The emerging revolution in nanotechnology research

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The world is experiencing rapid progress in the ability to design and fabricate mechanical and electronic devices and structures with dimensions on the order of a nanometer (10^{-9} m) or less. On this scale, matter is approaching or at the level of atoms and molecules. This work is inherently multidisciplinary since on the atomic scale mechanical, electronic, biological, and chemical components and systems are essentially the same. Novel structures can be created by control of the forces between atoms and fabrication of devices that can perform useful functions is possible by selective positioning and control of atoms of various materials. The ability to work on the nanoscale is an inevitable result of scaling, which has been a dominant trend in science and engineering, and from this perspective nanotechnology research is a well established. Scaling is, for example, a primary factor in the success of the computer revolution, and the ability to fabricate increasingly complex devices with minimum feature size less than a wavelength of light has kept the semiconductor industry on "Moore's Law".

These advances have been paralleled by materials scientists who have developed a variety of techniques, such as molecular beam, atomic layer, and organometallic epitaxy, to grow crystals one atomic layer at a time. Also, advances in chemistry and materials science have resulted in nanostructures such as buckyballs and nanotubes. It is now possible to grow and synthesize classes of materials, many of which do not exist in nature, with specific and selected properties.

Advances in several parallel fields now make it possible to significantly expand the range of activities that can be performed on the nanoscale. The development of instruments, such as the scanning tip microscope and atomic force microscope, make it possible to image materials on the atomic level. These same techniques can be used to manipulate materials one atom at a time to create atomic level structures and machines. Advances in self-assembly offer intriguing possibilities for novel structures. The development of picoprobes and electronic sampling measurement techniques permit characterization and testing to be performed on nanoscale devices. When taken in the aggregate, these technology advances establish the basis for a new revolution in working on the nanoscale. Further advances are expected to significantly impact the technologies for manufacturing, medicine and health, electronics, communications, energy production, transportation, and education. The U.S. Government has responded to this emerging opportunity by establishment of the National Nanotechnology Initiative. The NNI is six Federal agency collaboration for support of nanotechnology research, with a doubling of funds made available for support of research. The NNI will have a dramatic impact upon nanotechnology research.