Mitsubishi Materials Announces Low Defect Density GaAs Technology

Mitsubishi Materials Corp. has announced a new technology that can be used to produce 10-cm long, 4-inch diameter single-crystal gallium arsenide with one-fifth the defects (15,000 compared to 75,000 per cm^2) of GaAs produced using conventional techniques in which crystals are made by simultaneously lifting and rotating a seed crystal from melted gallium arsenide in a shielded container.

In the new method the container is filled with arsenic gas of a controlled pressure instead of inert gas while the rotated seed crystal is lifted from the pool of melted gallium arsenide. The source material is synthesized *in situ* before the growth process.

According to Koichi Sassa, leader of the research team at Mitsubishi, this method makes it possible to grow undoped semi-insulating crystals of low defect density and precisely controlled stoichiometry with high productivity. Sassa originally started work on GaAs "perfect crystals" in 1982 when he joined the (Junichi) Nishizawa Perfect Crystal project, sponsored by the ERATO program under the Research Development Corporation of Japan. By the completion of the ERATO project in 1986, the research team, which was a supporting subgroup of the project, had made crystals about 5 cm in diameter but they could not obtain a semi-insulating crystal without doping.

After the completion of the Nishizawa Perfect Crystal project in 1986, Sassa joined Mitsubishi Materials Corp., which began collaborating with JRDC to develop the GaAs crystals. As the main contractor for this phase, JRDC loaned Mitsubishi ¥260 million, supplementing Mitsubishi's funds for the two-year development project. Mitsubishi will repay the seed loan to JRDC over the next five years.

According to Genya Chiba, vice president of JRDC, "The Nishizawa Perfect Crystal project reflected Nishizawa's longtime philosophy that crystals need to be nearly perfect in order to make devices, especially when studying the feasibility of high-speed GaAs devices such as FET or HEMT. Nishizawa aimed at producing GaAs crystals with high purity, low defect density and correctly controlled stoichiometry, which are not available on the market."

The problem was to make a perfect crystal without doping. Doping was often used to strengthen the crystal against its own constraints in order to reduce the number of defects. However, Mitsubishi researchers say that by controlling the outside vapor pressure of the arsenide, the stoichiometry of the crystal can be controlled.

"Mitsubishi Materials," says Sassa, "is now making preparations for marketing their new technique and material." Chiba believes that these improvements are timely, since many people are now working on quantum devices, and other high-tech devices. GaAs has been used for LEDs and other light-emitting devices that require high-quality, low defect density crystals. Quantum and molecular devices, as well as other second-generation GaAs devices such as high-speed terahertz devices will also benefit. "This is a basic element that is necessary before actually designing devices," says Chiba.

According to Sassa, "The successful reduction of defects is expected to enhance the performance of gallium arsenic semiconductor elements, such as high-frequency devices and large-scale integrated circuits used for high-speed processing." The new process should enable the manufacture of ultra-high-speed switching elements two to three times faster than ordinary silicon single-crystal elements as well as high-efficiency photoelectric transfer elements," he said.

F. S. Myers

1960s Superalloy Viewed for New Applications

TAZ-8A, a high-performance metal developed for aerospace applications in the 1960s, has recently attracted attention for its ability to improve performance and extend the service life of industrial elements exposed to extreme heat, harsh abrasion, and thermal cycling.

Created at the NASA Lewis Research Center, the nickel-based superalloy's combination of properties make it ideal for high-temperature industrial processes. It contains tantalum and columbium and offers high-temperature strength, oxidation and abrasion resistance, and exceptional thermal shock resistance.

The superalloy is expensive, however, and so tough it resists many machining techniques. William Waters, a Lewis engineer and one of the material's original developers, said the drawbacks do not diminish its potential for wide application, but do suggest a need for careful evaluation. Lewis researchers will produce prototypes so that businesses can test TAZ-8A for specific tasks.

NASA has developed various plasma spray and modified plasma vapor deposition (PVD) techniques for applying the TAZ-8A as a coating on low-cost substrates. Using the superalloy as a coating would help reduce cost and fabrication difficulties. The PVD process provides a coating with high reflectivity, extreme hardness, and abrasion resistance. Tests have shown that TAZ-8A coating of steel rolls increases thermal shock resistance in temperature-cyclic applications by 300-400%.

From NASA Tech Briefs, *December 1991, p. 12-14.*

Rohatgi Receives Graduate School/UWM Foundation Research Award

Pradeep K. Rohatgi, Ford/Briggs & Stratton Professor of Materials, University of Wisconsin-Milwaukee (UWM) received the 1991 Graduate School/UWM Foundation Research Award. The award recognizes his outstanding research and creative activity in metal matrix composites.

Rohatgi's expertise in materials, especially in the area of composites, is internationally recognized. His research is funded by the Ford Motor Company, Briggs & Stratton, the Office of Naval Research, the Electric Power Research Institute, General Motors Corporation, Control Data Corporation, and the International Copper Association. Currently, Rohatgi serves as the director of three laboratories (tribology, foundry and solidification processing, and composite materials) in UWM's College of Engineering and Applied Science.

Rohatgi has authored or co-authored over 300 research articles, holds patents in both the United States and India, and has edited/co-authored six books.

He is a fellow of ASM International, the Institute of Metals (London), the American Association for the Advancement of Arts and Sciences, and the Third World Academy of Science, Italy. He is a member of MRS.

Argonne Offers Parallel Computing Courses for Faculty

Argonne National Laboratory is making courses in parallel computing available to colleges and universities across the nation. The series of one-semester courses is designed to enable faculty to start new parallel computing courses on their own campuses. Faculty will work hands-on with one of 10 parallel computers at Argonne's Advanced Computing Research Facility, a national center for the study of advanced parallel computing. Argonne intends to hold one course every semester for about 15 faculty members.

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The first group of about 14 faculty members from minority and women's colleges has already spent four days at Argonne and returned to their campuses to finish the course by using national computer networks to link campus computers to a parallel computer at Argonne. Faculty members will be able to use their new knowledge to teach undergraduate courses in parallel computing next semester, again accessing a parallel computer at Argonne over national networks. An important early goal is to attract more minorities and women into computer science by making advanced computer education more available to them.

Colleges and universities interested in participating can contact John Mateja, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439; phone (708) 252-7115; fax (708) 972-3193.

ESPRIT Referees 1,259 Proposals

More than 350 experts recently completed refereeing 1,259 proposals submitted to the European Community's Information Technology Directorate, DG XII, known as ESPRIT. Total funding requested came to $4,000 million ECUs (US$4,900 million).

Expert referees from around Europe applied rigorous criteria, rejecting many proposals, but the total money requested remains at $2,200 million ECUs, more than 2.5 times the available budget. Because of this, the Directorate will fund only those proposals that most precisely fit the initial criteria under consideration. This action is expected to reduce the number of proposals actually funded to about 20% of the submissions, still leaving nearly 1,000 of the submitted proposals unfunded.

One source roughly calculates that the costs to Europe, as a whole, for the 1,259 laboratories in travel, meeting, fax, and typing expenses for these submissions to be some $50 million ECUs, or just under 6% of the available budget.

IWB

Inexpensive Toughness Tester Eliminates Need to Pre-crack Samples

Most procedures to measure how well a material resists crack growth require several hours and machinery costing tens of thousands of dollars, but the new toughness tool developed at the University of Rochester costs only a few hundred dollars, eliminates the need to pre-crack the sample, and can be used to perform dozens of tests each hour.

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In a series of tests on such materials as soldered joints, high-strength steel alloys, and high-strength aluminum, results from the toughness tool closely matched results obtained through testing procedures laid down by the American Society for Testing and Materials (ASTM).

The tool requires that samples be prepared with a "chevron notch," a small notch that predisposes a sample to crack sharply in a particular manner when placed under stress. The notch eliminates the need to pre-crack the sample, normally done by repeatedly loading it over the course of several hours. Toughness tool samples are about 2 in. long and 0.5 in. wide, slightly smaller than those used in conventional (ASTM E399) tests.

"We wanted an instrument which could be used by the average person to break most materials," say Eric Stromswold and David Quesnel, the tool's developers. They estimate that about 62 lb of force is enough to break samples of even the toughest materials using the toughness tool.

A sample is placed between the two identical wrench heads of the toughness tool, which is made of hardened steel and resembles a specially designed torque wrench. The lower wrench head is held fixed in a vise, while the operator exerts a steadily increasing force to the upper wrench head by pushing down on the handle. A marker indicates the amount of force that was needed to break the sample.

The toughness tool may not be ideal for all testing situations, say Stromswold and Quesnel. A more elaborate procedure might be called for if an engineer wants full details on the fracture mechanics of a certain material. The tool's greatest use may be for quality control, where technicians must monitor large numbers of parts quickly.

Variable-Frequency Microwave Furnace Uses Traveling-Wave Tube

Working with Microwave Laboratories, Inc. (MLI), Raleigh, North Carolina, researchers at Oak Ridge National Laboratory have developed a variable-frequency microwave furnace with a uniform power environment that eliminates hot or cold spots by using a traveling-wave tube and a signal generator to sweep the frequencies.

Microwave furnaces are used to sinter high-tech ceramics, sterilize medical equipment and contaminated waste, and process other materials. Until now, variable-frequency microwave furnaces with power levels in the kilowatt range did not exist. Ordinarily, these furnaces use fixed frequency microwaves but because materials differ in energy absorption characteristics, much of the heating power can be wasted. Also, fixed frequency oscillations in a furnace cause uneven heat distribution—undesirable for sintering ceramics, where uneven heating can warp, weaken, or fracture the material.

Oak Ridge researchers proposed that a traveling-wave tube, commonly used for relaying satellite and spacecraft signals, could act as an amplifier for input microwaves and cover a range of frequencies. Only a low-power (tens of watts) component was available at first, but the researchers then learned of MLI's high-power tubes, produced for radar jamming.

The kilowatt-range tube works with a

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signal generator to vary or "sweep" the frequencies in the microwave furnace to produce the sought-for environment. Also, samples in the furnace sometimes have "magic frequencies" where they absorb optimum levels of energy. Researchers can monitor the sintering process and pinpoint those frequencies, maintain them, increase the power, and enhance the sintering capabilities of the furnace.

LDEF Materials Evaluated after Six-Year Exposure in Space

Analysis of 136 electrooptic components carried by NASA's Long Duration Exposure Facility (LDEF) for six years in space have revealed significant changes in the performance of items such as bandpass filters and mirrors. Other components appeared unchanged by the test, and one material seemed to work better even after being struck by meteorites, shocked by temperature changes, and scoured by upper atmospheric oxidants.

The investigation, carried out by Georgia Institute of Technology researchers, shows that organic materials like paints and polymer films, as well as mirrors and filters made by depositing dielectric films, are degraded in space. For instance, certain multilayer filters made to receive laser signals deteriorated more than expected, which shifted the frequency and amount of light they could receive.

Holographic crystals, which have potential to store large amounts of computer data, did not appear damaged, although the holograms originally stored on them degraded due to the length of the LDEF mission.

Infrared detectors performed as well after their return from space as they did when first installed on the LDEF test tray in 1978. A silicon-based infrared detector still performed as designed, despite a crater caused by the impact of space debris. Though scarred by the impact of micrometeorites, light-emitting diodes still worked well.

The researchers were surprised to find that six years in space appeared to improve the performance of black paints used for thermal control and low-reflectivity coatings. Preliminary study shows the ability of the paints to absorb far-infrared emissions seemed to improve, possibly due to the creation of new light-absorbing sites by the breakup of paint binders and pigments.

The filters, mirrors, diodes, lasers, and other components were part of a tray assembled in 1978 by Georgia Tech researchers to study the effects of space on electrooptic components. The components were placed to simulate how they would actually be used, and were partly covered by a sun shield. The tray was one of 86 experiments on LDEF, carried aloft by the Space Shuttle Challenger in 1984. The components were originally scheduled for a nine to 12-month trip, but the Challenger disaster forced LDEF to wait nearly six years for its return to Earth in January 1990.

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AST Receives Grant to Develop Coatings for Electronic Neural Protheses

Advanced Surface Technology, Inc. (AST), has received a $50,000 Small Business Innovation Research (SBIR) Phase I grant from the National Institute of Neurological Disorders and Stroke to develop plasma-enhanced parylene coatings for electronic neural prostheses. AST's goal is to develop biocompatible coating systems that let neural prosthetic implants function reliably over the implant recipient's lifetime.

Long-term insulation and protection of implanted devices are some of the most significant problems preventing the development of implantable neural prostheses for the neurologically handicapped. To be used reliably in humans, micromachined thin-film recording and stimulating microelectrode probes and miniature wires or cables connecting these electrodes with a source of control and power must be protected from the hostile ionic environment of extracellular fluids for decades.

Plasma-enhanced parylene, also used for improved biosensors, packaging materials, and orthopedics, will be deposited onto test structures following various surface pretreatments and coating layers. Life tests of plasma-enhanced parylene-coated assemblies will consist of voltage-biased saline soaks. Surface resistivity changes will be used as an indicator of the efficiency of various coating techniques.

MISCON Establishes Industrial Affiliates Program

The Department of Energy-supported Midwest Superconductivity Consortium (MISCON) has established an Industrial Affiliates Program to promote collaborations between its member scientists and scientists at industrial and national laboratories.

MISCON, a consortium of six Midwestern universities, seeks to develop the scientific and technological foundation for the commercialization of high temperature superconductivity. Its membership schools include Indiana University, Iowa State University, Ohio State University, Purdue University, and the Universities of Missouri and Notre Dame. The consortium focuses on key materials-related problems utilizing the various unique capabilities of the schools.

Membership in the Industrial Affiliates Program requires collaboration with a university consortium member and the development of an abstract for a program plan. Membership is based on collaborative efforts, not fees. Memberships are renewable annually and are reviewed by the director. Industrial members will be invited to attend the twice-yearly MISCON group meetings to present their collaborative work.

A list of university consortium members and their respective research programs is available through the director's office. Contact Gerry Liedl, MISCON Acting Director, Purdue University, 1125 Physics Bldg., West Lafayette, IN 47907-1125; phone (317) 494-5567; fax (317) 496-1178; e-mail liedl@ecn.purdue.edu.

Kostorz Becomes President of the Federation of European Materials Societies

Gernot Kostorz, professor of physics and director of the Institute of Applied Physics, ETH, Zürich, has begun his 1992-93 term as president of the Federation of European Materials Societies. The federation has 15 member societies in 13 European countries and represents about 20,000 individual materials scientists and engineers.

Kostorz holds a PhD in physics from the University of Göttingen and has worked in Germany, France, and the United States. He has authored or co-authored about 120 research and review papers, mainly in the field of plasticity and microstructure of alloys. He has also edited or co-edited three books.

The federation holds a biennial conference series, EUROMAT, started in 1989, to provide broad coverage of materials by leading experts. Last year's conference was held in Cambridge, and EUROMAT 93 will take place in Paris, June 7-10.

Rehn Named APS Fellow

Lynn Rehn of Argonne National Laboratory has been named a fellow of the American Physical Society. Rehn heads the Irradiation and Kinetic Effects group in Argonne's Materials Science Division. His research interests include the effects of radiation on materials, solid-state research, and superconducting materials, and use of charged particle beams to analyze and modify materials properties.

Rehn was a co-winner of the U.S. Department of Energy's award for outstanding sustained research in metallurgy and ceramics in 1984. He has edited four books, published more than 150 papers and organized several international scientific meetings. He is editor of the journal *Nuclear Instruments and Methods in Physical Research*, and associate editor for *Applied Physics Letters* and *Applied Physics Reviews*, and serves on the editorial advisory board for the *Journal of Nuclear Materials*. Rehn holds a BS degree in physics from Albion College and MS and PhD degrees in physics from the University of Illinois. He has served MRS as a symposium organizer and is one of the chairs for the 1992 MRS Spring Meeting in San Francisco. □

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