Funding the Nanotech Frontier

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The burgeoning field of nanotechnology is certain to play a critically important role in science and the global economy. Neal Lane, currently Assistant to the President for Science and Technology, has stated that nanoscale science and engineering are the areas most likely to produce the breakthroughs of tomorrow. Thus, it is important that a new national nanotechnology initiative, proposed by President Clinton with a budget of $500 million for fiscal year 2001, be implemented.

Nanotechnological devices have features with dimensions that range from about 10^{-9} to 10^{-7} meters [1 to 100 nanometers (nm)]. Because atoms or molecules at surfaces are often reactive, the behavior of nanostructures, which typically have high ratios of surface area to volume, is expected to differ from that of ordinary materials. For example, recent Japanese research involving nanoscale gold particles has demonstrated that they have potential practical applications. Gold particles that are 3 to 5 nm in size catalyze the oxidation of carbon monoxide at temperatures as low as –70°C. Gold nanoparticles are highly selective in partial oxidation reactions and show 100% selectivity in converting propylene to propylene oxide at 50°C. An existing commercial example of nanostructure catalysis is the synthesis and use of a series of nanoporous zeolites by the Mobil Corporation. Their zeolites play a substantial role in the global $210 billion catalyst market.

Evidence is mounting that materials science and technology will use multicomponent nanostructures often in the future. The giant magnetoresistance (GMR) effect is a commercialized example. GMR structures consist of alternating nanolayers of magnetic and nonmagnetic metal films. The transport of spin-polarized electrons that occurs between the magnetic layers is responsible for the ability of the structures to sense magnetic fields such as those created by magnetic bits stored on computer disks. GMR structures are currently revolutionizing the hard disk drive magnetic storage industry, which is worth $30 billion to $40 billion per year. A future application of GMR is nonvolatile random access memory that will compete in a $100 billion worldwide market. The mechanical behavior of deliberately created nanostructures is now being investigated. Some of the materials are prepared by a gas condensation method. Among these products have been pure metals with high hardness and strength and a grain size of about 10 nm. Their hardness and strength are two to seven times greater than those of larger-grained metals. An ongoing goal is to create nanoscale building blocks with precisely controlled size and composition and assemble them into larger useful structures.

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It should be obvious from this necessarily limited picture of nanotechnology that additional R&D is needed to create more ideas and possibilities for applications. Some of it will take place elsewhere. The Japanese are leaders in creating nanodevices and consolidated nanostructures. Europe is strong in new instrumentation, dispersions, and coatings. The United States is active in the synthesis and assembly of nanostructures to form materials with large surface areas, and in the creation of dispersions and coatings.

President Clinton's proposed $500 million budget for a national nanotechnology initiative has been accompanied by the release of federal reports and recommendations.* Some of the latter are directed toward universities. In order to speed the development of U.S. nanotechnology, an interagency working group has recommended that universities involve multiple departments in interdisciplinary work, foster on-campus nanotechnology centers for greater interactions, introduce nanoscience and engineering in existing and new courses, and establish graduate and postdoctoral fellowships for interdisciplinary work. However, implementation of these recommendations will be expedited only when they are accompanied by money. The past history of U.S. federal support for nanotechnology has not been impressive. In fiscal 1997, U.S. government funds totaled $116 million; the comparable number for Japan was $120 million, and for Western Europe, $128 million. In these countries as well as in the United States, industry is also supporting R&D at levels comparable to or greater than that of government.

In light of the opportunities offered by nanoscience and engineering and the realities of global competition, the proposed appropriation of $500 million for fiscal 2001 should be accorded a high national priority.

*National Science and Technology Council, *National Nanotechnology Initiative: Leading to the Next Industrial Revolution* (Office of Science and Technology Policy, Washington, DC, 2000).

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