Rare-earth Information Center NEWS

Ames Laboratory
Institute for Physical Research and Technology
Iowa State University / Ames, Iowa 50011-3020 / U.S.A.

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R & D Awards

Better Magnetic Powder

The Modified High Pressure Gas Atomization (HPGA) Technique to produce powdered rare-earth alloy material is one of this years' 100 best scientific innovations [*R&D Magazine* 33 [11], 76 (1991)]. This modified high-pressure gas atomization technique process produces rare earth alloy material with improved mechanical and magnetic properties while cutting energy consumption and waste. Compared with existing methods, the HPGA process produces magnetic materials that are stronger, more resistant to environmental attack, less hazardous, and more cost effective.

This process results in a powder product whose smooth, regular geometry is suited for making sintered magnets or for new techniques to make Nd-B-Fe permanent magnets. The process reduces or eliminates the need to grind magnets into final shape, reducing the amount of scrap.

I. Anderson and B. Lograsso of Ames Laboratory and Iowa State University, Ames, Iowa, developed the process. With worldwide sales of rare earth permanent magnet material expected to reach $1.5 billion US by 1995, HPGA should prove to be a valuable innovation.

YB_{66} Single Crystal

The YB_{66} soft x-ray monochromator is a complex binary semiconducting compound. It was designed for use as a high-energy resolution-dispersive element for soft x-ray radiation in the 1 to 2 keV region, in particular for use in intense synchrotron radiation. *R&D Magazine* 33 [11] 92 (1991) reports that it has unique x-ray and physical properties not possessed by known chromators, such as beryl, indium antimonide, and beta-alumina.

YB_{66} can be used in electron spectroscopy for chemical analysis (ESCA) and x-ray photoelectron spectroscopy (XPS). It opens up new experimental possibilities in physics, chemistry, biology, materials sciences, and metallurgy. ▲

Nobel Laureate

French physicist Pierre-Gilles de Gennes has won the Nobel science prize in physics for discovering the general rules for the behavior of molecules, and of magnetic and superconducting materials. Scientists had previously believed there was only disorder in molecular behavior. He has mathematically described (1) the molecular changes in polymer solutions and liquid crystals, and (2) the influence of *4f* electrons on magnetic ordering and the depression of the critical temperature of superconductivity.

Pierre-Gilles de Gennes

Rare earthers are familiar with de Gennes' work on exchange interactions in lanthanide metals and nuclear relaxation in certain paramagnetic lanthanide alloys. He was the first to show the influence of the quantum numbers of the unpaired *4f* electrons with the magnetic ordering temperature of lanthanide metals, their compounds, and the depression of the superconducting transition temperature by lanthanide metals dissolved in the superconducting matrix. This relationship is known as the "de Gennes factor".

De Gennes' discovery that there is order in the way molecules behave in materials such as liquid crystals has helped in making new products such as liquid crystal displays in watches and clocks, and flat television screens. Currently, he is working on a "super glue" that is so strong that it could be used to replace rivets in the construction of aircraft. ▲

Presidential Appointment

Mr. Yusuke Inoue was appointed President of Santoku Metal Industry Co., Ltd. in March, 1991. He replaces Mr. Fujiyuki Inami who is now retired. President Yusuke Inoue graduated from Kobe University of Commerce in 1959, then joined Santoku

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Metal Industry Co., Ltd. He was previously Sales Manager Director. ▲

ASM Fellows

Dr. O. Norman Carlson, Professor Carl C. Koch, and Dr. Robert A. Schiffman are among the 54 who was installed as ASM Fellows during Materials Week '91 which was held in Cincinnati, Ohio in October. ASM established the honor of Fellow to recognize members for distinguished contributions in the field of materials science and materials engineering.

O.N. Carlson, who is now retired, senior metallurgist and professor, Department of Materials Science and Engineering, Ames Laboratory, Iowa State University, Ames, Iowa, has done considerable work with the preparation and properties of high-purity rare earth metals and their alloying behavior including classic studies of effects associated with controlled additions of interstitials.

C.C. Koch, Professor, Department of Materials Science and Engineering, North Carolina State University, Raleigh, North Carolina, is installed "For pioneering research in solid state amorphization by mechanical alloying, and for contributions to understanding ductilization of intermetallic compounds and the role of defects in improving the properties of superconductors". Early in his career he worked extensively on the physical metallurgy of rare earth alloys.

R.A. Schiffman, president, R.S. Research Inc., Riverwoods, Illinois, was cited "For pioneering research in thermodynamics, for the development of innovative techniques in temperature, property and kinetic measurements at high temperatures, and containerless environments, and for the determination of thermodynamic data in complex binary systems". Dr. Schiffman studied the thermodynamics of ytterbium-lead and cerium-antimony materials during his post-doctoral days at the Ames Laboratory, Iowa State University.

RIC congratulates all newly installed Fellows. ▲

International Symposium on Radiation Protection

The First International Symposium on Radiation Protection in the Mining, Milling and Downstream Processing of Mineral Sands will be held in Bunbury, Western Australia, March 18-20, 1993. This will be the first major international scientific meeting of professionals from industry and academia dedicated to occupational and environmental radiation protection issues specific to mineral sands and downstream processing including the rare earths. Topics of the Symposium include: processing technologies and associated radiological hazards; internal/external dosimetry - models, standards; regulatory practices and developments; occupational radiation and its optimization; environmental radiation protection and waste management; radiation protection during transport, storage and handling; personal monitoring and dosimetry; instrumentation, measurement techniques, radiation research; and education and public information.

The aim of the Symposium is to stimulate discussion and exchange information on the "state of the art" in the field, to identify gaps in common knowledge, to set priorities for research and to provide practical guidance for industry.

Bunbury is the regional center of mineral sands mining and milling and is located 180km south of Perth on the Indian Ocean coast in Western Australia. For further information on the Symposium or to submit a paper or poster, contact: Minesafe Secretariat, The Chamber of Mines and Energy of Western Australia, 7th Floor, 12 St. George's Terrace, Perth, WA 6000 TEL:619 325-2955 FAX:619 221-3701. ▲

TMS-Australasian IMM Rare Earth Symposium

The Joint TMS-Australasian IMM Rare Earth Symposium: Sources, Science, Technology and Applications will be held March 2-5, 1992 in San Diego, California. The ten-part symposium will cover the subjects of: resources, geology, rare earth product preparation, beneficiation and extraction, magnetic materials, technology, alloys, separation technology, science of rare earth materials, and electrochemistry and corrosion. Sessions will also be devoted to applications, such as: industrial plant practice and high technology applications in electronic, magnetic, and optical devices.

Among the presentations of the symposium will be two plenary papers *The Availability of Resources to Meet Future Demand for Yttrium* by R.K.A. Taylor and *Lanthanide Applications in Emerging Technologies* by B.T. Kilbourn. A special reception has been planned for Tuesday evening March 3 for the attendees of this symposium.

The symposium is sponsored by the Minerals, Metals, and Materials Society (TMS), and the Australasian Institute of Mining and Metallurgy (IMM). For information on accomodations and registration for the symposium contact: TMS, 420 Commonwealth Drive, Warrendale, PA 15086 USA Tel:(412)776-9000 Fax:(412)776-3770 Telex:910-380-9397. ▲

Conference Calendar

*** A NEWS STORY THIS ISSUE**

March '92
Joint TMS-Australasian IMM Rare Earth Symposium: Sources, Science, Technology and Applications
San Diego, California, U.S.A.
March 2-5, 1992
RIC News, **XXVI**, [2] 2 (1991)
*Also this issue

April '92
22nd Journees des Actinides
Dieulefit, France
April 26-29, 1992
RIC News, **XXVI**, [3] 2 (1991)

June '92
Rare Earths '92 International Conference
Kyoto, Japan
June 1-5, 1992
RIC News, **XXV**, [3] 2 (1990)

July '92
2nd International Symposium on Physics of Magnetic Materials (ISPMM'92)
Beijing, People's Republic of China
July 3-8, 1992
RIC News, **XXVI**, [2] 2 (1991)

12th International Workshop on Rare Earth Magnets and Their Applications and 7th International Symposium on Anisotropy and Coercivity in Rare Earth Metal Alloys
Canberra, Australia
July 12-16, 1992
RIC News, **XXVI**, [2] 2 (1991)

Third International Symposium on Magnetic Bearings
Alexandria, Virginia
July 29-31, 1992
RIC News, **XXVI**, [3] 2 (1991)

September '92
International Conference on Heavy Fermion and Strongly Correlated Electron Systems (HFSCS '92)
Sendai, Japan
September 7-10, 1992
*This issue

March '93
International Symposium on Radiation Protection in the Mining, Milling and Downstream Processing of Mineral Sands
Bunbury, Western Australia
March 18-20, 1993
*This issue

April '93
Rare Earth Minerals: Chemistry, Origin, and Ore Deposits
London, England
April 1-2, 1993
RIC News, **XXVI**, [2] 2 (1991)

September '93
Actinides-93
Santa Fe, New Mexico, USA
September 19-24, 1993
RIC News, **XXVI**, [3] 2 (1991)

HFSCS '92

The International Conference on Heavy Fermion and Strongly Correlated Systems (HFSCS '92) will be held from September 7 to 10, 1992, at the newly constructed Sendai International Center, located near the Hirose River in downtown Sendai, Japan.

The conference is the successor of related previous conferences which were held in Grenoble (1987), Frankfurt (1988), Santa Fe (1989), Rio de Janeiro (1990) and Edinburgh (1991).

Members interested in recent developments in the rapidly growing area of heavy-fermion physics and highly correlated electron systems are invited to attend the

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Conference Proceedings

Rare Earth Minerals and Minerals for Electronic Uses is the name of the proceedings of the international conference held 23-25 January, 1991 in Hat Yai, Thailand *RIC News* **XXV** [2] 2 (1990). The proceedings reflect the conference topics: world resources/reserves, world supply/demand-present and future, mineralization, extraction, applications, national management plan, information management system, technologies of the next decade that need rare earth minerals, and other related areas. The results of the conference indicate that uses for rare earth oxides and metals with purities of up to 99.999% is growing. This requirement appeals for advanced processing technology to extract individual oxides or elements. Papers on this topic include: *Magnetic Separation of Monazite and Xenotime; Solution Chemistry and Separation of Metal Ions in Leach Solution; Separation of Sm, Eu, Gd and Tb by Extraction Chromotography; Yttrium, Its Separation and Application; and Recovery of Rare Earth Metals from Tin Tailings.* The conference proceedings discusses the needs of the materials science community and presents advances in the field by reporting on the resources of rare earths used in the electronics industry, new developments in processing rare earth ores, magnetic separation, and applications of rare earth materials. Several papers present current issues concerning the worldwide markets for rare earth concentrates, profiles of the mineral sands industry, and the supply and demand of rare earths in Japan.

The 663-page Proceedings are Volumes 70-72 of *Materials Science Forum* (1991) and is published by Trans Tech Publications, Ltd., Hardstr. 13, POB 10, CH-4714 Aedermannsdorf, Switzerland Fax:(41)62 74 1058 or (41)13 42 0529. The cost of the proceedings is $210.00 US. ▲

***HFSCS '92**/Continued from page 2* ⇨

conference and contribute to its sessions. The program will consist of invited and contributed papers and posters. The proceeding of the conference will contain all the papers accepted for publication and will be published after the conference.

The deadline for abstracts is May, 1992 and the submission of full papers is July, 1992. For further information on HFSCS '92 contact: Professor Takemi Komatsubara, Department of Physics, Faculty of Science, Tohoku University, Aoba-ku, Sendai 980, Japan Fax:022-225-1891. ▲

2nd ICRE Proceedings

The Proceedings of the Second International Conference on Rare Earth Development and Applications (ICRE '91) have been published. The Proceedings consist of extended abstracts, lectures and papers presented at the conference during May 27-31, 1991 in Beijing, China, see page 3.

The 1118-page Proceedings, edited by G. Xu, J. Xiao, Z. Yu, and M. Chen, are published in three Volumes. The 287 papers are grouped in three sections of the Proceedings: Rare Earth Chemistry, Rare Earth Resources and Metallurgy, and New Rare Earth Materials and Applications. The sections contain research in the fields of: coordination chemistry; solid chemistry and bioinorganic chemistry; molten salt, physical, and analytical chemistry; rare earth separation, extraction, and hydrometallurgy; preparation of metals, alloys and rare earth compounds; geochemistry and ore dressing; environmental protection; high T_c superconductivity; magnetic materials; hydrogen storage materials; materials of luminescence, phosphors and lasers; rare earth applications in glasses, ceramics, catalysts, steel, cast irons, nonferrous metals, agriculture and medicine.

For ordering and cost information contact the publishers and distributors: International Academic Publishers, Xizhimenwai Dajie, Beijing Exhibition Center, Beijing, 100044, China. ▲

$BaCeO_3$ Hydrogen Sensor

H. Iwahara et al. have reported the construction and testing of a hydrogen-concentration cell which uses a high temperature, proton-conducting oxide ceramic based on $BaCeO_3$ [*J. Electrochem. Soc.*, **138**, 295-99 (1991)]. Due to high protonic conductivity, the working temperature range of the censor was 200 to 900°C. The proton-conducting oxide ceramic used in this sensor was $BaCe_{0.90}Nd_{0.10}O_{3-\alpha}$ where α is the oxygen deficiency per perovskite-type unit cell. This material produced higher protonic conductivity than Yb-doped $SrCeO_3$ which was previously tested. EMF of the sensor was measured as a function of hydrogen partial pressure which was varied from pure hydrogen to 1% hydrogen in a helium carrier.

The cell produced a stable EMF over the entire temperature range 200 to 900°C and a plot of EMF against the logarithm of the hydrogen partial pressure showed a linear relationship. Response speed upon changes of the hydrogen partial pressure was fairly fast with a steady value reached within 2 minutes. ▲

The 2nd International Conference on Rare Earth Development and Applications Held in Beijing

The 2nd International Conference on Rare Earth Development and Applications (ICRE '91), which was sponsored by the Chinese Society of Rare Earths, was held at Beijing International Convention Centre from May 27 through May 31, 1991. 290 scientists attended this conference, of these, 63 were from other countries.

Prof. Yu Zongsen, vice-chairman of the Chinese Society of Rare Earths, presided over the opening ceremony.

Mr. Xu Daquan, deputy director of the Rare Earth Leading Group of the State Council, and vice-minister of the Ministry of Metallurgical Industry, warmly welcomed all the scientists and scholars on behalf of the government of the People's Republic of China and the Conference Organizing Committee. He hoped that this conference would promote international cooperation and exchanges through the oral and poster sessions and discussions among participants.

Mr. Zhou Chuandian, Chairman of the Chinese Society of Rare Earths (CSRE), said that, since the first ICRE in 1985, Chinese rare earth industry as well as scientific research has made considerable progress. The consumption of rare earths in China, especially in steels, agriculture, aluminum wires, and various new materials, has greatly increased. He also noted that CSRE has established contact with scientists throughout the world through its organization, members, journals, and academic exchanges.

Prof. Xu Guangxian (China), Prof. I. A. Smirnov (U.S.S.R.), and Prof. Gin-Ya Adachi (Japan), delivered plenary lectures. In addition, 82 scientists gave oral presentations in 15 sections; including 22 by non-Chinese scientists; and another 91 presented posters, 17 being contributed by non-Chinese scientists.

During the conference, the attendees had the opportunity to visit the National RE Exhibition, which highlighted new achievements and displayed many rare earth products.

A total of 287 papers were presented in this conference, and all of the papers were published in three volumes by International Academic Publishers. These proceedings, and how they can be obtained, are reviewed in the previous column. ▲

25 *The Rare Earths and I* 25

The following contribution was received from Dr. Adrian Daane, a long time associate and fellow scientist here at the Ames Laboratory. He is now associated with the Chemistry Department at LaGrange College in LaGrange, Georgia (Zip code 30240).

THE RARE EARTHS AND I: A RECOLLECTION

In our preparation of the rare earth metals in the 1950s at the Ames Laboratory at Iowa State College (later to become Iowa State University), we (Dr. F. H. Spedding and I, along with a number of our graduate students) had prepared all of the metals except samarium, europium and ytterbium — and, of course, promethium — by reducing the trifluorides with calcium; those three resisted our best efforts until Dave Dennison and I finally prepared samarium and ytterbium metals by heating the sesquioxides with lanthanum metal as the reductant in a high vacuum. We wanted to extend this method to the preparation of europium too, but the ion-exchange separations of Jack Powell had been with materials in which europium was so dilute that there was no Eu_2O_3 on hand for this work. I remembered that there was a small mayonnaise jar on the shelf in Dr. Spedding's office with about 100 grams of Eu_2O_3 in it, and he told me a story about it.

While at Berkeley, Dr. Spedding had been awarded the Langmuir Prize of the American Chemical Society for his work on the low temperature absorption spectra of thulium ethyl sulfate in which he had observed field-splitting. It was 1932, the year of the Century of Progress Exposition/World's Fair in Chicago. Part of the Langmuir Prize award ceremony was a lecture by Dr. Spedding and the Fair promoters were anxious to get the lecture as part of their program. Dr. Spedding told of the motley crowd that attended his lecture on the Fair grounds, including some mothers with young children, and some others who had been to Sally Rand's famous Bubble Dance show just down the boardwalk from where the lecture was given and had wandered in "just to see the show"! After the lecture a line of people came by the podium to shake Dr. Spedding's hand — I remember that Dr. Spedding remarked that some of the kids with cotton candy left sticky hand-prints in his. One wiry man in the line told Dr. Spedding how much he appreciated the lecture and asked, with a gleam in his eye, if he (Dr. Spedding) would like "some nice pure Eu_2O_3?" Dr. Spedding thought him to be some science freak who wasn't tuned in to the fact that Eu_2O_3, in high purity, was extremely rare, but Dr. Spedding said "sure" and forgot about it. Within the next month Dr. Spedding received a small mayonnaise jar with about 100 grams of a very white powder, labeled "Eu_2O_3". On analysis, it indeed turned out to be very pure Eu_2O_3 — a very generous gift from Dr. H. N. McCoy of the University of Chicago and a chemist/consultant to the Lindsay Light Company (later the Lindsay Light and Chemical Company), a processor of thorium and rare earth ores in their manufacture of Welsbach mantles for gas lighting. At the plant he had "milked" the light rare earth solutions of their small europium content by passing them through a Jones reductor and filtering off the $EuSO_4$ precipitate.

Suffice it to say, europium metal was prepared and was the subject of a paper by Dr. Joseph Hanak and me. An interesting sequel to this was that Dr. James C. Warf of the University of Southern California, Department of Chemistry, had considerable experience with the rare earths when he was a graduate student at Iowa State College working with Dr. Spedding, and had continued his research with the rare earths at USC. Warf wanted to do some work on europium metal and asked if we (Dr. Spedding and I) could supply him with some of the metal. Dr. Spedding wanted to help, as he had a very high regard for Warf and his work, but he was loath to dip any further into his mayonnaise jar of Eu_2O_3. We proposed to Warf that if he could come up with 30 grams of the oxide, we would make the metal and send him 10 grams, keeping any processing losses and product over the 10 grams. A bit to our surprise, Warf came up with the oxide, we prepared the metal for him, and out of his research was his report of the solubility of europium metal in liquid ammonia, the first observation of this property.

An interesting sequel to this is how Warf got the europium oxide: It turns out that in the meetings of the Los Angeles Section of the American Chemical Society, Warf had met Dr. Ellen Terry, the widow of Dr. H. N. McCoy, a chemist in her own right, living in the area. She was impressed with Warf's work and provided him with the pure europium oxide that he sent to us.

And an interesting sequel to this is how

Continued in next column ➪

Synthesis of Lanthanide and Actinide Compounds

A book entitled *Synthesis of Lanthanide and Actinide Compounds*, edited by G. Meyer and L.R. Morss contains a collection of 14 reviews on the optimum synthesis of lanthanide and actinide compounds. Since each article is written by one or two specialists, only minimal editorial constraints were imposed because preparation of the compounds was emphasized, rather than their structures and properties. State-of-the-art synthetic procedures are presented by solid-state chemists with two objectives. First, the best methods for the synthesis of pure *f*-element compounds, and second, a methodology for the discovery of new materials.

Each chapter focuses on a major class of compounds of current interest to the solid-state research community. Included in the text is the preparation of rare earth halides, oxides, sulfides, selenides, phosphates, carbonates, titanates, and *f*-element pnictides.

Synthesis of Lanthanide and Actinide Compounds was published in 1991 and is available in North America from Kluwer Academic Publishers, P.O. Box 358, Accord Station, Hingham, MA 02018-0358 Tel:(617)871-6600 Fax:(617)871-6528. Outside North America, Kluwer Academic Publishers P.O. Box 322, 3300 AH Dordrecht, The Netherlands. The cost of the 384-page book is $134.00 US. ▲

Rare Earths and I/*Continued from previous column* ➪

Dr. McCoy met Dr. Terry. At the University of Chicago, Dr. Terry's laboratory was directly above Dr. McCoy's, and when one of Dr. Terry's water baths overflowed and drenched Dr. McCoy's lab, he went up to see "what the hell was the matter" - - and met Dr. Terry!

Dr. Spedding delighted in telling about Dr. McCoy's rare earth work, and lauded him as a most generous provider of samples to research workers. It was through Dr. McCoy's help that there is an abundance of research papers on europium in the literature of the 1930s, 40s and 50s, far beyond what would be expected from the relative scarcity of europium in the rare earth ores. Thanks to Dr. McCoy.

Adrian H. Daane
Department of Chemistry
LaGrange College
LaGrange, GA 30240

RE Handbook 14

Volume 14 of the *Handbook on the Physics and Chemistry of Rare Earths* is the latest release of the comprehensive series that the editors have assembled to keep the scientific and technical communities informed of the rapidly expanding body of knowledge about the rare earths. Volume 14 differs somewhat from the previous volumes in the series by placing strong emphasis on the physical aspects of intermetallic compounds. This latest volume contains five chapters which brings the total number of chapters in the series to 97.

The first two chapters deal with relatively new experimental methods of studying rare earth metallic phases - high energy neutron spectroscopy and light scattering. In these chapters the authors explain the new kinds of information obtained from these techniques and how this complements the knowledge previously gained from the more common measurements: NMR, heat capacities, magnetic susceptibility, transport and elastic properties. One of the remaining three chapters deals with NMR studies of rare earth intermetallics, and the final two chapters are concerned with the physical phenomena such as electron-phonon interaction and heavy fermion behavior that occur in these compounds.

The authors from chapter one describe a fairly new technique for probing the lanthanide 4*f* levels within metallic solids using high-energy neutrons from spallation sources in order to study transitions between different $^{2S+1}L_J$ multiplets. Intermultiplet spectroscopy is extremely useful in studying intermediate valence and heavy-fermion materials because it can be used to study the mixing of the two valence configurations in the former and to obtain information on the degree of hybridization of the 4*f* level in the latter.

Chapter two reviews the advances that have been made in NMR spectroscopy over the past 12 years. The contribution is specialized as it concentrates on NMR in intermetallic, magnetically ordered compounds. The author points out that considerable progress has been made in experimental techniques which enable scientists to study materials and perform measurements that could not have been done ten years ago.

The third chapter describes how Raman and Brillouin light scattering has become a valuable complementary tool to neutron scattering. The authors show that these methods provide high resolution, strict symmetry selection rules, small sample sizes, and independence of the rare earth isotope. These optical studies give us detailed information about crystalline electric-field excitations, spin-orbit-split *J* multiplet excitations, and phononic and electric properties of rare earth intermetallic compounds including Kondo and intermediate valence materials.

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The last two chapters present the reader with interesting and stimulating assessments of electron-electron-phonon coupling and heavy fermion phenomena, respectively. The main emphasis of the fourth chapter concerns the interesting effects found in valence fluctuation, Kondo lattice, and heavy-electron materials. The fifth and last chapter is an overview of one of the most exciting areas of physics in the past 15 years - heavy fermion behavior. It includes the most least understood aspects of 4*f* electron hybridization and the effects of superconductivity. Volume 14 of the *Handbook of the Physics and Chemistry of Rare Earths*, edited by K.A. Gschneidner, Jr. and L. Eyring was published in 1991 by North-Holland and contains nearly 500 pages. The cost is $228.50 US (400Dfl) and it, and any of the previous 13 volumes, can be ordered from Elsevier Science Publishers, P.O. Box 103, 1000 AE Amsterdam, The Netherlands; or in the U.S.A. and Canada from Elsevier Science Publishing Company, P.O. Box 882, Madison Square Station, New York, NY 10159, USA. ▲

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A-axis Super Sandwiches

Scientists at Stanford University have produced multi-layered thin film structures of superconducting materials with the optimum current path at right angles to the film surface, as reported on page 6 of the February 18, 1991 issue of *Chemistry and Engineering News*. Alternating layers of superconductor $YBa_2Cu_3O_7$ and insulator $PrBa_2Cu_3O_7$, each 12 Å thick, have been built into a superlattice of 400 layers. A number of groups have grown superconductor/insulator superlattices with a c-axis orientation with the Cu-O current carrying planes parallel to the film surface. These structures have the disadvantage that electrical connections must be made at the film edge. With the new technique the CuO_2 planes are perpendicular to the film surface (in the a-direction), allowing for easier connections.

The method of preparation of the supersandwich has been described by Stanford graduate student Chang-Beom Eom and others on the research team [*Science*, **251**, 780-3 (1991)]. The system consists of two sputtering guns oriented at 90° to each other with the substrate (100)$SrTiO_3$, $LaAlO_3$, or MgO with a $SrTiO_3$ buffer, mounted on a rotating arm that switches between the guns. Growth conditions favoring the a-axis have been determined. The layers appear well separated, straight and continuous.

These a-axis oriented films should make it easier to construct sandwich- type tunnel junctions, which have yet to be made from any of the cuprate superconductors. These junctions will help in gaining a better understanding of the physics of superconductivity and in obtaining well-behaved Josephson junctions for uses in electronics. ▲

Desert Storm Citation

Joel Calhoun, Program Assistant and Staff Writer for RIC, was awarded the Navy Achievement Medal from the Department of the Navy for his services during the Persian Gulf War. He was one of the few who received this prestigious award. Joel served as Senior Chief Operations Specialist (Surface Warfare). The citation by A. M. Gemmill, Captain of the U.S.S. San Jose, to the Secretary of the Navy is as follows: "For professional achievement in the superior performance of his duties while serving as OC Division Leading Chief Petty Officer in USS San Jose (AFS 7) from 24 January 1991 to 24 April 1991 while deployed in support of Operation Desert Storm. Senior Chief Calhoun consistently performed his demanding duties in an exemplary and highly professional manner. In direct support of the largest Amphibious Task Force deployed since the Korean War, his superb leadership, unequaled operational skills, and aggressive commitment to getting the job done kept twenty amphibious ships and 22,000 sailors and embarked Marines at sea and combat ready. He supervised Combat Information Center's key role in coordinating efficient movement of 15,000 tons of material, 55 tons of mail, and 3000 passengers to Amphibious Task Force 156. As Assistant Operations Officer he assisted in the planning and execution of every facet of more than 200 underway replenishments and weekly resupply port visits. Senior Chief Calhoun's exceptional professional ability, initiative, and loyal dedication to duty reflected great credit upon himself and the United States Naval Service."

We are proud of his outstanding achievements. ▲

Selective Laser Spectroscopy of Activated Crystals and Glasses

The extensive applications of lasers in scientific research has given rise to rapid development in the scientific fields of photochemistry, photobiology, nonlinear optics, and laser spectroscopy of gases and solids. *Selective Laser Spectroscopy of Activated Crystals and Glasses* was published in 1991 and is Volume 9 of the Proceedings of the Institute of General Physics, Academy of Sciences of the U.S.S.R. This two-chapter book examines experimental methods that make it possible to obtain new information on the internal Stark structure and on the homogeneous broadening of inhomogene-ously-broadened bands. It also determines the elemental radiative and nonradiative transition probabilities and their dispersion from center to center in activated crystals and glasses. Included in the 220-page volume are analyses of important practical results from research on nonradiative energy transfer and interionic interaction resulting in spectral migration, delocalizations of excitations, and the quenching and sensitization of luminescence.

For rare earth laserologists, new capabilities of kinetic investigations of quenching interionic energy transfer and the migration of electron excitations in the coordinate and frequency spaces are demonstrated using Nd^{3+}, Yb^{3+}, Sm^{3+} and Eu^{3+} ions in laser glasses. For $62.00, *Selective Laser Spectroscopy of Activated Crystals and Glasses* can be obtained from Nova Science Publishers, Inc., 283 Commack Road, Suite 300, Commack, NY 11725-3401 Tel:(516) 499-3103/3106 Fax:(1)516-499-3146 Telex:510 101 2161. ▲

Homeless Monazite

ACI Industries, Ltd. currently has 124 metric tons of monazite sand that needs a new owner. The material is packaged in 50 kg bags and is available at no cost and may be delivered free. If you are interested and wish to receive an analysis of this material, please contact Alexis Manuelidis at ACI Industries, Ltd., The ACI Center, 5900 Cromdale Drive, Dublin, Ohio 43017 Tel:(614)764-8566 Fax:(614)764-7803 Telex:6972239. ▲

EUROPIUM, atomic number 63, was discovered in 1889 by Sir William Crookes, and as the name implies, it is named after the continent Europe. ▲

Video Short Course

A comprehensive magnetism short course entitled: *Introduction to Magnetism and Magnetic Materials* is now available to the public for the first time on video tape. The series of 19 one-hour lectures are given by Dr. Karl J. Strnat, the inventor of Sm-Co permanent magnets and an expert in the field of magnetism and magnetic materials. Dr. Strnat is also known for organizing the conference series "Workshops on Rare-Earth Permanent Magnets and Their Applications" and the complementary "Symposia on Anisotropy and Coercivity in Rare Earth-Transition Metal Alloys".

The video course offers a broad and systematic overview of the many topics relating to magnetism, magnetic materials and their engineering applications. The taped series is designed for an audience of persons from industry having widely varied educational backgrounds in terms of their technical or scientific specialization, educational and experience level, and a broad range of interests and needs. The course begins by analyzing the multidisciplinary nature of magnetics and reviewing the development of our knowledge of magnetism. It then covers enough of electro-magnetism, the systems of units, field-theory, physical metallurgy, crystallography and the physics of magnetic materials to lay the groundwork for an understanding of engineering materials and of many magnetic phenomena for all viewers. It progresses from qualitative discussions of atomic, ferro- and ferri-magnetism to magnetic anisotropy, magnetic domains and walls, then to microscopic magnetization reversal processes and their relationship to hysteresis-loop shape and the structure-sensitive properties, permeability and coercivity. Methods and instruments for magnetic property measurements are surveyed. The main types of technological useful magnetic materials are discussed, critical steps in their production are singled out, and their relation to the basic phenomena is explained. The course also develops a good basic understanding of the concepts of self-demagnetizing fields and of the magnetic-electric circuit analogy, both of which are prerequisites for the intelligent use of modern computer-aided device design tools.

The video tapes are in color and are available in VHS format for sale as a set of 19 one-hour cassettes. Supplementary course material includes a booklet containing a detailed outline and table of contents, copies of all the figures and tables shown in the videos, plus reproductions of essential black-board and flipchart sketches made during the lectures and discussions. A sample tape can be ordered for previewing.

The cost to receive the 19-tape set with supplemental material is $1900.00 US or $150.00 US for the single sample tape. For information contact: KJS Associates, 1712 Springfield Street, Dayton, OH 45403-1432 USA Tel:(513)254-9707 Fax:(513)254-3575. ▲

Magnetic Rare Earth Superlattices

Advances in molecular beam epitaxy deposition techniques have recently made it possible to grow, an atomic plane at a time, single crystalline superlattices composed of alternating layers of magnetic rare earths alloyed with metallic Y. C.F. Majkrzak et al. [*Advances in Physics* 40, No.2, 99-189 (1991)] describe the effects of artificial periodicity or compositional modulation, finite layer thickness, and epitaxial strain on the resulting long range magnetic order of Gd-Y, Dy-Y, Ho-Y, Er-Y, and Gd-Dy superlattices. The authors review the new and interesting magnetic structures which have been discovered in these novel superlattice systems and consider what implications the observed phases have on our understanding of the underlying microscopic magnetic interactions.

The paper contains segments on: molecular beam epitaxial growth of rare earth superlattices; diffraction studies of synthetic superlattices; theory of long-range exchange coupling in magnetic rare earth superlattices; and the magnetic behavior, chemical structure, magnetic x-ray diffraction measurements, neutron diffraction results, and superlattice magnetism of Gd-Y, Dy-Y, Ho-Y, Er-Y and Gd-Dy superlattices.

This review shows that although studies involving rare earth superlattice systems are relatively new and incomplete, and more comprehensive and systematic investigations need to be performed, much has already been learned. It is possible to create coherent, rare earth single crystal superlattices composed of alternating magnetic and nonmagnetic layers in which long-range magnetic order occurs across the nonmagnetic layers. In addition, the resultant magnetic order of the superlattice can be altered by varying the thickness of the nonmagnetic layer. The authors show that oscillation between ferromagnetic and antiphase domain structures as a function of Y layer thickness can be understood in terms of simple scalar RKKY interaction. ▲

Supermagnets, Hard Magnetic Materials

The discovery of the Nd-Fe-B hard magnetic materials has led to a recent resurgence in research in the field of rare earth-transition metal intermetallic materials. *Supermagnets, Hard Magnetic Materials* provides both an in-depth introduction to the fundamentals of hard magnetic materials and a broad survey of the physical and electronic properties of new magnetic materials. It also presents research into the design and analysis of new machines which use the new supermagnets. The 30 chapters in this volume address crystal-field effects, magnetic exchange interactions, electronic interactions, phase diagrams, spin-reorientations, domain-wall motions, and magnetic anisotropy in rare earth intermetallic compounds. Other chapters discuss the use of microscopic techniques, such as nuclear magnetic resonance, neutron scattering, and Mössbauer spectroscopy, as well as magnetic measurements, in the characterization of intermetallic compounds and magnetic materials.

Supermagnets, Hard Magnetic Materials is Volume 331 of Series C of the Mathematical and Physical Sciences NATO Advanced Science Institutes Series. The 1991 book is edited by G.J. Long and F. Grandjean, contains 864 pages, costs $220.00 and can be ordered in the U.S.A and Canada from Kluwer Academic Publishers, 101 Philip Drive, Norwell, MA 02061 and elsewhere from Kluwer Academic Publishers Group, P.O. Box 322, 3300 AH Dordrecht, The Netherlands for 340 Dfl. ▲

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New Fluoride Glass Plant

Galileo Electro-Optics Corp., Sturbridge, MA, has completed a state-of-the-art facility for manufacturing heavy metal fluoride glass (HMFG) optical fibers. The plant produces infrared transparent fibers under license from British Telecom Research Laboratories, which have applications in low-loss HMFG wave-guide technology.

The most stable fluorozirconate glass in use today is ZBLAN. With the composition $55ZrF_4$-$18BaF_2$-$6LaF_3$-$4AlF_3$-$17NaF$, the rare earth fluoride is not one of the major components but is important as a glass stabilizer and contributes to the formation of the glass framework.

The fluoride fibers exhibit attenuations of 20 dB/km or less near 2.5 μm, with less than 100 dB/km attenuation from 0.5 mm to 3.6 μm. Applications include remote spectroscopy, remote sensing, and lasing. ▲

ICI-Ferro

Ferro Corp., Cleveland, and ICI, Millbank, England, announce an agreement to form a joint venture to manufacture and market powder coatings worldwide. The venture should bring in sales of $200 million and would have manufacturing sites in 10 countries. The headquarters will be in Cleveland, Ohio.

The joint venture is consistent with Ferro's strategy to focus on core businesses. Albert C. Bersticker, Ferro's president and CEO commented "Powder coatings represent a growing market worldwide" and "We believe this joint venture can provide an exciting opportunity that will be mutually beneficial to Ferro, ICI and our customers around the globe".

ICI sees the venture in terms of its strategy to reshape and refocus its business structure during the 1990's toward future growth and prosperity, according to Sir Denys Henderson, ICI's chairman. ▲

Denison Mines Restructures

Denison Mines Ltd. has agreed in principle to restructure its debt with the Toronto-Dominion Bank and Bank of America, Canada. Denison will receive $130 million in credit, of which $110 million has been utilized. The agreement includes principal repayment of $44 million by Dec. 31, another $11 million by June 30, 1992, with the balance due January 2, 1993. In addition, Denison will be restricted on the use of funds, and cannot pay cash dividends on, purchase, redeem, or retire any of the company's shares. ▲

Processing High T_c Superconductors

Various processing and fabrication methods used in the preparation of bulk high-T_c superconductors are critically reviewed by S. Jin and J. E. Graebner in *Mater. Sci. Eng.* **B7**, 243-60 (1991). In a short introduction, the reviewers point out that the use of bulk high temperature superconductors have been hindered by relatively low capacity for carrying electrical current due to several serious problems, such as grain boundary weak links and flux line movement, which are related to processing techniques. Fabrication of the superconductors into configurations for specific applications is next considered. These include thin films, thick films, bulk semiconductors, wires and ribbons. The third section reviews processing techniques for the improvement of properties. There are two major causes for low T_c behaviors at 77 K in bulk polycrystalline HTSC: weak links at grain boundaries and flux line movements within grains. Several approaches to minimization of large-angle grain boundaries and techniques for flux pinning enhancement, are discussed. Progress has been made in all aspects of processing techniques for wire fabrication, weak-link removal and flux-pinning enhancement but further innovations are needed to accelerate progress toward major bulk applications. The review includes 99 references and 27 figures. ▲

BH Tunable PbEuSeTe/PbTe

Feit et al. have reported improvements in buried-heterostructure (BH) technology that enabled the achievement of 203K continuous wave (CW) operation of PbEuSeTe/PbTe diode lasers [*Appl. Phys. Lett.* **58**, 343-45 (1991)]. The quality of their device was demonstrated by the ability to perform high-resolution spectroscopy on CO_2 gas molecules while the laser was operating in the CW mode at 200K. The BH tunable PbEuSeTe/PbTe lasers were fabricated using a two stage molecular beam epitaxy growth procedure. Improvements in the processing technique produced lasers with performance characteristics significantly better than any previously reported. This laser exhibited exceptionally low threshold currents over previously published data. This is attributed to the elimination of growth discontinuities in the vicinity of the active layer that had been encountered in previous devices. ▲

Roskill Survey

The low-volume but high-value processed rare earth market is set to maintain strong growth, possibly in excess of 10 percent per year throughout the 1990's, says a new independent study from the information market analyst Roskill. *The Economics of Rare Earths and Yttrium 1991 Eighth Edition* describes in detail how demand is growing rapidly for high-value, high-purity oxides and metals. Major rare earth processors are upgrading existing capacity, and new plants are being built to meet increasing demand.

Roskill predicts that increased utilization of separated products will help to offset the recent declines in the high-volume rare earth concentrate markets such as metallurgy and petroleum cracking catalysts. The decline in these sectors is believed to have leveled out after falling in the late 1980's.

The report concludes that if processors of rare earths can maintain a reasonable balance between supply and demand for all the rare earth elements, the outlook for the rest of the industry is bright. High-tech end-uses such as permanent magnets, magneto-optical discs, optical fiber lasers and rechargeable nickel-hydride batteries are expected to be at the forefront of future demand.

The Economics of Rare Earths and Yttrium 1991 Eighth Edition contains 484 pages, 158 tables and 14 figures. The report gives a comprehensive account of the rare earths but does not include scandium. Included is a review of the industry in 50 countries, with additional information on the operations of 51 leading companies. The report will be of special interest to traders and suppliers of rare earths as imports and exports of these materials are listed by country. An appendix gives these vital international trade statistics by compiling the latest production quantities and prices of rare earth ores, concentrates, metals and compounds.

This report carries on the tradition of previous editions of Roskill rare earth surveys by providing an extensive review on the applications of rare earths and rare earth compounds listed by various category. For example, the stages involved in the manufacture of catalysts and the function of rare earths in automobile catalytic converters gives the reader a basic understanding of the production of these materials. Environmental factors are cited as the main reason the European market for automotive catalysts is the fastest growing and will likely equal the US market by the mid 1990's.

Continued in next column ➪

The price of the report is $1320.00 US (£600) and can be ordered from Roskill Information Services Ltd., 2 Clapham Road, London SW9 0JA Tel:071-582-5155 Fax:071-793-0008. Address your inquiries to Mr. Tom Kendall. ▲

Supporters

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Since the September issue of the RIC News went to press, RIC has received support from two new family members, and renewed support from 26 other organizations. The supporters from the second quarter who wish to be listed, grouped according to their appropriate catagory, and with the number of years that they have contributed to the Center in parentheses, are listed below.

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PRASEODYMIUM, atomic number 59, was discovered in 1885 by C.A. von Welsbach to be one of the two major components of didymium. The name is derived from the Greek words *prasios* and *didymos*, meaning 'green twin'. ▲

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