Correction

The figure below, part of the article Microscopic Properties of Thin Films: Learning About Point Defects, by A. Ourmazd, M. Scheffler, M. Heinemann, and J-L. Rouviere, was run in black and white in the December MRS Bulletin. Following is the color version.

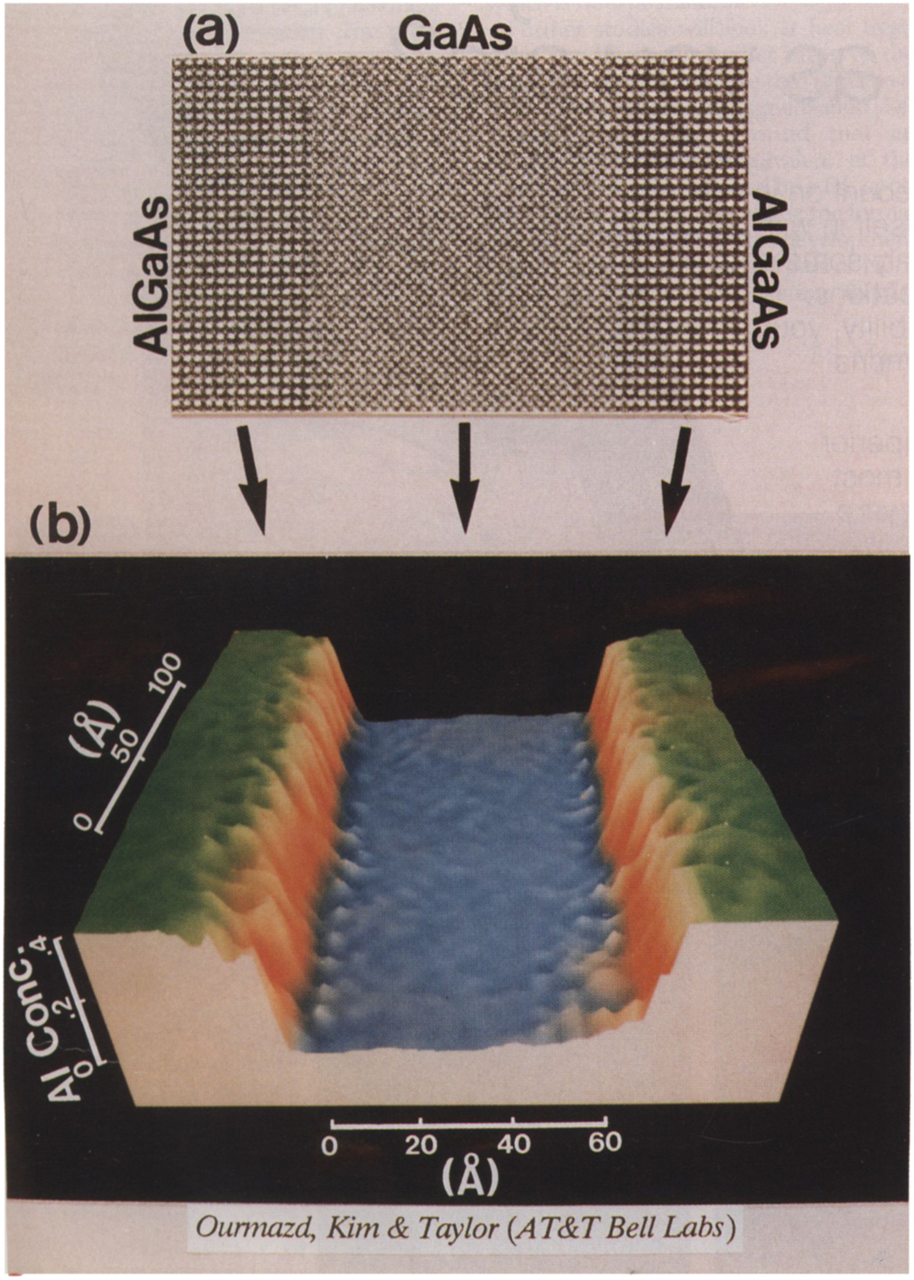

Figure 1. (a) Chemical lattice image of a GaAs quantum well between its two $Al_{0.4}Ga_{0.6}As$ barriers. Note that although the structure of the sample is zinc-blende everywhere, the image changes strongly as the composition changes across the interface. (b) Three-dimensional plot showing the result of pattern recognition analysis of the chemical lattice image shown in (a). Height represents the local composition, and color changes represent statistically significant changes in the composition.

Structure of Growing Crystal and its Composition Simultaneously Observed

An instrument originally conceived by Shozo Ino of the Science Department of the University of Tokyo and developed by Japan Vacuum Technology allows researchers to measure the form and elemental structure of the two-dimensional distribution of a growing crystal. Called a "total-reflection-angle x-ray spectroscopy observation instrument of molecular layer growth," the device allows measurements indispensable for precisely controlling the composition and structure of semiconductors and other materials during fabrication. It is necessary to observe the composition, crystalline structure, and form of surface elements of films produced for microelectronics during their growth.

Using this technology, the surface of a growing film is scanned by a slightly convergent high-speed electron beam. The crystalline structure and form of the surface can be observed using diffracted electron beams; the elemental composition of the surface can also be observed using the emitted characteristic x-rays. Both can be observed simultaneously in real time as a two-dimensional image.

F.S. Myers

DOE, Cray to Work on Massively Parallel Processing

The Department of Energy and Cray Research Inc. have entered into a preliminary agreement calling for Los Alamos and Lawrence Livermore National Laboratories to work with the supercomputer maker to develop massively parallel processing to enhance the labs' capabilities and U.S. firms' competitiveness in the global market.

Through this agreement, jointly funded at $70 million over three years, the two DOE labs and Cray will work together toward creating operating systems and capabilities for use on Cray's massively parallel processing (MPP) computer systems. Four areas—environmental modeling, defense systems, materials design, and advanced manufacturing—will be among the most direct beneficiaries. The labs have already held talks with several U.S. firms, including potential partners from the manufacturing, chemical, petroleum, aeronautical, and environmental sectors.

The agreement in part will focus on modeling these specific computer-related goals: to reduce and contain pollution, improve manufacturing processes, and design the next generation of semiconductor and microelectronic components.

Deposition Process Yields Iron Nitride Films with High-Saturation Magnetization

Ricoh Company, Ltd. and Migaku Takahashi of Tohoku University's Department of Electronic Engineering have jointly developed a deposition process for iron nitride magnetic thin films ($Fe_{16}N_2$) having a high-saturation magnetization. The process has possible application in magnetic heads used for high-density recording. The $Fe_{16}N_2$ magnetic thin films take advantage of two characteristics of the plasma evaporation method—reactive precipitation at room temperature and controllable film-deposition conditions.

The plasma evaporation (Ricoh's exclusive method of film deposition) is characterized by a high deposition rate. From a practical viewpoint, the thin films achieve the required thickness in less time. It is also possible to achieve a thickness of more than 2,000 Å. A further advantage of this method is that the equipment is inexpensive and high productivity could be implemented.

The application of this technology will permit the construction of high-performance magnetic heads for disks that can obtain 10 gigabits of information per square inch—more than ten times that which is now possible.

Further studies will look at heat treatment conditions and other areas of the process in order to achieve thin films having a higher saturation magnetization. Researchers at Tohoku found that an evaporation-produced equivalent of the plasma state can be attained by a DC sputtering technique, thus enabling the formation of $Fe_{16}N_2$ thin films. This development was conducted with the support of Noriyoshi Sato, Faculty of Engineering, Tohoku University.

F.S. Myers

U.S.-German Glass Research Agreement Signed

L. David Pye, director of the National Science Foundation's Industry-University Center for Glass Research, and Helmut Schaeffer, director of Germany's HVG (Hüttentechnische Vereinigung der Deutschen Glasindustrie), have announced the signing of a collaborative research agreement that calls for joint work on advanced glassmaking and processing, and involves the exchange of faculty and students. Projects will focus specifically on redox studies, surfaces, and properties of glass-forming melts.

"This agreement represents a significant advance in our engineering and technological base," Pye said. "It complements what we are already doing here, and will ultimately strengthen the glass industry. These efforts represent the expressed research needs of both our organizations, and the industries we serve."

Nb_3Al Cable-in-Conduit Developed for Fusion Superconductors

The Japan Atomic Energy Research Institute (JAERI), in cooperation with Sumitomo Electric Industries, Ltd., have put to practical use a niobium-aluminum superconducting material as a high-magnetic-field superconducting magnet.

Of the two commonly used superconductors, the alloy NbTi is easy to handle, but loses its superconductivity in high magnetic fields (critical field is about 12 T at 4.2 K) which generally limits its applications to low-field regions of less than ∿8 T. The compound Nb_3Sn has a high critical field (∿25 T at 4.2 K) and many high-field Nb_3Sn magnets have been manufactured. However, Nb_3Sn is sensitive to strain; only 0.4% strain degrades its superconducting current capacity by 30% at 12 T and 4.2 K.

The Nb_3Al compound is a known superconducting material with good superconducting characteristics. Its critical field is around 30 T at 4.2 K, and a 0.4% strain results in only a 5% degradation at 12 T and 4.2 K. Nb_3Al is difficult to manufacture, however, requiring heat treatment above 1,000°C, so its practical use has never been realized, although short laboratory-level wire could be manufactured.

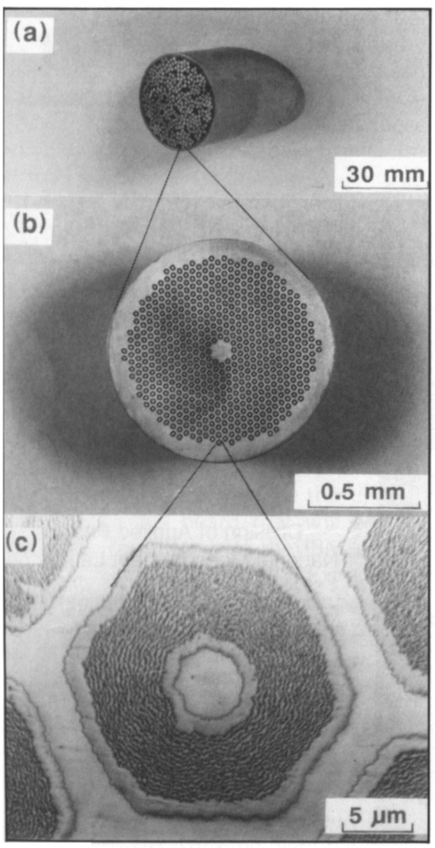

Figure 1. Cross section of a 30 kA Nb_3Al cable-in-conduit conductor (a), the Nb_3Al strand (b), and the Nb_3Al filament (c).

The latest method for developing Nb_3Al involves lowering the heat-treatment temperature to 800°C by using thinner sheets of niobium and aluminum to form the Nb_3Al, a phenomenon discovered many years ago. The resulting material can pass a current of 40,000 amperes in a magnetic field of 12 T. The superconductor itself must be fine and covered by a stabilizing low electrical-resistivity material. So present practical superconducting wires are a multifilament composite consisting of 100-100,000 fine (∿5-100 μm diameter) strands arranged in a stabilizing material such as copper or aluminum.

Large-current test conductors were fabricated using this Nb_3Al long wire. It was demonstrated through tests that the developed Nb_3Al wire can be used practically. There is still much room to improve its capacity, but practical-use Nb_3Al wire is expected with a much better superconducting capacity than that of Nb_3Sn.

JAERI has undertaken this Nb_3Al development program for future fusion reactors which will require a high-field-capacity (40-50 kA), high-performance, mechanically strong, large superconductor. Nb_3Al has thus become a strong candidate.

F.S. Myers

Bioreactor for Treating Volatile Chemicals Developed by ABB

A new bioremediation system produced by ABB Environmental Services, Inc. biodegrades hazardous volatile chemicals and has cleaned groundwater in tests at three Superfund sites, removing the contaminants coal tar and toluene; trichloroethylene, chlorobenzene, and toluene and vinyl chloride; and methyl methacrylate. Called a methanotropic air-tight rotating bioreactor (MARB), the device uses bacteria that feed on methane gas to reduce contaminants quickly to below detectable limits. The reactor degraded 500 parts per million methyl methacrylate to less than 1 ppm with a hydraulic retention time of about 6 hours, and similarly reduced vinyl chloride in less than one hour. The U.S. Office of Trademarks and Patents has agreed to issue a patent on the system.

According to Sam Fogel, director of ABB's Bioremediation Systems, chlorinated hydrocarbons have resisted degradation by conventional waste-treatment methods such as activated sludge and most types of fixed-film bioreactors. These contaminants are persistent in groundwater and slow to degrade in nature, he said, and are now widely distributed because of industrial discharges and spills.

The MARB is an air-tight enclosure containing rotating polyethylene disks on which microorganisms grow. These bacteria are selected for their adaptation to feeding on a gas—such as methane, which serves as a primary food source—and their ability to biodegrade volatile chlorinated hydrocarbon compounds. The bioreactor can be fitted with hundreds of polyethylene disks which are the host sites for the methane-oxidizing bacteria.

The first commercial field tests are capable of treating 1-5 g/min and will target groundwater contaminated with vinyl chloride, groundwater contaminated with mixtures of chlorinated chemicals and petroleum constituents, groundwater contaminated with methyl methacrylate and/or similar solvents, and stormwater contaminated with benzene and/or toluene.

The MARB will treat volatile and semivolatile contaminants in concentrations of less than 1 ppm to more than 500 ppm, and maintain viable biofilm at contaminant concentrations as low as one mg/l or less.

Center for Microelectronics Technologies Created at Sandia

A national Center for Microelectronics Technologies (CMT) is being established at Sandia National Laboratories for cooperative advanced research and development by the academic, industrial, and government sectors. CMT joins a major IBM (International Business Machines) donation of integrated-circuit processing equipment with extensive facilities and equipment being made available by Sandia. The initiative, a reorientation of traditional U.S. approaches to R&D, places greater emphasis on collaborative work among the different sectors for technologies vital to the nation's economic future. Sandia president Al Narath called it part of the GUILD concept: government, university, industry, laboratory development.

Paul Peercy, director of microelectronics and photonics at Sandia, said, "The Center has an important new capability in silicon-based microelectronics. In addition to our internal programs, we are inviting universities, industry, and federal labs to propose ways they can best make use of the new capabilities." The Center will be available to experts to work on concepts for devices, circuits, and tooling/processes for future microelectronics technologies. Researchers will be able to use the facilities to make prototype integrated circuits with selected feature sizes as small as 0.1 μm.

The Semiconductor Research Corporation (SRC), an industry-formed body that funds industry-supported microelectronics research at universities, has worked to define the facility operation and to help university researchers take advantage of the opportunities it offers. SRC chief executive officer Larry Sumney said, "The SRC views the Center as filling a critical gap in accelerating the transfer of university research to industry. It will allow the development of engineering prototypes in those instances where the change in technology is too dramatic to allow a direct transition from the university researcher to the industrial environment."

Sandia vice president for research and exploratory technology Paul A. Fleury said, "The primary purpose of the Center for Microelectronics Technologies is to help strengthen the U.S. microelectronics industry by supporting precompetitive device, circuit, and processing research and by providing advanced equipment validation testing. It will enhance substantially the DOE's initiatives in developing technology platforms for advanced manufacturing."

The Center complements Sandia's existing program with SEMATECH and the Contamination-Free Manufacturing Research Center recently formed at Sandia by SEMATECH. "Close synergy between these existing programs and the new facility will enhance the benefits of all these activities to the U.S. microelectronics industry," said Peercy.

Industry, through the SRC and SEMATECH Executive Technical Advisory Board, expressed a strong need for a facility to fill the gap between university research and industry. "Universities and industry need an 'incubation' facility where advanced research concepts can be inserted into a fully equipped integrated-circuit fabrication line so they can be refined and validated," Peercy said. The Center is designed to fulfill that role.

Access to the facility will be through an industrial review board that will review proposals. Installation of the IBM equipment will begin in early 1993. Expert personnel from IBM will assist during the installation and checkout phases, which will be completed in late 1993.

BASF, Argonne Look at Two Methods for Producing Superconducting Wire

A joint research project between BASF Corporation and Argonne National Laboratory will explore two ways to enhance the current-carrying ability of high-temperature superconducting wire. One method focuses on a mechanical means to align tiny grains of the high-temperature superconductor, and the other uses magnets.

Because of the brittleness of the materials and low current-carrying capacity in wire form, progress in making practical wire has been slow. Otto Ilg of BASF's Fibers Division said, "We hope to make superconducting wire more flexible by embedding superconductors in a polymeric carrier and then spinning fiber. But first, we have to find out if the superconductor is compatible with the dispersants and polymers used to make these fibers." Argonne will grow long, thin crystals of the yttrium-barium-copper-oxide superconductor and BASF will test their compatibility in a mix with certain fiber raw materials and dispersants. If compatible, BASF will then produce fibers containing high concentrations of embedded superconductor in a green state, which will be heated at Argonne to make them superconducting, and then tested.

Argonne scientist Steve Dorris said, "To make the wires carry higher current, it's important to get the crystals aligned inside the fiber." The researchers expect the crystals to partially orient in the same direction during extrusion. If so, and if they remain in good contact inside the fiber matrix during subsequent heat treatment, then thin flexible wires that carry current well could be produced.

In the second method, Argonne will expose the superconductor-embedded polymer matrix to a high magnetic field to align the crystals. The magnetic field strength will be 6 to 8 Tesla.

The $325,000 joint project is expected to take about seven months and will be funded by BASF and the U.S. Department of Energy's Office of Conservation and Renewable Energy, through Argonne.

USABC, SAFT, W.R. Grace Agree to Joint Development of Electric Vehicle Batteries

Under contracts with the U.S. Advanced Battery Consortium as part of a USABC partnership with the Department of Energy (DOE), W.R. Grace and Co. and SAFT of America will develop novel, high-energy batteries for use in electric vehicles. The research aims to make electric vehicles widely available by the year 2000, reduce oil dependence, improve the environment, develop new American technologies, and promote U.S. economic growth and job creation. USABC, a consortium of the Big Three auto makers and the Electric Power Research Institute, announced that Grace and SAFT will receive $41.6 million.

Also announced were cooperative research and development agreements

(CRADAs) between the USABC and three national laboratories—Argonne, Sandia, and Idaho National Engineering Laboratory.

Two different advanced battery technologies are covered under the industry contracts. W.R. Grace will work with Johnson Controls Inc. to develop a lithium polymer battery ($25 million) while SAFT will pursue a lithium iron disulfide battery ($17 million). In addition, a contract with Delco-Remy is pending DOE approval to develop lithium-polymer batteries.

Argonne will develop lithium iron disulfide batteries and test nickel/metal hydride and sodium beta batteries ($8 million). Sandia will conduct research on materials and fundamental studies related to lithium polymer batteries ($3 million). Idaho will test sodium sulfur and other advanced batteries ($1 million).

USABC's goals are to broaden the capability and availability of electric vehicles by the mid-1990s and to develop, by the late 1990s, batteries that will be competitive in terms of cost and performance with gasoline-powered vehicles.

University of Illinois Research Finds Unexpected Behavior in Lubricant Thin Films

University of Illinois researcher Steve Granick has found that thin films of lubricant behave more like a rubber than an oil, and show greater viscosity and elasticity than they do in bulk. This feature of lubrication "shows that large bulk studies give a misleading picture of the conditions you're buying oil for," said Granick. Because of the problems associated with lubricating certain devices, e.g., hard drives in computers or satellites in space, it has become critically important to better understand thin films of oil.

The November 20, 1992 issue of *Science* describes Granick's study on the viscosity and elasticity of thin films of lubricating polymers. He and Hsuan-Wei Hu brought two mica plates together to within a distance of only a few molecules and measured the behavior of a lubricant between the plates. They found that the thin film of the polymer, polyphenylmethylsiloxane, behaved in a completely different way from the same lubricant in bulk.

Previously, interactions of lubricant molecules had been observed on an atomic scale with STM and AFM, both of which use tiny tips to contact sample atoms. Granick, however, uses the relatively large plates to contact complex lubricating polymers, which he says is closer to the way things really happen. The findings on the new behavior of a lubricant may have implications for workers in many fields, such as biologists studying living cells and membranes which contain thin-film polymers, drillers pumping films of oil from between rocks, seismologists studying earthquakes in which rocks slide over films of water, and scientists creating materials from powders that typically must slide over films of liquid, Granick said.

His work may bring about a reconsideration of practices that cause difficulty in starting a device, or its malfunction while operating.

Sandia, Los Alamos, Du Pont Agree to Develop Diamond Coatings

Du Pont and the U.S. Department of Energy (DOE) have signed cooperative research and development agreements (CRADAs) to perform joint research on diamond film technology. Researchers at Du-Pont and at Sandia and Los Alamos National Laboratories plan to develop the technology and manufacturing capability for coating a variety of composite materials with diamond and diamondlike carbon to produce materials with improved mechanical, chemical, and thermal properties. This will generate a new class of composite materials with high strength and improved thermal conductivity.

The proprietary diamond film coating technology begins with methane gas, which reacts in the presence of an energy source such as a laser or microwave and breaks down into hydrogen and carbon deposits in the form of diamond or a diamondlike substance. The weight-reduction properties of new diamond-coated composites could find application in aircraft, space vehicles, automobiles, and construction. The improved thermal management could provide benefits in the aircraft and auto industries, such as better radiators, and in electronics in the form of substances on silicon chips, semiconductors, and optics, said Don M. Coates, the principal Du Pont investigator for this project.

The three-year, $6 million program will employ about 14 scientists, with costs to be divided evenly between Du Pont and DOE. □