Imaging Technique Pinpoints Cosmic-Ray Damaged Electronics

Researchers at Sandia National Laboratories have developed an imaging technique to pinpoint weaknesses in integrated circuits caused by ionizing radiation. Called single event upset (SEU) imaging, the technique can isolate malfunctions in single transistor components, and is detailed enough to be used to design more reliable circuits for use in satellites and equipment used in space.

Single event upsets are temporary but critical disruptions in an integrated circuit's memory cells resulting from a collision with high-energy cosmic rays. For example, the Hubble space telescope suffers from data loss due to such upsets in a focusing circuit.

With today's more densely packed integrated circuits and size reductions, radiation-induced failures have become more important. The imaging technique can help diagnose circuit weaknesses so the circuits can be redesigned to provide greater radiation hardness.

The SEU method is more precise than traditional whole-chip radiation testing for malfunctions, and can furnish information at the individual transistor component level by direct measurement. The technique involves directing a narrow ion beam (focused to about 1 μm) at a fixed point on a target. When the ion penetrates the silicon, it leaves a wake of excited electrons and holes. Electrons that group together and persist can induce memory cells to change their stored logic state. The emission of electrons is recorded by a detector in the target chamber. Because the microbeam can individually irradiate a single memory cell, transistor, or transistor component (like transistor drains or gates), SEU imaging can be used to image upset-prone microscopic regions.

The researchers use a microbeam generated by Sandia's Tandem Van de Graaff accelerator. The beam's position and component responses are monitored by an external computer which compares the electron image to a circuit design mask, providing detailed information showing which circuit elements are the origin of the single event upsets.

SEU imaging could also be used to measure the cumulative effect of ionizing radiation to a single memory cell, or by engineers to verify software codes used to simulate radiation upset processes.

Researchers Produce Flexible Concrete

A concrete that bends has been developed by scientists at Northwestern University, reports the June issue of *High Tech Ceramics News.* The concrete is made by a pultrusion method, which helps eliminate voids in the material, and is reinforced with polypropylene, steel, or glass fibers. The new concrete is four times stronger than its unreinforced counterpart and 100 times more flexible, making it potentially attractive for buildings, bridges, and roads, particularly in earthquake-prone areas.

The pultrusion method was developed by the Technical University of Denmark, a collaborator on the Northwestern project. Conventionally, vibration is used to compact concrete. In pultrusion, the material is forced through a die, similar to extrusion, except the material is pulled instead of pushed. The National Science Foundation Center for Science and Technology of Advanced Cement-Based Materials also participated.

The finished material is crack-resistant and can withstand more than 1% strain, while conventional concrete can resist only one thousandth that amount before breaking. Also, the concrete's increased tensile strength means that less material is needed to support the same load, so that components are lighter and easier to transport and assemble.

Researchers Demonstrate High T_c Magnetic Gradiometer

The first high-temperature superconducting magnetic gradiometer to be operated at liquid-nitrogen temperature has been reported by researchers at the IBM T.J. Watson Research Center. Like a magnetometer, the magnetic measuring device uses a superconducting quantum interference device, or SQUID, to measure extremely weak magnetic fields.

However, a gradiometer has the advantage of not needing cumbersome magnetic shielding used for magnetometers to prevent interference from external fields like those from the earth and nearby electrical equipment and electronic instrumentation.

The IBM gradiometer is similar in construction to the magnetometer, except that it has two adjacent pick-up coils configured as counterwound loops. Both loops are connected to the same multilayer spiral input coil. The counterwound coils react in exactly opposite ways when placed in a magnetic field that is uniform across the size scale of the coils. In combination, then, they produce no net effects at the spiral input coil, so no field is focused on the SQUID. A gradiometer therefore cancels out the effects of the earth's magnetic field, for example, yet allows measurement of non-uniform fields from localized sources such as in parts of the brain or heart.

Since gradiometers don't need shielding and operate at liquid nitrogen temperatures, they are more suited to real clinical medicine environments, for example, to produce magnetocardiograms or magnetoencephalograms to measure magnetic fields from the heart and brain. And like magnetometers, gradiometers are useful for other kinds of magnetic measurements as well, such as in geological exploration, scientific research, and in military applications.

Fabrication of the gradiometers relies on a wet-etching process. A highly selective etchant solution etches patterns in the thin films of materials used to insulate layers of superconductor and stops when the superconductor is reached. While wet etching had been used extensively in semiconductor processing, this is the first

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time it has been employed exclusively in fabricating multilayer high-temperature superconducting devices. IBM researchers have been able to achieve pattern linewidths of 5 μm in multilayer spiral input coils with as many as 20 turns.

AST to Develop Implantable Drug Release Device

Advanced Surface Technology, Inc., (AST) has received a $500,000 Small Business Innovation Research Phase II grant from the National Institute of Neurological Disorders and Stroke, a division of the National Institutes of Health, to develop a novel, implantable controlled drug release device for the treatment of certain disorders.

The implant, a bioelectrode, is composed of a conductive drug-binding polymer that, when electronically stimulated, can release varying amounts of drugs or other biologically active materials into the body. The device would be useful for treating such disorders as cancer, diabetes, or Parkinson's disease.

AST intends to establish a new company to fully develop the patented technology. Animal studies will begin immediately at Yale University in conjunction with research currently under way at Rensselaer Polytechnic Institute. The company is actively pursuing collaborative partnerships with major multinational pharmaceutical companies.

A. Schriesheim Appointed to NAE Committee

Alan Schriesheim, director and chief executive officer of Argonne National Laboratory, has been appointed to the National Academy of Engineering (NAE) Advisory Committee on Technology and Society.

The seven-year-old committee provides advice on NAE activities that examine the interaction between technological developments and various societal functions such as health, education, employment, and foreign affairs. The purpose is to examine these issues so that policy formulation in both public and private sectors can proceed on the basis of improved understanding.

Elected to the NAE in 1989, Schriesheim is a member of the Presidential National Commission on Superconductivity, the U.S.-U.S.S.R. Basic Sciences Joint Commission, the NASA Space Systems and Technology Advisory Committee, and numerous other scientific, technological, economic, and educational advisory committees.

Chemical Resins Separate Heavy Elements

EIChroM Industries, an Argonne National Laboratory spinoff company, has developed chemical resins that separate heavy radioactive elements formed in nuclear defense programs from chemical solutions. Future products will be aimed at helping clean up radioactive wastes left from nuclear weapons production and cleaning potentially toxic metals, such as

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copper, zinc, and lead from groundwater.

The firm currently manufactures and markets five products targeted at removing strontium, technetium, plutonium, americium, neptunium, uranium, and thorium.

The chemical resins selectively remove the long-lived radioactive elements from groundwater and other aqueous solutions. The resins also may be used to detect small amounts of the radioactive elements in human urine. Urinalysis is commonly used to help monitor possible intake of radioactive elements by people who work with them. The resins make it possible to detect concentrations of elements so low they were previously overlooked.

Elements caught in the resins can later be flushed out with water or acid for further analysis, and the new materials substantially reduce the time and effort needed to perform an analysis.

Barnacle-Free Hull Developed

An experimental ship built by NKK Corporation, a Japanese steel firm, uses cupronickel clad steel to prevent the adhesion of barnacles and other marine organisms. The clad eliminates erosion and the need for painting, thereby avoiding pollution sometimes associated with tin-based anti-fouling paints.

A comparatively thin 1.5 mm Cu-Ni (90% copper/10% nickel) plate is clad to a 4.5 mm steel plate to provide an economic material. A slight amount of copper dissolves from the cladding and has enough of an anti-fouling effect to ward off barnacles.

Peercy Appointed Sandia Director of Microelectronics and Photonics

Paul Peercy has been appointed director of microelectronics and photonics at Sandia National Laboratories effective August 1, 1991. This newly created directorate merges silicon-based microelectronics, compound semiconductor-based microelectronics, and optoelectronics technologies at Sandia. Prior to his appointment to this new position, Peercy was manager of the compound semiconductor and device research department at Sandia.

Peercy joined Sandia in 1968 and has performed research in several areas, including electronic band structure of semiconductors, solid-state plasmas, Raman and Brillouin scattering, ferroelectric and structural phase transitions in solids, ion implantation, ion beam analysis, and laser annealing. He is the author or co-author of more than 175 technical articles.

Peercy is an active member of MRS, currently serving as chairman of the program committee and of the journals subcommittee of the publications committee. He also serves as principal editor of the *Journal of Materials Research*. He is a past vice president of MRS and chaired the Conference Committee for the Washington Materials Forum, held in conjunction with the Forum of the Solid State Sciences Committee of the National Research Council.

In addition to his membership in MRS, Peercy is chairman-elect of the Electronic Materials Committee of TMS, fellow of the American Physical Society and of the AAAS, senior member of the IEEE, former member of the Solid State Sciences Committee of the National Research Council and member of the U.S. Department of Energy Council on Materials Science. He also serves on external advisory boards of various universities.

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Important Properties of Buckyballs Measured

Researchers at Los Alamos National Laboratory and the University of California, Los Angeles report measurements of two important properties of superconducting "buckyball" compounds. The researchers measured how the critical temperature varies with pressure, and they measured the materials's critical field, indicating how useful the superconductor may be for future applications.

Earlier this year, researchers learned that inserting a few atoms of potassium into the 60-carbon soccer-ball-shaped molecules, or buckminsterfullerenes, makes the compound a superconductor (see July *MRS Bulletin*, p.9) below about 19 K.

Measuring the critical temperature for superconductivity of the potassium-doped buckyballs as a function of the pressure, the researchers found that as they increased the pressure, the critical temperature of the material dropped dramatically, setting immediate constraints on the theoretical interpretations of the material's behavior, as reported in the June 28 issue of Science.

The critical temperature of the material while pressed mechanically was measured at pressures from ambient to 21,000 times normal. The critical temperature for the material dropped from 19 K to less than 8 K, opposite to the reaction found in copper-oxide compounds, where the critical temperature for superconductivity goes up with increasing pressure.

The pressure relationship found in potassium-doped buckyballs can then be applied to doping with larger molecules, which would create a "negative pressure" to raise the critical temperature, as is the case for rubidium-doped buckyballs, which superconduct up to nearly 30 K, the researchers note.

With bulk quantities of refined buckyball compounds supplied by UCLA, the material's magnetic properties were also measured by Los Alamos workers, who found that the material created substantial flux pinning. That is, the magnetic flux could be pinned in place so it could not wander through the material and dissipate energy, as in normal conductors. The results were presented in the July 8 issue of *Physical Review Letters.*

The researchers used the magnetic measurements to estimate the value of the buckyball compound's critical current, already calculated to be higher than that first reported for high temperature superconducting copper-oxide materials.

Tests indicate that another advantage of the carbon superconductors is that they superconduct in three dimensions, not just in specific planes as with the copper oxide superconductors. At present, however, buckyballs do not superconduct above liquid nitrogen temperatures.

The samples were produced by the UCLA team, who refined the method for manufacturing samples of potassium- and rubidium-doped buckyball compounds so that the entire sample is superconducting. Starting with a powder, the material is pressed into a pellet, sliced into thin strips, heated, ground into powder, and pressed again into pellets. Sliver-shaped pieces about three millimeters long were extracted from these pellets.

Eastman Kodak, Xerox, and University of Rochester Agree to Collaborate

A patent agreement among Eastman Kodak, Xerox, and the University of Rochester will allow an unusual collaboration of research between competitors and the university. The agreement, initiated in June, provides for open interaction and exchange of information among parties.

The arrangement helps break down legal and psychological barriers to collaborative research and concern about the ability of the United States to compete effectively in the global marketplace.

Kodak and Xerox are participating in the university's Center for Photoinduced Charge Transfer, which is sponsored by the National Science Foundation. Research at the center focuses on chemical processes in which a positive or negative electrical charge is transferred between molecules during the interaction between light and matter. These transfers underlie such processes as photography, photocopying, photosynthesis, photovoltaics, and enzymatic reactions.

Research projects are covered by a patent agreement that provides for open interaction and exchange of information among parties. The title to an invention resulting from work done at the center by one of the three parties belongs to that organization. Invention by either the university and Kodak or the university and Xerox results in a joint title shared equally. Ownership in the case of a three-party project resides with the university.

As a direct result of the pact, the three parties have begun a joint investigation to improve upon present artificial methods of charge separtion. Charge separation allows scientists to store one type of energy (such as light) and convert it to another type (such as chemical or electrical) for applications in technologies involved with light, such as imaging or solar energy.

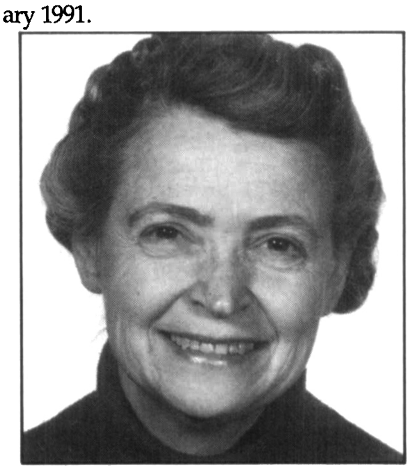
The key to tapping the stored energy is to create a current by forcing electrons to flow only in one direction. To do this, the spacing between molecules must be just right. If the molecules are too close to each other, energy will not be stored at all, and if they are too far apart, the current will not flow.

The Rochester group is using gold as a substrate while precisely positioning complex molecules containing sulfur on the surface. Anchored to the sulfur are chains of carbon that stand straight up from the gold. It is along these chains that current travels. Additional layers, however, usually formed by dipping the substrate many times in an electrolyte solution, are very unstable, so the Rochester team is working to make them more stable by binding them chemically to the substrate.

NAS Establishes Committee on Women in Science

M.S. Dresselhaus is Chair

Due to recently expressed concerns about the future adequacy of the U.S. science and engineering work force, the Committee on Women in Science and Engineering, a continuing committee of the National Academy of Sciences/National Research Council, was established in January 1991.



Chaired by Mildred S. Dresselhaus, Institute Professor of Electrical Engineering and Physics at the Massachusetts Institute of Technology, the committee will direct a national program of activities aimed at finding ways to attract and increase the participation of women in the U.S. science and engineering pool from the undergraduate through professional levels. In addition to serving as a clearinghouse for issues relevant to women scientists and engineers, the committee will propose research, conduct studies, and convene symposia and workshops. It expects to produce its first report by the end of this year.

November Conference Planned

The committee, composed of eminent scientists, engineers, and educators, has planned a conference on November 4-5, 1991 at the Arnold and Mabel Beckman Center, Irvine, California. The conference is titled "Programs Targeted to Potential Scientists and Engineers," and it aims to assemble information about programs that seem to be effective in recruiting and retaining both women and men in science and engineering. The programs will not be evaluated during the conference but will be examined to determine how well women fare in them, comparing, for example, the percentage of awards to women with the percentage of applications by women versus similar data for men.

The committee is gathering information on the range and availability of these programs at each level of the education/employment pipeline, beginning with college undergraduates and continuuing through the graduate, postdoctoral, and employment levels. Colleges and universities, private companies, federal agencies and foundations have been invited to contribute information on such programs as scholarships, fellowships and grants, coop programs and internships, research and teaching assistantships, traineeships, postdoctoral appointments, and continuing education programs for employed scientists and engineers.

For information about the November conference or the committee's work, contact Linda S. Dix, Study Director, 2101 Wisconsin Avenue NW, Green Bldg, Room 402, Washington, DC 20418; phone (202) 334-1841; fax (202) 334-2753.

Solder Science and Technology Center Established

Sandia National Laboratories has set up a Center of Solder Science and Technology to advance an overlooked but crucial manufacturing process.

Solder techniques have not kept pace with the industries that depend on them, and, for example, solder failure is the prime cause of failure in electronic equipment. Solder is also the target of environment legislation, because it contains about 40% lead and uses chlorinated and fluorinated solvents in many techniques.

The new center will address these concerns while facilitating and coordinating solder research, development, and applications.

The center is working with several industry partners, and is exploring or has established relationships with the University of California at Berkeley, the University of Wisconsin, Lehigh University, and the University of New Mexico.

Sandia officials believe solder producers and users could benefit by joining together in generic and precommercial research and development, in light of quality, environmental problems, and international competition. □

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