development: NTI coordinates the curriculum development and implementation, high school outreach, and faculty training for associate degree programs in nano-biotechnology.
- Economic research and policy development: NTI gathers information, assesses the region's position and opportunities, and recommends action steps in order to guide the NTI's growth, policies, and programs.

Significant progress has been made in each of these components. For example, NTI has developed infrastructure to reduce barriers to commercialization. This includes the NTI as the "single point of contact" for companies and uniform confidentiality, intellectual property, and sponsored research agreements among the nine university partners. The NTI research management's stress on outcomes has resulted in a disclosure rate per research dollar of seven times that of the individual institutions. Stimulated by NTI, the Commonwealth of Pennsylvania is now developing an integrated state nanotechnology strategy and has made nanotechnology one of the focal growth areas.

Virginia Nanotechnology Initiative (VNI)

(referred to as the Initiative for Nanotechnology in Virginia prior to 9/1/04)

Figure 1.1. Nathan Swami, University of Virginia and Virginia Nanotechnology Iniative (courtesy of Technology Administration, Department of Commerce).

The Virginia Nanotechnology Initiative is a statewide initiative model that builds the nanotechnology community in Virginia through the participation of university, industry, and state organizations. VNI enhances the scope, quality, and funding for collaborative research among Virginia's nanotechnology researchers, creates conditions to accelerate technology transfer to industry, develops a competitive workforce, and positions Virginia at the forefront of nanotechnology innovation.

VNI was established in August 2001 through seed funding from Virginia's Center for Innovative Technology (CIT). CIT was created by the General Assembly of Virginia in 1984 as a nonprofit organization designed to enhance the R&D capability of Virginia's colleges and universities.

To implement the Commonwealth's nanotechnology agenda, the director works with resources throughout Virginia, including a steering committee made up of university faculty, Federal laboratory program managers, and industry and regional technology council representatives. The initial leadership was primarily university based and has since expanded to include start-up and larger companies that are developing and seek to commercialize nanotechnology in Virginia.

VNI has chosen to focus on the scale-up and commercialization in nanomaterials manufacturing, based on Virginia's scientific strengths in materials and coatings, related research infrastructure at universities and Federal laboratories, and the technological strengths of related industry sectors (shipbuilding and space applications). In March 2004, Luna Innovations announced a $6.4 million investment in a new nanomanufacturing facility in Danville, Virginia. Headquartered in Blacksburg, Luna Innovations will renovate the facility for the production of cost-effective, carbonaceous nanomaterials to be used for R&D of new military and commercial applications.

Broadly, the primary activities undertaken by VNI include

- research development: information, support and interfacing to principal investigators on research proposals
- development of industry partnership and technology transfer for business and economic development
- interfacing to Federal funding agencies of the NNI and to the NNCO
- communication with elected officials
- state and university matching on Federal research proposals
- workforce development in collaboration with universities, industry and school systems

VNI's activities include statewide conferences, regional meetings, workshops, funding updates, development of inter-institutional and inter-departmental research proposals to enhance Federal funding, establishment and maintenance of a directory of nanotechnology assets in Virginia, facilitation of university-industry interactions for technology commercialization, and assistance in the development of

open access research instrumentation centers. In addition, VNI supports Virginia's state and Federal elected officials and economic development agencies, as well as national and other state initiatives, to promote the development of the United States and Virginia as major nanotechnology research and technology commercialization centers.

AtomWorks

In July 2002, a group of leaders from industry, academia, and government met under the auspices of AtomWorks and the Illinois Coalition for the first time with the goal of establishing Illinois and the Midwest more broadly as a world leader in commercializing nanotechnology-enabled innovations. (The Illinois Coalition is a not-for-profit, nonpartisan private/public partnership of the state's top leaders from business, labor, government, and research dedicated to strengthening Illinois' economy through science and technology.)

The initial leadership group drew from executives at Fortune 500 companies, city and state government officials, university nanotechnology center directors, and leading economic development groups. While exceptionally diverse, the group was united through one common thread: a belief that the Midwest could and should be a world leader in commercializing nanotechnology-based innovations. However, the group recognized the need for a shared understanding as to how to realize the vision across the diverse constituencies, so it decided to enlist the support of McKinsey and Company, a consulting firm, to develop a broadly accepted strategic roadmap.

In October 2002, the leadership team met again. At that meeting, the leadership approved the proposed McKinsey action plan, and established a formal governance structure. On October 9, 2002, AtomWorks was formally launched. It was decided that AtomWorks should be incubated by the Illinois Coalition for a period of 12–18 months while it built out the organization and funding sources to become a self-sufficient, independent 501(c)(3) institution.

The organization formed into an executive committee with three subcommittees: (1) Start-ups and Spin-outs, (2) Infrastructure Development, and (3) Education and Awareness. The goal was to engage as broad a constituency as possible, while minimizing bureaucracy. In contrast to many initiatives, AtomWorks was, from the outset, private sector driven. The university partners already had well-established nanotechnology efforts. Northwestern University and the University of Illinois each have NSF-sponsored Nanoscale Science and Engineering Centers (NSECs), while Argonne has one of five DOE Nanoscale Science Research Centers, so AtomWorks focused primarily upon acting as a trusted network integrator and coordinator. In that vein, AtomWorks has focused its activity on four key activity platforms:

1. **Education/awareness:** Educating the public, the business community, and the scientific community on the benefits of nanotechnology commercialization and the region's leadership in doing so
2. **Advocacy:** Serving as the voice of the Midwestern nanotechnology community to ensure a supportive environment for its development
3. **Resource aggregation and integration:** Assisting research institutions, nanotechnology companies, and prospective entrepreneurs in identifying and obtaining financial or other business-building resources, including access to infrastructure
4. **Community building:** Providing forums for interaction and networking to build trust across the constituencies

Texas Nanotechnology Initiative

At its founding in December 2000, the mission of the Texas Nanotechnology Initiative resembled that of any other regional, state, or local initiative: to bring together interested constituents in industry, academia,

and government to establish Texas as a world leader in the discovery, development, and commercialization of nanotechnology. TNI is reorganizing around a much more specific and urgent goal as it enters its third year. Its mission is to make nanotechnology in Texas a sustainable economic enterprise to the benefit of the state, the region, and ultimately, the Nation.

Unlike other regions, Texas state government has provided no support for attracting and retaining technology. There is no state-sponsored economic development office or program dedicated to technology; in fact, the state's sole economic development effort focuses on tourism. Local economic development groups in Houston, Dallas, and Austin have technology-centric offshoots, such as the Center for Houston's Future, the North Texas Technology Council, and the Austin Technology Incubator. By definition, however, these groups must focus on local constituents rather than the state as a whole.

Despite this lack of statewide coordination and funding, Texas has a set of existing resources that will contribute to economic development in nanotechnology. TNI is another of these resources. In three years, the organization has grown to 40 members and has representation on its board of directors from start-ups, established industry, service organizations, and universities. In addition to hosting quarterly meetings around the state, in 2002 and 2003, TNI organized and hosted NanoVentures, a three-day international conference focused on nanotechnology R&D and investment opportunities.

TNI leadership believes it is likely that these resources, left alone, will continue to produce successes, but state-sponsored and -directed coordination and funding will bring about these successes more quickly. TNI leaders believe the bottom-up, grassroots, volunteer-dependent initiative is no match for the top-down, goal-oriented economic development efforts that support nanotechnology in other regions. TNI plans to pursue its goal of making nanotechnology a sustainable, economic development enterprise in Texas through a number of channels.

The primary, near-term objectives are to

- **commission and support an input/output, economic impact analysis** to make the case for state-sponsored investment in attracting and retaining high-tech ventures
- **pursue stronger ties with local economic development organizations, state government officials, and Federal and national officials** to encourage support for tracking and retaining technology in Texas
- **develop www.texasnano.org to provide a Web-based nanotechnology clearinghouse** for tracking statewide accomplishments and nanotechnology-related events
- **partner with other organizations within Texas** to raise the profile of nanotechnology-events and create value-added content for members (e.g., make existing biweekly nanotechnology colloquia more accessible to university researchers; create a database of nanotechnology research and technology activity as a resource to members)
- **partner with regional and national organizations** to find ways to add value and promote Texas research and commercialization activity more broadly

2. Workforce Development and Education

It is well accepted that a trained workforce is a prerequisite for technology advancement and that companies view the presence of a trained workforce as a significant factor in their choice of locations. While this issue exists for all areas of technology, it is particularly relevant to nanotechnology, which, as an enabling technology, affects all disciplines and does not yet have well-established curricula.

THE NEED FOR TRAINED WORKERS

Studies have documented a growing skills gap, particularly for technicians, as well as growing shortages of qualified technical personnel. Estimates vary widely, but the number of nanotechnology technicians needed in the United States over the next decade may be as great as 800,000 [1]. For perspective, according to the U.S. Department of Labor, the employment level of engineering technicians in 2002 was only 478,000 [2] . Based on the average career length, and allowing for some attrition, the annual requirement for refreshing this technician workforce is ~15,000/year for this sector alone. Some of these engineering technicians may transition into nanotechnology, but many of the skills and knowledge areas for working in nanotechnology are new and not usually incorporated in conventional technician training and education. Looking forward, education in nanotechnology will be essential as nanotechnology becomes incorporated into more materials, manufacturing processes, and products.

While individuals with four-year undergraduate degrees and advanced degrees are relatively mobile, most will not pursue careers as technicians; thus, regions must rely on locally trained talent. This recognition has led many regions to concentrate on the goal of developing a technically skilled indigenous workforce using their community college systems as a source of technicians.

The Workforce Development and Education Session of this workshop concentrated on representative community college programs in the field of nanotechnology. Program developers have recognized that the national trend away from careers in technology poses particular challenges for them. To influence students to choose technical careers—even in nanotechnology, which currently has gotten considerable media attention and has a certain "buzz"—awareness must begin early, certainly in high school, and perhaps in middle school. The programs that were featured in this workshop session recognize this need for early education and include substantial high school outreach efforts.

REPRESENTATIVE MODELS AND APPROACHES

Pennsylvania State University

The Pennsylvania State University (Penn State) offers a comprehensive program through the Pennsylvania NanoManufacturing Technician (NMT) Partnership, a National Science Foundation (NSF) Advanced Technology Education Regional Center for Nanofabrication Manufacturing Education. The NMT Partnership comprises 20 institutions that offer associate degree programs in nanofabrication. The model can be considered as "Hub & Spoke," in which prerequisite science courses are taught at the individual community colleges for three semesters, followed by a capstone semester in nanofabrication at Penn State's main campus. This 18-credit suite of nanofabrication courses is taught three times per year at the Penn State Nanofabrication Facility. The $33-million facility is part of the five-member NSF-sponsored National Nanotechnology Infrastructure Network* and, with its staff of 20 full-time scientists and

* Now expanded to 13 members. See www.nnin.org.

engineers, offers complete top-down and bottom-up fabrication capability. The capstone semester gives students the experiential learning on state-of-the-art equipment that companies desire and that is a differentiating employment factor.

All seven of the first associate degree programs in nanofabrication were created as concentrations within existing programs in Electronics Technology or Electronics Engineering Technology. However, these programs are increasingly accommodating the broader applications of nanotechnology, and several of the more recently developed programs are not housed within electronics programs, to further emphasize this breadth of applications [3]. The program has a broad reach across the Commonwealth of Pennsylvania with nanofabrication associate degree programs now offered by every community college in Pennsylvania, as well as several other institutions. The NMT Partnership also supports development of baccalaureate degree programs within Penn State and at other Pennsylvania universities.

The NMT Partnership offers one-day and three-day summer "Nanotech Camps" for middle-school and high-school students from across Pennsylvania. The camps give students a broad sense of how nanotechnology is applied in many areas of study and industries. They provide secondary school students with an orientation to basic nanofabrication processes and applications, and the opportunity to observe these nanofabrication processes in the Penn State Nanofabrication Facility. As of the workshop date, the NMT program had graduated 97 students with associate degrees, with more than 500 students attending the Nanotech Camps.

Nanotechnology Institute

The Nanotechnology Institute (NTI), as described in the previous section, was founded by Drexel University, the University of Pennsylvania, and the Ben Franklin Technology Partners of Southeastern Pennsylvania and comprises nine regional universities. Through the University of Pennsylvania, it has developed a curriculum for education of nanotechnology technicians in the biopharmaceuticals and life sciences industries. This program, the Delaware Valley Nanobiotechnology Community College and High School Education Network, has concentrated on community college and high school education programs, both for students and teachers, as a result of discussions with corporations in which they identified two-year post-high school education level workers as their greatest personnel need.

Figure 2.1. Mark Modzelewski addressing a break out session (courtesy of Technology Administration, Department of Commerce).

The program is composed of four interrelated components: (1) development of a curriculum in nanobiotechnology at the community colleges; (2) training of community college faculty members; (3) development of Web-based instructional material libraries, collaboration portals, and virtual classroom and tele-experimentation capabilities to enable community college-based technical instruction; and (4) creation and implementation of an effective high school outreach program.

The corporate partners identified key components for a nanobiotechnology curriculum: a strong focus on fundamentals, experience with computer-controlled equipment, extensive work on time management and communication skill sets, and

an improvement in the content of particular courses. Following initial data gathering and instructional efforts, community college and university faculty designed a two-year curriculum in nanobiotechnology. Five university and 17 community college faculty members worked in five separate teams to construct detailed syllabi (including laboratory content) for five new courses: Introduction and Design courses in Nanobiotechnology, Chemistry for Nanobiotechnology (modern industry-relevant chemistry), Physics for Nanobiotechnology, and Molecular Biology for Nanobiotechnology.

The high school outreach program energizes and mobilizes the high school community through the Nanotechnology High School Teaching Fellows. The first Teaching Fellows core group of 16 teachers represented urban and suburban school districts. They are being given an intensive, 10-week course in nanotechnology using newly prepared material that includes lectures and laboratory work, resulting in development of modules to be introduced in their classes. The capstone event of the Fellows program is a Regional High School Nanotechnology Science Fair involving the Fellows' students.

Virginia Nanotechnology Initiative

The southern regions of Virginia traditionally have been major manufacturing destinations. The Institute for Advanced Learning and Research in Danville was established to attract technology and talent to Southside Virginia through advanced learning, strategic research, and technology transfer of next-generation technologies. The creation in Danville of private facilities for carbon nanomaterials and polymer manufacturing has provided an early focus for nanotechnology workforce development within this institute.

Summer short courses, partially funded by the NSF's Nanotechnology Undergraduate Education (NUE) and Research Experience for Undergraduates (REU) grants, are taught at institutions across the Commonwealth, including James Madison University and the University of Virginia, to train technicians in the scientific concepts of nanotechnology. In addition, businesses such as Luna Innovations provide hands-on experience at their facilities to future technicians. These courses include faculty from the Appalachian College Association and school teachers from Virginia. The summer courses have an enrollment of 20–30 students each year.

University of Wisconsin

The cornerstone of Wisconsin's nanotechnology education efforts is the Interdisciplinary Education Group (IEG) of the Materials Research Science & Engineering Center (MRSEC) of University of Wisconsin. This and other associated NSF-funded education grants operate under the theme of "Exploring the Nanoworld." These education efforts use nanotechnology in kits, teaching resources, and curriculum materials to explore science and engineering concepts at the middle school through college levels.

Informal science education also plays a large role at the University of Wisconsin–Madison as a way to engage with the public about the "wow" and potential of nanotechnology. These combined efforts, funded at approximately $500,000 annually, have reached more than 9,000 K–12 students, and have trained more than 3,000 K–12 teachers and college instructors in the 2002–2003 time frame. A partner of the MRSEC IEG, the Milwaukee-based Discovery World Museum, Wisconsin's largest science center, has helped the informal science education effort to connect audiences with world-class science expertise and cutting-edge research. A number of exhibits using the theme of "Dream Big, Think Small" are under development for the museum.

The University of Wisconsin–Madison has created a new undergraduate degree program in Engineering Physics that includes an option in Nanoengineering and has integrated nanotechnology into a variety of courses in fields such as chemistry, physics, and engineering. Several colleges in the Wisconsin Technical College System also are introducing courses in nanotechnology, and an effort is underway to develop nanotechnology-related associate degree programs at several institutions.

CHALLENGES

As the examples show, community college programs are an attractive mechanism for meeting the incipient national need for nanotechnology technicians. Community colleges thus far involved in addressing this need are pragmatic in their approach and want to be sure that there is a critical mass of students available and demonstrable job opportunities before they commit to developing or implementing new courses. This presents the classic "chicken & egg" problem.

The programs outlined here meet this problem in different ways. The Penn State NMT program utilizes existing community college science and mathematics courses and offers new content through the capstone semester, while the NTI Nanotechnology Education Network utilizes distance learning and tele-experimentation. Both focus on demonstrating a career path for students by exposing them to a variety of broadly applicable equipment and techniques in nanofabrication and bionanotechnology, respectively.

Additional challenges that are not within the scope of this review are

- **throughput:** The demand for technical personnel over the next decade is significant. Education programs must be cognizant of this and prepare for volume
- **extent of new course development:** Wherever possible, it is important to leverage existing courses since introduction of new courses in the community college and high school systems is difficult
- **articulation:** To optimize career paths for students, it is necessary to develop articulation (course-credit) agreements between community colleges and between community colleges and universities, and to address tuition discrepancies between the various institutional systems

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2. U.S. Dept. of Labor, Bureau of Labor Standards, http://www.bls.gov/oes/home.htm.
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3. Research and Development Infrastructure

PARTNERSHIPS FOR R&D INFRASTRUCTURE IN NANOTECHNOLOGY

Infrastructure for R&D is a crucial stepping stone towards the transitioning of nanotechnology from a "knowledge-driven" to a "product-driven" initiative. The September 2003 NNI Workshop provided a catalyst for data collection on state investments in this area and explanations for the respective state allocations.

The National Nanotechnology Initiative has made several key advances towards developing a balanced, accessible, strong, and flexible infrastructure to stimulate new discoveries and catalyze the commercialization of technological innovations. This is particularly significant because the cost of nanotechnology instrumentation, equipment, and facilities can be beyond the spending power of small businesses, academic institutions, and state organizations. [1].

Federal Investments

Table 3.1 describes the allocation of Federal investments in research infrastructure that is available to the public as "user facilities." These include the National Science Foundation's National Nanotechnology Infrastructure Network (NNIN), which aims to provide user facilities to academic and industry users, and the U.S. Department of Energy's five Nanoscale Science Research Centers, which aim to conduct breakthrough discoveries in a broad range of topics as indicated by the names of the centers. These centers focus on an array of materials research, such as functional materials, integrated nanotechnologies, nanophase materials sciences, nanoscale materials, and molecular foundry. In addition to infrastructure investments, the NNI funds nanotechnology research centers that are focused on excellence in specific research areas and on engendering strong interdisciplinary and multidisciplinary R&D among researchers from academia, industry, and government. These centers of excellence are generally not accessible as user facilities, but nevertheless play a significant role in facilitating development of nanoscale science and technology, and enable the formation of clusters based on regional critical mass in certain focused areas.

Table 3.1
Federally Funded User Facilities for Nanotechnology Research Infrastructure

Facility	Agency	Lead Institution	PI	Partner Institutions
National Nanotechnology Infrastructure Network	NSF	Cornell University	Tiwari	Cornell, Howard, Stanford, Penn State, UCSB, Georgia Tech, Harvard, NC State, U. of Michigan, U. of Minnesota, U. of New Mexico, U-T Austin and U. of Washington
Network for Computational Nanotechnology	NSF	Purdue University	Lungstrom	Illinois, Stanford, Florida, Texas, Northwestern, Morgan State
Center for Functional Nanomaterials*	DOE	Brookhaven National Laboratory	Hwang	
Center for Integrated Nanotechnologies*	DOE	Sandia/Los Alamos National Laboratories	Michalske	
Center for Nanophase Materials Sciences*	DOE	Oak Ridge National Laboratory	Lowndes	
Center for Nanoscale Materials*	DOE	Argonne National Laboratory	Bader	
Molecular Foundry*	DOE	Lawrence Berkeley National Laboratory	Alivisatos	
Center for Neutron Research	NIST & NSF	NIST	Rowe	

*under development

State Investments

State investments in nanotechnology are described in Table 3.2 and may be classified as follows for purposes of organization:

State-Corporate Partnership Model

The nucleus of the activity here is a major state-funded research infrastructure investment, most likely in a university-based nanotechnology institute that is strongly matched by investments from industry partners. Outstanding examples of this model are the State University of New York–Albany Nanotechnology Center and the California Nano-Systems Institute (CNSI), which have state investments of $100 million or more, matched to a great extent by industry partners (50% or greater). In many instances, such clusters have enabled the relocation of industrial nano-manufacturing research activities to the respective region, bringing with it investments from support industries, as well as state investment for workforce programs. Remarkable examples are the relocation of the Sematech and Tokyo Electron research centers to Albany.

State-University Partnership Model

The activity in this group is led by a mixture of state and university investments in a university-based nanotechnology institute that may also be a recipient of major Federal research awards. The corporate investment here is a smaller percentage. Most regional clusters fall in this category, including, for

example, the Biodesign Institute in Arizona, the workforce development effort within Penn State, and the University of Virginia's Institute for Nanoscale and Quantum Engineering Science and Technology (NanoQuEST). In most of these cases, the university contributes a larger portion of these investments from its endowments, alumni funds, or other sources.

Corporate Partnership Model

The activity in this group is led by a private consortium that leverages public-private partnerships and university-based research centers to capitalize on commercialization. This model is usually more popular in regions having a well-established industry base and strong university investments in a nanotechnology institute. Examples include the Washington Technology Center in Seattle; AtomWorks in the Chicago region, which leverages university investments within Northwestern University and the University of Illinois; the Nanotechnology Institute in Southeastern Pennsylvania, which leverages nanotechnology activity at nine regional universities; New Jersey's Nanotechnology Consortium; and the Texas Nanotechnology Initiative.

Industry Investments

Major industry investment for nanotechnology research infrastructure is restricted to major corporate research labs, such as those at IBM, Motorola, and General Electric, and research consortia such as Sematech and Semiconductor Research Consortium (SRC). Some small businesses have developed specialized research facilities, such as nanoprinting facilities of NanoInk in Chicago, nano-imprint lithography of Molecular Imprints in Austin, molecular manipulation technologies of Zyvex in Houston, or the carbon nanomaterial manufacturing plant of Luna Nanomaterials in Danville, Virginia. Most of these facilities are not user facilities in the strict sense, but may be available to other users based on collaborative partnership agreements.

REGIONAL ECONOMIC DEVELOPMENT ORGANIZATIONS

The investment of metropolitan and regional economic development organizations in research infrastructure is small. However, these organizations have played an important role in mobilizing users and development of clusters around existing Federal and state facilities. Examples include the collaborations of LARTA (Los Angeles Regional Technology Alliance) with the California NanoSystems Institute (CNSI); the San Francisco Chamber of Commerce with facilities at Berkeley; the Arlington and Fairfax County (VA) collaborations with facilities at the National Institute of Standards and Technology (NIST), the Naval Research Laboratory, and the University of Virginia; and various counties in New York for enhancing commercialization based on research at the State University of New York, Albany, and the Rensselaer Polytechnic Institute.

SUMMARY AND RECOMMENDATIONS

A key recommendation of the National Research Council's review of the NNI in 2002 (*Small Wonders, Endless Frontiers* [2]) was "to leverage NNI funds by 25% by working with states, universities, and the private sector to increase funding and synergism in R&D, to nucleate new clusters of industries" by Fiscal Year 2003. From the data presented thus far, it seems apparent that this 25% leveraging on research infrastructure has already occurred at the state and university levels, based on the scientific and commercialization promises of nanotechnology. The next step is to assess the breadth of usage of the research infrastructure and to study its role on broader impact factors such as industry clusters and workforce development. Additionally it would be of great interest to study the impact of the described infrastructure on cluster growth and outcomes in theory and practice. Data also are needed on the impact of these infrastructure sites on commercialization activities and on other R&D indicators, such as patents and technology transfer agreements.

Table 3.2
Estimated R&D Infrastructure Investments at the State-level (State and Federal Funding)*

State	Recipient	Description	Commitment	Initiative Model
AZ	Nano-bio research center	Research infrastructure	$5 million/yr for 20 yrs	University-state partnership
CA	California Nanosystems Institute	Building infrastructure	$100 million over 4 yrs	Metropolitan-state
CO	Denver University	Federal earmark	$250,000	
FL	Center at University of South Florida	Faculty recruitment and infrastructure	$5 million	University-state partnership
GA	Center at Georgia Tech	Building & research infrastructure	$90 million	
IL	Nanoscience Centers (NU,U of IL, ANL)	Building & research infrastructure	$63 million	AtomWorks Metro-regional partnerships
IN	Nanotechnology Center at Purdue	Building infrastructure	$5 million	
NJ	Support at NJIT and photonics consortium			NJ Nano-initiative Fab Shop with Lucent
NY	Nanoelectronics Center, Albany	Building & research infrastructure	$50 million (initial), $400M over 5 yrs	University-state partnership
OK	NanoNet	EPSCoR	$3 million/yr for 5 yrs (40% state match)	University-region partnership
OR	ONAMI – Oregon Nano-Micro Interface Institute	Research infrastructure	$20 million over 5 years	University-industry partnership
PA	Nanotechnology Center		$37 million	BFTP & Penn State NMT
SC	NanoCenter	Building infrastructure	$1 million	
SD	Center for Accelerated Applications at the Nanoscale	Research infrastructure	$2.5 million over 5 years	University-state partnership
TX	Four universities: Rice, University of Texas at Austin, Dallas, and Arlington	Federal earmark for SPRING Initiative	$10 million Federal, $0.5 million private	Corporate venture
VA	Various institutions & Luna Innovations	Research matching & infrastructure	$4 million for research matching, $8 million for bldg infrastructure	University-state partnership
WA	University of Washington, Washington Tech Center	Clean Room Maintenance	$3 million over 3 yrs	University-state partnership

*Source: based on data collected by N. Swami and M.C. Roco as part of NSF award CTS#0335961

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1. National Nanotechnology Coordination Office, *National Nanotechnology Initiative—Research and Development Supporting the Next Industrial Revolution, Supplement to the President's FY2004 Budget.* www.nano.gov/html/res/fy04-pdf/fy04-main.html
2. National Research Council, *Small Wonders, Endless Frontiers—A Review of the National Nanotechnology Initiative,* Washington, D.C. National Academy Press (2002).

4. Economic Development and Commercialization

If the creation and retention of private sector jobs is the desired end product of any economic development organization, then the more than 40 nanotechnology-related initiatives in the United States today can best be described as early-stage efforts. Of the 12 presentations at the September 2003 Workshop on Regional, State and Local Initiatives in Nanotechnology, only Albany claimed to have directly impacted jobs. All other initiatives appeared to be in the foundation-building stage.

JOB CREATION

Nearly all of the 425 [1] R&D, manufacturing, applications and equipment companies that make up the U.S. nanotechnology industry today were launched prior to, or largely independent of, emerging nanotechnology economic development efforts. These companies have generated nearly 23,000 new jobs [2]. These jobs can be attributed primarily to two sources:

- Growing nanotechnology research spending by the U.S. Government, which has funded much of the research that has been licensed and commercialized by the above-mentioned small spin-off companies. Federal funding for nanotechnology R&D more than tripled from $270 million in fiscal year 2000 [3] to $989 million in fiscal year 2004 [4].
- Major U.S. corporations are spending roughly the same per year for in-house research, for partnerships with smaller companies, and for funding of targeted university research. Future corporate spending is expected to outpace government spending as an increasing number of companies look to nanotechnology-enabled applications for the next generation of existing products and, in some cases, new products.

The early successes of small companies commercializing research from university and national laboratories is being studied by states and regions hoping to replicate the economic benefits spawned by earlier technology waves, particularly biotechnology. There are also lessons to be learned from successful start-up companies. The remainder of this chapter is directed to those lessons, foundation efforts being established by initiatives to support start-ups and attract existing companies, and challenges facing commercialization.

START-UP CASE STUDIES

Nanotechnologies, Inc. *(Austin, TX)*

When Nanotechnologies, Inc. was founded in late 1999, proximity to the University of Texas faculty and laboratories was a key reason the company located in Austin. Founder Dennis Wilson was a professor at the University of Texas, Austin, and the company has done some application development work with university scientists.

“We have built a strong relationship with the University of Texas and other laboratories for critical analytical and characterization capabilities,” said Wilson, who also serves as the company’s chief technology officer and chairman of the board. That relationship and the fact that employees like living in the Austin area largely account for the company’s location, he said.

Nanotechnologies, Inc. benefited from local venture capital investment during the early stages, but that has become less important as the company has moved to a model for funding by commercial and

Figure 4.1. Mary Jo Waits, Arizona State University (courtesy of Technology Administration, Department of Commerce).

government partners, Wilson said. The state and local governments have provided no financial incentives. Access to market opportunities has not been a factor, according to Wilson, because customers are primarily large original equipment manufacturers with global presence.

The Texas Nanotechnology Initiative (TNI) was formed in 2002, more than two years after Nanotechnologies, Inc. was founded. While TNI gets no credit for bringing the company to Austin, the initiative has found ways to offer support. According to Wilson, Austin has developed an infrastructure over 20 years of very fine support for start-up ventures. Legal, patent and financial services are available and excellent, he notes. He believes that TNI has helped to bring these service providers into the nanotechnology-related marketplace.

Luna Innovations *(Blacksburg, VA)*

Luna Innovations developed a portfolio in nanomaterials by licensing technology from Virginia Tech in the area of endohedral fullerenes. In conjunction with scaling up the production of these nanomaterials, research alliances were established with the aid of the statewide nanotechnology initiative to test these materials for biomedical imaging applications.

The funding for this early phase was provided by several National Science Foundation and Department of Defense awards through their Small Business Innovation Research programs, and one major Advanced Technology Program grant from the National Institute of Standards and Technology (NIST). Following promising *in vitro* results for application of these materials in magnetic resonance imaging (MRI), efforts are currently underway to scale up production for *in vivo* tests. In addition, with assistance from the statewide Virginia Nanotechnology Initiative, matching funds were arranged at the state and metropolitan level to match Federal funding for a major nanomaterials manufacturing facility in Danville, based on the technology commercialization and workforce development promise of these materials. Luna Innovations is currently exploring major venture capital funding to augment the Federal and state investments.

Quantum Dot Corporation *(Hayward, CA)*

Founded in 1998, Quantum Dot Corporation (QDC) develops and markets quantum dots used for biomolecular detection. QDC licenses technology developed by Dr. Moungi Bawendi (Massachusetts Institute of Technology) and Dr. Paul Alivisatos (University of California, Berkeley) and is located close to Berkeley.

At the time Quantum Dot Corp was looking for space, it was the height of the “dot com” frenzy and the real estate market was the primary consideration. According to Carol Lou, QDC’s president and Chief Operating Officer, “dot com” companies were driving up the commercial real estate costs and QDC had a difficult time finding space. She said the company considered moving to San Diego as an alternative location. While QDC finally found a facility that was well equipped and affordable, the company might consider relocating when its lease ends due to the escalating costs in the area.

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1. Small Times Media, *Nanotech Intelligence Quarterly,* 2004.
2. Small Times Media, 2004.
3. National Nanotechnology Coordination Office, *National Nanotechnology Initiative— Leading to the Next Industrial Revolution, Supplement to the President's FY 2001 Budget.*
4. National Nanotechnology Coordination Office, http://www.nano.gov/html/about/nnibudget.html.

5. Lessons Learned

Because the NNI and regional initiatives are young, many of today's start-up nanotechnology companies have been around longer than the economic development initiatives that are being created to attract and support them. The challenges and experiences of this first wave of companies offer valuable lessons for such initiatives:

- Every nanotechnology start-up requires core technology licenses and access to the researchers who developed the technology as an intellectual property "umbilical cord." Proximity to the inventor(s) becomes less important as companies mature and further develop the core technology with their own staff research. Economic development initiatives can use this knowledge to focus company recruitment efforts. Likely targets are spinouts from nearby universities, government labs, and large corporations. The odds are against attracting an early stage company from farther away than their "umbilical cord" will reach. However, once companies have had a few years to mature beyond their core research, these firms might be targets for relocation.
- Every nanotechnology start-up requires substantial cash investment. The highly educated staff researchers and the cutting-edge scientific equipment demand a cash investment far higher than many other types of new businesses. Early stage investors, including "angel" investors and venture capitalists, prefer to invest in companies that can be visited conveniently. Initiatives can use this knowledge to approach local early stage investors and work with them to identify promising nanotechnology opportunities.
- The availability of specialized support services such as law firms and marketing organizations with nanotechnology expertise is a bonus for an area. Companies likely will not choose a location based on these services, but a strong support system can help start-ups survive and succeed.
- Grants from Federal agencies can be critical in helping young companies survive and expand. Initiatives should identify the types of technologies and applications offered by local companies and routinely search for related grant opportunities to pass along. Many of these projects require partnerships with universities and/or other businesses. Initiatives can make these organizations aware of each other and bring them together when an opportunity appears.
- Financial incentives from state and local governments, often in the form of tax breaks and research funding, are a useful tool in directing development and attracting new industry to the area. A state such as Michigan that is already strong in transportation and life sciences encourages a strong pipeline of research with commercial potential by devoting a large share of research funding to projects dealing with transportation and life sciences. Few, if any, states or regions have the financial resources to completely underwrite a technology cluster, so careful attention should be given to establishing clear economic development priorities and using limited financial incentives to influence growth accordingly.

Appendix A. Workshop Agenda

Purpose

To provide regions, states and localities with information, models, and networking opportunities to assist them in developing, launching, and nurturing nanotechnology initiatives.

Place

U.S. Department of Commerce, Main Auditorium, 14th St. and Constitution Ave., N.W., Washington, D.C.

Agenda

September 30, 2003

08:30 **Welcome** (Dr. Mike Roco, Chair NSET, NSF)

08:35 **Introduction:** Purpose of the Workshop (Dr. Clayton Teague, Director, NNCO)

08:45 **Keynote Speech:** State Perspective (Hon. Aris Melissaratos, Secretary, Maryland Department of Business and Economic Development)

09:05 **Keynote Speech:** Federal Perspective (Hon. Phillip J. Bond, Under Secretary of Commerce for Technology, U.S. Department of Commerce)

09:30 **Keynote Speech:** Economic Development Perspective (Dr. David A. Sampson, Assistant Secretary for Economic Development, U.S. Department of Commerce)

Case Studies

09:50 **Plenary Speech:** Cluster-Based Models of Regional High Technology Economic Development and Commercialization (Mary Jo Waits, Arizona State University)

10:10 **State/Corporate Partnership Case Study:** New York (Jo Anne Feeney, Albany NanoTech)

10:30 **State/University Partnership Case Study:** California (Dr. Fraser Stoddart, California NanoSystems Institute)

10:50 **Break** (opportunity for one-on-one discussion)

11:10 **Regional/University Case Study:** Oklahoma (Dr. Warren Ford, Oklahoma State University)

11:30 **Local-led Network Cluster Case Study:** Chicago area (Sean Murdock, AtomWorks)

11:50 **State-Sponsored Initiative Case Study:** Pennsylvania (Dr. Barry Stein, Ben Franklin Technology Partners)

12:10 **Lunch** (Department of Commerce cafeteria or the Reagan Building food court located across 14th Street from the Department of Commerce)

13:30 **Panel Discussion:** Lessons learned from case studies (case study speakers, possibly others)

14:15 **Panel Discussion:** Starting a Successful Nanotech Initiative (led by Sean Murdock, AtomWorks)

15:15 **Panel Discussion:** Growing and Maintaining a Healthy Nanotech Initiative (led by Mark Modzelewski, NanoBusiness Alliance)

16:15 **Break** (opportunity for one-on-one discussion)

16:30 **Prepared Talk:** Nanotechnology Workforce Development and Education (Dr. Nathan Swami, Initiative for Nanotechnology in Virginia)

16:50 **Prepared Talk:** Nanotechnology Research Infrastructure Development (Dr. Larry Goldberg, National Science Foundation)

17:10 **Prepared Talk:** Economic Development and Commercialization (Mark Modzelewski, NanoBusiness Alliance)

17:30 **Open Discussion:** self-organization to establish working groups or other means for ongoing coordination among Federal, regional, state, and local activities (led by Mark Modzelewski, Sean Murdock, Dr. Nathan Swami; other volunteers invited)

18:00 **Reception and Poster Session** for workshop participants, at Department of Commerce, Technology Demonstration Center, Room 4813, 14th St. and Constitution Ave., N.W. (posters consisting of content from materials that each initiative submitted for the handouts and Web site in advance of the workshop; non-alcoholic drinks and light refreshments will be served)

October 1, 2003

Discussion of Future Activities

09:00 **Nanotechnology Workforce Development and Education**
(Short selected presentations followed by discussion led by Dr. Nathan Swami and/or Pennsylvania groups: Dr. Barry Stein, Ben Franklin Technology Partners, and Paul Hallacher, Penn State/NanoManufacturing Technology Partnership)

09:45 **Nanotechnology Research Infrastructure Development**
(Short selected presentations followed by discussion led by Dr. Mike Roco, NSET, and Dr. S. Tom Picraux, Arizona State University)

10:30 **Focus on Economic Development and Commercialization** (Short selected presentations followed by discussion led by Mark Modzelewski)

Summary/Wrap-up Sessions

11:15 **Focus on Best Practices, Case Studies, Success Stories**
(Opportunity for short volunteered presentations followed by discussion; led by Mark Modzelewski and Sean Murdock; sign-up for these presentations will be during the meeting)

11:55 **Concluding Remarks** (Dr. Mike Roco, Dr. Clayton Teague, state/regional reps, workshop leaders)

12:00 **Lunch**

13:00 **Report Drafting Session**
Open to any participants from the workshop who wish to play a role in preparing the final report focused around potential chapters for the final report, as follows:

- Best practices & lessons learned
- How to build an initiative
- Workforce development and education
- Research infrastructure development
- Economic development and commercialization

16:00 **Adjourn**

Appendix B. List of Participants

Cate Alexander
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Jennifer Andersen
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North Dakota State University

Deborah Ausman
Texas Nanotechnology Initiative

Rick Ballard
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John Bedz
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American Chemical Society

Kitu Bindra
Girvan Institute of Technology

Phillip J. Bond
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Keith Boswell
Virginia Economic Development Partnership

William David Brown
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Paul Burrows
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James J. Busse
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Pamela A. Houghtaling
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Tom Hubbard
Massachusetts Technology Collaborative

Daryush Ila
Alabama A&M University Research Institute

Tina Kaarsberg
U.S. House of Representatives, Science Committee

Barbara Karn
U.S. Environmental Protection Agency

Francis M. Keel
U.S. Department of Energy

Jon J. Kellar
South Dakota School of Mines and Technology

Randall Kempner
Council on Competitiveness

Bruce Kisliuk
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Uwe Kortshagen
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Sheryl H. Kunickis
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David I. Lackner
NASA Ames Research Center

Karen Laney-Cummings
U.S. Department of Commerce

Matthew Laudon
Nano Science and Technology Institute

Judith Light Feather
The NanoTechnology Group, Inc.

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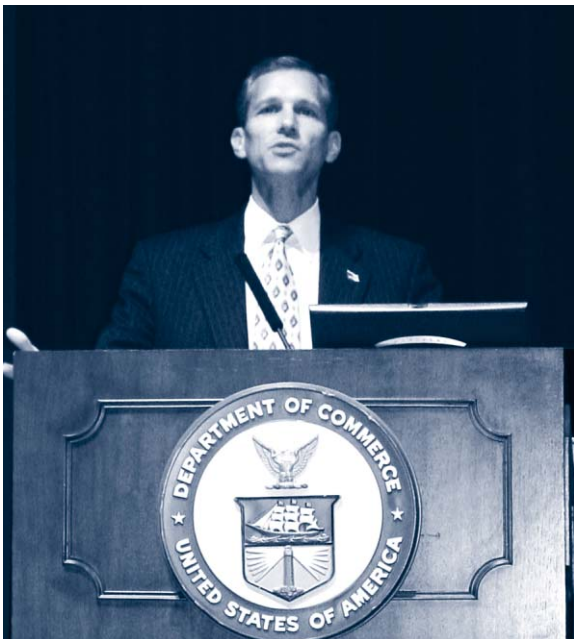
Appendix C: Remarks of Phillip J. Bond
Under Secretary of Commerce for Technology
United States Department of Commerce

Delivered September 30, 2003, at the Workshop on Regional, State and Local Initiatives in Nanotechnology, U.S. Department of Commerce Washington, D.C.



Phillip J. Bond, Under Secretary of Commerce for Technology, United States Department of Commerce

Thank you and welcome to the Department of Commerce. It's a pleasure to have you with us here, to be a host and to see so many friendly faces in this growing community of friends so devoted to the future.

We have today representatives of 22 different states along with the District of Columbia, and for that I want to thank Clayton Teague and his team, and Mike Roco and all the great work that goes on there [in the NNI].

The Commerce Department sought to sponsor this event because we have in our various bureaus a number of areas that touch upon the future of nanotechnology. Technology policy was mentioned; we have of course R&D funding that goes on here through the great scientists at the National Institute of Standards and Technology. Standards, incorporated into NIST's name, of course, are going to be critical as we move into a nanotechnology-enabled future. Many of the applications originally are going to be defense applications, so export controls and other Commerce responsibilities will be important, and, of course, international trade as we seek to market our new products and capabilities to the world.

Another reason for our interest is your purpose—economic development. We have here an Economic Development Administration headed by Dr. David Sampson, whom you will be hearing from later. He is, as you will find out, a great, great believer in technology-led economic development, so you should look forward to hearing David Sampson.

Well, I'm thrilled to be with this group. I'm thrilled every time I get a chance to speak to a nanotechnology group because as I have told other audiences, you invariably get a collection of incredibly bright people. You get to talk about some weird quantum scale phenomena that you don't find somewhere else. You get to hear revolutionary ideas. You get to meet original thinkers and true pioneers like Jim von Ehr, who is with us today.

There are a lot of reasons to be excited. And on top of that, nanotechnology perhaps uniquely has the capability to excite a new generation of scientists and technologists—kids, like my two daughters. If you can play with Legos, you can understand the concept of building from the bottom up.

I tested this on my own 11-year-old. She gets it. She's excited about it. She asked for materials from NIST about it. She created her own mock Web site on nanotechnology. This can excite kids. Another reason to be excited about nanotechnology.

In fact, speaking about kids, it occurred to be me last night in reviewing some notes that—bear with me for a hokey analogy—in the technology family, I would submit that nanotechnology is the toddler. The one whom we are all fascinated with, like to watch every new thing that it does, does not yet consume large portions of the family budget, and it will change the future of the family. It will be disruptive to the future. It's our intriguing toddler.

Just as intriguing is the agenda today. In fact, not just intriguing, but critical. Critical to come together to look at lessons learned, what worked, what didn't work, what people are looking at in the different states for the future, comparing notes. Tip O'Neill said famously that, "All politics is local." You are testimony to a corollary—that all economic development is local. You are the front line troops, the people on the ground on the front line, you are going to be critical to this unfurling technology as an enabler for our national economy and ultimately for America's global competitiveness. For that I thank you.

As you go about making America competitive in the future, nanotechnology is the future. It's been just a few years, as was alluded to by Mike [Roco] and Clayton [Teague], from original concept into the labs, out of sci-fi, into the labs, into the marketplace, into national advertising campaigns.

It's a fast moving, exciting time. The reasons for the creation of the national initiative are the four main pillars that keep it going today and excite folks in all 50 states:

- First, it is the new frontier, and the U.S. is used to working on frontiers and leading in frontiers, with space and electronics. You name the frontier, we have led.
- Second, economic potential. It's the next industrial revolution. And again, here America has a habit in leading in agriculture, semiconductors, Internet, biotechnology. This is the next revolution.
- Third, it's going to be critical to national security and homeland security. Some people think we are moving into the decade of the sensor. That is going to be critical to homeland security. Already we have seen nanotechnology applications in national security.
- Fourth, and certainly not least, nanotechnology brings with it dreams of the virtually miraculous—allowing the deaf to hear and the blind to see, to end hunger, to clean our environment.

And precisely because it's new and disruptive, and connotes a lot of change, some people are anxious. So this new technology is under greater scrutiny than probably any predecessor. It's under scrutiny because it's the next big thing. It's under scrutiny because investments have soared.

We talked about the national investments that Mike Roco has cited. Up from $116 million in its first year in 1997, to a request for $850 million in the current budget as a part of President Bush's record request for $123 billion in basic R&D.

We are not alone; all around the globe an estimated $3 billion dollars in public R&D, roughly divided between U.S., Europe, and Japan, but they are not alone. Many other countries are also involved. You know them.

The third reason that we are under scrutiny is that we live in the post-bubble time, and investors once burned are shy the second time. I think I've said in every nanotechnology speech I have given that we have to make sure in that environment to guard against "nano" becoming a four-letter word, not to over-promise but to over-deliver on the promise of nanotechnology.

So, we are under scrutiny. But that scrutiny aside, it still is the future, it still is the key to global competitiveness and we must press on. We must not wait.

One reason we shouldn't wait is that the body politic, the public, is susceptible to viruses, including the virus of fear or misinformation. So we can't wait for that to take hold, we must move out.

Secondly, our political system, which will be critical to a number of steps along the way, is not designed to move incredibly fast. It is designed to be a deliberative body. We must begin the deliberation.

Third, we've got private sector and societal phenomena like books and movies, which are going to begin to impact peoples' thinking about what nanotechnology is. We have to move quickly to fill that void, and we have to address the other improbable experts speaking around the world about slowing down or halting research into nanotechnology.

Well, that sounds a little bit too much like I'm lecturing about all these things that have to be done. I don't want to be the lecturing bureaucrat. Let me assure you that from the Federal side, we understand that we have a key role to play here.

First of all, to enable continued discovery. That means the R&D funding that I talked about. We have recommended record amounts of basic R&D.

It means facilitating the tech transfer, turning that science back into money. We will remain vigilant there. We will especially remain vigilant on protecting intellectual property, which will be the coin of realm.

We have to foster entrepreneurship, which continues to be the driver. We have to keep that entrepreneur in his garage or her garage firmly in mind at all times. Indeed, that's what animated much of the policy you saw in terms of tax cuts from this administration, in terms of expensing for small businesses. So we're keeping our eyes on the entrepreneur.

We have to ensure world-class education. This isn't going to happen without an informed workforce. That is what is behind *No Child Left Behind;* it's what is behind other efforts to look now at the future of education, and life-long learning and the Federal role there.

And, of course, we have to negotiate a global environment. Not just standards, but trade agreements, so that we can market the new products to the world.

So, we have responsibilities on the Federal side. We understand that. You certainly have responsibilities as the ground troops on the front line and given that, we, of course, must forge a partnership.

That's really what the meeting is about here, the vision of NNI to create this great coalition and partnership all across the country. In terms of partnership, I have what would be good news and bad news.

The good news is that information technology makes it very easy for us to collaborate, so that someone in Texas or Colorado could find a colleague in California or Boston and compare notes and move the frontiers of knowledge.

The flip side of that, the bad news if you will, is that your critics — we will talk more about that in a minute—also will have more visibility into what you're doing. They can go on-line and access information and find out about the advances that are coming. They can also spread misinformation easier with urban legends on the Internet.

I want to acknowledge, as Clayton implied, that critics have some legitimate points that we need to address.

The good way to think about this is establishing a bedrock of common sense. It was Oliver Wendell Holmes who said, "Science is a first-rate piece of furniture for man's upper chamber, if he has common sense on the ground floor." We've got to build that ground floor together all across the country. That means we have to address those legitimate concerns whether they are societal or ethical. We have to bring the

right and full range of people together into that discussion. Now, the good news is that history shows that we can do this. In fact, at every step along the way, technology has always been a two-edged sword. There's always been a huge benefit that is easy to envision, and there's always been a downside. Pick the example, there has always been a downside. We have shown that we can manage and blunt the downside while sharpening the upside.

That's where you come in. As we pursue technology-led economic development and a nanotechnology future, the burden on you, unfortunately, perhaps, is greater than it was on your predecessors.

There are greater challenges. Countries are entering the competition. You have to compete with them, with regions in other countries, with provinces in other countries, probably competing with the person to your right or your left, all with the eye toward attracting and retaining leading edge companies and investment that can provide jobs for the future.

I don't have to tell this audience that virtually any form of economic development these days would face some form of opposition or resistance because it represents some change for somebody, if nobody else than the local neighborhood group. Whether it's traffic or pollution or whatever, but I think in the current the situation, with the scrutiny we talked about, with fears about the potential of the technology, with ethical concerns, the challenges are greater for you.

That means, for you, that there are the challenges to get out into the public square, address those concerns, be well-informed, build that bedrock of common sense, engage with your local, state, and national political leaders, engage with the media (still the source of information for your fellow citizens), engage directly with the public to answer their questions, ensure a flow of balance and honest information.

This is the challenge before us. In other words, we have to engage because it is the right thing to do, and it's the necessary thing to do. It's the right thing to do because there are legitimate concerns. The powerful technologies that we are talking about—whether it's in cognitive or biotechnology or whatever it may be—powerful technologies that must be kept from the hands of evil people. We have to think about that, especially after 9/11. Powerful IT capabilities at the nanoscale could pierce privacy that we Americans hold dear, so we have to address that. That's an example of a legitimate concern. We could face a world, or a Nation or states of nanotechnology "haves" and "have nots" and end up with a technology dividing us rather than uniting us. So we have to address that. It's the right thing to do. It's also the necessary thing to do.

At the end of the day in the Department of Commerce, that's what we're about. We're about American jobs based on American values, so we have to address that value portion so that we can get to American jobs. And we know that we are going to face resistance. The Industrial Revolution had resistance, the automobile, different forms of energy, people thought that man was not suppose to fly and opposed the Wright brothers, so we know there's going to be resistance. That can inhibit, slow or stop adoption. Think of genetically modified organisms in Europe—the ability to feed more people being blocked by political concerns and fears.

If we lose the race of the speed of adoption, we will lose the benefits race as well, and American jobs will suffer. People in your communities will not have jobs and benefits and realize dreams that they otherwise would realize.

Make no mistake, when we talk about dreams, the dreams around nanotechnology are very promising. We can dream about clean water all around the world, the lack of which accounts for the vast preponderance of the world's illnesses. Medical technology is addressing this right now. Just one example that I'm aware of is Carlo Montemagno out at UCLA. He is working with nanotechnology-enabled protein cell membranes that will allow only pure H_2O molecules to pass through. The filters could be distributed in a coffee-can size to provide clean water in the developing world at a very low cost.

So, we can dream about clean water for the world and less disease. We can dream about cleaning the environment, or the recent breakthrough with nanoscale iron that could reduce toxic chemicals in soil by 96 percent. Think of the Brownfields that can be cleaned up. You can dream about bio-engineered tissues to replace damaged cells. We can think about nanoscale computers, as was mentioned earlier, about the size of a bacterium.

So, the dreams for potential jobs and benefits are real and powerful and luring, but they won't happen if we are impeded by fear. That means engaging, building that foundation of common sense. That's why it's so, so amazing to me to hear calls for a slowdown. I wonder very often if there are really calls for a slowdown so that other governments and countries might catch up. The U.S certainly leads. When you look at patents or publications, we are far ahead. That's a cynical view, perhaps, of the calls for a slowdown.

There are, as I've said, legitimate concerns.

Others call for an all-out-halt on anything having to do with nanotechnology research, and I would submit that when I look at the future and think about American jobs resting on American values, the notion of stopping is an unethical notion. The only ethical notion is to move ahead smartly and responsibly, address the downside, and reap the upside, address the legitimate concerns, build the basis of common sense so that we can reap those benefits. Among those benefits are jobs, the higher value jobs that we dream of for the American people.

Why in the world would we wait any longer than we have to for clean, renewable energy? Why in the world would we wait any longer than we have to for clean water? Why in the world would we wait any longer than we have to for cures to cancer? Why in the world would we wait any longer than we have to for greater security for our homeland? Why in the world would we wait any longer to end hunger in the world and a whole host of issues and frustrations that come with those shortages and that despair – why in the world would we wait for that?

No, I think, instead, it's press on with full engagement not just from scientists, not just from Federal policy officials, but from the local troops, the front line, you. In that regard, my message to you today is that speaking for the Department of Commerce, we are here to be your full-fledged partner, building American jobs based on American values. But critical, critical is that it's based on the energy, smarts and commitment of you on the front line. We're here to be your partner, we're here to realize the future, and we know that together we can make it happen.

Thank you very much and welcome to the Department of Commerce.

Appendix D. Initiatives*

ALBANY NANOTECH

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One of the world's largest centers for nanotechnology research and development, Albany NanoTech is pioneering a new paradigm for technology commercialization and regional development that merges the strengths of industry with those of government and universities. Its state-of-the-art $1 billion complex houses the New York State Center of Excellence in Nanotechnology and Nanoscience, the New York State Center for Advanced Technology in Nanomaterials and Nanoelectronics, and the northeastern headquarters of International SEMATECH, the research arm of the Semiconductor Industry Association. Based at the University at Albany – SUNY, Albany NanoTech is also home to the College of Nanoscale Science and Engineering, the world's first college devoted to the study of nanoscale scientific concepts.

Under the leadership of Governor George Pataki, Speaker Sheldon Silver and Majority Leader Joseph Bruno, Albany NanoTech has served as a linchpin in New York State's strategy to drive high-technology economic development. To date, Albany NanoTech's industrial and consortium research partners—numbering over 100 companies on-site, including IBM, Tokyo Electron, Infineon, AMD and GE—have invested over $1.6 billion towards developing facilities, tools and knowledge at Albany NanoTech. The unique confluence of industrial commitment, state support and academic rigor lays the groundwork for Albany NanoTech to become an internationally recognized center of innovation for nanoscale science and engineering. Albany NanoTech is dedicated to serving as a central force in the state's commitment to growing and protecting New York's high-tech economy and educating its citizens to be competitive in the 21st century.

* This section includes submissions from representatives of nanotechnology-development initiatives who participated in the 2003 Regional, State, and Local Initiatives in Nanotechnology workshop. While not intended to be exclusive, the section is not reflective of all initiatives that exist today. See also www.nanoinitiatives.net.

ARIZONA NANOTECHNOLOGY INVESTMENTS

S. Tom Picraux, Executive Director, Materials Research Program, Arizona State University, Tempe, AZ 85287

In 2000, a voter initiative, Proposition 301, was passed that created a 0.6% sales tax increase for the purpose of enhancing education in Arizona. A portion of this 20-year initiative estimated at $1 billion provides for infrastructure enhancement at the three state universities in support of new economy jobs in Arizona.

At Arizona State University (ASU), this $400 million state investment is focused on biotechnology, nanotechnology, information technology, and manufacturing science. The initiative started in State Fiscal Year 2002 and is currently in its third year. An Arizona Biodesign Institute (AzBio) was created in 2002 for the purpose of integrating new advances in biotechnology with that of nanotechnology and info-technology. The mission of the institute is to advance innovations for improving human health and quality of life through use-inspired, biosystems research and effective, multidisciplinary partnerships. AzBio currently contains eight centers with a significant effort focused on nanoscale biosystems and devices, including the Centers for Applied NanoBioscience, Single Molecule Biophysics, and Bio-Optical Nanotechnologies. Combining the 301 initiative and ASU's commitment, the Arizona Biodesign Institute's total investment over the next five years is estimated to be $200 million ($140 million for two new buildings) and approaching $500 million over 10 years. Approximately $100 million of this is specifically coupled to nanotechnologies. More information on AzBio can be found at http://www.azbio.org/. Additional investments in specific nanotechnology activities include Proposition 301 Materials/Nanotechnologies seed funding and equipment matches at approximately $0.5 million per year for shared user fabrication and characterization facilities at ASU (the Center for Solid State Electronics Research, http://www.fulton.asu.edu/nanofab/, and the Center for Solid State Science, http://www.asu.edu/clas/csss/csss/) and upcoming seed investments in nanoelectronics and in sensing.

ATOMWORKS

Sean Murdock, Executive Director, sean@atomworks.org

Mission

Establish Illinois, and the Midwest more broadly, as a world leader in commercializing nanotechnology-enabled innovations.

History

In July 2002, a group of leaders from industry, academia, and government met under the auspices of AtomWorks and the Illinois Coalition for the first time. This incredibly diverse group was united through one common thread: a belief that the Midwest could and should be a world leader in commercializing nanotechnology-based innovations. The group, recognizing the need for a shared vision across the diverse constituencies, decided to enlist the support of McKinsey & Company to develop a broadly accepted strategic roadmap.

In October 2002, the AtomWorks leadership team met again. At that meeting, the leadership approved the proposed McKinsey action plan, and established a formal governance structure. On October 9, 2002, AtomWorks was formally launched.

In less than one year, AtomWorks has made significant progress in creating the entrepreneurial ecosystem that will be required to secure global leadership. It has

- Developed a strategic roadmap with the assistance of McKinsey & Company
- Developed and expanded the Board of Directors to provide critical leadership for nanotechnology in the Midwest
- Established AtomWorks as the voice of the Midwest nanotechnology business community
- Built awareness locally, nationally, and internationally of the nanotechnology activity in the region through the AtomWorks Alert and direct marketing at large-scale nanotechnology events
- Inventoried key nanotechnology resources throughout much of the Midwest that will soon be made available online
- Partnered with the Chicago Microtechnology and Nanotechology Community (CMNC) to build community amongst the scientific and technical community in the Chicago area through a series of events and symposia.
- Supported proactive nanotechnology outreach events at the University of Illinois Urbana-Champaign, University of Wisconsin Madison, and Purdue University
- Catalyzed the formation of a student-led initiative to support nanotechnology development at Northwestern University and began the process of identifying leaders at other Midwestern universities to expand and improve upon the model
- Supported the efforts of local institutions to expand the physical, intellectual, and cultural infrastructures necessary to continue leading nanotechnology research and innovation on several large-scale grants, including the NNIN
- Established relationships with leaders of other similar efforts to enable coordination and collaboration and avoid destructive competition

Approach

AtomWorks focuses on four key activity platforms:

- **Education/awareness:** to educate the public, the business community, and the scientific community on the benefits of nanotechnology commercialization and the region's leadership in doing so
- **Advocacy:** to serve as the voice of the Midwestern nanotechnology community to ensure a supportive environment for its development
- **Resource aggregation and integration:** to assist research institutions, nanotechnology companies, and prospective entrepreneurs in identifying and obtaining financial or other business building resources, including access to infrastructure
- **Community building:** to provide forums for interaction and networking and to build trust across the constituencies

AtomWorks Leadership

Chair: Iwona Turlik	Corporate Vice President of Advanced Research, Motorola
Ilesamni Adesida	Director, Center for Nanoscale Science and Technology, University of Illinois Urbana-Champaign
Chris Anzalone	Chief Executive Officer, NanoInk, Inc.
Joseph Cross	Chief Executive Officer, Nanophase Corporation
Alan Feinerman	Director, Microfabrication Applications Laboratory, University of Illinois Chicago
Murray Gibson	Director, Advanced Photon Source, Argonne National Laboratory
Lewis Gruber	Chief Executive Officer, Arryx, Inc.
Hermann Grunder	Director, Argonne National Laboratory
Chip Hardt	Partner, McKinsey & Company
Don Jacobs	Dean Emeritus, Kellogg Graduate School of Management, Northwestern University
David Jacobson	Partner, Sonnenschein, Nath, and Rosenthal
Heinrich Jaeger	Director, Materials Research Science and Engineering Center, University of Chicago
Steve Johns	Executive Vice President, Ardesta
Tarsem Jutla	Director of Innovation, Caterpillar Inc.
Clyde Kimball	Director, Laboratory for Nanoscience, Engineering and Technology, Northern Illinois University
Jay Kouba	Vice President of Chemicals Technology, BP
Jack Lavin	Director, Illinois Department of Commerce and Economic Opportunity
Derrick Mancini	Associate Director, Center for Nanostructured Materials, Argonne National Laboratory
Manuel Marquez	Director, Nanotek Consortium, Kraft
Matthew McCall	Partner, Portage Draper Fisher Jurvetson
Stephen Mitchell	President, Knight Group LLC
Sean Murdock	Co-Founder and Executive Director, AtomWorks

Paul O'Connor	Executive Director, World Business Chicago
Mark Ratner	Co-Director, Institute for Nanotechnology, Northwestern University
Norbert Riedel	Chief Scientific Officer, Baxter
Dennis Roberson	Vice Chancellor, IIT and former CTO Motorola
Carlo Segre	Vice President of Research, Illinois Institute of Technology
David Swain	Chief Technology Officer and Office of the Chairman, Boeing
Tom Thornton	Executive Vice President, Illinois Coalition
Vijay Vasista	Chief Operating Officer, Nanosphere
Pierre Wiltzius	Director, Beckmann Institute, University of Illinois Urbana-Champaign
Max Yen	Director, Materials Technology Center, Southern Illinois University

Future Direction

Going forward, AtomWorks will broaden its reach throughout the Midwest by supporting the efforts of universities, localities, and states to establish cohesive nanotechnology commercialization efforts. AtomWorks will function as a network integrator, tying the efforts together and enabling each initiative to leverage the capabilities of the entire region.

Links

AtomWorks: http://www.atomworks.org
Chicago Microtechnology and Nanotechology Community (CMNC): http://www.chicagonano.org
University of Chicago: http://mrsec.uchicago.edu
University of Illinois Urbana-Champaign: http://cnst.uiuc.edu
University of Illinois at Chicago: http://www.mal.ece.uic.edu/
Northwestern University: http://www.nanotechnology.northwestern.edu/
Argonne National Laboratories: http://nano.anl.gov
Northern Illinois University: http://www.physics.niu.edu/lnset/
Purdue University: http://ncn.purdue.edu/
University of Wisconsin (Madison): http://www.xraylith.wisc.edu/homepage.html
University of Notre Dame: http://www.nd.edu/~ndnano/

CENTER FOR ACCELERATING APPLICATIONS AT THE NANOSCALE (SOUTH DAKOTA)

Dr. Jon J. Kellar, South Dakota School of Mines and Technology, Rapid City, SD 57701-3995, 605-394-2343, Jon.Kellar@sdsmt.edu

Goal of the Initiative

The goal of the local/regional initiative is formation of a Center for Accelerating Applications at the Nanoscale (CAAN).

History and Organization of the Activity

The idea for CAAN is the result of a six-state (ND, MT, ID, NE, WY, and SD) regional conference on Nano-Science and Engineering held August 2003, in Rapid City, South Dakota. The purpose of the workshop was to summarize current nanotechnology research areas in the region and to identify potential for new collaborative research areas and development of core research groups in theme areas related to the National Nanotechnology Initiative.

CAAN recently was funded by the state of South Dakota for $2.5 million over five years. The basic idea of the Center is to utilize developments from SD's nanotechnology research and accelerated technology transfer and commercialization. Initially CAAN will focus upon two technical areas: 1) nanoparticles/nanofibers (particular emphasis on nano-scale minerals) and 2) nanosensors.

Members/Participants in the Activity

CAAN is the SD component to a larger regional effort that includes the states of WY, NE, and ND, called the Northcentral States Nanosystems Consortium.

Current Status of This Activity

As mentioned above, CAAN development is in the formative stages, but is rapidly gathering momentum.

Link

Rushmore Regional Workshop on Nano-Science and Engineering:

http://www.sdsmt.edu/nano_conf, http://nsnc.sdsmt.edu

COLORADO NANOTECHNOLOGY INITIATIVE (CNTI)

Louis Hornyak, Ph.D., Colorado Nanotech, Inc., 12600 West Colfax Avenue, Suite C-440, Lakewood CO 80215, 720-530-3419, lhornyak@du.edu, lhornyak@coloradonano.org

The Colorado Nanotechnology Initiative (CNTI) was launched by a small team of local academics and businesspeople in April 2003. This grass-roots organization is now the generally accepted advocate for nanotechnology in the State of Colorado. Its mission is to develop Colorado's nanotechnology infrastructure by facilitating information flows between academia, business, venture capital and government, leading to profitable partnerships. Tactically, CNTI identified six focus areas:

- **Asset Management:** *Small Times* magazine [1] ranks Colorado 12th in raw nanotechnology assets. Our asset management focus team is considering how CNTI can support integration of these assets into cross-organizational projects. One topic under consideration is the formation of the Colorado Nanotechnology Infrastructure Network.
- **Education and Curriculum Development:** Colorado boasts the Nation's best-educated workforce; will its children follow in these footsteps? CNTI wants to help excite a love of science learning in Colorado's children, ensuring that they hold onto that top spot. From the "Gold Collar" worker to the post-doctoral specialist, Colorado needs to develop all of its assets to take a leading nanoscience role.
- **Technology Transfer:** Most nanotechnology intellectual property will originate in the universities. Colorado businesspeople and political leaders have identified technology transfer as one of the greater challenges. CNTI is rapidly moving up the competency curve should it be called upon to contribute to the discussion.
- **Nano-ethics and Societal Impacts:** Nanoscience is a disruptive innovation and we must be prepared to answer the resultant fears and concerns. Our first report on this topic recently went to our advisors; the next draft is in the works.
- **Colorado Nano-Technology Research Institute (CNTRI):** CNTI will support Colorado universities in achieving this shared goal.
- **Business Development:** CNTI will help Colorado businesses adopt nanotechnology and help nanotechnology companies nationwide expand their Colorado presence.

Link

The Colorado Nanotech Initiative: www.coloradonano.org

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1. http://www.smalltimes.com/document_display.cfm?document_id=5641

MASSACHUSETTS NANOTECHNOLOGY INITIATIVE

Tom Hubbard, Massachusetts Technology Collaborative, 508-870-0312, hubbard@masstech.org
Matt Laudon, Nano Science & Technology Institute, 508-357-2925, mlaudon@nsti.org

What It Is

Currently, the Massachusetts Nanotechnology Initiative is an informal network of key figures in nanoscale research and business development in Massachusetts. Participants include researchers from the state's research universities, public and private, as well as the venture capital community, early-stage nanotechnology firms, established information technology and biotechnology firms, and law firms that serve the state's technology community. The initiative is organized by the Massachusetts Technology Collaborative, a quasi-public economic development agency, in collaboration with the Nano Science & Technology Institute and other key organizations. The Initiative is guided by a steering committee of about 30 individuals from nanotechnology-related fields. Over time, the Massachusetts Technology Collaborative will organize the group into a sustainable organization.

Goals

The Initiative does not control grant or investment funds and does not act as a direct funding agent. Instead, the Massachusetts Nanotechnology Initiative serves to bring together existing programs and leaders in nanotechnology-related fields to promote action that will meet the following broad goals:

- intensify and broaden contact between Massachusetts-based industry and nanotechnology researchers in the state's research institutions so as to catalyze new collaborations, sponsored research, and the exchange of know-how
- facilitate greater contact between emerging nanotechnology entrepreneurs and the state's technology investors; the Boston-based venture capital industry is the second largest in the United States
- educate the public and policymakers on nanotechnology-related issues, and influence the state's emerging strategy on technology-based economic development so as to provide new means of support for nanoscale research
- promote Massachusetts as a global center of nanoscale research and business development

Members and Participants

Currently, the Massachusetts Nanotechnology Initiative is not a membership organization, although it may be reorganized as one in the future. Its activities are open to all interested parties. Regular participants include researchers, graduate students, entrepreneurs, and future entrepreneurs from the Massachusetts Institute of Technology (MIT), Harvard, Boston University, Boston College, Northeastern University, the University of Massachusetts, Tufts, Worcester Polytechnic Institute, Nantero Inc. and other early-stage nanotechnology companies, venture capital firms, law firms, and other service providers.

Current Status and Major Activities

Since its formation in late 2002, the Massachusetts Nanotechnology Initiative has sponsored or co-sponsored research open houses at Northeastern University, MIT, and Worcester Polytechnic Institute, with similar meetings planned for the University of Massachusetts.

The Initiative will host the first Massachusetts Nanotechnology Venture Forum and Conference at MIT on November 7, 2003, with keynote remarks from Dr. Mihail Roco of the National Science Foundation.

The Initiative also will serve as a sponsor of Nanotech 2004, the country's largest nanotechnology technical exposition, which is produced by the Nano Science & Technology Institute and will be held in Boston in March 2004. A major study on nanotechnology in Massachusetts, conducted by the Nano Science & Technology Institute and the Massachusetts Technology Collaborative, will be released at Nanotech 2004.

Links

Massachusetts Nanotechnology Initiative: www.masstech.org/nano

Massachusetts Nanotechnology Venture Forum and Conference:
www.masstech.org/nano/ventureforum/

Nanotech 2004: www.nanotech2004.com

Nano Science & Technology Institute: www.nsti.org

Massachusetts Technology Collaborative: www.masstech.org

MICHIGAN SMALL TECH ASSOCIATION (MISTA)

John Bedz, Director, Michigan Small Tech Association, 734-528-6258, johnbedz@michigansmalltech.com
Gary Krause, Special Projects Director, Michigan Economic Development Corporation, 517-335-0838, krauseg@michigan.org

Mission

The Michigan Small Tech Association (MISTA) is an initiative of the Michigan Economic Development Corporation, managed by Small Times Media. MISTA was established to serve Michigan small tech concerns by providing a cohesive, industry-focused network for Michigan based micro- and nanotechnology companies and those looking to expand here. The association includes companies and professionals working in the micro- and nanotechnology fields, business service providers to these concerns, and academic institutions involved in the research, development and commercialization of these technologies.

Its goal is to promote acceleration of the sector through research, commercialization, and the fostering of business relationships between academics, developers, and integrators of small tech. Small tech innovation in Michigan also benefits the state's emerging life sciences industry as well as the traditional manufacturing base. As a project of the state's economic development program, MISTA coordinates with other state initiatives to promote/support all technological advancement programs.

Work

MISTA operates as a trade association formed to identify opportunities and benefits for members, such as

- publishing michigansmalltech.com, a Web-based news resource and member Web site that provides news and information for and about members
- administering a member Web site featuring: funding (both public and private), human resource information, and business opportunities available for members
- publishing an electronic newsletter and print journal highlighting member accomplishments and other news and information helpful to contacts
- organizing and participating in technology-centric events at both a state and national level; providing an identity and a voice to help form policies and programs at the state, regional and national level that will spur commercialization of small technologies

Members and Participants

MISTA members are from business, academia and government. Corporate members range from multinational corporations employing hundreds of thousands to start-ups with just one employee. Public universities in Michigan with small tech programs are linked to the MISTA Web site and each has the ability to post news and licensing opportunities available. Tech transfer listings and highlights are also featured.

State government is squarely behind MISTA and recognizes the important role small tech plays as Michigan continues in its role as the center of global automotive intelligence.

Links

Michigan Small Tech Association: www.michigansmalltech.com
Affiliation with MISTA: www.michigansmalltech.com/Association/
Michigan Economic Development Corporation: www.michigan.org

NANOSIG

Bo Varga, Executive Director, bvarga@nanoSIG.org

NanoSIG, founded in April 2001, is a nonprofit nanotechnology business and education initiative with a primary focus on Silicon Valley and Northern California. Since its founding, it has organized and staged 60-plus conferences, forums, meetings, and symposia on nanotechnology business and education in Silicon Valley, Washington, D.C., San Diego, and Tokyo.

Our business mission is to promote nanotechnology jobs by helping build business networks between corporations, entrepreneurs, inventors, investors, and service providers. In addition, our members provide a range of business services from consulting to funding to recruiting.

Current Business Projects

- International outreach to Canada, China, Finland, Israel, Switzerland, and Japan to build nanotechnology business and job creation in Silicon Valley, including staging quarterly international nanotechnology forums and arranging Silicon Valley road shows for international visitors from academic, corporate, investor, and government domains
- Bimonthly conferences, forums, meetings, and symposia in Silicon Valley that are focused on nanobiotechnology, nanoelectronics and photonics, nanotechnology investing and commercialization, nanomaterials and manufacturing, and software and tools
- Partnering with business incubators such as The Enterprise Network in Silicon Valley to support nanotechnology entrepreneurs
- Partnering with funding networks such as Silicom Ventures to support nanotechnology entrepreneurs
- Participating in policy forums at the state, regional, and Silicon Valley level

Our education mission is to promote nanotechnology jobs in Northern California by helping develop the educated and skilled workforce that attracts and promotes the formation of nanotechnology ventures. NanoSIG provides a forum for the constituencies involved in the design, development, and implementation of curriculum, education, and training programs at the K–12, college, university, post-graduate, and continuing learning level. It helps organize information exchanges and networking activities among school districts, private schools, community colleges, colleges, universities, commercial training ventures, and the government and nonprofit organizations dedicated to the prosperity of Northern California.

Current Education Projects

- With SRI International, working to map nanotechnology concepts and learning to educational standards at the grades 8–12 level
- With San Jose State University, Foothill De Anza College, Carnegie Mellon University West, NASA-Ames Center for Nanotechnology, and SRI International, developing and staging a three-day nanotechnology Education, Training, & Jobs Conference and Career Fair in May 2005
- With local educational groups staging quarterly forums focused on nanotechnology programs for K–12, college, university, post-graduate, and continuing learning
- Participating in policy forums at the state, regional, and Silicon Valley level
- Publishing the bimonthly Silicon Valley Nanotechnology Report

THE NANOTECHNOLOGY GROUP, INC.

Judith Light Feather, President, 1247 Lone Oak Rd., New Braunfels, TX 78132, Advisor for Florida and Minnesota, Nanotechnology Initiative Planning, 830-227-5520

Goals

The goals of The NanoTechnology Group, Inc. in attending this workshop are to gather information in order to continue assistance for our Florida and Minnesota members to prepare and initiate state initiatives for nanotechnology. Both states are in the formative stages of planning, therefore, the information provided by the workshop leaders and participants should provide clarity in the many stages of organization, development, and launching of these new initiatives.

History

Minnesota

Over the past three years, our organization developed the planning sessions in Minnesota at the request of Jack Uldrich, who was the Long Range Technology Development Director at the state level. The original meetings were to support and inform his office, and led to the working group phase, directed by the Minnesota /Molecular Study Group led by Steven C. Vetter. After two years of work, including weekly editorial sessions for Uldrich's book contract, the state eliminated his position in a budget crunch. The MMEI group still meets monthly to address issues concerning the future of nanotechnology and seeks to find avenues for nurturing and promoting a statewide initiative. Dakota County Technical College is submitting grants with our Executive Director, Deb M. Newberry, as the principal investigator, while also working with the University of Minnesota until such time that the state budgets can support this initiative.

Florida

As a research advisor to Embry Riddle Aeronautical University (ERAU) since November 2000, our group has continuously worked towards developing NSF grants to expand the excellent aerospace engineering curriculum to include nanotechnology for space applications. We are currently working with Enterprise Florida Inc., the state economic development division with a goal of providing accurate information to formulate a packet for the Governor's approval in developing a state initiative.

The advisory efforts of TNTG will bring together other State of Florida universities as leaders of excellence in nanoscience education and research, along with the ERAU extended campus division and the School of Professional Development, which reaches the leaders in the aerospace industry, NASA space engineers and program managers, and the military to address the future workforce training for nanotechnology in space applications.

In discussing this workshop with Nathan Swami, a couple of issues to address in the agenda-planning session surfaced. He will be covering them in his presentation, but I will list them here for the other attendees:

- State initiatives need to support K–12 education modules for introduction of nanoscale science. NSF cannot support the entire funding for this important development of curriculum. Therefore, state and regional initiatives need to plan their agendas to secure state and regional funding for this very important level of education.
- Workforce and professional introductions to nanoscale science and technology as informal learning is a second area that needs to be addressed at state and regional levels. Many technical engineers in the microtechnology level of industry already have been displaced and down-sized, but have not had

any introduction to nanotechnology and are stranded in a "no work" zone. TNTG has a strong membership with interest at the two-year technical and community college levels.

Members/Participants in Support of Initiatives

Minnesota

The Minnesota Study Group, MMEI Inc., Dakota County Technical College, Center for the Development of Technological Leadership, University of Minnesota, The NanoTechnology Group Inc.

Florida

Enterprise Florida Inc., University of Central Florida, Florida State University, Embry Riddle Aeronautical University, School of Corporate Training and Extended Campus Division, ERAU–Volusia County Tech Park Development Group, The NanoTechnology Group Inc., United Space Alliance, Lockheed Martin, Boeing, Lobbyist Jerry H. Sansom, JHS Government Liaison, Volusia County Independent School District, Florida Head Start Program, and city government officials for Daytona Beach, Florida.

Link

The NanoTechnology Group Inc.: www.TNTG.org

THE NANOTECHNOLOGY INSTITUTE

RoseAnn Rosenthal, CEO of BFTP/SEP and a member of the NTI Oversight Committee, roseann@sep.benfranklin.org.

Goals

The goals of the Nanotechnology Institute (NTI) are to

- stake the Greater Philadelphia Region's claim as one of the leading international locations for nanotechnology
- build upon the nanotechnology initiative to create a multi-state, regional economic development strategy
- through nanotechnology, stimulate new growth and economic wealth for the entire community

The Nanotechnology Institute arose from the confluence of three factors:

- the Federal Government's National Nanotechnology Initiative, which identified nanotechnology as a principal enabling technology of the early 21st century, and which provides substantial Federal funding to stimulate nanotechnology activity
- the creation of a Commonwealth of Pennsylvania Authority to encourage major university-based research and development initiatives with integral commercialization components
- regional interest and capability in the field as evidenced by the participation of more than 100 company and university representatives in the region's first NanoForum®, organized by the Ben Franklin Technology Partners of Southeastern Pennsylvania (BFTP/SEP), at which National Nanotechnology Initiative staff presented the promise and opportunities of nanotechnology

Given these factors, in early spring of 2000, BFTP/SEP and regional university and company representatives met with Dr. Joseph Bordogna, Deputy Director & Chief Operating Officer of the National Science Foundation, and representatives from the Commonwealth of Pennsylvania's Department of Community & Economic Development for a working meeting to explore the role of nanotechnology as an engine for growth in the southeast region. At this meeting, the value of a collaborative regional nanotechnology initiative was uniformly endorsed. The founding partners, Drexel University, The University of Pennsylvania, and BFTP/SEP, developed and submitted to the Commonwealth a $10.5 million proposal to support formation of the Nanotechnology Institute (NTI), focused on bio/pharma applications of nanotechnology. Funding was approved in September 2000.

From its inception, the NTI set out to forge a unique pathway to growing the regional economy. Its mission states:

> In contrast to typical academic research centers, the NTI will focus on the transfer of discoveries and intellectual knowledge from universities to industrial partners and the promotion of rapid application and commercialization.

The NTI Model

The NTI model is designed to be a focal point for nanotechnology-related efforts, building on the collective strengths of corporate interests, life and materials science assets, research institutions, and economic development organizations. The NTI's innovative model incorporates a "wrap-around" approach represented by the alignment of six key components:

Research & Development

The NTI's R&D Team includes nine universities and medical schools, 41 faculty members, and more than 100 post-doctorates and advanced students. Four multi-university, interdisciplinary research teams are focused on the following topics, chosen after extensive discussion with companies: intelligent drug delivery systems, nano-biosensor development, nanotubular cellular probes, and nanofiber-based tissue engineering.

Entrepreneurial Development & Commercialization

Seeks to drive commercialization through a single point of contact system that provides financing and robust business development services and resources.

Risk Capital

Aims to provide seed capital now, as well as stimulating the creation of longer-term financial resources to fuel the growth of the region's nanotechnology activities.

Community of Interest Networks

Coalesces the region's emerging nanotechnology community by facilitating dialogue and interaction among Federal agencies, university faculty, corporations, entrepreneurs, and economic partners, and reaching out to identify potential national and international partners.

Education & Workforce Development

Builds partnerships throughout the Mid-Atlantic region among academia, nonprofits and companies in order to provide the infrastructure, curriculum development and implementation, high school outreach, and faculty training for associate degree programs in nano-biotechnology.

Economic Research & Policy Development

Gathers information, assesses the region's position and opportunities, and recommends action steps in order to guide the NTI's growth, policies and programs. Significant progress has been made in each of these components. For example, NTI has developed infrastructure to reduce barriers to commercialization. This includes the NTI as the "Single Point of Contact" for companies, and uniform confidentiality, intellectual property, and sponsored-research agreements among the nine university partners. In addition, stimulated by the NTI, nanotechnology is one of the growth areas identified in a regional roadmap process.

Link

The Nanotechnology Institute: www.nanotechinstitute.org

NANOTECHNOLOGY IN OKLAHOMA

Warren T. Ford, Oklahoma State University, wtford@okstate.edu

The State of Oklahoma has related academic and business goals for nanotechnology. First, the universities aim to establish themselves as leaders in niche areas of nanoscale materials where there is already research strength. Second, the State government and business leaders aim to promote economic development through nanotechnology. They see nanotechnology as a promising business area, and recognize that some developments will come from present and former university research personnel.

Coordination of nanotechnology research programs in Oklahoma began in January 2000 a few days before President Clinton's announcement of the National Nanotechnology Initiative. A group of faculty organized the Oklahoma Network for Nanostructured Materials (NanoNet) in response to a call for research proposals to include in the state proposal to the National Science Foundation Experimental Program to Stimulate Competitive Research (EPSCoR) Research Infrastructure Initiative program. The NanoNet proposed research on single-wall carbon nanotubes, molecular beam epitaxy routes to semiconductor quantum dots, solution-grown colloidal particles, and assembly of these building blocks into devices. The EPSCoR proposal was funded starting February 1, 2002, for three years with $3 million Federal and $1.5 million state funds annually.

Thirty-five per cent of the NanoNet budget is allocated mainly for equipment in user facilities (TEM, AFM), staff positions in user facilities, interdisciplinary postdoctoral positions, graduate student recruiting and support, seed grants for new faculty, and curriculum development. See http://okepscor.org/ for details of participants and programs. The NanoNet maintains an email list for information exchange among 50 faculty in 12 academic departments at three universities and 30 people in the private sector. An annual state conference has grown to 130 NanoNet participants over three years. The best outcomes of the NanoNet were stimulated by money, but are not what money can buy. Due to a new spirit of cooperation, interdisciplinary research projects are thriving. Participants in the NanoNet are seeking major research center funding from non-EPSCoR programs. There is improved cooperation between researchers at universities and at the five small and two large companies in Oklahoma with interests in nanotechnology.

In May 2003 the Oklahoma Legislature passed a resolution creating the Oklahoma Nanotechnology Initiative (ONI) to further business in nanotechnology via cooperation among companies, financiers, academe and government. Organization of the ONI, following the Texas ONI model, is in progress. In August 2003 the new Governor convened a program called EDGE (economic development generating excellence) to advise state government and universities. The EDGE program is short lived and focused. Twenty-three panels, of which one is on Advanced Materials/Nanotechnology, will make two or three specific recommendations each to a central steering committee by the first of October. The steering committee will discuss the recommendations, hold public hearings, and by December present a plan to the Governor and the Legislature to consider during the 2004 legislative session. The nanotechnology panel recommendations are to establish focused university/business research centers, to overcome the barriers to intellectual property agreements between universities and business, and to provide more state assistance for research and development and capital investment in nanotechnology businesses. The major issues in nanotechnology facing the state are what will be done with the EDGE recommendations, will the ONI develop into a strong force behind business development, and will the NanoNet progress continue when the EPSCoR grant is over.

THE NEW JERSEY NANOTECHNOLOGY CONSORTIUM (NJNC)

David Bishop, President, New Jersey Nanotechnology Consortium, 600 Mountain Ave., Room 1A-264, Murray Hill, NJ 07974, 908-582-3927, djb@lucent.com

NJNC is run by Bell Labs, the research and development division of Lucent Technologies. The NJNC, a wholly owned subsidiary of Lucent, is part of the Bell Labs facilities in Murray Hill, New Jersey, and provides rapid and cost-effective access to world-class nanotechnology research and development services, including licensing of relevant intellectual property. The NJNC can collectively facilitate the entire R&D cycle, enabling breakthrough nanotechnology-driven innovations from concept to commercialization.

The NJNC was formed with the support of the State of New Jersey and several of the New Jersey research universities. The nucleus of the NJNC is the world-renowned Bell Labs nanofabrication laboratory in Murray Hill, New Jersey, where the NJNC is supported by the entire community of Bell Labs scientists and researchers. The addition of Bell Labs' own technical capabilities, in collaboration with regional academic research institutions and universities, is powering the NJNC's mission: the application of basic and applied nanotechnology research with an emphasis on commercialization.

With a highly experienced research and development team, the NJNC offers design, prototyping, and fabrication capabilities to industry, academic, and government customers, including companies in the pharmaceutical, biotechnology, materials, optical/photonics, defense/aerospace and semiconductor markets. The distinguishing foundation of the NJNC is its collective expertise and track record in fabricating and developing manufacturing processes for nanotechnology devices. The consortium also supports development of the nanotechnology industry by educating the next generation of scientists, spearheading joint research projects, and driving nanotechnology roadmap programs.

Facilities and Resources

The New Jersey Nanotechnology Laboratory is currently the only fully operational 200mm wafer fab dedicated to nanotechnology development in the United States. It offers

- fully operational, end-to-end manufacturing facility with a 25-year history and state-of-the-art equipment
- world-class research team that has made seminal contributions to the field of electronics, optoelectronics, and micro-systems
- 16,400 square feet of class 100/10 clean room, including a 3,600 square feet class 100 electron-beam facility
- home to one of the world's only nano-lithographic e-beam tools, which are essential in the production of nanotechnology devices
- proven concept-to-commercialization capability

Capabilities: End-to-End Device Fabrication

- MEMS (Micro Electro-Mechanical Systems)—nanopositioning systems, actuators, sensors, accelerometers
- Optical devices (active and passive)—micro mirrors, lens arrays, optical scanners, wavelength selectable switch fabrics
- Nanofluidics, molecular probes, DNA fractionation

Device Prototyping

- Design, simulation, and optimization
- Process development and integration
- Industry collaboration
- Technology transfer

Special Services

- Electronic and photonic materials development
- Optical devices (active and passive)—waveguides, gratings, optical interconnects
- 193nm lithography and etch services
- E-beam lithography and etch services
- Multi-user MEMS process
- MEMS reliability physics
- MOS process modules
- Packaging

NORTH DAKOTA STATE UNIVERSITY CENTER FOR NANOSCALE SCIENCE & ENGINEERING

Dr. Philip Boudjouk, Vice President, Research, Creative Activities, & Technology Transfer, 701-231-6542

North Dakota State University's Center for Nanoscale Science and Engineering (CNSE) was launched in 2001 with the mission of engaging in pioneering, interdisciplinary research, and technology development on materials whose functional design starts at the atomic-molecular scale. CNSE's focus is on practical materials, processes and devices that are the basis of 21st century technology. CNSE operates through research and development contracts and grants from government and the private sector. Primary funding for the initiative has been through the U.S. Department of Defense.

CNSE is currently involved with various programs in the areas of microsensors, wireless electronics miniaturization, marine coatings for Navy ships, anti-corrosion coatings for military aircraft, robot-automated tools for nanomaterials discovery and optimization, and electronic and magnetic nanomaterials. A partnership and technology transfer arrangement is in place with Alien Technology™ Corporation from Morgan Hill, California, and discussions are underway with several other companies on similar collaborations in CNSE programs.

In addition to a growing full-time staff of 25, CNSE engages over 60 faculty members and students from NDSU's colleges in its research, mainly in the materials sciences and electrical and mechanical engineering. CNSE continues to hire scientists, engineers, technicians, and administrative specialists who have additional skill sets needed for its research programs.

In 1999, North Dakota State University, through permission from the State Board of Higher Education, established the NDSU Research & Technology Park. As part of its development, the NDSU Research and Technology Park is building a 77,000 square foot facility, much of which will be dedicated to nanoscale science and engineering research. The facility will contain clean rooms, electronics fabrication tools, state-of-the-art synthesis and characterization equipment, and space for more than 125 researchers and support staff. The scheduled completion date for the building is February 2004.

Links

NDSU Center for Nanoscale Science & Engineering: http://www.ndsu.nodak.edu/cnse/
NDSU Research & Technology Park: http://www.ndsuresearchpark.com/

NORTHWEST NANOSCIENCE & NANOTECHNOLOGY NETWORK (N4)

Don Baer, PNL don.baer@pnl.gov

Pacific Northwest National Laboratory (PNNL) is establishing an informal, multi-institutional network of researchers, educators, organizations and industries in the Pacific Northwest (Washington, Oregon, Idaho, Montana, and Alaska) with interest in nanoscience and nanotechnology (NS and NT). Called the Northwest Nanoscience & Nanotechnology Network (N4), it will foster communication and coordination among NS and NT researchers in the five-state region. N4 will interact closely with the Washington Nano Initiative and initiatives from other states in the region to provide an effective, convenient method for participants to identify and communicate with individuals and organizations involved in NS and NT, as well as providing an avenue for external audiences outside of the Northwest to learn about activities within the region.

PNNL will establish an initial website for N4 accessible to groups, organizations and people with an interest in NS and NT in the Pacific Northwest. This site will serve as a portal to Northwest NS and NT activities, and will feature a calendar, links to institutional websites, listings of regional NS and NT interests, activities and people, job postings, and a community bulletin board. An annual meeting will be organized to further enhance nanoscience and nanotechnology communication and interactions. The meeting will be coordinated with other regional symposia and events to draw in researchers, entrepreneurs, business leaders, investors and government representatives from the Pacific Northwest.

Prepare the Workforce

A Washington focus on research and commercialization of micro- and nanotechnology will require a new workforce, led by highly trained scientists, engineers and technical business professionals, but supported by an even larger group of skilled workers at the technician and operator level. Success will depend to a large extent on the ability to attract new workers at this level to technical fields, and to train them in job-specific skills relevant to the micro- and nanosciences. Participation by educators at the K–12, community and technical colleges, regional universities, and the state's two research universities will help to draw students into the micro- and nanotechnology fields, design curriculum in response to the anticipated research, development and manufacturing needs, and provide the needed facilities and instructional staff to offer a capable, competent pool of employees for the future.

Background

The Washington Technology Center (WTC) is a state science and technology organization committed to accelerating the innovation-based economy. Its Microfabrication Laboratory, a user-supported clean-room facility located on the UW campus, serves over 180 academic and industry clients whose interests range from pure research to prototype manufacturing in MEMS and nanotechnology. The State of Washington's MEMS, micro- and nanotechnology research expertise at the University of Washington (UW), Washington State University (WSU), and Pacific Northwest National Laboratory (PNNL) is nationally recognized. At the UW, the Center for Nanotechnology, established in 1997, has led to the Nation's first Ph.D. program in Nanotechnology. The UW's nanotechnology research is particularly strong in bioengineering and biomedical applications. The Joint Institute of Nanoscience, established in 2001 between the UW and PNNL, has brought together academic and national laboratory personnel to focus on common areas of research interest. The Joint Institute draws on the resources of PNNL's Environmental Molecular Sciences Laboratory for world-class analysis and characterization. At WSU, active nanotechnology research is underway in chemistry, physics and materials science areas, focused on bridging the gap between nano-lithography and molecular engineering approaches.

Contacts

WTC	Keith E. Ritala	(206) 616-1381	ritala@u.washington.edu www.watechcenter.org
PNNL	Donald R. Baer	(509) 376-1609	don.baer@pnl.gov https://secure2.pnl.gov/nano/n4.nsf
WNA	Len Pritchard	(206) 336-5575	lpritchard@chanenco.com

Link

Northwest Nanoscience and Nanotechnology Network: http://www.pnl.gov/nwnano/

SOUTH CAROLINA NANOTECHNOLOGY INITIATIVE

Jonathan S. Fletcher, Ph.D., 803-777-6804, fletchj@gwm.sc.edu

At this point there is no official South Carolina NanoTechnology Initiative. What will be described here is the present state of the University of South Carolina NanoCenter. Because it is the only entity that is funded by the state to pursue nanotechnology, we have been playing a dual role of university center and state initiative.

Goals

As a center, we have the following goals:

- create a nationally recognized focal point in South Carolina for research in nanoscale science and technology; generate new opportunities for NanoCenter participants to compete for external funding from Federal and industrial sources
- foster trans-disciplinary collaboration among a critical mass of researchers spanning the sciences, engineering, and medicine
- provide learning opportunities, through courses and research experiences, for undergraduate and graduate students—the high technology workforce of the future
- promote educational and technical outreach to collaborate with sister institutions (Clemson, Medical University of South Carolina, Historically Black Colleges and Universities), regional campuses, and K-12 schools.
- advance discussion of environmental, societal, ethical, and philosophical issues raised by nanoscience and nanotechnology

As a statewide initiative, we have the following goals:

- work with industries both within and outside the state to develop new nanotechnologies that will help them become more competitive in the marketplace
- help foster a level of nanotechnology expertise within the state that will be a fertile environment for the attraction of new nanotechnology companies into the state
- work closely with state, regional, and local development agencies to support their efforts to attract companies that have a vested interest in the advances of nanotechnology
- educate companies and government agencies of the potential of nanotechnology to influence industry profitability and the state economy
- work with existing university technology transfer and incubator programs to foster a supportive environment for the development of new nanotechnology companies in the state

History

The USC NanoCenter was established in June of 2001 with the appointment of Richard D. Adams as Director. For the last four years, the State of South Carolina has funded the NanoCenter at the level of $1 million per year. Management of the NanoCenter falls under the Vice President for Research, who answers to the President of the University. In September of 2002, an Industrial Relations Coordinator was hired to develop a multifaceted interface with government and industry. Approximately 15,000 square feet of newly renovated space was just completed in mid-August of this year that houses laboratory space, as well as an Office of Industrial Relations. Seminar and conference rooms are an integral part of the NanoCenter strategy for enabling communication among members and between research groups and industry.

Membership/Participants in the Activity

Center membership currently includes 43 faculty in nine disciplines throughout the University. Collaborations are being developed very rapidly with Clemson University and the Medical University of South Carolina, the two other major research institutions in the state. Activities include a very active nanoScience and Technology Studies group that is addressing the societal and ethical implications of nanotechnology. An active speakers program takes the message of nanotechnology into the schools and business community.

While no mechanism exists at this time for membership of governmental agencies or industrial companies, an Affiliates Program is being launched in the very near future that will allow for a wide participation in the activities of the NanoCenter.

Future

- Opportunities to expand the relationships with industrial development boards throughout the state are considerable. We have just scratched the surface.
- The Affiliates Program is an exciting opportunity that we are anxious to activate.
- The development of more sophisticated mechanisms for collaborating with industry in the area of research and intellectual property should help further our ability to interact meaningfully with industry.
- Our relationships with the various technology transfer offices and incubators should grow in time.
- Challenges continue to revolve around developing an effective interface between academe and industry that takes the needs and goals of each effectively into consideration.

Link

USC NanoCenter: http://www.nano.sc.edu

TEXAS NANOTECHNOLOGY INITIATIVE

Joe H. McCall, Texas Nanotechnology Initiative, 401 Congress Ave., Suite 2100, Austin, Texas 78701, 512-370-2929, JMCCALL@TEXASNANO.ORG

At its founding in 2001, the mission of the Texas Nanotechnology Initiative (TNI) resembled that of any other regional, state, or local initiative: to bring together interested constituents in industry, academia, and government to establish Texas as a world leader in the discovery, development and commercialization of nanotechnology. TNI is reorganizing around a much more specific and urgent goal as it enters its third year:

> Our mission is to make nanotechnology in Texas a sustainable economic enterprise to the benefit of the state, the region, and ultimately, the Nation.

Unlike other regions, Texas state government has provided no support for attracting and retaining technology. There is no state-sponsored economic development office or program dedicated to technology; in fact, the state's sole economic development effort focuses on tourism. Local economic development groups in Houston, Dallas, and Austin have technology-centric offshoots, such as the Center for Houston's Future, the North Texas Technology Council, and the Austin Technology Incubator. But by definition, these groups must focus on local constituents rather than the state as a whole. Despite this lack of statewide coordination and funding, Texas has amassed a rich set of raw materials essential to robust economic development in nanotechnology.

Research

Twelve Texas universities have laboratories and facilities, collaborative arrangements, or research centers dedicated to nanotechnology. The roster includes the Nation's first academic nanocenter—the 10-year-old Rice Center for Nanoscale Science and Technology—and the Center for Biological and Environmental Nanotechnology at Rice, an $11.8 million NSF-funded NSEC established in 2001, which has become the world's focal point for addressing nanotechnology health and safety issues. Three Nobel laureates run nanotechnology research programs in the state: Alan MacDiarmid at the University of Texas at Dallas and Richard Smalley and Robert Curl at Rice University. Through a collaborative research effort called SPRING, established in 2002, researchers at the University of Texas (UT) at Arlington, UT Austin, UT Dallas, and Rice are developing cross-campus research programs.

Commercialization

Of the 15 nanotechnology start-ups in Texas, nearly half are technology transfers from university research, and two were lured to Texas by the siren song of lower operating costs and access to unique, Texas-based infrastructure resources. Stand-outs include Zyvex Corporation, the first molecular nanotechnology company, which this year launched its first product, the S100 Nanomanipulator; Applied Nanotech, a subsidiary of SI Diamond that generated $1.5 million in revenue and attracted an impressive mix of strategic partners in 2002; Molecular Imprints, which generated its first revenues in 2002 and now offers two nano-imprint tools; and Carbon Nanotechnologies, Inc., which opened a pilot plant for bulk synthesis of carbon nanotubes in 2002.

Workforce Development

Educational initiatives delivered throughout Texas aim to train the next generation of engineers and physical scientists to fuel nanoventures. "Nano at the Border" allies five UT campuses—UT Arlington, UT Austin, UT Brownsville, UT Dallas, and UT Pan-Am—to create an integrated, interdisciplinary education and research program that extends from the Panhandle to the Gulf. The Center for Biological and Environmental Nanotechnology at Rice has developed teacher-training programs and curriculum

projects to enhance secondary science curricula. Texas is also home to The Nanotechnology Group, which is developing a virtual nanoscale science curriculum for grades K-20.

TNI is another of these raw materials. In three years, the organization has grown to 40 members and boasts a representative board of directors from start-ups, established industry, service organizations, and universities. In addition to hosting quarterly meetings around the state, TNI organized and hosted NanoVentures in 2002 and 2003, a three-day international conference focused on nanotechnology R&D and investment opportunities.

It's likely that these raw materials, left alone, will continue to produce successes. But it's even more likely that direction, in the form of state-sponsored and -directed coordination and funding, will bring about these successes more quickly. Our bottom-up, grassroots, volunteer-dependent initiative is no match for the top-down, goal-oriented economic development efforts that support nanotechnology in other regions.

TNI plans to pursue its goal of making nanotechnology a sustainable, economic development enterprise in Texas through a number of channels. Our primary, near-term objectives are to

- commission and support an input/output, economic impact analysis to make the case for state-sponsored investment in attracting and retaining high-tech ventures
- pursue stronger ties with local economic development organizations, state government officials, and Federal and national officials to encourage support for tracking and retaining technology in Texas
- develop www.texasnano.org to provide a Web-based clearinghouse for tracking statewide accomplishments and nanotechnology-related events
- partner with other organizations within Texas to raise the profile of nanotechnology events and create value-added content for members (e.g., make existing biweekly nanotechnology colloquia more accessible to university researchers, create a database of nanotechnology research and activity as a resource to members)
- partner with regional and national organizations to find ways to add value and promote Texas research and commercialization activity more broadly

Link

Texas Nanotechnology Initiative: www.texasnano.org

VIRGINIA NANOTECHNOLOGY INITIATIVE (VNI)

Lisa E. Friedersdorf, Ph.D., Virginia Nanotechnology Initiative (VNI), www.InanoVA.org, 540-447-0301, LisaAdviSci@aol.com

Goals of the Initiative

Mission

Enhance the scope, quality and funding for collaborative research among Virginia's nanotechnology researchers, and create conditions to accelerate technology transfer to industry.

Vision

To position Virginia as a leader in nanotechnology research, development, and education.

Methodology

Build a nanotechnology community in Virginia through a network of researchers, industries, business development specialists, and government agencies concerned with research, workforce and economic development.

Overview of Activities

- Research development—information, support and interfacing to PIs on research proposals
- State and university matching on Federal research proposals
- Industry partnership and technology transfer for business and economic development
- Federal interfacing to funding agencies, the NNI, and the NNCO
- Workforce development in collaboration with universities, industry and school systems

Areas of Emphasis

- Nanomaterials Manufacturing and Metrology
- Nanoscale Surgical and Biosensing Technology
- Nanofabrication of electronically functional materials
- Social and educational implications
- 3 ATP grants (Luna Innovations and Nanomatrix) and numerous SBIRs

History and Organization of Activity

Established in Augist 2001 through seed funding from Virginia's Center for Innovative Technology (CIT). Current funding from Virginia's CIT.

State Nanotechnology Funding since August 2001

- $3.5 million in direct and Federally matched contributions
- $7 million on the University of Virginia's (UVA) Materials Science Engineering & Nanotechnology Building
- $275,000 on Nanotechnology Coordination Activities

Management Model

The director and technical advisor work with a statewide steering and advisory committee to implement the regional nanotechnology coordination agenda.

Director: Lisa E. Friedersdorf

Technical Advisor: Nathan Swami (former Director INanoVA)
Steering Committee: Robert Hull (UVA), Harry Dorn (Virginia Tech), Gary Wnek (Virginia Commonwealth University), Colm Whelan (Old Dominion University), Brian Holloway (College of William and Mary), John Noftsinger (James Madison University), Estala Blastein (George Mason University), Nancy Vorona (CIT), Keith Boswell (Virginia Economic Development Partnership), Fred Dylla (Jefferson Lab), Mark Shuart (NASA Langley), Kent Murphy (Luna), Vic Peña (nanoTITAN), Steve Maebius (Foley & Lardner)

Members

Universities

College of William & Mary
George Mason University
James Madison University
Norfolk State University
Old Dominion University
University of Virginia
Virginia Commonwealth
Virginia Tech

National Labs

Thomas Jefferson Accelerator Facility
NASA Langley Research Center
Naval Research Laboratory

Industry

Luna Innovations
Foley & Lardner
nanoTITAN
Nanomatrix
Northrop Grumman
Newport News Shipbuilding
Leica Microsystems
Infineon Semiconductor

Statewide Agencies

Virginia's Center for Innovative Technology
Virginia Economic Development Partnership
Virginia Association of Science Teachers
International Technology Education Association

Current Activities

- State matching, education, and outreach on NSF-funded MRSEC on Nanoscopic Design at University of Virginia (UVA)
- Nanofabrication Laboratory Experience for Virginia teachers in collaboration with Pennsylvania's NanoManufacturing Technology Partnership and funded through NSF's Research Experience for Teachers (RET) program
- Physical science educational series at UVA for teachers (100 teachers trained annually)
- Development of a Statewide Users Network of Nanotechnology Research Instrumentation
- Development of an inventory of nanotechnology assets
- NanoManufacturing Initiative for promoting research, technology commercialization, development of standards, and workforce programs in manufacturing science
- Distance education programs through the state-funded Commonwealth Graduate Engineering Program (CGEP) for universities and community college system
- Proposal submissions planned with statewide and nationwide partners on the National Science Foundation's Nanoscale Science and Engineering Center, National Institutes of Health's Bioengineering Research Partnerships, and Defense Advanced Research Projects Agency opportunities

Links

Statewide Initiative: http://www.INanoVA.org/

Virginia's CIT: http://www.cit.org/

Innovation Avenue (for VA Enterprenuers): http://www.innovationavenue.org/

Virginia's Economic Development Partnership: http://www.yesvirginia.org/
Summary of VA's nanotechnology program: http://www.inanova.org/va-nanotech-prg.htm
Directory Search of VA's nanotechnology researchers: http://www.inanova.org/search.asp
Materials Research Science & Engineering Center (UVA): http://www.mrsec.virginia.edu/
Integrative Graduate Education and Research Traineeship Program (IGERT) on Lasers (UVA and Norfolk State University): http://faculty.virginia.edu/igert/selim/
Fiber & Electro-optic Center: http://www.ee.vt.edu/%7Efeorc/
UVA Virtual Lab for Educational Materials: http://www.virlab.virginia.edu/QTS/home.htm

THE WASHINGTON NANOTECHNOLOGY INITIATIVE

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Washington State has been devastated by the recent economic downturn and ranks second in unemployment nationally after losing nearly 40,000 skilled jobs. However, the state retains a strong base consisting of an entrepreneurial culture, highly skilled workforce and world-renowned research. The state is recognized as a leader in skilled manufacturing, wireless, biotechnology, software, Internet commerce and energy systems and must continue to create valuable intellectual property and commercialize breakthrough technologies for existing and new industries.

The Washington Nanotechnology Initiative has been launched to link academia and the business community, ensuring that the cutting-edge nanoscale research being conducted in the state today is translated into the leading Washington companies of tomorrow. Developed jointly by the Washington Technology Center (WTC), the University of Washington (UW), Washington State University (WSU), the Washington Nanobusiness Alliance (WNA), and Pacific Northwest National Laboratory (PNNL), the Washington Nanotechnology Initiative will identify, quantify, validate, and create a strategy to promote the potential of the state's economic development opportunity in micro- and nanotechnology. The WA Nano Initiative will educate and mobilize business, research, academic, and political leaders to secure the state's role in the emerging field of nanotechnology. The Initiative has been developed to this point using internal organizational funds. Funding support is currently being sought from state and Federal sources. Specific objectives of the Initiative are described below.

Understand the Opportunity

The business opportunities for Washington State in nanotechnology need to be identified and quantified by determining where the state's current research activity and industrial interest have application to globally recognized market needs. The academic, business, and government assets will be inventoried and correlated with market research to spot areas where the state's unique resources can capitalize on opportunities with the highest potential for commercial success.

Develop a Strategy

The Washington Nanotechnology Initiative will develop a business strategy that brings together the best possible physical, financial, and human resources for Washington State to use in nurturing and growing an industry cluster in micro- and nanotechnology. The strategy will be based on quantified market research and tangible, achievable goals, and will capitalize on the state's combined strengths in scientific research and entrepreneurial spirit to position Washington as a leading player in the emerging micro- and nanotechnology field.

Involve and Inform the Players

Washington State's ability to capitalize on emerging opportunities in nanotechnology will rely on a solid program of communication, outreach and interaction. Alerting government, business and academic leaders of the potential opportunities available in research, development, and commercialization of nanoscience, and providing a rich environment for networking and collaboration will be essential to the state's continuing economic growth. In recognition of the value of effective access, coordination, and communication regionally, the Washington Nanotechnology Initiative will become a founding member of the Northwest Nanoscience and Nanotechnology Network.

Link

Washington Nanotechnology Initiative:

http://www.watechcenter.org/index.php?p=Nanotechnology&s=99

Appendix E. Glossary

Act	Public Law 108-153, the 21st Century Nanotechnology Research and Development Act
Agencies	Departments and Agencies within the Executive Branch of Federal Government
ATP	Advanced Technology Program
CS	Committee on Science of the NSTC
CT	Committee on Technology of the NSTC
EPSCoR	Experimental Program to Stimulate Competitive Research
MOU	Memorandum of Understanding
MRSEC	Materials Research Science & Engineering Center
NEHI	Nanotechnology Environmental and Health Implications Working Group of the NSET Subcommittee
NIST	National Institute of Standards and Technology
NNAP	National Nanotechnology Advisory Panel
NNCO	National Nanotechnology Coordination Office
NNI	National Nanotechnology Initiative
NPAC	Nanotechnology Program Advisory Committee
NRC	National Research Council of the National Academies
NSEC	Nanoscale Science and Engineering Center
NSET	Nanoscale Science, Engineering, and Technology Subcommittee of the NSTC
NSF	National Science Foundation
NSTC	National Science and Technology Council
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
PCAST	President's Council of Advisors on Science and Technology
PI	Principal Investigator
RDI	Nanotechnology Research Directions Workshop (Jan. 27–29, 1999)
RDII	Nanotechnology Research Directions II Workshop (Sept. 8–10, 2004)
SBIR	Small Business Innovation Research

National Science and Technology Council

Committee on Technology

Subcommittee on Nanoscale Science,
Engineering, and Technology

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