Ionwerks, Argonne to Study Ion Beam Analysis Techniques for Commercial Production

Because conventional surface analysis methods won't work on a production line (they require vacuums thousands of times lower than those used during production), Ionwerks (Houston, Texas) and Argonne National Laboratory have joined forces under a CRADA to adapt and improve surface analysis techniques now used in scientific laboratories. The goal is to make them practical for use during commercial production to monitor growth, structure, and composition of ultrathin films.

The three techniques being studied—ion scattering spectroscopy (ISS), direct recoil spectroscopy (DRS), and mass spectrometry of recoiled ions (MSRI)—can work at pressures up to one hundred times higher than those used in electronics manufacturing. Information is reported in less than a second, and all instrumentation sits well back from the surface where it does not interfere with film growth.

Compared to conventional surface analysis methods, ISS reveals more information and does less surface damage. On the other hand, it cannot detect surface atoms lighter than the ions in the probe. DRS can detect all atoms, including hydrogen, which most conventional surface analysis methods overlook. DRS could be useful in producing diamond films, which are often grown in a hydrogen atmosphere to help stabilize the structure. MSRI is potentially one of the most sensitive surface analysis techniques known. It can distinguish among ions of similar mass while causing virtually no surface damage.

Photovoltaic Effect Observed in PPV

Working at the Center for Photoinduced Charge Transfer, scientists from Xerox Corporation and the University of Rochester have reported observation of the photovoltaic effect in the interface of a sandwich of aluminum and poly(p-phenylene vinylene). A conjugated polymer that is highly stable, PPV has good mechanical properties and is currently of wide interest for its electroluminescent capabilities. Scientists at the University of Bayreuth, Germany, recently reported similar observations.

As observed, the effect has several limitations to practical use, including low efficiency and the ability to produce voltage only from the green-blue spectrum of light. However, scientists believe that

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chemical modification could improve the material's performance. In particular, they expect to extend the material's response range into the red spectrum of visible light. The discovery has potential applications in organic solar cells, which would be less expensive and easier to fabricate than the inorganic materials currently in use.

Superconducting Magnetic Bearing Achieves Nearly Frictionless Behavior

A "super bearing" recently developed by Commonwealth Edison and Argonne National Laboratory uses a permanent magnet made of a neodymium-iron-boron alloy that is trapped and suspended in a magnetic field above high-temperature superconductors. The resulting coefficient of friction is only 9×10^{-7}. When the permanent magnet is placed above the superconductor, it generates an opposing magnetic field that repels the magnet. The magnet and superconductor never touch. By attaching a system of flywheels to a bearing's permanent magnet, engineers could create a repository for electric power.

"Adhesion Maps" Distinguish Surface Materials at Atomic Level

A technique developed by scientists from Xerox Corporation and the University of Rochester expands the information gathering ability of atomic force microscopes by measuring how electric fields change the adhesion of individual microscopic particles. Because adhesion and sensitivity to contaminants are different for different materials, the team reasoned that particle "adhesion maps" should permit distinguishing virtually any material in an inhomogeneous surface from any given surface material.

A tiny particle is attached to a cantilever or needle and put into contact with a surface, and the amount of force required to remove the particle from the surface is then measured. Because the cantilever and particle are so small, forces between individual atoms can be measured.

A long-term goal of the team's research is to distinguish the relative roles of electrical fields and a material's innate stickiness in particle adhesion and removal.

Bridgman Award Goes to Art Ruoff

Arthur L. Ruoff, professor in the Department of Materials Science, Cornell University, is the recipient of the 1993 Bridgman Award. The Bridgman Award is given biannually in recognition of outstanding contributions in the field of high pressure by the International

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Association for the Advancement of High Pressure Science and Technology.

Ruoff was cited for his fundamental studies of band-overlap metallization and of phase transitions in solids. This includes his optical and electrical resistivity studies which led to the metallization of the ionic solids BaTe, BaSe, and BaS and his demonstrations of the metallization of the molecular solids S, O_2, and Xe in the megabar regime. He was also the first to show that the bcc structure is the penultimate structure for metallic elements in the megabar regime (Zr, Hf, Sn, Pb). Ruoff also made important discoveries of new phases in the III-V semiconductors, which provided critical tests of the theories of bonding. He pioneered the use of microminiaturization, making him the first to reach pressures in excess of those at the Earth's core (361 GPa), and developed synchrotron x-ray diffraction techniques (CHESS) and optical studies which were used to study tiny samples to 560 GPa.

Georgia Institute of Technology Will Headquarter Phosphor Center of Excellence

Georgia Institute of Technology will be the headquarters for a Phosphor Technology Center of Excellence. The center will bring together a diverse group of university and industrial members to stimulate research and education in phosphors and to speed the transfer of phosphor technology from the laboratory to the commercial market.

The U.S. Advanced Research Projects Agency is providing $10 million for the first three years of operation and five university members will contribute $1.063 million. The American Display Consortium will add another $750,000. The universities involved are Georgia Tech, University of Georgia, University of Florida, Oregon State University, and Pennsylvania State University. Also joining these institutions is the David Sarnoff Research Center.

Phosphors luminesce after they have been excited by a flow of electrons, an electric field, or light itself. Though phosphor technology is mature, the demands of future displays require devices with improved resolution, brightness, energy, efficiency, and color quality. In addition, low-voltage phosphor devices must be made so they are reproducible in quantity, affordable, and dependable.

The center will use a variety of approaches for transferring phosphor technology to industry, including periodic short courses and seminars and also the creation of a technical database on phosphors. In addition, the center will offer educational opportunities by involving master's and doctoral students in its research projects and by creating a national phosphor fellowship program.

Research will focus on four specific areas: cathode ray tubes, thin-film electroluminescent displays, plasma display panels, and field emission displays. Specific projects will aim at improving low-voltage thin-film electroluminescence displays, field-emission display films, and thin-film cathode ray tube films. In addition, novel phosphor materials and structures and also new device and array processing techniques will be developed.

AACG Presents Crystal Growth Awards

The American Association for Crystal Growth (AACG) honored three distinguished representatives of the crystal growth profession at its recent conference banquet. Kenneth A. Jackson of the University of Arizona was honored with the AACG Award for seminal and lasting contributions to the theory of crystal growth. Jackson introduced the "α-factor" to predict the degree of atomic-scale roughening at the solid-metal interface. He also pioneered research in modeling crystal growth on an atomic scale by means of Monte Carlo simulations.

Two scientists were given the Young Author Award. Debra L. Kaiser of the National Institute of Standards and Technology was cited for originality and leadership in the growth of yttrium-barium-copper-oxide high-temperature superconductors. Jeffrey J. Derby of the University of Minnesota was honored for advanced modeling of heat transfer and convention in the Czochralski growth of semiconductors and oxides and the Bridgman growth of semitransparent crystals.

Industrial Team to Build Prototype Superconducting Current Limiter

Funding is being provided under the U.S. Department of Energy's Superconductivity Partnership Initiative to support a team effort by General Dynamics Space Systems Division, American Superconductor Corporation, and the Southern California Edison Company to build and demonstrate a novel superconducting current limiter prototype device for use in the electric utility industry.

A current limiter is used to momentarily reduce the flow of electric current during unexpected events such as lightning strikes or short circuits and thus protect expensive electrical equipment from damage. Using high-temperature superconducting wire technology, the team will build a prototype current limiter designed to reduce fault currents. This would allow utilities to use smaller, less expensive circuit breakers and fuses, thus requiring fewer upgrades as power demands increase.

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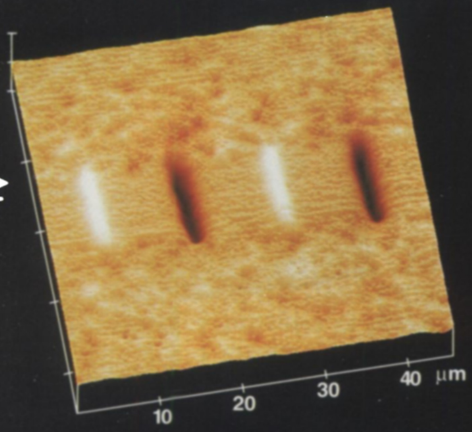
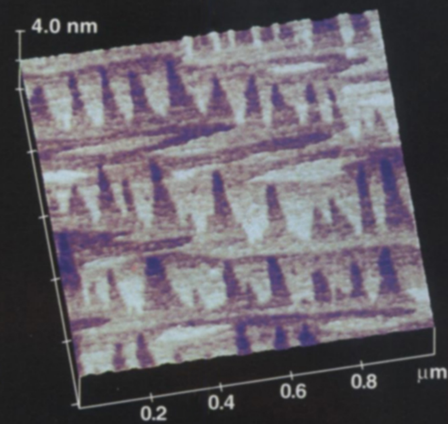


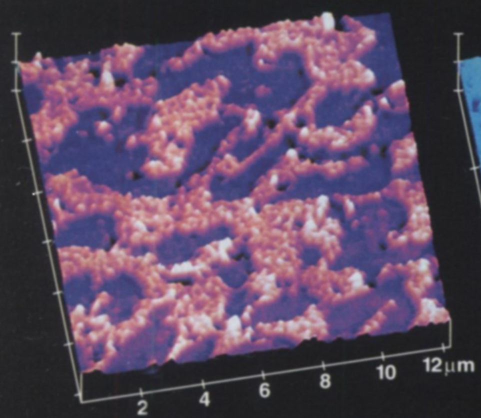
Magnetic Force Gradients ▶

These hard disk bits were written with alternating polarity and a slight skew. The speckle above and below the recorded track is due to the disordered magnetic domains in the virgin media.



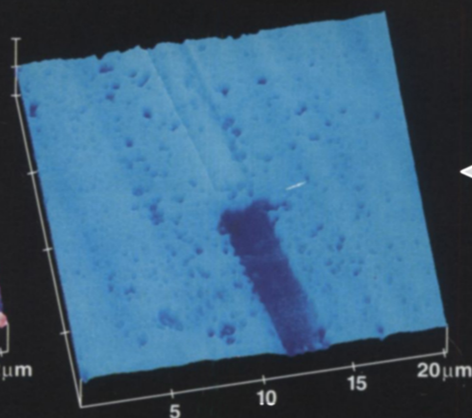
◀ TappingMode™ AFM Topography

These 1.6Å-high terraces of epitaxially-grown silicon were imaged using the NanoScope Large Sample Stage. Only the AFM probe touched the top surface of the intact 8in wafer.



Lateral Force (Friction) ▶

A mixture of EPDM and natural rubber scanned with a Si_3N_4 tip shows regions of higher friction (lighter color) and lower friction (darker color). These regions probably correspond to the two different types of rubber.



◀ Electric Force Gradients

A voltage applied to a broken metallization line on a GaAs test structure is shown. The image clearly indicates that the line is open at the break. This capability is another example of Digital Instruments innovation.

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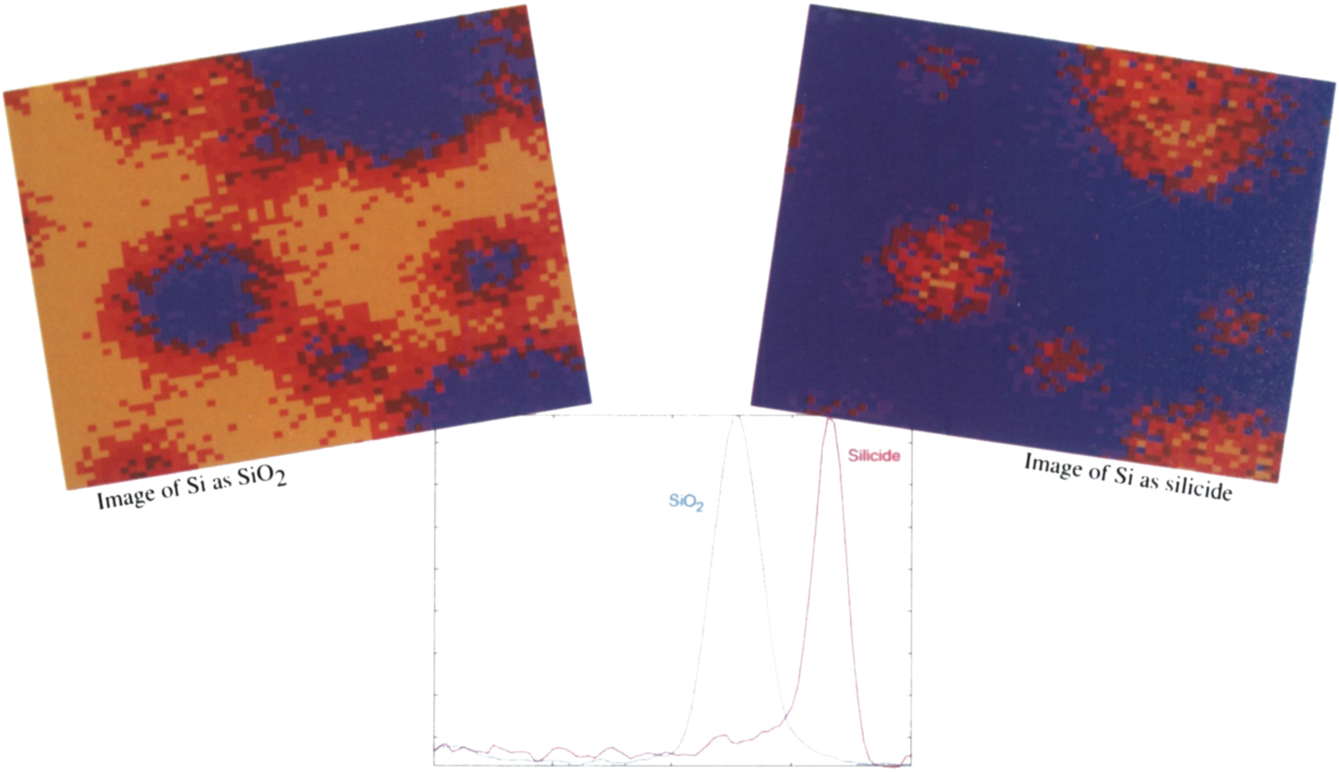
A New Definition of
Surface Chemical Analysis



The 5600ci was used to image the silicon chemistry of a blistered thin film. Spectral data stored at each pixel were examined and two separate silicon chemical states were identified (bottom). The map was separated into two images -- Si as SiO_2, and Si as silicide.

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Dearnaley Joins Southwest Research Institute

Geoffrey Dearnaley has joined the staff of Southwest Research Institute (SwRI) as institute scientist and program manager of surface modification in the Engineering and Materials Science Division. He is a Fellow of the Royal Society of London and is internationally recognized as a leader in research into ion implantation of semiconductors and metals.

As a key participant in the Institute's new biomaterials internal research initiative program, Dearnaley will work toward developing ion implantation to apply amorphous forms of diamondlike carbon to materials science for biomaterials applications. Dearnaley will also take a major role in the development of an ion beam surface modification facility at SwRI, which is expected to be fully operational this year.

His current research also involves new processes for diamondlike carbon coatings and for buried isolation of silicon, multilayered ceramic coatings for tools, the combination of laser-ablation and ion bombardment in coatings, and ultralow friction coatings for high temperatures.

Dearnaley attended Cambridge University, where his dissertation research centered on the energy levels of light nuclei. He joined the U.K. Atomic Energy Authority in 1958 as a research fellow in the nuclear physics division of Harwell Laboratory, near Oxford, and continued there until his recent retirement as chief scientist in the department of surface science and technology. At Harwell, he initiated a project to develop nuclear particle detectors based on the radiation sensitivity of the reverse-biased semiconductor diode.

His study of ion channeling in silicon, published in 1963, established the nature of the channeling process. He also pioneered ion implantation studies to improve wear and corrosion properties of metals and alloys, and subsequently applied the technique to a wide range of nonsemiconducting materials, including titanium alloy hip and knee components. With colleagues at Harwell, he designed the first ion implanter for metals in 1976.

Dearnaley consulted with the Los Alamos National Laboratory to assist in setting up a nuclear research laboratory, equipped with counter telescopes that he fabricated to distinguish particle type and energy in a single measurement.

Dearnaley is author or co-author of 207 technical papers and holds 51 patents. Among his many professional activities, he is a Fellow of the Institute of Physics in the United Kingdom and a visiting professor of physics at the University of Sussex.

Acid and Plasma Treatments Improve Polyethylene Fiber Adhesion

Treating ultrahigh-strength polyethylene fibers with chlorosulfonic acid has tripled their ability to adhere to the matrix materials, say Cornell University researchers. The simple, relatively inexpensive treatment triggers the production of reactive sites, or acid groups, on the surface of the fibers for covalent bond formation with epoxy resins.

The treatment resulted in superior interfacial adhesion between the polyethylene fibers and epoxy resins without adversely affecting the fibers' other mechanical properties, including strength, said Vasudha Ravichandran and Kay Obendorf, who presented their work at the American Chemical Society Meeting in August. They hope to develop an even less expensive method using a vapor of the acid instead of a liquid.

In related research, Peter Schwarz has been using a gas plasma to improve the adhesiveness of high-performance polyethylene fibers. Experimenting with an acrylic-based bond cement, Schwartz has been able to minimize its chances of cracking when used in joint replacement.

Schwartz chose ultrahigh-strength polyethylene fibers to toughen the cement because polyethylene is strong and approved for use in the human body. However, these fibers have poor adhesive properties. Using carbon dioxide, nitrogen, and argon gas plasmas improved the fiber-reinforced cement's adhesion, flexing strength, and reinforcing effect, said Schwartz. In addition, its fracture toughness improved sixfold.

Schwartz is also using plasma treatments on other high-performance fibers such as Kevlar, PBZT, and graphite fibers to modify their surface properties. He has used plasma treatments to form a polymer layer in composite material, which strengthens the bonds between the material's fibers and matrix. His work has been published in the *Journal of Adhesion Science Technology* and the *Journal of Materials Science: Materials in Medicine.*

University of Buffalo Reports Stable Hole-Doped Fullerene Superconductor

A fullerene superconductor that is stable in air and becomes superconducting at 60 K has been reported by University of Buffalo scientists. Their research is described in the August issue of *Solid State Communications.*

Stability in air, which is essential for any practical application, has been missing from all other carbon superconductors. The scientists reported that superconducting effects could still be detected in the fullerene superconductor after it was exposed to air for 40 days.

"This superconductor also presents an interesting theoretical challenge," said Yi-Han Kao, CEEM Professor of Materials Physics in the University's Center for Electronic and Electro-optical Materials. Kao explained that the well-known BCS theory has been successful in explaining superconductivity at temperatures lower than 20 K, but it cannot explain materials that superconduct at temperatures above 40 K.

The fullerene superconductor was synthesized by incorporating interhalogen molecules of iodine monochloride into a crystal made of C_{60} molecules and some "higher fullerenes."

It is the first carbon superconductor to be created through hole-doping, instead of doping with negatively charged particles. "Because hole-doped superconductors are mostly associated with much higher transition temperatures, as high as 90–135 K, this raises the hope that our technique could develop a carbon superconductor material with a very high superconducting transition temperature," Kao said.

Simplified Sensor Detects Giant Magnetoresistance

Writing in the August 20, 1993 issue of *Science*, IBM ADSTAR scientists describe how they observed the giant magnetoresistive effect at very small magnetic fields with the aid of simplified sensors.

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The reported magnetoresistive work showed an electrical signal more than five times as strong as that produced by heads based on conventional magnetoresistive technology. Because of the stronger signal, heads produced with materials exhibiting the giant magnetoresistive effect should be able to detect magnetic spots that are much smaller and more densely packed than those in current products.

The sensors were fabricated as stacks of alternating thin magnetic layers of a nickel-iron alloy and nonmagnetic silver layers. In order for the multilayered structure to effectively detect small magnetic fields, it was necessary to control the interactions between adjacent magnetic layers. This was done by annealing the completed structures to make the north poles in one layer point in the opposite direction from the north poles in adjacent layers.

When the annealed structure is placed in a magnetic field, the north poles in the magnetic layers flip directions so that all layers have the same magnetic orientation. It is this reorientation of magnetic poles that changes the resistance of the multilayered material, producing a "giant" signal that indicates the presence of a magnetic field.

II-VI Thin Films Studied as Possible Blue-Light Laser Source

Xingwu Wang and a group of researchers at Alfred University are using laser evaporation to deposit thin films of cadmium sulfide (CdS) on a substrate. The thin film they have developed appears to be potentially useful in photoconductors, piezoelectric transducers, solar cells, optical devices, and lasers, specifically the blue-light lasers.

CdS has long been recognized as an important semiconductor, but it has generally been used in its more stable hexagonal form, which is well-characterized. Deposition of CdS by laser evaporation has allowed use of the less stable zincblende form of CdS, which is cubic rather than hexagonal. The difference in shape enhances the ability of the CdS crystals to match other semiconductive materials to develop the blue-light lasers. The other crystals needed are cubic, not hexagonal, so developing a cubic crystal form of CdS should achieve a better fit between the crystals.

Results of the study co-authored by Robert L. Snyder and Vasantha Amarakoon, were published in the October 1993 *Journal of Materials Synthesis and Processing.*

Bandgap Leads Display Materials Consortium

Bandgap Technology Corporation, Broomfield, Colorado, is the lead organization in a \$5.1 million consortium to develop visible vertical cavity surface emitting laser (VCSEL) materials. The consortium, sponsored by the Advanced Research Projects Agency, will develop epitaxial compound semiconductor materials for visible red, yellow, green, and blue VCSELs over a two-year period. Other members of the consortium are Colorado State University, Photonics Research Incorporated, Brown University, Purdue University, and Sandia National Laboratories. □

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