RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
IOWA STATE UNIVERSITY / AMES, IOWA

Volume XI | March 1, 1976 | No. 1

A GREAT 10 YEARS

With this issue we celebrate our tenth birthday and during these ten years much has transpired. The golden age of science was at its peak, at least in America, when RIC was born and the emphasis was on understanding the basic laws of nature. Within a few years the pendulum began to swing toward the applied science and technology, and RIC was caught in the tide as our financial base shifted from the U.S. Atomic Energy Commission to the world-wide rare earth industry. In the eight intervening years the number of benefactors grew from five to a maximum of 40 in 1973; in total 57 companies have contributed financial aid.

RIC News

Ten years ago our first issue was mailed to a few hundred persons but by our first birthday we had 560 subscribers. In the following years we increased our circulation by about 23% per year, Fig. 1, and this issue is being mailed to over 3550 persons. Our readers from outside of the USA have increased from 20% to 33% of the total over the decade.

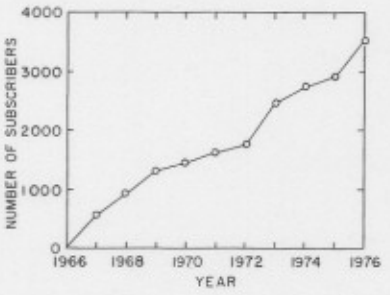

Fig. 1. **RIC News** subscribers as of January 1 for the year noted.

IS-RIC Reports

Our other major publishing activity is the preparation, writing and publication of state-of-the-art reviews and data compilations. To date seven have been distributed, and the last four (see below) are currently available (free) from RIC.

IS-RIC-4 "Rare Earth Metals in Steels", Nancy Kippenhan and Karl A. Gschneidner, Jr. (March 1970).
IS-RIC-5 "Thermochemistry of the Rare Earth Carbides, Nitrides and Sulfides fr Steelmaking", Karl A. Gschneidner, Jr. and Nancy Kippenhan (August 1971).
IS-RIC-6 "Thermochemistry of the Rare Earths. Part 1. Rare Earth Oxides, Part 2. Rare Earth Oxysulfides, Part 3. Rare Earth Compounds with B, Sn, Pb, P. As, Sb, Bi, Cu, and Ag", Karl A. Gschneidner, Jr., Nancy Kippenhan and O. Dale McMasters (August 1973).
IS-RIC-7 "Selected Cerium Phase Diagrams", Karl A. Gschneidner, Jr. and Mary E. Verkade (September 1974).

Information Inquiries

As an information center we receive requests for all kinds of information, data and assistance, even on non-rare earth materials. In the first eight years these information inquiries (IQ's) averaged about 200 annually, but with advent of service charges the number of IQ's dropped to nearly one-half of this figure. Of the IQ's received in the last two years only 42% were assessed service charges (see below) and of these 73% paid, 11% requested a waiver which were granted and 4% refused to honor the charge, and 11% are accounts receivable. The exceptions to imposing service charges are given below.

(1) No charges will be assessed to those companies which contribute to the support of RIC.
(2) Charges will be waived for those who state they do not have resources available to pay for the service.

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CONTRIBUTORS

Contributions were received in the third quarter from Allied Chemical Corporation, USA; British Flint & Cerium Manufacturers, England; and Companhia Industrial Fluminense, Brazil, all contributing for the fourth year; General Electric Company, Quartz & Chemical Products, USA who joins RIC's benefactors for the first time; W. R. Grace & Company, USA who has contributed to RIC for 8 years; Ohio Ferro-Alloys Corporation, USA, contributing for the second year; and Wako Bussan Co., Ltd., Japan who has contributed seven years. Benefactors for Fiscal Year 1976 now total 30.

THERMO REVIEW

The thermodynamics of the interaction of the lanthanides with other elements is the subject of a review and critical analysis by A. P. Bayanov [*Uspek. Khim.* **44**, 236-59 (1975); Eng. transl. *Russ. Chem. Rev.* **44**, 122-37 (1975)].

The experimental Gibbs free energies, enthalpies, and entropies of the interaction of lanthanides with halides, chalcogenides, pnictides, carbides, silicides, borides, hydrides, Al, Ga, In, Tl, Sn, Pb, Bi, Mg, Zn and Cd were analyzed and then compared with calculated values. Dissociation energies of gaseous rare-earth-gold compounds are briefly discussed. The relation of the thermodynamic properties of compounds across the lanthanide series is noted from the standpoint of the electronic structure of the components. The different behavior of europium and ytterbium is discussed. (360 ref.)

LaB_6 IS BETTER

LaB_6 single crystals have generated considerable interest lately due to their application as an electron source for microscopes. Papers by E. D. Gibson and J. D. Verhoeven [*J. Phys. E* **8**, 1003-4 (1975)] and T. Tanaka, E. Bannai, S. Kawai and T. Yamane [*J. Cryst. Growth* **30**, 193-7 (1975)] describe different methods for the preparation of single crystal LaB_6. Gibson and Verhoeven also describe a grinding device which allows the LaB_6 tips to be ground to a radius of curvature of less than 3 μm.

R. Shimizu, Y. Kataoka, T. Tanaka and S. Kawai have published 2 papers which deal with the application of LaB_6 single crystals as an electron source [*Japan J. Appl. Phys.* **14**, 1089-90 (1975) and *Appl. Phys. Letters* **27**, 113-4 (1975)]. The first paper reports the field emission pattern of a LaB_6 single crystal tip. Their second paper gives the results of a comparison of LaB_6 with tungsten in common electron microscopes (CEM) and scanning electron microscopes (SEM) under conditions which were developed for the tungsten cathode. Even though these are not the optimum conditions for LaB_6 emission, the authors found that the LaB_6 single crystal had higher brightness and better stability than the tungsten cathode in a CEM and SEM. Optimizing conditions for LaB_6 emission in the microscopes should further improve its performance.

RIC News

Vol. XI No. 1 March 1, 1976
published in
March, June, September and December
by
Rare-Earth Information Center
Energy and Mineral Resources Research Institute
Iowa State University

Second-Class postage paid at Ames, Iowa 50011

Telephone: Area Code 515-294-2272
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(3) No charges will be made for (a) information about a rare earth conference, (b) requests for information about the availability of commercial rare earth products or (c) requests for additional information on articles or material presented in the **RIC News.**

Our two year experience with the service charge has shown that many people are willing to pay for RIC's assistance and that the decrease in IQ's is much less than that experienced by other information centers when they started charging for their services.

Computerized Literature Retrieval System

On March 5 of this year we will have completed two years of retrieving information from our magnetic disk-storage system. As of February 1 we had 9567 documents indexed according to both authors (8913) and technical terms by subject and material (6945). Searches can be made on authors and/or technical terms, and can be limited to specific years or time periods if desired. Literature searches, especially if extensive (i.e. >100 references) can be supplied with both an author and subject index generated by the computer, enabling the requester to find the desired information more quickly and accurately than if he had to look over pages of citations. Each citation contains a document number, author(s), title, reference, and a list of the technical terms under which the document was indexed. We are adding current literature as it arrives at the Center while at the same time retroactively transferring the information in our files from before 1974 to the computer system. Most of the journal references are now stored on the magnetic disk, but reports, books and conference proceedings remain to be indexed. We hope to complete this in the next two years, but the large volume of papers in the last year has slowed our progress in indexing the older information.

Rare Earth Literature

As many of our readers know, the sources of information for our literature retrieval system come from them. Within a few months after a paper is published the author(s) usually receive a card from RIC requesting a reprint copy for our files, and your help in this regard is appreciated. We prefer a reprint over a duplicated copy, e.g. a Xerox copy, for two reasons—space and clarity, the latter is especially important if your article contains photographs.

Since our inception there have been two important trends concerning publications on rare earths (Fig. 2): the number of papers published on rare earths has nearly tripled and the number of USA papers, which accounted for slightly more than half of all papers published ten years ago, now only accounts for about one third. The numbers given in Fig. 2 are for papers, reports, books, etc. which deal with the physical metallurgy and solid state physics of the metals and their alloys and intermetallic compounds—our area of expertise. The total number of papers on the rare earths is roughly twice the values shown in Fig. 2. The Center has many papers in other areas but most of these are reviews or of a general nature.

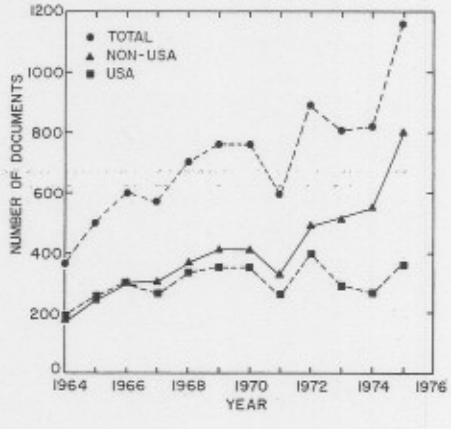

Fig. 2. The number of documents which deal with the rare earth metals, alloys and metallic compounds vs. the year of publication.

You're Better Informed with RIC

Because RIC reviews the original literature, many times new scientific and technical discoveries are presented to our readers in the **RIC News** well before the information appeared in the trade journals—sometimes by a year or more. These include the rare earth cobalt (RCo_5) permanent magnets, the RNi_5 hydrogen absorbers, magnetostrictive RFe_2 compounds,

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Heineman Award


P. W. Anderson

Bell Telephone Laboratories physicist P. W. Anderson has been awarded the Dannie Heineman Prize by the Göttingen Academy of Science. The Heineman Prize is awarded every second year to mathematicians and natural scientists who have made outstanding scientific contributions and includes a $12,000 stipend. The award recognizes Anderson's work dealing with conductivity and the phenomenon known as "Anderson localization". His theoretical research also involves rare earth magnetic and superconducting materials.

REO Metal Eutectics

J. W. Stendera and J. F. Benzel have studied the effect of adding CeO_2 to rare earth oxide-metal eutectic composites [*J. Am. Ceram. Soc.* **58**, 116-9 (1975)]. Either La_2O_3, Nd_2O_3, Gd_2O_3, Ho_2O_3 or Er_2O_3 was combined with 20% CeO_2 and 10% of either Mo or W in unidirectional solidification experiments. Solidification without CeO_2 resulted in structures containing non-uniform discontinuous fibers. The addition of CeO_2 to the composite dramatically improved the size and uniformity of the fibers. The authors attribute the improvement to the extra, loosely bound oxygen provided by the CeO_2 which increased the solubility of the metal in the molten oxide.

2nd International Magnet Workshop

The 2nd International Workshop on Rare Earth-Cobalt Magnets will be held June 8-11, 1976 in Dayton, Ohio just a week before the combined Intermag/MMM Conference for the convenience of those wishing to attend both of these meetings. The workshop will consist of prepared presentations by technical and business experts from industry, government and universities, formal panel discussions and informal organized discussions. Objectives of the workshop are to review the present state of rare earth magnet technology, inform present and potential users of permanent magnet devices or machines about the availability, technical features and economics of newly developed units or design concepts, and to stimulate further applications of rare earth-cobalt magnets. Six sessions are scheduled with the following topics to be covered: 1) Commercial Rare Earth Magnets: Availability, Properties and Handling, 2) Design Principles and Application Examples, 3) Specific Device Applications, 4) Permanent Magnet Motors and Generators, 5) Magnetic Bearings and Suspension Systems, and 6) New Magnet Materials and Production Methods. There will also be a small industrial exhibit featuring rare earth magnet products. No parallel sessions are scheduled and a collection of the papers presented will be available to conferees.

Total enrollment to the workshop will be limited. Those wishing to attend should contact K. Strnat, School of Engineering, University of Dayton, Dayton, Ohio 45469.

Potts Medal


L. G. Van Uitert

The Franklin Institute has named Dr. L. G. Van Uitert of Bell Laboratories, Murray Hill, NJ, as the 1975 recipient of its Howard N. Potts medal. The award recognizes Van Uitert for "outstanding ability in discovering and developing ferrites for microwave communications, garnets for magnetic bubbles and lasers, and niobates for nonlinear optical devices". Dr. Van Uitert joined Bell Laboratories in 1952 and has researched ferrites, lasers, bubble domain materials and optic materials, many of which contain rare earths.

RARE EARTH VOLUME

Volume 22 of *Structure and Bonding*, edited by J. D. Dunitz, P. Hemmerich, R. H. Holm, J. A. Ibers, C. K. Jørgensen, J. B. Neilands, D. Reinen and R. J. P. Williams and published by Springer-Verlag, Heidelberg (1975), consists of four articles which deal with the rare earths. The volume is 172 pages long and costs $29.70.

In "The Lanthanide Ions as Structural Probes in Biological and Model Systems," E. Nieboer briefly reviews rare earth ion coordination chemistry and biological activity and then assesses methods in which rare earth ions are used as structural probes in heavy ion isomorphous replacement, fluorescent probe, difference absorption, relaxation enhancement, chemical shift and conformational studies. (213 ref.)

"Partially Filled Shells Constituting Anti-bonding Orbitals with Higher Ionization Energy than their Bonding Counterparts" is an analysis by C. K. Jørgensen of the nephelauxetic effect on the photoelectron spectra and on visible and ultraviolet spectra of rare earth metals and compounds. This effect is compared with a new treatment of the negligible covalent delocalization. (126 ref.)

R. D. Peacock begins a discussion of the intensities of lanthanide *f - f* transitions with a review of the

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ferroelectric-ferroelastic $Gd_2(MoO_4)_3$, rare earth X-ray phosphors and rare earth oxide auto exhaust catalysts.

Help

In order to better serve you, our readers, and the other users of RIC we still need your assistance— we would especially like to receive news releases and contributions to our "Rare Earthers Around the World" feature (300 words and a group photograph with a caption). Our deadline dates for information to be included in the March, June, September and December issues of the **RIC News** are the first of February, May, August and November, respectively. Remember this is your quarterly publication and your input gives it much more balance and breadth.

It has been a great 10 years, let us make the next ten even better.

Karl A. Gschneidner, Jr.
Editor and Director

Ce PROTECTS FIBERS

In certain applications of fiber optics, where absorption losses are not a limiting factor, high numerical-aperture fibers such as lead silicate and barium crown glasses are preferred. Unfortunately, these materials are more susceptible to radiation damage. Since only minimal interruption can be tolerated in most fiber optics applications, E. J. Friebele has researched the effect of cerium doping on the time dependence of radiation-induced absorption on several fiber optic materials [*Appl. Phys. Letters* **27**, 210-2 (1975)].

The Ce^{3+} competes with hole traps in the glass for the radiation-produced holes and the Ce^{4+} competes with the electron traps for the radiation-produced electrons. It is the hole traps and electron traps that result in unwanted radiation-induced absorption bands in the materials. Friebele found that the cerium dopant not only decreased the loss at a given time but also increased the decay rate of the absorption. The decrease at 1 msec is much less than 10^4 sec after irradiation which suggests that the holes still form but then migrate to the Ce ions. The author concludes that for time < 1 msec cerium does not significantly reduce radiation-induced absorption loss but for time > 1 msec the loss at a given time is decreased and the decay rate of the absorption is increased.

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Judd-Ofelt theory. The hypersensitivity of certain transitions is examined using inhomogeneous dielectric and dynamic coupling theories. Specific praseodymium and europium transitions are discussed (113 ref.)

Radiative and nonradiative transitions of rare earth ions in glasses is the subject of R. Reisfeld's review. The Judd-Ofelt theory is invoked in describing radiative transitions. To explain nonradiative transitions a multiphonon process relaxation theory is used in which the highest energy phonons are responsible for the nonradiative relaxation in the glasses.

CHINA R. E. INDUSTRY

RIC has acquired an article published in the *Peoples Newspaper*, Peking, in October, 1975 which describes China's developing rare earth industry. A complete copy of the article may be requested by writing to the Center.

Briefly, the article claims extensive rare earth deposits in China and a rapid increase in production and use of rare earths since 1958. The article noted that rare earth products are being used in ferrous and non-ferrous metallurgy, machine building, petro-chemical, glass-making and ceramics, electronics, medicine, building material and light industry as well as agriculture and national defense.

RIC FTS Number

The Rare-Earth Information Center has received a new Federal Telecommunications System (FTS) number—865-2272. If your phone is not hooked-up to FTS, you should continue to use our commercial telephone number which is (515)-294-2272.

RE's in the News

Garnet Bubbles Remember

Rare earth doped yttrium iron garnets will play a memorable role in a large capacity data recorder being built by the Autonetics Division of Rockwell International, Anaheim, CA. A number of Rockwell's garnet film chip bubble domain semiconductor devices will be used giving the recorder a total capacity on the order of 100-million bits. The garnet system will eliminate shut-downs due to tape breakage.

Scandium Encyclopedia

The development of knowledge concerning scandium in the last 20 years has dictated the publication of a comprehensive review entitled *Scandium, Its Occurrence, Chemistry, Physics, Metallurgy, Biology and Technology*, C. T. Horovitz, K. A. Gschneidner Jr., G. A. Melson, D. H. Youngblood and H. H. Schock, Academic Press, London (1975). 598pp, cost £16.00 ($42.25 U.S.A.).

This reference work is interdisciplinary in nature, containing information useful to research workers, post-graduate students, inorganic, organic and analytical chemists, physicists, metallurgists, biologists, toxicologists and geologists.

Topics covered include scandium's discovery, history, distribution in nature, geochemistry, mineralogy, derivation, extraction, preparation, physical metallurgy, chemical properties, isotopes, inorganic compounds, alloys and intermetallic compounds, organic compounds, analytical chemistry, technology, application and economy, occurrence in living systems, biological significance and toxicity. Author and subject indexes are also contained.

TERBIUM

Terbium, atomic number 65, was discovered by C. G. Mosander in 1843, who originally called it erbium. Later workers confused erbium and terbium, and today, because of common usage, element 65 is known as terbium. The name terbium is derived from the town of Ytterby, Sweden.

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