NTT Develops Coherent-Light Source Based on Semiconductor Microcavities

Nippon Telegraph and Telephone Corporation (NTT) has announced that a research group at its Basic Research Laboratories, headed by Yoshihisa Yamamoto, (presently a visiting professor at Stanford University) is close to realizing a novel semiconductor light source, which it calls the "Controlled Spontaneous-Emission Diode" (CSD). This new coherent-light source is based on the control of spontaneously emitted light using three-dimensional semiconductor microcavities. The CSD is different from conventional semiconductor laser diodes (LDs) and light-emitting diodes (LEDs) due to its extremely high conversion efficiency, but has the high directionality of LDs and the low-current drive capability of LEDs. NTT says that CSDs should be useful for a wide range of applications.

Yamamoto's group has demonstrated that spontaneous emission in a semiconductor structure, which is usually in random directions, can be made highly directional by controlling the vacuum field fluctuations surrounding the atoms, thus making "spontaneous emission" become, in a sense, "stimulated emission." This is done by coupling the semiconductor gain medium to an optical microcavity, rather than to the vacuum field fluctuations, the basic principle of the CSD.

Semiconductor microcavities have recently been fabricated on the order of the optical wavelength, comprising a thin active layer sandwiched between multilayer reflectors. An important advance is a microlens structure, embedded in one of the multilayer reflectors, that acts to confine the optical field to the lateral direction. Experiments have confirmed that the microlens structure acts to control spontaneous emission; for example, the coupling efficiency of the total spontaneous emission to the fundamental modes of the cavity (i.e., the two orthogonal polarized modes) was measured at 10%, an increase of four orders of magnitude over that of conventional laser diodes. A further enhancement of the coupling efficiency is theoretically expected through improved cavity design.

According to Shigenobu Yamakoshi of Fujitsu Laboratories Ltd., the main feature of this device is the curved dielectric Bragg mirror introduced to a previous design by Yamamoto. He explains that since this CSD still has no cavity structure in the horizontal plane, it is not a "real" three-dimensional microcavity, the most important point in controlling spontaneous emission. Thus, since external spontaneous light can easily penetrate into the cavity from along the horizontal plane, spontaneous emission cannot be completely controlled. On the positive side, Yamakoshi says that controlling spontaneous emission is an interesting and important topic, and this new CSD should be a good, basic advancement in this field for scientists to consider, while pursuing a "real" three-dimensional microcavity.

Still, the CSD, in contrast to conventional laser diodes, does produce spatially-coherent light, even when operating below the laser oscillation threshold. This offers a practical light source that can operate at extremely low drive currents, therefore dissipating small amounts of thermal energy. The CSD thus promises to be a light source that can be used for advanced applications, for example, in optical interconnections inside a VLSI chip—the communication of data between different parts of a chip. The present electrical communication is considered a severe problem, a bottleneck that limits advances in processing speed. According to Yoshifumi Katayama of the Optoelectronics Technology Research Laboratory (OTL), on loan from Hitachi's Central Research Laboratory, the CSD is one candidate for this key technology that will allow faster data flow within VLSIs.

Further, since the CSD is expected ultimately to emit light in a laserlike fashion without population inversion, it perhaps can generate coherent light even in the x-ray region where population inversion usually cannot be achieved. However, according to company representative Yoshimasa Hashimoto, at the present stage this device represents very basic research concerning how light can be emitted efficiently, and that practical applications will be worked out in time.

F.S. Myers

New Mission for Oak Ridge Heavy Ion Facility

Oak Ridge National Laboratory's Holifield Heavy Ion Research Facility is redirecting its mission and engaging in a two-year, $3 million facility upgrade that will enable the lab to accelerate radioactive beams for probing atomic nuclei. The researchers will be able to create 200 more nuclei than was possible under Oak Ridge's previous nuclear structure studies, helping to answer fundamental questions about the forming of the universe.

The idea for the conversion of the laboratory was conceived when Oak Ridge researchers realized they already had most of the necessary equipment. The 25-million-volt tandem accelerator is configured to accelerate stable, heavy ions, and the Isochronous Cyclotron serves as a booster after the ions exit the tandem accelerator. Jerry Garrett, a division physicist, said, "To produce exotic beams, we would simply reverse this configuration. We would use light ions from the cyclotron to produce radioactive elements, magnetically separate the desired isotope, transform it into negative ions, and run it through the tandem accelerator as a radioactive beam." In addition, he said a recently constructed recoil mass spectrometer would also be used to study the proton-rich nuclei that would be produced at the facility.

Micrion, SEMATECH to Study Phase Shifting Mask Repair Issues

Micrion Corporation and SEMATECH have agreed to jointly study focused ion beam repairs of phase-shift masks, as part of a larger SEMATECH program to develop a U.S.-based manufacturing capability for phase-shift masks. In addition, Micrion will recommend to SEMATECH a course of action that should result in a fully production-worthy phase-shift mask repair system.

The semiconductor industry has developed an increasing interest in using phase-shift masks to extend the resolution limits of optical lithography. A phase-shift mask can, in certain circumstances, significantly improve minimum printable feature sizes with a given type stepper and further expand the process windows for important parameters such as depth of field and exposure latitude.

Phase-shift masks differ from conventional chrome-on-glass masks and reticles. John Doherty, Micrion vice president of marketing and contract manager for the SEMATECH program, said, "The use of focused ion beam techniques for repairing chrome reticles is now well-established in the industry. However, phase-shift masks involve technical questions that must be answered before a system can be designed to handle the more complex repair problems." Bill Thompson, Micrion's chief scientist and project manager of the SEMATECH program, said, "We have isolated the major technology risks in using focused ion beam technology for phase-shift mask repair and have developed a comprehensive program plan that will address each of these areas. At the end of the program, we should have a clear road map for developing a phase-shift mask repair system that will give the industry one of the key tools for making phase-shift masks in a high-yield production environment."

NRC Program Seeks Hosts for CIS Researchers

The National Research Council's Cooperation in Applied Science and Technology program invites applications from American universities and research institutions that wish to host colleagues from the Commonwealth of Independent States (CIS) of the former Soviet Union (not including the Baltic states) for an academic year to carry out joint research projects. Nine-month incentive grants will be in the range of $10,000–12,000. This program, funded by the U.S. Agency for International Development, is intended to help CIS scientists and engineers who have worked in defense-related research in the CIS apply their skills to civilian activities.

Consideration for financial assistance will be given to those proposals that address:

- probable benefits of the proposed research to the CIS and the United States,
- improved scientific and technological linkages in research,
- the defense-conversion aspect of the proposed research, and
- potential commercial applications stemming from the research and the potential contribution to private sector development in the visitor's home country.

American hosts and CIS applicants must have acquired doctoral degrees or the equivalent at least six months prior to the requested beginning date of the visits. Young CIS specialists with a strong potential to contribute to the development of the private sector in their home country will receive special consideration. Thus, placement in U.S. university laboratories with strong industrial ties is of particular interest. Plans for the visiting specialists to return to their home countries where they can utilize their research experience should also be evident in the proposal. American hosts are expected to make all logistical and administrative arrangements for the visits directly with their CIS colleagues. All visits must commence in calendar year 1993.

The application deadline for this program is **March 1, 1993.** Notification of awards will be given in May. Requests for more information and application packets should be made to: Office for Central Europe and Eurasia, National Academy of Sciences, 2101 Constitution Avenue, NW (FO2014), Washington, DC 20418; telephone, (202) 334-3680; fax, (202) 334-2614.

Metal Melted while Levitated above a Crucible

The National Research Institute for Metals under the Science and Technology Agency (STA), along with Chubu Electric Power Co. and Fuji Electric Co., Ltd., have jointly developed a method to melt metal while it is completely levitated above a copper crucible. The group has so far managed to melt titanium and a titanium-aluminium alloy at the kilogram level (2.3 kg), each, by electromagnetically suspending the metal above the crucible, thereby preventing the inclusion of impurities.

Although, to date, niobium, titanium, zirconium, and other metals having a high melting point, as well as active metals and alloyed materials have previously been melted using an electron beam or a plasma, it has been difficult to achieve uniform melts. Further, there is usually much loss due to the evaporation of aluminum and other low-melting-point materials added as alloys.

The method of melting a metal by suspending it electromagnetically was originally proposed in the 1920s by Siemens & Halske Akt.-Ges. Researchers had originally hoped to scale up the furnace because its processing capacity was quite small. The present version uses a melting furnace with a capacity of 0.1–0.2 kg. In the new equipment, two coils are wound around a hollow copper crucible through which water is circulated. The two sets of coils are driven at different frequencies, about 50 kHz for the upper coil and 3–10 kHz for the lower one. By using this configuration, the lifting power and temperatures of the melted metals can be controlled separately. Further, the crucible can be used repeatedly to melt any material. Niobium, zirconium, and other high-melting-point materials, as well as active metal materials, can be melted easily due to the agitation effects of the electromagnetic power. Using this system, it is possible to obtain an alloy with uniform composition.

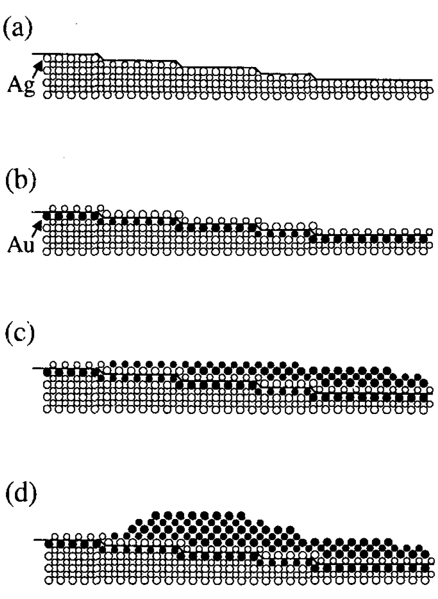
F.S. Myers

IBM Researchers Observe Unexpected Growth Behavior of Gold on Silver

IBM workers at the Almaden Research Center have observed behavior not predicted in the growth of thin metal films. In a vapor deposition process, gold atoms buried themselves an atom layer deep in the surface of a perfect single crystal of silver, not accumulating as a film on the silver surface until a complete "underlayer" of gold had been formed beneath an atom layer of silver.

The IBM report was published November 30 in *Physical Review Letters*. Team members included Shirley Chiang, David E. Fowler, and David D. Chambliss of Almaden, and Sylvie Rousset of the University of Paris, who was an Almaden visiting scientist.

The findings were based on experiments conducted at Rutgers University and published in *Physical Review Letters*, March 5, 1990. The Rutgers work suggested that somehow gold atoms were blocked, or not on the surface of silver, after partial deposition. The researchers suggested that either initially deposited gold atoms were blocked by gold laid down later, or that the first gold layer mixed with surface silver atoms, or that gold might form a subsurface underlayer.



The unusual growth behavior of gold on silver (110) is shown in this four-part diagram of cross-sectional views. Silver atoms are represented as open circles, gold atoms as solid circles. Some circles appear smaller than others because the atoms they represent are actually located just beyond the cross-section plane of view.

IBM workers, learning of the gold-on-silver behavior, investigated with an STM capable of sensing the locations of individual atoms. They found no gold blocking gold, but that all gold was beneath the silver surface. Chiang said she and her co-workers were "surprised by this counterintuitive and unexpected result."

In later stages of film growth, the IBM group found that the gold formed long, flat, finger-shaped plateaus, all oriented in the same direction. These fingers next formed the foundations for three-dimensional gold islands that eventually grew and coalesced into a solid gold film.

Independently, physicists at Ames Laboratory and Iowa State University used computer models of atomic-scale interactions to calculate that an underlayer would be preferred because it would lower the overall energy of the silver surface. The two groups were aware of each other's activities but did not collaborate. Both studies were completed in early 1992. The Ames calculations were published in *Physical Review Letters*, September 14.

Los Alamos, Neocera to Develop Laser System for Making Superconducting Thin Films

Los Alamos National Laboratory and Neocera Incorporated, under a two-year cooperative research and development agreement, will build a prototype automated pulsed laser system to deposit high-temperature superconducting thin films onto crystalline wafers. The system, with potential use for communications, optics, computers, and other microelectronics, will be marketed by Neocera.

The immediate goal is to use the system to coat superconducting thin films on sapphire-based wafers, which are used in microwave communication devices. Eventually, the laser system could be used in manufacturing a variety of advanced ceramic thin films for computer memories, photovoltaics, optoelectronics devices, electrical insulators for optical coating, biological and other smart sensors, and superconducting wires.

Neocera president, T. Venkatesan, said he believes a successful, ready-to-use pulsed laser deposition system could be on the market within two years, although prototypes already are available and two have been sold. "The project has no technical roadblocks, since the basic physics and chemistry of the process are well-known," he said.

Researchers have studied pulsed laser

deposition and ablation, or creating plumes, for more than 20 years. About five years ago, Venkatesan, Xin Di Wu (now of Los Alamos' Superconductivity Technology Center), and co-workers discovered how to use the technique to create multicomponent films whose composition was identical to the target.

"A pulsed ultraviolet laser with just the right amount of energy atomizes the surface of the target material almost instantaneously, so we preserve the molecular composition of the target material in the thin film, no matter how complex the material," Wu said.

Another advantage is the rate at which the vaporized target material is deposited on the thin film. At deposition rates as high as 150 Å per second, the desired thickness of 5,000 Å is reached in less than a minute. Thin films deposited by pulsed laser deposition need no additional processing and, most importantly, the superconducting material grows in a crystalline form of high quality.

Los Alamos researchers will first tackle developing a reliable heater for the wafers and thin-film wafer, Wu said. The temperature across the wafer, about 800°C, must be maintained to within a few degrees for optimal deposition. The heater cannot introduce any contaminants into the chamber. For high-temperature superconducting oxides, the chamber contains pure oxygen at a precisely maintained pressure.

Neocera and Los Alamos chose to use the first manufacturing system to make electronic thin films built on two-inch sapphire wafers because of the demand for such wafers in microwave devices. Although sapphire and the superconducting material do not bond well, the laser system can be used to deposit a metal oxide buffer layer that is compatible with sapphire.

Argonne Joins with Caterpillar to Study Laser Heat Treating of Carbon Steels

Argonne National Laboratory and Caterpillar Incorporated, under a two-year, $360,000 cooperative research and development agreement, have agreed to a joint research project to refine and improve the use of lasers in heat treating carbon steels. The work could lead to longer-lasting gears, cylinder walls, piston rings and other vehicular parts. Heat treating is widely used to harden metal surfaces subject to wear.

David Bowman, corporate heat-treatment engineer in Caterpillar's process and materials research department, said, "The project's goal is to work out the procedures and put them in place on the manufacturing floor."

Heat treatment commonly involves induction heating or carbon dioxide lasers. Induction heating uses rapidly oscillating magnetic fields to induce heating currents in metal parts, but is nonselective and can cause distortion. Carbon dioxide lasers deposit heat selectively, usually without distorting parts, but their energy can be reflected by metal, so adsorbent surface coatings, like carbon or flat black paint, must be applied.

The Argonne-Caterpillar project will test YAG lasers and also work to improve heat-treatment processes for carbon-dioxide lasers. YAG lasers have recently become available commercially in kilowatt-power levels needed for heat treating, Bowman said. They produce light of a shorter wavelength that is more readily absorbed, possibly avoiding the need for absorbent coatings.

Super-Heavy Conduction Electron Observed

Haruyoshi Aoki of the National Research Institute for Metals of the Science and Technology Agency and Yoshichika Onuki of Tsukuba University recently observed an electron 120 times heavier than its static mass, the heaviest conduction electron ever observed. A conduction electron moving in metal becomes less mobile than an electron in a vacuum, due to magnetic interaction and other factors—in other words, "heavier." This phenomenon is the basis of the properties of magnetism and superconductivity in metals and its understanding has been a critical problem of modern physics.

Although the existence of superheavy conduction electrons has been assumed theoretically, observing such an electron was difficult because it has a mass far greater than that of the heaviest conduction electron previously observed (90 times as heavy as the electron's static mass). The research team made a high-purity single crystal of the rare-earth compound $CeRu_2Si_2$, measured it under experimental conditions at an extremely low temperature of 20 mK and a strong precise magnetic field of 16 T, and observed the superheavy electron.

This achievement helps experimentally verify the theory that a specific electron is responsible for conduction.

F.S. Myers

Cornell Machine Tests Cable Fibers

The U.S. Army is seeking a heavy-duty cable to support large targets for practice missiles, and to that end Cornell University has developed a device capable of testing strands of various materials to determine which would produce the most applicable cable. The cable, to be strung between two mountain peaks three miles apart and supporting a rapidly moving "trolley," would break under its own weight if made of metal, and would wear severely if made of most new synthetics.

However, one synthetic material, Dupont's Kevlar, appears promising. Extremely strong when strands of it are twisted into a two-inch cable, it is being studied on a cable-wear machine that can test a single strand, yet simulate the wear on a whole cable. The device, designed and built by Alex Deyhim under the supervision of S. Leigh Phoenix, professor of theoretical and applied mechanics and an associate dean in the College of Engineering, circumvents the need to make and test on site 25 different whole cables, at a cost of $1 million each.

The cable tester can subject an individual strand to load patterns and pressures seen in the whole cable—which has a 500,000-pound breaking strength—to determine how a cable breaks, where the damage occurs, and how to avoid it. It uses a sheave—the grooved wheel on which a cable rolls—and a Teflon backplate to simulate the internal pressure in the cable, thus simulating wear. An electric motor powers the sheave to roll eight inches at 20 rpm, at a load or pressure that can vary depending on the use. The load is simulated using a nitrogen-air cylinder and piston assembly. Information is fed directly into a computer, and the damaged strands can be analyzed by electron microscopy to determine what happened.

Still undetermined is what coating, or jacket, would best protect the cable from damage due to excessive wear of a rolling wheel or slider, and Cornell researchers are investigating that now. Their guess: a blend of polyester and Kevlar, and a sub-jacket of a type of polyurethane. Teflon was discarded as a coating because the trolley would be difficult to brake.

The researchers say the machine may also be useful for testing cables for offshore rigs or ocean vessels, for example. Phoenix said, "There has never been a good way of testing fiber surface treatments to resist fatigue. This machine is going to be able to provide the ability to study fiber wear in many kinds of cables."

U.S. Air Force Seeks Researchers for Summer Program

For the 14th year, the Air Force Office of Scientific Research (AFOSR) is soliciting academic scholars in technical disciplines to participate in eight to 12 weeks of paid research in its Summer Research Program (SRP) at one of eight Air Force laboratories. In addition, select SRP associates may continue their AFOSR-sponsored work at their home institutions with follow-on research grants. SRP researchers work on key technologies having a direct bearing on national interests.

For 1993, AFOSR is seeking 100 graduate students under the following qualifications:

- Applicants' fields must match the Air Force's needs (for information on obtaining a program guide, see below).
- Researchers must be free to work for a continuous 8- to 12-week period between April 1 and September 30.
- Applicants must be U.S. citizens, must have earned a bachelor's or master's degree (doctoral degree holders are not eligible), must be enrolled in an accredited graduate program, and must be willing to be supervised by a faculty research associate or an Air Force laboratory scientist.

Under the terms of the program, SRP associates must complete a questionnaire and write a report summarizing their accomplishments. If a master's degree holder, a researcher receives $455 per week; a bachelor's, $391 per week. A compensation of $37 per day is allowed if the researcher lives more than 50 miles from the work site. Applications will be accepted no later than **March 15, 1993**.

For a program containing an application, laboratory locations, disciplines, and other information, contact Research & Development Laboratories, Summer Research Program Office, 5800 Uplander Way, Culver City, CA 90230; telephone, (310) 410-1244 or 1-800-677-1363.

Organic Refinement Used to Purify Metals with High Melting Points

The Research Development Corporation of Japan (JRDC) has put to practical use a new technology which can highly purify metals with high melting points—such as niobium and tantalum—utilizing an organic refinement method. Such metals are widely used as electronic, optical, and superconductive materials. The process, which was originally developed by the late professor Michio Nanjo of the Research Institute of Mineral Dressing and Metallurgy, Tohoku University, was commissioned by JRDC for further research and commercialization by Tohoku So Chemistry Corp.

The technology has been developed to the extent that ultramicropowder oxide of niobium with a high purity of 99.99% or more can be obtained from scraps of a niobium-titanium alloy. The scrap metal is cleaned by washing and degreasing and then chloridized with chlorine gas. The metal chloride produced is distilled to increase its purity, and then reduced by using hydrogen to separate the chloride of niobium or tantalum. The chloride is combined with alcohol to produce alkoxide, which is subjected to distillation, hydrolysis, and oxidation to obtain superpurified supermicroparticles.

F.S. Myers

Sandia Researchers Construct 1.3 μm Reflectance Modulator

Sandia National Laboratories scientists have constructed a reflectance modulator that operates at a 1.3-μm wavelength using strained-layer superlattice technologies. Reflectance modulators are tiny compound semiconductor mirrors that can receive light waves generated from a distant source and, using electrical signals, impress information on the reflected beam. Light reflects back and forth in the Fabry-Perot cavity between the mirrors, building energy and allowing the devices to operate at low voltage. This low operating voltage feature is significant because it makes the reflectance modulators practical devices for optical connections in computers, radars, remote site communications, and security systems.

In 1991, Sandia scientists reported construction of a reflectance modulator that operated at a commercial laser wavelength–1.06 μm. Building on that research and using the same techniques, the team recently constructed the reflectance modulators that operate at 1.3 μm.

Ian J. Fritz, one of the scientists who developed both modulators, said the 1.3-μm wavelength reflectance modulator has two advantages over the 1.06-μm model: higher speed due to the longer wavelength and less danger to the eyes in free-space communication.

The wavelength for operating reflectance modulators is determined by geometry and the natural frequencies of materials used for fabrication. The multilayers for the modulator were prepared by computer-controlled molecular-beam epitaxy using wafer rotation during growth. Multiple alternating thin layers of indium gallium arsenide and indium aluminum gallium arsenide form quantum-well resonators, which are surrounded by thicker layers of indium gallium arsenide and indium aluminum arsenide that form mirrors.

The low-power, longer-wavelength reflectance modulators would be particularly useful in any system that benefits from locating signal processing remote from transmission equipment. Such configurations are advantageous to systems like phased array and synthetic aperture radars since these systems require many different microwave signals to locate images. Reflectance modulators employed in each of the high-power transmitter-receiver units can impress the microwave information on a laser signal for processing at a common remote site.

The research team included Fritz, Burrel E. Hammons, Arnold J. Howard, Thomas M. Brennan, and David R. Myers, who work in Sandia's Microelectronics and Photonics Core Competency Center.

Stable Ultradense Bonded Layer Demonstrated

A new type of chromatographic phase, functionally equivalent to monomeric bonded phases on silica, is more resistant to damage by acids and bases, due to bonding chemistry that creates an ultrahigh-density surface within the first few angstroms above the silica substrate. The coating shows stability to hydrolysis, and tests at both high and low pH show high strength in comparison to conventional monomeric bonded phases.

The water-shedding layer also prevents growth of cracks caused by dissociative chemisorption, the sequential rupturing of interatomic bonds. Water can accelerate crack growth rates more than a million times by reducing the amount of energy required to break the silicon-oxygen bond by a factor of 20. The process is scalable, environmentally benign, and possibly adaptable to the treatment of fiber optic strands to prevent flex crack propagation. Other potential applications include crack-resistant and water-shedding windshields, labware, and insulation, as well as preservatives for such materials as masonry and statuary.

The inventors, Mary Wirth and Hafeez Fatunmbi of the University of Delaware, demonstrated surface stability to both acid and base hydrolysis (see *Analytical Chemistry* **64** (1992) p. 2783-2786) by boiling monolayer-coated silica in concentrated nitric acid for 25 minutes with no sign of deterioration. The silica-based monolayer also endured a boiling solution of pH 12 for three hours.

Silica packing material is dipped into a solution of n-octadecyltrichlorosilane, n-propyltrichlorosilane, anhydrous n-hexadecane, and the desired chromatographic functional group. The surface monolayer bonds to the silica at room temperature.

A few angstroms away from the surface, the monolayer density is nearly solid, thereby providing protection from both acid and base hydrolysis. A few angstroms above this layer, the structure of the stationary phase is more open, allowing chromatographic separations to occur. For C_{18} bonded phases, the average bonding density can be varied from 0 to 7 μmol/m^2. Functional groups can be introduced into the bonded phase while preserving its acid- and base-resistant properties.

Information can be obtained from Joe Stumpf, Research Corporation Technologies, telephone (602) 296-6400; fax (602) 296-8157.

Gösele to Co-Direct Max-Planck-Institut in former East Germany

Ulrich M. Gösele, a professor of materials science at Duke University's School of Engineering in Durham, North Carolina, has accepted a position as co-director of the newly founded Max-Planck-Institut of Microstructure Physics, Halle, in the former People's Republic of Germany. Gösele's research focuses on point defects and diffusion processes in silicon and III-V compounds, thin film reactions, and semiconductor wafer bonding. In his most recent research, he and postdoctoral colleague V. Lehmann submitted the first paper on quantum confinement in porous silicon. A patent was granted for this work. Also, the microclean concept for silicon wafer bonding developed by his group at Duke University has been licensed to AT&T.

Gösele received his diploma and his PhD in physics from the University of Stuttgart and the Max-Planck-Institut of Metal Research, Stuttgart, where he also worked for a number of years. He was employed at Siemens Research Laboratories in Munich before joining the Duke faculty in 1985 and held visiting appointments with the Atomic Energy Board of South Africa, IBM T.J. Watson Research Center, Mobil Solar Corporation, Cornell University, Massachusetts Institute of Technology, and Nippon Telegraph & Telephone LSI Laboratories, Japan.

Gösele is a principal editor of *Journal of Materials Research* and a new member of the editorial board of *Journal of Applied Physics, Reviews in Applied Physics,* and *Applied Physics Letters.*

High-Quality Diamond Thin Films Produced with Laser-Liquid Interaction

Jogender Singh, currently a researcher with NASA's George C. Marshall Space Flight Center, reports the synthesis of high-quality diamond thin films by pulsed-laser irradiation on copper substrate immersed in liquid benzene. During irradiation, Singh said, carbon released from benzene (C_6H_6) at the liquid-solid interface converts into diamond as a result of rapid quenching. The researchers observed primarily a mixture of cubic diamond and simple polytypes of diamond such as 2H and 6H hexagonal diamond. The diamond synthesized by this process is also used as seed material for subsequent growth of thicker layers by hot-filament CVD.

In the experiments, Singh immersed single crystal (100) and polycrystalline copper specimens in benzene and irradiated them with high-power excimer laser pulses. The pulses traveled through a 3-mm-thick layer of liquid onto the 10 × 10 mm samples. The diamond crystallites were characterized by HRTEM and electron diffraction methods.

"The process is simple, economical, and controllable for the selective growth of diamond," Singh said. "The most significant advantage is that the substrate will not be exposed to the contaminating environment of oxygen during the diamond thin-film deposition process."

Singh conducted his work as a researcher in the Materials Science Department, North Carolina State University, in collaboration with NCS researchers M. Vellaikal and J. Narayan.

DOE Announces Distinguished Postdoctoral Fellowship Awards

The Department of Energy (DOE) has announced 12 fellowship awards in its Distinguished Postdoctoral Research Program, which provides recent outstanding recipients of doctoral degrees opportunities to participate in DOE's research programs.

Selection of fellows is based on previous research accomplishments; scientific/engineering background and experience; statement of research to be performed; compatibility of the applicant's background and research interests with DOE-sponsored research programs at participating laboratories; academic records; recommendations; awards and honors; career goals; and the availability of funds, programs, staff, and facilities. Disciplines appropriate to this fellowship program include those in the physical sciences, computer sciences, engineering, and supporting disciplines with applications to energy-related fields.

Recipients of the fellowship are: Karen E. Carter, University of Texas, geology; Lois V. Curfman, University of Virginia, applied mathematics; Daniel S. Dessau, Stanford University, applied physics; Hui-Jou H. Kung, Cornell University, materials science; Sarah C. Larson, Harvard University, chemistry; John D. March-Russell, Harvard University, physics; John F. Mitchell, University of Chicago, chemistry; Maya Paczuski, Massachusetts Institute of Technology, electrical engineering; David A. Rabson, Cornell University, physics; Earl E. Scime, University of Wisconsin-Madison, physics; Roger A. Vesey, Rensselaer Polytechnic Institute, nuclear engineering; and David T. Wu, Harvard University, applied physics. □