Rare-earth Information Center NEWS

Center for Rare Earths and Magnetics
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Institute for Physical Research and Technology
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RIC Support

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For more information, or to request a preliminary computer search, contact: Rare-earth Information Center, 112 Wilhelm Hall, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515 294 5405; Fax: 515 294 3709; ric@ameslab.gov. ▲

Er-Doped Si LED

During the last ten years, Er doping has been recognized as a promising approach to the fabrication of an efficient light source in silicon. Er ions exhibit an internal 4*f* shell transition at 1.54 µm, a standard telecommunication wavelength, that can be excited electrically when the rare earth ions are incorporated into silicon. However, two problems have so far hampered the optoelectronic applications of Er-doped Si light emitting diodes (LEDs): 1) the efficiency of the light emission at room temperature appears to be impracticable because of a reduced pumping efficiency at high temperatures and of the onset of fast non-radiative processes, and; 2) since the radiative lifetime of the excited Er ions is close to 1 ms, the elimination of non-radiative routes, which are necessary for high efficiency, would impede a direct modulation of the diode frequencies above 1 kHz, thus requiring external modulation of the light signal.

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Recently, a research team at CNR-IMETEM, a laboratory of the National Research Council in Catania, Italy, {*Appl. Phys. Lett.*, **69** [14], 2077-9 (1996)} designed and fabricated Er-doped LEDs which can operate at 1.54 µm with high room temperature efficiency (>1 x 10^{-4}) while allowing direct modulation of the light signal at MHz frequencies.

The new diode structure was prepared by performing multiple Er and O implants at a uniform concentration of 10^{19} Er/cm^3 and 10^{20} O/cm^3 in the depletion layer of a p^+-n Si diode. Operation of the diode under reverse bias at the breakdown, which occurs via Zener at 5V, results in an intense 1.54 µm light emission. The researchers also report that within the depletion layer, Er ions are efficiently pumped by hot carriers impact excitation (with a cross section of 1x10^{-16} cm^2) and decay with a long lifetime (100 µs) since non-radiative processes are severely inhibited within this layer. When the diode is turned off, the electroluminescent signal dies off in a time as short as 100 ns, which allows fast modulation of the light signal. This fast turn-off is a result of very efficient, Auger-type, non-radiative decay of the excited Er ions which only occurs when the depletion layer shrinks, causing the Er ions to be embedded in the heavily doped (~10^{19}/cm^3) neutral regions of the diode.

These results open new perspectives to the use of Er-doped Si LEDs as efficient and fast switching light sources in integrated Si-based optoelectronics. Furthermore, detailed investigations of the excitation mechanisms clearly indicates that by proper design of the device structure, efficiency up to 1% and modulation up to 100 MHz can be achieved.

For more information, contact Dr. Salvo Coffa, CNR-IMETEM, Stradale Primosole 50, I95121 Catania, Italy; Tel: 39 95 591 212; Fax: 39 95 713 9154; coffa@ct.infn.it. ▲

Practical CMR?

N.D. Mathur, Cambridge University, UK

Until recently, the applications potential of cubic perovskites which display colossal magnetoresistance (CMR) was thought to be limited by the magnetic fields of several tesla to effect a significant magnetoresistance (MR) - in a typical material such as $La_{0.7}Ca_{0.3}MnO_3$ (LCMO). Moreover, from a scientific point of view, the complex and intriguing link between the magnetic, electrical and structural properties remains unsolved.

Both of these issues have recently been addressed by the Materials Science Department of Cambridge University, UK, as reported by N.D. Mathur et al. in *Nature* **387** 266-68 (1997). Efforts to isolate the behavior of a single (artificial) grain boundary in a CMR thin film led to a device which not only gives a clue as to the role of structural disorder in the CMR effect, but, in addition displays a large low-field MR.

A 200 nm epitaxial film of LCMO was grown by pulsed laser deposition on a bicrystal substrate consisting of a $SrTiO_3$ (001) bicrystal with a misalignment of 24°. This film was then patterned into a Wheatstone bridge device which had two arms crossing the artificial grain boundary created in the film, and the other two arms sampling the bare film. When a constant current was passed through the bridge, the device output represented the contribution of a single grain boundary of well-defined orientation to the electrical resistivity of LCMO film. To improve the signal/noise ratio of the device, each arm of the bridge comprised a meander track with 19 turns.

The MR response of the device was found to be extremely smooth and sharply peaked in low magnetic fields (e.g. 30% in 20 mT at 77 K), below the curie temperature of the material. It is envisaged that this large low-field MR, which arises due to the presence of structural disorder in CMR materials, will shed light on the fundamental mechanism which governs the CMR

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phenomenon. Moreover, the discovery suggests a brighter future for CMR materials - they could constitute the active elements of sensors of small magnetic fields. Possible applications include disc-drive heads and position sensors.

For more information on this article, contact Dr. N.D. Mathur, Department of Materials Science, New Museums Site, Pembroke Street, Cambridge CB2 3QZ, UK; Tel: 44 1223 334 375; Fax: 44 1223 334 373; ndm12@cus.cam.ac.uk. ▲

Conference Calendar

*** A NEWS STORY THIS ISSUE**

Note: Reach as many potential conference attendees as possible! Send us your conference announcement and we will publish it here. ▲

September '97

Fourth International School on Excited States of Transition Elements (4th ESTE'97)
Wroclaw-Duszniki Zdroj, Poland
September 6-12, 1997
RIC News **XXXII**, [3] 2 (1997)

Third International Conference on f Elements (ICFE3)
Paris, France
September 14-19, 1997
RIC News **XXXI**, [2] 3 (1996)

October '97

Commercializing Fuel Cell Vehicles 97
Frankfurt, Germany
October 22, 1997
RIC News **XXXII**, [1] 2 (1997)

March '98

International Forum on Rare Earths: Technology and Trade
Beijing, China
March 24-26, 1998
RIC News **XXXII**, [3] 4 (1997)

August '98

15th International Workshop on Rare-Earth Permanent Magnets and Their Applications
Dresden, Germany
August 30-September 3, 1998
RIC News **XXXII**, [1] 5 (1997)

September '98

Tenth International Symposium on Magnetic Anisotropy and Coercivity in Rare-Earth Transition Metal Alloys
Dresden, Germany
September 4, 1998
RIC News **XXXII**, [1] 5 (1997)

7th European Magnetic Materials & Applications Conference (EMMA'98)
Zaragoza, Spain
September 9-12, 1998
RIC News **XXXII**, [1] 5 (1997)

October '98

Rare Earths '98
Freemantle, Western Australia, Australia
October 25-30, 1998
RIC News **XXXII**, [2] 5 (1997)

Ga substitution - Cool!

A new class of materials that may lead to improved magnetic refrigeration devices was discovered when the magnetic ordering temperature of Gd_5Si_4 was lowered by adding gallium. Gallium was substituted for silicon in the gadolinium silicide, Gd_5Si_4, in an effort to find a suitable magnetocaloric compound to be used in magnetic refrigerators. The substitution resulted in the formation of the new compound $Gd_5Si_2Ge_2$.

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Arnold Catalog

The Arnold Engineering Company offers a new 95-page *Magnetic Powder Cores* catalog that includes MPP, HI-FLUX™ and SUPER-MSS™ powder cores. The comprehensive catalog features design information, formulas and definitions for design calculations, and comparative magnetic curves of ARNOLD™ magnetic powder core products. The information can be used for performance evaluation and comparisons with other manufacturer's products. Electrical and physical specifications with part numbers along and ordering information are also included. The catalog provides a listing of the company's headquarters, development centers, outlets, laboratories and rare earth permanent magnet manufacturers.

For a copy of the catalog, contact Mark Bokerman, The Arnold Engineering Company, 300 N. West St., Marengo, IL 60152 USA; Tel: (in the USA): 800 545 4578; (elsewhere): 815 568 2000; Fax: 815 568 2228; http://www.arnoldengr.com. ▲

New Area Code

The New Jersey region has introduced a new area code which affects the Fairfield office of Molycorp. The office can now be reached at: Molycorp, Inc., A Unocal Company, Executive 46 Office Center, 710 Route 46 east, Fairfield, NJ 07004 USA; Tel: 973 808 8880; Fax: 973 808 9060. ▲

The new gadolinium-silicon-germanium alloy exhibits a magnetocaloric effect about twice that of gadolinium, which was the best known refrigeration material for near-room temperature applications. The new material has two advantages over existing magnetic coolants in that it 1) exhibits a "giant" magnetocaloric effect (that is, the ability of a material to heat up and subsequently cool down when placed in and out of a magnetic field) and 2) its operating temperature can be "tuned" from about 30 K to 290 K by adjusting the ratio of silicon to germanium in the alloy composition. The operating temperature can be lowered by increasing the ratio of germanium to silicon in the Gd-Si-Ge alloy. ☛

New NEOLOR™ Colors

Rhône-Poulenc has extended the range of colors for its line of rare earth-inorganic pigments that it offers under the trade name NEOLOR™. The pigments are free of heavy metals and are used in coloring plastics and industrial coatings in the automotive industry, snow and recreational vehicles, tools and garden equipment. The new colors are light burgundy and burgundy, which were added to the existing line of colors; light orange, orange, and red.

NEOLOR™ pigments have been shown to exhibit heat stability up to 350°C, resistance to fading and migration, excellent opacity, and ease of dispersion in the coloring medium. They are particularly suited for use in technical plastics such as ABS, polyamide 6 and 6/6, polycarbonates, and for powder, coil, and automotive coatings.

For more information, contact: Rhône-Poulenc, 25. Quai Paul Doumer 92408 Courbevoie Cedex, France; Tel: 33 1 47 68 05 88; Fax: 33 1 47 68 22 99. In the U.S.A. contact Harry Sarvis, the Technical expert at Ferro, the North American distributor; Tel: 216 641 8580. ▲

U.S.G.S. Publications

In 1995, the U.S. Geological Survey temporarily suspended production of its *New Publications of the U.S. Geological Survey*, which had been released on a monthly basis. Now, the *New Publications* will be sent, free of charge as before, but quarterly. This publication is somewhat useful in keeping informed of various geologic occurrences of rare earth minerals and rare earth mineral deposits.

To receive future editions of *New Publications of the U.S. Geological Survey*, contact: USGS Information Services, Box 25286, Denver Federal Center, Denver, CO 80225 USA; http://pubs.usgs.gov/publications/index.html. ▲

For more information, contact Steve Karsjen, Office of Public Affairs and Information, 111 TASF, Ames Laboratory, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515 294 1856; Fax: 515 294 3226; karsjen@ameslab.gov. ▲

Polishing Powder

Baotou Tianjiao Seimi Polishing Powder Co., Ltd., a joint venture between Baotou Iron & Steel Co., Ltd., and three Japanese companies (Seimi Chemical Co., Ltd., a subsidiary of Asahi Glass Co., Okura & Co., Ltd., and Chugai Steel & Rare Earth Co., Ltd.) became operational in August and has a production capacity of 1,200 mt of polishing powder per year.

For information about product specification, prices, and availability, contact Mr. Weiji Cui, Baotou Rare Earth & Steel Co. (USA), 520 El Camino Real, Suite 228, San Mateo, CA 94402 USA; Tel: 650 343 6644; Fax: 650 343 6266; baotoure@aol.com; http://www. baotou.com. ▲

Chinese Industrial Partners

In June of this year, a delegation of Chinese entrepreneurs led by Prof. Yu Zongsen, Vice Chairman and Secretary of the Chinese Society for Rare Earths, visited the RIC and a number of US companies. The delegation consisted of representatives for enterprises which produce rare earth oxides, chlorides and metals. The purpose of the visit was to gather information on rare earth consumption and emerging requirements in terms of both the materials required and the quality required. As a result of the visit the RIC has been contacted by delegation members and asked to help identify potential industrial partners. Particular interest has been expressed in automotive catalysts and lamp phosphors.

For more information contact R. W. McCallum, Director RIC; Tel: 515 294 4736; FAX: 515 294 3709. ▲

Baotou (USA) Website

Baotou Steel & Rare Earth Co. (USA) has set up a World Wide Web site. It can be accessed at http://WWW.BAOTOU.COM and is one of the better sites that we have seen. For more information, contact Mr. Weiji Cui, Baotou Steel & Rare Earth Co. (USA), 520 El Camino Real, Suite 228, San Mateo, CA 94402 USA; Tel: 415 343 6644; Fax: 415 343 6266; E-mail: BAOTOURE@AOL.COM. ▲

Ten Years of High T_c

A review which describes the background leading to the discovery, and important developments during the first few years of high T_c superconductors, "High-temperature superconductivity - ten years on"was written by P.J. Ford and G.A. Saunders {*Contemporary Physics*, **38**, [1] 63-81 (1997)}. The authors emphasize the two-dimensional layer-like structure of these materials. Their basic properties are described as well as the present theoretical understanding of the physical nature of their superconducting behavior.

The review presents an overview of these superconductors in five sections. Following a brief history of early theory and discovery of low-T_c superconductivity in the introduction, the authors describe the search for high-T_c superconductors, including the breakthrough by Bednorz and Müller in 1987. The intrigue and skepticism surrounding their claims were quenched when they received the Nobel Prize for Physics only one year after their discovery was announced to the scientific community.

The fabrication and structure of the rare earth-cuprate superconductors is included with a concise description of their composition, structure, and basic properties. The next section deals with the search for the physical origin of high-T_c superconductivity, including how the shapes of the electron pair wavefunctions of isotropic *s*-wave and anisotropic *d*-wave states may describe the electron pairs in high temperature Y-Ba-Cu-O superconducting materials.

The most comprehensive section in the review, and rightfully so, covers the most promising present and future applications of high-T_c superconductors. Some potential high-field applications of the high temperature superconductors include: magnetic resonance imaging (MRI) for medical diagnostics, particle accelerators for experimental physics, magnetically levitated transportation systems, ship propulsion motors and generators, electric power station generators, fusion and magnetohydrodynamic power systems, electric power energy storage systems, and electric power transformers. Although only the first two applications have made it to the prototype stage, the remainder (and no doubt others will follow) should provide the incentive to continue the research and development of these important materials.

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"High-temperature superconductivity - ten years on" is recommended reading for undergraduate students looking for direction in their studies, graduate students working in this field who want "the whole story" in a brief format, and scientists currently conducting research in this area. ▲

1997 R&D 100 Award

A partnership between Idaho National Engineering and Environmental Laboratory (INEEL), Idaho Falls, Idaho and Ames Laboratory, Ames, Iowa, resulted in a 1997 R&D 100 award. Each year, *R&D Magazine* reviews the latest scientific and technological developments, patents, and research results each year and chooses the 100 top discoveries for its award. Six scientists comprised the team which won the 1997 R&D 100 Award. The INEEL team consisted of D.J. Branagan, T. Hyde, and C. Sellers. The Ames laboratory team members were R.W. McCallum, Director, Rare-earth Information Center, M. Kramer, and K. Dennis.

The winning entry for the award was the procedure for producing Nanocrystalline Composite Coercive Magnet Powder. The development and application of this new alloying approach in rare earth-based permanent magnet systems is expected to facilitate industrial production of high-strength bonded magnets. The new alloy is suitable for gas atomization, which is a significant accomplishment since current commercial rare earth permanent magnet alloys do not retain their hard magnetic properties when atomized. Atomization processing of the new alloy not only maintained its hard magnetic properties, but was also easier to process than conventional gas atomized powders. The adaptation of the new gas atomized Nanocrystalline Composite Coercive Magnet Powder will make possible high volume, low cost production that will meet market demands of the future. The rare earth permanent magnet industry growth rate of 15% per year is expected to continue with this new development. ▲

Martian Oh-Two

In 1979, M.L. Stancati, et al., *AIAA* Paper 79-0906 (1979), identified a method by which oxygen could be produced from the carbon dioxide-rich atmosphere of Mars by utilizing solid oxide electrolyzers. The oxygen would supply life support and propulsion needs for both manned and unmanned missions to and from the planet. This approach has taken another step toward application of the process, which utilizes yttria-stabilzed zirconia, Y_2O_3:ZrO_2 (YSZ) to produce oxygen. The paper was written by K.R. Sridhar and B.T. Vaniman (Department of Aerospace and Mechanical Engineering, The University of Arizona, Tucson, AZ 85721 USA; Fax: 520 621 8191) and appears in *Solid State Ionics* **93**, 321-8 (1997). The performance characteristics of planar solid oxide electrochemical cells, which incorporate YSZ as essential materials in the device, is reported by the researchers.

The ceramic solid oxide electrolysis cell used in the study was made up of YSZ (8 mol % Y_2O_3) and doped ceria (CeO_2). The cell becomes an oxygen ion conductor at elevated temperatures. A thin, nonporous disk of YSZ was sandwiched between porous platinum electrodes and held in place with ceramic cement. The electrodes were also held in place by ceramic cements. The YSZ disk allowed CO_2 to pass and react chemically with the ceramic electrolyzer which was operating between 750°C and 1000°C. A potential of 2V is then applied to the electrodes, which begins the electrolysis process. An oxygen atom is liberated from the CO_2 molecule and picks up two electrons from the cathode to become an oxygen ion (O^{2-}). The ion is then transported through the electrolyte by means of oxygen ion vacancies in the crystal lattice of the electrolyte. At the anode-electrolyte interface, it transfers its charge to the anode, combines with another oxygen atom to form O_2, and then diffuses out of the anode. CO_2 gas is fed into the electrolyzer, and O_2 vented from the device, via alumina (Al_2O_3) tubes.

The researchers tested two cells for over 3000 cumulative hours and found no degradation of performance.

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Rare Earths in the CIS

Roskill unveils the mystery surrounding rare earth reserves and production capacity of the former Soviet Union (Commonwealth of Independent States) with their latest report *Rare Earths in the CIS*. The report was prepared for Roskill by INFOMINE of Moscow and includes all the information concerning rare earth mining, beneficiation, production, processing, and exporting that was available to anybody at the time of compilation. Information included in the report covers primarily the period from 1992-1994, the data is useful because it includes trends in production, exports, and other useful information previously not disseminated.

The report is broken down into eight sections: reserves of rare earths, mining and beneficiation of rare earth ores, production of rare earth products, potential rare earth operations, current status of rare earth producers, trade in rare earths, consumption of rare earths, and future prospects of rare earth production. Thirteen tables are included as are three appendices. Companies and organizations with interests in this area will no doubt find the listing of 129 domestic consumers of rare earths helpful, as well as the names, addresses, and telephone numbers of rare earth producers located in Russia, Ukraine, Estonia, and Kazakhstan. The most comprehensive appendix lists the composition of rare earths that are produced in the CIS.

The 55-page report was published in 1996 and is available from Roskill Information Services Ltd., 2 Clapham Road, London SW9 OJA, England; Tel: 44 71 582 5155; Fax: 44 71 793 0008. The List price of *Rare Earths in the CIS* is US$700.00 but readers of the *RIC News* can receive a 20% discount by referencing the date and number of the issue in which this review appears. ▲

An independent study by NASA Johnson Space Center indicated that an identical unit operated for over 3600 hours with similar results. Not only is the durability of the device an important attribute, but also the finding that oxygen ion flow was not due to electron transport. These results increase the possibility of more frequent missions to the red planet. ▲

La Boride Coatings

The potential for development in the field of decorative coatings on metals could be substantial provided that certain optical and mechanical property requirements are met. If a metal surface can be made to exhibit a pleasant color as well as provide adequate protection from a corrosive environment without using conventional coatings or paint, a new growth sector of rare earths could emerge. As it turns out, recent research on decorative ZrB_2-alloyed LaB_6 coatings by C. Mitterer (Institut für Metallkunde und Werkstoffprüfung, Montanuniversität, Franz-Josef Straße 18, A-8700 Leoben, Austria) et al., *J. Alloys and Compounds*, **239**, 189-192 (1996), hints at promise in this area.

The researchers deposited Lanthanum boride/zirconium boride coatings onto steel and molybdenum substrates by non-reactive magnetron sputtering using various targets. The goal of the experiment was to improve the mechanical properties of violet-colored LaB_6-based coatings since these films seem to suffer from high stresses and porosity as well as low adhesion, which limits their utility. The rare earth hexaborides form a crystal lattice in which the rare earth atoms and boron octahedra are arranged in the same manner as Cl^- and Cs^+ ions in the CsCl structure type. The boride structure is dominated by strong B-B bonds which allow for a wide range of compositions (LaB_6 to $LaB_{7.8}$) without significantly altering the lattice parameter. The variance in composition is accommodated by the formation of lanthanum vacancies within the compound.

After sputtering LaB_6-ZrB_2 coatings onto steel and molybdenum surfaces in an argon atmosphere, various material characteristics were determined, such as chemical composition, crystal phase, hardness, and coloration. Although hardness values and color were less than optimum, the authors demonstrated that deposition of lanthanum hexaboride coatings onto substrates can provide the material with a variance of color, depending on the stoichiometry of the boride deposited. The mechanism by which certain mechanical properties and color rendering (optical properties) are controlled remains somewhat elusive at this point. The deposition of LaB_6 coatings using different sputtering techniques, now underway, may yield favorable results. ▲

Japan-France Seminar Proceedings

The Proceedings to the Japan-France Seminar on Magnetic, Electric and Thermal Properties of Rare Earth Compounds, which was held March 13-15, in Toyama, Japan, 1996 are now available. The proceedings, published as Supplement B to *J. Phys. Soc. Jpn.*, **65**, (1996), were edited by Y. Isikawa, K. Maezawa, and J. Sakurai.

Magnetic, Electric and Thermal Properties of Rare Earth Compounds contains 27 papers submitted by researchers from Japan and France who collaborated the results of their work on strongly correlated electron systems. The proceedings is presents the seminar in eight sections: heavy fermion, cerium compounds, Kondo effect and magnetism, low carrier systems, cerium and cerium compounds, magnetic symmetry, heavy rare earth compounds, and superconductors. The most contributions to the seminar dealt with cerium compounds. Some of these included antiferromagnetism and ferromagnetism in $CeRu_2(Si_{1-x}Ge_x)_2$, vanishing of magnetic order in $Ce_{0.8}La_{0.2}Ru_2Si_2$ under pressure, transport and magnetic properties of a new heavy-fermion metamagnet $CeNi_2Ge_2$, and transport properties of $CeNi_2Sn_2$ and $CePd_2Sn_2$, thermopower behavior of Kondo antiferromagnet compounds, and others. The section on superconductors introduces the reader to some new Hg-cuprate superconducting compounds and reports on the normal and superconducting state properties of the rare earth intermetallic compounds $CeRu_2$, $CeCo_2$, and Yb_3Rh_4S.

The 235-page hard cover *Magnetic, Electric and Thermal Properties of Rare Earth Compounds* is available for ¥11,300 (US$98.00) by contacting the publishers: The Physical Society of Japan, Rm. 211, Kikai-Shinko Bldg., 3-5-8, Shiba Koen, Minato-ku, Tokyo 105 Japan; Tel: 03 3434 2671; Fax: 03 3432 0997. ▲

High T_c Series 19 & 20

Studies of High Temperature Superconductors Volumes **19** & **20** are devoted to thermal properties and tunneling studies of ceramic high temperature superconductors. Volume **19** "Thermal Properties and some Miscellaneous Aspects of High Temperature Superconductors" is made up of 6 chapters that contain not only thermodynamic data on rare earth superconductors, but various physical properties that experimental researchers should find useful. All contributions are from established experts in the discipline of high temperature superconductors.

Chapter One is not only the longest chapter in the book, but also presents what is probably the most exhaustive analysis to date on the specific heat measurements of high temperature superconductors (primarily $YBa_2Cu_3O_{7-\delta}$ and $Bi_2Sr_2CaCuO_{8-x}$) under high magnetic fields. The next chapter reviews the elastic behavior of RBa2Cu3O7 (where R=Y, Sm, Gd, Tb, Dy, and Tm) and Y-124 superconducting compounds. Chapter Three reports on the specific heat on pure and substituted phases of high-T_c cuprates. The characterization of high-T_c compounds by various thermal techniques such as thermogravimetry (TGA), differential thermal analysis (DTA) and differential scanning calorimetry (DSC) is reviewed in Chapter Four. The final two chapters deal with the anomalous metallic phase and high-T_c superconductivity of Cu oxides, and an investigation of effect and mechanisms of low-energy neutron irradiation on high-T_c superconductors.

Volume **20** "Tunneling Studies of High temperature Superconductors" reports on the advances made using scanning tunneling microscopy and spectroscopy in studying these compounds. The premier problems encountered in high-Tc superconducting compounds, ranging from the symmetry of order parameter to tunneling-based device engineering are covered in seven chapters.

Both books were published in 1996, were edited by Anant Narlikar, and are hard cover bound. Each volume contains a subject index. The cost to receive the 256-page Volume **19** is US$89.00, while the 234-page Volume **20** is available for US$97.00. Orders can be sent to Nova Science Publishers, Inc., 6080 Jericho Turnpike, Suite 207, Commack, NY 11725 USA; Tel: 516 499 3103; Fax: 516 499 3146. ▲

Permanent Magnet Review

A review which deals with the definition and development of hard magnetic materials, by H. R. Kirchmayr, Institute for Experimental Physics, Technical University Vienna, Wiedner Haupstrasse 8-10, A-1040 Vienna, Austria, appeared in *J. Phys. D: Appl. Phys.*, **29**, 2763-78 (1996).

"Permanent magnets and hard magnetic materials" briefly discusses the fundamental properties of all hard magnetic materials based on their intrinsic and extrinsic properties. The history of hard magnetic materials and permanent magnets is topically introduced with only a brief mention of the important hard ferrites. The emphasis of the paper concerns the rare earth intermetallic and rare earth hard magnetic materials. The experimental techniques that are utilized in the measurement of the basic magnetic properties, such as ordering temperature, magnetization, anisotropy field, hysteresis loop, are discussed.

The magnetic materials that are used in the production and experimentation of permanent magnets includes rare earth intermetallic compounds, $SmCo_5$, Sm_2Co_{17}, $Nd_2Fe_{14}B$ and related compounds. Modern permanent magnet materials including modern bonded rare earth cobalt magnets, sintered and melt-spun Nd-Fe-B, and hydrogen desorption disproportionation recombination (HDDR) magnet powder for bonded magnets is covered. The most important aspect of permanent magnets, however, is how they will be used in their final form, and the author discusses the applications of modern permanent magnets in static and dynamic devices, as well as low and high-power devices. A look into the future developments of magnets with large energy products including the research of modern rare earth intermetallics is introduced.

The author uses 22 figures in the paper to present various physical and

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magnetic properties of these materials, chronology of magnet development, phase diagrams of the Sm-Co and Nd-Fe-B systems, crystal structures, and the comparison of demagnetization curves of different permanent magnets. The flow diagrams of the major processing routes such as the *Magnequench* and *GM* procedures are included. The preparation of bonded magnets, applications of magnets based on the energy products, and annual world production figures of sintered and bonded Nd-Fe-B permanent magnets are nice touches that will serve beginners as well as seasoned professionals in this field. ▲

Magnetic Composite

A research team consisting of a group from Nagoya University and Nisshin Flour Milling Company, Ltd., Tokyo, Japan have developed a functional structural ceramic material which has magnetic particles grown in-situ {*Jpn, New Materials. Rept.* **XII**, [1] 2-3 (1997)}. The structural ceramic is Ce-stabilized cubic zirconia (Ce-TZP) and the magnetic particles are $La(Fe,Al)_{12}O_{19}$.

The composite is prepared from a mixture of $La(Fe,Al)O_3$, Fe_2O_3 and Al_2O_3 particles. After sintering the lanthanum compound at 1400°C, Al_2O_3 is added and the mixture is shaped and sintered again. The final step involves adding Ce-TZP and sintering again to obtain the completed composite. The $La(Fe,Al)_{12}O_{19}$ particles in the composite have hexagonal symmetry.

Fracture and hardness tests indicated that the material is strong and tough. However, magnetic measurements show a saturation magnetization of 2.1 emu/g and a coercive force of 11 kOe. The team suggests that an application for the material could be as an "intelligent" magnetic shield which would be able to detect and located cracks within it's own structure by changes in the magnetic field of the ceramic.

For more information, contact Nisshin Flour Milling Company Ltd., (Nisshin Seifun), 19-12 Nihonbashi Koami-cho, Chuo-ku, Tokyo, Japan; Tel: 81 3 3660 3111; Fax: 81 3 3660 3870. ▲

Rare Earths III

The third TMS symposium was held during the TMS Annual Meeting in Orlando, Florida, USA February 9-13, 1997. The proceedings of this meeting are published in *Rare Earths: Science, Technology and Applications III.* We have come to look forward to receiving the published proceedings from this meeting as they contain helpful information to anyone involved with rare earths. The topics that were presented at the meeting deal with current and potential uses of rare earths worldwide. Topics of the meeting included separation and processing, battery and materials chemistry, magnets, melts and metals reduction, and applications and markets.

The first section, "Separation and Processing" contains five papers that discuss topics from basic separation of rare earth minerals such as monazite, the secondary separation of rare earths, to the preparation of $DyCl_3$ and α phase $Nd_2Fe_{14}B$ nanocomposites via mechanical milling. "Battery and Materials Chemistry" covers this important field with three papers that describe rare earth and mischmetal hydrides, and two papers that present results of rare earth laser fluorites and the characterization of surface films. Four papers make up the section on "Magnets" and review the giant magnetostrictive materials, Nd-Fe-B powders for bonded magnets, and corrosion and factors that affect coercivity in rare earth permanent magnets. "Melts and Metals Reduction" deals with the electrolysis of neodymium oxide as well as the magnetic properties of NdFeB melt spun ribbons and filaments. The final section, entitled "Markets and Applications" should interest those involved with providing materials and developing new markets for rare earths.

The book reports that since the late 1970's, the mixed rare earth element applications market has been growing at a rate of 10 to 15% per year, whereas the markets for separated rare earths have not yet experienced that growth, but are poised for market expansion in the 21st century. The predominant applications for mixed rare earths are:metallurgical additives

Continued in next column ☛

☛ *Continued from previous column*

for ferrous and nonferrous metals, fluid cracking catalysts, lighter flints, glass industry as polishing compounds and as additives, and carbon arc cores for lighting. New markets that can expect growth are: colored pigments such as those used in plastics and paints, new catalytic materials, refrigeration, and solid oxide fuel cells.

The 275-page *Rare Earths: Science, Technology & Applications III* was published in 1997 and is indexed by subject and author. The book can be ordered by contacting The Minerals, Metals & Materials Society, 420 Commonwealth Drive, Warrendale, PA 15086 USA; Tel: 412 776 9000 and 800 759 4867. List price is US$60.00, US$45.00 for TMS members, and US$33.00 for students. Shipping for single copies is US$5.00 for domestic orders and US$15.00 overseas, multiple copies can be sent at a reduced per copy rate. ▲

Ion Exchange 50th

Fifty years ago, In 1947, F.H. Spedding and coworkers at Ames Laboratory demonstrated in a series of three landmark papers {*J. Am. Chem. Soc.*, **69**, 2777-81, 2786-92, 2812-18 (1947)} that ion exchange is a practical method for the separation and purification of large quantities of rare earths. The papers describe the procedure used to separate cerium, yttrium, neodymium and praseodymium. In addition, the papers also describe pilot plant scale operations and are models even today. Prior to their work, ion exchange was considered useful for separating and purifying rare earths only in small quantities. Among their other contributions, Spedding et al. also published "Improved ion exchange method for separating rare earths in macro quantities" in 1948, and "Large-scale separation of rare earth salts and the preparation of the pure metals" in 1949. ▲

RIC Database

The total number of documents referenced in our system is now over 88,000. The documents are stored as citations in the RIC data base and represent books, journal articles, government, company, and laboratory reports, patents and theses which contain information on rare earth metals, their alloys and compounds. A typical citation from a search contains the author(s) name(s), title of paper or contribution, reference line, and keywords that we have assigned to the citation after we have reviewed the document (see below).

MAJOR-SOSIAS;MA
Rare earths: an industry review and market outlook
Elements, Vol. 6, [2], 10-19 (1997)

1997	RARE-EARTH	INDUSTRY	MINERAL
RESERVES	PRODUCTION	CONSUMPTION	MINING
APPLICATION	IMPORT-EXPORT	CATALYST	PERMANENT-MAG
CHINA	UNITED-STATES	JAPAN	PRICES
MARKETS	ABUNDANCE		

The minimum cost to receive the results of a computer search is US$50.00 (for 25 citations and US$2.00 for each citation over 25 per search). However, many organizations become supporters which allows them to not only receive as many searches as needed for one year, but as an added benefit, they receive the monthly two-page newsletter *RIC Insight*. *RIC Insight* provides a provocative view into recent developments of rare earth science and technology and how these may impact the rare earth industry. The cost to become a supporter is US$100.00 for an individual, or US$300.00 for a corporate membership.

Send requests to: Rare-earth Information Center, 112 Wilhelm Hall, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515 294 5405; Fax: 515 294 3709; ric@ameslab.gov. ▲

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Since the March issue of the RIC News went to press, RIC has received support from 5 new family members and renewed support from 38 other organizations and individuals. The supporters from the fourth quarter of the 1997 fiscal year who wish to be listed, grouped according to their appropriate category, and with the number of years that they have contributed to the Center in parenthesis, are listed below.

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RE "Ignition" Lasers

Scientists at Lawrence Livermore Laboratory, Livermore, California, and the Naval Research Laboratory, Washington DC, are preparing to build lasers that are capable of delivering high power to a hydrogen "target" by using lightning-fast pulses {*Science*, **275**, 1569 (1997)}. The new high power lasers are required to start the fusion reaction in an inertial-confinement fusion power plant.

The advantage of hot-fusion reactors is that they would produce more energy than they consume, provided that a battery of powerful lasers can compress a hydrogen "pellet" sufficiently so that it can self-sustain a thermonuclear burn. However, current Neodymium-glass lasers heat up much too quickly and cannot dissipate the massive amount of heat generated during the repetitive lasing cycle necessary for thermonuclear ignition.

The new lasers to be used in the fusion reaction will be a new generation of Ytterbium-doped strontium fluorapatite, which can not only dissipate heat faster than Nd glass, but can store four times as much energy. The new laser will also be pumped with laser diodes, which produce light in a narrower band of frequencies that more closely match that of the beam they would feed, which will increase laser efficiency. The new rare earth laser should be operational by 1999, and hopefully, will pioneer in a new age of power generation early in the next century. ▲

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