UMR Researches Environmentally Friendly Lost Foam Casting Process

Metallurgists at the University of Missouri-Rolla are studying a cost-effective, environmentally sound method of metal casting, using polystyrene. Researcher Donald R. Askeland, calling the process lost foam casting, said, "Polystyrene foam is approximately 96% air, so very little emission is released into the environment." He added that lost foam casting is more flexible and less expensive than current processes.

Patterns are produced from hollow polystyrene beads which are blown into molding machines fitted with aluminum tooling dies. The beads are heated with steam, which is injected into the tooling cavity. The beads flatten and melt together at the surface to form the foam pattern, and a thin coating of liquid ceramic is then applied to the foam pattern and allowed to dry. Coarse sand is then poured in and vibrated around the pattern. After the pattern is completely imbedded in the sand, molten metal is poured into the pattern. The metal displaces the polystyrene, creating a metal duplicate of the original foam pattern. Askeland and other UMR faculty members and graduate students are trying to determine what happens to the foam during this process.

"The foam pattern initially melts into a liquid plastic and then evaporates into gases as the metal is poured," Askeland said. "The liquid plastic and gases then enter and eventually pass through the solid ceramic coating and into the surrounding sand." An advantage of the process is its efficiency and low cost. Internal cavities and holes in the final casting can be exactly reproduced, and the expensive binders ordinarily used to hold the molds together aren't needed.

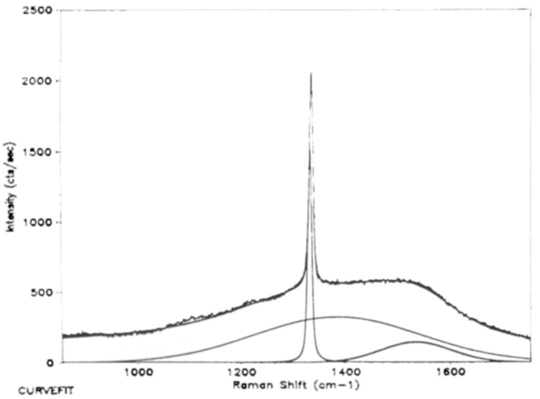
The project is funded by the U.S. Department of Energy and about 30 corporations. Research participants include the American Foundrymen's Society, the Southern Research Institute, and the University of Alabama.

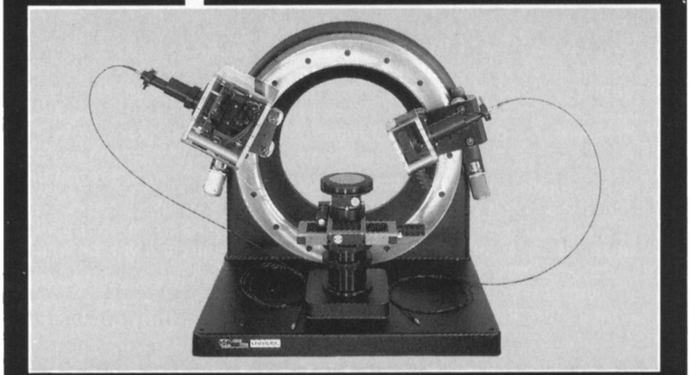
CERAM and Keele Collaborate to Foster Materials Applications

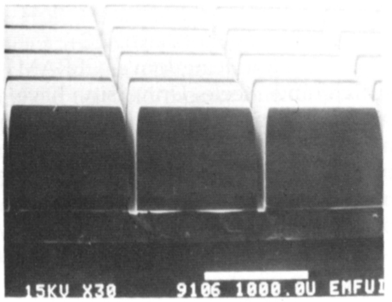
The United Kingdom's CERAM Research and Keele University have announced a partnership, forming a new materials science group to exploit innovation in materials and processing technology. The collaboration is designed to promote technology transfer from university to industry, with CERAM Research playing an intermediate role.

Research and application development will encompass ceramic, composite, and inorganic materials for both traditional and novel applications. Themes include novel processing for production of advanced inorganic materials, property enhancement of ceramics and composites, application of inorganic chemistry to the production of new ceramic materials, and biomimicry to enhance performance of biomedical implants.

The group at Keele University is headed by Derek Birchall and Kevin Kendall, who







were with ICI Advanced Materials. Birchall pioneered macro-defect-free cements, invented Saffil, a synthetic inorganic fiber, and recently has worked on advanced ceramics and biomimicry. Kendall, who with Birchall explored new process technology for advanced ceramics, is working on the development of fuel cells. The two have been appointed to chairs at Keele and will also be senior research associates at CERAM.

Residual Stresses in Welds Mapped with Neutron Scattering

A team of researchers at Oak Ridge National Laboratory (ORNL) have used the neutron scattering technique to map residual stresses formed in a complex multipass weld. Since it is the combination of residual stress and applied stress that determines if and when an object will deform or fail, it is important to know the distribution of residual stresses. The team used a modified spectrometer system at ORNL's High Flux Isotope Reactor (HFIR) to do the analysis.

The stresses were mapped by studying how the neutrons from the HFIR were scattered by the atoms in a solid weld material. The mapping was done on a 30-cm square welded plate of ferritic steel. The sample consisted of two steel plates, welded together using a matching ferritic steel wire and gas tungsten arc welding process.

The scientists irradiated the welded sample with a neutron beam having a fixed wavelength of 1.65 Å, selected to make the scattering angle close to 90°, for a stress-free ferritic steel sample. The strains are determined by observing the diffraction angles and calculating the lattice spacings.

The researchers obtained a three-dimensional map of strains in a series of "volume elements" in the weld, the heat-affected zone, and the base metal of the steel plate. Each volume element was several cubic millimeters. From the measurements of the strains along the length, width, and height of each volume element, the researchers calculated the residual stresses in each of the three principal directions.

By changing the sample position and using a special detector to accurately count the neutrons scattered at various angles, the researchers obtained a detailed map of residual stresses in the weld sample. A key to their success was the computer-controlled sample stage, beam collimators, and detector attachment added to the existing triple-axis neutron spectrometer at the HFIR. In the experiment on the ferritic steel weld sample, the researchers found large tensile stresses parallel to the weld line in the weld metal and out into the steel plate where the stresses eventually became compressive.

"We found that the tensile stresses approach the yield stress of the materials and may nearly exceed this stress in the weld zone," said Cam Hubbard, of ORNL's Metals and Ceramics Division. "If these stresses are not minimized, such welds could show signs of cracking after exposure to applied loads. These residual stresses can be reduced in the weld by post-weld, stress-relief heat treatments. Our ability to map residual stresses in welds will allow us to evaluate the effectiveness of such treatments."

Multipass welds are commonly used in many industries. "Our data," said Hubbard, "will be useful in predicting the properties of multipass welds in ferritic plates and will provide a basis for modeling multipass welds." He added that the HFIR could also be used to map residual stresses in industrial objects such as ceramic-coated turbine blades or oil well casings.

Bowen Appointed Professor at Harvard

H. Kent Bowen, expert on advanced materials and materials processing, has been appointed a full professor at the Harvard Business School. He teaches in the Technology and Operations Management area.

Much of Bowen's current research involves work with the Manufacturing Vision Group (MVG), a collaborative project among academics and practitioners that seeks to improve new product and process development. The MVG aim is to combine ideas from business and technology in an effort to establish principles for manufacturing science that will further the work of both scholars and managers.

Bowen earned his BS degree in engineering at the University of Utah and his PhD degree at the Massachusetts Institute of Technology, where he began teaching in 1970. Bowen has developed curricula and taught at the undergraduate and graduate levels, mentoring more than 60 doctoral and postdoctoral students. Most recently, he has focused on the education of operations professionals, especially in collaboration with manufacturing companies.

Bowen has been elected to the National Academy of Engineering and the American Academy of Arts and Sciences. He serves on the Defense Science Board and the Manufacturing Sub-Council of the Competitiveness Policy Council, among other professional society, government, and corporate advisory committees.

AT&T to Commercialize Synthetic-Diamond Laser Submounts

AT&T has announced the commercial application of a novel synthetic diamond material combined with an advanced metallization bonding technique developed for use in making microelectronic heatsinks as submounts for high-power semiconductor lasers. The submounts, made of chemically vapor-deposited (CVD) thick films of synthetic diamond, combine high functionality and maximum heat-extraction capability.

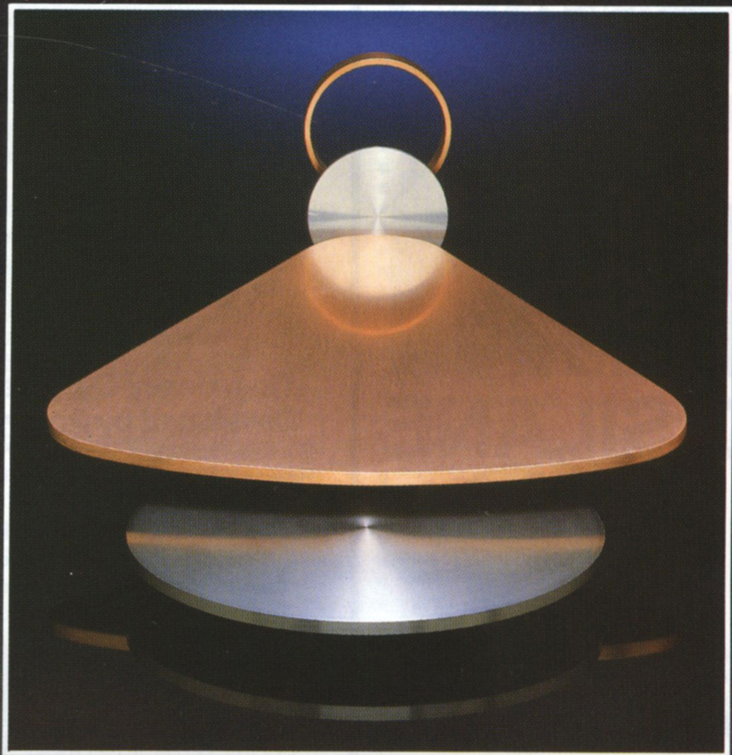
William C. Dautremont-Smith, a supervisor in the Semiconductor Laser Technology department, said, "We needed a submount with the very high thermal conductivity of single-crystal natural diamond, but without the very high cost." His group worked with AT&T's Diamond Materials Research Team. Another group, the Metallurgy and Ceramics Research department, developed and applied critical thermal conductivity methods which showed that diamond wafers can have thermal conductivity at least as good as the best natural diamond.

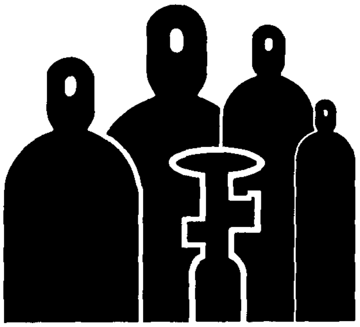
Making usable laser submounts from CVD diamond, however, requires advanced thin-film bonding metallization compatible with diamond processing. This technology was provided by a development team led by Avishay Katz of the Semiconductor Laser Technology department. Katz worked with AT&T's vendors worldwide to develop and implement the required processing technologies to fabricate completed heatsinks.

The technology enables efficient heat removal from lasers, a key to achieving both the high-power performance and reliability needed in high-power laser applications. The development team is pursuing further optoelectronics applications, and envisions broader applications in silicon and gallium-arsenide high-performance integrated circuits and in high-density interconnects.

UWM Professor Receives 1992 CEAS Outstanding Service Award

Pradeep K. Rohatgi, Ford/Briggs & Stratton Professor of Materials, University of Wisconsin-Milwaukee (UWM), has been named a recipient of the 1992 CEAS Outstanding Service Award, given in recognition of his outstanding service to professional organizations and to industries. He has organized and chaired numerous sessions and participated in the committee work of ASM International,





American Institute of Mining, Metallurgical and Petroleum Engineers, American Foundrymen's Society, and the Great Lakes Composites Consortium. He is the director of three laboratories in the College of Engineering and Applied Science at UWM, and has been a founder/director of two research laboratories of the Council of Scientific and Industrial Research in Trivandrum and Bhopal, India, and a professor at the Indian Institute of Science, Bangalore, India.

Rohatgi's materials expertise focuses on composites. He has authored/co-authored more than 300 published research articles, edited/co-authored six books, and earned patents in the United States and India.

Tiny, Heavy-Duty Gas Sensor Developed by Argonne

Researchers at Argonne National Laboratory have invented a tiny, rugged ceramic-metallic gas sensor that may find wide use identifying gases in harsh industrial environments where ordinary sensors could not survive. The prototype is about 1/4 by 1/2 inch in size, and could apply to monitoring vapors inside plant machinery, fire detecting, or gas sampling in automobile fuel injectors, manifolds, or cylinders.

The sensor requires little maintenance, operates on little electricity, and is inexpensive to make. One of its inventors, Michael Vogt, said that vibrations, corrosive environments, and water should not be a problem for this sensor.

An initial goal of the project was to create a device that fits inside a computer chassis and senses overheating components. Computer circuit boards are made with epoxy resin and fiberglass and when the epoxy gets hot, it releases a vapor. The Argonne sensor can detect these vapors and could be wired to shut off electricity to the circuit before the board catches fire.

The sensor consists of layers of readily available materials. Vogt uses low-cost thick-film screen printing to build up the layers. Mixtures of inks and metals are screen-printed on the base material and oven-fired for several hours.

Gases are detected by varying a small voltage across the sensor's electrical leads and monitoring the resulting electric current. Different gases produce current spikes at different voltages, creating unique, identifiable "signatures." Unlike most sensors designed to recognize some particular gas, the Argonne sensor can detect several gases in a mixture. The scientists are also adapting standard computer pattern-recognition programs to automatically identify gas signatures.

LBL Studying Aerogel-Based Nanocomposite Materials

Scientists at Lawrence Berkeley Laboratory have developed an inexpensive, energy-efficient process for creating aerogel-based nanocomposite materials with a wide variety of compositions.

Aerogels are typically composed of 5% solid and 95% fine pores, and have low density (0.1 g/cc) with an internal surface area of about 900 m^2/g. In the LBL process, a second or third phase of material with a characteristic size of 10 nm or less is introduced into the aerogel structure. These nanoparticles can induce profound changes in the optical, magnetic, and chemical properties of the material. Combinations of different aerogel materials and nanoparticles provide a wide variety of new nanocomposite materials.

An improvement in aerogel thermal insulating properties has also been shown with the process. Prior research showed that while aerogels are an excellent insulator, they were not effective at blocking the infrared (IR) component of radiant heat transfer in the 3-8 μm range. Introducing nanoparticle-sized IR-blocking agents into aerogels reduced the aerogels' thermal conductivity. For example, transmission by a 0.5″ thick aerogel at 4 μm was reduced from more than 50% to less than 1%. The result is an insulation performance of about four times the R value of an equal thickness of polyurethane foam, commonly used for refrigerator insulation.

More information on this process is available from the Technology Transfer Department of Lawrence Berkeley Laboratory; telephone number: (510) 486-6463; fax number: (510) 486-6457.

Oak Ridge Develops Hard-Surfaced Polymers With Properties of Polymers, Metals

Researchers in the Metals and Ceramics Division at the Department of Energy's Oak Ridge National Laboratory have created a new class of materials called hard-surfaced polymers, that have the low density and flexibility of polymers, combined with a hardness and wear resistance exceeding that of metallic alloys.

The new materials were produced by high-energy ion-beam modification. In the past, polymers were irradiated to change their electronic properties, but for hard-surfaced polymers, the researchers focused on the mechanical properties. Full utilization of the desirable properties of conventional polymers, such as their light weight and corrosion resistance, has traditionally been constrained by their inherent softness and poor resistance to wear, abrasion, and fatigue. Louis Mansur, a co-developer, said, "This newly developed process helps overcome these constraints and opens up new design possibilities for a wide range of manufactured products."

To create these new polymers, three high-energy ion beams are aimed at a polymer sample. This bombardment changes the structural linking of the polymer molecules, displacing some atoms and ionizing others, thus forming new bonds. The ion species injected by the accelerator also become incorporated into the polymer structure. The result is a highly cross-linked microstructure with enhanced hardness, often several times harder than steel, and with much greater resistance to wear and abrasion. Conventional polymers subjected to the ion-beam process have proven to be up to 40 times harder than they were before the treatment.

Abrasion-resistant polymers are good candidate materials for high-speed moving parts and load-bearing components requiring light weight. In addition, polymer films can be spin-cast on any surface and ion-beam treated for protective coating where hardness and wear resistance are required.

Ion-beam processing also improves resistance to oxidation and chemical attack, suggesting that hard-surfaced polymers could be useful in low-earth-orbit applications, in which atomic oxygen impacts cause severe erosion of polymers.

More than 50 manufacturers have shown interest in hard-surfaced polymers for applications including medical materials such as joint prostheses; machinery components such as gears, bearings, and sliders; electronics, for static charge elimination; and protective exteriors, for applications in the marine, aircraft, aerospace, and other industries.

Institute for Advanced Space Materials and Structures Established

Three major research centers, Los Alamos National Laboratory, Sandia National Laboratories, and the U.S. Air Force's Phillips Laboratory, have established an Institute for Advanced Space Materials and Structures to increase the reliability of U.S. spacecraft and space-based systems. Spacecraft demand exceptionally high reliability for national security and economic reasons. Improving reliability also should mean lower long-run costs.

The institute will qualify new materials, processes, and structural concepts for use in space systems, drawing on existing Defense and Energy Department programs related to space technology. The program is also expected to include collaboration with regional research universities (University of New Mexico, New Mexico State University, New Mexico Institute of Mining and Technology, University of Texas–El Paso), and other laboratories such as Wright Laboratory.

Highway Coatings and Materials Center Created at BIRL

BIRL, Northwestern University's industrial research laboratory, has established a Center for Coatings and Materials for Highway Construction. The center is the result of a $400,000 Federal Highway Administration contract. The center's initial project is to find economical, environmentally safe methods of paint removal and recoating, particularly for U.S. bridges that need repair. Almost 90,000 of these bridges are coated with lead-based paints, for corrosion resistance.

The principal investigator for the project, and a specialist on coating processes, is Thomas F. Bernecki. He and his team of BIRL researchers will examine safe removal and disposal of existing paint; testing and application of new coating materials; automation of cleaning, inspecting, and recoating; technology transfer; and long-term maintenance and repair costs.

A test chamber will be built to analyze pollutants generated by both coating and removal systems. Removal research will focus on experimental and current coatings.

Thermal spraying, particularly with metallized coatings—a technique used on most bridges in Europe—will be investigated. The technique can be used in high humidity and low temperatures, and will be field-tested to measure exposure to various weather conditions.

Other aspects of the program include using new electrochemical techniques for accelerated testing of corrosion protection and determining the feasibility of developing an inexpensive hand-held device for measuring surface conditions prior to recoating.

BIRL researchers will tap resources at Northwestern's materials science and civil engineering departments, at the J.L. Kellogg Graduate School of Management, and at other campus centers. Industrial consultants and highway departments will contribute as well.

Grant for Transparent AlON Ceramics Awarded to Sienna Research

Sienna Research, Inc. has received a $100,000 research grant from Defense Advanced Research Projects Agency (DARPA) to develop optically transparent aluminum oxynitride (AlON) ceramics for ballistic armor applications. Sienna will provide an improved transparent armor—weighing only half as much as today's armor—for military and commercial applications.

In addition to its hardness, strength, and high-temperature properties, AlON is also infrared transparent. Typical applications will be for high-temperature windows, scratch-resistant headlight covers, watch glasses, and metal vapor lamp envelopes.

Phase I of the development program aims for production of transparent AlON with a minimum 80% transmission and a maximum 10% haze. Phase II will test the ballistic properties of an AlON transparent composite armor.

AT&T to Work With Ioffe Institute

AT&T Bell Laboratories has contracted to work with the A.F. Ioffe Physico-Technical Institute, St. Petersburg, Russia, for the services of 27 scientists who are with four research teams there. They will conduct fundamental research into semiconductor physics and semiconductor lasers. The one-year contract is renewable by mutual consent.

The agreement covers basic research into:

- Auger recombination in heterostructures;
- Photoluminescence of hot (energetic) electrons and scattering processes in quantum-well structures;
- Radiative efficiency dependence on quantum-well thickness for various types of heterostructures grown by molecular-beam epitaxy and metal-organic chemical-vapor deposition techniques; and
- Optical properties of quantum wires and quantum dots fabricated by reactive ion etching of aluminum-gallium-arsenide/gallium arsenide heterostructures.

David V. Lang, director of Bell Labs Compound Semiconductor Device Research Laboratory, said these were extensions of work already pursued at the Ioffe Institute.

Fiber-optic technology, which offers ultrahigh-capacity information transfer (for simultaneous transmission of voice, data, and images, and for high-definition television transmission and high-speed data networks), depends on lasers and other semiconductor devices. ☐

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