Er_3Ni Regenerator Helps Superconducting Magnet Sustain 4 K

Last November, Japan's Toshiba corporation announced the fabrication of a prototype superconducting magnet able to reach and sustain a temperature of 4 K without cooling by liquid helium. The magnet's low operating temperature is complemented by its ability to generate a 6 T magnetic field and by the small dimensions of the vacuum container which houses it. The bore-type Nb-Ti magnetic, 180 mm in diameter at room temperature, is housed in a vacuum container 650 X 500 X 490 mm, one-third the size of a conventional liquid-helium-cooled magnet.

Drawbacks to using liquid helium to achieve a 4 K operating temperature for a superconducting magnet are numerous. The Gifford-McMahon (GM) refrigerator, a smaller, less complicated cooling system, attempts to circumvent some of these drawbacks, but its performance relies on the heat capacity of the regenerator material. The thermophysical characteristics of the lead typically used as the regenerator cause it to lose its heat capacities below 10 K. As a result, standard GM refrigerators have trouble maintaining temperatures below 10 K. To overcome this problem, Toshiba developed a GM refrigerator that uses Er_3Ni as the regenerator. Er_3Ni can sustain temperatures of 4 K. Nb-Ti superconducting wire forms the coil of the magnet. The wire is widely used in magnets for magnetic resonance imaging; it is also cheap, relatively easy to handle, and reliable. The coil is surrounded by a soft metal that is highly conductive and maintains flexibility at very cold temperatures. This coil is inserted in a copper housing connected to the second stage of the GM refrigerator. This structure allows the magnet to cool quickly and uniformly.

As an additional innovation for this superconducting magnet, a Bi-oxide-based superconducting rod developed by Toshiba is used for the current supply to the magnet. Since the Nb-Ti wire can generate a higher electric current in a strong magnetic field, it can operate in the field generated by the magnet. Toshiba expects to commercialize the superconducting magnet within the next few years.

F.S. MYERS

Gas-Surface Reactions Can Occur Directly or Indirectly

Reporting in *Science* (January 21, 1994), Charles T. Rettner and Daniel J. Auerbach of IBM's Almaden Research Center have confirmed experimentally that gas/surface chemical reactions can occur either directly or indirectly. Their results and the techniques used to obtain them are expected to stimulate a much wider understanding of the fundamental nature of gas-surface reactions, including such technologically important ones as catalysis and etching.

In the direct Eley-Rideal mechanism, the reaction occurs the very instant an incoming atom collides with an atom on a surface. When the reaction follows an indirect path, called the Langmuir-Hinshelwood mechanism, the incoming atom rests on the surface and comes to equilibrium with it before reacting with a nearby atom.

To probe these mechanisms, researchers fired a beam of hydrogen atoms at a gold surface that had been covered with chlorine atoms, and they measured the velocities and angles at which the newly formed molecules left the surface. The molecules made by the direct mechanism had very high velocities that varied with the energy of the incident hydrogen atoms. These molecules emerged at angles that indicated a "memory" of the direction and velocity of the incident hydrogen atoms. The researchers concluded that an incoming atom can effectively strip an atom off the surface and react with it to form the new molecule in a single bounce. Molecules produced by the indirect mechanism were found to have relatively slow velocities; these molecules left the surface symmetrically in all directions.

These findings are consistent with the work of Keith Lykke and Bruce Kay (*SPIE Proceedings* **1208**, 1990, p. 18), who suggested in 1990 that this particular reaction might proceed by both mechanisms. Their experimental results, however, did not show the correlation between the initial-and final-state products needed to prove that the Eley-Rideal mechanism applies.

CRADA Targets Lithium Ion Batteries

Sandia National Laboratories has signed a cooperative research and development agreement (CRADA) with AT&T Bell Laboratories and three battery manufacturers—Eveready Battery Company, Rayovac Corporation, and Wilson Greatbatch Ltd.—to work jointly to identify and characterize a carbon anode material that can efficiently and reversibly insert lithium ions into the carbon lattice.

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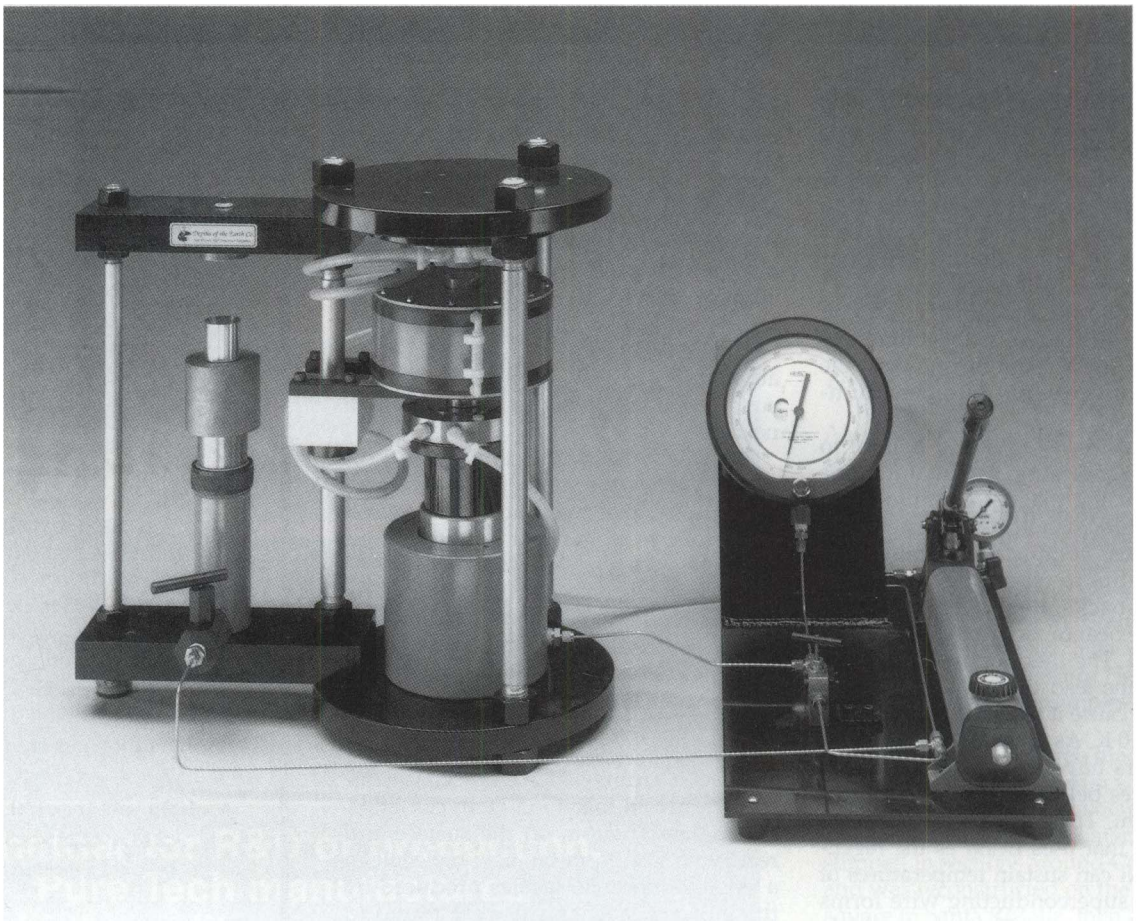

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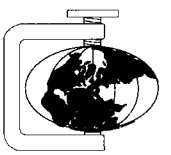

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The aim of the research is to improve the rechargeable lithium ion batteries currently being introduced by Japanese companies to power new lines of cellular phones and camcorders. These batteries have the high voltages and energy of metallic lithium systems while offering safety advantages and improved cycle life. With higher energy densities than conventional rechargeable systems (e.g., nickel cadmium), the lithium ion systems allow longer use times between charges.

J.A. Armstrong Named to ATMI Board

John A. Armstrong, retired vice president of science and technology for IBM, has been named to the board of directors of Advanced Technology Materials Inc. Armstrong is also the Karl Taylor Compton visiting lecturer at the Massachusetts Institute of Technology.

Armstrong, who was the Plenary Speaker at the 1992 MRS Fall Meeting, is a member of the National Academy of Engineering, the 1989 recipient of the George E. Pake Prize of the American Physical Society for management of research in industry, a past member of the Commission on the Future of the National Science Foundation, and a member of MRS. (See the February 1993 *MRS Bulletin*, p.4-9, for the text of Armstrong's plenary address.)

Princeton Plasma Lab Produces 3 Million Watts of Controlled Fusion Power

Researchers at Princeton University's Plasma Physics Laboratory have produced more than three million watts of controlled fusion power in experiments at the laboratory's Tokamak Fusion Test Reactor (TFTR). The magnetic fusion experiments used a fuel mixture composed of equal amounts of deuterium and tritium.

Experiments will continue through most of 1994 to allow studies of whether the particles that are produced will, as expected, help sustain the temperature of the fusion reaction. Following completion of the D-T experiments, the TFTR will be decommissioned and replaced by a long pulse, advanced device, the Tokamak Physics Experiment (TPX) that will make use of the TFTR test cell and existing equipment at the Plasma Physics Laboratory site. Plans are to operate the TPX as a national research facility to develop the scientific and technical basis for a compact, continuously operating tokamak fusion reactor. Current year funding for the TPX is $20 million.

TPX research will also be applied toward the development of the International Thermonuclear Experimental Reactor, now being designed by the U.S., the European Community, Japan, and the Russian Federation. The projected cost of the ITER is $7 to $10 billion, to be shared by the participants.

Princeton's success has come at a critical time in the U.S. national funding process. The U.S. Congress has been supportive of the fusion energy program, but the administration's management of the program has been criticized. The administration's FY 1995 budget request for the Department of Energy's fusion energy program is $372.5 million, an 8.44% increase over FY 1994.

Photovoltaic Thin-Film Solar Panel Reaches 10.2% Conversion

Photovoltaic thin film technology recently passed a major milestone when the Department of Energy and United Solar Systems Corporation announced the achievement of a stable 10.2% conversion factor on a one-square-foot photovoltaic thin-film solar panel.

This mark, say the technology's developers, makes photovoltaics competitive with fossil fuels. Current costs for electricity from photovoltaics run from 25 to 50 cents per kilowatt hour. The new development is expected to bring the cost down to 16 cents/kWh and eventually to 12 cents/kWh.

DOE cost-shared the $6.26 million development of USSC's thin film. USSC, a 50-50 partnership between Energy Conversion Devices Inc. and Canon Inc. of Japan, plans to market the technology to the housing industry for use in roofing shingles and to the utility industry. USSC plans to begin manufacturing panels next year at a $30 million plant in Newport News, Virginia. The plant expects to manufacture 10 megawatts worth of thin film per year.

In addition to domestic applications, the efficient photovoltaic films is expected to open up markets abroad. Right now, only 30% of the international photovoltaic market goes to U.S. companies.

S.L. Sarkar Receives NATO Grant to Study Ancient Concrete

Shondeep L. Sarkar, professor in the Department of Civil Engineering at Sherbrooke University, has received a grant from NATO to coordinate the pro-

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ject, Micromechanical Investigation of Mortar/Concrete in Historical Monuments in Istanbul, Turkey, in collaboration with Prof. M.A. Tasdemir of the Istanbul Technical University. The grant, BF 223,000.00, or about $6,300, will be used to study concretes from periods from 537 to 1619 A.D. to cast light on why modern concretes fail and on ways to help concrete technologists design mortar and concrete for long-term durability. The collaborative research project will last two years.

Thicker, Tougher Ceramics Made Quicker, Cheaper

Researchers at Oak Ridge National Laboratory (ORNL) have developed a method for producing thicker, tougher ceramic materials more quickly and at lower cost. The process can create ceramic components in 40 hours, compared to the several months currently needed by U.S. manufacturers. Using a forced-flow thermal gradient technique, the researchers produced thick-walled, simple-shaped component silicon carbide disks up to 12 inches in diameter and one inch thick. Previous technology is able to produce disks of only three inches or less in diameter.

Ted Besmann of ORNL's Metals and Ceramics Division said, "Until now, conventional techniques for fabricating ceramic composites have involved fiber-damaging extremes of temperature and mechanical stress. This limitation has produced characteristic brittleness, or low toughness, which has made it difficult to penetrate commercial markets. Our technique allows the formation of very high melting point materials at relatively low temperatures, which spares the fiber material from being degraded."

Using a forced chemical vapor infiltration furnace heated to 1204°C, Besmann and ORNL principal technologist Jerry McLaughlin created a chemical reaction to produce solid silicon carbide. The furnace was configured to allow a mixture of methyltrichlorolane and hydrogen gases to react with 50 or more layers of ceramic cloth. The cloth fibers were fused to reinforce the ceramic material, closing voids between the fibers to yield a tough ceramic composite material.

"What's really important about our success is that we made the process of producing thicker (greater than 1/8 inch), tougher, and more impact-resistant component parts practical," Besmann said. "We demonstrated that related projects we had worked on for almost eight years could in fact, be scaled to industrial-size components."

The disk is being spin-tested for structural integrity at speeds of 30,000 rpm or greater by Williams International Corporation, Walled Lake, Michigan. Earlier, ORNL researchers subjected it to x-ray radiography and computer tomography tests to determine the disk's density and uniformity.

"A variety of other materials are available for producing these composites, including carbide, nitride, and boride. Perhaps we'll be able to test these materials for possible application as well," Besmann said. "As we look ahead, we see a need to develop new materials, such as oxide matrices with oxide fibers, that will help us further utilize the vapor infiltration technique we have developed to date."

N.A. Peppas Honored for Contributions to Bioengineering

Nicholas A. Peppas, professor of chemical engineering at Purdue University, has been named Showalter Distinguished Professor of Bioengineering. He is best known for his work in bioengineering and biomaterials, especially in the controlled release of drugs. He has developed a number of biomaterials, polymers, and drug-delivery systems to introduce medicines or artificial devices into the human body.

A founding fellow of the American Institute of Medical and Biological Engineering, Peppas has received numerous awards for research and teaching. He is the author of more than 450 publications and the co-author or editor of 19 books. He joined the Purdue faculty in 1976 after receiving his doctorate from the Massachusetts Institute of Technology.

Reliance Electric Demonstrates 5 HP Superconducting Motor

Reliance Electric Company has announced the successful operation of a superconducting motor with an output power of 3,730 W or 5 hp. The motor's high-temperature superconducting (HTS) coils also rotate at 1,800 rpm. This is a significant step beyond an earlier prototype that had stationary HTS coils and 1,490 W (2 hp) output power.

The rotating field, synchronous motor is an engineering prototype of the same type of construction visualized for larger synchronous motors (1,000 to 10,000 hp) that may be utilized for industrial and electric utility applications.

Institute of Materials Polymer Award Recognizes Powder-Free Surgical Glove

The Institute of Materials' Prince Philip Gold Medal Award for Polymers in the Service of Mankind was presented to Regent Hospital Products for their powder-free surgeons' glove. First introduced in 1983, the powder-free surgeons' glove has a polymer film coating on the inside which facilitates donning the gloves even with damp hands.

Established in 1973, the Prince Philip Award is presented to an individual or a team from an organization anywhere in the world which has succeeded in using plastics or rubbers for the betterment of mankind. The Award has recognized pioneering work with plastics for artificial hip joints; plastic netting now used throughout the world for crop protection and gathering, packaging, etc; the steel belted radial-ply tire; Kevlar aramid fiber and more.

For information about the Award, contact: Keith Wakelam, The Institute of Materials, 1 Carlton House Terrace, London SW1Y 5DB, United Kingdom; tel. 44-71-839-4071; fax 44-71-839-2078.

Kelvin's Conjecture on Minimal Surfaces Countered

In 1887 *Philosophical Magazine* published Kelvin's classic analysis of the following problem: What space-filling arrangement of cells of equal volume has minimum surface area? Kelvin's conjecture rested on a bcc arrangement of tetrakaidecahedra (14-sided cells) with subtle curvatures incorporated to minimize the total area.

That conjecture has been examined and challenged, but never refuted until researchers studying various foam structures reported a counter-example (*Philosophical Magazine Letters*, Vol. **69**, 1994). The solution offered by Denis Weaire, a professor in the Physics Department at Trinity College Dublin, and Robert Phelan, a postgraduate research student, is based on two cell types, one 14-sided and one 12-sided.

Weaire and Phelan describe their structure as analogous to that of some

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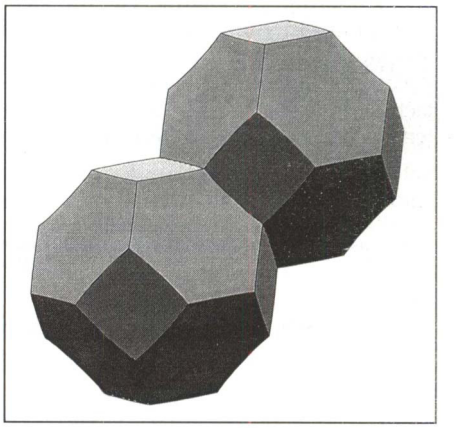
clathrate compounds and also related to the ß-tungsten structure. Its surface area is approximately 0.3% less than that of Kelvin's structure.

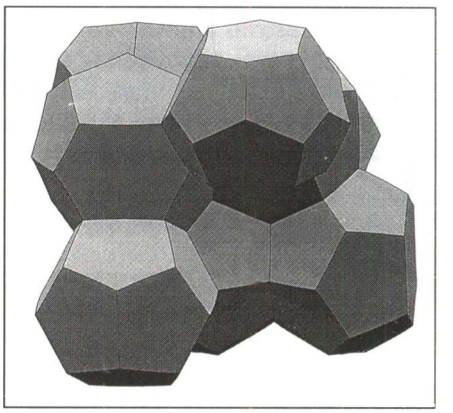
Surface Evolver software developed by U.S. mathematician Kenneth Brakke (Susquehanna University, Pennsylvania) was used to analyze and optimize their structure. This public domain software is described in *Experimental Mathematics*, **1** (1992), p. 141.

Weaire and Phelan recently submitted another paper to *Philosophical Magazine Letters* in which they review their experimental position. They explain how their realization that what they thought was a bulk transformation was predominantly the transformation of the surface cells. This led to their re-examination of Kelvin's proposition for the bulk and eventually to the work that refutes his conjecture.

They also conclude that the analysis of monodisperse foams has suffered from an excess of theorizing and a shortage of experiments, citing the easy, rapid (and old) method of blowing bubbles under water. "Now that computation of minimal surfaces is also straightforward, we can expect futher rapid progress toward a full underdanding of this systems and its variety of phenomena," they say.



Kelvin's structure constructed using Brakke's Surface Evolver software and depicted using the GEOMVIEW package.



Arrangement of the cells that make up the new minimal structure reported by Weaire and Phelan. It consists of six 14-sided polyhedra and two 12-sided polyhedra. This is the repeating unit on a simple cubic lattice. □

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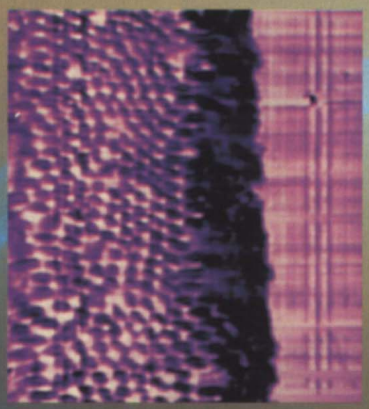

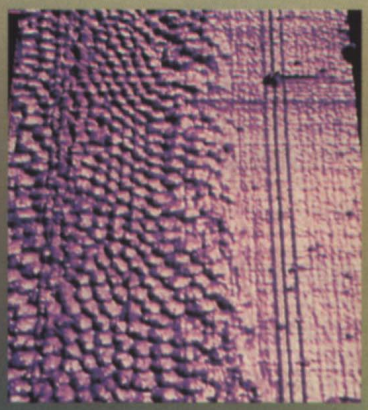

***SNOM** image (above) and topographic image (right) of eye tissue were acquired simultaneously by Aurora.*

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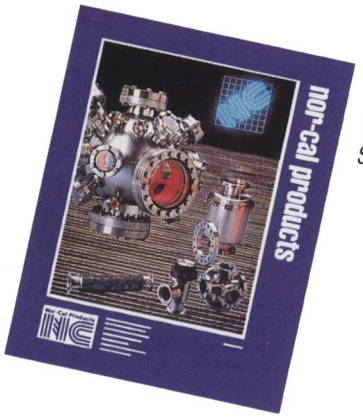

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