



# RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE  
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No. 1



Front row from left: A. V. Golubkov, T. I. Volkonskaja, L. S. Parfen'eva, G. A. Marchenko, S. G. Shul'man, Back row from left: L. N. Vasil'ev, V. M. Sergeeva, V. V. Kaminskii, V. V. Tichonov, A. I.

Shelich, I. A. Smirnov, I. N. Kulikova, N. N. Stephanov, T. T. Dedegkaev.

## A. F. Ioffe Physico-Technical Institute— Rare Earth Semiconductor Research

In 1973 at the A. F. Ioffe Physico-Technical Institute, a rare earth research group headed by Prof. I. A. Smirnov was organized. The main research directions of the group are the search for, preparation and study of rare earth semiconductors, which have possible application in microelectronics, lasers and devices for recording, storage and processing of optical information.

An up-to-date technology for the synthesis and preparation of single crystals and thin films of many rare earth semiconductors has been developed. The single crystals are grown by Bridgman's method using an induction furnace. Several methods are employed for the thin film preparation: evaporation from three independent sources, flash

evaporation and RF-sputtering. In recent years, single crystals and thin films have been obtained from the following rare earth compounds:  $RX$ ,  $R_2X_3$ ,  $R_3X_4$ ,  $RB_6$  and solid solutions:  $R_2X_3-R_3X_4$ ,  $Sm_{1-x}R_x^{+3}X$  ( $R$  = rare earth metal,  $X$  = S, Se, Te). Single crystals of several compounds were produced for the first time.

The physico-chemical, structural, electrical, thermoelectrical, galvanomagnetic, magnetic, thermal and optical properties of the above-mentioned materials have been studied. The measurements were made in a wide range of temperatures and magnetic and electric fields. Some investigations are carried out at hydrostatic pressure. There is a small theoretical group to interpret the results.

Special interest in recent years has been paid to the investigation of the semiconductor-metal and metal-semiconductor phase transitions in SmS. It is known that at the hydrostatic pressure of 6.5 kbar ( $T = 300$  K) SmS undergoes an isostructural (NaCl-NaCl) first order semiconductor-metal phase transition. With the removal of pressure there is a reverse (metal-semiconductor) transition. Thin films of the metallic phase of SmS which are stable at atmospheric pressure have been prepared. The reverse metal-semiconductor transitions in SmS metallic films occur only after heating up to 200-400°C. This property has been used for information recording by a laser beam. The minimum energy necessary to induce the phase transition and the threshold recording energy density were measured (the latter was found to be  $\sim 0.046$  J/cm<sup>2</sup>), the phase

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## ISOTOPES

If isotopes are what interest you, then Books B5 and B6 of the *Gmelin Handbuch der Anorganischen Chemie, System 39, Rare Earth Elements* should definitely be on your list. The preparation, separation, enrichment and decontamination of both stable and unstable isotopes of the rare earth elements plus yttrium and scandium are detailed. Additional topics presented include applications, detection and determination, chemical reactions with various elements, organic and inorganic compounds, and catalytic actions. Volume B5 contains information on the isotopes of Sc, Y and La-Sm and volume B6 treats the isotopes of Eu through Lu. Information on over 350 nuclides of the 17 rare earth elements was gathered from the literature up to the end of 1976.

Published in 1978 by Springer-Verlag, Book B5 is 152 pages long and costs \$217.70 and Book B6 is 184 pages long and costs \$267.30. Both volumes contain an English table of contents, preface, margin notes and a brief review at the beginning of each chapter.

## Two Rare Earthers Die

RIC has been informed of the deaths of two well known rare earthers, Dr. C. E. Lundin and Dr. W. H. Zachariassen, during September and December, respectively, last year. Dr. Lundin received his M.S. in metallurgy from the Illinois Institute of Technology in 1952. In 1955, he joined the Denver Research Institute and in 1970 he received his Ph.D. from the University of Denver. At the time of his death, he was head of the Metallurgy and Materials Science Division of the Denver Research Institute and Senior Research Metallurgist. He is best known as an authority on rare earth metals and metal hydrides.

Dr. W. H. Zachariassen died last December after a short illness at the age of 73. Zachariassen, a professor emeritus from the University of Chicago, originally came to the U.S. from Norway. One of the senior physicists on the Manhattan Project, he is best known to the rare earth community for his crystal chemistry study of various rare earth compounds and most recently on the various polymorphs of cerium.

## REers on the Move

L. A. Luyckx, recently named as an executive vice president of REMACOR, has left that company to form his own consulting firm under the name Metserve, Inc. which is located in Newcastle, PA.

Ronson has announced the promotions of three of its staff. They are E. Klein to the position of vice president-manufacturing, W. A. Otis to vice president-marketing and S. R. Poch to the position of controller of Ronson Metals Corporation. All promotions will be in effect January 1, 1980.

## RE Handbook

*Volume 3: Nonmetallic Compounds I* and *Volume 4: Nonmetallic Compounds II* of the *Handbook on the Physics and Chemistry of the Rare Earths*, K. A. Gschneidner, Jr. and L. Eyring, eds., have been published by North-Holland Publishing Co., Amsterdam in 1979. Volume 3 is 664 pages in length and costs \$97.75 (Dfl. 220). Volume 4 contains 590 pages and costs \$86.75 (Dfl. 195). Subscription price for 3 and 4 are \$83.00 (Dfl. 187) and \$73.75 (Dfl. 166), respectively. It is anticipated that this will become an open ended series with supplements being issued on a regular basis to keep the Handbook up-to-date. Chapters and authors are listed below.

Volume 3:  
 "Geochemistry and mineralogy of the rare earths" L. A. Haskin and T. P. Paster  
 "Separation chemistry" J. E. Powell  
 "Theoretical chemistry of rare earths" C. K. Jørgensen  
 "The absorption and fluorescence spectra of rare earth ions in solution" W. T. Carnall  
 "Complexes" L. C. Thompson  
 "Hydrides" G. G. Libowitz and A. J. Maeland  
 "The binary rare earth oxides" L. Eyring  
 "Mixed rare earth oxides" D. J. M. Bevan and E. Summerville  
 "Perovskites and garnets" C. P. Khatkhat and F. F. Y. Wang  
 "Rare earth molybdates" L. H. Brixner, J. R. Barkley and W. Jeitschko  
 Volume 4:  
 "Sulfides, selenides and tellurides" J. Flahaut  
 "Halides" J. M. Haschke  
 "Rare earth pnictides" F. Hulliger

## REs Indentured

Rare earthers have been known to get together at conferences and meetings and "chew the fat" about this or that rare earth application. Well, there finally is a rare earth application with which anyone can literally chew the fat. M. Smyth and J. Lee-You have patented a process in which small percentages (in the molar range) of cerium and terbium oxides are incorporated into dentures (U.S. Patent 4,170,823). Apparently natural teeth fluoresce under ultraviolet light while false teeth do not. Smyth's and Lee-You's patent corrects this oversight. Large-scale production of the fluorescing false teeth has not begun yet so producers do not foresee any cavities forming in the cerium or terbium oxide supplies.

"Chemistry and physics of R-activated phosphors" G. Blasse  
 "Rare earth lasers" M. J. Weber  
 "Nonradiative processes of rare earth ions in crystals" F. K. Fong  
 "Chemical spectrophotometric and polarographic methods" J. W. O'Laughlin  
 "Trace element analysis of rare earth elements by spark source mass spectrometry" S. R. Taylor  
 "Analysis of rare earth matrices by spark source mass spectrometry" R. J. Conzemius  
 "Optical atomic emission and absorption methods" E. L. DeKalb and V. A. Fassel  
 "X-ray excited optical luminescence of the rare earths" A. P. D'Silva and V. A. Fassel  
 "Neutron activation analysis" W. V. Boynton  
 "Mass-spectrometric stable-isotope dilution and analysis for lanthanides in geochemical materials" S. Schuhmann and J. A. Philpotts  
 "Shift reagents and NMR of paramagnetic lanthanide complexes" J. Reuben and G. A. Elgavish  
 "Bioinorganic chemistry: lanthanides as probes in systems of biological interest" J. Reuben  
 "Toxicity" T. J. Haley  
 All four volumes are available from Elsevier's Science Division, P.O. Box 211, 1000 AE Amsterdam, The Netherlands.

## Steel Applications

The theory and practice of rare earth additions to steel have been reviewed by P. E. Waudby (*Intern. Metals Rev.* 1978, [2] 74-98). The occurrence, physical properties and affinity of the rare earth metals for O, S, C and N and the free energy of formation of various rare earth compounds are reviewed along with theories for the prediction of rare earth activities in steel. The effects of rare earth additions including deoxidation, desulfurization, inclusion formation, cleanliness and modification of mechanical properties are discussed. Finally various aspects of commercial application are presented. These include the type of rare earth alloys used, addition rates, optimum conditions and several different methods of adding the rare earths in the ladle and the mold. Possible future areas of study of rare earth addition to steel are mentioned.

## Industrial Applications

A two day American Chemical Society Symposium on the Industrial Applications of Rare Earth Elements has been scheduled for August 24-29, 1980 in San Francisco, California. Organized by K. A. Gschneidner, Jr., the symposium will consist of invited talks in four areas: metallurgical applications, ceramics and catalysts, electronics and phosphors, and miscellaneous applications. Additional information will appear in the *RIC News* as soon as it becomes available.

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K. A. Gschneidner, Jr. ...Editor  
Bernie Evans...Staff Writer

## Address Change

The Goldschmidt Chemical Corporation (formerly Th. Goldschmidt Products Corporation) has moved to Route 2, Box 101, Hopewell, Virginia 23860. Their new telephone number is (804) 541-8658.

## Sintering Symposium

The Proceedings of the International Symposium on Factors in Densification and Sintering of Oxide and Non-Oxide Ceramics, held October 3-5, 1978, at Hakone, Japan, and edited by S. Sōmiya and S. Saito, have been published by Gakujutsu Bunken Fukyu-Kai in 1979. Eight of the 50+ articles deal with rare earth-stabilized zirconia, rare earth-containing multicomponent oxides,  $Y_2O_3$  ceramics,  $Y_2O_3-Si_3N_4$  composites, gas turbine rotors and PLZT applications. The book is 677 pages long and costs \$40.00. Copies may be obtained from Bunken Fukyu-Kai c/o Tokyo Institute of Technology, Ookayama, Meguro, Tokyo 152, Japan.

## About Garnets—

"Everything you always wanted to know about garnets but were afraid to ask" could be an alternative title for a new release in the *Landolt-Bornstein Numerical Data and Functional Relationships in Science and Technology Series, Group III, Volume 12, Part a: Magnetic and Other Properties of Oxides and Related Compounds*, K.-H. Hellwege and A. M. Hellwege, eds., Springer-Verlag (1978). The cloth-bound volume costs \$225.00 (DM 510) and contains 520 pages. Group III, Volume 12, Part a is a supplement to Group III, Volume 4, Part a which carries the same title and was published in 1970. Taken together these books constitute a comprehensive critical evaluation of the information available up to 1976/1977 concerned with the crystallographic, magnetic, electric, optical, thermodynamic and elastic properties of garnets, perovskites and perovskite-related compounds.

For more information contact Springer-Verlag New York, Inc., 175 Fifth Avenue, New York, NY 10010 or Springer-Verlag KG, Postfach, Heidelberger Platz 3, D-1000 Berlin 33, West Germany.

## BENEFACTORS

Contributions were received from nine companies during the third quarter of FY 1980. Eight of the companies listed below renewed their support of RIC and one new member was added to our family. The number in parentheses is the number of years of support for the Center.

Aldrich Chemical Co., Inc., USA (1)  
British Flint & Cerium Manufacturers, England (8)  
Colt Industries—Crucible, Inc., USA (6)  
Comphania Industrial Fluminense, Brazil (8)  
General Electric Company, USA (5)  
GTE Laboratories, Inc., USA (8)  
Middlewest Investment Co., USA (2)  
Mischmetal & Flints Private, Ltd., India (4)  
Pokmen Company, Hong Kong (2)

## REs in the News

### Ce Solar Energy

Cerium oxide is under consideration in a process which uses solar energy to release hydrogen from  $H_2O$  according to scientists at the Oak Ridge National Laboratory. The cerium oxide is reacted with sodium hydrogen phosphates yielding sodium cerium phosphate. Sodium carbonate is added to this and heated in the presence of steam to produce  $CO_2$  and hydrogen.

### Fast Crystal Structures

A neodymium-doped glass laser has been used to take single-pulse extended x-ray absorption fine structure spectra of atoms having a molecular weight of 40 or less according to researchers at Battelle's Columbus Laboratories. The laser focus time is measured in nanoseconds. Several advantages would be time savings, x-ray data for light weight molecules and for molecules whose lifetime is measured in parts of a second.

### Bubble Memories Online

The first commercially available megabit memory device has been introduced by Intel Magnetics of Palo Alto, CA. Intel's support circuits and components for a megabyte memory

(Continued on page 4)

## Ce Senses REs

A new rare earth ion selective electrode which uses a cerium (IV) oxide membrane has been developed by Y. Takasaka and Y. Suzuki [*Bull. Chem. Soc. Japan* 52, 3455-6 (1979)]. A cerium concentration of 55% oxide/45% adhesive gave the closest response to the Nernst theory. The electrode's response behavior to trivalent lanthanum, praseodymium, dysprosium, lutetium and yttrium in solution plotted versus activity resulted in slopes of around 58 mV. Optimum pH range was from 3 to 5.5. Barium and zirconium did not interfere with the electrode, however alkali metals showed appreciable interference.

## 18th InterMag

A program of more than 29 invited and 252 contributed papers has been set for the 18th International Magnetism Conference to be held April 21-24, 1980 at the Sheraton Boston Hotel, Boston, MA, USA. Forty sessions will cover the newest developments in applied magnetism, related magnetic phenomena information storage technology and superconductivity. There will also be an exhibit of equipment, component materials, services and technical literature from prominent commercial firms. For registration information contact R. M. Josephs, Sperry-Univac, P. O. Box 500, Blue Bell, PA 19424.

## New Catalyst Bibliography

Molycorp, Inc. has announced the completion of a new bibliography on catalysis with the rare earths covering the years 1971-1976. 801 abstracts are included covering rare earth catalyst application in cracking, hydrocracking, alkylation and dealkylation, isomerization, hydrogenation, dehydrogenation, dehydration, reforming, hydrolysis and hydration, disproportionation, hydrocarbon conversion, halogenation, desulfurization, polymerization, oxidation, exhaust gas treatment and miscellaneous. This edition supplements the original bibliography which covered the period 1964-1970. Both are available free of charge by writing to Molycorp at 6 Corporate Park Drive, White Plains, NY 10604.

## RE Semiconductor

(Continued from page 1)

transition rate was estimated to be  $\sim 10^{-8}$  sec. The influence of various factors on the threshold recording energy density was assessed (time and wavelength of the recording pulse, film thickness, presence of the atmosphere). A recording was made with the density of  $3 \times 10^7$  bit/cm<sup>2</sup>.

The complex investigation of the metallic and semiconductor phases of SmS has contributed to the understanding of the band structure which has allowed the refinement of the theoretical model of the semiconductor-metal phase transition in this compound.

The Information Center on the Rare Earth Semiconductors of the Academy of Science USSR is also located at the A. F. Ioffe Physico-Technical Institute. This Information Center regularly publishes review books and a bibliography on rare earth semiconductors.

## 26th MMM

The twenty-sixth annual Conference on Magnetism and Magnetic Materials will be held November 11-14, 1980 at the Dallas Hilton, Dallas, Texas. The conference traditionally emphasizes both experimental and theoretical research on magnetism, the properties and synthesis of new magnetic materials and advances in magnetic technology. Those wishing to contribute a paper must meet an abstract submission deadline of July 25, 1980. For more information contact Dr. H. C. Wolfe, American Institute of Physics, 335 East 45th Street, New York, NY 10017.

## RE News

(Continued from page 3)

device can be constructed on 90 square inches of board space.

## Lasers and Bubbles

Lasers and magnetic bubble devices, two up and coming rare earth applications, have finally gotten together thanks to International Business Machine's (IBM) scientists. In europium-yttrium and lanthanum-yttrium gallium iron garnets the magnetic properties can be controlled by the gallium-iron distribution in various crystal locations. To tilt the distribution towards randomness lasers heat the garnet films almost to the melting point and then the films are rapidly cooled to affect the desired distribution/magnetic properties.

## Up- and Down-graded Lasers

With the addition of two neodymium glass amplifiers and other equipment the Australian National Laboratory in Canberra has upgraded its laser system to provide peak power of up to 250 GW. Studies to obtain very high spatial resolution x-ray images of plasma are continuing.

Shiva, the world's largest laser complex, was unexpectedly downgraded by the earthquake that rocked Northern California January 25, 1980. The 132-foot-long laser was knocked off its support pins when one inch diameter bolts, which held it to a metal frame, were broken. Scientists expect Shiva to be out of commission for at least a month for cleaning, repair and realignment.

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