Dr. Thomas O’Neal
Associate Vice President of Research
Office of Research & Commercialization
University of Central Florida

written testimony regarding the

Commercialization and Potential for NanoScience Technology

submitted to the

Subcommittee on Science and Space

of the

Senate Committee on Commerce, Science, and Transportation

July 12, 2011

Distinguished members of the Subcommittee on Science and Space of the Senate Committee on Commerce, Science, and Transportation: Please let me thank you for the opportunity to provide testimony related to an area that holds great potential to make a significant contribution to the US economy. I wholeheartedly support the renewal and expansion of the National Nanotechnology Investment: Manufacturing, Commercialization, and Job Creation.

My testimony will focus on the commercialization aspects of nanotechnology:

- Industry potential
- Technology transfer
- University / Industry Interaction
- Economic Development

The Potential of NanoScience

Nanotechnology has been recognized as a revolutionary field of science and technology, comparable to the introduction of electricity, biotechnology, and digital information revolutions. Between 2001and 2008, the numbers of discoveries, inventions, nanotechnology workers, R&D funding programs, and markets all increased by an average annual rate of 25 percent. The worldwide market for products incorporating nanotechnology reached about $254 billion in 2009. (Lux Research)

Nanoscience or Nanotechnology, the study and design of materials at the nanoscale (on the order of billionths of a meter) truly has the potential to address untold challenges and market opportunities because nanomaterials have fundamentally different chemical and physical properties than bulk materials. Understanding and exploiting these properties will allow scientists to tailor materials for specific uses that will create new market opportunities and commercial success.

In its comprehensive publication, *Societal Implications of Nanoscience and Nanotechnology*, the National Science Foundation (2001) suggested that among the expected breakthroughs [in nanoscience and nanotechnology] are orders-of-magnitude increases in computer efficiency, human organ restoration using engineered tissue, “designer” materials created from directed assembly of atoms and molecules, and the emergence of entirely new phenomena in chemistry and physics (p. iii). The authors added that the effect of nanotechnology on the health, wealth, and standard of living for people in this century could be at least as significant as the combined influences of microelectronics, medical imaging, computer-aided engineering, and man-made polymers developed in the past century (p. 2). This should not be ignored in terms of the economic development policy and practice in the US.

A report by Lux Research (2006) showed that the industries most impacted by nanotechnology will be Aerospace and Defense, Chemicals, Computer Peripherals, Computers, Office Equipment, Electronics, Energy, Medical Products & Equipment, Metals, Pharmaceuticals, Scientific, Photo, Control Equipment, Semiconductors and Other Electronic Components.

While the US is a dominant player in the nanotechnology sector, Japan, Germany, and South Korea are also major players that are gaining ground.

There are things to consider when discussing the commercialization of nanotechnologies.

1. Nanoscience is an enabling, general purpose technology. It is a key building block for multiple applications across many sectors.
2. It represents a mixed bag of incremental improvements and disruptive technology breakthroughs.
3. Processes and products in the sector are key to the innovation process.

Things that affect the commercial potential include:

1. It is a new field and the average incubation time for a discovery to make it through the patent and licensing process is 7 years. Add to this the fact that the emphasis on nanoscience is relatively new and scientific research is often a slow hard road, especially in tight budget times.
2. We learned from microelectronics that the flip side of Moore’s law is that the smaller the feature size the larger the machines that are often needed to make these features and the larger the increase in cost. For example, the initial printed circuits could be made with standard photographer’s equipment available at any photo hobby store. Whereas now the light sources can cost up to a billion dollars and individual pieces of optics can easily exceed a million dollars in cost. This trend continues on the nano-scale.
3. As an enabling technology, nano often “disappears” from view as it is integrated into a system. Just one example, photonic band gap materials are nano devices that can enhance telecom but one does not think of the telecom device as either a nano device or a photonics device. Another specific example is photo-thermal-refractive (PTR) glass, which, at its heart, is a nano structure material. PTR glass is used to bend light at different angles by using nanoparticles and Bragg gratings.
4. In summary, nanoscience has already ‘infiltrated’ or enabled new devices or improvement in older devices, but their identity as nano enabled products disappears.

Commercialization Hurdles and Risks:

The commercialization of nanotechnology has non trivial technical and business issues. Key problem areas are Manufacturing and Scale-up, FDA Issues, Business Investment Capital, and the decreasing Investments in Research.

Manufacturing and Scale-up phenomena runs rampant in nanoscale materials. For example, thin films/surface treatment deposition techniques, traditionally require expensive, large vacuum chambers that do not accommodate large scale production. Metallic and ceramic nanoparticles become non-uniform in high volume manufacturing. In other words, the physics of things change drastically at the nano-scale. Things don’t do what they do in bulk.

FDA hurdles for nanoparticles are also a key issue. Dendrimers is the only FDA approved therapeutic in the market, and any non-dendrimer nanoparticle is susceptible to poor uniformity in bulk production. FDA scientists fear that sub-100 nm particles could interact with DNA or cause cell damage. The environmental, health, and safety issues associated with nanosocience must be examined and addressed in order to proceed with the technology in this arena.

Business capital must flow into this venue to ensure success in the market. Venture capitalists are investing in nanotech, but not aggressively due to the long cycles it takes from discovery to commercial viability. It should also be noted that US investors are now putting more new money into international stock funds than into US stock funds by a substantial margin. As recently as 6 years ago, only 8 percent of the money newly invested in US stock funds went overseas; now the fraction has reached 77 percent. This hurts US investment in nanoscience.

Commercialization of NanoTechnologies

To increase the commercialization of nanotechnology innovations, I submit for consideration the following:

1. Invest in research at a level that will make a difference.
2. Spur university and industry interactions.
3. Address the capital problem.

Investment in Research

Research results supply the raw materials for new emerging fields such as nanotechnology. To increase the commercial throughput, increase the supply of raw materials. Conversely, reducing the available innovative technologies available for commercialization reduces the amount of economic benefits available.

Norman Augustine in his National Academy of Science essay, “Is America Falling off the Flat Earth” makes the point that while “America remains extremely productive, ample warning signs are to be found in considering the future. For example,”

- In 2004, federal funding of research in the physical sciences as a fraction of GDP was 54 percent less than in 1970. In engineering, it was 51 percent less.
- By the end of 2007, China and India will account for 31percent of the global R&D staff, up from 19 percent as recently as 2004.
- The share of US post-doctoral scientists and engineers who are temporary residents has grown from 37 percent to 59 percent in two decades.
- In 2005, only four American companies were among the top 10 in receiving US patents.
- The National Intelligence Council reports that in 2003 “foreigners contributed 37 percent of the research papers in Science, 55 percent in the Journal of Biological Chemistry, and 71 percent in the journals of the American Physical Society.”
- For the first time, the world’s most powerful particle accelerator does not reside in the United States; this virtually ensures that the next round of breakthroughs in this fundamental discipline will originate abroad.
- In the recent ranking by the Organisation for Economic Co-operation and Development (OECD), the United States is in 22nd place in the fraction of GDP devoted to nondefense research.

- Federal annual investment in research in the physical sciences, mathematics, and engineering combined is equal to the **increase** in US health care costs experienced every 6 weeks.

These statistics are included in this testimony not to insinuate that the sky is falling but show a trend that needs to be reversed if the US is to maintain the current dominant position it enjoys now and more. It is an undeniable fact that, in the foreseeable future, the US will have to have the best scientists and engineers in sufficient supply. However, that alone will not ensure America's ability to compete in the 21st century. Funds must be available to underwrite the efforts of scientists and engineers who conduct the cutting edge research that creates business opportunities that in turn creates new jobs. The funds must provide for modern laboratories and instrumentation as well as the research enterprise itself. It is research that will keep the United States prosperous in the long term.

Recommendations:

At a minimum, double the amount of Federal research expenditures overall within the next 5 years and consider an even higher increase in Nanotechnology. Simply put, we can't afford not to.

The Federal Government should also take steps to retain scientific and engineering talent trained in the United States by developing a program to provide U.S. Permanent Resident Cards for foreign individuals who receive an advanced degree in science or engineering at an accredited institution in the United States and for whom proof of permanent employment in that scientific or engineering discipline exists.

Spur University and Industry Interactions.

Universities typically receive no funding for technology transfer or commercialization activities. Most are funded from Facilities and Administrative (F&A) cost (indirect cost) recovery. This is often problematic in that there is limited funding to pursue patent protection and even less resources to proactively commercialize technology developments. That means that most technology transfer offices protect a fraction of their technologies and then hope someone will discover it and take a license. Also as state budgets decline, universities must use the F&A cost recovery to fund facility construction, provide bridge funding for faculty competing for federal grants, provide capitalization for labs, etc. This creates too much pressure on too little money!

A few home run hits have also created the notion that tech transfer activities are a source of income for universities. Truth is that less than 10 percent of tech transfer offices break even, much less generate income. The premise of income though often creates very adversarial license negotiations and can jeopardize fruitful, long term partnerships.

Lastly, resources for the commercialization activities are also difficult to obtain. Incubators and entrepreneurship centers are on the rise but often are office spaces, not suited for high tech ventures, operated on shoestring budgets, and are often not woven into an overall innovation ecosystem. Proof of Concept Centers that help move technologies from ideas to viable commercial product are needed for nanoscience as well as manufacturing centers that can help resolve the scale up problems that thwart technology exploitation.

Create a University Entrepreneurship and Technology Commercialization Initiative

It should be funded at a level comparable to the very successful SBIR program (2 percent of Federal R&D budget). Tasks to be undertaken include:

1) Enhance the STTR Program to catalyze university and industry collaboration
    a) Significantly increase the amount allocated
    b) Provide supplements to projects for:
        i) Translation grants
        ii) Gap funds to move technology or venture forward
        iii) Provide matching grants to universities to further research efforts on company's behalf (company funding required and possibly university match)
    c) Create open application deadline program option (SBIR and STTR)
        i) Updated as needed
        ii) Ability to make awards for promising opportunities quickly (weeks, not months)

2) Create Proof of Concept and Manufacturing Centers
    a) Provide shared facilities to bring technology to commercial viability
    b) Enable industry and university partnerships
    c) Access provided on a competitive basis
    d) Scale-up assistance and manufacturing expertise to move technologies into production

3) Enhance University Entrepreneurship Infrastructure
    a) Support for University Affiliated Incubators and Accelerators
        i) Facility development and enhancement
        ii) Operational and program support
        iii) Client support
        iv) Support for networking events between startups, university personnel, investors
        v) Development of support infrastructure for second stage companies (10 + employees)
    b) Student ventures and entrepreneurship support such as:
        i) Linking senior design classes to entrepreneurship and business classes
        ii) Business plan competitions support and promotion
        iii) Entrepreneurship curriculum development
        iv) Internships with startups
        v) Technology based entrepreneurship for technical students
    c) Entrepreneur support
        i) Federal assistance for faculty/staff sabbaticals to start companies

ii) Assistance with conflict of interest management
iii) Market research support
iv) University Presidents, Provosts, other senior staff, and faculty members should be rewarded in appropriate ways for entrepreneurial activities.

4) Regulatory Support
   a) Relax faculty ownership regulations for SBIR and STTR programs
   b) Conflicts of Interest
      i) Need to allow faculty to start companies without fear. Current mechanisms create a mine field that is difficult to navigate. Clear guidance documents should be created and shared liberally. Assistance should be provided to help people stay in compliance while spinning off companies.
   c) Provide incentives that spur investment in new companies and relax rules and regulations that thwart it

   Overall, a growing problem is increased 'compliance' demands that divert critical resources and destroys initiative (faculty are zapped for working extra hours, perhaps on the commercialization part of their work). It makes no sense to penalize a faculty member who put in their 40 hours and then some.

5) Patent Reform
   a) Patents need to be issued quicker (months not years)
   b) Patent reform should not hurt small business

Entrepreneurs Should Be Celebrated

Universities and other government officials should recognize and reward entrepreneurs. Faculty should be given credit towards tenure and promotion, as well as help with compliance (COI). The system should create openness that encourages these activities, and sabbaticals to start companies should be accommodated. Take action to remove the barriers and confusion. University Presidents, Provosts, senior staff, and faculty should be rewarded in appropriate ways for entrepreneurial activities.

Address the Capital Problem

The lack of access to capital is a huge problem. As pointed out earlier, the time lag between discovery and commercialization in nanoscience is long, typically 3 – 10 years. Patient money is required and incentives should be considered to increase this investment.

- Establish a Fund of Funds to increase the number venture capital investments
- Establish a National Nano Investment fund similar to the CIA fund to move promising technologies firms forward.
- Provide incentives for Angel investors

Conclusion

Advances in the field of nanoscience present a tremendous opportunity to improve the quality of life and create economic wealth. It represents a long term investment with large returns. We must continue to press forward in nanotechnology development with a sense of urgency. One could liken this to President Kennedy's call to land a man on the moon by the end of the decade. A strong, concerted effort to accelerate the potential of nanoscience and technology by the end of this decade is warranted. It should be a prominent national agenda that the country can rally around. It must be done by increasing the level of discovery, creating strong partnerships between academia and industry, and by filling the gaps in the commercialization ecosystem. An entrepreneur-centric approach is needed even when large commercial entities are involved.

The commercialization of nanoscience, as with many technology companies, is a messy business. If you've met one entrepreneur with their business needs, you've met one entrepreneur with their business needs. The entrepreneur must be at the center of the innovation ecosystem. Identifying them, engaging them, and supporting their needs in real time are key to increasing their success rates and helping them reach their full growth potential.

Universities are increasingly "getting it" in terms of commercialization but have very limited resources and need their rewards systems to align with commercialization. Faculty that start new companies to commercialize their research should be helped and guided through the process to make sure everything is done properly and compliance becomes a service as opposed to a policing action. The entrepreneurs (faculty or not) should be celebrated and given the time they need to be successful. Faculty members have full time jobs when they start a commercialization activity -- teaching, conducting research, and doing service tasks. They need to be relieved of some of these responsibilities to increase chances of commercial success or, at a minimum, not be penalized by time and effort reports if they chose to work extra time on the commercialization activities!

Sincerely,
Thomas O'Neal