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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KOREA 1992

In early December, 1992 the editor was fortunate to be one of eight American scientists to take part in a Korea-U.S. Joint Symposium on Advanced Materials, which was held on the campus of Seoul National University. The main purpose of this Symposium was to provide an impetus to scientific collaboration between the two countries. After two days of formal presentations by both U.S. and South Korean scientists, the U.S. scientists traveled to several institutes throughout Korea to visit the Korean laboratories and to enter into detailed one on one discussions on topics of mutual interests. The symposium focussed on processing and characterization of metal matrix composite materials, thin films, intermetallic compounds and high temperature materials, optoelectronic materials and other high performance materials.

Seoul National University

I spent considerable time visiting with Prof. Yeun Shik Kim of the Department of Metallurgical Engineering, Seoul National University. Prof. Kim is probably the lead scientist working on rare earth materials in South Korea and he is pushing hard to expand research and development of rare earth materials in Korea. He has many effective and influential relationships with directors and leading scientists at other research institutes, universities and industry. He also was president of the Korean Institute of Metals and Materials in 1991. Three interesting projects he and his students are working on are: (1) a process for preparing Nd-Fe master alloys by a calcium metallothermic reduction process in a $CaCl_2$ flux, (2) the preparation of fine Y_2O_3 particles using urea at 90°C to obtain amorphous spheres 0.5 to 3 µm in diameter, and (3) a combustion process for making aluminum yttrium garnet (YAG) by mixing urea and the hydrate nitrates of yttrium and aluminum.

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Korea Institute of Geology, Mining and Materials

The Korea Institute of Geology, Mining and Materials (KIGAM) is located in Taejon which is south and slightly east of Seoul. KIGAM's history goes back more than 70 years through several predecessor organizations, the most recent being the Korea Institute of Energy and Resources. KIGAM is divided up into two Centers — Geology and Resources Research Center and the Minerals, Materials and Analysis Center — and the Geological Museum. My visit was spent with Dr. Hyo Shin Yu, director of the Minerals, Materials and Analysis Center, and his staff in the Materials Research Division, headed by Dr. Gunchoo Shim, and two group leaders Drs. Kang-in Rhee and Joon Soo Kim. The Division is working on refining and purification of materials (including refractory and rare metals), manufacturing and process technology of new materials, and recovery of valuable materials from wastes. In particular they are concerned with the purification of Mo and Nb by an electron beam floating zone method, and the solid state electrolysis (electrotransport purification) of Nd; the separation and refining rare earth metals using solvent extraction techniques; and developing simulation software for the separation and refining processes for rare earths.

Research Institute of Industrial Science and Technology

The Research Institute of Industrial Science and Technology (RIST) is located in Pohang in the southern part of Korea on the Sea of Japan. RIST was established in 1987 by Pohang Iron and Steel Co., Ltd. (POSCO) to carry out applied (and some basic) research to further industrial development and promote technological advancements. Most of the financial support comes from POSCO, but scientists also carry out con-

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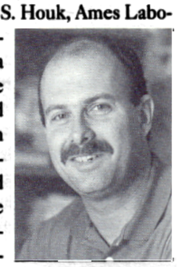
Maurice F. Hasler Award

The Maurice F. Hasler Award will be presented to Chemistry Professor and Senior Chemist Robert S. Houk, Ames Laboratory, U.S. Department of Energy, Iowa State University. He will receive the award at the 1993 Pittsburgh Conference on Analytical and Applied Spectroscopy to be held in Atlanta, Georgia, U.S.A. The biennial Hasler Award is named after one of the founders of Applied Research Laboratories "to recognize and encourage notable achievement in spectroscopy which has resulted in significant applications of broad utility."



Prof. R. S. Houk

Professor Houk earned this award for his work in inductively-coupled plasma mass spectrometry (ICP-MS), an area in which he has led the way since the method was first used. ICP-MS has become an extremely valuable method for the determination of the rare earths and is widely used for this purpose in geochemistry and materials science.

Professor Houk is an Assiociate Editor of *Journal of the American Society for Mass Spectrometry* and serves on the Editorial Advisory Board of *Spectrochimica Acta, Part B*. His research involves the fundamental study and applications of plasma ion sources for mass spectrometry, with particular emphasis in inductively coupled plasmas (ICP's), and time-of-flight and ion mass spectrometry.

He has published approximately 80 papers in these areas, including "Elemental Analysis by Atomic Emission and Mass Spectrometry With Inductively Coupled Plasmas" which appeared as Chapter 91 of Vol. 13 of ***Handbook of thePhysics and Chemistry of Rare Earths.*** ▲

Korea/*Continued from page 1* ➪

tract research for other industrial organizations. RIST employs nearly 1000 persons, of which over 55% are researchers which are supported by technicians (~33%). RIST is divided into five Divisions — Administration and Technical Services, Iron and Steel, Science and Engineering, Advanced Materials, and Management and Economics. Scientific discussions were held with Dr. You Song Kim, head of the Advanced Materials Division and Dr. Choong-Jin Yang, who heads the Electromagnetic Materials Group. Dr. Yang's group is concerned with magnetic recording media, permanent magnet materials, magnetic iron oxide single crystals, magnetic thin films and soft magnetic iron oxides. They are studying a variety of rare earth-iron intermetallic compounds, in an effort to find new permanent magnet materials. Dr. Yang also described his laser ablation method of preparing thin film ferrites (YIG) which are deposited on a variety of substrates, the most common one is sapphire (Al_2O_3).

Pohang Institute of Science and Technology

Pohang Institute of Science and Technology (POSTECH) was started in July 1985 and opened its doors to students in March 1987. It is supported financially by Pohang Iron and Steel Co., Ltd. (POSCO), and located next to RIST. POSTECH was formed as part of a cooperative triad with RIST and POSCO to transfer research results and foster the creation of new technologies. Most of the professors in the physical sciences and engineering departments also have offices in RIST, and some RIST staff members hold teaching appointments with POSTECH.

My visit with the condensed matter physics staff at POSTECH was hosted by Drs. H. Jeong Yoon, an experimentalist, and Associate Professor Il Min Byung, a theorist. We discussed magnetic phenomena, in particular anomalous *f* materials (Ce and U), spin fluctuators and magnetically ordered solids. Dr. Yoon explained his research on amorphous Fe-Cu alloys doped with H or D, to see if there is any observable effect of phonons on spin fluctuations.

There is a lot of good, solid, and interesting science going on in Korea — I was favorably impressed. The Korean scientists were extremely kind hosts — thanks. It was a great, but too brief, a trip. ▲

Conference Calendar

*** A NEWS STORY 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
RIC News, XXVI, [4] 2 (1991)
RIC News, XXVII, [2] 2 (1992)

The Second East/West European Magnetic Materials Conference
Budapest, Hungary
March 22-23, 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)
RIC News, XXVII, [2] 2 (1992)

Rare-Earth Doped Semiconductors
San Francisco, California, USA
April 12-16, 1993
RIC News, XXVII, [3] 2 (1992)

July '93

MAG '93 International Conference and Exhibition Alexandria, Virginia, USA
July 29-30, 1993
*This Issue

August '93

International Conference on Luminescence and Optical Spectroscopy of Condensed Matter (ICL'93)
Storrs, Connecticut, USA
August 9-13, 1993
*This issue

International Conference on Strongly Correlated Electron Systems (SCES '93)
San Diego, California, USA
August 16-19, 1993
*This issue

European Magnetic Materials & Applications Conference (EMMA '93)
Kocise, Czecho-Slovakia
August 24-7, 1993
RIC News, XXVII, [3] 2 (1992)

September '93

20th Rare Earth Research Conference
Monterey, California, USA
September 12-17, 1993
RIC News, XXVII, [1] 2 (1992)
RIC News, XXVII, [3] 2 (1992)
*Also this issue

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

Magnetic Materials Conference

The Second East/West European Magnetic Materials Conference will be held March 22-23, 1993 at the Intercontinental Forum Hotel, Budapest, Hungary. This is an international conference for executives and engineers concerned with the applications of NdFeB and other rare earth magnets, magnetization in mass production, future permanent magnet use in motors and automobiles, rare earths from the Commonwealth of Independent States (CIS), review of the East European magnet industry, magnetization and test equipment, and import/export/trading.

For more information contact: Kathy Barnett, Intertech Conferences, 170 U.S. Route One, Portland, ME 04105 USA; Tel:(207)781-9800; Fax:(207)781-2150. ▲

20th Rare Earth Research Conference

The First Announcement for the 20th Rare Earth Research Conference names the Monterey Convention Center in Monterey, California, U.S.A. as the location of the conference which will be held September 12-17, 1993. The 20th RERC will focus on recent developments in the fundamental and applied chemistry of the *f*-elements. Included in the symposia are: industrial applications, new lanthanide materials, energy levels in non-transparent materials, lanthanide biochemistry and medical diagnostics, and comparative aspects of lanthanide and actinide behavior. The list of speakers who have so far agreed to participate in the spectroscopy session of the conference are: Dr. Roger M. McFarlane, IBM, "High reso-

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Conference/*Continued from page 1* ⇨

lution Laser Spectroscopy of Rare Earth Ions in Solids"; Prof. Jean-Claude G. Bünzli, "Novel Polarization Dependencies in Two-Photon Absorption"; and Dr. Nigel C. Cockroft, "Application of Energy Transfer Phenomena to Novel Laser and Phosphor Design".

There will be a session on actinides, which will also include some spectroscopy, and a session on energy levels in opaque materials, such as metals, high-T_c materials, etc., which should also be of interest.

To receive additional information and/or the second announcement, contact: Dr. Herbert B. Silber, 20th Rare Earth Research Conference, Chemistry Department, San Jose State University, San Jose, CA 95192 USA; Tel:(408)924-4954; Fax:(408)924-4945. ▲

MAG '93

MAG '93 is the third industrial conference on applications of magnetic bearings, magnetic drives, and dry gas seals sponsored by the Center for Magnetic Bearings. The conference will be held July 29-30, 1993, in Alexandria, Virginia, USA.

Magnetic bearings have begun to be used widely in industry for the support of rotating shafts. They provide advantages such as oil-free operation, low friction losses, enhanced vibration control and long life.

Discussion groups during MAG '93 will feature representatives from the industry and will be held on various topics of interest related to magnetic bearings, magnetic drives, and dry gas seals. These groups will present a forum for discussion between experts in the field and interested industrial users. Some of these discussion topics include: magnetic bearings for compressors-specifications, installation and initial tests; experience with magnetic bearings in canned pumps; future developments of magnetic bearings; dry gas seals; and magnetic drives. A two day short course, "Introduction to Magnetic Bearings", will be held July 27-28 prior to the conference.

For an announcement of the conference and more information contact: Center for Magnetic Bearings, University of Virginia, Dept. of Mechanical, Aerospace, and Nuclear Engineering, McCormick Road/MEC 105, ROMAC Laboratories, Charlottesville, VA 22903 USA; Tel:(804)982-3049; Fax:(804)982-2246. ▲

ICL '93

The International Conference on Luminescence and Optical Spectroscopy of Condensed Matter (ICL'93) will be held at the University of Connecticut, Storrs, Connecticut, U.S.A., August 9-13, 1993. This conference is the latest in the series of meetings that are organized every three years. The International Conference on Luminescence provides an interdisciplinary forum for the presentation of recent developments in the optical properties and luminescence of organic, inorganic and biological systems.

Included in the conference will be several sessions devoted to rare earth and actinide spectroscopy in solids. In addition, there will be a special symposium on scintillators.

To receive the call-for-papers or further information contact: Professor Douglas S. Hamilton, ICL'93, Department of Physics, 2152 Hillside Road, University of Connecticut, Storrs, CT 06269-3046 USA; Tel:(203)486-4914 Fax:(203)486-3346 E-mail: Hamiliton@main.phys.uconn.edu. ▲

SCES '93

The International Conference on Strongly Correlated Electron Systems (SCES '93) will be held August 16-19, 1993. The conference will take place at the University of California, San Diego, La Jolla, California, USA.

Topics covered in this conference will be: anomalous *d*-and *f* electron systems, valence fluctuation and heavy fermion phenomena, Kondo lattice and multichannel Kondo phenomena, marginal and non-Fermi liquid behavior, hybridization gap semiconductors, magnetic ordering and correlations, crystal field effects, and high T_c and heavy fermion superconductors.

Abstracts are due May 1, 1993. For further information or to receive the first and second announcements, contact: M.B. Maple, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0319 Fax:(619)534-1241. ▲

Permanent Magnets 1993 Update

Wheeler Associates, Elizabethtown, Kentucky, have announced an April, 1993 availability of their world-wide reference standard report on permanent magnets. This report, updated and published every four

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Upconversion in Er^{3+} Doped Phosphor

Rare earth ion-doped materials capable of converting infrared to visible light have been attracting increasing attention, as a result of the development of high-power infrared laser diodes. J. Ohwaki and Y. Wang report efficient infrared to visible upconversion in the YCl_3-$ErCl_3$-$PbCl_2$-KCl phosphor system in *Jpn. J. Appl. Phys.*, Vol. **31** [10B], L1481-3 (1992). Under 1.52 μm laser diode excitation, a specimen containing 20 mol% Er^{3+} dopant emitted bright green luminescence, resulting in fluorescence lines at 410 nm, 550 nm and 660 nm that reached respective intensities of 48, 20, and 9 times those of conventional Er^{3+}-doped fluorides. The strong upconversion fluorescence at 496 nm due to $^4F_{7/2}$-$^4I_{15/2}$ transition is observed in the fluoride phosphor under 0.972 μm laser diode excitation. The authors explain that this direct two-step excitation process occurs when multiphonon relaxation is suppressed in the chlorides.

The phosphor was prepared by starting with 99.9% $ErCl_3$, YCl_3, $PbCl_2$ and KCL powders. After thoroughly mixing, the powders were heated in a carbon crucible at 950°C for one hour and then slowly cooled to room temperature. Water and oxide impurities in the samples were controlled by passing N_2 and CCl_4 or Cl_2 gas into the furnace.

This upconversion in the YCl_3-$ErCl_3$-$PbCl_2$-KCl phosphor system offers the possibility for use in devices for the visualization of 1.5 μm light in optical fiber communications systems and infrared imaging. In addition, the study also offers useful information for the development of visible solid laser materials pumped by infrared laser diodes. The authors are studying methods to optimize the matrix composition, dopant concentration and sintering conditions. ▲

Ultra-Pure Yttrium

Nippon Mining Co., Ltd. of Tokyo, Japan, is now producing ultra-pure yttrium with a purity of 99.99999% [*Superconductor Industry*, **5**, [2], 41 (1992)]. The new 7N (seven nines) purity yttrium is produced by electron-beam processing. Applications for this material include superconductive materials and next-generation 64-Mbit DRAMS (Direct Read Access Memory) for computers, and is now being shipped to electronics manufacturers.

For more information on this new product, contact: Nippon Mining Co., Ltd., 2-10-1, Toranomon, Minako-ku, Tokyo 105.

AntiREflection Coatings

The sensitivity and efficiency of semiconducting photoelectric devices are lowered as incident light is reflected from the surface. These losses can be reduced by coating the working surface of the device with a layer of antireflection material. Yu. A. Anoshin, et al. report in *Pis'ma Zh. Tekh. Fiz.* **18**, 54-8 (1992) that various rare earth oxides may be useful as antireflection coatings.

The authors found these compounds promising because they have high transparency, a refractive index that is optimum for antireflection coatings on silicon devices, and high chemical and thermal stability. The authors found that since the maximum antireflection effect in the cells occurs at 600 nm, the thickness of the oxide layers should be 750 Å. The rare earth metal coating was deposited in air and thermally oxidized at ~500°C. The oxides used in the study were Dy_2O_3, Yb_2O_3, Gd_2O_3, and Y_2O_3.

The results of the experiment showed that these oxide films lowered the reflection coefficient of monochromatic light from 34.7-37% from the bare surface to 0.01-0.7% which essentially eliminates the reflected light from the surface of the semiconductor. The dysprosium oxide film was found to be the best antireflection coating by reducing reflection to the lowest figure of 0.01%. This proves the excellent potential for the use of these materials on silicon solar cells. ▲

***Magnets**/Continued from page 3* ➪

years, provides comprehensive information on the permanent magnet industry, markets, technology, materials and trends. This latest 1993 edition is the sixth in a series spanning 24 years of reporting, documenting and forecasting the permanent magnet industry. Rare earth permanent magnets play an important role in a host of subsidiary industries: automotive, motors, sensors, military/space, medical, computer peripheral and consumer.

As editor and principle author, Mr. Port Wheeler has assembled expert guest authors from the U.S.A., Europe and Asia who contribute their insight and experience in the critical areas of research and development, material availability, manufacturing capacity, application trends, and more.

For more information contact: Wheeler Associates, P.O. Box 825, Elizabethtown, KY 42701 USA; Tel:(502)765-6773 Fax:(502)765-2137. ▲

Workshop Proceedings

Magnetism, Magnetic Materials and their Applications is the title of the Proceedings of the International Workshop held in La Habana, Cuba, May 21-29, 1991. The proceedings contain contributions from an international group of well-known authors that discuss recent advances in the field of magnetic materials and the impact they have had on modern technology.

Topics covered in the book are: the physics of magnetic phenomena in solids; magnetization in ferromagnetics; amorphous and microcrystalline soft and hard magnetic materials; rare earth intermetallic alloys; magnetic thin films and multilayers; growth and preparation of materials; and magnetic properties of high-T_c superconductors. Section I contains nine papers on Fundamentals and Techniques, concentrating on the magnetic properties, NMR and domain wall mobility, and microscopy of rare earth-metallic compounds containing boron and iron, among others. Section II, Materials and Applications, deals with new compounds suited for permanent magnets, which reviews permanent magnet materials already in use, including $R_2(Fe,M)_{14}(B,C)$ and $R_2Fe_{17}(B,N,C)$ compounds. Phase formation and properties of rare earth intermetallic alloys are also included. The second part of Section III, Ferrites, Intermetallic Alloys, and Superconductors, reports on the magnetic properties, oxidation studies and thermomagnetic characterization of Nd_5Fe_{17}, Nd-Fe and Pr-Fe alloys, and Nd-Fe-B and Pr-Fe-B alloys.

Although only 14 of the 49 papers contain specific research results of rare earth magnetic materials, and an additional 9 papers mention rare earths in their studies, the major portion of the information contained in this book should prove helpful to researchers working in the field of magnetism and magnetic materials and their applications, and condensed matter physics.

The 342-page hardcover proceedings was edited by F. Leccabue and J.L. Sánchez Llamazares and published by Institute of Physics Publishing, Bristol, England in 1992. To purchase a copy, send £45.00 ($90.00 US) to the publishers, Techno House, Redcliffe Way, Bristol BS1 6NX, England. ▲

Scientists use the radioactive isotope Lutetium-174 to monitor the efficiency of nuclear explosions.

Supermagnet

A superconducting permanent magnet with impressive magnetic properties has been prepared by S. Gotoh, M. Murakami, H. Fujimoto and N. Koshizuka at the Superconducting Research Laboratory, Tokyo, Japan and published in *J. Appl. Phys.*, **72**, [6] 2404-10 (1992). This "superpermanent magnet" has a composition of $YBa_2Cu_3O_x$ (1:2:3), and produces an energy product of 110 MGOe while in the superconducting state at 5K, which exceeds the best magnetic strength of Nd-Fe-B or Sm-Co permanent magnet materials.

The possibility of a superconducting permanent magnet has been considered since the discovery of type-II superconductivity, but has been difficult in practice because of flux jumping due to thermal instability and poor mechanical strength. However, Gotoh et al., reasoned that melt processed 1:2:3 superconductors would be excellent choices for a superpermanent magnets because of their high J_c values and good mechanical properties. The high J_c values are the result of the presence of pinning centers in the matrix, which prevent the flux vortices from moving. These pinning centers are actually nonsuperconducting Y_2BaCuO_5 (2:1:1) inclusions in the $YBa_2Cu_3O_x$ matrix, a result of melt processed Y-Ba-Cu oxide. The result of these large pinning forces is that large magnetic fields are trapped in the sample, making it ferromagnetic.

The authors prepared and studied two separate melt processed 1:2:3 samples. One sample was prepared by a quench and melt growth process (QMG) and the second by the melt-powder-melt-growth process (MPMG). During preparation, both compositions were adjusted to ensure that the 1:2:3 phase contained some 2:1:1 inclusions, dispersed in the matrix, to act as pinning centers. In both cases, the powders were heated in air to 1400°C and then quenched by copper hammer plates. The sample is reheated to 1100°C in the QMG process, held for 20 minutes, cooled to 1000°C in one hour, followed by slow cooling at 5°C/hr. A final anneal at 600°C for 1 hour was carried out in an oxygen atmosphere and then slowly cooled to room temperature. The MPMG samples were powdered, mixed and pressed after the initial quench step. This material was then melted at ~1100°C and slow cooled at several different rates, depending on the temperature regime. This allows the 2:1:1 inclusions to precipitate out of solution. ▲

Magnetic Thin Films

A report entitled "Magnetic Thin Films for Data Storage," written by M.H. Kryder, appeared in *Thin Solid Films*, **216**, 174-180 (1992). The paper reviews the applications of magnetic thin films in data storage technology and provides a glimpse of opportunities for research in this field. The author predicts that in the near future, magnetic recording densities 100 times greater than today, will be acheived. This may certainly come true if work currently conducted at various laboratories are any indication. However, many advances in thin film technology are needed, including: improved wear resistant overcoats for magnetic media; higher coercivity thin film media with isolated grain structure and multilayers to achieve low noise; high magnetization, high permeability multilayer thin film materials for advanced recording heads; and giant magnetostrictive materials for advanced read heads.

Even though magneto-optic materials are expected to have an increased role as a removable data storage medium for large files of data involving images and multimedia, magnetic recording films should still dominate the data storage industry for the next two decades, according to Kryder.

To increase the storage density of magneto-optics, materials with improved sensitivity to shorter wavelength light are needed. These films would not only have to exhibit large magneto-optic coefficients, but must also have a microstructure that is conducive to low noise during playback. However, magneto-optical disk drives are less cost-efficient than magnetic disk drives in volumetric storage density (cost per megabyte stored). Today, most magneto-optical disk drives use thin films of amorphous rare earth-transition metal alloys (Tb-Fe-Co) for the magneto-optic media.

In 1989, storage densities of 0.15 Gbit/cm^2 were achieved by IBM on a thin film disk using a thin film record head and thin film magnetoresistive read head. In 1991, Hitachi announced a magnetic disk drive with double this storage density, and just recently, the Engineering Research Center in Data Storage Systems at Carnegie Mellon University, Pittsburgh, Pennsylvania, USA, set a goal of reaching a storage density of 0.6 Gbits/cm^2 by 1995. If this goal is met, it would mean that 60 Gbytes of information could be handled on a 9 cm drive and as much as 600 Mbytes in a 2.5 cm drive mounted on a circuit board.

To reach this goal, research in the laboratory is needed to better understand the magnetic and magneto-optic properties of thin films and multilayer materials. Not only must work be done to improve the actual recording properties, but also to better protect the surfaces of these materials from the effects of mechanical and chemical weathering. ▲

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Thin Films/*Continued* ⇨

$ErSi_2$ as an Infrared Detector

Schottky diodes made from erbium silicide *n*-type silicon were studied and reported by M.H. Unewisse and J.W.V. Storey in *J. Appl. Phys.*, **72**, 2367-71 (1992). Infrared detectors in use today contain metal silicides that use palladium, platinum, or iridium and exhibit the low Schottky barriers, which are necessary to detect low-energy infrared photons. For example, platinum has a barrier of 0.84 eV on *n*-type Si and 0.24 eV on *p*-type Si, while palladium silicide gives values of 0.72 and 0.35 eV for *n*- and *p*-type Si, respectively.

Most metals form silicides, but most of those on *n*-type silicon have high Schottky barriers, yet, low barriers on *p*-type silicon. Thus, most of the work on the design of infrared detectors has been done with this type of silicon.

The authors fabricated the erbium-silicide *n*-type silicon devices by thermal evaporation onto phosphorus-doped <100> silicon wafers which had a resistivity of 10 Ω cm. They report that aluminum was first thermally evaporated onto the backside of the wafers in strips lying between the diodes which provided the reverse contact for the diodes. The diodes were then turned over and about 800 Å Er was thermally evaporated onto 1000 μm holes through a shadow mask. The wafers were then sintered in a vacuum with a quartz-halogen heater at 410°C for 30 min. The final step involved evaporating a layer of Al onto the erbium silicide to provide a contact surface to the diode and also to protect it from corrosion.

After making electrical measurements by current-voltage and current-voltage-temperature techniques, the authors found a electrical barrier height of 0.28 eV. The photon barrier height of the $ErSi_2$ diode was found to be close to the electrical barrier height, resulting in a quantum efficiency of 0.52% as measured at 2.0 μm. These numbers reflect the potential of $ErSi_2$ for use in infrared detector arrays. ▲

Landolt-Börnstein New Series Subvolume e2

Landolt-Börnstein:Numerical Data and Functional Relationships in Science and Technology-New Series, Subvolume e2, *Compounds of Rare Earth Elements with Main Group Elements Part 2*, is a continuation of Volume **19** (Magnetic Properties of Metals, of Group III:*Crystal and Solid State Physics*). Subvolume e2, compiled by A. Chelkowski, P. Morin, H. Oesterreicher and K. Oesterreicher, and edited by H.P.J. Wijn, was published in 1989. The earlier editions of *Landolt-Börnstein* (6th Edition), Vol. **II**, part 9, deal with the magnetic properties of a wide variety of substances. However, since the volume of material has grown considerably, this new compilation was necessary.

This volume specifically deals with the magnetic properties of metallic rare earth compounds with main group elements of the periodic table. The first section, by P. Morin, provides information on rare earth-binary and ternary compounds, including the RX_2 and RX_3 compounds where X= Be, Mg, Zn, Cd or Hg. The second section, by H. Oesterreicher and K. Oesterreicher, reviews valuable information on the magnetic properties of rare earth borides, including RB_2, R_2B_5, RB_4, RB_6, and RB_{12} binary compounds. Ternary boride compounds containing Ru, Rh, Os, Ir, Cr, Mn, Fe, Co, as well as Y, Sm, Gd, Pr, are also covered. The third section by A. Chelkowski deals with rare earth compounds containing Al, Ga, Tl, C, Si, Ge, Sn or Pb.

The volume is complete with crystal and magnetic structure diagrams, electrical resistivity measurements, magnetic moment, temperature dependence, susceptibility, and other magnetic properties of these compounds. These properties are displayed using many tables, graphs and diagrams. All of the information is arranged in a logical format and is easy to locate for quick reference. This feature alone makes these series a premier source for this type of information.

The 440-page *Compounds of Rare Earth Elements with Main Group Elements Part 2* contains 943 figures, 56 tables and 739 references. It can be ordered from Springer-Verlag GmbH & Co. KG, Postfach D-1000, Berlin 33, Germany for 1,230DM (~$790.00 US). ▲

The rare earth isotope Yttrium-90 is used in the radiation treatment of cancer tumors.

★★★

Letters to the Editor

★★★

November 5, 1992

Dear Karl,

Your response to Bud Otis' letter [*RIC News*, September 1, 1992, p.4] concerning the rare earth distribution in mischmetal derived from bastnasite is not correct. Ronson and Goldschmidt have produced thousands upon thousands of tons of mischmetal from Molycorp bastnasite via anhydrous rare earth chlorides by the Goldschmidt chlorination process. We have never analyzed the composition you mentioned. The lanthanide composition of this mischmetal is as follows: La - 18-28%, Ce - 50-55%, Pr - 4-6%, Nd - 12-18%, Sm - < 0.1%, Other, RE < 2%.

Klaus Reinhardt
The Goldschmidt AG,
Essen, Germany

Editor's Response
Dear Klaus:

Thank you for setting the record correct. In checking with the authors (of which I am one) of the *J. Less-Common Metals*, [87, 135 (1982)] article, we found that the "bastnasite" concentrate which had been purchased from a reputable firm, was actually a cerium-depleted carbonate containing 40.4% La, 34.3% Ce, 6.5% Pr, 17.4% Nd, 1.5% other RE. [The nominal rare earth distribution in bastnasite is 32% La, 49% Ce, 4.4% Pr, 13.5% Nd, 1.1% other RE]. Thus when the mischmetal was prepared, it had the unusually low Ce content as you noted. It is unfortunate that the authors (especially me) did not note this discrepancy at the time we did this work.

Sincerely yours,
K. A. Gschneidner, Jr.
Director RIC

Dear Dr. Gschneidner:

The December 1992 *RIC News*, p.4, covered the very interesting topic "Ceramic Scintillators for XCT". One of the x-ray ceramic scintillators briefly mentioned was $(Y,Gd)_2O_3$:Eu^{3+}, with no mention of the specific chemical composition engineered for optimum properties nor of the particularly successful commercialization of this material in advanced medical x-ray detectors.

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Nd:YAG Laser Identifies DNA Molecules

For the first time ever, scientists have been able to identify individual DNA molecules {*Photonics Spectra*, **26**, [10] (1992)}. Researchers at Los Alamos National Laboratory used ultra-short light pulses generated by a Nd:YAG laser to illuminate fluorescent dye-tagged DNA molecules. The discovery could lead to the development of an instrument able to detect a wide variety of molecules, such as hormones and enzymes.

The new technique is said to be much faster and more sensitive than methods currently used that must concentrate or amplify the amount of DNA in a sample. The longer the DNA molecule, the more fluorescent dye it carries and the stronger the signal it produces. ▲

***Letters**/Continued* ⇨

Recently, the "Feature Article" in *Amer. Ceramic Soc. Bull.*, 71, [7], 1126 (July 1992) entitled "Ceramic Scintillators for Advanced, Medical X-ray Detectors" describes the development of the first polycrystalline ceramic scintillator, $Y_{1.34}Gd_{0.60}Eu_{0.06}O_3$ that is now used in medical x-ray detectors in commercial Computer Tomography (CT) scanners. Some of the important properties of competitive single crystals of CsI:Tℓ and $CdWO_4$ are compared to the unique $Y_{1.34}Gd_{0.60}Eu_{0.60}O_3$ ceramic scintillator, tailor-made specifically for the application. This ceramic scintillator is a transparent, cubic rare earth solid solution with a density of 5.92 g/cm^3 and a refractive index of about 1.96 at the main Eu^{3+} emission peak at 610 nm. The 610 nm emission is better matched for higher spectral response by Si photodiodes in the detector array than the shorter emission wavelengths of CsI:Tℓ and $CdWO_4$. The high relative light output (2.5X higher than $CdWO_4$), low luminescent afterglow (<0.1% at 100 ms), especially low x-ray damage (<1% for a 450 R dose) and high optical transparency in the visible region (>90% of the theoretical transmission) give the $Y_{1.34}Gd_{0.60}Eu_{0.06}O_3$ scintillator outstanding performance and long life in GE's premium CT scanners.

Sincerely yours,
Charles D. Greskovich
GE Corporate Research
and Development
General Electric Co.

Fluoride Glass Fiber Optics

Fluoride Glass Fiber Optics, edited by I.D Aggarwal and G. Lu, is a nine chapter book compiled by leading researchers in the field. The Introduction and Concluding Remarks sections were written by the editors. This book provides a comprehensive review of research and should be valuable to people who want an introduction to fluoride glasses as well as researchers who need a good reference book.

The book contains chapters on: fluoride glass composition and processing, fluoride glass structures, transparency of bulk halide glasses, purification and analysis of metal fluorides for use in heavy metal fluoride glasses, preform and fiber fabrication, optical fiber loss mechanism, chemical durability of fluoride glasses, effects of high energy radiation on halide glasses and active phenomena in rare earth-doped halide glasses.

Since the discovery of fluoride glass in 1974, there has been a concerted effort by industrial and academic researchers to develop glass suitable for use in fiber optics, infrared windows, and fiber lasers. The ultimate objective is to use these fibers in an optical communication system that needs no (or very few) repeater stations, making it capable of transoceanic use.

At the present time, rare earth and rare earth-doped fluoride glass fibers are used in laser surgery, gas and liquid sensors, infrared spectroscopy, and remote monitoring. In addition, a virtually crystal-free laser window, weighing 20 kg, has been fabricated.

The 415-page book was published in 1991 by Academic Press, Inc., 1250 Sixth Avenue, San Diego, CA 92101, USA, and costs $69.95 US. It can also by ordered from Academic Press Ltd., 24-28 Oval Road, London NW1 7DX, UK. ▲

Magnequench

Dr. John J. Croat was recently appointed as the director of Magnequench, which is part of the Delco-Remy Division of General Motors Corp., located in Anderson, Indiana. Dr. Croat was a member of the General Motors team who developed the rapid solidification process for making neodymium-iron-boron permanent magnets in the early 1980's. As a result of their work, Croat was named along with J. Herbst, N. Koon and M. Sagawa as the winners of the 1986 International Prize for New Materials for the discovery of this new high energy product permanent magnet material. ▲

A Leaner, Meaner Rhône-Poulenc

The French government announced late last year to offer six million shares of common stock in the giant chemical company and rare earth producer, Rhône-Poulenc, to the public. This sell-off, which represents 10% of total ownership, is consistent with the government policy of reducing it's share in state-owned companies. The sale of stock should raise between $580 million and $770 million, which the government intends to use for job creation programs {*C&EN*, **70**, [45] 6 (1992)}. Even after the sell-off, the state will still own 68% of the company.

Private investors had a chance at purchasing voting stock, which traditionally sells at a higher price, because they would have a say in managing the multinational chemical and pharmaceutical maker. In addition, a portion of the stock was reserved for company employees, which gave them equity interest in the company for the first time. The move should enable the company to raise capital overseas more easily, such as competitors Du Pont and ICI. ▲

Name Change

The rare earth marketing specialists at HJD Enterprises announce that their name has now changed to HJD Intnl. This change reflects the truly international flavor of their business, but does not change the company's purpose. Their main phone number has also changed. For more information contact: HJD Intnl, International Marketing, 5 Hemlock Terrace, Sparta, NJ 07871 USA; Tel:(201)729-9777; Fax:(201)729-1712. ▲

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New RE Magnet Factory in England

Swift Levick Magnets Ltd., (SLM), a company based in Sheffield, England, and wholly owned by the Finnish metallurgical group, Outokumpu, has finalized plans to build a new £7, ($13.4 US) million rare earth magnet factory. The 2000 square meter plant will be located on 10 acres on the outskirts of Sheffield and is scheduled for operations this June.

The factory will be equipped with the latest in automated production technology and advanced computer technology. The factory will use some of the production equipment acquired from the Magnets Division of Treibacher Chemische Werke AG, which recently announced that it will cease magnet production.

The new magnet facility will concentrate on the production of $SmCo_5$ and Sm_2Co_{17} permanent magnets but may also produce Nd-B-Fe magnetic materials.

For more information contact: Martin Satur, Technical Director, Swift Levick Magnets Ltd., Foremost Works, Grange Mill Lane, Wincobank, Sheffield S9 1HW, England; Tel: Rotherham (0709)550 099; Fax: (0709)560 482.

SLM will use rare earths from its rare earth factory at Barbot Hall in Rotherham. Recent process developments have led to new magnet grade materials and improved production technology. ▲

Fine Magnetic Particles

The International Workshop on "Studies of Magnetic Properties of Fine Particles and their Relevance to Materials Science" was held November 4-8, 1991 in Rome, Italy. Forty-six of the papers presented have been published by North-Holland, in 1992, in a book entitled *Magnetic Properties of Fine Particles*. The book, edited by J.L. Dormann and D. Fiorani, contains 430 pages and costs Dfl. 300.00 (~$172.00 US). It can be ordered from Elsevier Science Publishers, P.O. Box 211, 1000 AE Amsterdam, The Netherlands, or in the USA/Canada from Elsevier Science Publishers Company, Inc., P.O. Box 882, Madison Square Station, New York, NY 10159, USA.

The purpose of the Workshop, and thus the book, was to advance the understanding of the fundamental properties of fine magnetic particles and to discuss the latest developments in both theoretical and experi-

Continued in next column ⇨

Magnetic Grain Alignment of Superconductors

To carry large current densities, the grains of polycrystalline ceramic high-T_c bulk superconductors must be aligned so that their current-carrying cuprate planes are parallel (c-axis alignment). This can be achieved mechanically by rolling or pressing, or by the use of a magnetic field. Although it is known that the intergrain coupling is strongly improved if in-plane crystal axes are also aligned with respect to each other (a-b axes alignment), such two-axes alignment has not been possible before in bulk material.

B.C. Giessen, R.S. Markiewicz and coworkers at Northeastern University in Boston have recently developed a process for biaxial alignment [U.S. Patent No. 5,114,905 (1992)] and applied it to lanthanide-substituted bismuth-copper oxide (BSCCO) [*Japan J. Appl. Phys.* **30**, L1096 (1991)] and 1-2-3 yttrium-barium-copper oxide (YBCO) [*Mater. Lett.*, **14**, 193 (1992)]. The method is based on the property of cuprates containing either Eu or Yb, to orient in a magnetic field so that a specific in-plane axis lies parallel to the field.

To align superconductor grains along two orthogonal axes, plate-like superconductor grains are suspended in a fluid medium while exposed to a field of 2-5 T and magnetically "in-plane" aligned. The fluid is then removed, and the c-axis alignment of the platy grains is performed mechanically, producing triaxial alignment.

The treatment forms a reconstituted "granular single crystal" which can then be densified by sintering. According to B.C. Giessen, this method for total grain alignment should be applicable to other compounds containing lanthanides that show crystal field effects. ▲

Fine Magnetic Particles*/Continued* ⇨

mental aspects. Special emphasis was placed on the applications in different branches of science and technology, areas such as magnetorecording, mineralogy, geomagnetism, catalysis, biology, fine arts, etc.

Only five papers deal directly with rare earth materials. However, many of the theoretical papers and some of the papers dealing with other materials, are of importance to people studying, or using, fine magnetic particles that contain rare earth elements. ▲

Dr. J.N. Daou (1929-1992)

Dr. J.N. Daou died of a heart attack while working in his laboratory in Orsay, France on July 24, 1992. A native of Houmal, Lebanon, he received his Diploma in Physics and Mathematics from the University of Lyon, France in 1952, and then went on to join the Centre National de la Recherche Scientifique (CNRS) in 1956. In 1962, while working at the Laborartoire de Chemie Physique of CNRS in Paris, he earned his PhD studying the electric properties of the systems lanthanide-hydrogen, for which he received the bronze medal of the CNRS.

In 1975, Dr. Daou became head of the Hydrogen et Defauts dans les Metaux Laboratory at the University of Paris-Sud at Orsay where he stayed until his death. His most recent work dealt with physical and electrical properties of rare earth-metal hydrides and semiconductors. ▲

Thulium Gets the Blues

Tm-doped ZnS has been known for some time to be a blue emission phosphor due to the *4f-4f* transition of Tm^{3+}. However, intensity of this blue-colored luminescence is low. T. Hatayama, S. Fukumoto, and S. Ibuki [*Jpn. J. Appl. Phys.*, **31**, 3383-4 (1992)] report their success in codoping Tm with Li, increasing luminescent intensity.

The ZnS:Tm,Li phosphor was prepared by mixing ZnS, $TmCl_3$ and Li_2CO_3, firing for 1 hour at 1100°C in an atmosphere of H_2S using Ar as a carrier gas. The resulting powder was found to be hexagonal.

During testing, the authors found that sharp lines appeared in the luminescence spectra of Tm^{3+} when codoped with Li. Blue emission intensity was also stronger as compared with that of infrared emission when the codoped Li concentration in ZnS:Tm was 0.1 at.%. However, the infrared emission intensity decreases with increased Li codoping.

At low temperature, the spectra of ZnS:Tm,Li phosphor became very sharp and the blue intensity increased. At 12 K the blue line intensity was more than 10 times stronger than at 290 K and more than 1000 times stronger as compared to ZnS:Tm. Hatayama et al. explain the effect of Li codoping by stating that since ZnS:Tm emits a broad band and very weak Tm^{3+} lines, the lithium ion may fill defects in the ZnS host, easily transferring excitation energy from the ZnS host to Tm^{3+}. ▲

Supporters 1993

★★★★★★★★★★★★★★★★★★★★★★★★★

Since the December issue of the RIC News went to press, RIC has received financial support from six new family members, and renewed support from 22 other organizations. The supporters from the third quarter of fiscal year 1993 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 parentheses, are listed below.

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Quasi-Particles

G. Zwicknagl's article in *Adv. Phys*, **41**, [3] 203-302 (1992), reviews nearly independent particle excitations, known as quasiparticles, in heavy fermion systems. He emphasizes a realistic, material-specific description of the highly correlated Fermi liquid state which develops at low temperatures. Landau's Fermi liquid theory and its application to metals is discussed with an explanation of renormalized band structure calculations. The fundamental ideas are covered, and derivations of the calculations are made which allow for a phenomenological account of the strong local correlations. Crystal structure, Fermi surface and effective masses, renormalized bands, the influence of strong local correlations, metamagnetism and dHvA data are given for $CeRu_2Si_2$. $CeAl_3$ is also discussed. The paper concludes by discussing quasiparticle collisions, and a short review of ideas and theoretical models which are used to describe superconductivity of heavy fermion compounds. ▲

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