Nanomaterials (CFN) that are expected to lead to transformational breakthroughs in the effective use of renewable energy through improved energy conversion, transmission, and storage. The CFN is one of five nanoscale science research centers (NSRCs) that DOE's Office of Basic Energy Sciences is operating at national laboratories around the country. These centers provide scientific expertise and advanced instrumentation for creating new nanostructured materials. By locating the NSRCs next to DOE's light source and neutron facilities, the power of the world's finest experts and facilities for fabricating and characterizing advanced materials are brought together to accelerate the pace of discovery.

In summary, the unique characteristics of NSLS-II will enable scientists to explore the "grand challenges" they face in developing new materials with advanced properties.

Extending the Light

Work at the NSLS-II will build on a foundation of important scientific discoveries made by some of the thousands of visiting researchers who come to Brookhaven every year. The new machine will replace the original NSLS, which began operations in 1982. NSLS provides essential scientific tools for scientists from academic, industrial and government institutions. Their myriad research programs produce about 900 publications per year, with more than 125 appearing in premier journals such as Science and Nature. For example, NSLS has been used by researchers to explain how a class of proteins helps to generate nerve impulses – the electrical activity that underlies all movement, sensation, and perhaps even thought. This work was awarded the Nobel Prize in Chemistry in 2003. Work conducted at NSLS also led to the 2009 Nobel Prize in Chemistry. The prize was shared by visiting researchers Venkatraman Ramakrishnan (Cambridge University) and Thomas Steitz (Yale University) for investigating the structure and function of the ribosome. The NSLS has also been used by researchers from IBM to develop materials processes required to use copper instead of aluminum in integrated circuit interconnects – leading to faster, lower-power computer chips.

The NSLS allows scientists to "see" the tiny molecular structures of many substances and specimens. With this capability, scientists at the NSLS have made many fascinating discoveries and are engaged in many ongoing projects. These include:

- Revealing a potential explanation for super conductivity, a little-understood phenomenon that may revolutionize computers and electronics
- Studying the chemical composition of bones, which may aid in the understanding of arthritis and osteoporosis
- Determining the structure of a section of genetic materials known as RNA, which may lead to new ways to prevent or treat genetic disorders
- Using plants to clean up environmental contaminants, a technique known as phytoremediation
- Producing the first images of HIV, the virus that causes AIDS, attacking a human cell
- Determining a new way to use x-rays to study carbon nanotubes, tiny cylindrical carbon molecules with exceptional strength, conductivity, and heat resistance
- Studying how the structure and properties of various materials change when subjected to extreme high-pressure, high-temperature conditions of cells. This work opened a doorway to understanding the mechanism of ion channels, which are responsible for all nerve and muscle signals in the body

The 2003 Nobel Prize in chemistry was shared by NSLS visiting researcher Roderick MacKinnon for his work exploring how one class of proteins helps to generate nerve impulses.

The 2009 Nobel Prize in chemistry was shared by visiting researchers Venkatraman Ramakrishnan and Thomas Steitz for investigating the structure and function of the ribosome.

U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY

Brookhaven National Laboratory

The National Synchrotron Light Source II

A New Light on the Horizon

The National Synchrotron Light Source II

A New Light on the Horizon

A new light shines on the horizon at the U.S. Department of Energy's Brookhaven National Laboratory. A cutting-edge new user facility will soon illuminate the path to discoveries in fields ranging from energy to medicine.

Each year, thousands of scientists from the U.S. and abroad travel to Brookhaven's National Synchrotron Light Source (NSLS) to perform experiments using its bright beams of x-ray, ultraviolet, and infrared light. These researchers study proteins, polymers, metals, minerals — to name just a few examples — to learn about their unique structures and properties. As the boundaries of scientific discovery have expanded, many researchers are looking for additional capabilities beyond those that can be provided by the NSLS or, indeed, by any other synchrotron in the world. To take their research to the next level — to see even smaller, subtler details of their samples — they need more intense, better-focused beams of light. Although the NSLS has been continually updated since its commissioning in 1982, today the practical limits of its performance have been reached. And while newer synchrotrons far surpass the performance of the present NSLS, no synchrotron anywhere in the world — either currently operating, under construction, or in design — will enable scientists to image and characterize materials down to billionth-of-a-meter (nanometer) resolution.

To address this need, Brookhaven is building a replacement facility — NSLS-II. The new facility will be a state-of-the-art synchrotron that would be among the most advanced in the world.

Like an extremely powerful microscope, NSLS-II will provide scientists with the world's finest capabilities for x-ray imaging. Its superior capabilities will reinforce U.S. scientific leadership, giving researchers here a competitive advantage in numerous scientific fields, which, in turn, will benefit our nation's economy. NSLS-II will be the newest member of a suite of advanced light sources and neutron facilities operated by the DOE's Office of Basic Energy Sciences and used by more than 9,000 researchers annually from all disciplines.

A Giant Microscope

NSLS-II will be a medium-energy storage ring designed to deliver world-leading brightness and flux. It will provide advanced tools for discovery-class science in condensed matter and materials physics, chemistry, and biology – science that ultimately will enhance national and energy security and help drive abundant, safe, and clean energy technologies. For example, major advances in energy technologies – such as the use of hydrogen as an energy carrier; the widespread, economical uses of solar energy; or the development of the next generation of nuclear power systems – will require scientific breakthroughs in developing new materials with advanced properties.

The combination of capabilities at NSLS-II will have broad impact on a wide range of disciplines and scientific initiatives in the coming decades, including new studies of small crystals in structural biology, development of nanometer-resolution probes for nanoscience, coherent imaging of the structure and dynamics of disordered materials, greatly increased applicability of inelastic x-ray scattering, and properties of materials under extreme conditions. Such a high-brightness light source will foster research in areas such as structural genomics and drug design. In the area of biological and medical imaging, NSLS-II will extend the studies of early disease detection.

NSLS-II's leading-edge ability to analyze materials will help guide the development of new materials at the Brookhaven Center for Functional

(continued on back)

Visiting Researchers

At Brookhaven National Laboratory, visiting researchers — nearly 4,000 each year — are a vital component of the Lab's rich scientific community. They come from around the world to take advantage of the capabilities offered by Brookhaven's multiple user facilities, including the Relativistic Heavy Ion Collider, Alternating Gradient Synchrotron, Accelerator Test Facility, NASA Space Radiation Laboratory, and Center for Functional Nanomaterials.

The majority, however, come to Brookhaven to work at the National Synchrotron Light Source (NSLS). In fact, the NSLS is one of the busiest scientific facilities in the world, each year hosting more than 2,000 guest researchers from approximately 400 universities, laboratories, and corporations.

About 60 percent of these researchers are from either the life or materials sciences, but many also conduct research in chemistry, geosciences and ecology, and applied science and engineering. The remaining users perform research in optical, nuclear, and general physics, or other fields.

All told, these user scientists publish, on average, more than 900 papers each year, all stemming from experiments performed at the NSLS.