NRC Panel to Evaluate Redesign of Shuttle Rocket Booster

At the request of the National Aeronautics and Space Administration (NASA), the National Research Council (NRC) has appointed an independent panel to review the joint activities of NASA and its contractors in developing an improved booster. The newly formed Research Council panel includes well-known authorities in propulsion, materials, structures, reliability, and aerospace engineering, and experts in related industrial technologies. It will evaluate key steps in the redesign process, comment on the technical adequacy of scheduled NASA reviews of the redesign, and submit written recommendations to the NASA administrator. Following the first flight of the shuttle with the redesigned booster rockets, the panel plans to review the new data obtained from instruments on the boosters during the flight and then prepare a final report.

The panel's recommendations will be advisory. It will have no responsibility for approving NASA's plans for the booster's redesign or for determining when the space shuttle is ready for launch.

H. Guyford Stever, foreign secretary of the National Academy of Engineering, will be the panel chairman. Stever, Science Advisor to President Ford and former director of the National Science Foundation, is considered an international authority in aerodynamics and aeronautical engineering. He is also a member of the National Academy of Sciences.

Quasicrystals Formed by Solid-State Interdiffusion

During their studies of the formation and properties of the icosahedral phase of aluminum-manganese, James A. Knapp and David M. Follstaedt (both of Sandia National Laboratories and both members of MRS) developed a new process to make quasicrystals.

Quasicrystals are a new phase (icosahedral phase) of solid matter that is neither crystalline nor amorphous. They are somewhere in between and exhibit diffraction patterns that seem to violate the rules of crystallography. (See "Quasiperiodic Crystals: A Revolution in Crystallography" in the March/April 1986 BULLETIN, p. 9-14.)

The new process, annealing at 250-425°C to cause interdiffusion of the layers, produces the icosahedral phase in the solid state without melting or even the energetic atomic displacements associated with ion irradiation. Not only is this new process much easier and less expensive, it will permit the formation of bulk material."The capability to form the icosahedral phase by such a relatively simple method may have important implications for other research as well as for potential applications, for instance using powder metallurgy, if such alloys are found to have useful properties," conclude Knapp and Follstaedt.

Knapp and Follstaedt, who began their studies less than a year ago, have formed the icosahedral phase of aluminum-manganese by five different methods: line source electron beam annealing, pulsed electron beam annealing, laser melting, ion-beam mixing, and, most recently, solid-state interdiffusion. Each method provided analytical information useful to the scientific understanding of the new phase. Knapp and Follstaedt have made the following deductions about properties of the icosahedral phase:

- The melting point of the icosahedral phase must be higher than 660°C but less than 960°C.
- The time needed to nucleate the phase, revealed by the laser treatment, is less than 20 nanoseconds.
- Icosahedral grains as small as 2 nanometers have been formed.
- Icosahedral phase formation from the liquid state requires a rapid cooling rate of at least 1 million degrees Kelvin per second.
- The growth rate of the icosahedral grains is at least 1 cm/s.
- The icosahedral phase is stable against radiation damage, but only at 100°C and above. Under ion bombardment at room temperature, it converts to an amorphous phase.

R.F. Pinizzotto Becomes Visiting Professor of Physics

Effective May 1, 1986, Dr. Russell F. Pinizzotto joined the faculty of North Texas State University as a visiting professor of physics. Pinizzotto will work with the University staff on the development of the recently established Materials Characterization Center. He plans to continue his work on the applications of transmission electron microscopy to materials problems. Pinizzotto chairs the MRS Publicity and Public Relations Committee.

NRC Predicts Shortage of Physicists in the 1990s

A shortage of physicists may occur in the next decade, just when "major advances are to be found in every field," concludes a National Research Council (NRC) committee. The committee's forecast is part of a major review of physics, the first in more than ten years. The review tracks recent developments and future opportunities in six subfields of physics and in areas involving other disciplines.

Although U.S. physics research is generally in good health, the committee says, an expected increase in physics faculty retirements in the 1990s, combined with fewer physics PhDs to replace them, may spell a decline in academic research. Contributing to the likely shortage of PhDs in academic research is the decline in physics graduates and the increase in physics PhDs joining technology firms or doing technology-related research. Currently only about 900 PhDs a year are awarded in physics, compared to a peak of 1,500 in 1970. Foreign graduate student enrollment has been increasing since 1970, and the proportion of foreign enrollment was 40% in 1982.

The committee cites a need to preserve support for small research projects in a university setting, as emphasis increasingly shifts to such large-scale facilities as particle accelerators at national laboratories. "We must have a balance in support for large facilities and small research groups in order for both to survive," commented William F. Brinkman, a physicist at Sandia National Laboratories and chairman of the NRC review committee.

Even though small research suffers from obsolete equipment, small research groups "make an exceptionally strong contribution to educating new physicists," says the committee. (See Viewpoint: "Team Research: Education Consequences" in the May/June BULLETIN.)

Despite the committee's emphasis on small research projects, it recognized the value of large facilities. The committee recommended several major funding proposals, including the much-debated \$3-\$6 billion superconducting supercollider that would smash protons against protons.

The NRC committee report includes a detailed review of recent progress in physics. Among the highlights are new techniques for "bottling" atomic particles for longer times in order to verify physical theories more precisely; better understanding of the physics of fluids; new theories describing the birth and future of the universe; and the discovery of a fourth phase of matter, making it possible to construct atom-thin layers for the next generation of computer chips.

Copies of the report, *Physics Through the 1990s: An Overview*, are available from the National Academy Press, 2101 Constitution Avenue NW, Washington, DC 20418; telephone (202) 334-2000.

Editor's Note: The NRC news release about the physics survey does not indicate if those students not pursuing physics are being drawn off through cross-disciplinary opportunities into allied areas of materials research or technology. If they are, the impact of this shift on the materials community may, in fact, be positive.

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Space Charge Mapping Used to Study Dielectrics

Scientists at Sandia National Laboratories are using a new method to pinpoint the distribution of electrical charge within dielectric films in order to study the physics of dielectric breakdown. Among the questions being explored are how and why electrical insulation fails in the presence of high voltages or sometimes becomes conductive in the presence of radiation.

Physicist Robert A. Anderson and MRS member Steven R. Kurtz, both of Sandia's Electronic Property Materials Division, have developed an instrument for measuring space charge in dielectric films directly and unambiguously with micron resolution. Combined with computer processing, the instrument uses a compression wave generated by the heat absorbed from a subnanosecond laser pulse.

Most of the experiments have been done on Mylar. Space charge is injected into the film (coated on both sides with a metal) by subjecting it to high voltages. A pulse from an infrared laser generates an acoustic pulse that propagates through the film. The resulting compression changes the capacitance so that any layer of space charge within the film yields a pulse of induced current in the external circuit when the pressure pulse arrives. The induced current provides a map of the space charge distribution. By relating distance and time according to the speed of sound in the dielectric, the method reveals the depth and amount of the charge.

Anderson and Kurtz are the first to use this technique to study pre-breakdown (the space charge in a dielectric up to high-voltage breakdown). They observed new high-electric-field phenomena that they interpret as electronic injection and transport processes believed to initiate breakdown. They found that the distribution of charge next to the electrode does not continue to build with increasing field, but decreases as it approaches a field of 4 million volts per centimeter. Calculations and other data support their view that this behavior is caused by the onset of tunneling of electronic carriers into high-energy electronic states. They speculate that this process may produce large current densities leading to dielectric breakdown.

They also found evidence that the initial decay of current in a Mylar capacitor is not caused by space-charge-limited electronic injection transport as had been thought. They observed negligible charge trapped in the dielectric during the observable period of the decay. They propose that the decay current is caused by dipolar orientation or the conduction of ions in the bulk of the dielectric.

Their studies of the small persistent current that continues after the initial decay showed a small bulk space charge distributed roughly symmetrically around the center of the film. The space charge appears to form slowly, and Anderson and Kurtz speculate that it is caused by formation of ions by electrochemical reactions at the capacitor's electrodes. Under applied electric fields, these ions slowly drift into the bulk of the film, producing the observed space charge and causing the persistent current.

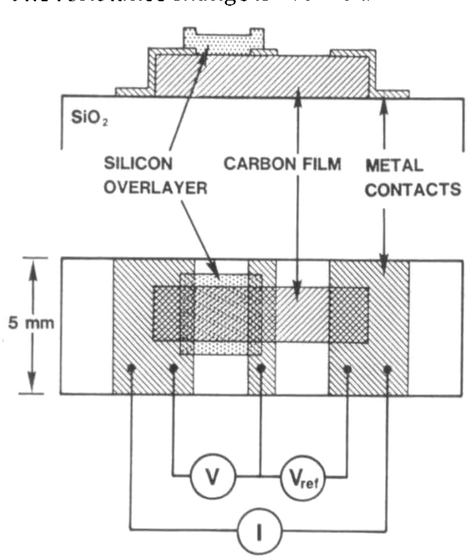
New studies at Sandia are examining the effects of radiation-induced conductivity and charge injection.

Particle Analyzer Uses Electrical Resistance

A carbon-resistance particle analyzer, invented by Sandia National Laboratories physicist William R. Wampler, measures in real time the quantities and energies of particles bombarding it. The analyzer has been used inside fusion research reactors in the United States and Europe to provide valuable information about particles that escape from magnetically confined plasmas and interact with the walls of the reactors in potentially harmful ways. It can measure the fluxes and energies of escaping hydrogen isotopes as a function of position and direction at the plasma edges of fusion reactors.

The carbon-resistance probe is expected to prove valuable in other technologies involving low-energy ion bombardment. The range of fluences (about 10^{12} to 10^{15} particles per square centimeter) and energies (above 30 eV) that the probe can measure is well suited to studies of plasma materials interactions.

The solid-state analyzer (see diagram) uses the increase in electrical resistance of a thin film of carbon as it is bombarded by atoms such as hydrogen and deuterium. The resistance change is used to determine the energy of the bombarding particle. Once the particle energy is known, the particle flux can be determined from the measured resistance change and a model calibration."



Carbon-resistance particle analyzer.

The capabilities of the carbon-resistance particle analyzer are at present unique," says Wampler. It provides real time data during fusion-reactor operation; it is sensitive at very low energies; and it operates at elevated temperatures.

Wampler has used the analyzer to measure particles in the PLT and PDX machines at the Princeton Plasma Physics Laboratory; in the TEXTOR fusion machine (designed for studying plasma materials interactions) in Jülich, West Germany; in the ASDEX machine at Max Planck Institüt; and in the TMX-U tandem mirror fusion device at Lawrence Livermore National Laboratory.

Lasers Reduce Time for IC Fault Analysis

A laser assisted cut-and-patch technique can reduce from several weeks to a day or so the time needed to conduct fault analyses of prototype integrated circuits (ICs) and to correct them. The dramatic time reduction is possible because Sandia National Laboratories researchers have found a way to use low laser power to cut, re-route, and patch the microscopic metal lines that carry electric current through ICs. Extremely low laser power is the key because it largely eliminates the chip damage that higher laser power could cause.

The technique makes confirmation of a test chip's design change relatively easy if only moderate rewiring is needed, says A. Wayne Johnson, supervisor of Sandia's Laser and Atomic Physics Division and a member of MRS. "After determining where the conducting lines should be routed, we simply remove the part we don't want by carefully directing pulsating laser light onto it in the presence of a reaction gas. We then use another type of laser and a different reaction gas to properly rewire the circuit," Johnson says. This procedure may take only minutes. Then the part is ready for retesting to confirm its performance.

Sandia researchers believe that the cut-and-patch technique lends itself to the development of more reliable redundant memory chips by offering increased design flexibility. They also believe the process could reduce the time it takes to test and evaluate gate array chips.

The cut-and-patch process is relatively straightforward. Both steps occur in a small vacuum reaction chamber that holds silicon wafers. Cutting requires a krypton fluoride laser to heat the aluminum line, causing the oxide film coating to crack and exposing the aluminum line to chlorine gas.

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Aluminum and chlorine spontaneously react to form aluminum chloride, a volatile vapor that is removed from the chamber. Cutting occurs only where the laser strikes the aluminum.

Line patching uses a continuous-wave ultraviolet argon ion laser operated at up to 0.4 W, and a reaction chamber filled with a mixture of diborane and silane gases. The laser simultaneously traces and heats a preplanned path over the silicon dioxide insulating layer. When that path reaches a sufficiently high temperature, the silane and diborane spontaneously decompose and conducting polysilicon is deposited. (This deposition technique is similar to processes being used at the Lincoln and Lawrence Livermore National Laboratories.) For more critical tests and for production parts, an additional thin tungsten film can be deposited on the polysilicon line. MRS

MRS
MATERIALS RESEARCH SOCIETY

In Memoriam

Norman L. Peterson, Head of the Department of Metallurgy and Mining Engineering at the University of Illinois, Urbana, died suddenly on April 17, 1986. A Union Carbide fellow at Massachusetts Institute of Technology, he had BSc, MSc, and DSc degrees in metallurgy. From 1961 to 1985, he was employed at Argonne National Laboratory, rising to senior metallurgist and earning a worldwide reputation for his studies of diffusion in solids. He also served as associate director of the Materials Science Division in charge of basic research for nine years, after which he returned to research and headed the Basic Ceramics Group at Argonne. During his distinguished career, he was awarded Ford Foundation, National Science Foundation, and Humboldt fellowships, and was a frequent visitor at European scientific institutions. In November 1985 Peterson joined the University of Illinois to become Head of the Department of Metallurgy and Mining Engineering and to develop a Department of Materials Science.

Research Resources

A summary of new products and services for materials research. . .

Materials Information: Materials Information, previously known as Metals Information, is a joint service of the American Society for Metals and The Institute of Metals (London). Materials Information will cover business and technical developments in polymers, ceramics, and composites industries in addition to metals technologies. A new Materials Business File is accessible through several online systems. American Society for Metals, Metals Park, OH 44073; telephone (216) 338-5151, or The Institute for Metals, 1 Carleton House Terrace, London SW1Y 5DB, England; telephone 01-839-4071.

- *Literature Search Service:* Materials Information offers two types of searches for anyone without library or computer facilities: (1) current awareness searches (monthly updates) and (2) retrospective searches (a comprehensive record of all citations for a specified subject area).
- *Directory of Metallurgical Consultants and Translators:* Second edition, published by Materials Information, lists nearly 1,000 consultants and translators with metals-related expertise. Extensively indexed directory lists translators by language and consultants by technical specialty.
- *Source Journals in Metals and Materials:* Third edition of this reference lists over 1,500 scientific, engineering, and trade journals processed for abstracting and indexing by Materials Information.
- *Metadex User Manual:* Third edition of this reference from Materials Information details how to make the best use of the METADEX database on metals and metallurgy.
- *Thesaurus of Metallurgical Terms:* Seventh edition published by Materials Information provides a standardized terminology for metallurgy and related sciences, with main terms and cross references corresponding to the usage in METADEX.
- *Engineered Materials Abstracts:* New monthly publication from Materials Information covers international published literature on polymers, ceramics, and composite materials.

Programmable R&D Plasma System: The Microplasmalab addition to Microscience's range of R&D plasma systems features the same modular chamber assembly, electrodes, and vacuum options used in the Plasmalab series together with a new microprocessor-based control system. Microplasmalab can be used for all major plasma processes including RIE, PECVD, and planar etch. Microscience, Inc., Forbes Business Center, 182 Forbes Road, Braintree, MA 02184; telephone (617) 849-1952.

250 MHz FT-NMR Spectrometer: IBM Instruments' spectrometer provides reliable, high field performance at an affordable price. Excellent automation (including automatic shimming, lock, sample-eject, observe receiver gain, and 120-position sample changer) permits unattended operation for long periods. IBM Instruments Inc., Orchard Park, P.O. Box 3332, Danbury, CT 06810; telephone (203) 796-2500.

High-Capacity Thermal Analysis System: Cahn Instruments' TG System 131 is the world's first high-capacity, high-sensitivity, corrosion-resistant system for thermogravimetric analysis. The system features a sample capacity of 100 g, yet it is sensitive to 10 μg. Cahn Instruments, Inc., 16207 S. Carmenita Road, Cerritos, CA 90701; telephone (800) 423-6641.

Chromatrography Workstation Programs: Five software programs for use with the IBM Instruments Chromatography Workstation are outlined in a new brochure. The five programs—Chromatography Applications II (CAP II), Touch and View, Utilities Library, Gel Permeation Chromatography, and GC/9630 Emulation Program—are designed to increase the productivity of the workstation with the 2.0 Operating System. IBM Instruments Inc., Orchard Park, P.O. Box 3332, Danbury, CT 06810; telephone (203) 796-2500.

Tunable Optical Isolator: The Model IO-4-IR optical isolator (Faraday rotator) from Optics for Research is a totally self-contained and passive unit for operation with the InGaAsP family of infrared laser diodes. Its tunability is over the 1.2-1.6 μm spectral range. Optics for Research, Inc., Box 82, Caldwell, NJ 07006; telephone (201) 228-4480.

Specimen Exchange System: The WA Technology specimen exchange system Microscience allows several sample cartridges to be quickly loaded from atmosphere into an exchange chamber and then transferred individually under vacuum into the microscope. Samples can be loaded individually into the microscope in less than one minute. Microscience, Inc., Forbes Business Center, 182 Forbes Road, Braintree, MA 02184; telephone (617) 849-1952.

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