rials that fall into a state between solid and liquid, whose properties can be engineered to replicate those of conventional "hard" materials, yet are lighter, transparent, cheaper, and, in some cases, biocompatible.

Of current interest is the development of methods that mimic nature to assemble hybrid nanosystems that combine inorganic and biological components that maintain biofunctionality. Such nano-engineered systems will find applications in advanced optical, magnetic and electrical devices that require the placement of nano-objects with high precision. To achieve this, scientists are developing novel ways to biofunctionalize nanoparticles and nanotubes with DNA and proteins.

Using the advanced facilities available at the CFN, scientists are devising ways to use biomolecules as scaffolds, or "guides," to build two- or three-dimensional arrays of organized nano-objects, and they are learning how cooperative effects among those objects can be exploited in applications.

Electronic Nanomaterials

At the nanoscale, materials can exhibit electrical and optical characteristics that are not present when they have macroscopic dimensions. For instance, the electronic mobility is enhanced drastically in certain nanomaterials, and, in others, their emission or absorption of light is improved significantly by their small size. These novel properties give electronic nanomaterials the potential for strongly impacting the performance of energy-conversion devices.

The CFN program emphasizes the preparation of nanomaterials and understanding of their optoelectronic properties to create both individual nanostructures and organized assemblies of them. Developing nanomaterial assemblies is important, for example, for use in large-area energy conversion devices.

The energy-efficient CFN facility will occupy nine square acres and house 150 people. The state-of-the-art building will attract an estimated 300 researchers from the Northeast annually.

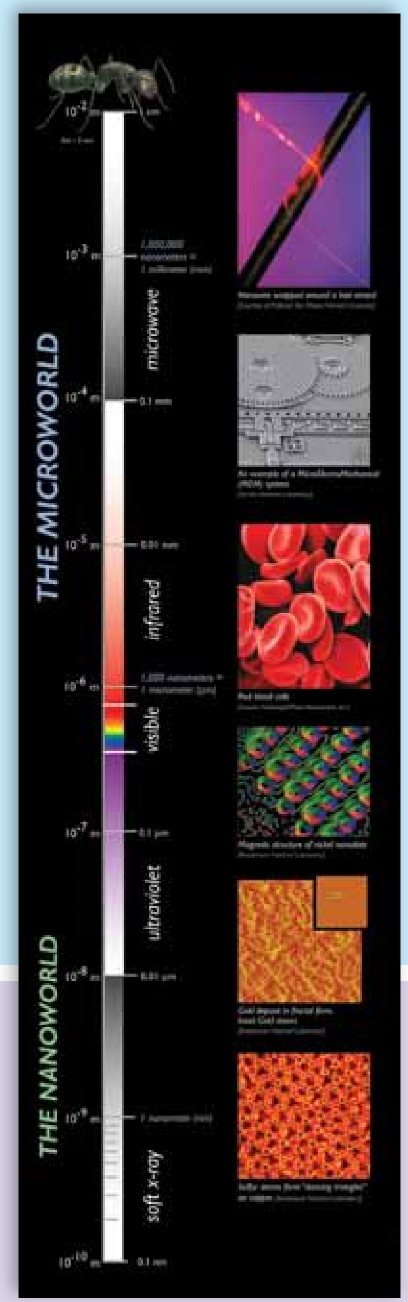
U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY

Brookhaven National Laboratory

Center for Functional Nanomaterials

Science for Discovery at the Ultrasmall



Scientists at the CFN will study materials at nanoscale dimensions, 10,000 times smaller than a human hair.

On the cover: CFN researchers will use advanced probes and new fabrication techniques to study materials at nanoscale dimensions.

Nanoscience is the synthesis and study of structures with atomic-scale sizes, or about a billionth of a meter (nanometer). Although still part of a nascent area of research, nanostructure materials have the potential for creating or accelerating new technologies across fields as diverse as energy, electronics, medicine, and industrial processes.

The Center for Functional Nanomaterials (CFN) at Brookhaven National Laboratory was inaugurated in May 2007. Built and supported by the U.S. Department of Energy (DOE), the CFN is one of five Nanoscale Science Research Centers located at national laboratories. This 94,500-square-foot user-oriented science facility will be a hub for cutting-edge nanoscience and is expected to attract an estimated 300 researchers annually from the northeastern United States and other parts of the world.

The CFN provides scientists with state-of-the-art capabilities for fabricating and studying nanometer-scale functional materials. Nanomaterials can possess chemical and physical properties different from those of their larger-scale, bulk counterparts. Understanding and enhancing nanomaterial functions is of capital importance, as it is these properties that ultimately enable practical applications.

The scientific directions of the CFN are primarily aligned with our national challenges in energy. Nanostructured materials may enable energy-efficient processes and devices for alternatives to fossil fuels, in the form of efficient catalysts, fuel cells, photovoltaic (solar cell) elements, or solid-state lighting.

Research programs in the CFN focus on three key areas:

- Nanocatalysis, which helps accelerate chemical reactions using nanoparticles
- Biological and soft nanomaterials, such as biomolecules and polymers, in which specialized designs can mimic nature and lead to new functions
- Electronic nanomaterials, whose optical and electronic properties can be enhanced for incorporation into efficient energy-conversion devices

Nanocatalysis

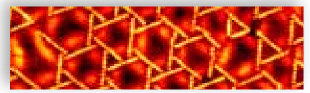
Nanocatalysis uses tiny structures, a few nanometers in size, to speed up chemical reactions essential to modern life.

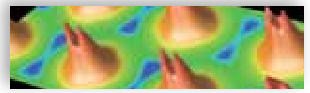
Metal-containing nanoparticles are indispensable ingredients in industrial chemical production and energy-related processes. For instance, fuel cells for powering electric vehicles use bi-metallic particles of platinum and ruthenium to catalyze the conversion of chemical energy into stored electrical energy. These particles are less than 100 nanometers in size and make up only a few percent of the catalyst's weight, yet they provide the active sites where chemical reactions take place.

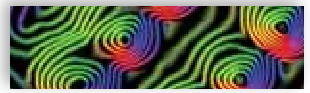
CFN scientists are now developing new experimental and theoretical tools to image and understand chemical reactions activated by such nanoparticles.

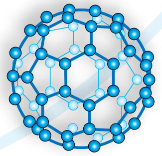
Biological and Soft Nanomaterials

Soft nanomaterials include polymers, liquid crystals, and other relatively "squishy" mate-









Hydrogen Research

Scientists are investigating ways to combine hydrogen research with nanoscience to find innovative solutions to energy problems. To develop efficient hydrogen fuel cells for powering cars, homes, and businesses, materials that can store and release a lot of hydrogen are a necessity. To be practical, these materials must be cheap, safe to handle, and have a high reactivity rate and storage capacity. At Brookhaven National Laboratory, scientists are addressing this challenge by studying metal hydride compounds, which release hydrogen when reacted with a catalyst. With DOE guidelines in mind, they are looking for materials that hold nine percent hydrogen by weight (a relatively large amount) and are reusable.

One of the roadblocks to the practical use of hydrogen as fuel is finding a hydrogen source that does not produce much waste. Natural gas, oil, and coal are good sources of hydrogen, but the reaction process is very wasteful, producing enough carbon monoxide (CO) to eventually "poison" the catalyst and stop the reaction entirely. Brookhaven scientists are working on new catalysts that would lower the CO poisoning rate, allowing the fuel cell to function longer. This research may help lead to practical fuel cells that can power cars for days instead of hours.