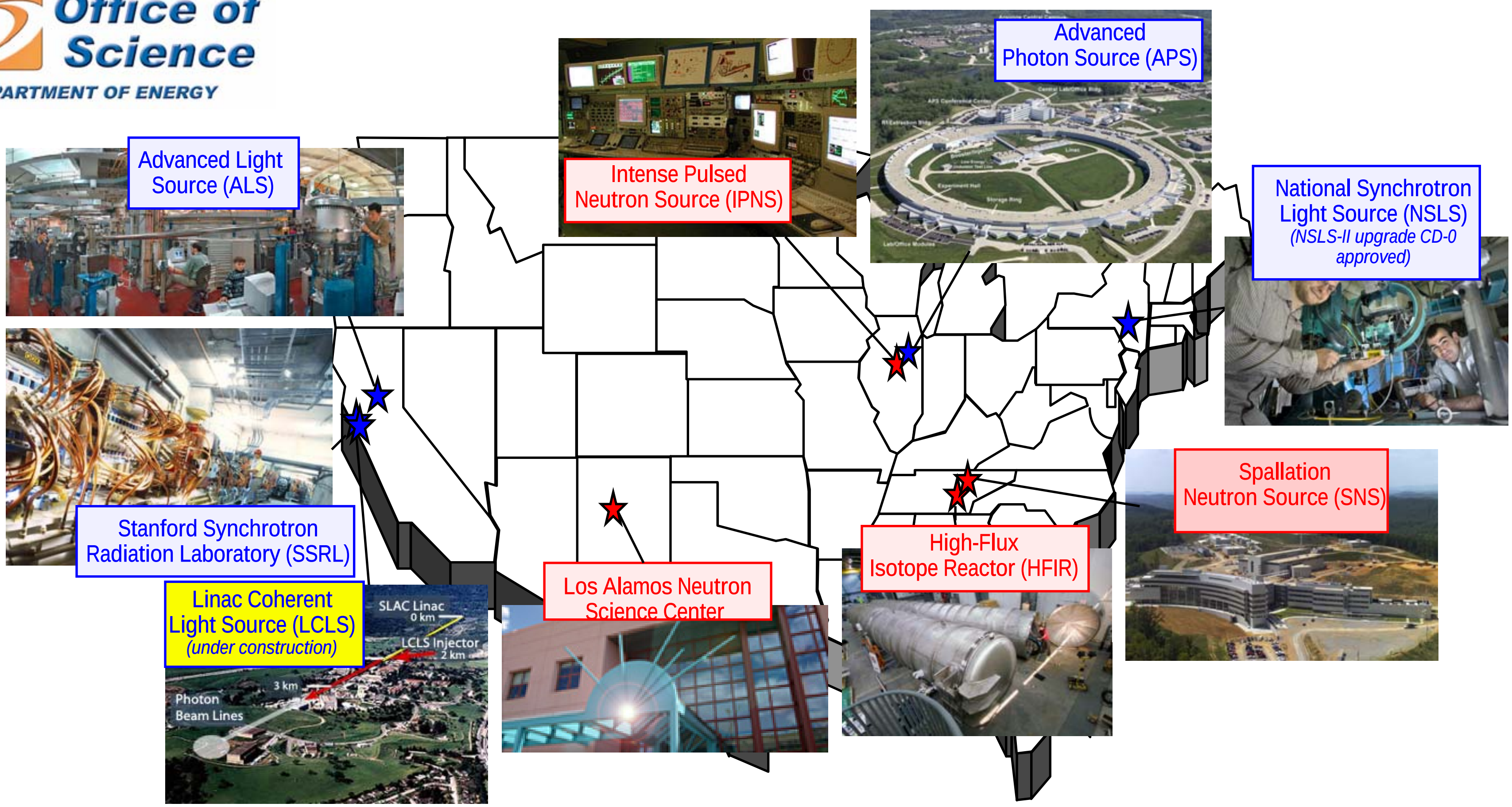
DOE Synchrotron and Neutron Facilities
What They Do, Why They Matter

Office of Science
U.S. DEPARTMENT OF ENERGY



The Synchrotron and Neutron Users' Group (SNUG) represents:

- **5 Photon Light Sources**
- **4 Neutron Sources**
- Including one under construction

Who We Are

The Synchrotron and Neutron Users' Group (SNUG) represents over 9,000 faculty, student, industrial and government scientists. Their research is *critical* to every sector of the economy:

- ***Materials Chemistry and Nanotechnology***
- ***Electronic Materials and Devices***
- ***Energy Production, Storage and Conversion***
- ***National Security***
- ***New Medicines and Disease Treatments***
- ***Environmental Sciences***
- ***Human and Molecular Biology***

- **These scientists are from all over the USA**

- **Their work is critical to American Competitiveness**

Who We Are

Approximately 600 scientists from over 160 companies representing technology, manufacturing, energy, chemical, and bio-pharmaceutical industries use the synchrotron and neutron facilities.

E.I. duPont de Nemours & Co
ExxonMobil Research
Dow Chemical Company
Lucent Technologies
IBM Research Division
Bristol-Myers Squibb
Pfizer Global R&D
SmithKline Beecham
Bruker AXS Inc.
UOP
Merck & Co., Inc.
Abbott Laboratories
PPG Industries, Inc
Eli Lilly & Co.
Pharmacia & Upjohn, Inc.
Glaxo research Institure
Biogen Inc.
Bechtel Nevada
Monsanto/Searle
Emerald BioStructures, Inc
Adelphi Technology, Inc.
Proctor & Gamble
Roche Biosciences
Exxon Research & Engineering Co.
Shering-Plough Research Institute
Fred Hutchison Cancer Research Ctr.
Novartis Inst. for Functional Genomics
Whitehead Inst. for Functional Genomics
McPherson Industries Division of S.I.C.
Containerless Research, Inc.
Structural GenomiX, Inc.
Agouron Pharmaceutical, Inc.
Chevron Research & Tech
3-Dimensional Pharmaceuticals
Boehringer Ingelheim Pharm.
International Fuel Cells
BP-Amoco Corporation
Cummins Engine Company
Dana Farber Cancer Institute
Kinetix Pharmaceuticals
Lockheed Research Lab.
Creatv MicroTech, Inc.
Montell Polyolefins USA
Vertex Pharmaceuticals
MediChem Research, Inc.
Parker Hughes Institute
Applied Materials
Berlex Biosciences
Wyeth Research
Cytokinetics Inc.
EUV Technology
The EXFAS Co.
Indoff/K&M
Komag Co.
Photon Imaging Inc.
Canmet
AMGEN
Chiron Corp.
Tularik Inc.
Aracor
Genetics Institute
Burnham Institute
Intel Corporation
Hoffmann-LaRoche
IBM Corp.
Motorola
Genentech
Hewlett Packard
Eastman Kodak Co.
Advanced Micro Devices
Gladstone Laboratory
STI Optronics, Inc
Northrop Grumman ATDC
Scientific Manu. Techno. Inc
Edge Analytical, Inc.
Digital Semiconductor
National Semiconductor
Ovonic Synthetic Materials Co.
New Century Pharmaceuticals
Area Detector Systems Corp.
Axson Technologies, Inc
Corvas International
Genencor International
Hughes Space & Comm.
Walschon Fire Protection
William Hassenzahl Consulting
Dupont-Merck Pharmaceuticals
The Molecular Biology Consortium
Daimler Chrysler AG
Radiation Monitoring Devices
BASF Bio-Research Corporation
Kraft Foods Technology Center
SFA, Inc.
Corning, Inc
BASF
Orthologics
Alpha Braze, Inc.
Anticancer, Inc.
Aventis Gencell
Chevron
Conductus Inc.
Crystal Logic Inc.
Exelixis
Genomics Institute
GETOM Corp.
Lumileds Lighting
Pyro Fusion
Xradia
Veeco-Ion Tech
Pratt & Whitney
Spectra-Tech Inc
MVA, Inc.
Landauer Inc.
Neocera Inc.
SAIC Corp.
Spectragen, Inc.
Rigaku Corporation
Althexis
Bruker Optics Inc
Panametrics, Inc
Photons Unlimited
Varian Vacuum Products
BioSpace Int'l. Inc
Millennium Chemicals Inc
Dow Corning Corp.
Memc Electronic Materials
Aventis Pharma
Bell Laboratories
NEC Research Institute
Osram Sylvania, Inc.
Princeton Gamma-Tech
Wyerth-Ayerst Research
Advanced Fuel Research
Akzo Nobel Chemicals
General Electric
Pall Corp
Bicron NE
Eveready Battery Co.
Ford Motor
Aerospace Corp.
Hinds Instruments, Inc.
Air Products Chemical Inc.
Rohn & Hass Co.
St. Jude Children's Res. Hosp.
Molecular Structure Corp.
Texas Instruments
Physical Sciences, Inc.
Boeing Co.
Balazs
Xencor, Inc.
Innovene
INOES Technologies
GE Global Research
Palo Alto Research Corp.
Infineon Technologies
Evergreen Solar
Schott Solar
BP Solar
MER Corporation
Micell Technologies
Micron Technologies

WHY Are These Machines So Valuable?

Synchrotrons:

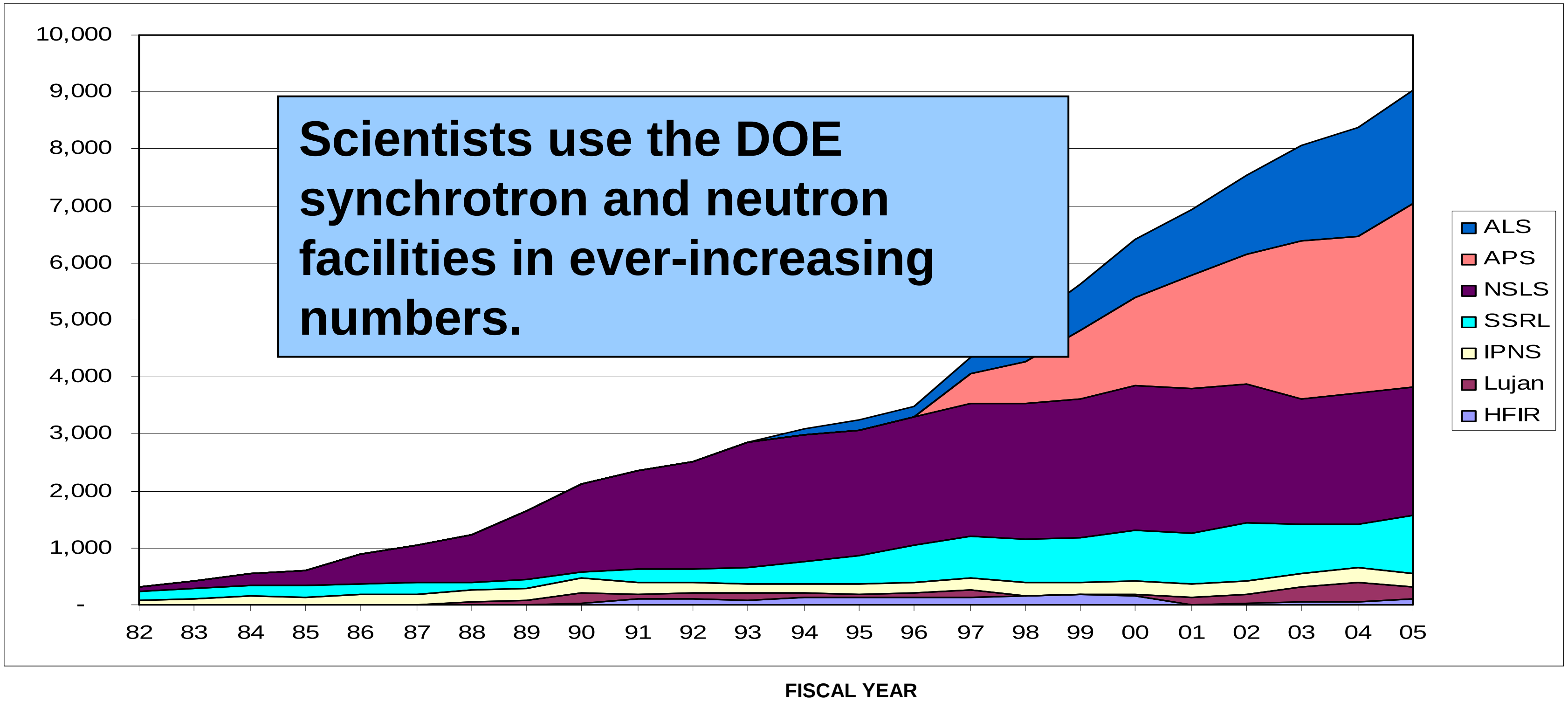
- produce ultra-high intensity light over a wide range of energies from **infra-red** to **visible light** to **ultraviolet** to **X-rays**.
- the energy of this light can be precisely tuned allowing many different kinds of element-specific investigations, such as:
  - » determining atomic scale and **nanoscale STRUCTURE** in proteins, semiconductors, and nanoparticles;
  - » determining the **MECHANISM by which superconductors work, cells respire, diseases infect, and catalysts operate;** or
  - » **ANALYZING and IDENTIFYING trace quantities of harmful substances** in lakes, oceans, air, soils, or human tissues.

Neutrons:

- are uncharged, so they **can penetrate deep into materials to give precise information about positions and motions of atoms** in the interior of a sample.
- are particularly **well-suited to study the magnetic structure and properties of materials**.
- are especially **sensitive to the presence of light elements such as hydrogen, carbon, and oxygen** which are found in many biological molecules.

The federal government is uniquely capable to design, build and operate facilities large and sophisticated enough to be of continuing use to thousands of individual industry and government researchers.

A Significant and Dramatic increase in our fundamental science output is due to our synchrotron and neutron sources



Foreign Nations had 10 synchrotrons worldwide in 1980.

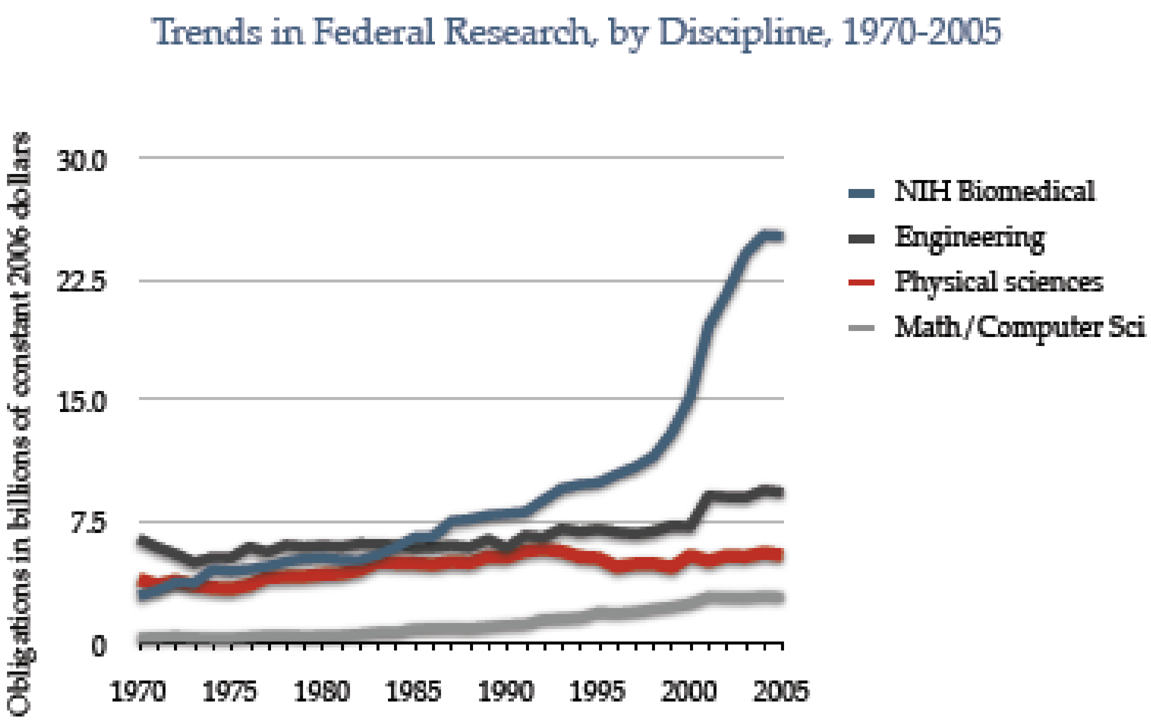
They have > 50 worldwide today, with more under construction.

Considering only beam ports on 3rd generation synchrotrons worldwide, by 2009 the US will be outnumbered by the rest of the world 7:1.

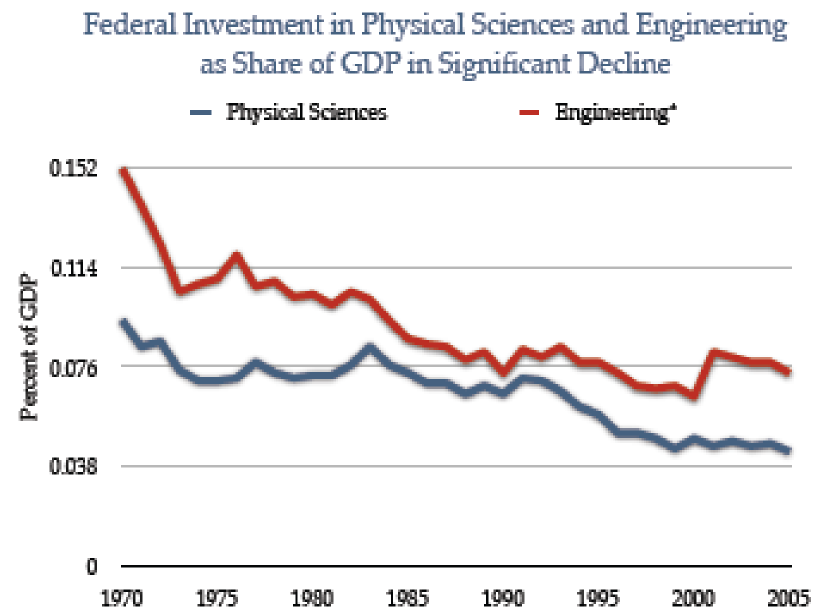
A fully funded Office of Science budget of 4.4 billion and continued future increases would restore more efficient use of this national investment, and greatly increase support for peer-reviewed research into energy efficiency and supply, toxic waste clean up, bio-terrorism and disease detection, electronics, telecommunications, and manufacturing.

Constrained Funding for 35 years has Slowed U.S. Progress

Trends in Federal Research by Discipline, FY 1970-2005



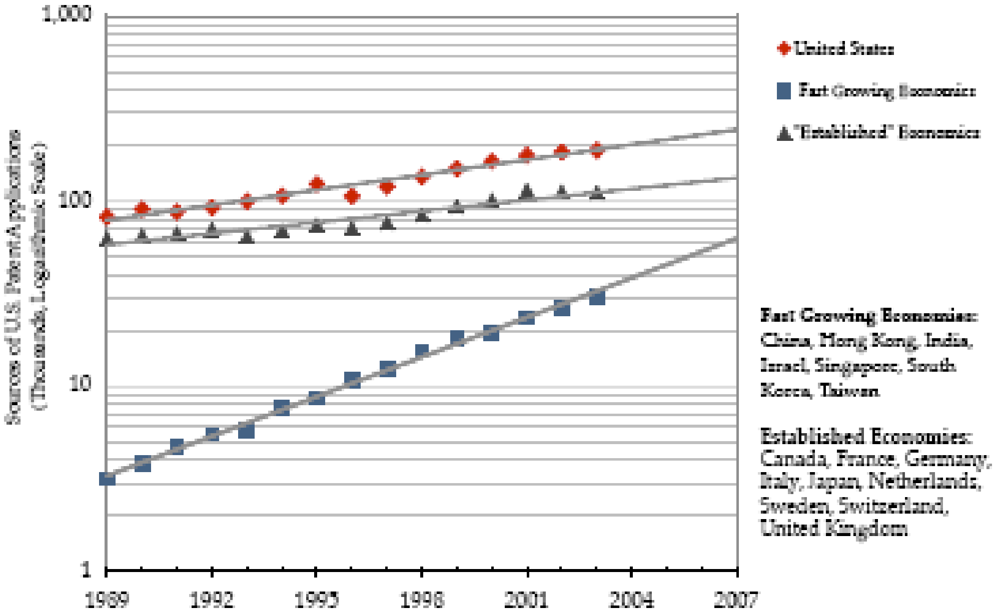
* Other includes research not classified. Includes basic research and applied research, excludes development and R&D facilities. Life sciences -- split into NIH support for biomedical research and all other agencies' support for life sciences.
Source: National Science Foundation, *Federal Funds for Research and Development, FY 2003, 2004, 2005, 2006.* FY 2005 and 2006 are preliminary. Constant dollar conversions based on OMB's GDP deflators for FY 2006.



*The 2001 jump in engineering is due to reclassification of funding and is therefore artificial.
Source: American Association for the Advancement of Science. http://www.aaas.org/spp/rd/guidisc.htm.
Compiled by the APS Washington Office.

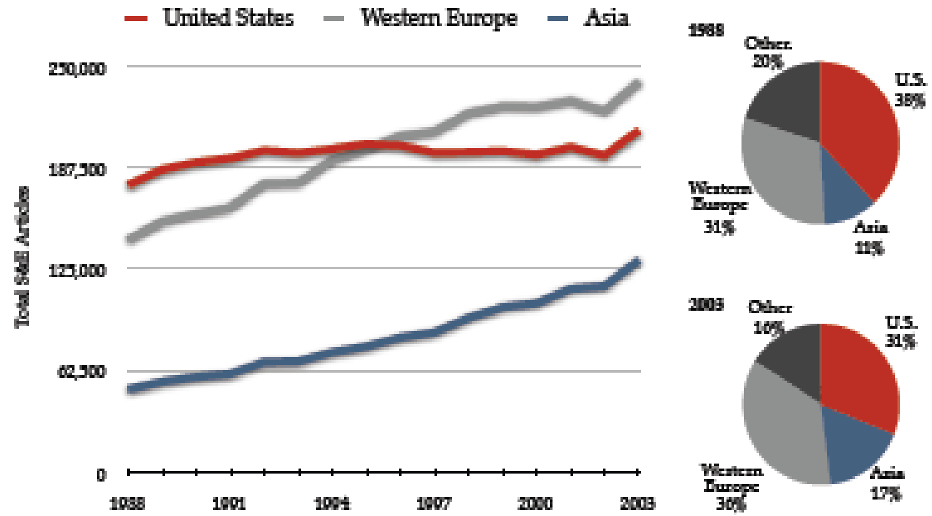
Underfunding Erodes U.S. Position

U.S. Patent Applications:
Fast Growing Economies Gaining on U.S. Rapidly



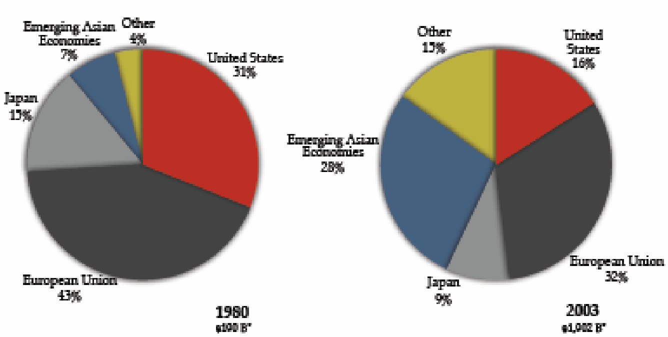
Source: National Science Foundation, *Science and Engineering Indicators 2006.*
Compiled by APS Washington Office.

S&E Publications: U.S. Already Passed by Western Europe, Asia Rapidly Closing



Source: 2006 NSF Science and Engineering Indicators.
Compiled by the APS Washington Office

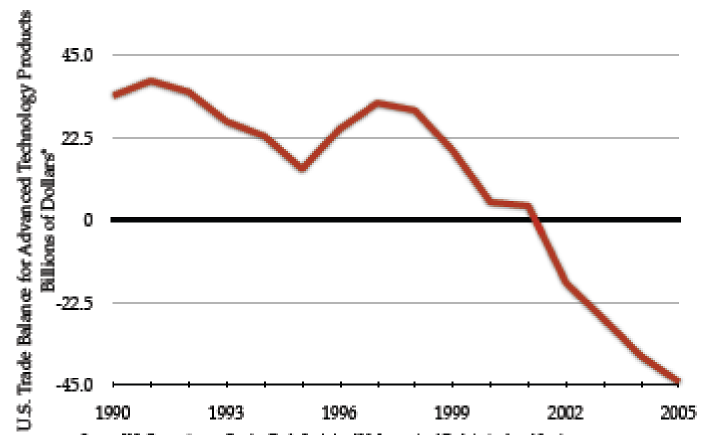
High-Tech Industry Exports:
U.S. Losing World Share



Emerging Asian Economies: China, South Korea, Taiwan, Singapore, Hong Kong, India

* 1997 U.S. Dollars. High-tech includes Aircraft, Pharmaceuticals, Office and computing machinery, Communication equipment, Medical, precision, and optical instruments.
Source: National Science Foundation, *Science and Engineering Indicators 2006*
Compiled by Association of American Universities and APS Washington Office.

U.S. Advanced Technology Trade Deficit Deepens



Source: U.S. Census Bureau Foreign Trade Statistics, *U.S. International Trade in Goods and Services.*
Compiled by the APS Washington Office.
* Constant Chain-weighted 2000 Dollars

Radioisotopes for medical and industrial applications

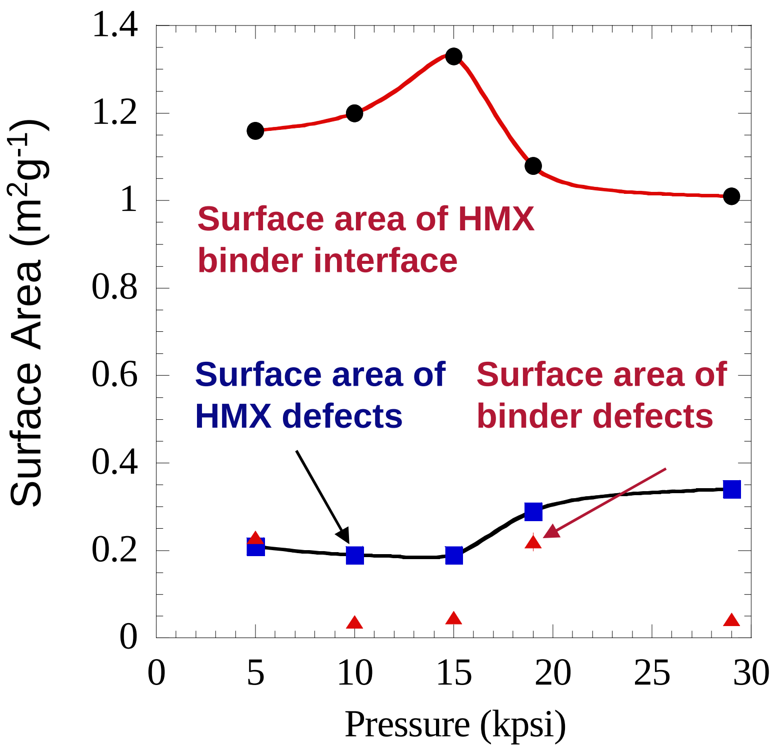
- Radioisotopes are produced for medicine, environmental tracers, basic and applied physical science R&D, and industrial products, e.g.:
  - ^{82}Sr, cardiac imaging
  - ^{65,67}Cu, ^{32}Si for cancer/other research, treatment, diagnosis
- LANSCE customer base consists of over 250 hospitals, research institutions, and private sector companies
  - Customers include major pharmaceutical manufacturers, such as GE Healthcare, Mallinckrodt, and DuPont
  - Demand is growing
- In January 2007, LANSCE addressed a critical national shortage of ^{82}Sr by dedicating operations to supply over 10,000 cardiac patients nationwide with this vital radiopharmaceutical

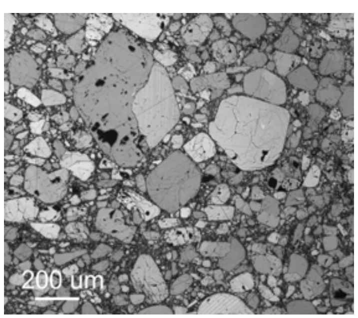
The new $23 M, 100 MeV Isotope Production Facility (IPF) at LANSCE.

DUPONT The miracles of science

MALLINCKRODT

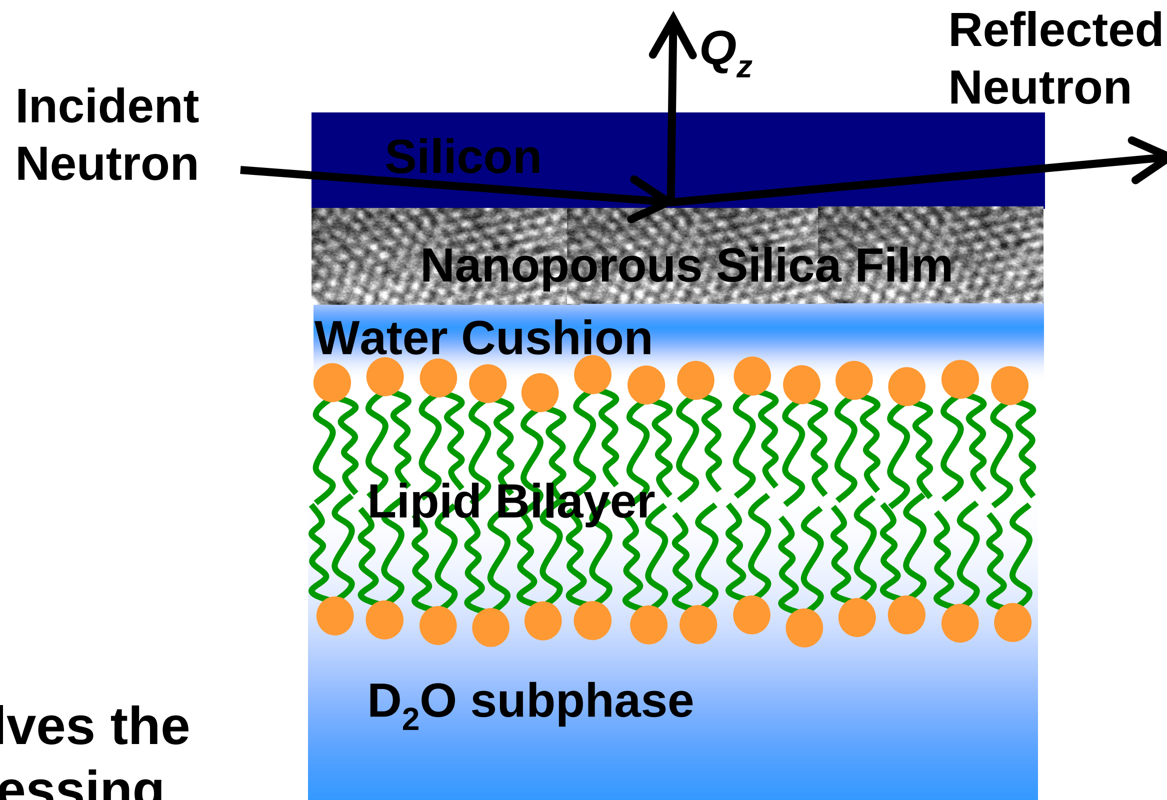
Soft matter research contributes to national security





Scattering resolves the influence of pressing force on cracking.

High explosives



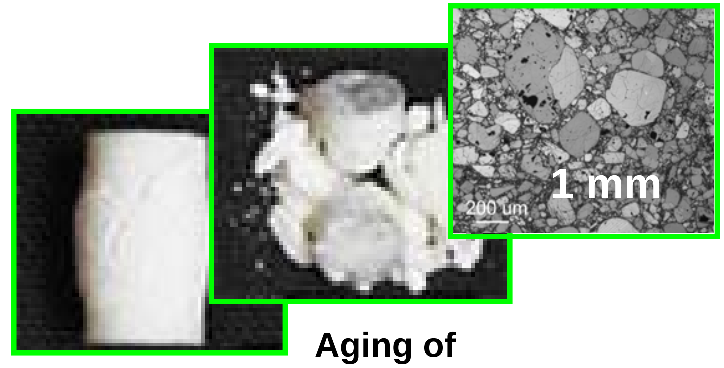
Biosensors identify battlefield agents.

Biothreats

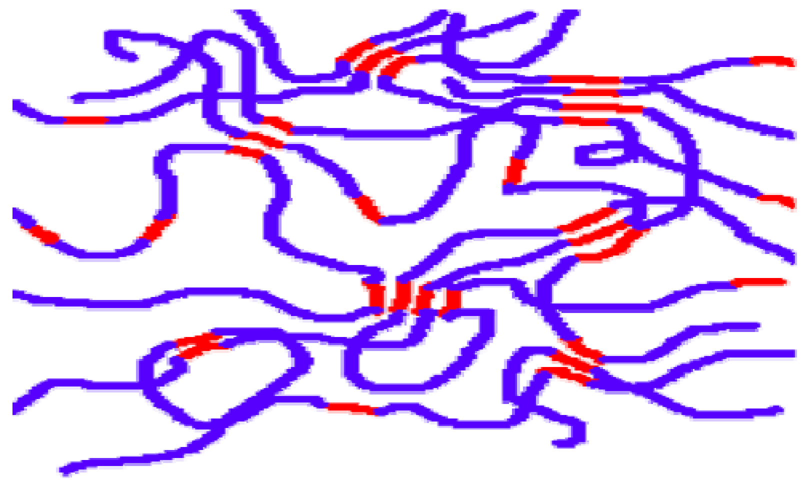
LANSCE LUJAN CENTER Los Alamos National Laboratory

Small-angle Neutron Scattering Reveals How High Explosives Age Ungracefully

- Researchers have found that polymer explosives age due to a process called crosslinking, which decreases material strength
- Study of this problem **can aid in national defense applications, where an understanding of the aging of explosives** is essential. Neutron scattering can help to determine the molecular origin of polymer aging and correlate this with mechanical properties.



Aging of PBX9501



Work funded by DOE

Polymer Preprints, 93, 294-295 (2005)

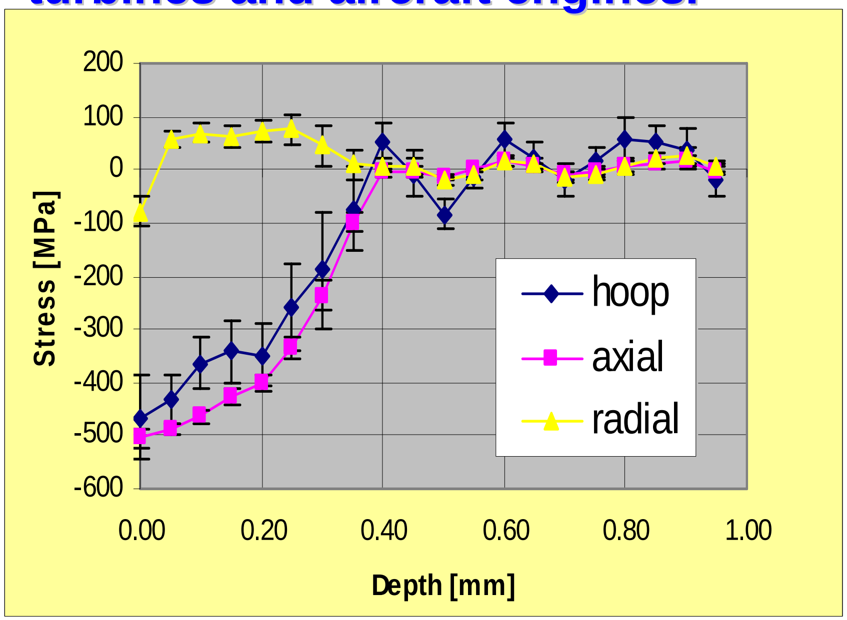
Los Alamos NATIONAL LABORATORY EST. 1943

NNSA

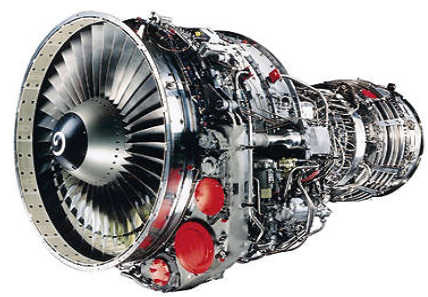
Characterizing Industrial Materials

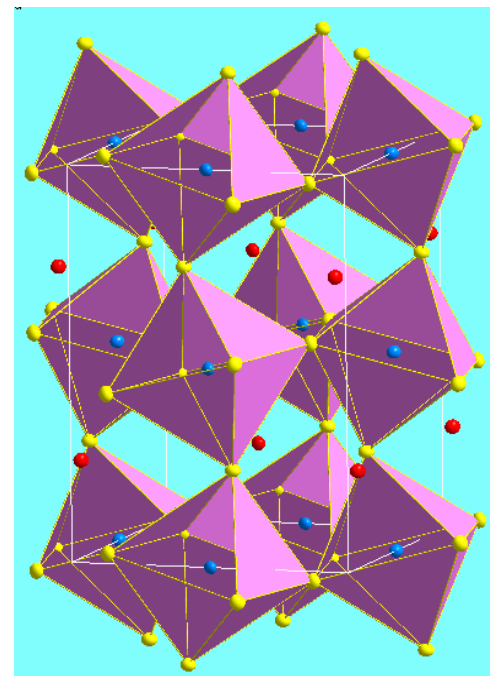
GE is using unique synchrotron capabilities to analyze residual stresses, which contributes to understanding of **life and performance of gas and steam turbines and aircraft engines.**

GE is developing novel classes of ceramics with improved performance for **lighting, medical imaging and homeland security applications**.



Non-destructive analysis of residual stress distribution below surface with high-energy x-rays





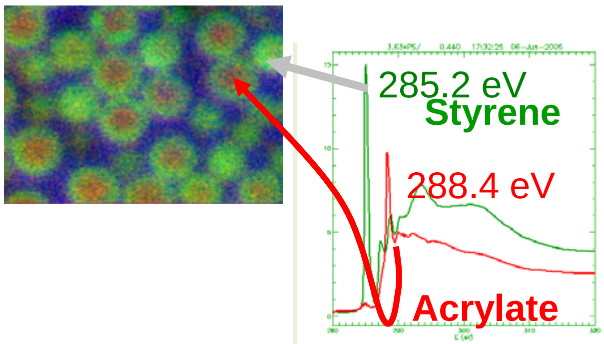
Accurate determination of atomic positions in a doped Lu and Al based perovskite crystal using neutron diffraction

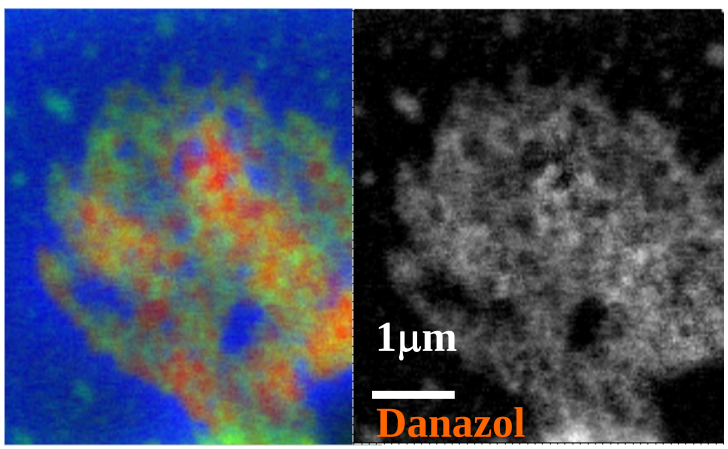
Funded by GE Global Research

GE Global Research

Improving America's Billion Dollar Industries: From Paper Coatings to Baby Diapers

DOW Chemical Company funds synchrotron studies on diverse materials in order to characterize new materials and methods for manufacturing. The synchrotron x-ray microscope was used to:





Imaging using different x-ray energies reveals the composition of hollow latex particles (top); and shows the location of drug vs inert components (bottom).

…reveal the substructure of hollow latex particles, which helped DOW researchers determine how to make them work as glossing aids in paper coatings.

…analyze drug particles that had been enhanced for bioavailability.

…reveal the phase structure of membranes used to purify water.

…characterize super-absorbent polymer materials used in baby diapers

In all these examples, DOW used the experimental results to help develop new process technology for manufacturing plants.

ALS ADVANCED LIGHT SOURCE

Research funded by DOW Chemical Company

Low Weight Magnets for all purposes

General Motors and the University of Missouri have used neutron diffraction to determine the magnetic structure of a new permanent magnet material. This led to the identification and understanding of the magnetic structure of $Nd_2Fe_{14}B$, which has since become widely used as a permanent magnet in electric motors.

Because of very favorable magnetic characteristics, combined with relatively low cost and low weight, this material has allowed for the development of more compact electric motors that find a wide range of applications.

This technology is found in electric windows in cars, in almost every computer hard drive, speakers and roller coasters.

A crucial engineering challenge to making this car actually happen is the 53 kw "Generator". A great leap forward in technology will be made possible because of new magnet technologies used in permanent magnet motors [from GM website].

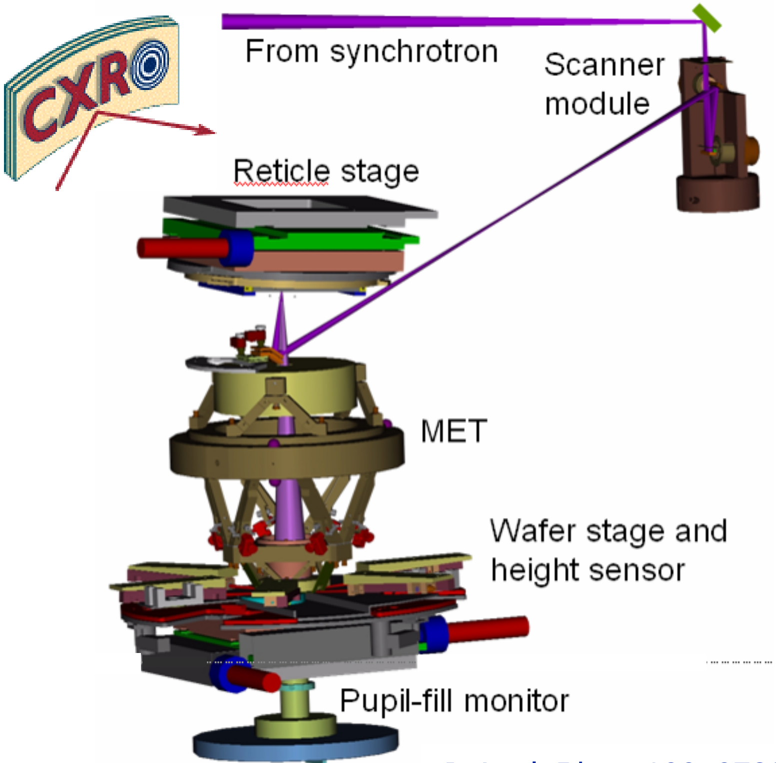
Work done at the University of Missouri Research Reactor

HFIR Center for Neutron Scattering

More Powerful Computers for the Information Age

Improved computational power comes from shrinking transistors to squeeze more of them into a microprocessor. Extreme Ultraviolet (EUV) Lithography is the leading next generation technology to make those continued improvements possible. The pioneering work done with synchrotron radiation has driven this technology forward toward commercialization.

EUV lithography exposure tool using synchrotron radiation

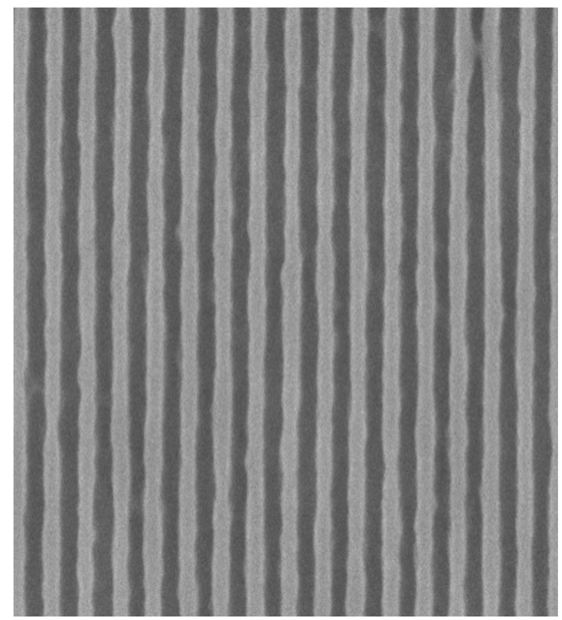


J. Appl. Phys. 100, 073303 (2006)

Funding organizations include SEMATECH, Intel, IBM, AMD, Micron, Samsung, Qimonda

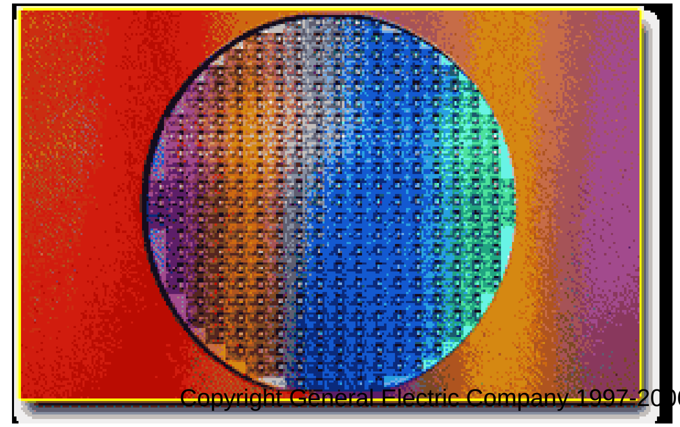
ALS ADVANCED LIGHT SOURCE

Printed image showing 28 nm circuit lines in photoresist

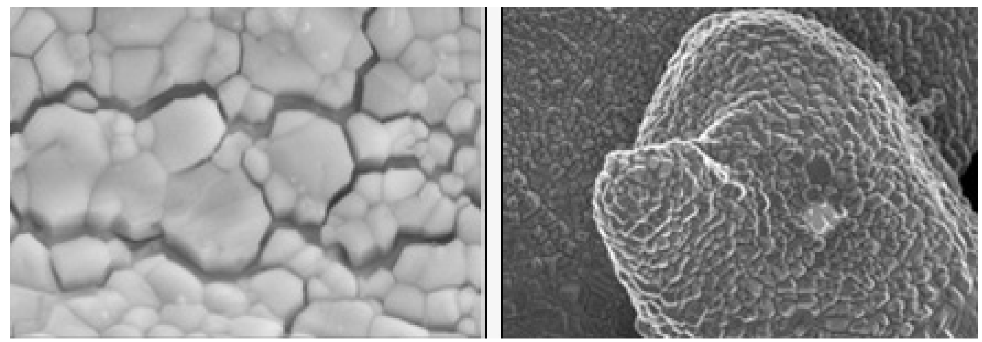


Current technology will allow manufacturers to print circuits as small as 45 nm in width, or 1/2,000th the width of a human hair. EUV lithography technology will extend this down to 22 nm or less, paving the road to 20 GHz computers and beyond.

Tougher Electronic Components?



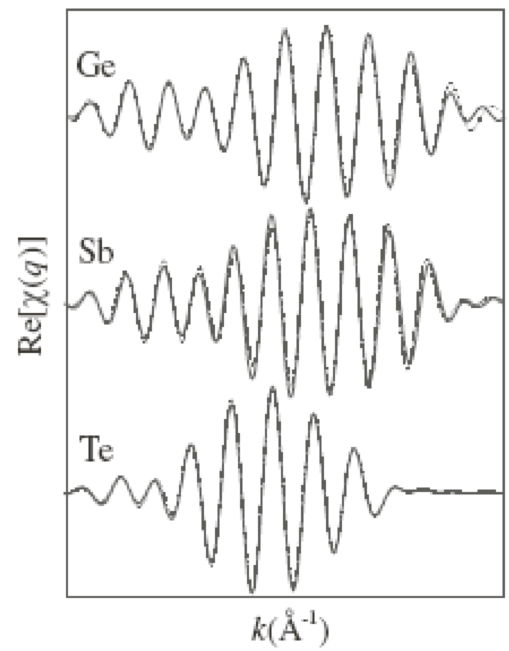
- Researchers at the APS have used extreme temperatures and pressures to make two durable compounds called noble metal nitrides
- Both nitrides possess diamond-like hardness, and some compositions might have very low, nearly super-conductive electrical resistance—a blend that could prove valuable to industry
- The two could eventually replace titanium nitrides used by semiconductor industry as surface coatings because of their strength and durability



SEM image of iridium nitride crystals (left), SEM image of platinum nitride crystals (right). (Courtesy: Carnegie Institution of Washington)

Fast-forward to Better DVDs?

- High-brightness x-rays let us search for important new information about mature technologies
- DVDs are composed of alloy w/3 elements: germanium, antimony, tellurium. North Carolina State University researchers used EXAFS to examine the alloy at the microscopic level. Bond constraint theory produced optimum ratio of elements within the material
- Ability to "fine tune" the alloy could lead to the development of more efficient data storage devices, remotely reconfigurable electronics (e.g., computers sent into orbit and reprogrammed in place as needed)

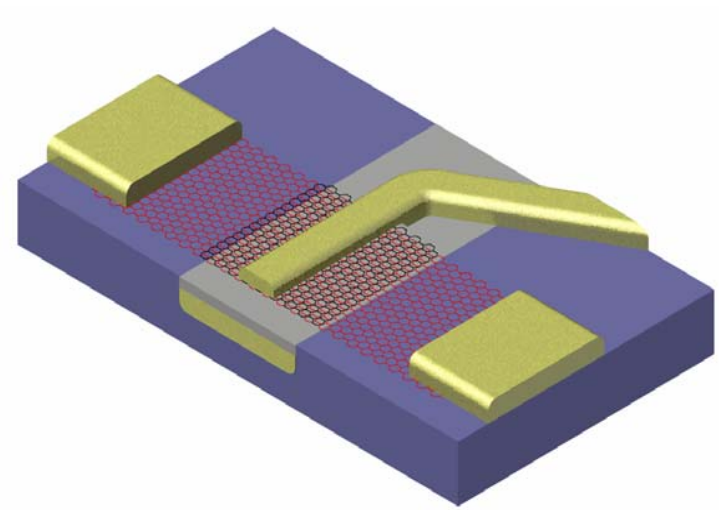


Plots of k^3-weighted normalized EXAFS spectra for $Ge_2Sb_2Te_5$. Solid lines are data; dashed lines are fits.

D.A. Baker et al., Phys Rev Lett 96, 255501, (2006)

ARGONNE NATIONAL LABORATORY

The Next Leap in Computer Size: the Nanoswitch



Graphene, a single honeycomb layer of carbon, is the building block of graphite, nanotubes, and buckyballs.

Recent experiments at the synchrotron using angle-resolved photoemission demonstrated that is it possible to use a bilayer of graphene as a switch: current flows when the switch is closed (bilayers electronically close together), and does not flow when the switch is open (bilayers electronically separated).

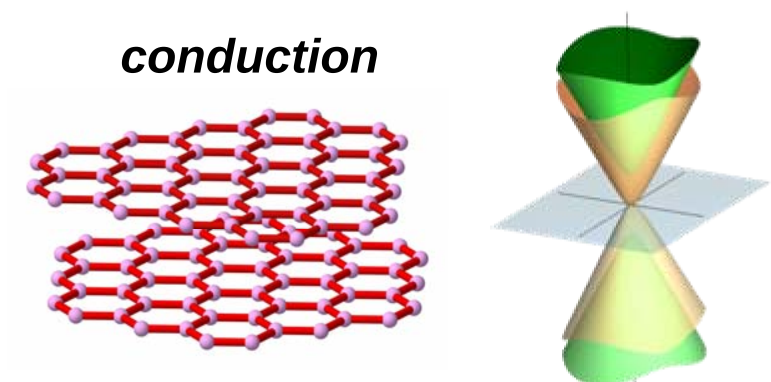
This proves it is possible to build and control an electronic switch as small as two atoms, paving the way for computers at least 100 times smaller than current technology allows.

ALS
ADVANCED LIGHT SOURCE

Science, 313, Aug 2006.

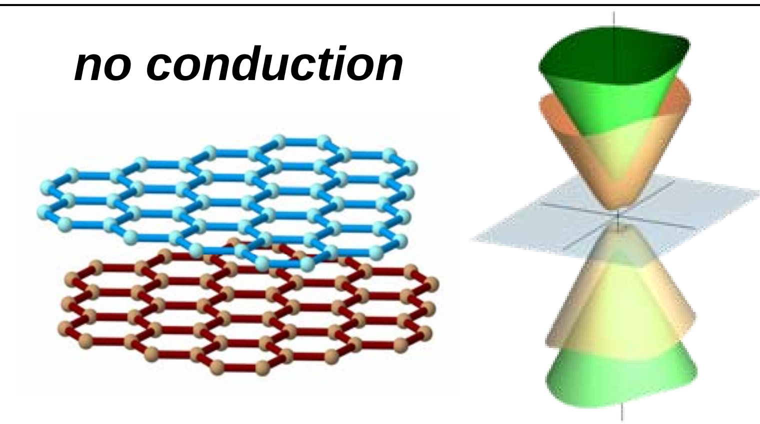
Unbiased

conduction



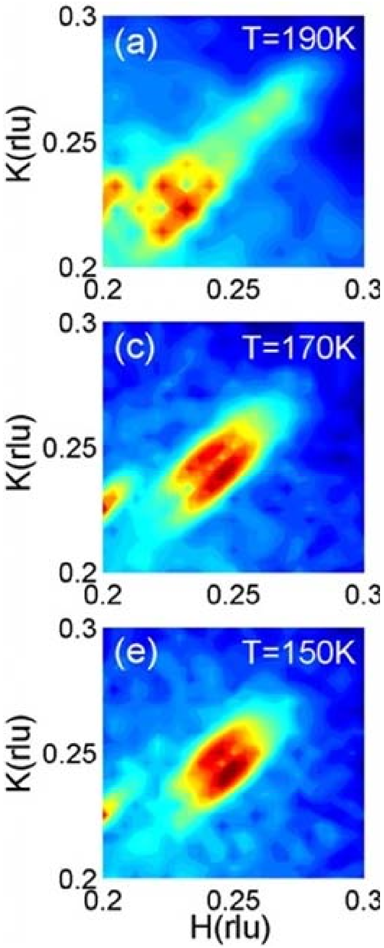
Biased

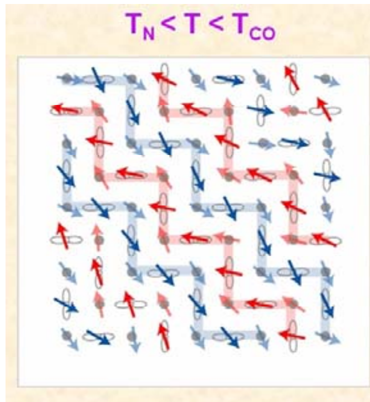
no conduction

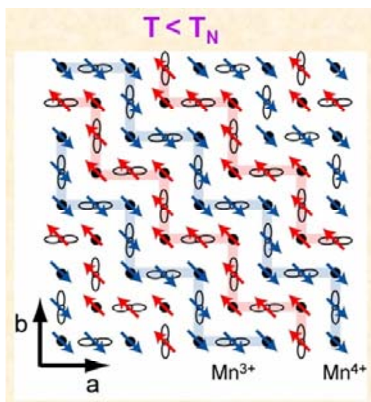


Research funded by: DOE, the Max Planck Society, and the European Science Foundation

Improved Data Storage: Liquid Crystal-Like States in Colossal Magnetoresistance Materials







Neutron scattering in a CMR material (left panel) revealed that the charge order in the insulating state is formed by linear spin chains that are weakly coupled (top right panel). Eventually these chains lock in a two-dimensional structure (bottom right panel).

Ye, et. al., *Phys. Rev.* B **72**, 212404 (2005).

In recent years, a great deal of attention has been paid to a new class of materials that exhibit huge changes in their electrical resistivity when a magnetic field is applied.

The interest in these colossal magnetoresistance (CMR) materials stems from the fact that **the unusually strong coupling between the magnetism and electron transport in these materials could be used in technological applications like data storage or magnetic sensors.**

This technology could improve data storage by 1000%.

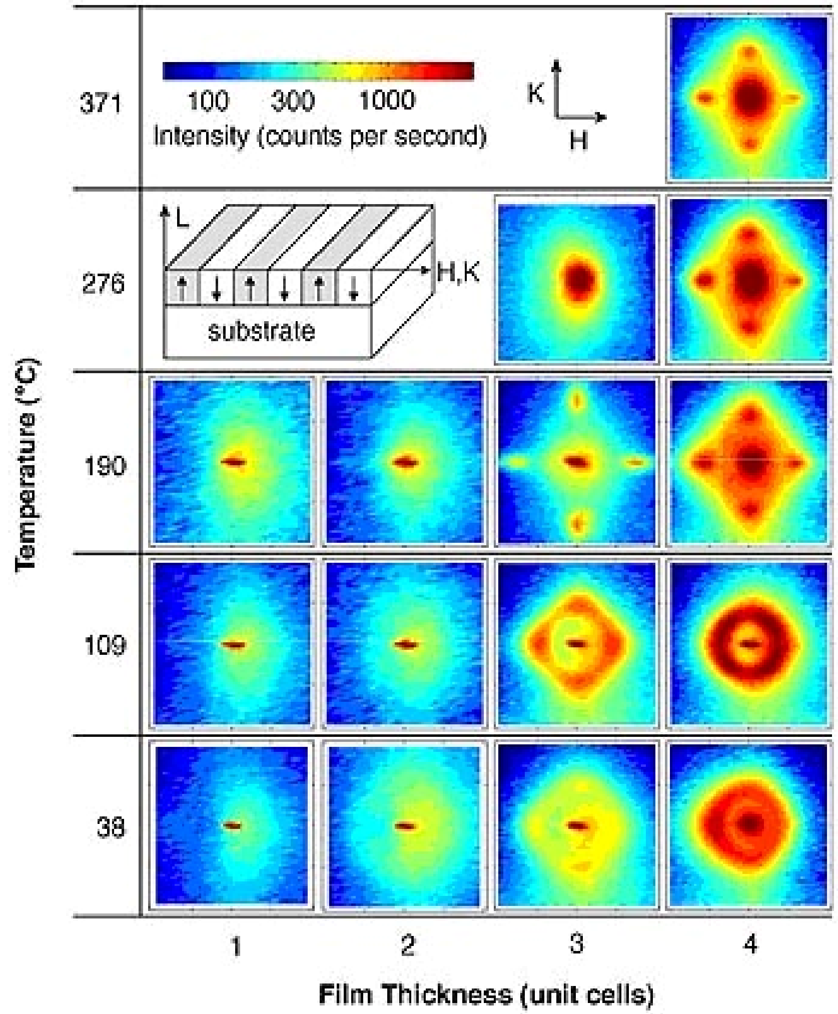
Work funded by DOE

A Major Discovery for Tiny Devices

Synchrotron-based research has shown that the ability to generate and hold a switchable electric field (ferroelectric behavior) is possible in materials as thin as 1.2 nanometers (one-billionth of a meter, several hundred thousand times smaller than the period at the end of this sentence).

Ferroelectric thin films have a broad range of applications for both military and industrial equipment including specialized light and infra-red sensors, memory systems involving holographic optical storage of unprecedented capacity, tuneable microwave components (useful for phase-array radar), and microelectromechanical systems.

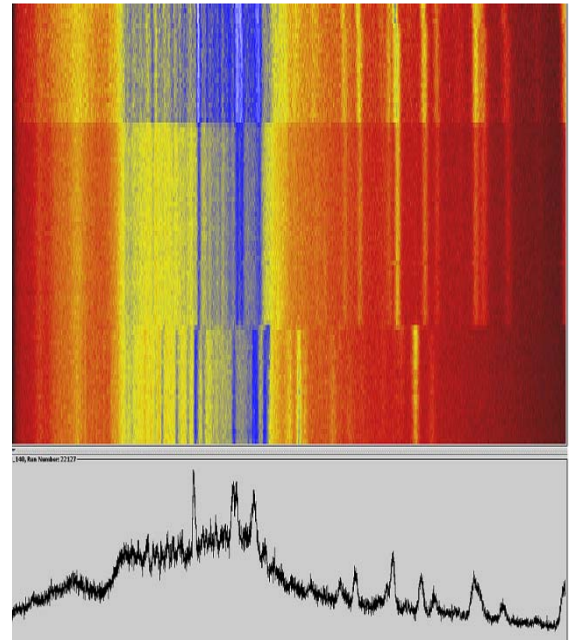
The technological potential of these materials depends on maintaining stable ferroelectric properties as electronic devices continue to be miniaturized. Studying such devices requires Synchrotron-based techniques.



Intensity of ferroelectricity (the ability to retain a switchable electric polarization) over a range of temperatures.

.

Improved Catalysts Reduce CO_2 Emissions



Acrylonitrile-based acrylic fibers are used to make many things, for example clothing, carpeting, blankets and rubber for hoses and gaskets.

About 5,000,000 tons of acrylonitrile are made each year, with CO_2 as an undesirable byproduct. Neutron powder diffraction analyses have been critical to the **development of manufacturing catalysts that perform best at the high reaction temperatures, therefore reducing CO_2 by as much as 33% compared to previous catalysts.**

Work funded by Innovene

INEOS Technologies

Argonne NATIONAL LABORATORY

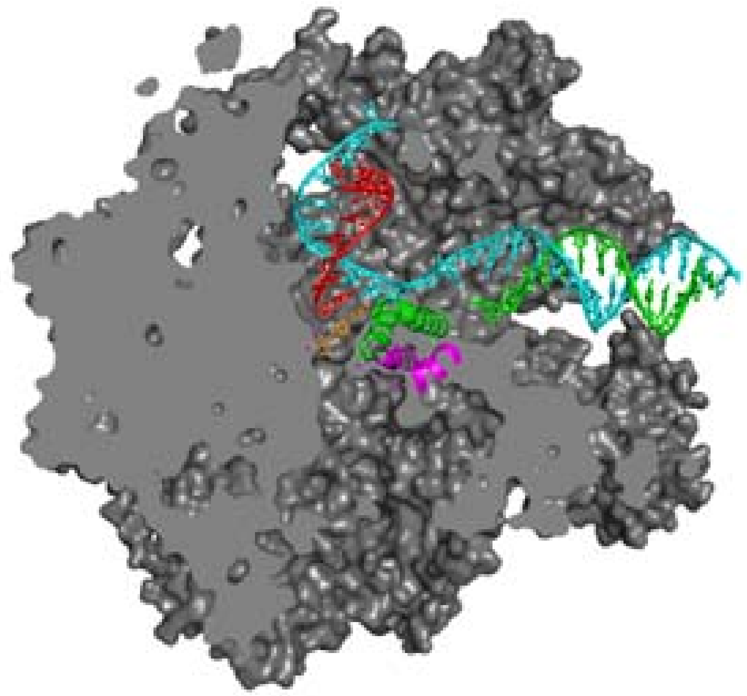
bp

innovene

Nobel Prize Work on Gene Transcription

Life as we know it depends on turning on and off the proper genes at the correct time. Gene transcription is how our DNA gets translated into proteins, and ultimately into biological organisms. This work done by the 2006 Chemistry **Nobel Prize Laureate Roger Kornberg** at the SSRL and ALS synchrotrons shows the structural basis of this. This work can potentially lead to insights into cancer treatment, gene therapy, and other important disease treatments.

This process of gene expression starts when an RNA message is copied from DNA. But the exact mechanism by which RNA does this has not been well understood. The study revealed that a structural element of the RNA enzyme called the trigger loop is involved.



Cutaway view of the Pol II transcribing complex. Template DNA, nontemplate DNA, RNA, GTP in the A site, are shown in cyan, green, red, orange, respectively. The bridge helix (Rpb1 815-848) is in green; trigger loop (Rpb1 1065-1110) is in magenta and Mg2+ ions are shown in magenta spheres. The pol II surface is shown in gray.

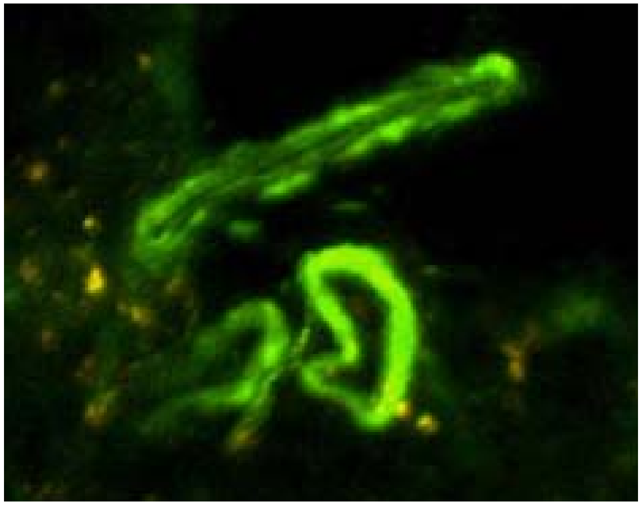
Wang, D., Bushnell, D.A., Westover, K.D., Kaplan, C.D., and Kornberg, R.D. (2006) Structural basis of transcription: role of the trigger loop in substrate specificity and catalysis. Cell 127, 941.

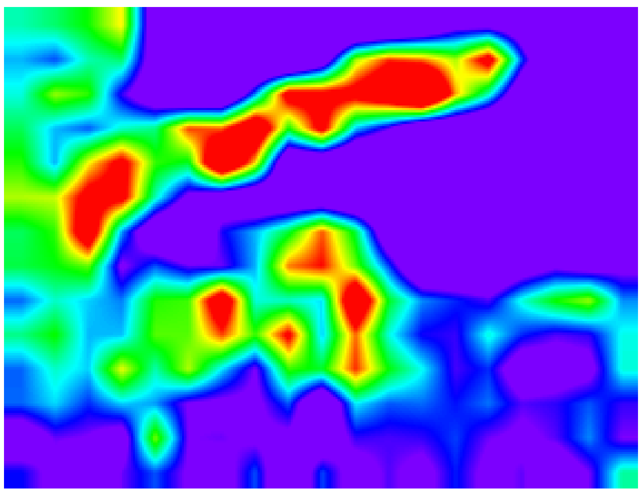
SSRL

Research team includes Stanford University, SSRL and ALS

ALS ADVANCED LIGHT SOURCE

Preventing Plaque Formation in Alzheimer's Disease





In Alzheimer's Disease (AD), the brain contains a buildup of a misfolded protein, called "plaque," that is believed to kill brain cells. It is thought that normal metal ions in the brain play a role in plaque formation. At the NSLS and APS, scientists showed that copper and zinc ions accumulate in AD plaques, suggesting that metal ions may impact plaque formation**.**

These findings can be used for developing drugs to prevent this process.

Funded by National Institutes of Health

Eli Lilly is in the process of starting a collaboration to extend this work

L. Miller *et al.*, *J. Structural Biology* in press.

nsls IR UV X

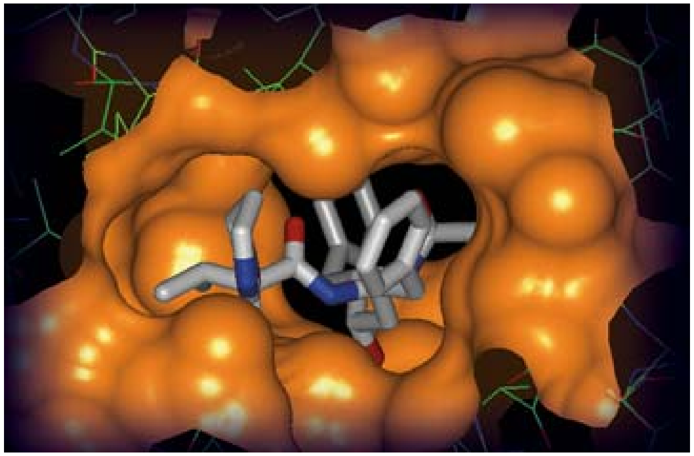
Argonne NATIONAL LABORATORY

Slowing the Progress of AIDS

Important weapon in battling the scourge of HIV has been forged from knowledge gained at the APS

AIDS caused by HIV virus, which produces 12 different kinds of proteins. Organic compounds that interact with these proteins, interfere with virus reproduction are potential drugs for treatment of AIDS.

- X-ray crystallographic studies of protein HIV protease reveal atomic details of how compounds interact with protein.
- Also: determination of crystallographic structure of the Abbott Laboratories pharmaceutical known as Kaletra®.
- Since FDA approval in 2000, Kaletra® has had positive impact on progression of the AIDS in patients infected with HIV virus.
- In 2002, Kaletra® became the most-prescribed ("preferred") drug in its class for AIDS therapy; referred to as a drug that helped turn a situation where patients were dying from AIDS to a situation where patients are living with AIDS.



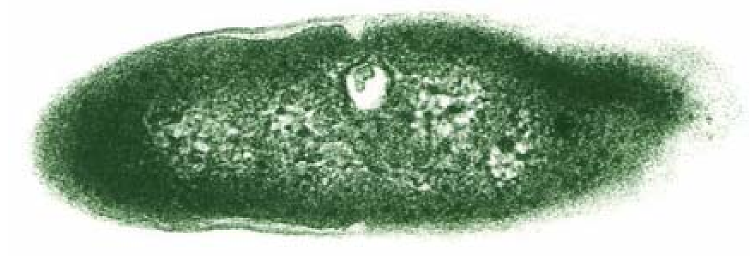
Close-up view of the drug binding site within HIV protease. A mathematically calculated surface (orange) shows the active site of the protein is a cavity inside the protein. The drug fits inside this cavity, much like a key fits into a lock. X-ray crystallography studies provided the scientific details of how the atoms of Kaletra® (carbon atoms are gray; nitrogens, blue; oxygens, red) interact with the viral protein.

Abbott Laboratories

Argonne NATIONAL LABORATORY

Making Methanol: How Bacteria Do It

- How to exploit the fuel potential of extensive methane reserves?
- Converting methane to methanol would make natural gas a desirable energy alternative
- Certain bacteria can live on methane by turning it into methanol
- Studies at the APS characterized the first enzyme (pMMO) in the pathway that bacteria use to convert methane to methanol *at room temperature*
- Synthetic production of methanol from methane has required high temperatures for catalysis—temperatures at which methanol not stable
- Provides clear picture of the enzyme structure and is an important breakthrough in understanding how to improve the synthesis of methanol



Methanobacterium, a methane producing bacteria

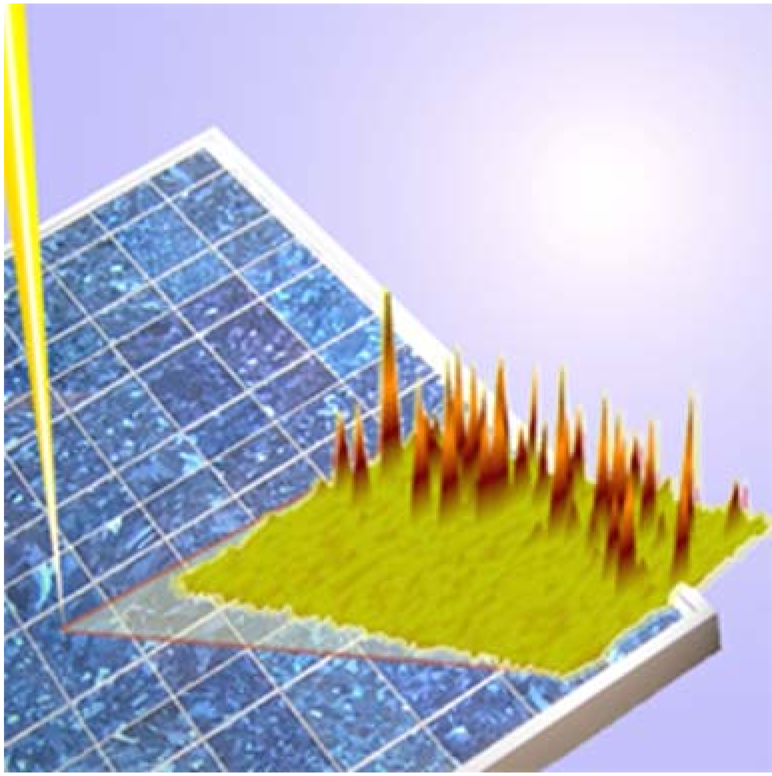
Structure of pMMO, showing three subunits and metal centers (cyan: copper; magenta: zinc). A semi-transparent molecular surface is superimposed.

ARGONNE NATIONAL LABORATORY

Cheaper, More Efficient Solar Cells

The efficiency of solar cells depends on their purity, but ultrahigh-purity silicon is expensive and difficult to produce. Previous research efforts have concentrated on ways to decrease contaminants in solar cells. Now scientists at the synchrotron have discovered an alternative: "lasso" the contaminants into one area, rather than trying to get rid of them altogether.

This process, dubbed "defect engineering", is much easier and much more cost-effective than trying to produce ultrapure silicon. These studies show that **solar cells with defects confined to smaller areas outperform up to 4 times solar cells with the *same total number of defects* spread over a larger area.**



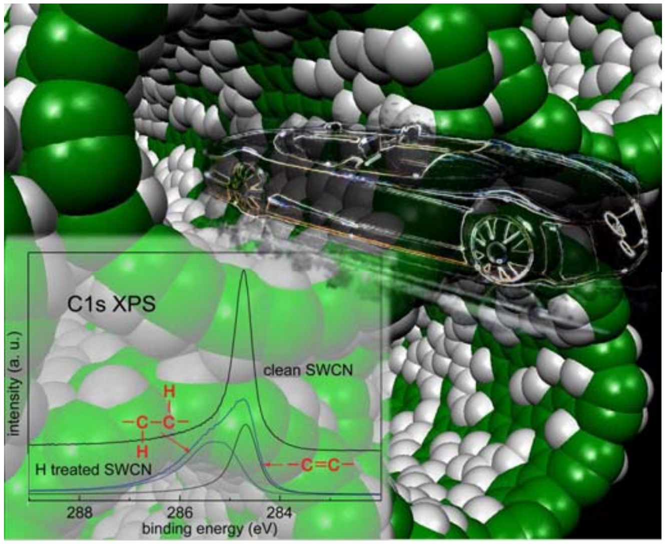
Synchrotron x-ray beam strikes the surface of a solar cell and produces fluoresence which is used to determine the type and location of impurities (Artist's rendition).

Work supported by: the National Renewable Energy Laboratory, GE Energy, Evergreen Solar, Schott Solar, BP Solar.

Nature Materials **4**, 676 (2005);
J. Crystal Growth, **287**, 402-407 (2006)

ADVANCED LIGHT SOURCE

Steps Toward Hydrogen Vehicles

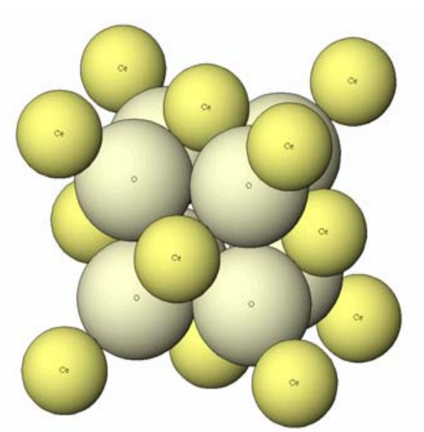


Nikitin et. al., *Phys Rev Lett.* **95**, 225507 (2005)

Synchrotron research has shown that **carbon nanotubes, 50,000 times more narrow than a human hair, are a promising material for storing hydrogen safely, efficiently and compactly.**

The **DOE Freedom CAR program** has set the goal of a material that can hold 6% of the total weight in hydrogen by the year 2010. Theoretical calculations indicate they may exceed these goals substantially.

Funded by DOE, NSF and Global Climate and Energy Project (alliance of scientific researchers and leading companies in the private sector, including ExxonMobil, General Electric and Schlumberger)



Liu, et al. J. Phys. Chem. B. 108, 2931 (2004)

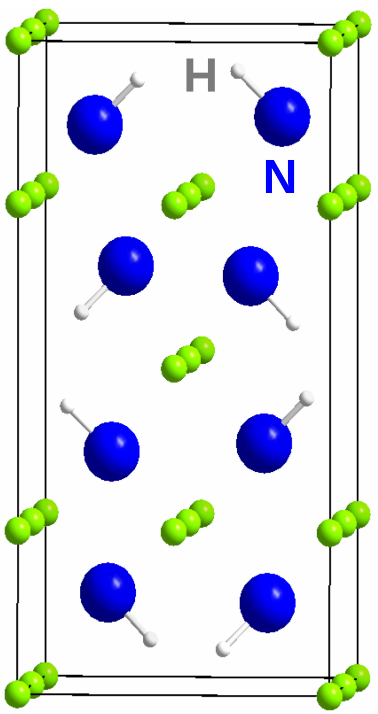
Scientists at NSLS are studying nanoparticles made of the compound ceria that could **improve the ability of catalytic converters to lead to more efficient ways to generate hydrogen fuel because it is clean and renewable.**

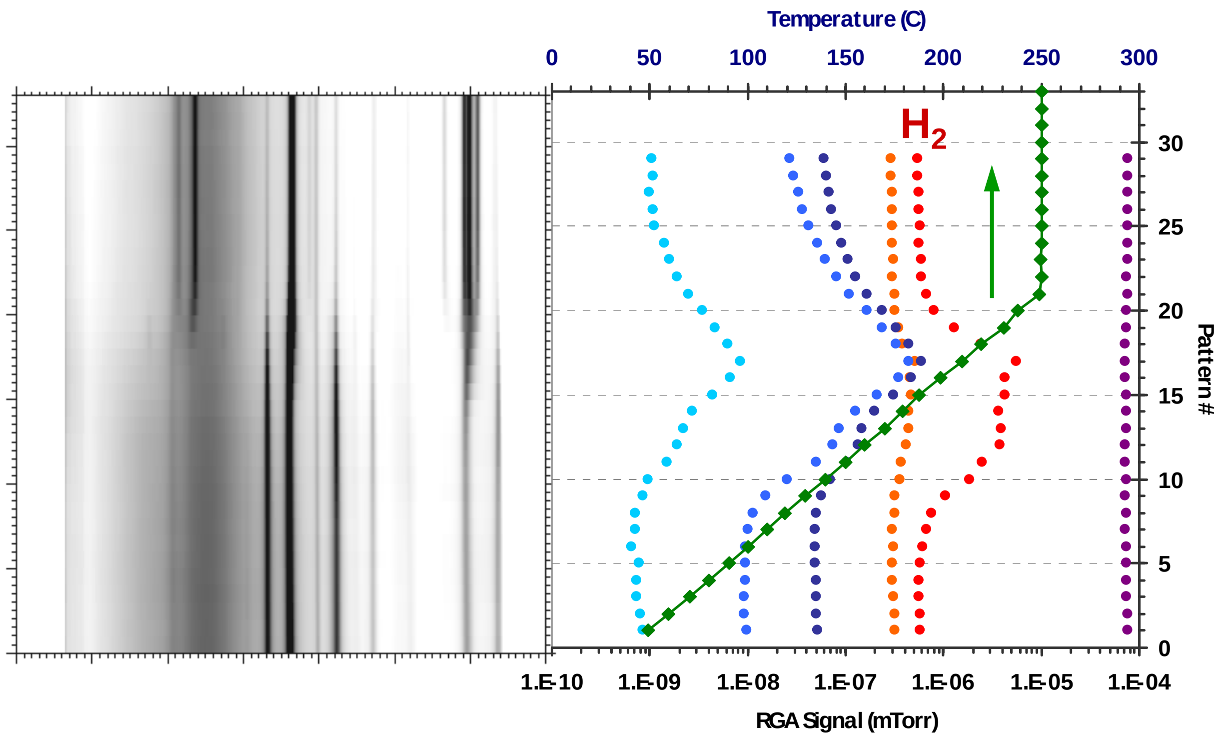
Funded by DOE and NSF

Discovering Hydrogen Storage Materials

Aiming at using hydrogen as an alternative fuel, **GE is working with DOE to develop onboard hydrogen storage storage materials for automotive applications**. $Li_2Mg(NH)_2$, which contains 5.6% hydrogen and has reversible storage capability, has been the recent research focus. GE is using both synchrotron x-rays and neutrons to study the reaction pathways and crystal structures in unprecedented detail.

Structure of $Li_2Mg(NH)_2$

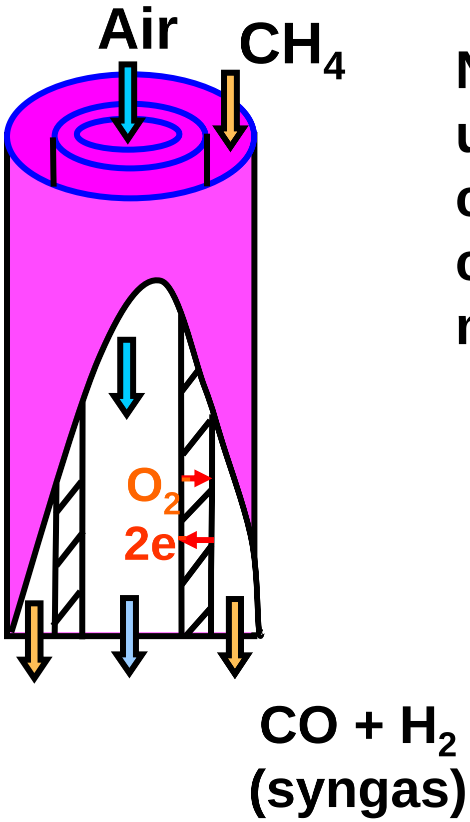




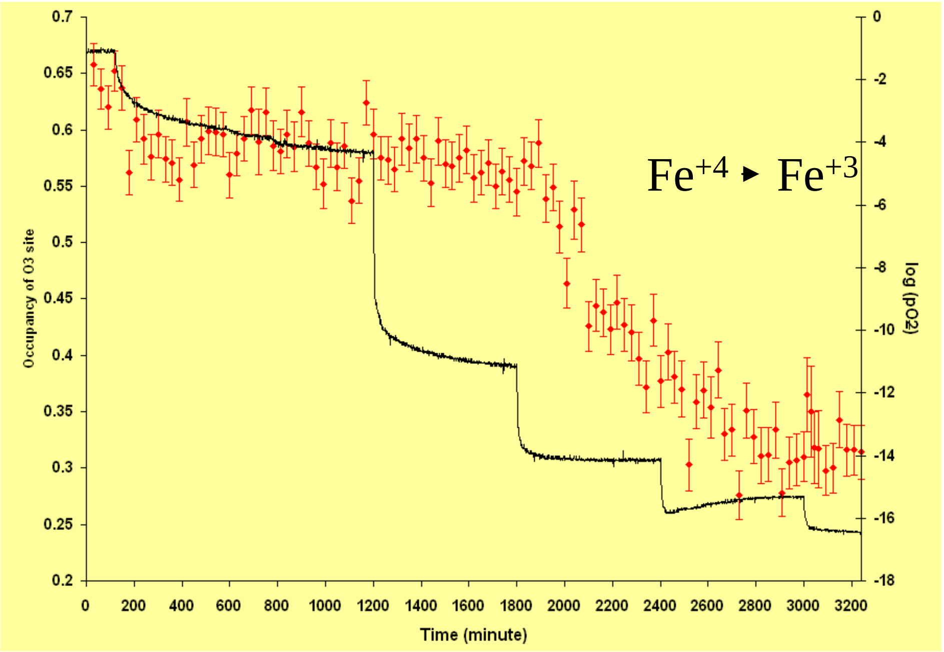
Following the decomposition (left) and hydrogen release (right) in real-time during dehydrogenation of a lithium and magnesium amide-imide system, by using synchrotron x-rays and mass spectrometry.

Funded by DOE and GE Global Research

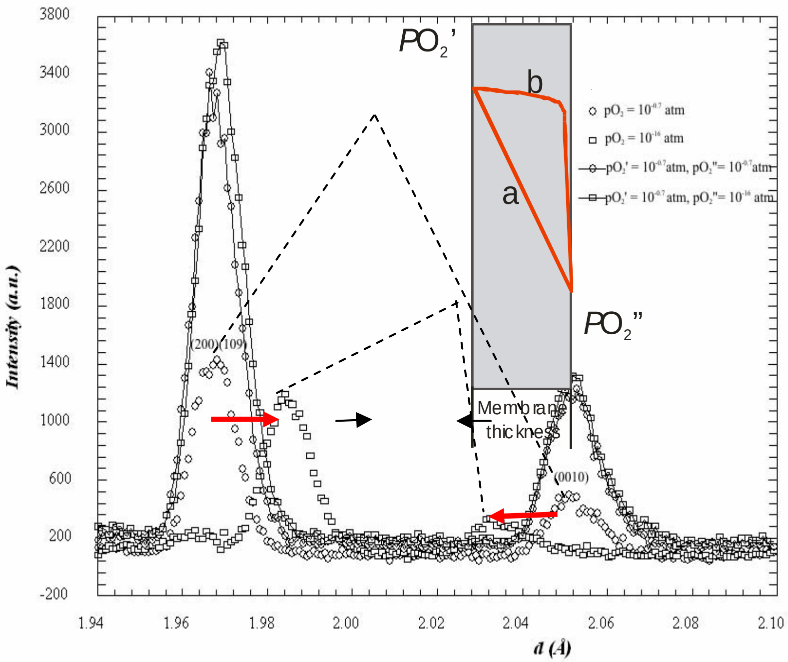
O_2 Membrane for H_2 Production at 900ºC



Neutron data taken under real-world conditions show changes in the ceramic membrane as it is used



Static versus simulated experiments provide an explanation for the unique stability of these materials

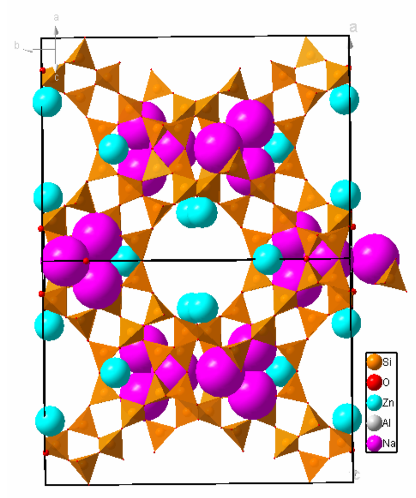


Richardson et al., *J. Am. Ceram. Soc.* 88, 1244-1252 (2005)

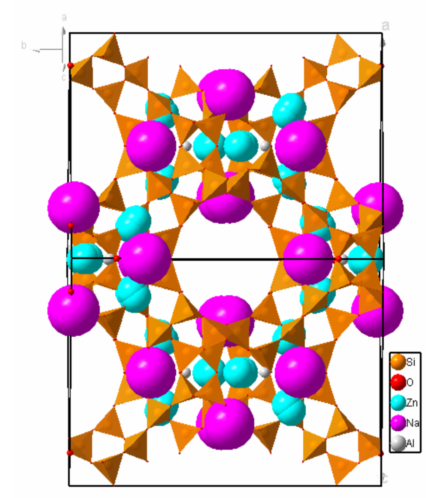
Improved Catalysts Increase Gasoline Production

About half the gasoline used in the U.S. is produced in Fluid Catalytic Cracking (FCC) units in refineries.

Experiments at NSLS show how to formulate catalysts that perform best at the extreme temperatures at which refineries operate, and thus **improve the yield of gasoline from each barrel of crude oil by up to 20%.**



ambient



300°C

Work funded by Amoco/BP

The Nation Needs to Keep Basic Research Moving Forward!

From The American Innovation Proclamation:

Renew America's commitment to discovery
by doubling the basic research budgets at the National Science Foundation, the National Institute of Standards and Technology, the Department of Energy's Office of Science and the Department of Defense;

Improve student achievement in math and science
through increased funding of proven programs and incentives for science and math teacher recruitment and professional development;

Welcome highly educated foreign professionals,
particularly those holding advanced science, technology, engineering, or mathematics degrees, especially from U.S. universities, by reforming U.S. visa policies;

Make permanent a strengthened R&D Tax Credit
to encourage continued private-sector innovation investment.

- **"We owe our current prosperity, security, and good health to the investments of past generations, and we are obliged to renew those commitments in education, research, and innovation policies to ensure that the American people continue to benefit from the remarkable opportunities provided by the rapid development of the global economy and its not inconsiderable underpinning in science and technology."**
- **From "Rising Above the Gathering Storm"**

FY 2008 Funding Needed to "Right the Ship"

- **The U.S. needs to optimize knowledge-based resources, particularly in science and technology**
- **Scientific progress and competitive position of U.S. depends on how wisely we invest in research capability**
- **User research has broad applications of national interest, including: energy efficiency and supply, toxic waste cleanup, bioterrorism and disease detection, electronics, telecommunications and manufacturing**
- **After several decades of constrained spending, support for American Competitiveness is essential in FY 2008, with continued increases in the following years, to reinvigorate the U.S. science base, including efficient maintenance and use of the large U.S. investment in synchrotron facilities and neutron facilities**