

U.S. NANOTECH AT A CROSSROADS

Future support and reauthorization of a decade-old **FEDERAL PROGRAM** remain uncertain

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THE U.S. GOVERNMENT has invested more than \$14 billion in nanotechnology research and development over the past decade through the National Nanotechnology Initiative (NNI). The 10-year-old program has led to an explosion of nanotechnology research, about 100 federally funded nanotech R&D user facilities, and hundreds of commercialized products.

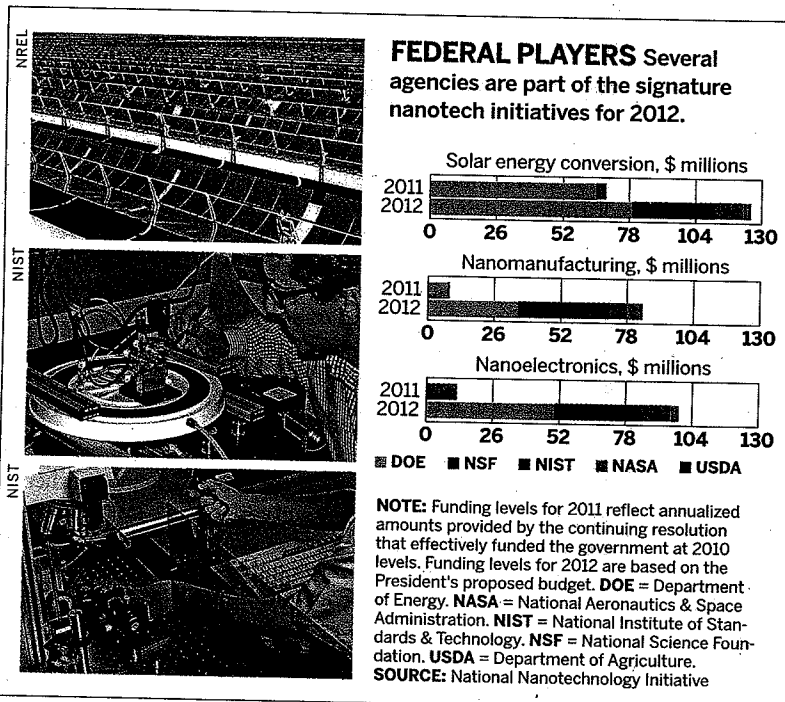
Despite its successes, NNI faces an uncertain future. For the past three years, the Senate has failed to pass a reauthorization bill that would provide direction for the program. Congress has continued to fund NNI, and President Barack Obama has requested an 11% increase in nanotech R&D funding for fiscal 2012 compared with 2010 enacted levels. However, lawmakers are seeking to trim that budget.

Established under the Clinton Administration, NNI coordinates nanotech R&D across 25 federal agencies, including the Department of Energy, the National Institutes of Health, the National Science Foundation, the Department of Defense, and the National Institute of Standards & Technology. The effort has grown from an initial budget of \$464 million in fiscal 2001 to an estimated \$1.9 billion in 2011.

Enhanced oversight of NNI was provided under the 21st Century National Nanotechnology R&D Act of 2003. The act authorized federal funding for NNI through fiscal 2008 and provided the first statutory framework for the program.

After a decade of funding exploratory research, NNI is now shifting its focus to

areas of high economic and national importance. In fiscal 2012, NNI agencies plan to invest in three key initiatives—solar-cell conversion, sustainable manufacturing, and nanoelectronics. The agencies also plan to increase funding for environmental, health, and safety (EHS) research.



Some members of Congress, however, are questioning whether the investments are necessary. During a hearing in the House of Representatives last month, members of a subcommittee of the Science, Space & Technology Committee heard a mix of opinions regarding how much the federal government should invest in nanotechnology, particularly with respect to manufacturing and EHS research.

At that April 14 hearing of the Research & Science Education Subcommittee, lawmakers also heard about the economic benefits of nanotechnology and how stiff competition from China, South Korea,

Japan, and the European Union threatens U.S. leadership in the field.

"NSF projects that 6 million nanotech workers will be needed worldwide by 2020, with 2 million of those jobs in the U.S.," testified E. Clayton Teague, who announced at the hearing that he would be stepping down as director of the National Nanotechnology Coordination Office on April 15. NNCO is the point of contact for federal nanotech R&D activities and conducts public outreach for NNI.

"The U.S. is not the only country to recognize the tremendous economic potential of nanotechnology. At least 60 countries now have national nanotechnology strategies," Teague noted. And for the first time, in 2010 the EU spent more on nanotech R&D than did the U.S., he stressed.

"A recent analysis of the number of nanotech patents, publications, and citations shows that our leadership is being strongly challenged," Teague warned. "This could put our national security at risk since technological superiority is a foundation of our national security strategy."

Teague and other witnesses at the hearing urged lawmakers to continue increasing funding for nanotech R&D. "With continued support of NNI, the U.S. will play a major role in what is unfolding as the next economic and technological revolution. Without it, the U.S. could fall behind in this extremely important race," Teague said.

Representatives from several nanotech companies told lawmakers that NNI has been crucial to the success of their companies. Nanosphere, an 11-year-old manufacturer of molecular diagnostics, "would not exist if it had not been for NNI," testified William Moffitt, the company's president and chief executive officer.

Moffitt noted that Nanosphere received about \$5 million in federal money, which was later augmented with more than \$200 million in private and public equity financing. "We would not have crossed that valley of death," he said, referring to the perilous time between proof of concept and entry

into the market, "had it not been for the NNI government funding which supports the transition of core science into commercializable technologies."

An increased emphasis on manufacturing, commercialization, and safety will mark the next decade of nanotechnology, according to NNI's most recent strategic plan, released in February. But basic research is far from done, and some lawmakers are concerned that there isn't enough money to fund both basic research and the new priorities.

When lawmakers asked what NNI should fund—basic research or nanomanufacturing—James M. Tour, a professor at the Richard E. Smalley Institute for Nanoscale Science & Technology at Rice University, replied that both are needed. "We are not finished with basic research and translational development in nanotechnology. The programs must continue."

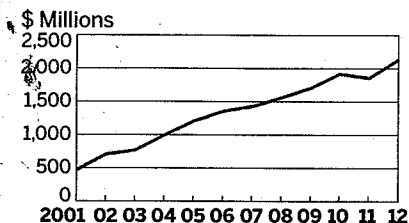
Lawmakers also asked whether the President's proposed 37% increase in funding of nanotech EHS research is justified. Tour testified that he would rather see the additional funds go to basic research. "As basic researchers," he pointed out, "we are already doing a lot of the EHS" work. Tour warned lawmakers that if researchers can't get science funding and money to transition research into commercial products, they will go abroad. He said that he has been approached by officials from Singapore, Russia, China, and Japan who are interested in building him a lab and providing him capital to launch new nanotech companies in their countries, which have lower tax burdens than the U.S.

"Foreign competition is now on our shores, successfully wooing the best and the brightest away," Tour said.

SOME PROPONENTS of the nanotech industry worry that Congress' failure to reauthorize NNI for the past three years could signal to other countries that the U.S. is not serious about being the leader in nanotechnology. Reauthorization of NNI is also a way for Congress to provide guidance to NNCO, so federal agencies have a clear understanding of what Congress wants NNI to fund.

"I hope that working together with Chairman [Mo] Brooks [(R-Ala.)], we will have the opportunity to take up NNI reauthorization" during this Congress, subcommittee ranking member Rep. Daniel W. Lipinski (D-Ill.) said. "I don't think NNI requires major revisions," but there are opportunities to formalize recommendations made by the President's Council of Advisors on Science & Technology and the National Academies to strengthen NNI, he said.

NANO INVESTMENT Federal investments in nanotech R&D have grown steadily under NNI.



NOTE: Funding level for 2011 reflects the annualized amount provided by the continuing resolution that effectively funded the government at the 2010 level. The level for 2012 is based on the President's proposed budget.

SOURCE: National Nanotechnology Initiative

One recommendation is to focus on commercialization. After 10 years of NNI funding, several nano-enabled products have emerged. The most promising include catalysts, transistors and memory devices, structural coatings and materials, biomedical devices, anticancer drugs, energy storage and conversion devices, water filtration systems, and video displays, according to Mihail C. Roco, senior adviser for nanotechnology at NSF. But many people are wondering why there haven't been more products.

The biggest challenge to commercialization is access to venture capital, says Vincent Caprio, executive director of the NanoBusiness Commercialization Association, formerly called the NanoBusiness Alliance. The group, which represents the nanotech industry, recently changed its name to reflect its dedication to increasing commercialization of nanotech products.

"Because of the great recession, venture capital plummeted in 2008, 2009, and

the first part of 2010," Caprio tells C&EN. Another challenge to commercialization is barriers to entry, such as not knowing where a product fits into the market or not having connections to get a product into the appropriate market, he says.

Scientists are having trouble getting venture capital to launch nanotech companies because they have not proven themselves as entrepreneurs, says James M. Hussey, CEO of NanoInk, an Illinois-based company that develops nanofabrication systems. Hussey suggests that scientists who are interested in commercializing nanotech products get coaching from experienced, successful entrepreneurs.

"NNI has been an unqualified success in fostering basic research," but the number of commercial entities that it has spawned has lagged, Hussey points out. NNI has not done well in transferring nanotechnology to commercial companies, educating a workforce independent of Ph.D.s, and investigating the EHS aspects of nanomaterials, he says.

Indeed, many EHS concerns, which began to surface in about 2004, have yet to be resolved. Today, there are "several compelling, near-term issues for which we are moving in circles rather than forward in reaching consensus," Sally Tinkle, deputy director of NNCO, said at a workshop held in Washington, D.C., in March, to harmonize U.S. and EU nanotechnology EHS research efforts.

In particular, researchers have yet to agree on how to measure the dose of a nanomaterial used in toxicology studies, Tinkle noted. Other problems include the lack of standards for measuring biological responses, poor understanding of the role of surface modification on the chemical behavior of nanomaterials, inadequate information about the behavior of nanomaterials in environmental and biological matrixes, and the absence of data to predict exposure in the general population.

Despite the challenges and uncertainties facing NNI, many people believe that nanotechnology is too important, and too much money has been invested in it, to turn back now.

"Nanotechnology represents a great deal of promise for the future of the U.S. economy, both in terms of leaps and bounds in the scientific knowledge base and in terms of potential products and employment opportunities," Brooks said at last month's hearing. "Many believe it has the potential to be the next industrial revolution leading to significant social and economic impact." ■

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