National Nanotechnology Initiative Progressing Rapidly

A little more than a year after the federal government began its National Nanotechnology Initiative (NNI), the program already has hundreds of research and development (R&D) projects under way. New regional research centers are under development. Government officials involved hold monthly interagency planning meetings, and the respective agencies update Congress on the results. A series of workshops is planned to educate prospective target industries, and a national nanotechnology database is in prospect. Nearly every agency involved in the initiative has sought substantial increases in R&D funding for fiscal year 2002.

The actual rate of progress in nanotechnology has been almost as fast as that envisioned by the originators of the initiative. Only a few years ago, the main task was to explain what "nano" was and how it could affect manufacturing industries and the economy in general, according to Mike Roco, who chairs the National Science and Technology Council's subcommittee on nanoscale science, engineering, and technology (NSET). But now, Roco said, "we're moving quickly out of the theory phase to the phase of competition."

Even in the relative near term, the impact may be enormous. Roco estimates that nanotechnology may be a $1 trillion industry within 20 years. For example, within 15 years, the entire semiconductor industry will be working at the nanoscale, he said, as will half or more of the pharmaceutical industry. Other areas such as water distillation, solar-energy conversion, and sustainable development will experience a major impact.

"Companies are no longer questioning whether the technologies will work," Roco said. "It's becoming a matter of who gets to lead."

Lance Haworth of the National Science Foundation's Division of Materials agrees. He said that NSF is looking at what is needed to move toward manufacturing applications for the nanotechnologies that have been already developed. One possibility is building a network of facilities for instrumentation. Toward that end, NSF is requesting a "modest amount," $5-6 million, to build two or three nodes in that network, placing them at university facilities, and allowing free access to private industry. The nodes would offer both manufacturing hardware and research capabilities.

Such optimism is reflected in both the size of FY 2002 budget requests and by the new programs envisioned for the next few years. For example, NSF's nanoscale science and engineering request is nearly $175 million, or $24 million more than FY 2001. NSF intends to use the extra money to focus on "interdisciplinary research and education teams, nanoscale science and engineering centers, and exploratory research and education and training." In other words, the agency is laying the foundation for a national R&D infrastructure that can be accessed by private industry.

Basic research will continue, however. About $8 million of NSF's nano budget will be channeled into its traditional research ("Grand Challenge" projects), in order to fund nanostructured materials "by design," nanoscale electronics, optoelectronics and magnetics, nanoscale-based manufacturing, catalysts, and chemical manufacturing.

NSF is also planning to collaborate with the Department of Defense on nanostructured materials and modeling. DoD has requested $133 million in FY 2002 for its own nano programs, $23 million over 2001. The increase will go for three research Grand Challenges of prime interest: nanoelectronics, optoelectronics, and magnetics; nanostructured materials "by design"; and bio-nanosensor devices. DoD said it will allocate funding among these areas in consultation with the other NNI participating agencies (e.g., NSF and the Department of Energy for nanomaterials research). An additional $10 million will go to the Air Force Research Laboratory for programs in nanostructured materials, as well as nanofabrication technologies, sensor components, and simulation of nanomaterials.

DOE's FY 2002 request of $97 million represents a modest increase of $4 million over FY 2001. Much of that increase is for projects related to establishing user centers for nanoscale science, engineering, and technology research. According to DOE budget documents, the funds will allow four centers to "proceed from conceptual design into definitive design." Other funding areas include about $36 million for nano R&D at universities and three national laboratories—Sandia, Los Alamos, and Lawrence Livermore; $29 million for DOE's nano Grand Challenges, $15 million for centers, and $15 million for research infrastructure.

The largest nano R&D increase in percentage terms would go to the National Aeronautics and Space Administration (NASA), which requested $46 million for FY 2002, up nearly 50% from FY 2001. Nearly one-quarter of that total is for materials (led by NASA's Langley Laboratory). NASA's nano investment plan covers work at several of its laboratories—mainly Ames, Langley, and the Jet Propulsion Laboratory—as well as projects that are partially funded by outside institutions. New nano programs at NASA in FY 2002 will include

- manufacturing techniques of single-walled carbon nanotubes for structural reinforcement;
- electronic, magnetic, lubricating, and optical devices;
- chemical sensors and biosensors;
- tools to develop autonomous devices that articulate, sense, communicate, and function as a network, extending human presence beyond the normal senses; and
- robotics using nanoelectronics, biological sensors, and artificial neural systems.

Given the breadth of its research efforts, however, NASA's nano budget is considered relatively moderate. The agency is focusing primarily on its unique needs, including "high-strength materials that perform with exceptional autonomy in the hostile space environment." NASA also will look to NSF to support more general research and will cooperate with DoD in some Grand Challenge areas, including aerospace structural materials, radiation-tolerant devices, and high-resolution imagery.

For FY 2002, the National Institute of Standards and Technology (NIST) also is seeking a large percentage increase in nano funding—$17.5 million, or over 40% more than FY 2001. The funds will be distributed across the NIST laboratories to develop several areas:

- nanomagnetics research to provide measurement and standards for current and near-term applications of nanotechnology in the semiconductor, communications, and health-care industries;
- nanocharacterization to produce standards and tools for visualization and characterization at the nanoscale, already in high demand by a broad base of U.S. industries; and
- fundamental measurement standards for the future generations of information-technology hardware that will replace semiconductor electronics technology in about a decade.

According to NIST's current planning documents, the agency is working to "develop stronger strategic alliances and collaborations with universities, businesses, and other government agencies that possess leading expertise in nanotechnology." In other words, the agency is attempting to outsource much of its nano R&D efforts. NIST wants to "avoid developing costly, complex in-house capabilities that may only be used once," according to the documents. NIST also is working with counterpart agencies in other countries to develop international nano standards.

The National Institutes of Health's FY 2002 budget for nano is $45 million, or $6 million higher than FY 2001. The National Institutes of Health said it plans to issue several new nano-related R&D program announcements. One of the major theme areas will be biomaterials.

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