House Committee on Science and Technology

Testimony on
The National Nanotechnology Initiative Amendments Act of 2008

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Chairman Gordon, Ranking Member Hall, Members of the Committee, thank you for the opportunity to testify today on the *National Nanotechnology Initiative Amendments Act of 2008*. This legislation is a natural follow-on to the America COMPETES Act signed into law last summer, and we thank this Committee for playing such a critical leadership role in that effort.

Texas Instruments (TI) has a 78-year history of innovation. While our products have changed many times over the years, we have always fundamentally been a company of engineers and scientists. We have always looked to the future by investing in R&D. Based in Dallas, TI has become the world's third largest semiconductor company. TI is focused on developing new electronics that make the world smarter, healthier, safer, greener and more fun.

I am also appearing on behalf of the Semiconductor Industry Association (SIA). SIA has represented America's semiconductor industry since 1977. The U.S. semiconductor industry has 46 percent of the $257 billion world semiconductor market. The semiconductor industry employs 216,000 people across the U.S., and is America's second largest export sector.

While my testimony today focuses directly on the draft *National Nanotechnology Initiative Amendments Act*, please note that TI strongly supports the testimony presented last month to the Subcommittee on Research and Science Education by Dr. Jeff Welser, Director of the Nanoelectronics Research Initiative (NRI) at the Semiconductor Research Corporation on assignment from IBM. TI is an active member of the NRI, as well as the Semiconductor Research Corporation and the Semiconductor Industry Association.

Nanotechnology holds the promise of solving a number of major challenges facing our country, in areas such as energy, health care, and security. Nanotechnology research is extremely interdisciplinary, bringing together any combination of biologists, chemists, electrical engineers, physicists, medical doctors and materials scientists. This

interdisciplinary nature is one of the reasons that it is essential federal research agencies be encouraged to work collaboratively in the field of nanotechnology.

The *21st Century Nanotechnology Research and Development Act* signed into law in 2003 created the mechanism to coordinate federal research agencies on a major scale around this subject. The creation of the National Nanotechnology Coordinating Office (NNCO) provided a focal point of these federal activities, leading to the development of strategic plans that identified program component areas, and brought together key stakeholders for workshops on major nanotechnology topics.

The *National Nanotechnology Initiative Amendments Act of 2008* expands upon the foundation of the original legislation to improve interagency activities on critical nanotechnology research. Section 2 contains a number of elements that would enhance the way National Nanotechnology Initiative (NNI) is planned and implemented. Using the NNI strategic plan to establish clear metrics and time frames for both near and long-term objectives, including plans for technology transition with industry and the states, allows better measurement of progress towards NNI goals. The explicit funding mechanism for the NNCO and authorization of travel expenditures are also positive proposals for improving the way the NNI is planned and implemented. The modifications to the Advisory Panel will allow a more direct role for industry input and specific focus on nanotechnology. While PCAST has addressed nanotechnology on a detailed level, it also has a vast scope of work in a range of other areas.

My testimony today will focus on two core aspects that TI and the U.S. semiconductor industry see as key components to the legislation: identification of areas of national importance and the translation of basic research into innovations that can be commercialized. These are essential to ensuring that the NNI program maintains U.S. leadership in nanotechnology.

Areas of National Importance (Section 5)

The draft legislation's inclusion of "Areas of National Importance" is an essential element to the bill. The identification of the areas specifically named in the bill as well as subsequently by the Advisory Panel, will facilitate prioritization of interagency activity and resources around nanotechnology research that addresses the most critical challenges facing our country. It is indeed appropriate with this legislation for Congress to set some initial areas of national importance, with flexibility embodied in the Advisory Panel to identify additional areas. The legislation importantly recognizes that the projects in these areas will be selected on a merit and competitive basis.

The draft bill identifies electronics, health care, energy, and water purification as initial areas of national importance. TI and the U.S. semiconductor industry are encouraged that electronics is the first area listed, and strongly advocate that it be renamed nanoelectronics and that the reference be retained in the final bill.

The semiconductor industry makes major contributions to the U.S. economy. Semiconductor price reductions and performance improvements have driven

productivity. Semiconductors drive the information technology sector, which has contributed to 25 percent of gross domestic product (GDP) growth since 1995 while only making up three percent of GDP. U.S. semiconductor companies are technology leaders, capturing nearly half of the over $250 billion worldwide market.

As Dr. Welser testified, nanoelectronics research is needed to advance the current semiconductor technology to its ultimate limits, and to examine nanoelectronics alternatives to go beyond those limits, which will probably be reached by around 2020.

Progress in nanoelectronics is essential to continued advances in information and communications, enabling breakthroughs in applications that depend on rapidly accessing huge volumes of data and increasing the speed of computations with that data, such as improved mapping of the human genome and protein folding, predicting the path of hurricanes, and modeling the behavior of nanomaterials and nanoparticles. There is no doubt that nanoelectronics will play a key role in essentially every area of national importance, such as energy, health care, and national security.

In addressing energy challenges, nanoelectronics and nanostructured materials will be essential to developing new sources as well as to greatly improved means of energy harvesting, storage, distribution, conservation, scavenging, and exploration. Nanostructured materials are already showing promise for low-cost, high-efficiency solar cells, fuel cells, super capacitors, batteries, and light-emitting diodes (LEDs).

As our country faces rising health care costs for a growing and aging population, the application of nanotechnology to medical diagnoses and treatments will be critical. Advances in nanoelectronics, and nanotechnology more broadly, can lead to less invasive procedures, better imaging and monitoring, and targeted treatment at the cellular level (e.g. cancer).

Security is another major area of national importance. Even if the Committee decides not to address this area in the legislation, this topic should certainly be prominent in the interagency context. Further progress in nanoelectronics will continue to benefit national security in very many ways, including even smarter weapons, better and quicker situational awareness, and a broad range of small sensors such as single-chip chemical and biological analysis platforms.

Models and Resources Required to Address National Areas

Collaboration among federal and state government, industry, and academia will be essential in addressing the application of nanotechnology to national challenges, through partnerships such as the NRI. The NRI currently supports university basic research in nanoelectronics at 35 universities and four regional centers. NRI efforts are primarily focused on finding a new switch with improved speed, energy efficiency, and/or cost compared to the field-effect transistor, which is today's workhorse for processing information. The National Science Foundation also recognized this nanoelectronics challenge in its 2009 budget request by including a $20M initiative for research addressing "Science and Engineering Beyond Moore's Law."

The NRI started as a result of the semiconductor industry recognizing that university research in nanoelectronics must be accelerated. In 2005, Advanced Micro Devices, Freescale, IBM, Intel, Micron Technology, and Texas Instruments all agreed to provide industry funds to form a consortium that would fund university research in nanoelectronics. From the beginning, it was clear that the scope of the challenge and basic science questions involved would require engagement and resources from the federal government, and conversations began with NSF and NIST.

NRI is a model collaboration that leverages funding and expertise from industry, NSF, and NIST, and contributions from state and local governments. To quote the most recent NNI strategic plan profile of the NRI, "these government-industry-academic partnerships blend the discovery mission of NSF, the technology innovation mission of NIST, the practical perspective of industry, and the technical expertise of U.S. universities to address a nanotechnology research and development priority. It is one example of the creative methods the NNI uses to accelerate research that contributes to the Nation's economic competitiveness." We are pleased that the draft legislation recognizes and encourages such models in Section 5.

An extremely valuable addition to the reporting requirement in Section 5 would be to track investments in the areas of national interest, at the same level of detail as is currently done for the Program Component Areas. This information is currently disaggregated across agencies and extremely difficult to obtain and compile. For example, there is no central location to determine overall federal investments in nanoelectronics research, and certainly not on a fiscal year-to-year basis to determine trends.

To pursue critical research in the areas of national importance, universities and federal labs such as NIST will need adequate resources in terms of research funding and necessary equipment/relating operating costs--this should be recognized in the bill. While the *National Nanotechnology Initiative Amendments Act of 2008* establishes an important framework, corresponding appropriations will need to follow. TI and many of our colleagues in the U.S. semiconductor industry have been among the leaders in the business community advocating for appropriations to meet the research levels established by the America COMPETES Act, House Democratic Innovation Agenda, and the President's American Competitiveness Agenda.

Research to Commercialization (Sections 4 and 6)

The federal government is uniquely positioned to fund basic research. Historically, it has been the primary source of basic research funds for universities. The federal government plays an especially important role in supporting higher-risk, exploratory research for which the economic benefits may not be realized for decades.

We applaud the Committee for recognizing that appropriate critical areas of basic research must have a mechanism for translating research into commercial applications. This must be balanced with sustained emphasis on continuing the exploratory research itself, which is required to answer remaining fundamental questions in the science and engineering of nanotechnology. We believe that industry can play an important role in

establishing this balance by providing insights on appropriate goals and needs for both "directed" basic research and its potential commercialization. This input can be provided through the revised Advisory Panel, consortia, and various industry advisory liaisons' input into federal agency merit review processes. Direct agency partnership through pre-competitive industry consortia is one of the best mechanisms to achieve close industry-government collaboration and facilitate commercialization of promising research.

Nanomanufacturing
The language in Section 6 calling for instrumentation and tools for nanoscale manufacturing is an important one for the semiconductor industry. As we move to nanoelectronics, measurement, or metrology, challenges will only increase. NIST is best suited to address these challenges given its mission of metrology and its laboratory resources.

Using the NRI research as an example, the new nanoelectronics switch must be extremely reliable, fast, low power, functionally dense, and capable of being manufactured in commercial volumes at low cost. There are a number of candidates for the new nanoelectronics switch, including devices based on spin or other quantum state variables rather than classical bulk electric charge. Commercialization of such devices into a new class of integrated circuits may very well require an entirely new nanomanufacturing paradigm.

Role of the States
Section 4 of the draft legislation highlights technology transfer and explicitly identifies the important role of state leverage through research, development, and technology transfer initiatives.

We agree that state governments should play an important role in leveraging federal funds and facilitating commercialization from universities to industry. For example, Texas created a $200 million Emerging Technology Fund. The fund has three goals: invest in public-private endeavors around emerging scientific or technology fields tied to competitiveness; match federal and other sponsored investment in science; and attract and enhance research talent superiority in Texas. Several other states have similar mechanisms. Of course, state governments are also critical in supporting public research universities from an overall budget perspective.

As part of the establishment of the third regional NRI center, the Southwest Academy of Nanoelectronics (SWAN), the State of Texas, the University of Texas System, and Texas industry collaborated to establish a complementary package of leveraged support. The resulting $30 million of matching funds is focused on attracting and supporting top academic researchers in nanoelectronics. Specifically, this is a three-way match, with the State of Texas contributing $10 million from the Emerging Technology Fund, the University of Texas System matching with $10 million, and the remaining $10 million being contributed by Texas industry for endowed chairs, including $5 million from TI.

The other regional NRI centers provide similar state and local leverage to industry, NSF, and NIST funds. Overall, states are contributing approximately $15 million annually to the NRI in funding, equipment, and endowments, in addition to the major investments in new buildings. New York has provided significant research funding for the Institute for Nanoelectronics Discovery and Engineering (INDEX), as well as a major expansion of the College of Nanoscale Science and Engineering Complex in Albany. The State of Georgia, a partner in INDEX through Georgia Tech, has provided new facilities. The Western Institute of Nanoelectronics (WIN) Center has leveraged funds through the University of California's Discovery program. The recently-established Midwest Academy for Nanoelectronics and Architectures (MANA) at Notre Dame has attracted Indiana state funds and even city resources from South Bend, as well as a commitment to a nanoelectronics building and adjacent innovation park for commercialization activities.

While the states have provided these resources to the four regional NRI centers, it is important to note that the regional centers are "virtual" and involve researchers from several universities outside these states, thus the local investments benefit research on a national level.

The President's Council of Advisors on Science and Technology issued a five-year assessment report on the NNI in 2005. One of the recommendations was to increase federal cooperation with the states, especially by leveraging state research investments. Further, the report recognized the important role of states in commercializing nanotechnology research results. We agree with these conclusions and endorse the draft legislation's emphasis on the role of the states in nanotechnology.

Conclusion

Thank you for the opportunity to testify on *National Nanotechnology Initiative Amendments Act of 2008*. The draft bill makes a number of improvements to the planning and implementation of the NNI. We strongly support the focus on areas of national interest, and specifically the language on nanoelectronics. The translation of basic research to commercialization must occur to ensure that the NNI maximizes the contributions to U.S. economic competitiveness and maintains our country's leadership in nanotechnology. TI and the semiconductor industry look forward to continuing to work closely with the Committee as this bill proceeds towards final passage.