Superconducting Magnet Made with Niobium-Tin Alloys Achieves Field Strength of 13.5 Tesla

Researchers at the Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab) built and tested a superconducting electromagnet featuring coils wound out of 14 miles of niobium-tin wire, reaching a field strength up to 13.5 Tesla. The magnet is among the first to use a niobium-tin alloy for the superconductivity of its coils. Accelerator magnets have traditionally been made with niobium-titanium alloys, operating up to 10 Tesla.

While research had determined that niobium-tin could, in principle, reach higher field strengths, niobium-tin, unlike niobium-titanium, is not ductile, and was thought to be too fragile and brittle to withstand the stress of fabrication. Ron Scanlan, a materials scientist with Berkeley Lab's Accelerator and Fusion Research Division, and his group overcame the brittleness obstacle by making their cable from separate strands of niobium and tin in a copper composite strand while the materials were still ductile. After they wound their cable into four magnet coils, they melded the separate niobium and tin strands into the superconducting compound. The alloy was made by heating the coils to 950 K, baking them for about 10 days, then cooling the material to ambient temperature. Once the four coils were assembled into a dipole magnet they had to be cooled to about 4.3 K to make them superconducting.

"The thermal expansion-contraction effects in going from a reaction temperature of 950 K to a test temperature of 4.3 K are enormous," said Scanlan. To withstand this and other stresses, the wound coils are impregnated with an epoxy filler.

After being filled with epoxy, each coil is encased in an iron yoke that contributes to the strength and stability of the magnetic field. The coils are then wrapped in 18 layers of sheet stainless steel, forming a collar that prevents the coils from separating under the force generated when their magnetic field is energized. The finished meter-long magnet is also about one meter in diameter and has a 50 mm bore. It weighs about seven tons.

"Inside the iron yoke and stainless steel wrap of each coil is something that is as brittle as glass," said Scanlan.

To attain its peak field strength, the magnet is chilled until its coils become superconducting (using liquid helium) then energized up in field strength until superconductivity is lost in some parts of its coils through inadvertent warming. When quenching occurs, the magnet must be given time to recover, then recooled.

"The magnet was ramped to slightly above 10 Tesla before the first quenching occurred," said Scanlan. The magnet was then slowly but steadily trained upward in field strength until, after 13 quenches, it reached 11.14 Tesla. When further training at 4.3 K failed to raise the field strength, Scanlan and his group began lowering the temperature. Field strength reached a maximum of 13.5 Tesla after the temperature had been dropped to about 1.8 K.

"This became a test of the magnet's structural integrity as well as its field strength because of the stress involved," Scanlan said.

Infrared Spectroscopy, Array Detector, and Microscopy Combine to Obtain Images of Biological and Synthetic Materials

Scientists have long relied on infrared spectroscopy as an analytical tool to identify the chemical components of an unknown sample. Likewise, they have used a variety of imaging techniques to study spatial relationships between chemical components. Scientists at the National Institute of Standards and Technology (NIST) have joined with a team at the National Institutes of Health (NIH) to improve a system that combines infrared spectroscopy, an array detector, and microscopy to rapidly obtain sensitive spectral images of complex samples. The spectral imaging technique is being used to study biological samples, such as brain tissue, as well as advanced polymer composites.

Edwin J. Heilweil of NIST's Optical Technology Division contributed expertise in infrared detector array technology to improve the system that E. Neil Lewis's team from the National Institute of Diabetes and Digestive and Kidney Diseases at NIH had developed, as reported in the May 15 issue of *Optics Letters.*

The apparatus uses a mercury-cadmium-telluride infrared detector array. The detector array has 256 by 256 pixels, which can collect infrared spectra of reactive molecules or imaging data from over 65,000 points on a sample simultaneously. The array is coupled to a step-scan, Fourier transform infrared spectrometer. When infrared light is directed through a sample onto the array, the resulting data are converted to detailed chemical images by way of Fourier transform. The approach, as with conventional microscopy, requires the use of thinly sectioned samples but is otherwise nondestructive.

Molecules such as proteins or polymers absorb some of the infrared radiation at very specific frequencies that serve as fingerprints for spectral identification. NIST is planning to apply this technique to gather transient spectroscopic images of intermediates formed during chemical reactions in polymer films. The system produces images in about an hour that otherwise would be impractical using a conventional scanning microscope and Fourier transform infrared spectrometer.

Hydrogel Bead Synthesized for Drug Delivery

Researchers at Duke University and Access Pharmaceutical Inc. are jointly devising microscopic beads that can place drugs directly onto tumors by mimicking the way substances are secreted within cells. "We've made essentially an artificial secretory granule," said David Needham, an associate professor of mechanical engineering and materials science who directs the Cell and Microcarrier Engineering Research Facility at the university.

Needham and Patrick Kiser, a chemist with Access Pharmaceuticals and graduate student, said their approach resembles the way large secretory molecules are encased within "granules" that bud from a cellular structure called the Golgi apparatus. These granules can later swell and secrete their contents on demand in response to a chemical signal.

The researchers synthesized absorbent microscopic hydrogel beads that can take up and hold large concentrations of drugs. Made of both natural and synthetic polymers, the beads have a very useful property for drug delivery. They will stay condensed and intact until they are exposed to the sodium in blood plasma. After encountering sodium, the beads will swell and burst explosively, releasing the entrapped drug.

To prevent the beads from bursting prematurely, the researchers surround the beads with protective double-layered coatings or capsules composed of lipids, the same materials that make up cell membranes and secretory granules. These "bilayer" shells serve to insulate the beads from sodium-rich blood plasma for as long as the lipid covering stays intact.

To trigger the erosion of the lipid coating, the chemistry of the bilayer could be primed to react to "some aspect of the disease site," Kiser said. Pores could be made to open in response to ultrasound beamed into the body through the skin.

Needham has investigated another delivery system using liposomes. Smaller than red blood cells, these artificial lipid capsules can be filled with drugs and are tiny enough to penetrate small blood capillaries that keep tumors nourished.

Studies at the university's medical center have shown that, after reinforcement with other chemicals, liposome bilayers can remain intact for several days after injection into the bloodstream, which is long enough for large numbers of doxorubicin-filled liposomes to migrate to a tumor site and accumulate there, Needham said.

However, no one has found a way to make liposomes release a drug reliably. "It will leak out slowly, but to get a lot of release quickly is tough," Kiser said.

Needham and Kiser are working on strategies that would combine the best of both techniques to overcome that problem. Because it carries an electric charge that varies with acidity or alkalinity, the hydrogel bead can be made to both attract an oppositely charged drug and repel a like-charged lipid shell.

If the pH of its surroundings is properly manipulated, the bead can be made to take up as much as 200% of its own weight in drug. Protected with a lipid bilayer shell, the drug-loaded bead can then patrol the bloodstream. When it is time to expel its drug, the bead can also engineer the quick and thorough destruction of its surrounding shell if it and the lipid's chemistries have been tailored to carry the same charge.

Since like charges repel, "when the bead swells, the bilayer is now repulsed by the bead," Needham said. "Then the bilayer rolls into little blocks. You can actually dissociate the coating from the bead."

Once the bead swells and breaks, the drug can be expelled with a pressure as high as 12 atm.

Thick Flywheels Fabricated with Elastomeric Material Promise Reduced Probability of Catastrophic Failure

Christopher W. Gabrys, a recent graduate of The Pennsylvania State University, and Charles E. Bakis, associate professor of engineering science and mechanics, developed a composite flywheel rotor impregnated with a rubberlike elastomeric material to glue the filaments together and hold them in a rigid disk or cylinder shape. They reported in the May issue of the *Journal of Reinforced Plastics and Composites* that their method "should theoretically allow fail-safe or limited failure flywheels to be constructed." The technique reduces the possibility of catastrophic failure of the flywheels by changing the area where the flywheel can be expected to fail and by limiting the amount of the rotor that will fly off if the wheel is spun too fast.

Bakis said that composite flywheel rotors are usually made from high-strength, lightweight, carbon, glass, or synthetic fibers formed into a continuous filament that is wound around a spindle or mandrel. The filaments are usually impregnated with epoxy to glue them together. In the new approach, the filament passes through an elastomer solution bath that soaks it thoroughly with the material. The elastomer-impregnated filament then solidifies within minutes after being wound on the mandrel. High-performance composite flywheels are capable of storing or providing 20–40 times more power per kilogram than chemical batteries.

Bakis said, "The result is a flywheel in which we predict failure will result in only the outer edge fibers peeling from the wheel. The breakdown process is also self-arresting since the inner material is operating at lower stress levels due to the properties of the elastomeric matrix flywheel. This is in contrast with rigid epoxy matrix wheels which usually fail explosively—all at once."

While the use of elastomers in composite flywheels had been theorized and reported in the technical literature previously, no production of such a flywheel had been reported. Gabrys and Bakis have developed a way to make very thick disks and cylinders using elastomer-impregnated filaments. They have achieved a ratio of inside to outside diameter of 0.1, without wavy fibers.

Nine Scientists Receive 1997 National Medal of Science

President Clinton announced nine recipients of the 1997 National Medal of Science, recognizing exemplary work in such diverse fields as human genetics, mathematics, physical science, and cognition and learning. Among the recipients is **Darleane C. Hoffman**, director of the Glenn T. Seaborg Institute for Transactinium Science at the Lawrence Berkeley

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Laboratory, University of California—Berkeley, for her discovery of plutonium in nature and for her numerous contributions to the understanding of radioactive decay, notably of heavy nuclei. She is an internationally recognized leader in nuclear chemistry, particularly in the topics of nuclear fission, properties of actinide elements, and reactions of heavy ions.

Marshall N. Rosenbluth, professor and research physicist, University of California—San Diego, received the medal for his fundamental contributions to plasma physics, his leadership in the quest to develop controlled thermonuclear fusion, and his wide-ranging technical contributions to national security. His theoretical studies of the behavior of plasmas and their instabilities provided a significant foundation for the design and development of prototype devices for fusion power.

Shing-Tung Yau, professor of mathematics at Harvard University, received the medal for profound contributions to mathematics that have had a great impact on fields as diverse as topology, algebraic geometry, general relativity, and string theory. His work insightfully combines two different mathematical approaches and has resulted in the solution of several long-standing and important problems in mathematics.

The National Medal of Science, established by Congress in 1959, was intended to be bestowed annually by the President of the United States. The National Science Foundation, which administers the Medal of Science program, solicits nominations. The President appoints a 12-member Committee on the National Medal of Science, comprised of outstanding researchers from a variety of disciplines in the natural and social sciences. The President of the National Academy of Sciences and the Assistant to the President for Science and Technology serve as *ex officio* members. The committee reviews the nominations and sends its list of recommendations to the President for final selection.

Vice President Gore Awards First PNGV Medal

Vice President Al Gore awarded the first Partnership for a New Generation of Vehicles (PNGV) medal to a team of scientists and engineers from five Department of Energy laboratories (Argonne National Laboratory, Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories) and from Chrysler, Ford, and General Motors.

The citation recognizes significant scientific progress toward the development and eventual commercialization of technologies for advanced catalytic converter systems to meet current and near-future standards for motor vehicle emissions set forth in the Clean Air Act. Priority is placed on reducing nitrogen oxide (NO_x) emissions in exhaust from lean burn engines.

Development and evaluation of advanced catalyst formulations, such as hydrous metal oxides (HMOs), zeolites, and aerogels were examined. Catalyst systems were fabricated on a small scale using HMO coating and ion exchange techniques, and similarly tested. The best catalyst systems were then evaluated on a larger scale in both bulk and coated forms. These catalysts used in automotive exhaust systems could reduce NO_x by at least 50 percent.

These compounds will also serve as an enabling technology to the advanced compression ignition direct injection engine (CIDI).

The PNGV was established in 1993

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Materials-Related Research Highlights Reported at ACS Meeting

The American Chemical Society (ACS) held its 213th National Meeting and Exposition in San Francisco from April 13 to 17, providing research reports on monolayer polymers, a series of gold-cluster molecules, and a device to print drugs into pills to control dosage.

Monolayer Polymer Tends to Form in Valleys of Substrate

According to University of Michigan chemists Christine E. Evans and Mark D. Mowery, peaks and valleys in underlying substrates have a direct impact on where and how polymers form in single molecular layers. Monolayer polymers seem to have a preference for valleys. Understanding substrate roughness in polymer formation is important when attempting to use ultrathin molecular films and polymers, instead of silicon and microcircuitry, to create the organic equivalent of a semiconducting microchip.

"Varying the surface topography gives us one more tool we can use to direct and control the growth of these single-layer polymers," said Evans, who presented results of the experiments on April 14 at the ACS meeting.

The researchers exposed monomers, which were attached to an underlying gold substrate, to ultraviolet light. UV light causes the monomers to polymerize. Evans and Mowery discovered that polymers formed primarily within the valleys of the substrate. By varying the uv light exposure, the substrate's surface texture, and the chemical structure of the monomer layer, they expect to learn how to control the polymerization process.

Technology Developed to Print Drugs into Pills for Dosage Control

Using a three-dimensional printing device, scientists at Massachusetts Institute of Technology (MIT) have printed drugs into pills. This solid free-form fabrication device forms tablets using pharmaceutical-grade materials. "The technology represents a new way of formulating drugs with unprecedented dosage control," said Michael J. Cima, a professor in the Department of Materials Science and Engineering.

Cima and Emanuel M. Sachs, a professor in the Department of Mechanical Engineering, presented their work on April 13 at the ACS meeting where they demonstrated the integration of continuous-jet and drop-on-demand technologies on one three-dimensional printing machine, and the fabrication of tablets from FDA-approved pharmaceutical-grade materials. Three-dimensional printing works by dropping precise drug doses onto thin layers of fine powder as the tablet is formed. Pharmaceutical-grade powder which forms the structural matrix of the pill is then spread to form the next layer, which is 100–150 μm thick. The continuous-jet printhead then sprays a pharmaceutical-grade binder. From 30 to 50 layers are required to complete the building process, but hundreds or thousands of pills can be produced at once. The drop-on-demand technology can place dots of one drug, or multiple drugs, precisely throughout the layers for the most effective release.

In contrast with continuous-jet printing, which delivers a fluid under pressure, drop-on-demand technology only forms droplets when an electrical pulse signal is applied. Drug waste and contamination of the powder bed with other drugs that may be deposited into the same tablet are, therefore, reduced.

Traditionally, pills are made by mixing pharmaceutical powders, binders, and drugs, compressing them into tablet form, and coating them. Conventional pills release medicine continuously, so medication taken before sleep will not last until the next morning. With three-dimensional drug printing, the placement of drops on the layers and the use of different binders allow for precision time-control of drug release. So patients could take a tablet before bed, but the drug would be released one hour before they awaken.

"Some drugs don't work well if they are released continuously. Our technology works more like an injection," said C. William Rowe, a visiting scientist in the Materials Processing Center and a senior scientist at Therics Inc. "The goal of controlled time releases is to better match the pharmacology of drug absorption." Implantable drugs also release drugs continuously, and the drug release rate decreases over time. Some current implants must be removed after they release their contents. The three-dimensional printing process is being used to make implantable devices that are biodegradable in the body, Rowe said.

With three-dimensional printing, each pill in a bed can be made with a different formulation, reducing waste and time to perform formulation studies, Cima said.

The process is currently limited to drugs of low dosages, such as a few milligrams, because the drug is deposited as a solution. Other methods such as mixing the solid form of the drug with the matrix powder and enhancing the drug's solubility are being investigated to overcome these limitations.

Researchers at MIT also apply three-dimensional printing technology in other areas. For example, Linda G. Griffith, Karl Van Tassel Associate Professor of Chemical Engineering, and colleagues use this technology to construct bioerodible scaffolds for tissue-engineering studies.

Series of Gold Clusters Possess Charged-Quantization Effect in Macroscopically Obtained Material

An interdisciplinary team of researchers at the Georgia Institute of Technology has isolated a series of highly stable and massive gold-cluster molecules that exhibit the charge-quantization effect in a macroscopically obtained material, for which every cluster behaves identically. The measurements were conducted by Phil First at Georgia Tech by observing the steplike changes in the current passing from a scanning tunneling microscope tip to a gold plate through a single gold cluster molecule as the voltage was increased. The Coulomb staircase showed that the molecules' gold core is charging like a small metal sphere in a series of discrete steps by adding or removing single electrons. The quantization of the energy levels of the conduction electrons is observed separately in optical spectroscopy experiments that reveals discrete level structure at room temperature.

"With these properties, the molecules are very attractive building blocks for testing one type of ultra miniaturized architecture envisioned by some for 21st-century nanoelectronics, as well as for other chemical and molecular-biological applications," said Robert L. Whetten, professor of physics and chemistry at Georgia Tech. The work was reported April 16 at the ACS meeting.

Each molecule in the series has a compact, crystalline gold core. This pure metallic core, 1–2 nm across, is encapsulated within a shell of tightly packed

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Gold Clusters Continued

hydrocarbon chains linked to the core by sulfur atoms.

The principal members of the series have core-masses of about 14,000; 22,000; and 28,000 protons, corresponding to about 75, 110, and 145 gold atoms, respectively, and are thus in the same mass range as larger protein molecules, as reported by M. M. Alvarez and colleagues in the February 1997 issue of *Chemical Physics Letters*. These members differ, both in size and the higher yield with which they are obtained, from their heavier analogues described by Whetten and colleagues in the May 1996 issue of *Advanced Materials*.

The precise structures of the cores are as yet unknown, but theoretical and experimental evidence suggests they are faceted with a particular gem-stone shape, as reported by Whetten, Uzi Landman, and their co-workers in the June 1997 issue of *Zeitschrift fer Physik*.

"The surrounding chains can be of any length, and can be modified to confer particular chemical properties, so that they can be incorporated into various solid-state and solution structures," Whetten said. "Most importantly, each member of the series behaves as a substance composed of infinitely replicated molecules, which can be separated from other members of the series to yield pure substances with precisely defined properties."

The gold cluster molecules emerge spontaneously during the decomposition of gold-thiolate polymers of the type commonly used in decorative gold paints and in gold anti-arthritis drugs. With sufficient control of the decomposition process, this series can be isolated without concurrent production of larger gold crystals. It is then relatively easy to separate the principal members of the series from each other to obtain the necessary homogeneity. Once purified, the molecules spontaneously assemble into crystalline thin films, powders, or macrocrystals, while preserving the discrete properties of the individual gold nanocrystal cores.

"The main fascination of very small metal crystals, and the foundation for their envisioned use in future electronics, arises from the fact that their conduction electrons are quantized both in their number—charge quantization—and in the states they can occupy—energy quantization," Whetten said. "In crystals larger than a few nanometers, these effects can only be observed and used at very low temperatures, such as that of liquid helium, near absolute zero. The new series of nanocrystals are both sufficiently small that these effects are prominent even at ordinary temperatures and yet are large enough to have the robust crystalline properties of the bulk metal."

The electromagnetic and conduction properties of the clusters are extremely sensitive to charging, and less so to energy level.

with a federal investment matched by the United States Council for Automotive Research (USCAR). The Department of Commerce leads the federal agencies and government laboratories involved.

Theory Disputes Shock-Wave Model for Sonoluminescence

Sonoluminescence, the puzzling glow emitted by a bubble in a field of high-pitched sound waves, may be caused by a tiny jet of liquid that shoots across the interior of the bubble at supersonic speed and slams into the opposite side, said Andrea Prosperetti, the Charles A. Miller, Jr. Distinguished Professor of Mechanical Engineering at Johns Hopkins University. At the point where this powerful jet strikes the bubble wall, it fractures the liquid, releasing energy in the form of light.

Prosperetti's theory, published in the April 1997 issue of the *Journal of the Acoustical Society of America*, offers an alternative to the widely held view that the bubble glows because of shock waves that concentrate energy in its center as it shrinks. His theory also deflates the hope among some researchers that sonoluminescence generates enough pressure and heat to produce nuclear fusion, a potential source of cheap, clean energy.

Some scientists have speculated that bubble temperatures during sonoluminescence exceed 2 million°F, near the levels needed for fusion. If Prosperetti's theory holds true, the heat inside the bubbles would peak at about 10,000°F, the level found at the sun's surface. "It's enough to explain the chemical activity, but it's far below the amount needed to produce nuclear fusion," said Prosperetti.

In his paper, Prosperetti said it is unlikely that shock waves within the shrinking bubble trigger sonoluminescence because the bubble would need to maintain a near-perfect spherical shape. "I think it is absolutely impossible for the bubble to remain spherical," he said. "In a sound field, there is a very well-defined mechanism that will prevent this from happening. The fluid wants to push a jet, a finger of liquid, through the bubble, hitting the other side. What you see in sonoluminescence is the initial result of this 'hammer of water.'" This jet, moving at perhaps 4,000 mph, or more than five times the speed of sound in air, strikes so quickly that water molecules do not have time to flow away from the point of impact. Instead, the fluid fractures.

Ice and Wint-O-Green Lifesavers candy sometimes give off light when they crack, and water molecules could produce the same effect, Prosperetti said. His theory holds the promise of explaining many facets of the phenomenon. For example, bright light emission requires tiny amounts of a noble gas such as xenon, argon, or helium dissolved in the liquid because, Prosperetti said, these inert atoms create flaws or weaknesses in water's crystal-like structure that provide a foothold where the fracture begins.

Model Predicts Evolution of Atomic Structures

Microscopist Andreas Schmid and theorist Norm Bartelt of Sandia National Laboratories have developed a model that reveals how a structure of around one million atoms is built, atom by atom, minute by minute, without having to infer how the final form evolved.

Bartelt said, "We want to know the dynamics of how each defect actually evolves."

While Schmid was taking scanning tunneling microscope (STM) pictures of oxygen atoms forming flat crystal patterns on ruthenium, close up, he could see single oxygen atoms hopping randomly, resembling fuzzy black dots on a lattice. Viewing a larger sheet of about one million oxygen atoms, he saw small regions, enclosed by white boundaries, that coalesced like soap bubbles over time. Schmid snapped images of these regions at a minimum of seven-second intervals. The regions represent four different grain orientations. Each region has an amorphous shape and each grain orientation joins regions of similar orientation over time, finding a preferred lower energy state.

To deduce which orientations matched, Schmid ran his film of the sequential STM snapshots back and forth, seeing which regions coalesced with areas of matching grain orientation over time. He color-tinted each of the four different orientations on the gray images.

Bartelt wrote a probability code to predict how the pattern would evolve, based on physical forces measured at the atomic level.

"This system is very similar to a soap bubble froth," Bartelt said. "Each boundary has a tension like a soap bubble and the system is trying to lower its free energy. The simulation samples different configurations and finds more likely ones, simple configurations without grain boundaries."

The fact that large numbers of moving atoms form a predictable pattern over time and distance indicates how small and seemingly random events can lend direction to a larger system. Bartelt demonstrates this by briefly running small-scale movies of the motion of a small number of oxygen atoms backwards and forwards in time with no apparent difference.

According to the collaborators, atoms of most elements move too quickly or slowly at room temperature to be easily visualized. "Once we saw atoms in this system making hops at room temperature," Bartelt said, "we knew we could measure all the events necessary to predict a large-scale evolution of thousands of atoms. The standard way to interpret STM pictures is to look at them and try to guess how they were built, sort of like archaeology, but this way, we can actually look at them and see each 'brick' being laid."

Tandem STM/FIM Instruments Analyze Microscope Tips

Researchers at the National Institute of Standards and Technology (NIST) have built an instrument that features a scanning tunneling microscope (STM) and a field-ion microscope (FIM). Both microscopes can view individual atoms, but, for FIMs, this level of scrutiny is limited to needle-like specimens with a radius measuring between 1 and about 100 nm. Probe tips are characterized with the FIM and then transferred in ultrahigh vacuum to the neighboring but physically isolated ultrahigh vacuum STM. With the STM, researchers will test the probes on silicon samples with well-controlled, atomically ordered surfaces, featuring, for example, a series of nanometer-scale steps or terraces. Like all STMs, this instrument produces profiles of surfaces by sensing a tunneling electrical current that flows between atoms on the probe tip and those on the sample surface. Maintaining the probe at a constant height relative to the surface maintains the current. Successively scanning the tip over the surface yields a three-dimensional image with atomic resolution.

This combination instrument can accommodate up to six probes, which are shuttled between microscopes on a rotating carousel. In addition, the apparatus features a separate ultrahigh vacuum chamber where tip and sample surfaces can be heat treated.

Tips also can be sculpted with the FIM. By varying the electric field in the chamber, researchers can evaporate clusters and even planes of atoms from probe tips. NIST physicist Rick Silver, co-designer of the instrument, said that while this capability cannot be controlled precisely, it will permit modifications useful to the research effort.

The tandem arrangement of microscopes will enable measurements of probe tip geometries and dimensions to be correlated with tip performance in STMs and other scanning probe microscopes (SPMs). One goal of this research effort is to develop methods and tools that enable direct characterization of SPM tips, which would eliminate much of the measurement uncertainty resulting from unknown variations in tip geometry. Initially, work will focus on tungsten and platinum-iridium tips.

SBIR Update

Biogel Technology, Inc. (Indianapolis, Indiana) has been awarded a grant from the National Science Foundation. The grant will fund research on two phases of biodegradable particle work: (1) modification of microparticles to increase their suspendability and reproducible injectability; and (2) development of targeted nanoparticles to break down blood clots directly and only at their intended site of delivery. The Phase II award provides $300,000 of funding for the 24-month effort.

Bravman Named Bing Centennial Professor

John Bravman, professor of materials science and engineering at Stanford University, has been named to the Bing Centennial Professorship, a university-wide position that recognizes the highest level of excellence in teaching.

"This appointment was made on the unanimous recommendation of the deans of the Schools of Humanities and Sciences, Earth Sciences, and Engineering in recognition of [his] extraordinary record of teaching excellence, [his] commitment to undergraduates, and [his] dedication to making Stanford the best education institution it can be," wrote Provost Condoleezza Rice in the letter about the selection.

The selection was made from a pool of 95 faculty members who have received teaching awards in the last five years.

The professorship was awarded for a three-year term, from July 1997 to July 2000. Bravman is the second faculty member to receive this honor. Brad Osgood, associate professor of mathematics, was named the first Bing Professor in 1992 and was given a two-year extension in 1995.

The Bing Professorship is Bravman's eighth award for teaching. Since 1993 Bravman has served as the associate dean for undergraduate affairs in the School of Engineering and last year took on the duties of chair of the Materials Science and Engineering Department.

Protonic Computer Memory Recalls Information When Power Goes Off

Scientists at Sandia National Laboratories and France Telecom have developed a prototype memory-retention device, referred to as "protonic," to save what is on a computer screen in the event of a power outage or a screen freeze-up that forces the operator to shut down the computer. As reported in the April 10 issue of *Nature*, to transmit data, the device uses embedded protons, which remain where they are when the power turns off, thus preserving the information. In devices such as dynamic random access memory (D-RAMs), typically based on electron flow, the information is lost when the power is turned off.

To create the memory-retentive chip, a few steps must be added to those currently used to fabricate microchips. The key additional step is to bathe the hot microchip in hydrogen gas. The gas, permeating the chip, breaks up into single ions—protons—at defects in the silicon dioxide. (The defects were created by the heat of the manufacturing process.) The protons can roam only within the chip's central layer of silicon dioxide, where they are trapped by two layers of silicon that sandwich the silicon dioxide.

The researchers found that a positive low-voltage applied to one side of the silicon repels the protons to the far side of the silicon dioxide and a negative low-voltage applied to the silicon attracts the protons to the near side of the silicon dioxide. If the power is turned off, the protons stay where they are, retaining information in the chip circuit.

Cornell Receives Waterman Award from NSF

Eric A. Cornell, a physicist at the National Institute of Standards and Technology (NIST) and adjoint professor at the University of Colorado—Boulder (CU), has been named the 1997 recipient of the Alan T. Waterman Award. The award recognizes an outstanding young researcher in any field of science or engineering supported by the National Science Foundation (NSF). Cornell was recognized for "his leading role in the creation of Bose-Einstein condensation in a gas, and for innovations in the manipulation, trapping and cooling of atoms that led to the realization of this new state of matter." Cornell's work with CU professor Carl Wieman on the Bose-Einstein condensate previously was honored during the past two years with the King Faisal International Prize in Science, the AAAS-Newcomb Cleveland Prize, the Carl Zeiss Award, the Fritz London Prize in Low Temperature Physics, and NIST's Samuel W. Stratton Award.

Sol-Gel Sorbent Detects and Measures Airborne Pollutants

A sol-gel sorbent product developed by researchers at Oak Ridge National Laboratory may find use as a cost-effective way of detecting and measuring airborne pollutants such as carcinogens. The air sampler comprises a tube containing a sol-gel sorbent trap, which collects organic contaminants from the air, and is then heated to release collected samples into a modified gas chromatograph for analysis, said co-inventors Mike Sigman and Amy Dindal of the Chemical and Analytical Sciences Division.

The researchers found that the use of a single-sorbent configuration allows the air sampling trap to be applied to a broad range of sampling methods, and while the conventional carbon-based traps can be heated to 400°C before the materials degrade, the sol-gel material can be heated to 600°C.

Miniature Medical Telesensors Transmit Temperature Readings Remotely

Tom Ferrell, a researcher at Oak Ridge National Laboratory, has built a temperature sensor 2.3 mm on a side, which can be attached to a finger or placed in an ear. There, it can measure body temperature and transmit a reading when queried by a remote receiver. The chip contains a temperature sensor that measures absolute temperature using bipolar transistors whose electronic properties are sensitive to temperature. These components are incorporated on a single chip together with analog signal processing, transmission electronics, and an antenna that sends the data by radio signals to a monitor when the chip is queried. Each chip, Ferrell said, is planned to have a unique identifier—a characteristic radio signal pattern in which the frequency spectrum changes every few microseconds. In addition, thin-film lithium-ion batteries developed by John Bates of the Solid State Division could be used to supply the very low levels of power required by the circuit.

The medical telesensors are being developed for military troops in combat zones and can also be used outside of the military such as by intensive-care patients in hospitals. The ultimate research goal is to develop an array of chips to monitor vital signs collectively. □

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