SB 551

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Testimony of Prof. Mark A. Reed, Harold Hodgkinson Professor of Engineering and Applies Science, Associate Director for the Yale Institute for Nanoscience and Quantum Engineering (YINQE), Yale University, March 4, 2008. –

The emerging field of nanoscience is widely recognized as THE frontier for pioneering research in the biological, engineering, and physical sciences. The field reflects a far reaching revolution in the understanding and control of increasingly complex phenomena and systems at the nanoscale, and is opening new collaborative and interdisciplinary opportunities.

Nanotechnology is the manipulation of matter at an unprecedented scale – individual atoms and molecules. Whereas the 1st Industrial Revolution (i.e., machinery and mechanical engineering) was based on the manipulation of bulk material; the 2nd Industrial Revolution (mass production, spawning the chemical and electronic industries) were based on chemical and electrical sciences; modern healthcare and medicine based on the biomedical sciences; the Next Industrial Revolution will likely come from the unimaginably small. Reducing the dimensions of materials leads to novel designer properties heretofore unavailable with what Nature provided, and opens up new opportunities in nearly all the physical and biological sciences ranging from drug delivery to battle cancer, materials of unprecedented strength, and information processing that could potentially dwarf present computer technologies.

Nanoscience is not the futuristic fantasy of movies or novelists, but real developments that have led to advances in virtually all industry sectors. Consider an example: solar power has long been considered as a clean, sustainable energy source but has not had substantial technology insertion because of cost and efficiency limitations, which are primarily materials issues. Photovoltaic cells made using "quantum dots" – nanometer-sized particles of semiconductors – have been engineered to yield devices of significantly higher efficiency than what is commercially available, and with the promise of significantly lower production cost. Similar impacts are occurring in drug delivery, medical diagnostics, and fuel cells.

The National Nanotechnology Initiative, started in 2001, has launched programs in 25 federal agencies that invest approximately $1.4B annually in support of R&D in nanoscale science. This funding supports the National Nanotechnology Infrastructure Network (NNIN), and approximately 70 Centers of Excellence, for which Connecticut has garnered only one (Yale MRSEC). State and regional initiatives have followed (a partial

Table 1
NNI Budget, 2007-2009
(Dollars in millions)

	2007 Actual	2008 Estimate*	2009 Proposed
DOD	450	487	431
NSF	389	389	397
DOE**	236	251	311
DHHS (NIH)	215	226	226
DOC (NIST)	88	89	110
NASA	20	18	19
EPA	8	10	15
DHHS (NIOSH)	7	6	6
USDA (FS)	3	5	5
USDA (CSREES)	4	6	3
DOJ	2	2	2
DHS	2	1	1
DOT (FHWA)	1	1	1
TOTAL	1,425	1,491	1,527

list is shown in the Table), to not only leverage Federal programs, but additionally to stimulate business development and to develop a technically skilled workforce.

State	Recipient	Description	Partnership Model
AZ	Nano-bio research center	Research Infrastructure	University-State
CA	California Nanosystems Institute	Building Infrastructure	Metropolitan-State
FL	Center at University of South Florida	Faculty Recruitment & Infrastructure	University-State
GA	Center at Georgia Tech	Building & Research Infrastructure	
IL	Nanoscience Centers (Northeastern Univ., U. of IL, Argonne National Laboratory)	Building & Research Infrastructure	Non-profit-Metropolitan-Regional
IN	Nanotechnology Center at Purdue	Building Infrastructure	
NJ	Support at NJ Institute of Tech. and photonics consortium	Building Infrastructure	State-Industry
NY	Nanoelectronics Center, Albany	Building & Research Infrastructure	University-State
OK	NanoNet	EPSCoR	University-Region
OR	ONAMI – Oregon Nano-Micro Interface Institute	Research Infrastructure	University-Industry
PA	Nanotechnology Center		Non-profit-University-State
SC	NanoCenter	Building Infrastructure	
SD	Center for Accelerated Applications at the Nanoscale	Research Infrastructure	UniMversity-State
VA	Various institutions and Luna Innovations	Research Matching & Infrastructure	University-State
WA	University of Washington, Washington Tech. Center	Clean Room Maintenance	University-State Partnership

Source: NSTC Report of the NNI Workshop on Regional, State and Local Initiatives in Nanotechnology, September 30-October 1, 2005 (2005). Note: The examples offered here provide a sampling of infrastructure investments by various U.S. States. This list is not comprehensive and does not include non-infrastructure investments.

Tangible benefits that arise from Connecticut state funding will be;

1) Immediate and future jobs – the investment into economic growth of budding industries that creates future job opportunities is important, but it should not be forgotten that immediate jobs are created from the investment. In addition, states that have invested in nanotech has seen their investment matched many times over by Federal investments, which multiplies job growth

2) Competitiveness – Nanotechnology is universally regarded as the Next Industrial Revolution. To bring more high tech jobs back to Connecticut, a trained work force is essential. We must grow this workforce by a combination of higher education initiatives, STEM initiatives, and local nanotechnology expertise.

3) Recruitment and retention – Nanotechnology is at the forefront of scientific research, which makes it one of the most aggressively recruited areas in technology today. To attract (and even retain) the best world class scientists and researchers in this area, the State along with universities and companies must cooperate to provide the most attractive and vibrant innovation climate possible, increasing competitiveness for recruiting top talent and large research grants at the federal and foundation level.

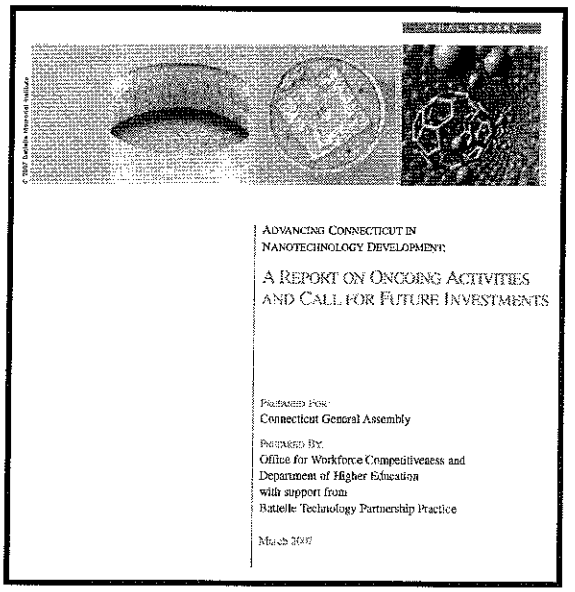
Over the past four years, Connecticut has been diligently at work in setting out a path for advancing nanotechnology development in the state. Last year, pursuant to Public Act 05-198, Connecticut developed an action plan to advance nanotechnology development in 2006 in consultation with the Advisory Council for Nanotechnology. This action plan was well-received and enacted into legislation through Public Act No. 06-530, "An Act Concerning The Advancement of Nanotechnology Development In Connecticut".

Given the strategic importance of nanotechnology, Connecticut cannot accept anything less than being among the top 10 states in nanotechnology development. Nanotechnology, as one of the key drivers of the next industrial age, will be critical to the future competitiveness of Connecticut's diverse manufacturing sectors, from aerospace to advanced materials to fuel cells to pharmaceuticals and biotechnology. Today, Connecticut is at risk of not keeping pace with the development of nanotechnology. While Connecticut has a growing base of activity in nanotechnology across its universities and companies, it is lacking in key infrastructure and targeted development activities. By 2011, when nanotechnology is expected to be even more widely applied, Connecticut will be have key nano-related applications endangered, including:

- Fuel cell systems and advanced materials
- Sensors and detectors (physical, chemical and biological)
- Drug discovery and development

In March 2007, the CT Advisory Council on Nanotechnology issued its final report, "Advancing Connecticut in Nanotechnology Development". The report detailed a number of recommended efforts and investments. Four specific initiatives were set out to advance Connecticut's nanotechnology development:

1. Establish an active nanotechnology product innovation focus by building on the Connecticut Small Business Innovation and Research (SBIR) Office
2. Pursuing a Connecticut Nanotechnology University/Industry Collaboration Initiative
3. Advancing Post-Secondary Education Program Development in nanotechnology
4. Developing the Connecticut Center for Nanoscale Sciences and Development, a shared use nanotechnology instrumentation facility with related programs.


ADVANCING CONNECTICUT IN NANOTECHNOLOGY DEVELOPMENT:

A REPORT ON ONGOING ACTIVITIES AND CALL FOR FUTURE INVESTMENTS

PREPARED FOR:
Connecticut General Assembly

PREPARED BY:
Office for Workforce Competitiveness and Department of Higher Education with support from Battelle Technology Partnership Practice

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Today we address the final initiative (Centers for Nanoscale Sciences and Development). In summary, the report recommends to:

- establish a shared-use facility for advanced microscopy and microanalysis to address physical sciences and life sciences related applications (pg. 10)
- fund a Phase I development over a five year period, approximately $23 to $25 million, comprised of:
    - One time instrumentation purchase costs of $10-12 million for advanced microscopy instrumentation systems and ancillary equipment.
    - Annual operating costs of $2.65 million, or $13.25 million over five years.

The report also addresses the location of the Center(s), recognizing that extensive infrastructure (including not just laboratory-ready space, but extensive personnel and expertise) already exists at University of Connecticut (UConn) and Yale University, and recommends a distributed approach.

Significant progress has been made in all but this critical effort. The inventions and generation of new ideas arising from research are a keystone to the other three components (SBIR, industry, and education). Without a strong drive in nanoscience research from the major research institutes, the entire effort would languish. To meet this concern, leaders from the state's top tier research institutions – which have been cooperating on this initiative since 2002 - have met and developed a framework to move forward consistent with the Advisory Council's recommendations and the research conducted by Battelle.

It was quickly recognized that "existing infrastructure" must also include the world-class research personnel and expertise found at the research institutions. For example, a location geographically split between UConn and Yale (e.g. Hartford) is generally agreed to be disastrous. (On the other hand, a co-located center has been shown to be extremely effective, as demonstrated by the California NanoSystems Institute (CNSI), co-located at UCLA and UCSB). Both Yale and UConn have major investments in personnel active in nanoscience research areas (50 to 100 each), providing a resource and environment absent from any conceivable centrally located Connecticut facility.

The implementation of the Centers at UConn and Yale will be highly leveraged due to the ongoing nanoscience activities (the NSF MRSEC and YINQE Centers at Yale, and the IMS and Nanobionics Centers at UConn), and help attract and retain the world's best talent to Connecticut. The Eminent Scholars Program and the Stem Cell Research Program are existing examples that recognize this value. It has been recognized that such investments has not just the obvious long-term benefits and enhanced federal grant opportunities , but also produces short term return in the retention and augmentation of jobs in local economies. States with substantial nanotech investments (California, New York, Texas) have already seen considerable multipliers on their investments.

A hallmark of successful nanotechnology efforts in other states is the firm support and commitment of the State. We are grateful that Governor Rell has recognized the importance of making this investment by her inclusion of $5 million in her budget this year for Nano Centers and $500,000 to support additional university/industry research collaboration in nanotechnology.