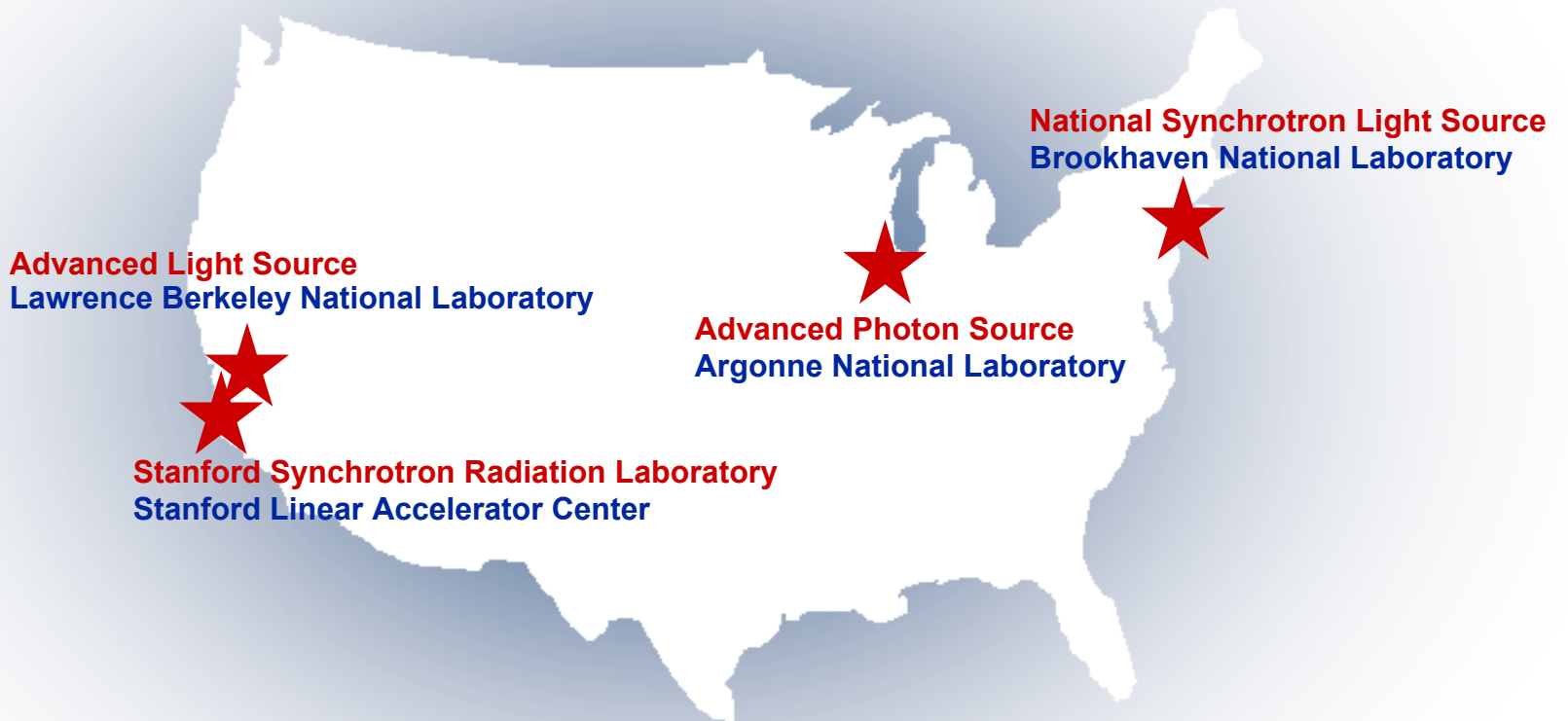
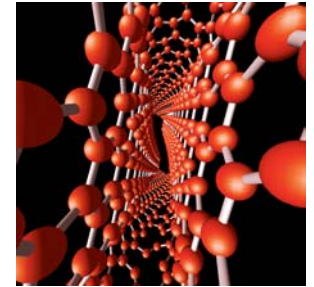
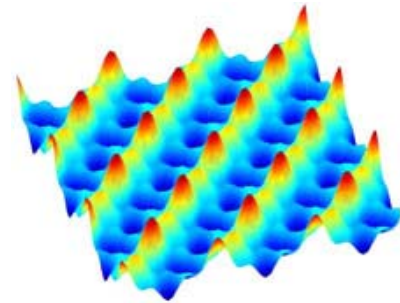


The Synchrotron Light Sources of the DOE Office of Science: A Vital National Resource for Science and Technology



The Users of the DOE Synchrotron Light Sources :

**World-class Science,
responding to the Nation's needs,
pushing the limits of Facility support.**



Advanced Light Source
Lawrence Berkeley
National Laboratory



Advanced Photon Source
Argonne National Laboratory



National Synchrotron Light Source
Brookhaven National Laboratory



Stanford Synchrotron Radiation Lab
Stanford Linear Accelerator Center

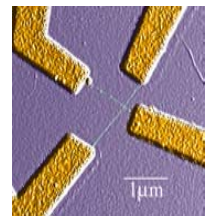
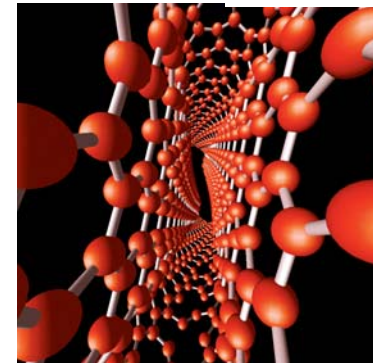
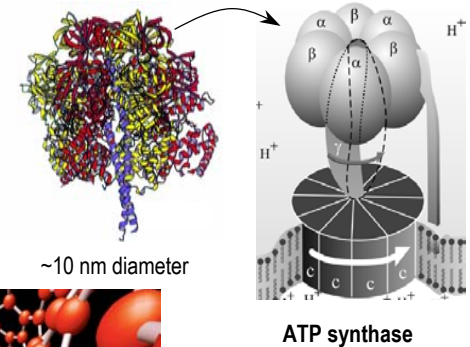
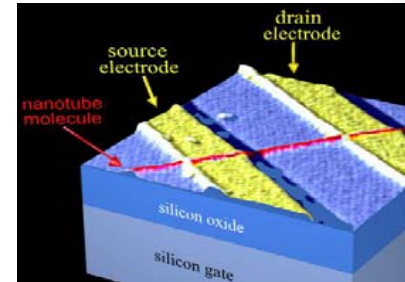
The DOE-BES Light Sources - Forefront Research in Science and Technology



- **Four DOE light sources.** The U.S. national laboratory system hosts four synchrotron radiation facilities constructed and operated by DOE's Office of Science - Basic Energy Sciences (BES).

- **Fields of research.** The radiation ("light") is used for state-of-the-art studies in materials science, physical and chemical sciences, geoscience, environmental science, life sciences, medical science, and pharmaceutical science.

- **Materials investigated.** Research is conducted on materials such as semiconductors, polymers, alloys, catalysts, nanomaterials, superconductors, magnetic materials, proteins, biomaterials, and pharmaceuticals.

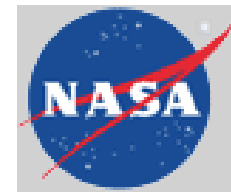


Much of this research is multidisciplinary, and benefits more than one science or technology.



The DOE-BES Light Sources - Thousands of Users

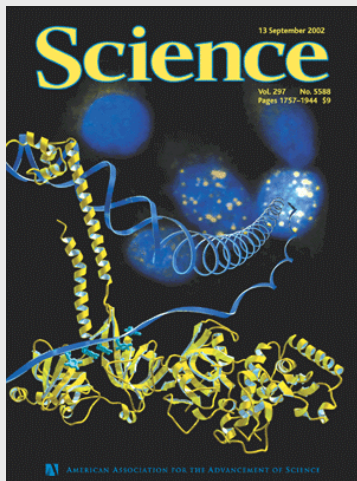
- More than 7100 scientists used the light sources in 2002 and come from all parts of the country.
- Other Federal agencies depend on the light sources. In addition to scientists and engineers from U.S. industries and government labs, light source users include university scientists supported by the National Science Foundation, the National Institutes of Health, the Dept. of Agriculture, the Dept. of Defense, the Environmental Protection Agency, and NASA.



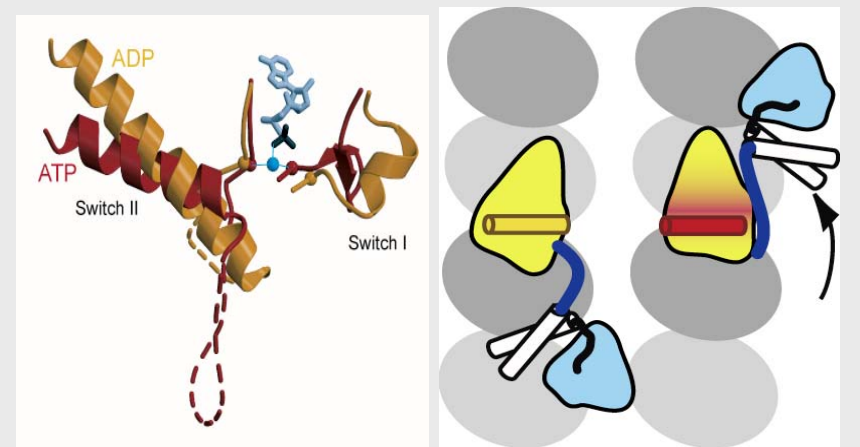
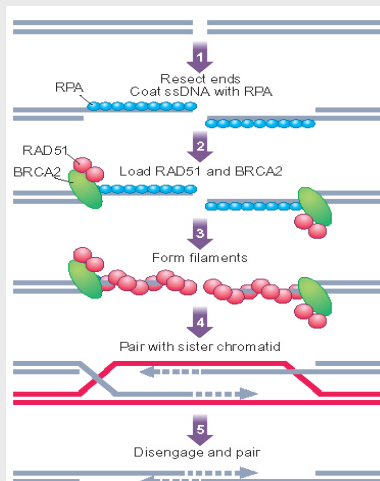


Research Highlights from Light Source Users

Breast Cancer Research - how proteins and DNA cause tumors. The tumor-suppressing gene BRCA2 makes a protein which new x-ray data reveal to be essential for repairing damage to DNA. Defective genes prevent this, leading to malignant tumors. Mechanisms revealed by x-rays may suggest new ways to prevent or to treat breast cancer.



From Yang et al., *Science* 297, p 1827 (2002); research done at NSLS, APS, and CHESS synchrotrons.



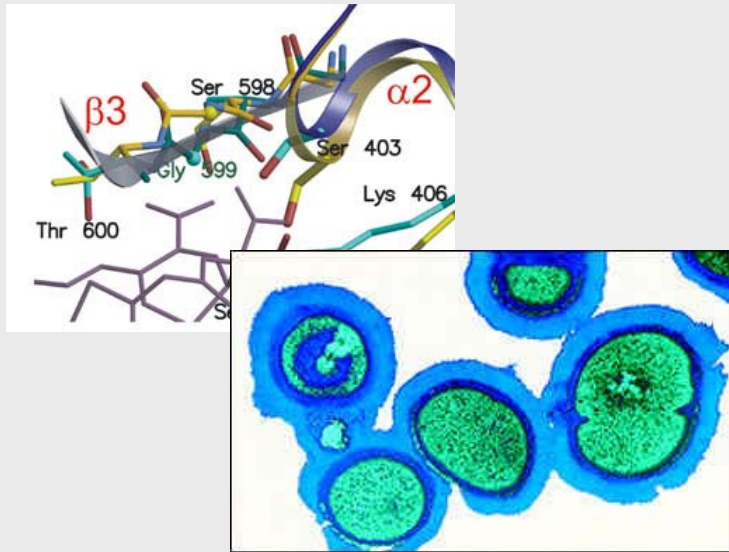
Locomotion of molecules in cells.

Transportation systems exist inside cells that move big molecules along specific tracks. Kinesins are a class of motor molecules with two “feet” that move along the microtubule tracks, that now have been imaged at two different stages. New insights from x-ray crystallography help explain how these molecular motors work, which may inspire new concepts in nanobiology and treatment of disease.

From Kikkawa et al., *Nature* 411, p439 (2002); research done at ALS and SSRL.



Research Highlights from Light Source Users

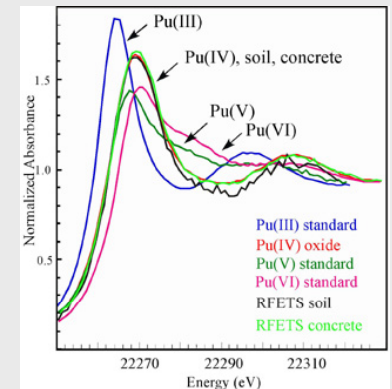


Cause of “superbug” Resistance to antibiotics revealed. Scientists have determined the structure of a protein that is responsible for resistance of some strains of the bacterium *Staphylococcus aureus* to antibiotics. These results may help design more effective inhibitors of the bacterium.

From: D. Lim and N. C. J. Strynadka, “Structural basis for the PBP2a from methicillin-resistant *Staphylococcus aureus*,” *Nature Structural Biology* 9, 870 (2002).

Environmental Cleanup at Rocky Flats.

Decades of nuclear weapons production have left behind trace plutonium in the soils of Rocky Flats, Colorado. Using X-ray absorption spectroscopy methods at SSRL's actinide facility, researchers have determined that the main species of Pu in the contaminated soils at Rocky Flats is a relatively insoluble form of Pu(IV), and is generally localized in the upper 12 cm of soil. In general, insoluble phases pose less risk to humans, wildlife, and water supplies because the rate of metal ion release is slow. This understanding of the contamination has played a key role in determining appropriate remediation strategies while saving taxpayer dollars.

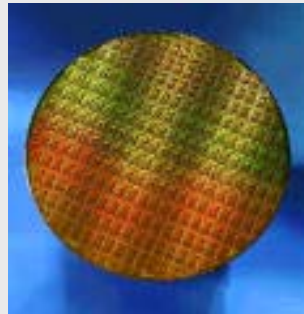
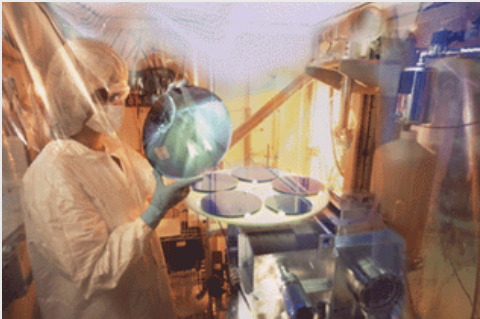




Research Highlights from Light Source Users

Trace Impurities on Silicon Wafers.

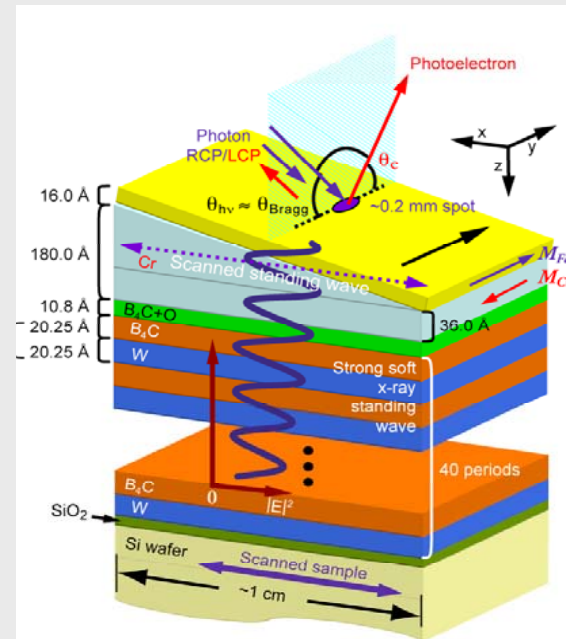
Today's very sophisticated integrated circuits contain more than 100 million transistors and their fabrication involves complex processing steps. Surface contamination, even at very low levels of metal impurities can cause serious degradation of silicon integrated circuits.



Scientists at the SSRL have developed a nondestructive analytical technique available for detecting and determining the chemical state of trace impurities on semiconductor surfaces with extremely high surface sensitivity.

X-rays probe internal interface structures.

X-rays penetrate deeply into materials and permit scientists to nondestructively examine the atomic arrangements at internal boundaries between artificially layered materials, to better design and fabricate advanced microstructures and nanomaterials.





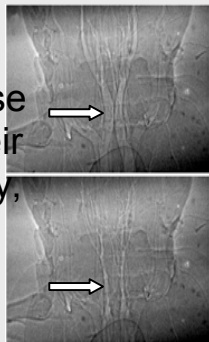
Research Highlights from Light Source Users

A Breath of Fresh Air for Insect Physiology.

Scientists using brilliant x-ray beams from the APS have discovered a surprising insect breathing mechanism. Using real-time, phase-enhanced imaging, many insect species were observed to exhibit rapid cycles of tracheal compression and expansion in the head and thorax, demonstrating a previously unknown mechanism of respiration in insects analogous to the inflation and deflation of vertebrate lungs.

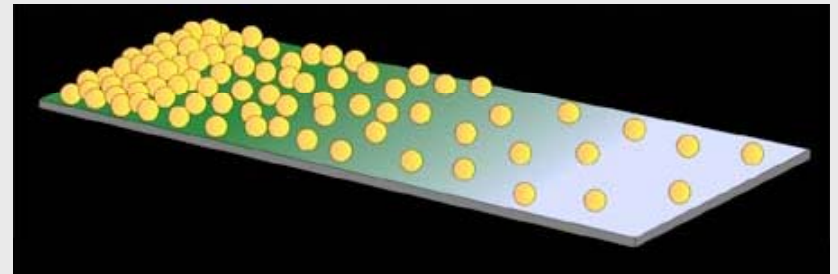


These x-ray imaging techniques may lead to an increased understanding of the basic principles of mammalian, fish, or insect physiology. Because many of these functions have their counterparts in human physiology, this new knowledge may have important implications for human health care.



Formation of Gold Nanoparticles

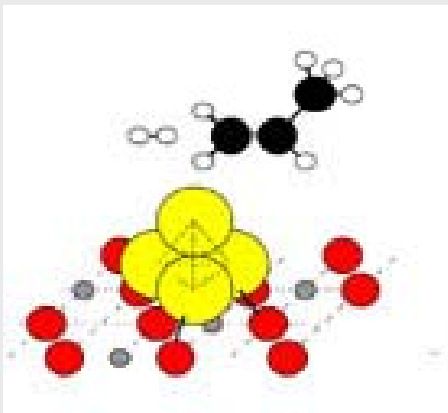
The properties of gold have long made it important to the semiconductor industry. Now, the drive toward ever-smaller microelectronic semiconductor devices makes those properties even more important. Consequently, there is considerable interest in processes to fabricate gold nanoparticles for nano-scale electronic and optical devices. Researchers at the SSRL have shown that ordinary alfalfa plants can accumulate nanoparticles of metallic gold extracted from the soil. And scientists at the NSLS have created a material with a gradient of gold nanoparticles on a silicon surface using a molecular template.



Research Highlights from Light Source Users

Tiny Catalysts in Action. Scientists have prepared and characterized nearly uniform nanocatalysts – metal particles a few billionths of a meter in size dispersed on supports – used to speed up petroleum refining or automobile exhaust conversion. The researchers successfully elucidated the inner workings of the nanocatalysts by using a technique called extended x-ray absorption fine structure (EXAFS) spectroscopy at the National Synchrotron Light Source.

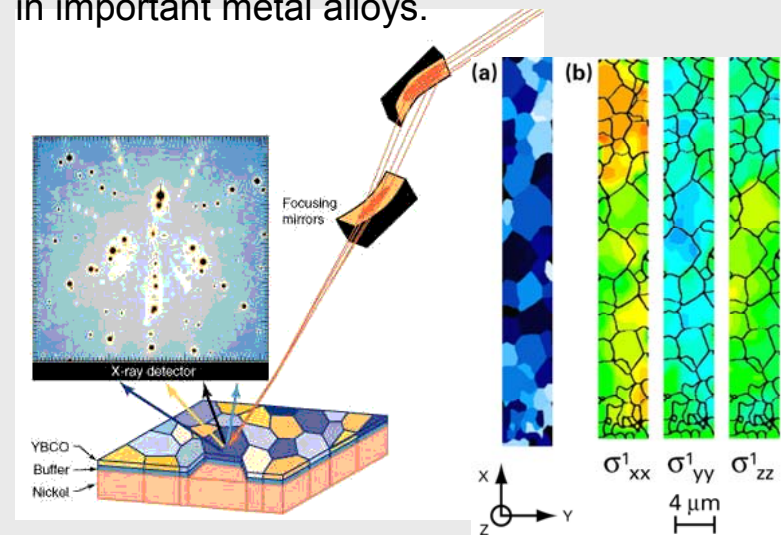
From: "Observation of Ligand Effects during Alkene Hydrogenation on Supported Metal Clusters," A. M. Argo, J. F. Odzak, F. S. Lai, and B. C. Gates, *Nature*, 415, 623 (2002).



Materials Analysis Using New X-ray Microbeams.

New x-ray beamlines at the APS and the ALS permit scientists to study the fine details of grain behavior in materials, including their orientation, and the effects of stress and chemical activity.

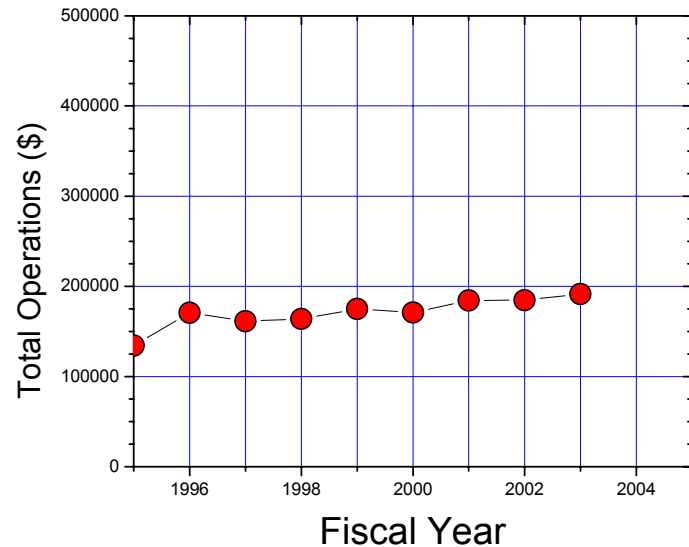
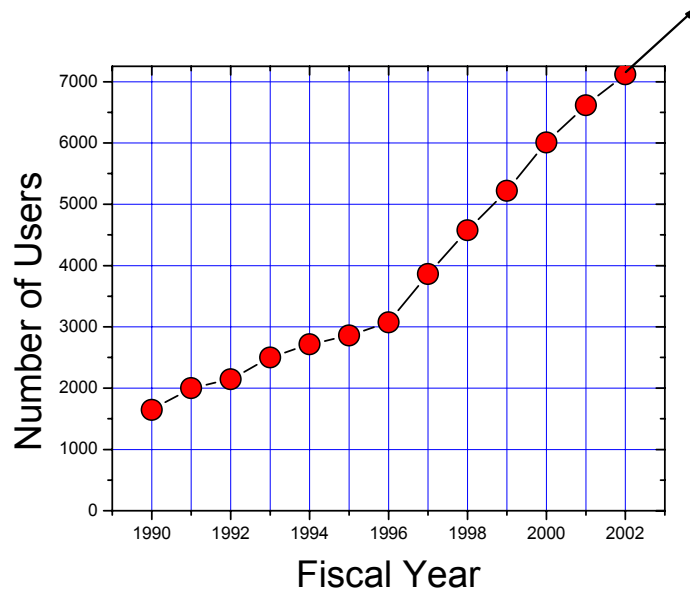
These nondestructive probes provide structural information with sub-micron spatial resolution *in 3 dimensions*. Researchers have measured localized shear stresses due to electromigration in thin conducting wires, and have determined grain-growth, fracture, and deformation behavior in important metal alloys.



Trends in Funding of US Synchrotrons



The number of researchers using the light sources is expected to reach ~11,000 annually when beamlines are fully instrumented.



Flat funding but number of users continually increasing

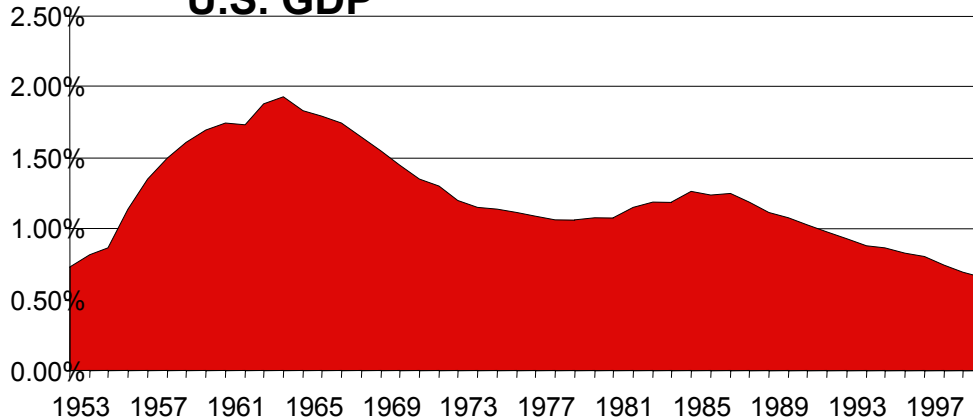
The Basic Energy Sciences program of the Office of Science is the steward and principal funding agency for the operations of the synchrotron radiation facilities.

Substantial increases to the Office of Science funding will permit facility operations and user science support at levels required by the growth of the user population.



Trends in Federal Funding

Federal R&D As a Percentage of U.S. GDP



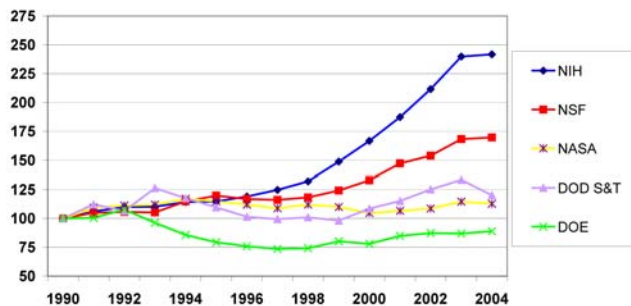
SOURCE: National Science Foundation Engineering Indicators 2002

Federal R&D as a percentage of GDP is in a long term decline...and reached an all-time low in 2000.

In constant dollars, the federal investment in the physical and engineering sciences has stagnated for the last 30 years; the budget for the DOE Office of Science is still only at its 1990 level.

Nearly 50% of growth of the US economy in the last 50 years was due to Federal investment in scientific and technological innovation from research in the physical sciences at our nation's research universities and national laboratories. Further research in these areas will be important for new developments needed in the defense of our nation and economic sectors such as semiconductors, advanced materials and energy efficiency. Additional long-term breakthroughs in the health sciences will rely on strengthening the physical sciences. The growing investment imbalance between biomedical fields and physical sciences and engineering research will hamper the vital connections and reliance among these fields of science.

Trends in Federal R&D, FY 1990-2004 selected agencies in constant dollars, FY 1990=100



Source: AAAS analyses of R&D in AAAS Reports VIII-XXVIII. FY 2004 figures are President's request; FY 2003 figures are AAAS estimates of final FY 2003 appropriations.
MARCH '03 REVISED © 2003 AAAS



The Department of Energy is a Science Agency

Physical Sciences

Mathematics & Computing

Engineering

Life Sciences

Environ. Sciences

R&D Facilities

1. Energy (1,732)	1. Energy (739)	1. DOD (2,169)	1. HHS (13,523)	1. NASA (1,015)	1. Energy (939)
2. NASA (959)	2. DOD (673)	2. NASA (1,964)	2. USDA (1,313)	2. NSF (522)	2. NASA (403)
3. NSF (558)	3. NSF (409)	3. Energy (1,038)	3. DOD (609)	3. Interior (371)	3. DOD (386)
4. DOD (382)	4. HHS (147)	4. NSF (482)	4. NSF (435)	4. DOD (352)	4. NSF (271)
5. HHS (233)	5. Commerce (81)	5. Trans. (300)	5. Energy (313)	5. Commerce (313)	5. HHS (227)

** Numbers are FY 2000 Dollars in Millions (R&D Facilities is FY 1999) - Source: OMB*

*** DOE is sixth in Environmental Sciences with \$306 million in FY 2000*



Funding for Operations at DOE Synchrotrons

Continued funding at prior levels will not address our needs! There will be increasing discrepancy between number of users and operations support - productivity will decline.

Full return on investment not achieved. The DOE synchrotrons produce the world's most powerful x-ray beams yet:

- a significant fraction is wasted because beamlines and/or experimental stations have not been built.
- many beamlines and experimental stations are not fully utilized due to inadequate staffing, or due to outdated equipment.
- research groups are not able to fully utilize resources due to research grants being too few in number and provide too little support.

The DOE Office of Science should be funded so that these facilities may operate at their full potential. Return on investment could be significantly increased with reasonable increases to the facilities for operating funds and to the scientists for research support.



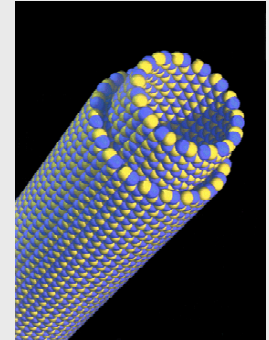
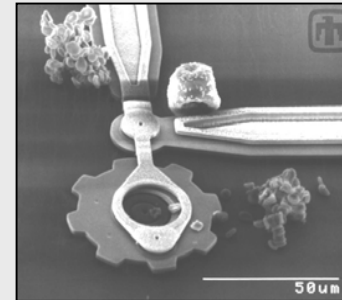
Synchrotrons and the National Nanotechnology Initiative



National Nanocenter User Facilities will be built at Argonne National Laboratory, Lawrence Berkeley National Laboratory and Brookhaven National Laboratory. These new facilities create a direct synergism with the synchrotron radiation facilities at these laboratories.

Nanostructures for high technology.

The emerging fields of nanoscale science, engineering, and technology - the ability to work at the molecular level, atom by atom, to create large structures with fundamentally new properties and functions - are leading to unprecedented understanding and control over the basic building blocks and properties of all natural and man-made things.



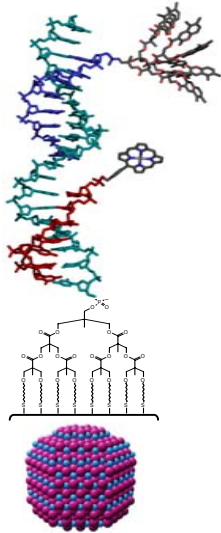
Data from the four light sources will be critical in the design of new materials at the atomic level. These new structures will lead to faster computers, improved solar energy conversion, stronger and lighter materials, more energy efficient catalysts, and better conservation of materials.

New DOE Nanoscience Centers need the synchrotron light sources!

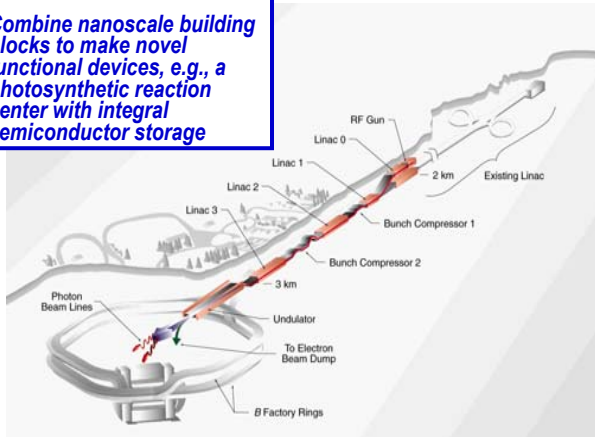
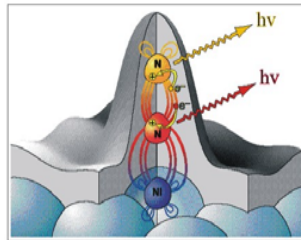
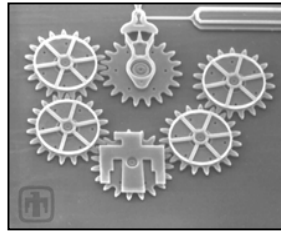


The DOE-BES Light Sources - The Future

21st Century Challenge



Combine nanoscale building blocks to make novel functional devices, e.g., a photosynthetic reaction center with integral semiconductor storage



Increased brightness will lead to significant new scientific breakthroughs

Increase in brightness of x-rays from synchrotron radiation sources has been growing at a rate faster than Moore's Law for the number of transistors per integrated circuit (doubling every two years).

Increased brightness essential for:

- providing 10 nm x-ray beams for characterization of nano-systems.
- improving spatial resolution and time scale in chemical kinetics studies.
- studying materials under extreme conditions
- determining structure of small crystals and large unit cells in protein crystallography

New sources, and upgrades to existing facilities, are planned that will continue this development and continue to provide unique breakthroughs in all fields of science.

The DOE-BES Light Source Users - Support for Increased Funding to the Office of Science



President's Council of Advisors on Science & Technology (PCAST)

recommends “that beginning with the FY04 budget and carrying through the next four fiscal years, funding for the physical sciences and engineering across the relevant agencies be adjusted upward to bring them collectively to parity with the life sciences”.

We urge the administration and the Congress to increase the resources for the DOE Office of Science so that it may provide much needed increases in the support of the synchrotron light sources and Users.

Organizations across the Nation utilize the DOE-BES Light Sources

