Materials Science

Richard Lipkin reports from San Francisco at a meeting of the Materials Research Society

A superconducting tape...

A flexible superconducting tape that carries more than 1 million amperes of electric current per square centimeter of material has proven itself in the laboratory, scientists report. Stephen R. Foltyn, a materials scientist at the Los Alamos (N.M.) National Laboratory, and his colleagues describe making bendable strips that superconduct at 75 kelvins, the temperature of liquid nitrogen.

For a superconductor to carry so much electricity in such a small area — a density of current 100 times greater than similar compounds have carried — sets a record for electric transmission at that temperature, the scientists state. By contrast, the number 12 copper wire used in most homes carries only 800 amperes of current per square centimeter.

The researchers produce the tape as a three-layer sandwich by depositing yttrium-barium-copper oxide, a superconducting ceramic, onto nickel alloy coated with cubic zirconia. The resulting tape bends so easily that even after repeated flexing it shows no signs of cracks. That property is unusual for a metal coated with a ceramic, the scientists say.

To layer the superconducting ceramics on the nickel, the researchers used a technique called ion-beam-assisted deposition, says Paul Arendt, a materials scientist at Los Alamos. The method uses two beams of charged particles. One beam deposits atoms of the superconducting material, while the second one aligns the crystals as they form. The tape's ability to stay intact after a tight winding may facilitate the production of tiny, powerful magnets.

Such micromagnets could lead to small magnetic resonance imaging machines for examining parts of the body, such as a knee or elbow, rather than the whole-body scanners used today, the scientists say. Manufacturing highly efficient electric motors or portable devices for removing contaminants in soil at toxic waste sites might also become possible with flexible superconducting tape, they add.

Foltyn/Los Alamos National Laboratory

The superconducting tape bends without cracking.

...mass-produced?

For any type of superconducting wire or tape to become practical, a manufacturer has to produce it efficiently on a large scale.

In an effort to solve this problem, Amit Goyal, a materials scientist at the Oak Ridge (Tenn.) National Laboratory, and his colleagues have developed a system for producing high-temperature superconducting wires in bulk.

The key lies in depositing the superconductor onto a carefully chosen substrate so that the crystal grains fall into alignment. Researchers call such alignment "biaxial texture," a quality that strongly affects how much current a superconductor can carry.

The new method, or "rolling-assisted biaxial texture" process, enables a manufacturer to produce superconducting strips quickly and in large quantities. "Since it's a bulk process, in theory someone can produce any length or width," Goyal says. "There's no limit."

So far, the team has made flat, 1-inch-wide wires with yttrium-barium-copper oxide deposited on them. Tests show that the superconductor does in fact have biaxial texture. If it did not, the material would not superconduct effectively in the presence of a magnetic field.

The technique, say the researchers, should work for other types of superconductors as well.

Physics

Ivars Peterson reports from Washington, D.C., at an American Physical Society meeting

Counting down the top 200 and more

"The investigation reported in this paper was begun as the result of an accident which occurred in this laboratory in April 1925."

So begins an article published in the December 1927 PHYSICAL REVIEW. In this report, Clinton J. Davisson and Lester H. Germer of Bell Telephone Laboratories in New York described the first experimental evidence that particles can behave as if they were also waves. They demonstrated that a single crystal diffracts electrons in much the same way that it diffracts X rays to create a characteristic pattern of beam intensities.

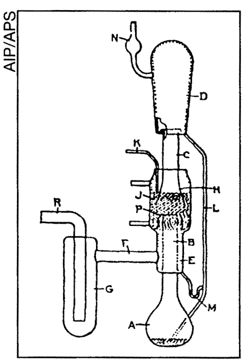
Their introduction goes on: "At that time we were continuing an investigation . . . of the distribution-in-angle of electrons scattered by a target of ordinary (polycrystalline) nickel. During the course of this work a liquid-air bottle exploded at a time when the target was at a high temperature; the experimental tube was broken, and the target heavily oxidized by the inrushing air . . . . When the experiments were continued it was found that the distribution-in-angle of the scattered electrons had been completely changed."

The explosion had melted the nickel target, and upon cooling, the nickel had resolidified into a single crystal. Davisson and Germer could then observe, to their surprise, that the crystal deflected electrons only in certain directions rather than dispersing them evenly.

The Davisson-Germer paper is one of 200 included in a new book consisting of noteworthy articles reprinted from the PHYSICAL REVIEW and PHYSICAL REVIEW LETTERS, along with commentaries and overviews. A CD-ROM edition that accompanies the 1,250-page volume contains a sampling of 1,000 important papers drawn from these journals. Published jointly by the American Institute of Physics and the American Physical Society, the compendium is called *The Physical Review: The First Hundred Years.*

Among the top 200, one finds Robert A. Millikan on determining the elementary electric charge (1913), Carl D. Anderson on the discovery of the antimatter counterpart of the electron (1933), Albert Einstein, Boris Podolsky, and Nathan Rosen (1935) on the strangeness of quantum mechanics (with a later reply by Niels Bohr), Hans A. Bethe on energy production in stars (1939), John Bardeen and Walter H. Brattain on the invention of the transistor (1948), and Richard P. Feynman on a spacetime approach to quantum electrodynamics (1949).

More recent entries include Alan H. Guth on the inflationary universe (1981), Gerd Binnig and his collaborators on scanning tunneling microscopy (1982), and Dan Shechtman and his coworkers on quasicrystals (1984).



AIP/APS

Irving Langmuir's high-vacuum mercury pump (1916).

"An examination, even if cursory, of the papers published [over the last 100 years] . . . shows a constant interplay among theory, experiment, the invention of new techniques and instrumentation to advance the experiment, and unforeseen applications of the new techniques," notes H. Henry Stroke of New York University in New York City, who edited the volume. "It is also interesting to observe that many fundamental contributions came from a few forward-looking industrial research centers."

Of course, some important developments and papers are missing because they were published in other scientific journals or they remained classified for a considerable period, as in the case of nuclear fission. In a few instances, such as the first realization of the laser, the original paper was rejected by PHYSICAL REVIEW. Nonetheless, this collection represents a remarkable record of achievement in physics.

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