Energy Security

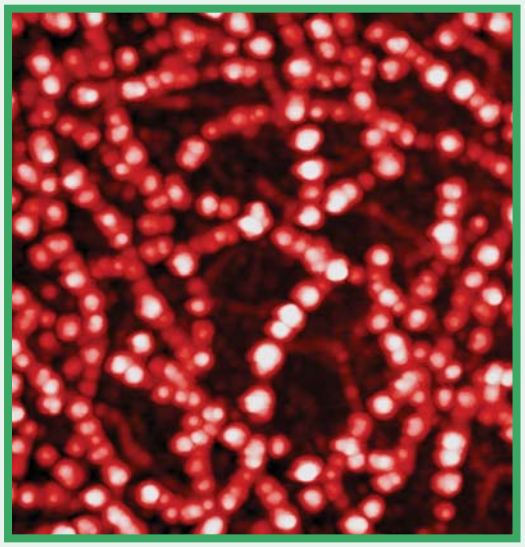
Meeting the Energy Challenge

Interested Agencies: CSREES, DOE, DOD, NASA, NSF

The world demand for energy is expected to double by the year 2050. The difficulty of meeting this demand is compounded by the growing need to protect our environment. To resolve this challenge and provide secure energy resources, energy efficiency must be increased and new "clean" energy sources developed.

Nanotechnology may provide novel solutions to these challenges. At the root of the opportunities nanoscience offers in energy research is a simple fact: many of the elementary steps in the storage and conversion of energy take place on the nanoscale. Furthermore, new functionalities of nanoscale materials emerge from high surface area, quantum size effects, high aspect ratio, reduced dimensionality, and intimate connectivity. The properties of engineered nanoscale materials, as well as the techniques used to image, measure, and manipulate these materials, create new opportunities for energy technologies.

Nanomaterials offer new ways to store and transform energy and to control catalytic activity. Photovoltaic cells made of nanoscale semiconductors offer several mechanisms to enhance the efficiency and reduce the cost of solar energy. For example, nanomaterials can be designed to absorb a broad range of colors from the solar spectrum. Harvesting solar energy with twenty percent power conversion efficiency and a hundred times lower costs than present photovoltaic technology could be within reach. Solid-state lighting involving the use of semiconductor-nanocrystal-based light emitting diodes for general illumination is another rapidly developing technology with the potential to save immense quantities of energy. Nanostructured materials offer a number of opportunities for the development of enhanced power storage and conversion, and for the design of improved catalysts. Nanostructured catalysts can achieve high selectivity and turnover. For example, it is envisioned that the emerging tools of nanoscience will enable one-step conversion of cellulose or carbon dioxide into liquid fuels and economical photocatalytic conversion of water into hydrogen and oxygen. Fuel cell catalysts fabricated from nanoparticles of ruthenium-platinum have been shown to exhibit enhanced resistance to poisoning. Three-dimensional structuring of electrode materials can greatly enhance power storage in batteries and ultracapacitors, and provide advantages over existing technologies in terms of power losses and charge rates. Development and commercialization of these technologies would usher in entirely new energy storage systems that change the economics of solar and wind technologies, greatly contributing to energy independence and security.



Atomic force microscope image of palladium nanoparticles electrodeposited on the surfaces of single-walled carbon nanotube, as part of a study on using these materials as mechanically flexible hydrogen sensors. Reproduced by permission from *Appl. Phys Lett.* © 2007, American Institute of Physics.