New Process Makes Amorphous Metals More Ductile

Utilities Could Save Energy, Dollars

Energy worth millions of dollars never makes it from the power plant to the consumer. Instead, it's eaten up by the electrical transformers commonly located near households, on utility poles, or on transmission lines.

James C.M. Li, a University of Rochester professor, has discovered a way to overcome the manufacturing difficulties associated with amorphous metals, which can cut the energy loss in those transformers by two-thirds. Li, Albert Arendt Hopeman Professor of Engineering, recently patented a process to make the metals much more ductile and consequently less expensive to manufacture.

In a transformer, the magnetic properties of the core material are used to vary the voltage and current. The easier the core material is to magnetize, the less power is required to vary the voltage and the less expensive the transformer is to operate.

Some amorphous metals (such as those consisting of a mixture of iron, boron, and silicon) are more easily magnetized than any known material and are ideal candidates for use in transformers. Distribution transformers with an amorphous core typically require 65–70% less energy than conventional core materials such as silicon steel, according to Ben Damsky, senior project manager at the Electric Power Research Institute (EPRI) in Palo Alto, California.

Despite the energy savings, only 3–4% of the 1 million transformers shipped to U.S. utilities by EPRI during the past year had amorphous cores because amorphous cores typically cost about 30% more than conventional ones.

The higher price is due mainly to manufacturing difficulties related to the brittleness of amorphous materials. Heating these materials in a furnace improves their magnetic properties, but makes them nearly as brittle as glass. The materials are difficult to cut, shape, or even ship, since an amorphous core typically consists of a few thousand closely packed layers of these metals, each about one-thousandth of an inch thick.

Instead of heating the metals in a furnace, Li heats them with a pulsed high current (approximately 1,000 A/cm^2) for anywhere from 1 second to 2 minutes, with a pulse duration ranging from one-billionth to one-tenth of a second. The method is faster, and the resulting materials are much less brittle.

An amorphous-core transformer requires about $20 less in energy each year to perform the same function as other transformers. According to Damsky, utilities put into service about one million new transformers each year; each transformer has a lifetime of approximately 30 years. If Li's work makes the price of an amorphous core competitive with traditional materials, the energy savings will be substantial.

The ductile amorphous materials could also be used in security systems for department stores, where amorphous metals are now sometimes used, and in libraries, where thin magnetic metal strips prevent readers from secretly removing books.

Before this latest discovery, Li had made fundamental contributions to many areas of materials science and is credited with making amorphous metals widely available for commercial use. His current work was sponsored by China Steel Corporation, which also holds the U.S. patent (4,950,337).

Li recently received the 1990 Acta Metallurgica Gold Medal, awarded by Acta Metallurgica Inc. Li is a Fellow of ASM International, the American Physical Society, and The Mineral, Metals & Materials Society, and is a member of the Materials Research Society.

Chalcogenide Glass Fiber Research Targets Laser Surgery

Alfred University's New York State College of Ceramics will use a $150,000 glass fiber drawing tower donated by General Electric's Lighting Business Group to conduct research into the potential use of chalcogenide glasses to transmit mid-infrared wavelength laser beams during microsurgery. Chalcogenide glasses are made by melting selenium, germanium, and antimony instead of the more usual silica. Arun Varshneya, professor of glass science and engineering at the university, will conduct the research along with William LaCourse, professor of glass science, and Alexis Clare, assistant professor of glass science.

While medical experts say they could greatly benefit from the use of such laser power, particularly for procedures like removal of cardiovascular plaque, no suitable material is currently available to transmit the longer wavelengths, says Varshneya. The Alfred University researchers believe

https://doi.org/10.1557/S0883769400058061 Published online by Cambridge University Press

https://doi.org/10.1557/S0883769400058061 Published online by Cambridge University Press

the chalcogenide glasses, in fiber form, have the potential to do that.

Conventional glasses used to make fibers for laser transmission can carry wavelengths up to 4.5 μm. This wavelength is adequate to remove cataracts, for example, but not for invasive procedures such as the removal of plaque from artery walls because the beam is absorbed by too much of the surrounding tissue.

Some researchers are investigating the use of hollow metal fibers or exotic crystal fibers to transmit the mid-infrared wavelength laser beams, says Varshneya, but each has problems. The hollow metal fibers, for example, do not bend easily, so they are difficult to use in delicate procedures, and the crystal fibers are "not very reliable and damage easily."

Glass fibers made from chalcogenide glasses are the answer, predicts Varshneya and his co-researchers. They have formed a partnership with Wolf Seka from the Laser Energetics Laboratory at the University of Rochester, and with Raymond Lanzafame, assistant professor and director of the laser center at Rochester General Hospital.

"We're proposing an interdisciplinary effort, combining the materials science skills of the Alfred University researchers with the laser and surgical expertise of the Rochester scientists, to explore the use of the chalcogenide glass fibers in laser surgery," said Varshneya.

ASM International Honors Bravman for Materials Science Teaching

John C. Bravman, assistant professor of materials science and engineering at Stanford University, was named the 1991 recipient of ASM International's Bradley Stoughton Award for Young Teachers. The citation carries the words "For enthusiasm and dedication in the teaching of materials science and for inspiring students by example." The award was established in 1952 in memory of Bradley Stoughton, an outstanding teacher of metallurgy who served as president of ASM in 1942.

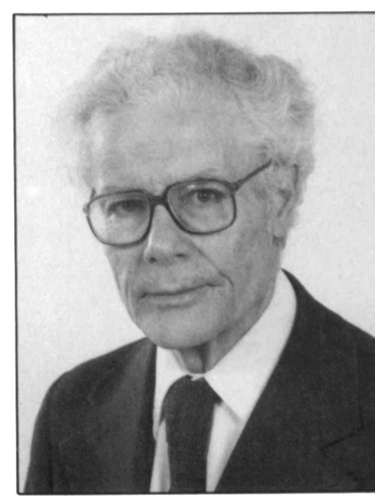
Bravman, who joined the Stanford faculty in 1985, received all his university education at Stanford, completing a BS degree in 1979 and a PhD in 1984. Bravman teaches both undergraduate and graduate level courses in materials science and engineering, and with his graduate students conducts research on semiconductor and superconductor materials.

Bravman has already received several honors for his work with students both in and out of the lecture hall. In 1988 he was selected by the Stanford Chapter of the Society of Black Scientists and Engineers to receive their Excellence in Teaching Award. He was designated a recipient of the Walter J. Gores Award, Stanford's highest honor for teaching, at the 1989 commencement ceremonies. This past June he was presented the 1990 Tau Beta Pi Award for Excellence in Undergraduate Teaching in the School of Engineering at Stanford. In 1987 he was given the Distinguished Adviser Award in the School of Engineering.

Bravman served as an MRS symposium organizer in 1987 and 1988 and as meeting chair in 1990. In January 1991, he will begin a three-year term as an MRS councillor.

Turnbull to Receive Bruce Chalmers Award

David Turnbull, McKay Professor of Applied Physics, Emeritus, at Harvard University, was named to receive The Minerals, Metals & Materials Society's (TMS) 1991 Bruce Chalmers Award, which is given for outstanding contributions to the field of solidification science.



Turnbull received his BS from Monmouth College and his PhD in physical chemistry from the University of Illinois. Since his career began in 1939 as a member of the faculty of the Case Institute of Technology, Turnbull has also served as research scientist at the General Electric Research Laboratory as well as on the faculty of Rensselaer Polytechnic Institute. He also spent one year on leave to the Cavendish Laboratory at Cambridge University. In 1962 he assumed his present position at Harvard.

Turnbull is co-editor of *Solid State Physics* and has received many honors and awards for his contributions to the fields of nuclea-

https://doi.org/10.1557/S0883769400058061 Published online by Cambridge University Press

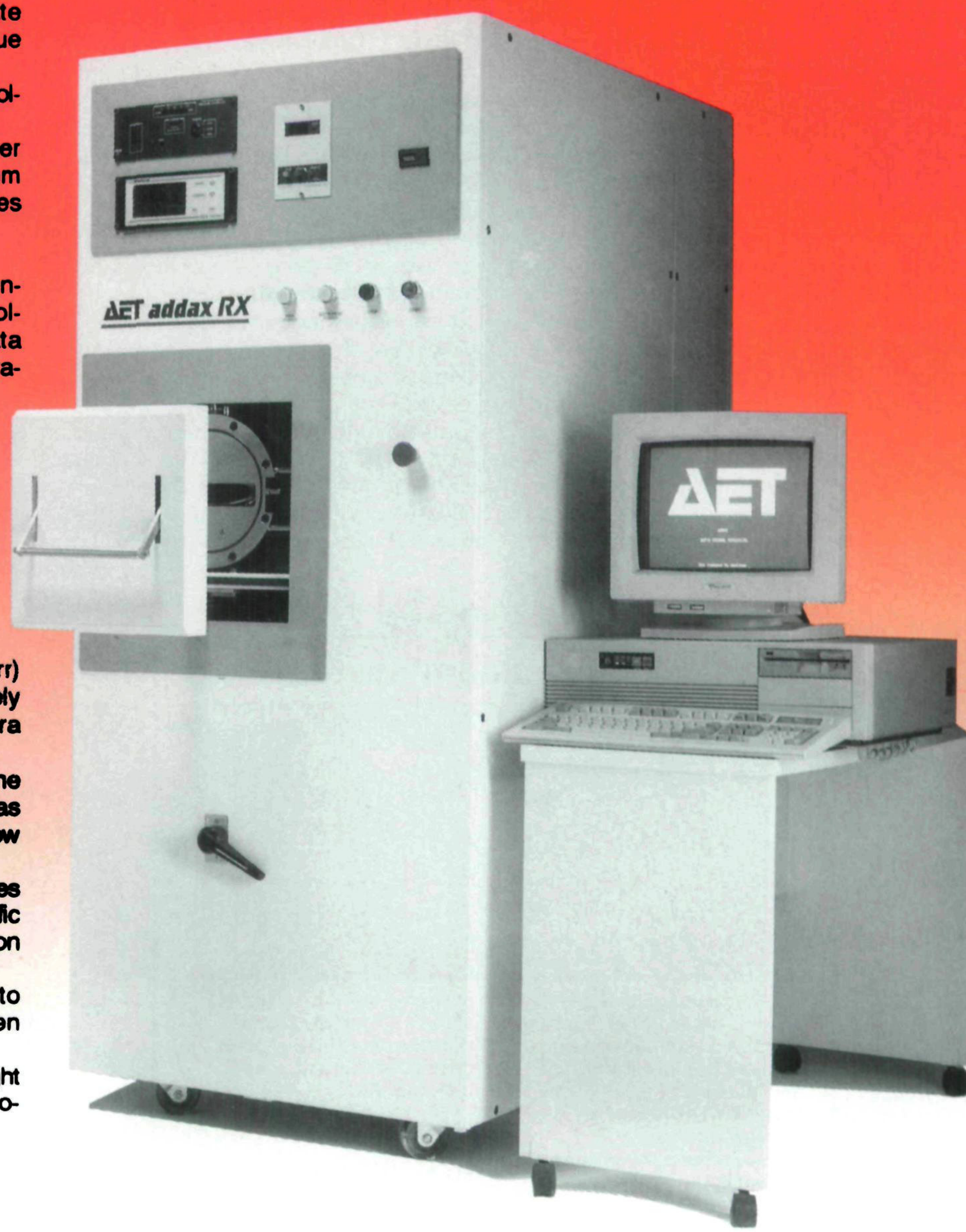
Rapid Thermal Processing - LPCVD

The new modular RX Series, lets you configure precisely the system you need to perform or develop virtually any application demanding a thermal process - from the most basic annealing process to the most complex LPCVD environment. Ask for the price, you will be surprised!

The RX series for RTP.

The RX is a fully automated integrated processor featuring:

- Fast heating rates with ramp-up rates up to 400°C/sec and fast cooling rate to get abrupt junctions with a unique cooling system.
- Temperature uniformity computer controlled in real time, with multizone furnace.
- Cleanliness with a quartz chamber designed for medium or high vacuum options with automatic vacuum cycles and pressure programming.
- Gas control/mixing.
- Unique graphics software. The environment is entirely computer controlled, including complete process data storage and retreival, hardware calibrations and maintenance.



The RX series for LPCVD.

With its many years of experience in Rapid Thermal Processing, AET Addax has developed proprietary features for LPCVD, and has addressed major concerns regarding the application of RTP to LPCVD:

- The ultra high vacuum (10-9 torr) quartz chamber offers an extremely clean environment to generate ultra pure films.
- The combination of a very small volume processing chamber and fast gas switching system produces a low memory effect for sharp transitions.
- The advanced cooling system provides "cold wall quartz" capabilities. A specfic module is available for installation on UHV stainless steel chambers.
- Removable chamber for cleaning or to avoid cross contamination between processes.
- Safety features with interlocks, leak tight double enclosure for toxic gases, automatic reset procedures.

AET addax

SEMICONDUCTOR EQUIPMENT DIVISION

743 Ames Avenue, MILPITAS, CA 95035. Tel: (408) 263-5464. Fax: (408) 263-9825.

https://doi.org/10.1557/S0883769400058061 Published online by Cambridge University Press

tion and growth of crystals, diffusion in solids and liquids, solid state reactions, nature of the glassy state, and thermionic emission. Turnbull received the Materials Research Society Von Hipple Award in 1979.

Ben Franklin Grant Supports High T_c Superconductor Research

The Kurt J. Lesker Company (KJLC) was awarded a grant from the Ben Franklin Technology Center to develop a process for making large-area, highly oriented, high-quality Y-Ba-Cu-O thin film high T_c superconductors. The total project, valued at approximately $300,000, will last one year and involve researchers from KJLC and Carnegie Mellon University.

The best available thin film deposition techniques—magnetron sputtering and laser ablation—have restricted substrate sizes for manufacturing purposes. "Even preferred substrate materials such as $SrTiO_3$ and $LaAlO_3$ are limited to a 1-inch diameter," says Michele Migliuolo, director of research and development at KJLC. "Our aim with the grant funds," he explained, "is to extend the technology to cover 3-inch diameters on commercially significant wafer materials such as Si, MgO, ZrO_2, and $Al2O_3$."

Using KJLC sputter guns and laser ablation sources, various groups have produced state-of-the-technology YBCO thin films with a 1-inch diameter coverage on every substrate mentioned above. All show transition temperatures above 90 K with transition widths (10–90%) less than 1 K and c-axis preferred orientations.

Batstone to be Awarded Hardy Gold Medal

Joanna L. Batstone, who works in the Materials Science Department at IBM's T.J. Watson Research Center, was recently named to receive The Minerals, Metals & Materials Society's (TMS) 1991 Robert Lansing Hardy Gold Medal Award. The award is presented to an individual under the age of 30 who shows outstanding promise of a successful career.

Batstone, a member of the Materials Research Society, received a BSc degree in chemical physics and a PhD in physics from the University of Bristol in England. Before joining IBM she was engaged in postdoctoral work at AT&T Bell Laboratories in Murray Hill, New Jersey.

Batstone's research interests center around the structural and electronic properties of defects in semiconductors and epitaxial thin films, using the techniques of cathodoluminescence and high-resolution electron microscopy. Her investigations have included identifying optically active dislocations in II-VI semiconductors and determining atomic structures at metal/semiconductor and insulator/semiconductor interfaces.

Aerogels and Plastics Make Solid-State Radioluminescent Lights

Researchers at Sandia National Laboratories have used aerogels and plastics to make novel solid-state radioluminescent (RL) light sources. The glowing pieces of plastic or aerogel, or hybrid thin films, require no electrical power supply, can be made in various sizes and shapes, and can produce almost any desired color.

The solid-state technology, still not totally developed, promises brighter light, more safety and stability, and more adaptable shapes and sizes than current commercially available tritium-based RL lights, say the researchers. They have speculated on applications ranging from airport or emergency lighting to uses in optical computing and photonics and as long-term power sources in space.

Commercially available tritium-based RL lights—glass tubes coated on the inside with an inorganic phosphor, filled with radioactive tritium gas, and sealed—are breakable and their brightness is limited by self-attenuation and opaqueness.

Inorganic Aerogel RL Lights

With the possibility of being made 10 times brighter than standard gas-filled RL lights, the solid-state inorganic lights made at Sandia are considered good power source candidates. The basic idea, says researcher Robert J. Walko, is to surround a very bright RL light with a photovoltaic light converter to make electricity. The bright light has been demonstrated, says Walko, and the engineering team has developed several processes and compositions for making the devices.

To make the inorganic lights, a phosphor such as zinc sulfide is dispersed in an aerogel, which is 90-95% open space. Tritium gas incorporated into the aerogel becomes chemically bonded to the aerogel matrix. Beta particles given off during tritium decay strike the phosphor particles, exciting them and causing them to emit light. Because the phosphor particles are highly dispersed and the aerogel is very transparent, a large fraction of the light escapes. Phosphors can be chosen to produce different colors of light.

https://doi.org/10.1557/S0883769400058061 Published online by Cambridge University Press

The researchers (Walko, S.T. Reed, C.S. Ashley, and C.J. Brinker) say they can achieve tritium densities up to 17 times greater than for tritium gas under normal atmospheric temperature and pressure. This helps accounts for the brightness of the light. Also, no appreciable radiation is emitted because it is attenuated within the aerogel matrix after traveling only microscopic distances.

Organic RL Lights

Another team of researchers (C.L. Renschler, R.L. Clough, T.J. Shepodd, and J. Gill) has made a completely organic, optically clear RL light with tritium bound into a transparent plastic matrix.

An organic molecule, DEB (p-di[phenylethynyl]benzene) is tritiated with the aid of a catalyst. The process allows up to eight atoms of tritium to chemically bond into each DEB molecule. The tritiated DEB is dissolved in optically clear styrene. Organic dyes are also dissolved in the plastic.

Beta particle excitation of electrons in the polystyrene molecules does not produce visible light, but the dyes dissolved in the plastic red-shift the energy in steps until the emitted light is the desired wavelength. Orange and blue lights have been produced this way.

Tritium is bound even more tightly into the organic solid than into the aerogel medium, enhancing the safety of the organic lights. "You could put a bullet through them and only the bullet hole itself would go dark," says Renschler. However, the current organic versions discolor over time because of the effects of the beta radiation. They lose much of their efficiency and may prove best for shorter term uses.

Hybrid Versions

An organic/inorganic hybrid system in thin-film form combines the brightness of a zinc sulfide phosphor with the safety of tritium-loaded organic materials. The thin-film light is produced by dissolving tritiated DEB in ethylbenzene, mixing it with copper-doped ZnS, and pressing the material between a mirrored surface and a glass cover.

The researchers caution that they are still in the developmental stage and still investigating all three types of RL lights, the organic, inorganic, and hybrid. The work at Sandia is being done with the collaboration of researchers at other laboratories: H.M. Smith at Allied-Signal Kansas City Division, J. Gill and R. Ellefson at EG&G Mound Applied Technologies, L. Leonard of the RL program at Department of Energy Headquarters, and A. Tompkins formerly of Oak Ridge National Laboratory. Patent disclosures have been filed for all three technologies.

ATM Announces Diamond Photoconductive Switch Contract

Advanced Technology Materials, Inc. (ATM) of New Milford, Connecticut was recently awarded a $500,000 contract from the Strategic Defense Command in Huntsville, Alabama to design and demonstrate a high-power microwave source. A photoconductive switch fabricated from a diamond semiconductor base will be used to generate the microwaves. The two-year program targets the fabrication of a microwave power source from single-crystal diamond prepared by chemical vapor deposition (CVD).

Diamond is the ideal candidate for high power semiconductor and photoconductive applications. Diamond has dark resistivities in excess of 10^{13} Ω-cm, and its room temperature thermal conductivity can be up to five times that of copper, permitting rapid dissipation of heat so that dark current and thermal runaway effects are negligible. The electron and hole mobilities of diamond are nearly equal at 1,900 and 1,600 cm^2/Vs, respectively, and the saturated carrier drift velocity is larger than either Si, GaAs, or InP. Diamond also has significantly larger dielectric breakdown strength than either GaAs or InP.

The basic diamond photoconductive power switch is simple in concept. Optical energy from a laser ($\lambda = 1 \mu m$) is used to rapidly switch the bulk diamond semiconductor from an insulating to a conducting state. In principle, for diamond semiconductors, voltages greater than 100 kV cm and current densities about 100 kA/cm^2 can be controlled over subnanosecond times. Overall power densities in excess of 10 GW/cm^3 may be possible. Large peak power densities ~6 GW/cm^3 have been switched using laser-activated silicon switches, but thermal runaway effects have prevented switching of such high power densities at high repetition rates. One of the major obstacles to the successful application of photoconductive power switches has been the inability of GaAs-based devices to switch high voltages and currents at repetition rates greater than 10–1,000 Hz.

https://doi.org/10.1557/S0883769400058061 Published online by Cambridge University Press