



Rare-earth Information Center NEWS

Ames Laboratory
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No. 2

ACS Southeastern Texas Section

John L. Margrave, E.D. Butcher Professor of Chemistry at Rice University and chief scientific officer at Houston Advanced Research Center, received the 1993 award for dedicated and distinguished service to the ACS Southeastern Texas Section. He has served on the ACS Council for more than 20 years and has participated in planning both regional and national ACS meetings.



John L. Margrave

Professor Margrave is noted for his work on thermodynamic properties, vapor pressures, and structures/symmetries of rare earth compounds with emphasis on rare earth fluorides. He has determined the ionization potentials, bond energies, and vibrational frequencies for mono-, di-, and tri-fluorides of Sc, Y and most of the other rare earths using levitation/drop calorimetry, high temperature mass spectrometry and matrix-isolation spectroscopy. ▲

Old Books

RIC recently received five books of historical interest and we have added them to our collection. The books were sent to us by Mr. Isador S. Hirschhorn and include: *Industrie des Metaux Secondaires et des Terres Rares*, P. Nicolardot, 1908; *The Rare Earth Industry and The Industry of Radioactive Substances*, S.J. Johnstone and A. S. Russell, 1915; *The Metals of the Rare Earths*, J.F. Spencer, 1919; *Chemistry of the Rarer Elements*, B.S. Hopkins, 1923; and *The Rare Earths*, S.I. Levy, 1924. We are grateful to Mr. Hirschhorn for providing these fine old books to us. ▲

20 Years

Crucible Materials Corporation

Johnson Matthey-Rare Earth Products

Mitsubishi Kasei Corporation

NUCLEMON Minero-Quimica Ltda.

10 Years

Ergenics, Inc.

F. G. Jones Associates, Ltd.

Mitsubishi Materials Corporation

Philips Research Laboratories

Sumitomo Light Metal Industries, Ltd.

Vacuumschmelze GmbH

This year we have four companies that we wish to honor for their 20 years of support. Crucible Materials Corporation, Johnson Matthey-Rare Earth Products, Mitsubishi Kasei Corporation, and NUCLEMON-Minero-Quimica Ltda. join the previous eighteen companies on our growing list of long time members.

Six additional companies, Ergenics, Inc., F. G. Jones Associates, Ltd., Mitsubishi Materials Corporation, Philips Research Laboratories, Sumitomo Light Metal Industries, Ltd., and Vacuumschmelze GmbH join the growing number of companies who have been with us for at least ten years. We wish to express our appreciation to all ten companies for their long and continued support. ▲

ICL '93 Prize

Dr. Marvin J. Weber, a Lawrence Livermore National Laboratory Physicist, is the recipient of the 1993 International Conference on Luminescence Prize. The prize was established in 1984 by a consortium of organizations interested in the promotion of luminescence. Dr. Weber received a plaque citing his contributions in luminescence research, and a stipend of \$1,000 US, which was provided by Elsevier Science Publishing Company.



Marvin J. Weber

The Prize is awarded every three years at the International Conference on Luminescence, which was held August 9-13, 1993 at the University of Connecticut. The award cited Dr. Weber for his "fundamental studies of dynamical processes in solids which effect luminescence efficiency and the application of that knowledge to laser and scintillator materials."

He is also a member of the steering committee of the Crystal Clear Collaboration based at the Centre Européen pour la Recherche Nucléaire (CERN) in Geneva, which is an international group interested in research and development of scintillator materials for high energy physics experiments and medical imaging. ▲

Year of Discovery
Y
 1794

Conference Calendar

* A NEWS STORY THIS ISSUE

June '94

Interstitial Alloys for Reduced Energy Consumption and Pollution

Il Ciocco, Castelvecchio Pascoli, Italy

June 12-24, 1994

RIC News, XXVIII, [4] 2 (1993)

International Conference on Nitromagnetics (ICN'94)

Honolulu, Hawaii, USA

June 15-17, 1994

RIC News, XXVIII, [2] 2 (1993)

RIC News, XXIX, [1] 3 (1994)

6th Joint MMM-Intermag Conference

Albuquerque, New Mexico, USA

June 20-23, 1994

RIC News, XXIX, [1] 5 (1994)

Novel Magnetic Structures and Properties

Santa Fe, New Mexico, USA

June 24-25, 1994

RIC News, XXIX, [1] 5 (1994)

July '94

Eleventh International Conference on Solid Compounds of Transition Elements (SCTE-11)

Wroclaw, Poland

July 5-8, 1994

RIC News, XXVIII, [2] 2 (1993)

4f ↔ 5f 1st Workshop on Comparative Science of the f-Elements

Bühlerhöhe, Black Forest, Germany

July 28-30, 1994

*This issue (p. 3)

August '94

2nd International Conference of Elements (ICFE-2)

Helsinki, Finland

August 1-5, 1994

RIC News, XXVIII, [3] 2 (1993)

Relativistic Effects in Heavy-Element Chemistry and Physics: Electronic Structure Methods for Lanthanides and Actinides

Helsinki, Finland

August 8-9, 1994

RIC News, XXVIII, [4] 2 (1993)

Strongly Correlated Electron Systems (SCES '94)

Amsterdam, The Netherlands

August 15-18, 1994

RIC News, XXVIII, [3] 2 (1993)

*Also this issue (p. 3)

International Conference on Magnetism

Warsaw, Poland

August 22-26, 1994

RIC News, XXVIII, [3] 2 (1993)

Fourth International Symposium on Magnetic Bearings

Zurich, Switzerland

August 23-26, 1994

RIC News, XXIX, [1] 3 (1994)

The 1994 First International Economic and Commercial Negotiation Meeting of Rare-Earth Science and Technology of Baotou of China

Baotou, Inner Mongolia, China

August 28 - September 1, 1994

*This issue (p. 3)

4th International Symposium on Research in High Magnetic Fields

Nijmegen, The Netherlands

August 29-31, 1994

RIC News, XXVIII, [3] 2 (1993)

14th International Colloquium on Magnetic Films and Surfaces

Düsseldorf, Germany

August 29-September 2, 1994

RIC News, XXVIII, [3] 2 (1993)

September '94

Thirteenth International Workshop on Rare-Earth Magnets and Their Applications and Eighth International Symposium on Magnetic Anisotropy and Coercivity in Rare-Earth Transition Metal Alloys

Birmingham, England

September 11-15, 1994

RIC News, XXVIII, [4] 2 (1993)

August '95

The Third International Conference on Rare Earths Development & Application

Baotou, Inner Mongolia, China

August 21-25, 1995

RIC News, XXIX, [1] 3 (1994)

September '95

European Magnetic Materials and Applications Conference (EMMA 95)

Wein, Austria

September 4-8, 1995

RIC News, XXIX, [1] 3 (1994)

1996

21st Rare Earth Research Conference (RERC)

Charlottesville, Virginia, U.S.A.

1996

RIC News, XXVIII, [4] 2 (1993)

Conference Proceedings

The conference proceedings "Anais do XVIII-Simpósio Anual da ACIESP, Vol. 1, Química dos Lantanídeos e Actinídeos" is available by contacting Prof. Shiguieo Watanabe, Acedemia de Ciências do Estado de São Paulo-ACIESP, C. P. 22297, CEP 01498-970, São Paulo, Brazil. The cost of the proceedings, including postage, is \$25.00 US. ▲

Dy_2O_3 is a dielectric ceramics dopant, and is also used in stainless steel.

Electron Systems

Strongly Correlated Electron Systems is a collection of papers presented at the Gordon Godfrey International Workshop held at the University of New South Wales, Sydney, Australia, July 1-5, 1991. The papers describe a variety of systems which share the designation "strongly correlated electron systems", and which possess both extraordinary and unexpected properties.

This collection of papers was written for either physics post-graduate students or scientists and engineers involved in this im-

Continued in next column ⇨

portant field. The book is primarily theoretical in nature and has much bearing on the magnetic and electronic behaviors of rare earth materials, including cerium and uranium compounds and alloys.

The 252-page hardcover book *Strongly Correlated Electron Systems* was published in 1992, edited by M.P. Das and D. Neilson, and is available for \$89.00 US by contacting Nova Science Publishers, Inc., 283 Commack Road, Suite 300, Commack, NY 11725-3401 USA; Tel: 516 499 3103 or 3106. ▲

4f ↔ 5f Workshop

In the years 1945-1960, there was a close relationship between lanthanide and actinide scientists who recognized the similarity between these two groups of elements. However, as these two sciences matured, separate scientific communities developed, thus degenerating lines of communication. The 1st Workshop on Comparative Science of the *f*-Elements will aim to bring together lanthanide and actinide scientists to once again share the common aspects of *f*-elements.

The Workshop is interdisciplinary between physics and chemistry on the one hand, and between solid state science and solution chemistry on the other. Up to 15 invited talks will cover the essential physical and chemical aspects which are relevant for comparing lanthanide and actinide properties, such as the different ways in which *f*-elements can interact, and the different models and terms used for these interactions. The number of participants that will be allowed to attend the Workshop is limited.

For additional information contact: Dr. Ulrich Benedict, 4f ↔ 5f European Commission Joint Research Centre, Institute for Transuranium Elements, Postfach 23409, D-76125 Karlsruhe, Germany; Tel: 49 7247 951 377; Fax: 49 7247 951 590. ▲

SCES '94

The International Conference on Strongly Correlated Electron Systems (SCES '94) will be held August 15-18, 1994 in Amsterdam, The Netherlands. SCES '94 will bring together physicists exploring the various aspects of correlated electron systems. The central issue of SCES '94 is the anomalous behavior of hybridized electron systems, primarily rare earth and actinide based materials.

Other topics of the conference will include: Kondo (lattice) defects; charge and spin fluctuations; heavy-electron phenomena; superconductivity in heavy-fermion systems; electron correlations and magnetic order; anomalous *f*- and *d*-electron systems; and electron correlations in high- T_c compounds.

For additional information, contact the Conference Secretariat: A. de Visser, Van der Walls-Zeeman Laboratorium, Universiteit van Amsterdam, Valckenierstraat 65, 1018XE Amsterdam, The Netherlands; Tel: 31 20 525 5732/5716; Fax: 31 20 525 5788; E-mail: SCES94@phys.uva.nl. ▲

Baotou Meeting

The 1994 First International Economic and Commercial Negotiation Meeting of Rare-Earth Science and Technology of Baotou of China (First Annual Rare Earth Festival) will be held August 28 to September 1, 1994. The meeting is being held in honor of the 200th anniversary of the discovery of yttrium, and will take place in Baotou, Inner Mongolia.

The Festival will feature several activities: a symposium on rare earth science and technology, The Third Annual Meeting of the Chinese Society of Rare Earths, The Sixth Meeting of Chinese Rare Earth Enterprises, and a Rare Earth Products Exhibition. The meeting will offer opportunities for international economic cooperation with Chinese producers, including products and trade in rare earths, as well as a tour of the Bai Yun Ebo Mine, located near Baotou, Inner Mongolia. Baotou also has 17 large rare earth factories, including the Baotou Iron and Steel Company which produces 60 thousand tons of rare earth concentrate annually, and 8 rare earth scientific research units.

For more information, or if you would like to attend the First Annual Rare Earth festival, contact: ShiXiu Yuan LiHui, Office of the First International RE Negotiation Preparatory Committee of Baotou, Inner Mongolia, China; Tel: 0472 552255-584; Fax: 0472 556246; or Mr. William Cheng, Westlake Rare Earth Industries, 520 El Camino Real, 9th Floor, San Mateo, CA 94402 USA; Tel: 415 579 5797; Fax: 415 340 8459. ▲

Super Paint

ZYP Coatings, Inc. announces the availability of a complete line of thermodynamically stable yttria (Y_2O_3) ceramic paints. These yttrium oxide paints are ideal for crucible and mold coatings for use in highly reactive molten metals and as a reaction barrier coating between reactive materials. Other uses include high temperature lubrication/release with superplastic forming, diffusion bonding, and hot pressing. Yttria paints also make an excellent mask for welding and brazing.

For information on these high temperature paints, or for product data sheets on their line of yttria products, contact: ZYP Coatings, Inc., P.O. Box 4005, Oak Ridge, TN 37831-4005 USA; Tel: 615 482 5717; Fax: 615 482 1281. ▲

RE Doped Fiber Lasers and Amplifiers

The concept of doping optical glass fibers with rare earths is a relatively straightforward one and involves incorporating a laser ion into the core of the fiber. This results in a glass fiber that exhibits low propagation loss, as well as other interesting laser properties. These improvements enable newer, more powerful lasers to be smaller, with excellent mechanical and thermal stability due to the properties of the glass host. Perhaps the most exciting use of RE-doped optical fibers is in fiber-optic telecommunications. For example, erbium-doped fiber amplifiers (EDFA) may enable multiple signals to be sent to distances in excess of 10,000 kilometers without the aid of relay stations. The market potential of these materials appears increasingly promising as research and development continues and new technologies are developed.

Rare Earth Doped Fiber Lasers and Amplifiers is a twelve chapter book containing information on the basic concepts, preparation, properties, and applications of fiber lasers and amplifiers. Specific topics covered in the book are: rare earth doped fiber fabrication; optical and electronic properties of rare earth ions in glasses; devices and configurations for fiber laser sources; theory of operation of fiber laser devices; rare earth-doped silica fiber lasers; narrow line width and tunable fiber lasers; broadband operation of erbium and neodymium-doped fiber laser sources; Q-switched and mode-locked fiber lasers; rare earth doped heavy-metal fluoride glass fibers; basic physics of erbium-doped fiber amplifiers; and applications of these fiber amplifiers to telecommunications systems.

The book is suitable for beginners entering this field, especially graduate students, scientists, engineers and technicians seeking an understanding of the fundamental principles and performance of rare earth doped fiber devices. It will also serve as an excellent reference tool for experienced workers in the field.

The 659-page *Rare Earth Doped Fiber Lasers and Amplifiers*, edited by Michel J.F. Digonnet, was published in 1993 and is available in hardcover for \$165.00 US. To order, contact Marcel Dekker, Inc., 270 Madison Avenue, New York, NY 10016 USA; Tel: 212 696 9000; Toll Free: 800 228 1160; Fax: 212 685 4540, or contact the company at Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland; Tel: 061 261 8482; Fax: 061 261 8896. ▲

Australian Workshop Proceedings

Rare Earths '93 Processing and Utilisation Workshop Papers, the proceedings of the workshop held at Lucas Heights Research Laboratories, Sydney, Australia, October 8, 1993, is a book containing 16 papers that were presented at the workshop. It covers the topics of processing and chemistry; rare earth mineral processing; and rare earth alloys used in magnets.

The papers include: "Rare Earth Mineralogy of the Olympic Dam Cu-U-Au-Ag Deposit, South Australia", "The Behaviour of Radionuclides in the Processing of Rare Earth Minerals", "Ore Characterization of a Detrital Heavy Mineral Deposit", "The Use of Radiotracers in the Study of Solvent Extraction Kinetics", "Hydrogenation and Disproportionation Reactions in HDDR Processed $\text{Sm}_2\text{Fe}_{17}$ Based Magnets", and "Preparation and Magnetic Properties of High Energy Ball Milled NdFe(CoZr)B Permanent Magnet Powders". Some of the papers also cover topics on the preparation of lanthanide complexes, kinetic studies of solvent extraction of yttrium, regiospecific carbon-fluorine activation by rare earth organometallics, and considerations of manufacturing magnetostrictive transducer rods.

The 148-page soft cover *Rare Earths '93 Processing and Utilisation Workshop Papers* was published in 1993 and is available for \$A65 (Australian dollars only). Orders are to be addressed to: Australian Mineral Foundation Bookshop, 63 Conyngham Street, Glenside SA 5065, Australia; Tel:618 379 0444; Fax:618 379 4634; Telex:AA87437 AMFINC. ▲

Really Cool Er_3Ni

A prototype superconducting permanent magnet, able to reach and maintain 4 K without cooling by liquid helium, was announced last November by Toshiba Corporation (*MRS Bulletin*, 19, [3], p. 13 (1994)).

The new Toshiba system uses a Gifford-McMahon (GM) refrigerator which uses Er_3Ni as the regenerator material to reach and sustain temperatures of 4 K. The coil of the magnet is made of Nb-Ti superconducting wire, which is relatively easy to work with and is inexpensive. The Nb-Ti magnet coil is 180 mm in diameter and is housed in a vacuum container 650 x 500 x 490 mm, which, according to Toshiba, is one third the size of a conventional liquid-helium-

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RE Radiation Detectors

An article which appeared in *Prog. Crystal Growth and Charact.*, 23, [1-4] 245-311 (1991), but published in 1992 and authored by M. Ishii and M. Kobayashi, reviews the recent progress in crystal growth technology and how they are used to detect radiation. "Single Crystals for Radiation Detectors" provides a basic background in the characteristics and uses of scintillators and provides physical, emission, and other properties of these materials. Scintillation crystals doped with Ce^{3+} , Eu^{3+} , Pr^{3+} , and Tb^{3+} are covered. Scintillation characteristics of $\text{Ce:Gd}_2\text{SiO}_5$ (Ce-GSO) and the effect of CeO_2 concentration on light output is an example of the information included in the review. Other crystals include rare earth-doped: Lu_2SiO_5 , YAlO_3 , CdF_2 , and CaF_2 .

Scintillation crystals that are used in x-ray computed tomography (CT), positron emission CT (PET), nuclear and high energy physics detectors, astrophysics, and gamma-ray detectors for underground drilling operations are included.

One of the recent uses for these radiation detectors, using CT scanner technology established for medical diagnosis, is nondestructive evaluation (NDE) in industry. These scintillators can be used to inspect mechanical parts such as pipes, shafts, propellers, engines, motors and pumps, as well as fluids and rocket fuel. Safety and reliability of each of these components can be determined by detecting defects in the material. However, industrial applications require a much higher output power and a better detection capability, so new radiation detection crystals are required. A huge advantage of NDE is that it allows the inspection of assemblies without the need to take the device to be inspected apart or out of service.

One of the aspects of the paper that makes this review interesting is the section regarding research and development of the new dense, fast, and radiation-hard scintillators. These new cerium-doped materials will find uses in high-energy physics.

"Single Crystals for Radiation Detectors" contains 48 figures, 11 tables, and 243 references. ▲

cooled magnet. The current is supplied to the magnet by Bi-oxide superconducting rods. Toshiba is expected to commercialize this new technology within the next few years. ▲

Transport and Thermal Properties

The Hiroshima Workshop on Transport and Thermal Properties of *f*-Electron Systems (T³PfS) was held August 30 to September 2, 1992 near Hiroshima, Japan. The conference brought together scientists actively involved in the research of 4*f*- and 5*f*-electron systems; particularly the transport and thermal properties such as electrical resistivity, Hall effect, thermoelectric power, thermal conductivity, thermal expansion and specific heat.

Transport and Thermal Properties of f-Electron Systems is the proceedings from the conference and focuses on five major topics: Kondo-lattice semiconductors, superconductivity of *f*-electron systems, anomalous transport and thermal properties of 4*f*- and 5*f*-electron compounds, low-carrier heavy-electron systems, and theoretical investigation heavy-electron and mixed-valence states. The information and research results are dominated by cerium-based compounds (CeNiSn , $\text{Ce}_2\text{Bi}_4\text{Pt}_3$, $\text{Ce}_2\text{Pt}_3\text{Sb}_4$, $\text{Ce}_2\text{Pt}_3\text{Bi}_4$, CeRu_2Si_2 , CeCu_2Ge_2 , CeSb and others) and Yb compounds. A separate section on short presentations focuses on electrical resistivity of CeNiSn , specific heat in Yb monopnictides and low energy excitations in CeSb and Yb monopnictides. The summary chapter, by T. Kasuya, provides not only an overview of *f*-element research and knowledge, but also where future research should lead us. He talks primarily of impurity Kondo states, low carrier-semimetal-narrow gap systems, Fermi surface and mass enhancement, non trivial gap states, heavy fermion superconductivity, and transport properties of *f*-electron systems.

All of the papers make the book an excellent review of both the recent advances and historical background of each topic and is a superb text for researchers working in the field of solid state physics.

The 318-page hardcover book *Transport and Thermal Properties of f-Electron Systems* was published in 1993, edited by G. Oomi, H. Fujii, and T. Fujita and includes author and subject indices. The book is available in the U.S.A. and Canada for \$89.50 US and elsewhere for \$107.40 US by contacting: Plenum Publishing Corporation, 233 Spring Street, New York, NY 10013 USA. ▲

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

Chinese Rare Earths

For the past few years, the entry of Chinese rare earths into the world market has had definite economic effects on western rare earth industries. A review prepared by Dudley J. Kingsnorth and Karen Harries-Rees of Ashton Rare Earths Ltd., West Perth, Western Australia, summarizes the current status of Chinese rare earth production and its impact on the world-wide rare earth industry [*Ind. Min.*, July, 1993, 45-9 (1993)].

According to the paper "Chinese Rare Earths The Dragon Has Entered", the United States and China dominate world production of light rare earths from primarily bastnasite deposits located at Mountain Pass, California and Baotou, Inner Mongolia, respectively. Less abundant yttrium and other heavy rare earth mining operations are located at xenotime placer deposits in Malaysia and Thailand, and increasingly, from ion adsorption clays in southern China.

The authors state that current world reserves of rare earths are estimated to be about $70\text{-}90 \times 10^6$ metric tons (mt) which should supply current and projected demands for these materials for the next 500 years. The largest share of reserves are located in China and represent over 50% of the world total. The United States owns 17% of the total, Australia 6.4%, India 2.9%, leaving the rest of the world to claim the remaining 23.7%.

China currently has over 20 separate commercially-viable rare earth deposits with the major source located at a bastnasite/monazite deposit near Baotou, Inner Mongolia. This huge mining operation is a source of light and medium rare earths which is obtained in concentrate form as a by-product from iron ore mining. Baotou production results from a fortuitous combination of a coexisting mining operation (iron ore) and the reasonably simple and inexpensive separation of rare earths from secondary minerals extracted from the open pit deposit.

Regardless of potential, Chinese production of monazite has been falling steadily, from 1,500 mt REO (rare earth oxide) in 1987 to 610 mt in 1991. Xenotime production has also fallen, from 100 mt REO in the late 1980's to 80 mt in 1990, and still further to 40 mt in 1991. Production of bastnasite and ionic adsorption ores peaked in 1988 at 16,780 mt REO and fell to 8,500 mt REO in 1991. Total REO production in 1988 was 29,640 mt. Total capacity of Chinese rare earth production was claimed to be 30-35,000

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mt annually in the late 1980's, but actual production had dropped to about 16,150 mt by 1991.

For the years 1988-92, the level of annual domestic Chinese consumption of rare earths has averaged roughly 20,800 mt concentrates and about 7,500 mt processed rare earth oxides for a total of 28,300 mt REO. In fact, Chinese rare earth consumption is estimated to represent about 25% of world demand and worth about \$400m US, according to the authors. The major area of rare earth usage in China is in metallurgical applications and accounts for 44% of total consumption, as compared to 23% in western nations. Catalysts earns the second strongest share of the market at 26% (29% in the west). The use of rare earths in the glass industry is tops in the west at 33% of total consumption, but only 10% in China. This gap is expected to close drastically in the next few years as China develops its CRT industry. Other important areas of domestic consumption is in agriculture and textiles.

The most significant growth of Chinese rare earth usage has been in high tech applications. In 1990, 23 mt of phosphors were used in trichromatic fluorescent lamps and 20 mt for color television tubes. These figures represent growth of 53% and 33% respectively, since 1989. Consumption of processed rare earths in China is growing at a rate of 10-14% per year and matches the growth of China's Gross National Product (GNP).

A direct result of the entry of Chinese rare earths into the world market is the depression of prices. The key victim to falling prices has been yttrium oxide, with a decrease in price of 85% during the period 1988 to 1993. Most of the other rare earths are currently holding only 40-60% of their 1988 value. Western producers have not been the only casualty of these falling prices, other non-western producers in India, southeast Asia and even China have suffered from this downturn. Ironically, even some Chinese producers have been victims of their own success and recently find themselves in the unenviable position of having to scramble for market share. The Chinese government may control future production in order to keep prices from falling.

As the markets and demand for rare earths continue to grow world-wide, it will be interesting to see how the producers of these important materials adjust in the next few years. ▲

Humidity Sensor

Humidity sensors for use in industry, agriculture, and in environmental controls for use in office buildings and large complexes are important applications for sensor technology. These sensors utilize porous ceramic materials that detect the presence of water, or other gases dissolved in air. The physical principle of humidity measurement with ceramic (protonic-type) sensors is the resultant change in resistivity or capacitance as a result of water vapor absorption and/or capillary condensation in the pores of the sensor element. It has been known for some time that some semiconducting perovskite-type oxides (ABO_3) where A is an alkaline earth metal ion, that is sensitive to humidity, and B is a transition metal, could be used as sensors. The humidity sensitivity of these compounds are enhanced by partially substituting the A-site element with a rare earth ion.

A recent paper by H.K. Ardakani et al. [*J. Mater. Sci. Lett.*, 12, 63-5 (1993)] reports on the preparation of a La^{3+} -doped $BaTiO_3$ semiconductor thin film that was deposited by excimer laser ablation. The semiconductive humidity sensor action of this material is known to be surface sensitive, so the authors wanted to discover if controlling the composition and microstructure of the film would improve performance.

A lanthanum-doped barium titanate pellet which was prepared by standard chemical methods, and found to have a resistivity $508 \Omega \text{ cm}$ at room temperature and a Curie point of 120°C , was used in the study. This pellet was then laser ablated by a KrF excimer laser and deposited on a quartz substrate. Texturing of the film surface was prevented by continuously rotating the quartz target at 10 r.p.m. The film was then annealed, in situ, in ambient oxygen at 450°C for 20 minutes and slowly cooled.

Humidity adsorption testing was carried out at room temperature in a closed chamber under relative humidity conditions from 10 to 90%. The adsorption response times were determined by conductivity measurements and found to be within 2-3 seconds, which is excellent for a humidity sensor. The results show that La^{3+} -doped $BaTiO_3$ materials have promise as humidity sensors for various applications. ▲

THULIUM, atomic number 69, was discovered in 1879 by P.T. Cleve and was named for Thule, the ancient name for Scandinavia.

Quality Assurance ISO-9000 Series

RIC acknowledges four more companies who have achieved the International Organization for Standardization accreditation (ISO): Rhône-Poulenc Basic Chemicals Company, Molycorp, Inc., Vacuumschmelze GmbH, and GE Lighting Chemical Products Plant. The certification, ISO-9002, identifies those companies who have successfully completed a rigorous series of inspections of their quality management systems.

We recently discovered that Rhône-Poulenc Basic Chemicals Company Rare Earth facility, Freeport, Texas, earned ISO-9002 in December, 1992. This makes Rhône-Poulenc the first rare earth company that we know of that has achieved this level of excellence.

Molycorp, Inc. received ISO-9002 certification for its quality systems at its lanthanide-processing plant at Mountain Pass, California, and its sales office at White Plains, New York.

Vacuumschmelze GmbH, Hanau, Germany, the largest producer of rare earth permanent magnets in Europe, was recently assessed by the German Association for the Certification of Quality Systems (DQS) and found to have fully met the requirements of ISO-9001. The standard was met by the company's facilities at Hanau, Speyer, and Schrobenhausen.

The General Electric Chemical Products Plant, located in Cleveland, Ohio, produces halophosphors that are used in fluorescent lamps. The company provides material for customers in 30 countries around the world and has recently met ISO-9002 requirements as well. The ISO-9002 standard covers 18 different activities, ranging from purchasing raw materials to customer feedback.

RIC congratulates all four companies on meeting these world-wide standards for quality. If your company has been certified as meeting an ISO-9000 standard, please inform us of this achievement for future listing in this column. ▲

Takuo Takeshita

Dr. Takuo Takeshita was promoted to General Manager of the Central Research Institute of Mitsubishi Materials Corporation in June, 1993. The laboratory, located in Omiya, Japan, has about 500 personnel. RIC congratulates Dr. Takeshita on his new position. ▲

Photostimulated Optical Memory

Optical memory based on photostimulated luminescence (PSL) in electron trapping phosphor materials for optical storage have uses in optical Boolean logic operations, two dimensional optical associative memory, and optical neural networks. Phosphors are used to store information which can later be extracted by a laser beam scanning the phosphor material. The unique features of electron trapping phosphors that exhibit PSL is that they have high potential for high bit storage densities, high data transfer, and fast recovery speeds [*J. Appl. Phys.*, 74, [2], 1445-7 (1993)].

H. Nanto, et al. discovered that transparent KCl single crystals, doped with Eu, exhibit efficient PSL for optical stimulation. The Eu:KCl crystals were grown by the Bridgeman method from a mixture of molten KCl and EuCl_3 hexahydrate. The Eu^{2+} concentration of the $5 \times 5 \times 1$ mm crystals was 1.4×10^{18} ions/cm³. The specimens were kept at 550°C for 30 minutes then quenched to room temperature to disperse the aggregation of Eu impurities.

After preparing the samples, the authors exposed the Eu:KCl crystals to visible light following ultraviolet (UV) irradiation at room temperature. A PSL emission peak of 420 nm was then observed which is attributed to the inner ionic transition ($4f^6 5d \rightarrow 4f^7$) of isolated Eu^{2+} ions, which occupy cation sites in the KCl crystal. Thus, a transparent Eu-doped KCl crystal can be used to store optical information using UV light, then extract the same information using visible light.

This phosphor may also be used in devices for arithmetical computations such as subtraction, addition and multiplication within a dynamic range covering a few orders of magnitude, since the 420 nm emission intensity is proportional to the UV radiation dose. This emission lifetime was about 1.6 μs which is fairly good for high speed operation of optical memory. With these developments, Eu:KCl phosphors may find uses as erasable and rewritable optical memory devices. ▲

Chinese Book

RIC has received a copy of *Rare Earth Optical Glass*, a softcover book, printed in Chinese and published in 1989. It contains 9 chapters and 326 pages and was written by

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Fluorine-Doped Magnets

It has been known that by adding carbon or nitrogen to R_2Fe_{17} (R=rare earth) permanent magnet systems, the magnetic anisotropy and Curie temperatures can be improved. Recently, two German scientists, M. Fähnle and T. Beuerle [*Phys. Stat. Sol. (b)*, 177, K95-7 (1993)] have shown, by band structure calculations, that doping fluorine into these rare earth interstitial permanent magnets may also improve magnetic properties.

They found that adding fluorine increases the interatomic distances between the Fe atoms, as nitrogen and carbon have been demonstrated to do experimentally, which could lead to higher Curie temperatures. The calculations were performed for hypothetical $\text{Y}_2\text{Fe}_{17}\text{F}_3$. Because the atomic radius of F is similar to that of N, they assumed the same geometrical shape of atoms as in the nitrogenated sample. The resultant structure in the p-density of states would be far below the Fe band, negating hybridization with the Fe states, and hence no additional structure in the density of states at the lower Fe band edge would occur. If this prediction is verified through experimentation, then the explanation could lie in the avoidance of the counteractive chemical effect, which would indicate that fluorine would be the optimum dopant for large magnetic moments.

The authors admit to two uncertainties in the calculation. The first is the atomic-sphere approximation, which is critical for interstitial compounds because of the large overlap of the atomic spheres for the various constituents. This would effect the details of the charge transfer, which could be quite large in $\text{Y}_2\text{Fe}_{17}\text{F}_3$. The second is that the sample volume was not determined by the atomic radius of F, but more appropriately by a partially negative F atom, which would mean that the sample volume is much larger than for the nitrogenated system. This would yield a larger geometrical effect than for the present calculation and a further increase in the magnetic moment per formula unit, but not necessarily a larger magnetization because of the larger volume.

It will be interesting to see experimental results of fluorinated rare earth permanent magnets. ▲

Guanming Qiu, Department of Materials Engineering, Changchun College of Optics and Fine Mechanics, 130022 Changchun, Jilin, China. ▲

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Plus Shipping...

RIC reviewed the 192-page *A Short Course in Permanent Magnet Materials*, by William A. Cassaday, on page 3 of the September 1, 1993 issue of the *RIC News*. However, air-mail shipping costs of \$15.00 US for orders received outside the USA were not included in the quoted price. The book can still be purchased at the special price of \$49.99 US, plus \$15.00 US for foreign customers. Contact SJL Publishing Company, P.O. Box 152, Hanna, IN 46340-0152 USA; Tel: 219 324 9678; Fax: 219 324 3606. ▲

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SG Magnets Limited

SG Magnets Limited announces that it has been appointed as a distributor of Neodymium-Iron-Boron magnets for San Huan New Materials and High-Tech, Inc. in China. SG Magnets has been a producer of sintered AlNiCo permanent magnets, but now, with this new joint venture, is able to offer a range of plastic bonded ferrite and Nd-Fe-B materials. The company uses compression molding and injection molding technologies to produce these permanent magnets.

For additional information on products and services, contact: Richard Anderson, SG Magnets Limited, Tesla House, 85 Ferry Lane, Rainham, Essex RM13 9YH, UK; Tel: 44(0)708 558 411; Fax: 44(0)708 554 021. ▲

Joint Venture Ends

France's Rhône-Poulenc and Japan's Sumitomo Metal Mining have decided to end their joint venture, Nippon Rare Earth, which is located in Japan. The joint venture between these two companies was created in 1986, which opened markets in Japan for Rhône-Poulenc's products. In 1987, Nippon Rare Earth started producing materials for the rare earth market, using the French company's imported intermediates.

Rhône-Poulenc Japan will continue to import rare earths and will supply intermediates to customers in Japan. The company has also acquired a minority stake in Anan Kasei, a subsidiary of Santoku, which is a major customer. They will specialize in the production of rare earth salts and oxides, while Santoku Metal Corporation will handle marketing. ▲

Rare Earths & Minerals

A new company has stepped into the business of trading and distribution of rare earths in American and European markets. R.E.M. s.p.r.l. is active in delivering rare earths of primarily Chinese and Russian origin from stock located in Rotterdam. The company offers materials for use in the electronics, metallurgical, ceramic, magnet and glass industries.

For more information, contact: Mr. Vincent Willemart, R.E.M. s.p.r.l., Avenue du Zodiaque, 48, 1410 Waterloo, Belgium; Tel: 32 2 351 16 40; Fax: 32 2 351 2008. ▲

**Joseph G. Cannon
(1924-1993)**

Joseph G. Cannon, a long time rare earther and former employee of Molycorp, died December 27, 1993. Mr. Cannon joined Union Molycorp as a sales manager for rare earths and chemical products in 1965, advancing to Director of Product Development in 1969 and Manager of Modern Metals in 1971. He retired in 1986. He was instrumental in forming joint ventures with other organizations to make industrial uses of rare earths a reality. Most of his publications in the field dealt with the markets and applications of the rare earths. It was his background, training, and experience which helped shape the rare earth industry as we know it today. In addition to his rare earth activities he was an accomplished musician and he often displayed his talents by playing either the saxophone or clarinet at some of the rare earth research conferences. The rare earth community owes a great deal of thanks and gratitude to Joseph G. Cannon. ▲

Eveready Battery Deal

The Eveready Battery Company purchased the rechargeable battery division of Gates Energy Products in a deal reached last August. However, the aerospace and lead-acid battery portions of Gates were not included in the purchase. The rechargeable battery manufacturing facility is located near Gainesville, Florida, and produces both nickel-cadmium and nickel-metal-hydrate batteries, which include LaNi₅ based materials. The facility is operated by Energizer Power Systems of Eveready Battery Co., Inc. and sells their batteries under both the Eveready, and Gates' Millenium brand. About 130 million cells are manufactured annually and are shipped to Juarez, Mexico, Hong Kong, and Newcastle, England for assembly into battery packs for a variety of products, including laptop computers, cellular phones and cordless tools. The new deal will make Eveready the world's largest battery manufacturer and will now produce both nonrechargeable and rechargeable batteries. Other producers of rechargeable batteries are Sanyo and Panasonic in Japan, Varta in Germany and Saft in France. Eveready is a division of the Ralston Purina Corporation. ▲

New Laser Crystal

A new efficient laser crystal has been developed and tested at the Center for Research in Electro-Optics and Lasers, University of Central Florida {*Appl. Phys. Lett.*, 62, [11] 1197-9 (1993)}. X.X. Zhang et al. report that Nd-doped GdLiF₄ (GLF) works well as a laser crystal in both continuous wave (cw) and pulsed laser pumped operations. Currently, Nd³⁺ lasers have advantages of small size, high efficiency, and a long operating lifetime. The only other commercially-available laser glass crystals available for these applications are Nd:LiYF₄ (YLF) and Nd:Y₃Al₅O₁₂ (YAG).

The GLF crystal can accept a high Nd³⁺ concentration without unacceptable degradation of crystal quality, unlike YLF and YAG. It is the ability of the crystal to accept a higher Nd³⁺ concentration that allows the crystal to be smaller in size.

Single crystals of Nd:GLF were grown by the Czochralski pulling technique with the composition of the LiF:GdF melt of 68:32 and an a-axis Nd:YLF rod used as seed. The crystal was extracted from the melt at a rate of 0.3 mm/hr while being rotated at 15 rpm. The Nd³⁺ doping concentrations in the two crystals used in spectroscopic and lasing tests were 4 and 1 at.%, respectively.

Spectroscopic and lasing tests revealed performance similar to those of Nd:YLF. A slope efficiency of 60% was demonstrated in both cw and pulsed laser operation. The absorption coefficient of Nd:GLF is more than three times higher than that of Nd:YLF, which is probably due to the combined effects of the large Nd ion concentration and the Gd³⁺ ions (⁸S_{7/2} to ⁶P_{7/2}, ⁶I_{7/2-11/2} transitions) in the GdLiF₄ host material. The emission spectra are similar to that of Nd:YLF, but fluorescence decay takes about 475 μs, as compared to roughly 192 μs for YLF. The similarities between absorption and emission spectra, as well as the fluorescence decay times of Nd:GLF and Nd:YLF indicate that these two crystals are isostructural.

The lasing threshold is 50 μJ, a little higher than YLF, but this, as well as the slope efficiency, is expected to improve by improving the optical quality of the crystal. The authors report that tests on successive crystals have shown an increase in lasing efficiency. ▲

CeO₂ oxidizes iron in glass.

Supporters 1994

Since the March issue of the RIC News went to press, RIC has received support from 8 new family members, and renewed support from 30 other organizations. RIC recognizes those long-term supporters each year in our June issue (see front page for 10 and 20-year supporters). The supporters from the fourth quarter of fiscal year 1994 who wish to be listed, 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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