News Briefs and Reports

Developments

INITIAL STUDY OF ELECTRONIC STRUCTURE IN Y-Ba-Cu-O HIGH TEMPERATURE SUPERCONDUCTOR

Researchers in the NBS Surface Science Division have published one of the first papers on the electronics structure of the high-temperature superconducting ceramic $YBa_2Cu_3O_7$. Electronics structure, which describes the permissible energy levels of electrons in the material, is a critical piece of information for understanding the still-mysterious mechanism of high-temperature superconductivity. In experiments run in collaboration with colleagues from the Naval Research Laboratory, physicists Richard Kurtz and Roger Stockbauer used the NBS synchrotron light source and resonant photoemission to map the electronic structure above and below the transition temperature for superconductivity, and to identify the atoms which contribute to the important valence bands of the structure. The data show no major changes in electronic structure with the transition to superconductivity, and that the predominant copper valence state comes from Cu^{2+} atoms. Both results should significantly affect current efforts to develop a theory of high-temperature superconductivity. "Resonant Photoemission Study of Superconducting Y-Ba-Cu-O" appears in the Rapid Communications section of the June 1 issue of *Physical Review B.*

NBS RESEARCHERS SUCCESSFULLY OPERATE 10-VOLT JOSEPHSON ARRAY

Researchers at the NBS Boulder Laboratories have achieved an extremely precise 10-volt output from an array of superconducting Josephson junctions. The array may eventually serve as a new standard for the U.S. legal volt at an unprecedented level of accuracy for this voltage.

The scientists believe the new array has more active elements—over 14,000—than any previous fully operational superconducting integrated circuit. The main challenge in designing and fabricating this complex circuit lay in making such a large number of flawless junctions with sufficiently uniform properties. A 2-year program to improve NBS' microcircuit fabrication capability made the success possible.

Development of this array was driven by increasing demands for calibration of popular 10-volt Zener diode standards. Such standards are gradually replacing 1-volt Weston-type cells as secondary standards in industrial and military laboratories around the country.

The legal unit of voltage in the United States and most other countries is defined in terms of the ac Josephson effect, in which microwave radiation (very high frequency radio waves) impinging on a superconducting junction generates quantized voltage steps that are exactly proportional to the frequency and to the ratio of Planck's constant to the electron charge. Since the latter ratio has been internationally defined, it is possible in principle to measure voltage as accurately as frequency, which is to say, as accurately as any physical measurement can be made at present.

Each Josephson junction can generate only a few millivolts. Previous 1- or 2-junction Josephson standards required the use of a complicated resistance bridge to compare the tiny standard voltage with that of devices being calibrated. Increased accuracy is possible when many Josephson junctions in series can be fabricated on a single chip, eliminating the need for the resistance bridge.

During the late 1970s, the Bureau contributed to research on Josephson junctions which revealed a possible method for connecting many junctions in series to provide high output voltages. NBS' Richard Kautz first demonstrated the new mode of operation for Josephson standards in 1980. By

March 1987, an array of 2076 junctions operating at the 1-volt level was placed in service as the new official U.S. legal volt standard. A month later, researchers Frances Lloyd, Clark Hamilton, James Beall, Diane Go, Ronald Ono, and Richard Harris succeeded in operating an array of 14,184 Josephson junctions to provide a 10-volt output, realizing a voltage standard at an even more useful level.

These long arrays of superconducting junctions are constructed using technology borrowed from the semiconductor integrated circuit industry, substituting thin films of superconducting metals such as lead and niobium for the semiconductors. Various patterned layers of superconductors and insulators are deposited onto insulating thumbnail-sized substrates. They must then be cooled to within 4 degrees of absolute zero to reach the superconducting state.

The potential accuracy of the voltage determined using these arrays is essentially the same as the accuracy of the frequency used to irradiate the junctions. Atomic clocks could be used as a source of the frequency to provide an accuracy of better than 1×10^{-13}. However, for useful calibrations, noise and other practical limitations at present limit voltage accuracy to a few parts in 100 million.

GENCORP, INC. TO STUDY ELASTOMER BLENDS AT NBS

A joint research program to develop quality control information for the manufacture of tires and advanced elastomer products made from polymer blends has been established between NBS and GenCorp, Inc. Leon F. Marker and John J. Beres of the Akron, Ohio-based GenCorp are synthesizing samples of butadiene polymers, copolymers, and other elastomeric blends for examination of their microstructures by small-angle neutron scattering (SANS) at the NBS research reactor. The SANS technique allows these scientists to determine the phase separation of molecules as a function of temperature and composition. SANS measurements will be used by the researchers to develop phase diagrams showing the mixing and curing times required to obtain specific properties in polymer materials.

The joint project is part of the NBS Research Associate Program, which provides an opportunity for people from industry, universities, technical societies, and other organizations to conduct cooperative research at the Bureau on programs of mutual interest. Salaries are paid by the sponsor.

For further information on RAP, contact David Edgerly, Rm. A402 Administration Building, National Bureau of Standards, Gaithersburg, MD 20899, or call 301/975-3087.

NEW TECHNOLOGIES, QUALITY IMPROVEMENT, GLOBAL COMPETITION PUSH DEMAND FOR BETTER MEASUREMENTS

New technologies, the push for improved product quality, and global competition are dramatically increasing the demand for new measurement-related research and services, according to a report NBS delivered to Congress in late June [1].

The report was prepared at the request of the House Committee on Science and Technology and the Senate Committee on Commerce, Science and Transportation. It reviews current NBS measurement-related services to industry, government, and academia, and includes the views of key organizations which rely on those services. As part of the study, NBS officials visited senior managers in industry and government.

Among the study's conclusions:

– Industry needs greater numbers of individual measurements over a diversity of parameters and ranges. Because very high-accuracy measurement capability is being built into commercial devices, NBS needs to develop more measurement standards which are based on the invariant properties of matter which can be used in such devices (e.g., electrical/electronic measurement and test structures on a picosecond time scale.)

– Mature technologies need calibration services such as mass, flow, force, temperature, pressure, and optical radiation to be maintained, refined, or advanced.

– The trend toward real-time feedback and modification of process control and quality assurance systems will require different and better sensors, measurement devices, and calibration methods.

– Industrial concern for quality seems to be translating into concern for achieving traceability to NBS, which is increasing demand for NBS Standard Reference Materials (SRMs) of all types. In particular, new emerging technologies have produced a growing demand.

– "Multi-parameter" SRMs in which both physical and chemical properties are certified for the same materials are of especially high priority for the future.

– U.S. industry has come to rely on the Bureau's SRMs to calibrate "relative" measuring instruments (automated devices which do not measure absolutely). Most firms no longer have any laboratory capability of their own to calibrate such instruments.

The report includes a summary of specific measurement needs in advanced materials, advanced

electronics and semiconductors, microwave systems, automation, biotechnology, computer applications, electro-optics, physics and chemistry, and safety and health.

Reference

[1] Process and Quality Control and Calibration Programs of the National Bureau of Standards, available by sending a self-addressed mailing label to: Program Office, A1002 Administration Building, National Bureau of Standards, Gaithersburg, MD 20899.

NBS CONSORTIUM ORGANIZED TO HELP METAL POWDERS INDUSTRY

ALCOA, Crucible Materials Corporation, General Electric Company, and Hoaganaes Corporation are the first private sector organizations to join a new consortium established by NBS. The consortium's goal is to develop the basic measurement system needed for the automated or "intelligent" processing of rapidly solidified metal powders by high-pressure, inert-gas atomization. The 3-year program is open to researchers from industry, universities, and government agencies who are concerned about quality control in the production of rapidly solidified metal powders for aerospace and other high-technology products that require materials with superior performance. These powders can be processed into usable parts to near-net shape by various consolidation methods such as extrusion and hot pressing that generally preserve the rapidly solidified microstructures.

For information on the consortium, or to join the program by providing either funds or researchers, contact Tom Yolken, B344 Materials Building, National Bureau of Standards, Gaithersburg, MD 20899, or call 301/975-5727.

GUENSLER BECOMES CHAIRMAN OF NCWM AT 72ND MEETING

Darrell A. Guensler, who heads the Division of Measurement Standards in the California Department of Food and Agriculture, has been chosen chairman of the National Conference on Weights and Measures (NCWM). Guensler, active in weights and measures activities for 25 years, assumed office at the July 1987 NCWM annual meeting in Little Rock, AR.

NCWM is an organization of state, county, and city weights and measures enforcement officials and associated business and consumer representatives. Through the NBS Office of Weights and Measures, the Bureau provides technical assistance to NCWM and its committees.

For information on the conference, contact the National Conference on Weights and Measures, P.O. Box 3137, Gaithersburg, MD 20899, or call 301/975-4004.

SYNTHETIC HYBRID LUBRICANTS STUDIED AT NBS

Working jointly with NBS scientists, researchers from Technology Assessment and Transfer, Inc., Gambrills, MD, have shown that it is possible to develop a hybrid solid-liquid lubricant with improved performance for use in high-temperature friction and wear environments. Using NBS' high-temperature sliding wear test system, the researchers conducted studies on various combinations of synthetic lubricants with liquid and dry powder additives. The formulations consisted of nickel and chromium intercalated graphites at concentrations of about one-weight percent in the liquid carriers. Tests were performed up to 500 °F under highly loaded boundary lubrication conditions.

Further studies also indicated that solid composites of metal or ceramics with these intercalated graphites may have desirable wear and friction characteristics for such applications as ring-liner combinations in high-temperature engines. The work is being done as part of the NBS Research Associate Program, which provides an opportunity for people from industry and other organizations to conduct cooperative research at the Bureau on programs of mutual interest. Salaries are paid by the sponsor.

For further information on RAP, contact David Edgerly, Rm. A402 Administration Building, National Bureau of Standards, Gaithersburg, MD 20899, or call 301/975-3087.

ANTENNA MEASUREMENT ERRORS DESCRIBED, EVALUATED

When antennas are measured or calibrated in anechoic chambers, a misalignment of the receiving and source antennas will lead to errors. In the case of near-field measurements, uncertainty about the location of the probe with respect to the antenna will cause relatively large errors. Two recently published reports from NBS rigorously examine these errors to quantify their effects on measurement accuracy. *Evaluation of Off-Axis Measurements Performed in an Anechoic Chamber* (TN 1305) and *Displacement Errors in Antenna Near-Field Measurements and Their Effect on the Far Field* (TN 1306) are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. TN 1305 may be ordered for $2.25 prepaid; order by stock no. 003-003-02779-1. TN 1306 costs $2 prepaid; order by stock no. 003-003-02776-6.

CHEMICAL REACTIONS LEADING TO SOOT FORMATION REVIEWED

For several years, NBS chemists Kermit C. Smyth and J. Houston Miller have been studying the chemical reactions in flames that lead to soot formation. In an article in *Science* magazine [1], Smyth and Miller review their studies and discuss their most recent research. The NBS scientists say that identifying the detailed mechanisms by which large hydrocarbon molecules are produced during combustion continues to be one of the most challenging problems in high-temperature chemistry. But through recent laboratory experiments and computer modeling at NBS and other organizations, significant progress has been achieved in identifying the growth reactions that lead to soot inception. Smyth and Miller speculate that a single, dominant mechanism may be involved in soot formation for all types of flames. Understanding this process is important for several reasons. Soot is a particular problem during a fire because it hinders vision and impairs breathing, and soot formation plays a key role in efficient burning and energy transfer such as in power plants.

Reference

[1] Smyth, K.C.; J.H. Miller, Chemistry of Molecular Growth Processes in Flames, Science, Vol. 236, No. 4808: 1540-1546; June 19, 1987.

NBS Services

NBS RECOMMENDS 400TH ENERGY-RELATED INVENTION FOR ASSISTANCE

A new process for continuous casting of steel cylinders used in manufacturing seamless pipe and tubing recently became the 400th invention to be recommended by NBS to the Department of Energy (DoE) for possible assistance in development and marketing.

Through the Energy-Related Inventions Program, conducted jointly by NBS and DoE, inventors can receive help in getting their ideas from the workshop to the marketplace. NBS provides, at no cost to the inventor, evaluations of energy-related inventions and recommends those it considers promising to DoE. In turn, DoE can provide financial support or help in marketing an inventor's idea.

The 400th invention to get NBS' recommendation is the idea of Gerhard E. Schwarz of Avon Lake, OH. Schwarz, a former senior engineer at the USX Corporation, has developed a way to continuously cast hollow, round steel cylinders used to manufacture seamless steel pipe and tubing.

About a million tons of seamless steel pipe and tubing worth roughly a billion dollars is used annually by the gas, oil, and power-generating industries as well as by chemical processors. Seamless pipe and tubing are in demand because it is strong, more reliable, and allows the use of thinner walls—and, thus, less material.

Continuous casting substantially reduces production costs, raises yields and productivity, and improves product quality. But the use of this technology in the United States is well below the levels of other major industrialized countries. During the first half of 1986, 49 percent of all raw steel processed in the United States was continuously cast; in 1985, 91 percent of the raw steel processed in Japan was continuously cast, and 71 percent in the European community.

The conventional method for manufacturing seamless steel pipe starts with solid ingots which first must be shaped into billets—short, thick bars of steel. They are then reheated, hollowed out, stretched, reheated, and finished. Schwarz's method, for which he holds a patent, would eliminate many of these steps by initially pouring the molten steel into a cooled vertical mold which forms a hollow round. Other attempts have been made, both in the United States and abroad, to cast hollow rounds, but so far these methods have not produced high-quality steel.

George Lewett, chief of the NBS Office of Energy-Related Inventions, says Schwarz's invention could save the equivalent of 200,000 or more barrels of oil per year. But, adds Lewett, "the principal value of Schwarz's process is expected to be a higher quality product which should cost no less to produce. This would give American manufacturers of seamless pipe and tubing a significant competitive advantage in an area that has been heavily invaded by imports." According to the Bureau of the Census, in 1985 the United States imported more than 4 million tons of all types of steel pipe and tubing, including seamless, worth about $2.4 billion.

Inventors getting a favorable NBS review are a relatively select group, those with very promising, new ideas. Of the 23,700 inventions submitted to NBS since the program started in 1975, NBS has recommended just 400 for DoE assistance.

These inventions have ranged from a portable pothole patcher, to a new way of making a composite material, to a new packing ring that could save electric utilities up to $200 million annually.

Many of the inventions have been successfully introduced into the market. According to a recent evaluation of the program conducted by

Oak Ridge National Laboratory, 70 of 204 recommended inventions that were studies were commercialized by 1985. They accounted for more than $200 million in sales from 1976 through 1984.

For example, California inventor Norman Fawley designed a lightweight aluminum cylinder, reinforced with resin-impregnated glass filaments, which makes it practical to use natural gas as a vehicle fuel. The cylinders being produced by Fawley's company, now a subsidiary of Aluminum Company of America (ALCOA), have been installed in fleet vehicles of 20 companies in the United States and Canada. John A. McDougal of Detroit, MI, developed a system that senses knocking in an automobile engine and controls spark timing in individual cylinders. McDougal recently licensed his system to the Ford Motor Co. in exchange for royalties.

An invention that passes initial NBS review undergoes a rigorous evaluation by the staff of the NBS Office of Energy-Related Inventions, relying in part of a national network of hundreds of expert consultants from government, industry, and universities. Typically, NBS evaluators obtain written opinions from at least two consultants on each invention evaluated.

The engineer-evaluators ask three key questions: Is the invention technically feasible? Will it save a significant amount of energy or increase supplies from nonnuclear sources? Does it have a reasonable chance of becoming a commercial success?

If the invention is considered promising, NBS forwards it to DoE for financial support and/or help with marketing the invention. The one-time DoE grants typically have ranged between $50,000 and $200,000, with an average of $80,000 per invention.

Inventions that are not recommended to DoE do get the benefit of a free evaluation by NBS. If an invention does not warrant further review, the key reasons are identified and sent to the inventor, who is welcome to try again. "We're always willing to reconsider our position if the inventor can provide further details or new information," says Lewett.

The assistance the program gives to inventors does not stop at evaluations and financial and marketing support. For the past 7 years the program has been bringing together inventors through a series of National Innovation Workshops held nationwide. The 2-day workshops give practical guidance and information to inventors and prospective inventors through lectures and panel discussions. Advice is given on turning ideas into inventions, and getting help from both public and private sources. More than 5000 inventors and would-be inventors have attended these workshops.

Those with ideas that will help save energy or who would like information on the workshops should write to:

Office of Energy-Related Inventions
Room 209 Engineering Mechanics Building
National Bureau of Standards
Gaithersburg, MD 20899

USERS, VENDORS COMPLETE OSINET FILE TRANSFER TESTS

The first group of 13 computer users and vendors has completed a series of tests across OSINET, an experimental computer network for Open System Interconnection (OSI) standards. The group succeeded in accessing, transferring, and managing files as well as demonstrating that their OSI systems could work together. Coordinated by NBS, this network is helping to speed the development and use of commercial OSI products in industry and government.

Twenty-two computer and communications manufacturers and users, including several government agencies, are participating in the program. OSINET participants have developed their implementations of OSI standards, called "protocols." Using these implementations to communicate with each other and with the Network Information Center located at the NBS, product developers are able to verify that their systems work with other systems.

The file transfer protocol implementations in use by the OSINET participants are based on agreements reached at the NBS ongoing workshops for implementors of OSI. More than 200 computer manufacturers, semiconductor manufacturers, word processing vendors, process control vendors, communications carriers, and industry and government users participate in the workshops to advance the development of commercial products implementing OSI standards. The OSINET Steering Committee recently invited nonparticipants to submit proposals for joining the network.

For more information, contact Gerard Mulvenna, B217 Technology Building, National Bureau of Standards, Gaithersburg, MD 20899, or call 301/975-3631.