RARE-EARTH INFORMATION CENTER NEWS

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

Volume XII | March 1, 1977 | No. 1

Who is .... 'The Rare Earth Industry'?

CERAC, Incorporated

CERAC, incorporated was formed in April of 1964 by Dr. Ervin Colton as an outgrowth of his R & D activities in inorganic materials, and in particular refractory materials, at Allis-Chalmers in Milwaukee. At that time, there was a demand by R & D scientists doing research related to space, nuclear science, optics and electronics, for a comprehensive source of rare inorganic chemicals actually produced and not merely resold. Beginning in the corner of a small industrial building, CERAC today occupies a three-story building with 45,000 square feet of working area and currently employs 35 people. Dr. Colton is the company's President and Research Director.

CERAC's rare earth product line and R & D activities encompass the following areas:

1. *Syntheses.* An extensive program of preparing rare earth derivatives is under way. Products include:
   - A. Salts, both hydrated and anhydrous.
   - B. Refractory compounds, such as borides, carbides, nitrides and silicides.
   - C. Non-metallic compounds, such as sulfides, selenides, phosphides and tellurides.
   - D. Alloys, such as aluminides, nickelides and cobalt combinations.

2. *Hot-pressing.* All rare earth derivatives are being hot-pressed, without added binders, to form dense bodies in the form of discs, rods, crucibles and custom shapes. These include LaB_6 and Gd-Co alloys.

3. *Arc melting.* The rare earth oxides are arc melted to produce fully dense, free-flowing powders for use in flame spray applications, e.g. Y_2O_3- and CeO_2 - stabilized ZrO_2.

4. *Vacuum melting.* Rare earth compounds, particularly the fluorides, are vacuum melted to produce granular forms.

Many of these materials such as CeS, CeO_2, PrF_3 and Gd-Co alloys are sputtered and evaporated to give optical, electronic and amorphous films on various substrates.

A unique aspect of the CERAC manufacturing program is the use of X-ray diffraction for quality control. All preparations are subjected to X-ray diffraction, spectrographic and wet chemical analysis to complete the Certificate of Analysis sheet that accompanies each shipment at no additional cost to the buyer.

Comprehensive catalogs are available by writing to CERAC, incorporated P. O. Box 1178, Milwaukee, Wisconsin 53201, U.S.A. CERAC can also be reached by telephone at 414-289-9800 or by telex at 269452 (CERAC Mil).

EDITOR's NOTE:

This is one of a continuing series of features on rare earth industry. The information contained herein was supplied by the company featured and its publication should not be construed to constitute an endorsement by RIC or Iowa State University of the products or services offered by the company.

EDITORIAL

With this issue we begin a new feature entitled "Who is .... 'The Rare Earth Industry'?" We have become increasingly aware over the years that the industrial and commercial areas play a large and significant role not only in the rare earth community but also in many parts of the total scientific and technological world. In recognition of this, the new series will be given equal status to our long standing feature "Rare Earthers Around the World." Indeed, as is found in this issue, we anticipate many future newsletters will carry both features.

Shortly before this issue went to press we informed all of our current benefactors of this new series and furnished them guide lines and rules which will govern submissions to the *RIC News* for inclusion in this feature. If you and/or your company are interested in this series please write me and we will furnish you additional information.

Karl A. Gschneidner, Jr. Editor

CONTRIBUTORS

'FULL SPEED AHEAD' seems to be the trend for rare earth industry this year if the response RIC has received is any indication. Nine companies have renewed their support to the Center this quarter and two new companies joined their ranks for the first time. Contributors are listed below (the number in parentheses is the number of years the company has supported RIC).

Allied Chemical Corp., USA (5)
British Flint and Cerium Manufacturers, England (5)
Cerac, Incorporated, USA (1)
Companhia Industrial Fluminense, Brazil (5)
General Electric Company Quartz & Chemical Products Section, USA(2)
GTE Sylvania, USA (5)
Nuclemon-Nuclebras de Monazito e Associados Ltda., Brazil (5)
Research Chemicals, USA (9)
Rhone-Poulenc-Chimie Fine, France (7)
Union Carbide, Linde Division, USA (1)
U. S. Radium Corp., USA (7)

Atomic Data Tabulated

Comprehensive descriptions, at the Hartree-Fock level, of all the elements of the Periodic System and many of their positive ions have been tabulated by S. Fraga, J. Karwowski and K. M. S. Saxena in their book *Handbook of Atomic Data*, Elsevier Scientific Publishing Co., Amsterdam and New York (1976). The book is 551 pages in length and costs $49.75.

The book begins with a brief review of atomic structure theory and a description of the tabulated data. The balance of the book consists of tables of configurations, functions, energies, spectra, coupling constants, external interactions, integrals and parameters, expectation values and data for additional configurations. Data is tabulated by topic to aid in comparison. For the rare earths information on the neutral atom, all the positive ions but one of scandium, the first eleven positive ions for the elements yttrium and lanthanum thru ytterbium, and the first four positive ions of lutetium and the actinides is given. This work establishes a permanent point of reference for theoretical calculations and is useful to the experimental researcher as a reference or a basis for future work.

Dy Sheds Light on Psoriasis Treatment

In developing an effective photochemotherapeutic treatment of psoriasis, T. Fischer and J. Alsins have used dysprosium lamps [*Acta Dermatovener (Stockholm)* **56**, 383-90 (1976)]. The Dy lamps are of the gas discharge type, operate at approximately atmospheric pressure and have a high emission of visible light and high intensity in the UV-A region. The result of treatment with trioxsalen baths and dysprosium lamplight was found to be equal or superior to the currently used Ingram method in all but one case when tried on 26 patients. The authors found this treatment practical and easily managed, giving good cosmetic results, and it avoids the risk of toxic side effects sometimes connected with peroral treatment.

RE's in the News

Tiny 3D

Soon it will be possible not only to see microscopic objects but to see them in three dimensions if Hitachi, Ltd., Japan, is successful in its development of a sterioscopic attachment for scanning electron microscopes. The device contains a PLZT (Pb, La, Zr Titanate) electro-optical shutter.

Possible Earthquake Detection

NASA's Goddard Space Flight Center, Greenbelt, MD, has incorporated a Nd:YAG laser into a spaceborn earthquake detection monitor. The laser bounces light off of cubic reflectors placed along quake-prone faults and measures shifts in the earth's crust with an accuracy of 2 to 5 cm.

New Milling Process

Th. Goldschmidt A. G. has joined with Machinenfabrik Wiener and Co. of Amsterdam to develop a gas-proof attritor for milling rare earth cobalt alloys. The new equipment yields powder which has a constant oxygen content and reduces the milling time considerably.

RARE! EARTHLY GOOF

In the last issue of *RIC News*, Volume **XI**, [4] 2 (1976), we incorrectly reported that A. J. Rard was the editor of *Encyclopedia of Electrochemistry of the Elements*, Vol. 6, Marcel Dekker, Inc., New York (1976). It should have read A. J. Bard. Sorry 'bout that!

MEETING

13th Rare Earth Research Conference CALL FOR ABSTRACTS

The organizers of the 13th Rare-Earth Research Conference to be held October 16-20, 1977 at Ogleby Park, Wheeling, West Virginia, have issued a call for abstracts. Solid state chemistry, chemistry, physics, industrial and spectroscopy are the general categories of topics. This year there will be a choice of the mode of presentation, either by poster session or oral delivery. Abstracts are due by April 15, 1977 and should describe original, unpublished work except for invited review papers. For more information contact Dr. G. J. McCarthy, Program Chairman, 205 Materials Research Laboratory, The Pennsylvania State University, University Park, PA 16802 USA.

Rare Earths and Actinides Conference

The invited speakers and their topics have been named for the Conference on Rare Earths and Actinides which will take place July 4-6, 1977 at the University of Durham in the United Kingdom. They are, respectively, K. A. Gschneidner, Jr., Introductory Address; D. W. Jones, Materials and Crystal Growing; D. K. Ray, Crystal Fields; B. Johansson, Structural and Elastic Properties; A. J. Freeman, Band Theory and Fermi Surfaces; P. A. Lindgard, Excitations-Spin Waves; G. H. Lander, Magnetic Properties; H. Kirchmayr, Intermetallics; H. Zilstra, Permanent Magnets; and J. R. Fairholme, Magnetic Bubbles.

Contributions concerning physical properties of the rare earths and actinides including materials with potential applications are solicited. Abstracts are due by April 1, 1977. For more information contact Dr. W. D. Corner, Physics Department, University of Durham, South Road, Durham DH1 3LE, United Kingdom.

XVIII ICCC TO MEET

The XVIII International Conference on Coordination Chemistry will take place July 18 to 23, 1977 at the University of São Paulo, São Paulo, Brazil. The official language of the conference is English. One of the five sessions is devoted to lanthanide chemistry. For more information write to Prof. Paschoal Senise, Instituto de Quimica, Universidade de São Paulo, Caixa Postal 20780, São Paulo, Brazil.

LaF_3 DETECTS IR

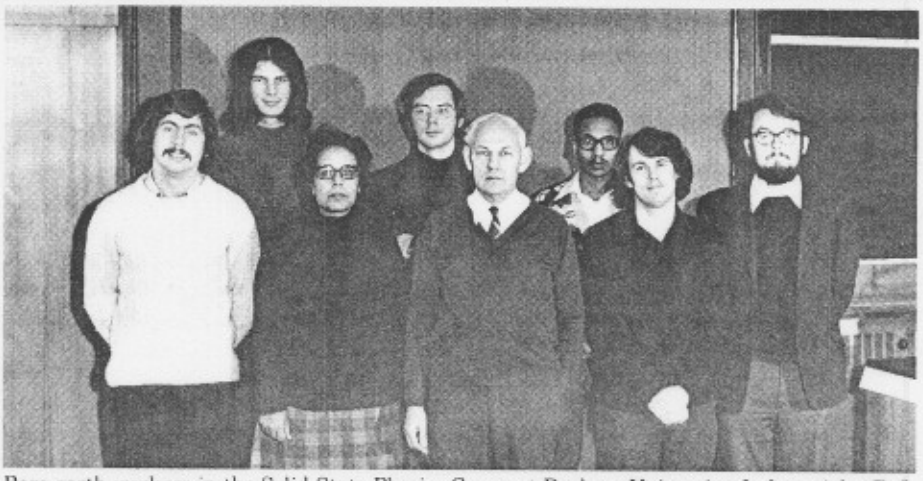
A prototype device for infrared detection has been developed by A. Sher, C. L. Fales and J. F. Stubblefield which employs LaF_3 [*Appl. Phys. Letters* 28, 676-8 (1976)]. LaF_3 is an ionic conductor with a capacitance which varies exponentially with temperature. This temperature sensitivity is the basis for the infrared detector. Based on observations from the prototype, the authors predict that an operational device could be constructed which would have a detectivity comparable to the currently available pyroelectric detectors. However pyroelectric devices are often limited by piezoelectric noise which would not be the case with LaF_3 detectors.

GMELIN Handbook Series Adds Two

With the publication of Books B4 and C2 of *System 39, Rare Earth Elements, the Gmelin Handbuch der Anorganischen Chemie* comes two volumes nearer to completion. Books which are currently available include Section A, 1 and 2, Section B, 1, 3 and 4 and Section C, 1 and 2.

Book C2 deals with compounds of scandium, yttrium and the lanthanides with hydrogen and oxygen, and with nitrogen. Preparation and various properties are given for the rare earth hydridooxides, hydroxides, oxide hydroxides, peroxo compounds, oxometallates, hydroxometallates, nitrides, imides, amides, azides, hydroxide azides, nitrites and nitrates. Published in 1974, this book is 299 pages in length, costs $196 and features an English table of contents and margin notes.

Book B4 is devoted to describing atomic scandium, yttrium and the lanthanides. The properties of rare earth atomic nuclei and diatomic molecules are discussed along with the properties of the atoms and ions including electron configuation, optical spectra, energy levels, ionization energies, electron affinity, atomic scattering factors, binding energy of inner shell electrons, cross sections, level widths, X-ray absorption and emission spectra, Auger spectra, Mossbauer spectra, Coster-Kronig transitions, and atomic and ionic radii. In addition to the regular table of contents and margin note features approximately 58% of this volume is written in English. Book B4 is 427 pages long, costs $324.40 and was published in 1976.



Rare earth workers in the Solid State Physics Group at Durham University. Left to right, F. J. Jones, G. F. Clark, F. M. Saad, B. K. Tanner, W. D. Corner, A. A. Joraide, R. L. Smith and R. F. Warnock.

DURHAM UNIVERSITY

Magnetic Properties of Rare Earths

Over the past two decades there has been a continuing interest at Durham in the magnetic properties of rare earth metals, alloys and compounds. Current work is concerned both with investigating magnetic domain structures and making basic magnetic measurements. The group is led by Dr. W. D. Corner and under his direction research student R. L. Smith has been remeasuring the magnetocrystalline anisotropy of Gd by torque magnetometry, using ultrapure crystals produced by solid state electrolysis (SSE) at the Centre for Materials Science, Birmingham University. R. F. Warnock and A. A. Joraide are respectively measuring the anisotropy and magnetostriction of a series of Gd-Tb alloys in an attempt to distinguish between single and two ion contributions to the anisotropy. Low temperature domain configurations in the SSE Gd have been revealed by F. M. Saad using a technique of evaporating iron in a low pressure of helium. Detailed interpretation of the patterns is in progress.

Dr. B. K. Tanner joined the group in 1973 on the appointment of Dr. K. N. R. Taylor to a chair in Australia. His expertise is in the field of X-ray diffraction topography, a technique usually used for assessment of crystal perfection but also suitable for imaging magnetic domains via the magnetostriction. Studies of the perfection of the rare earth compounds RVO_4, RPO_4, $RAsO_4$ and $RAlO_3$ have been performed. With G. F. Clark, Dr. Tanner is developing X-ray topographic techniques using synchrotron radiation. Ferromagnetic domains in Tb and $(Ho_{1-x}Tb_x)Fe_2$ crystals have recently been revealed by X-ray synchrotron topography. F. J. Jones is developing a technique for magnetostriction measurements using double crystal X-ray diffraction.

Russian Book

The Russian book *Redkozemel'nye Metally i Splavy (Rare Earth Metals and Alloys)*, E. M. Savitskii and V. F Terekhova, eds., Izdatelstvo Nauka, Moscow (1971) has been translated to English as Report No. AEC-tr-7408 and is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA, U.S.A. 22161. The cost is $6.00.

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K. A. Gschneidner, Jr. . . .Editor

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Rare Earthers Promoted

T. A. Henrie has been appointed Chief Scientist of the U. S. Department of Interior's Bureau of Mines. He will serve as the principal advisor to the Bureau of Mines Director on research policies and goals and will give technical leadership to innovative research by the Bureau on minerals and materials technology. Henrie formerly served as Bureau of Mines Deputy Director for Mineral Resources and Environmental Development.

M. J. Lalich has been named Manager of Cast Iron Research and Development for the Ferroalloys Division of Foote Mineral Company, Exton, PA. His responsibilities will include the development and application of Foote products for the cast iron industry. Prior to his appointment, Lalich served as Foote's Senior Research Metallurgist and Research Associate for Ferrous Metallurgy.

BULLETIN AVAILABLE

A new bulletin entitled "Rare Earth Reviews" has been initiated by Rare Earth Products Limited, Waterloo Road, Widnes Cheshire WA8 0QH, United Kingdom. The bulletin will generally describe properties of individual rare earths and their applications. Anyone interested in receiving this bulletin should contact Rare Earth Products, Limited or their U. S. representative, United Mineral & Chemical Corporation, 129 Hudson Street, New York, NY 10013.

Yttria Molds Ti Alloys

Yttria has found an application in a program to develop titanium alloy casting technology conducted by D. R. Schuyler, J. A. Petrusha, G. S. Hall and S. R. Seagle [AFML-TR-76-80 (August 1976)]. New low melting titanium alloys were developed and new crucibles had to be designed which would not react with the molten titanium. Two crucibles showed favorable results. The compositions which were successful were Y_2O_3-15% Ti and Y_2O_3 with a Y_2O_3-K_2SiO_3 face coat. Typical casting contamination levels were 0.2-0.4% oxygen and 0.2-0.5% yttrium. The authors note that these materials provide a good foundation for the development of a low-cost investment casting process for producing titanium alloys.

ANOTHER RE VOLUME

Volume 30 of *Structure and Bonding*, edited by J. D. Dunitz, P. Hemmerich, J. A. Ibers, C. K. Jørgensen, J. B. Neilands, D. Reiner and R. J. P. Williams, is now available and contains considerable information for rare earthers. The book is 197 pages long, costs $27.90 and was published by Springer-Verlag, Heidelberg (1976). A brief synopsis of the articles follows.

In "A Systematic Correlation of the Properties of the f-Transition Metal Ions" S. P. Sinha reviews the history and development a systematic classification of various lanthanide properties. The Inclined W hypothesis is presented and used in the correlation of separation factors, formation constants, thermodynamic properties, oxidation potentials, ionization potentials, spectroscopic properties and several miscellaneous properties. The hypothesis is shown to incorporate the gadolinium break and the tetrad effect and also finds application in correlation of actinide properties. (98 ref.).

Excited states and energy transfer from donor cations to rare earths in the condensed phase is the topic of a review by R. Reisfeld. Various transfer probabilities are discussed including resonance energy transfer, macroscopic energy transfer, migration of energy, inhomogeneous broadening and phonon-assisted energy transfer. A correlation is then drawn between the optical properties of ions having strong absorption and the host medium. (74 ref.)

In "Spectroscopy of Homogeneous Mixed Valence Rare Earth Compounds," M. Campagna, G. K. Wertheim and E. Bucher review the application of X-ray photoemission spectroscopy (XPS) to the study of the electronic structure of mixed valence rare earth compounds. A history of the development of XPS is given and homogeneous mixed valence compounds are defined. Application of XPS to specific mixed valence systems is discussed. (76 ref.).

The fourth article is by C. K. Jørgensen and deals with deep-lying valence orbitals and problems of degeneracy and intensities in photoelectron spectra. Information on the rare earths is included. (224 ref.).

FIND MORE RE'S

This past summer a U. S. Geological Survey team discovered granite-like rock in Western Alaska which contained possibly useful amounts of thorium, uranium and rare earths. Samples from this deposit which is located 15 miles northeast of Golovin, a small town 50 miles east of Nome, contained up to 0.15% uranium oxide, 1.05% thorite and more than 2% rare earths.

Solubility Data Project

Prof. A. S. Kertes of the Institute of Chemistry of The Hebrew University of Jerusalem, Jerusalem, Israel has called our attention to IUPAC'S Solubility Data Project of which he is chairman. In this project all available literature data for a given system are being compiled and will undergo critical thermodynamic evaluation. The most reliable data are selected for the final compilation which includes data sheets of numerical and/or graphical data from the literature, critical evaluation and recommended solubility data. Several of the expected fifty volumes will include solubility information on rare earth compounds. For more information interested persons should contact Prof. Kertes.

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RARE-EARTH INFORMATION CENTER NEWS

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Left to right, M. J. Weber, S. E. Stokowski, J. E. Lynch, R. Morgret, R. R. Jacobs, A. J. DeGroot, R. A. Saroyan, C. B. Layne, and W. F. Krupke. In the foreground, disks of neodymium laser glass used in laser amplifiers.

Lawrence Livermore Laboratory

Rare-Earth Laser Research

Laser-induced thermonuclear fusion requires large, high-power lasers. The most powerful and versatile lasers presently available for fusion experiments are pulsed neodymium glass lasers. These lasers, which operate at 1.06 μm, consist of long amplifier chains and multiple beams. Nd glass disk amplifiers with beam apertures of 30 cm have been built. The largest neodymium glass laser in the world, the 100-1000 picosecond, 30-terawatt Shiva laser, is currently under construction at the Lawrence Livermore Laboratory in California. This laser contains approximately 1000 liters of rare-earth-doped materials.

The performance of fusion lasers is limited by materials properties. Improvements in the gain and efficiency of neodymium lasers are desired. The search for improved rare-earth laser materials at LLL is conducted in a group headed by Dr. M. J. Weber. Many different glasses have been investigated. In particular, the effects on the spectroscopic properties of Nd^{3+} ions of changing the glass network former (silicate, phosphate, borate, fluoroberyllate, . . .) and the network modifiers (alkali, alkaline earth, and higher valence state ions) are studied using special computer-controlled spectroscopy facilities assembled for this survey. The results have shown that large variations in absorption and emission cross sections, radiative transition probabilities, and the rate of nonradiative decay by multiphonon processes in glass are possible. Thus, the lasing properties can be tailored for specific laser performance by compositional changes.

The high optical fields in fusion lasers cause intensity-dependent changes in the refractive index of transmitting materials. This, in turn, leads to self-focusing of the laser beam and loss of energy to the fusion target. Therefore, optical materials with small refractive index nonlinearities are required. Because of

(continued on page 4)

Hydrogen Storage System

The electrochemical storage of hydrogen using a cathodic charge is the subject of recent research conducted by G. Bronoel, J. Sarradin, M. Bonnemay, A. Percheron, J. C. Achard and L. Schlapbach [*Int. J. Hydrogen Energy* **1**, 251-4 (1976)]. Using a 5N KOH medium at room temperature in an unpressurized system they observed a mass capacity of 5H per molecule of $LaNi_5$—much higher than predicted by thermodynamic equilibrium. The irreversibility of several reactions occurring at the solution-surface interface is employed by the authors to explain the non-equilibrium state in which the hydrogen is held. The effects of compound stoichiometry, substitution with calcium, strontium, yttrium, barium, titanium, etc. and temperature variation were studied. The best results were obtained at room temperature with minor substitution of copper or chromium for nickel. Electrodes, such as these, which can semi-reversably store large quantities of hydrogen are of possible use in the development of high density batteries.

NEW BROCHURE

As everyone knows, a lot of changes can take place in the course of ten years and the Rare-Earth Information Center is no different than anyone else. In light of these changes we felt it was time to update our brochure to let everyone know where RIC is today in terms of its scope and services provided. A new feature of this brochure is a listing on the reverse side of all the companies who have contributed to the support of the Center during the last two years. Copies are available by contacting the Center.

Distinguished Professor


W. E. Wallace

W. E. Wallace has retired as of April 1 of this year as chairman of the department of chemistry of the University of Pittsburgh, the post he has held for the last fourteen years. Upon retirement he was named Distinguished Service Professor of Chemistry. In relinquishing most of his administrative duties, Wallace hopes to be able to devote more time to his research activities which have included work on the magnetic properties, heat capacities and crystal field effects in rare earth metals and alloys.

RE CHAPTERS

USBM Bulletin 667, the 1975 edition of *Mineral Facts and Problems* is now available and contains two chapters of interest to rare earthers. Both the chapter "Scandium," written by R. V. Sondermayer, and "Yttrium and the Rare Earth Elements," written by J. H. Jolly, contain a wealth of information concerning rare earth industry size, organization and geographic distribution, applications, resources and reserves, technology, supply and demand relationships, byproducts, strategic considerations, economic factors and the future outlook. For more information contact the U. S. Government Printing Office, Washington, D.C. 20402.

SUPPLEMENT

Supplement No. 1 to NBS Special Publication 363, *Bibliography on Atomic Energy Levels and Spectra, July 1971 through June 1975* by L. Hagan (January 1977) is now available from the U. S. Government Printing Office, Washington, D.C. Besides atomic energy levels and spectra there are notations when the references contain information on energy levels, new designations, classified lines, wavelengths, Zeeman effect, Stark effect, hyperfine structure, quantum field effects, ionization potentials, isotopic and isomeric shifts and various theories. Approximately 2150 references are included and there is an author index.

Soviet MHD Research

Recent Soviet research on high temperature materials for MHD power plants has involved two different materials that contain rare earths [Report from the Institute of High Temperatures of the USSR Academy of Sciences by A. I. Rekov, F. A. Akopov, E. G. Spiridonov, A. I. Romanov and D. A. Vysotskii, JPRS-67586, July 13, 1976]. A ternary system of the composition 85 mole % ZrO_2-12 mole % CeO_2-3 mole % Y_2O_3 has been prepared and examined as a possible ceramic electrode. A layer of the ternary material forms the working surface and is backed by a CeO_2 ceramic. This system was found to have 40 to 50% electron conductivity and may be used in channels of open-cycle MHD generators that operate on gaseous or low sulfur liquid fuel with wall temperatures above 2000°C.

A 60% $LaCrO_3$-40% Cr cermet also received attention as a possible electrode for future large MHD generators. This cermet displayed high electrical and thermal conductivities and suitable thermionic emission properties. Addition of 3 wt. % of palladium significantly reduced oxidation under channel conditions. The authors feel this electrode material would be useful for large stations with high heat fluxes because of its high heat resistance.

PROCEEDINGS

The proceedings of the International Meeting on Hydrogen in Metals held January 5-6, 1976 at the University of Birmingham, United Kingdom has been reprinted from the *Journal of Less-Common Metals* **49**, [1/2] (1976) in book form entitled *Hydrogen in Metals*. The book (508 pages long) is published by Elsevier Sequoia S. A., Lausanne.

Eleven of the forty papers presented deal with hydrogen interaction with rare earth metals and their alloys and intermetallic compounds with cobalt, iron, manganese, nickel and palladium. Topics covered include specific heat of the dihydrides, hydrogen equilibrium pressures, adsorption and absorption of hydrogen and deuterium, effect of hydrogen on crystalline properties, formation of stable hydrides, hydrogen solubility and nuclear magnetic resonance.

International Prize for New Materials


H. T. Hall

H. T. Hall has been named one of four co-recipients of the 1977 American Physical Society International Prize for New Materials as a result of his work in developing high pressure, high temperature procedures for synthesizing new materials. To date Hall and his associates have prepared and characterized over 100 new solid state compounds, many of which contain rare earth elements.

Hall earned his doctorate at the University of Utah in 1948 and worked for General Electric's Research and Development Center from 1948 to 1955. At that time he received an appointment as director of research with Brigham Young University which he held from 1955 to 1967. In 1967 he was named to the post of Distinguished Professor of Chemistry, the position he currently holds.

Possible Thin Film Capacitors

The dielectric properties of thin film rare earth oxides have been examined experimentally by A. T. Fromhold, Jr. and W. D. Foster to determine their suitability for use as thin film capacitors [*Electrocomponent Sci. and Tech.* **3**, 51-62 (1976)].

Various properties including breakdown voltages, capacitance, dissipation factor and dielectric constant were measured for thin film oxides of scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, gadolinium, dysprosium, holmium, erbium, and ytterbium. Comparison of ease of preparation along with dielectric properties has lead the authors to conclude that the oxides of lanthanum, cerium, praseodymium, neodymium, gadolinium and erbium show the greatest promise for development as thin film capacitors. Several avenues of research are proposed to aid in understanding the role of gaseous impurities, conduction channels, heating and subsequent decomposition of dielectric materials.

CONTRIBUTORS

Six companies renewed their support of the Center in the fourth quarter of fiscal year 1977 setting a new record for the total number of companies which came to the support of RIC. The record now stands at 41 and surpasses the mark of 40 set in 1973. Of the 41, eight companies joined the family of RIC benefactors for the first time this year. The contributors for this quarter are listed below (the number in parentheses is the number of years the company has supported RIC).

American Metallurgical Products Co., U.S.A. (8)
Colt Industries—Crucible, Inc., U.S.A. (3)
GTE Laboratories, Inc., U.S.A. (5)
Industrial Minera Mexico, S.A., Mexico (3)
Lunex Company, U.S.A. (7)
Santoku Metal Industry Co., Ltd., Japan (7)

If contributions to RIC are a barometer then it is apparent that excellent progress has been made by the rare earth industry in recovering from a rather gloomy economic picture in 1976. Fiscal year 1977 is almost history now so we hope 1978 will be an even better year for all rare earthers.

I. T. Oiwa Dies

RIC has received word that Dr. I. T. Oiwa passed away April 15 of this year following a lengthy illness. Up to the time of his illness he was employed as the Director of New Metals Division of Shin-Etsu Chemical Company, Ltd. The rare earth industry and RIC will miss his contributions as a scientist, colleague and friend.

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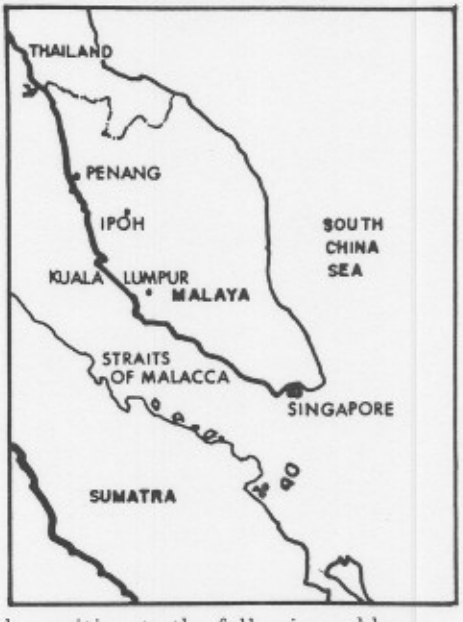
Who is .... 'The Rare Earth Industry'?

MAREC

MAREC which stands for the Malaysian Rare Earth Corporation is the first chemical plant in Malaysia to upgrade locally produced xenotime. Located at Ipoh in the state of Perak, MAREC represents a joint venture between Mitsubishi Chemicals of Japan and BEH Minerals Sdn. Bhd. of Lahat, Malaysia to recover xenotime from the waste products of the Malaysian tin mining industry. Initially conceived four years ago, MAREC's planning and construction stage culminated in August 1976 and its trial run and commissioning were completed November 1976. Incidentally the first overseas shipment also occurred on November 11, 1976. The plant was officially opened April 15, 1977. MAREC is running at full capacity today and is designed to produce 120 metric tons of a 50% yttrium concentrate per year. Principal officers include Mr. Loke Kong Kan, Managing Director; Mr. Leong Pak Cheong, Technical Director; Mr. T. Kobayashi, Plant Advisor (MCI); Mr. Chang Pek Hai, Plant Manager; and Encik Hamid bin Baharom, Administrative Manager.

More information can be obtained



by writing to the following address:

Malaysian Rare Earth Corp.
4¼ Mile, Lahat Road
Lahat, Perak
Malaysia
Telex: BEHMIN MA 44088

EDITOR'S NOTE:

This is one of a continuing series of features on rare earth industry. The information contained herein was supplied by the company featured and its publication should not be construed to constitute an endorsement by RIC or Iowa State University of the products or services offered by the company.

Lighter Flints Spark RE Education

F. C. Hentz, Jr. and G. G. Long have discovered that even the lowly lighter flint can be a key which unlocks some interesting rare earth chemistry [*J. Chem. Ed.* **53**, 651-2 (1976)]. When questioned most students did not know what a lighter flint was made of and most were amazed to learn that an 'ordinary lighter flint' contained such exotic elements as cerium, lanthanum, neodymium and praseodymium. Using the flints as the unknown, the authors devised four analytical experiments. These are determination of the hydrogen equivalent, determination of iron, determination of cerium and determination of both iron and cerium in the same sample. The iron and cerium determinations were checked and found to yield accurate and precise results. These experiments can provide the student in analytical chemistry good exercise in solution chemistry and oxidation-reduction techniques.

Segregated Platinum Is The Culprit

Following up on reports that $La_{0.7}Pb_{0.3}MnO_3$ displayed very promising catalytic properties, J. J. Croat, G. G. Tibbetts and S. Katz have discovered that platinum on the surface of the lanthanum lead manganite is responsible for much of the catalytic activity of these compounds [*Science* **194**, 318-20 (1976)].

Manganites containing as little as .005 atomic percent Pt showed much higher catalytic activity than platinum-free samples. Analysis revealed an almost 100-fold segregation (.5 at. %) of platinum on the surface of the crystals. Assuming this platinum has the same activity as platinum supported on alumina, then much of the activity of the manganites is attributable to the segregated platinum. Etching the crystals increased catalysis but the authors feel this due to the exposure of a more reduced form of platinum on the surface.

More X-Ray Screen Parameters Examined

Nine different rare earth x-ray screen/film systems have been investigated by B. A. Arnold, H. Eisenberg and B. E. Bjarngard for line spread function (LSF) and modulation transfer function (MTF) under practical conditions [*Radiology* **121**, 473-7 (1976)]. The screens consisted of yttrium, lanthanum or gadolinium oxysulfides doped with terbium and were compared with two fast calcium tungstate systems. Results indicate that the rare earth screens offer a significant advantage over calcium tungstate in that better screen MFTs are possible at a given speed. In addition smaller focal spots can be used to increase resolution which at the same time reduces patient exposure.

R. P. Rossi, W. R. Hendee and C. R. Ahrens have examined several commercially available rare earth screen/film combinations for base-plus-fog density, relative speed, average gradient, resolution, noise and overall performance [*Radiology* **121**, 465-71 (1976)]. The screens consisted of lanthanum, gadolinium or yttrium oxysulfide doped with terbium, and lanthanum oxybromide. The rare earth systems were up to 13 times faster than conventional screens and still had acceptable retention of detail and low image noise. Other advantages cited included reduced patient exposure and improvement of several operational parameters, e.g. use of small focal spots and ability to make better use of direct magnification techniques. The main disadvantage according to the authors would be the problems associated with switching over from calcium tungstate systems to the new rare earth systems.

Possible Merger for Molycorp and Union Oil

Molycorp officials have agreed in principle to a proposal by Union Oil to acquire all of Molycorp's common stock (~ four million shares) in an exchange of 1.035 shares of Union Oil stock for each share of Molycorp. The ~ $200 million deal would make Molycorp a wholly owned subsidiary of Union Oil and is still subject to approval by the boards of directors of each company and Molycorp's shareholders.

RE Laser Research
(continued from page 1)

the low refractive indices of fluoride-containing glasses such as fluorophosphates and fluoroberyllates, these materials are currently being investigated for fusion laser applications.

Rare-earth materials are also used in optical isolators. These devices are based upon paramagnetic Faraday rotation and provide isolation between amplifier stages and between the laser and the fusion target. Rare-earth ions which have large Verdet constants and which transmit in the visible-near infrared spectral range of interest for fusion lasers are Tb^{3+}, Ce^{3+}, and Eu^{2+}. Both crystalline and amorphous host materials are being studied.

In addition to research on Faraday rotator and Nd laser materials, other activities of Dr. Weber's group include the study of new rare-earth lasing schemes, fluorescence sensitization, and the application of laser-induced fluorescence line narrowing techniques to the investigation of rare-earth sites in amorphous materials.

While Nd glass lasers are powerful and versatile sources for fusion research, because of their low efficiency and pulse repetition rate they are not adequate for fusion power plants. The transition from a solid to a gaseous lasing medium could reduce damage and self-focusing problems and permit high average power usage via flowing the gas. The search for such laser systems is conducted in the Advanced Laser Research program headed by Dr. W. Krupke. Among various gas laser systems under investigation are three rare-earth vapor carriers: RE^{3+}-trihalogens, RE^{3+}-transition metal trihalides, and RE^{3+}-chelates. Measurements of fluorescence kinetics, determination of rates of radiative and nonradiative processes, and demonstration of gain and oscillation in rare-earth molecular vapors are underway. Other activities include the use of efficient gas lasers to pump selected excited states of other rare-earth lasers.

RE's in the News

Laser Separates RE's

Lasers which are efficient in the ultraviolet region have been successfully used by T. Donohue of the Naval Research Laboratory to separate rare earths from aqueous solutions. The laser photochemically reduces europium which then forms a relatively insoluble salt with sulfate ions and can be easily recovered. Donohue believes the procedure will also work for samarium, ytterbium and the actinides.

Shortest Wavelength Laser

Researchers at the Naval Research Laboratory have been successful in producing the seventh harmonic of Nd-YAG laser light which resulted in the generation of coherent radiation at 380 Å . The ultimate goal of this research is the development of an x-ray laser (~ 100 Å or less) which could be used to study crystals or in the manufacture of microcircuits.

Rare-Earth Information Center
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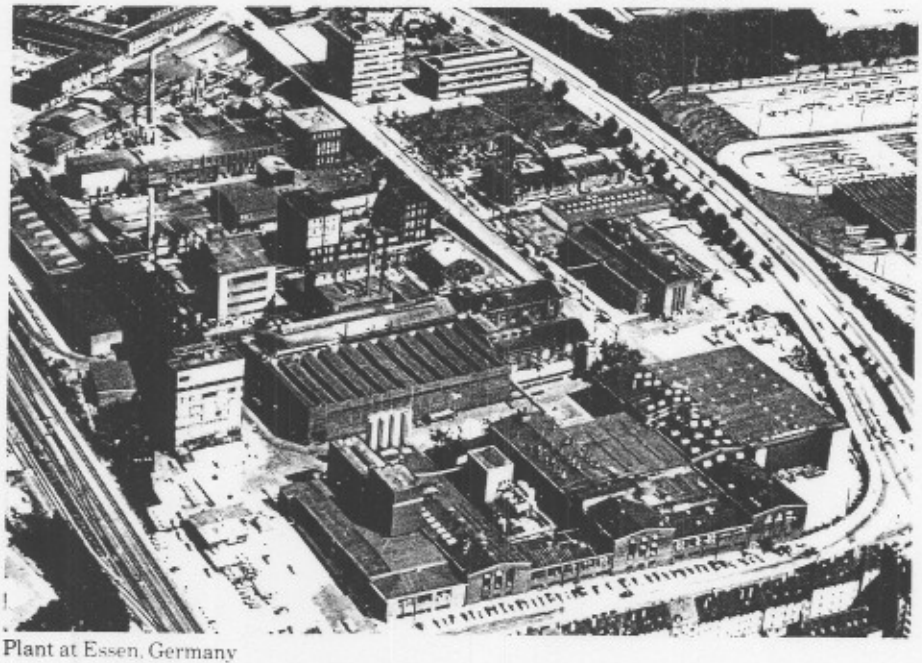
RARE-EARTH INFORMATION CENTER NEWS

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

Volume XII | September 1, 1977 | No. 3

Who is .... 'The Rare Earth Industry'?



Plant at Essen, Germany

Th. Goldschmidt AG

Goldschmidt is an independent producer of chemical and metallurgical specialty products. The company is more than 125 years old and currently employs 3,000 people with sales of $200 million.

Goldschmidt has been active in the rare earth field for about 30 years. They developed the extrusion process of rare earth metal lighter flints which was licensed to users in Austria, France, Great Britain and the USA.

Today, Goldschmidt has the highest production capacity for cerium mischmetal in the world, using the largest known electrolytic cells. Mischmetal is offered mainly to the steel industry in various shapes and forms. Goldschmidt's technical service staff is in touch with users to improve addition methods, e.g. addition of steel-clad mischmetal wire for continuous casting of steel.

They have a unique process to make anhydrous rare earth chloride, mainly based on bastnaesite ore. The mischmetal process is used under license in the United States by Ronson Metals Corporation, Newark, N.J. Goldschmidt also has experience in making rare earth oxides and chemicals, however, these products are currently not being offered in the open market.

Recently, a new line of rare earth cobalt alloy powders has been introduced for rare earth cobalt magnets. Goldschmidt developed their own patented co-reduction process to reduce a suitable oxide-mix to alloy powders under calcium. The process offers uniform alloy powders of complex compositions containing

(continued on page 6)

FISCAL YEAR 1978. . .

is upon us already and during the first three months contributions were received from twenty-seven companies representing eight countries. This response surpasses the record of twenty-three set in 1973 for donations in the first quarter of a fiscal year and hopefully signals another banner year for rare earthers. Twenty-five of the companies renewed their support of RIC and we welcome two new members to our family of benefactors. Contributors are listed below (the number in parentheses is the number of years the company has supported the Center).

American Metallurgical Products Co., U.S.A. (9)
Atomergic Chemetals Corp., U.S.A. (6)
BBC Brown, Boveri & Company, Ltd., Switzerland (6)
Cerac, Incorporated, U.S.A. (2)
Denison Mines Limited, Canada (6)
Eastman Kodak Company, U.S.A. (1)
Th. Goldschmidt AG, Germany (9)
W. R. Grace, Davison Chemical Division, U.S.A. (10)
Hitachi Magnetics Corp., U.S.A. (4)
Inland Motor Division, Kollmorgen Corp., U.S.A. (2)
Kolon Trading Co., Inc., U.S.A. (5)
Leico Industries, Inc., U.S.A. (9)
Lunex Company, U.S.A. (8)
Metalurgica Corona Ltd., Brazil (2)
Mitsubishi Chemical Industries, Ltd., Japan (5)
Molycorp, Inc., U.S.A. (10)
Reactive Metals and Alloys Corp., U.S.A. (2)
Reactor Experiments, Inc., U.S.A. (8)
Research Chemicals, U.S.A. (10)
Rhone-Poulenc-Chimie Fine, France (8)
Ronson Metals Corporation, U.S.A. (10)

(continued on page 5)

GERMANY and ENGLAND—1977

The editor had an opportunity to visit several laboratories and universities and attend the Rare Earth and Actinide Conference in Durham in late June and July. The cool and sometimes wet weather in Europe was a welcome relief from the hot and humid, but rainless conditions in central Iowa.

The first port-of-call was the Institut für Festkörperforschung, Kernforschungsanlage Jülich (KFA), Jülich, West Germany. Most of my discussions were with the superconducting and low temperature group headed by Dr. F. Pobell. They are in the process of building a large adiabatic demagnetization cryostat with which they expect to reach at least 0.3 mK by using $PrNi_5$ as one material to cool the working chamber. Dr. J. Wittig of this group is conducting electrical resistance measurements at high pressure (up to 200 kbar) and temperatures as low as 50 mK. He is studying the superconducting behavior of solids, including rare earths, as a function of pressure. The KFA is one of the best equipped and supported laboratories in Europe.

From Jülich, I traveled to the Zentralinstitut für Tieftemperaturforschung (ZTTF) in Garching, just north of Munich. The ZTTF is also thinking about using $PrNi_5$ in their adiabatic demagnetization cryostat. There are some problems, especially in the preparation of thin rods of $PrNi_5$, which need to be solved before many low temperature laboratories will be using it. My host, Dr. C. Probst, and I spent several hours discussing superconductivity of Sc, Y, Lu and Ce at high pressures and the significance of these results. Dr. Probst is working closely with Dr. Wittig at the KFA on this subject.

The next stop was the Clarendon Laboratory of the Oxford University, England. The main portion of my visit was spent with Dr. D. Hukin whose specialty is the growth of metallic rare earth single crystals and purification of metals by liquid zoning techniques. Dr. B. Wanklyn, who is another of twelve crystal growers at the Laboratory, described her efforts to grow mixed oxides, e.g. $RAlO_3$, $RAsO_3$, from a molten flux.

From Oxford, an hour and a half train ride took me to Birmingham to visit Dr. D. Jones and his staff at the Centre for Materials Science of the University of Birmingham. Their major effort is to purify rare earth metals, single and polycrystals, by solid state electrolysis. This Centre has been set up to supply UK scientists with high purity metals, when their research requires the same. Other work at the University is concerned with de Haas-van Alphen measurements to obtain information about the Fermi surfaces of the rare earth metals under the guidance of Dr. R. Young and physical metallurgical studies on $CeRh_3$-$CePd_3$ alloys under the supervision of Dr. I. R. Harris.

The last stop before the Conference was to see Dr. K. McEwen at the University of Salford. He is carrying out electrical resistivity, magnetoresistivity and neutron diffraction studies on the light lanthanide metals and some intra-rare earth alloys. He has found some interesting behaviors in Y-rich alloys containing Nd and Pr, e.g. $Nd_{0.2}Y_{0.8}$ orders antiferromagnetically with a basal plane spiral structure at 18 K, almost the same temperature as pure Nd.

It was a special pleasure for the editor to attend and participate in the Third Rare Earth and Actinide Conference, since he had the privilege to present the Introductory Address, and also because it was a wonderful opportunity to meet and talk to old friends, to make new ones, and to get the latest information on scientific studies in Europe. It was a well run Conference thanks to the organizing talents of our hosts Drs. Corner and Tanner. The weather cooperated beautifully, tempting scientists to miss part of the sessions. Of the nine invited papers, all of which were interesting, I thought three were outstanding. Those were the presentations by D. W. Jones on the preparation of metals, alloys and crystals, A. J. Freeman on band structure calculations and H. Kirchmayr on magnetic properties of intermetallic compounds. The ~ 70 papers are to be published by the Institute of Physics and when they become available we will announce this in the *RIC News*.

I found that there was a great deal of interaction between research groups in Europe, not only within the same country, e.g. the KFA and ZTTF, Birmingham and Oxford, etc. but also across national boundaries —an indication of future research trends.

In the past 11 years since my first trip to Europe to visit various laboratories and universities there has been a notable change especially in the way these institutions are being funded and supported. All are well equipped with new and up-to-date apparatus. It is my impression (also confirmed by my discussions with other scientists, both American and European) that European support of science is now on par with or ahead of American support (ten years ago the U.S.A. was way ahead) and if this rate of change continues in the future American science will be second rate.

PROCEEDINGS AVAILABLE

The proceedings of the first joint conference of Magnetism and Magnetic Materials with the International Magnetism Conference, held in Pittsburgh, Pennsylvania, June 15-18, 1976, are now available as a two volume set.

Half of the proceedings are presented in *AIP Conference Proceedings No. 34, Magnetism and Magnetic Materials-1976.* Edited by J. J. Becker and G. H. Lander this clothbound volume measures 8¼ in. by 11¼ in., is 399 pages in length and costs $19.50. Over one third of the papers included deal with rare earth materials. Fundamental topics, metals and alloys, transition metal systems, magnetoresistance in soft magnetic materials, superconductivity, surfaces and fine particles, domain walls, bubble physics, bubble materials, mixed valences, magnetic insulators, resonance in rare earth systems, microwave devices, amorphous magnetic alloys, crystalline alloys, spin glasses, critical phenomena and phase transitions are among the subjects discussed.

The other half of the proceedings appears in the *IEEE Transactions on Magnetics*, volume **MAG-12,** No. 6 (November 1976). This volume deals mainly with devices and applications. Hard magnetic materials including rare earth-cobalt permanent magnets are discussed in two sections.

INTERNATIONAL C.N.R.S. COLLOQUIUM ON "PHYSICS OF METALLIC RARE EARTHS"

The colloquium will be held at St-Pierre de Chartreuse, some 30 km from Grenoble, France, during the period September 4-7, 1978. St-Pierre de Chartreuse is a village resort beautifully situated at 1000 meters on the western edge of the Alps.

The program will cover the following topics: intermediate valence, magnetism, crystal fields, critical phenomena, induced magnetism, theory and experimental determination of electronic structures, amorphous materials and liquids. A special session will be devoted to a review on technical applications.

Each subject will be presented by one or two guest speakers in a plenary session and several related papers will follow. Plenty of time is allocated for discussions during the sessions, and further informal discussions will be promoted by the fact that the participants are all to be lodged together.

Participation in C.N.R.S. colloquia is by invitation, and the total number of participants is limited to *one hundred.*

Planning will be greatly facilitated if each person who is interested in attending the colloquium will complete and return before November 1, 1977, the preliminary information form provided below.

(Detach)

INTERNATIONAL C.N.R.S. COLLOQUIUM ON "PHYSICS OF METALLIC RARE EARTHS"

St-Pierre de Chartreuse, France September 4-7, 1978

Please complete the following and send before November 1, 1977 to:

The Secretary
Colloquium on "Physics of Metallic Rare Earths"
Laboratoire Louis Néel
C.N.R.S.
166X
38042 Grenoble Cedex, France

This form is for information only and carries no final commitment.

PLAN TO ATTEND ☐ Yes ☐ No PLAN TO PRESENT A PAPER ☐ Yes ☐ No

(Please type or print)

Possible subjects: _____

_____

_____

Name _____

Address _____

_____

CONFERENCE ON THE ELECTRONIC STRUCTURE OF THE ACTINIDES

The "Third International Conference on the Electronic Structure of the Actinides" will be held in Grenoble, France, from August 30 to September 1, 1978. The aim of the Conference is to review and discuss the progress made in the basic aspects of the solid state properties of the actinides and their alloys and compounds. Topics:

—Physical properties of metals and metallic compounds
—Physical properties of ionic and semiconducting compounds
—Correlation between electronic structure, thermodynamics and crystal structure
—Sample preparation and characterization for physical measurements.

Each subject will be presented by guest speakers and developed in poster sessions, and panel discussions.

The International Advisory Committee includes: E. F. BERTAUT (France), J. M. FOURNIER (France), A. J. FREEMAN (U.S.A.), J. FRIEDEL (France), J. CRUNZWEIG-GENOSSAR (Israel), S. IMOTO (Japan), K. MENDELSSOHN (England), W. MÜLLER (F.R.G.), M. V. NEWITT (U.S.A.), R. PASCARD (France), W. I. SPITZYN (U.S.S.R.) and W. TREBIATOWSKI (Poland).

The Conference is sponsored by C.E.A. (French Atomic Energy Commission, C.E.N.-GRENOBLE), Euratom (I.T.U.), E.P.S. (European Physical Society), S.F.P. (French Physical Society), I.U.P.A.P. (International Union of Pure and Applied Physics) and S.F.E.N. (French Society for Nuclear Energy).

For further information write to:

J. M. FOURNIER, An 78
DRF/PHS - C.E.N.-G
85 X - 38041 GRENOBLE CEDEX
France.

P. W. Bridgman Award


H. G. Drickamer

The International Association for the Advancement of High Pressure Science and Technology has chosen Dr. H. G. Drickamer to be the first recipient of the P. W. Bridgman Award. Drickamer, currently a professor of chemical engineering and physical chemistry at the University of Illinois, Urbana-Champaign, is being cited for his development of high pressure techniques to investigate the electronic behavior of solids and liquids, crystal structures and electronic transitions. Current research interests include high pressure luminescence studies on phosphors doped with rare earths.

Russian RE Semiconductor Bibliographies

In the past few months RIC has received *Redkozemel'nye Poluprovodniki. Tekushchaya Bibliograficheskaya Informatsiya 4* [*Rare Earth Semiconductors. Current Bibliographic Information, No. 4*],V. P. Zhuze, editor, Fiziko-Tekhnicheskii Institut im. A. F. Ioffe, Akademii Nauk SSSR, Leningrad (1976), and also No. 5, which carries the same title, editor and publisher as No. 4, except that it was published in 1977. The fourth bibliography on semiconductors has 954 citations while the fifth has 665. The references are printed in their original language—English, Russian, French, etc. A brief subject index (20 entries) is also included in each volume.

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

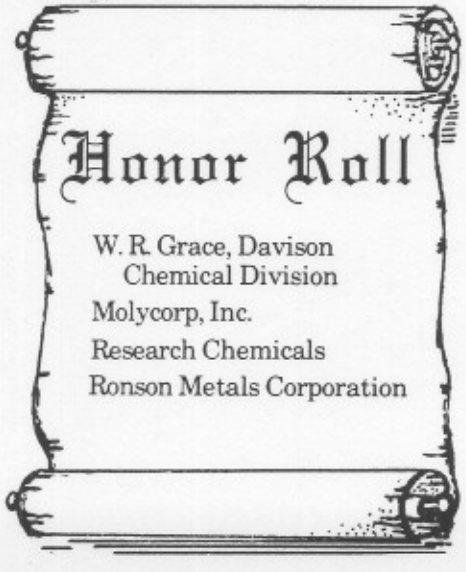
Spectroscopy

An international conference on Spectroscopie des Elements de Transition et des Elements Lourds dans les Solides was held at the Lyon I University in France June 28-July 3, 1976. Sessions were devoted to electronic states and chemical bonding, electron-phonon interaction, radiative and non-radiative processes, the migration and energy transfer between ions at different sites, the study of the real structure in solid state, optical study of magnetic interactions, new materials and recent progress in solid state spectroscopy. Over half of the forty-eight papers presented contain information on rare earth materials. The proceedings of this conference have been published as a single volume 302 pages in length which is available from Editions du C.N.R.S., 15, quai Anatole France, 75700 Paris, France. The cost is 190 francs.

Fiscal year
(continued from page 1)

Shin-Etsu Chemical Co., Ltd., Japan (8)
V/O Techsnabexport, U.S.S.R. (1)
Transelco, U.S.A. (2)
Treibacher Chemische Werke AG, Austria (6)
U. S. Radium Corp., U.S.A. (8)
Wako Bussan Co., Ltd., Japan (9)

In addition the following companies are being recognized for their important role in the success of the Rare-Earth Information Center. With this year's contribution each of these companies has contributed to the support of RIC for ten years.



Distinguished Professor


S. Legvold

Ames Laboratory rare earther Sam Legvold has been named Distinguished Professor of Physics by Iowa State University. This appointment recognizes exceptional teaching and research activities and is accompanied by a $500 honorarium. Legvold joined Ames Laboratory in 1947 after receiving his Ph.D. from Iowa State University in 1946. Before that he was an assistant professor of physics at Luther College and a Lydia Roberts fellow at Columbia University. Legvold is primarily known for his research on the electrical, magnetic and transport properties of the pure rare earth metals and their alloys.

SCANDIUM ECONOMY

The economics of scandium is the subject of a report published by the Roskill Information Services Ltd., 14 Great College Street, London, SW1P 3RZ England in September 1974. Information on scandium-containing ores, their sources, world production figures, commercial sources, end uses, economic factors such as import tariffs and an analysis of current research is presented and discussed. The cost is 220DM (~$100 U. S.). More information and details for obtaining this report are available by contacting the company directly.

Crystal Field Effects

Crystal Field Effects in Metals and Alloys [A. Furrer, Ed., Plenum Press, New York (1977)] is the published proceedings of the second international conference bearing the same name held September 1-4, 1976 at Zurich, Switzerland. The book consists of 58 papers which deal with spin waves and excitons, soft modes and critical effects, magnetic properties, physical properties influenced by crystal field effects, and valency. Theoretical aspects as well as new experimental data on crystal field effects in metals and alloys are comprehensively discussed. Information on a wide range of rare earth materials is presented. The book is 365 pages in length and costs $37.50.

Nodularization Theory in Cast Iron Aided by REs

S. Yamamoto, B. Chang, Y. Kawano, R. Ozaki and Y. Murakami have conducted several experiments involving rare earths to test the role of gas bubbles in molten cast iron during the nodularization process and to determine the mechanism of graphite nodularization [*Metal Science* **9**, 360-9 (1975)].

One of the experiments involved the addition of cerium, lanthanum or yttrium which had absorbed a large amount of hydrogen to the cast iron melt. The typical structure of nodular cast iron was obtained. When the rare earths were degassed before they were added to the melt only undercooled graphite resulted. The authors postulate that the hydrogen is evolved in the form of small bubbles from the rare earths as the temperature rises. Graphite nucleates around the bubbles and grows inward. Several other features such as density and hollow nodules are satisfactorily explained by the proposed gas bubble theory.

RE's in the News

Annular Momentum-Control Device (AMCD)

Research performed by J. Lyman, C. H. Henrikson and F. M. Manders for the Langley Research Center has resulted in the development of an AMCD, a rotating ring used to store momentum in a mechanical system, which contains samarium cobalt permanent magnets. The magnets, placed at 3 inch intervals in the rim, provide magnetic discontinuities which are required by the drive system.

Amorphous Conductivity

The electrical conductivity of amorphous materials can be increased up to nine orders of magnitude according to S. R. Ovshinsky, head of Energy Conversion Devices, Inc. Modifiers, including rare earths, are co-sputtered with glass onto a substrate and then bombarded with argon to knock bits of the metal and glass into the substrate. Generating electricity from sunlight is a potential application for these materials.

Observe Domains

B. K. Tanner, M. Safa and D. Midgley have applied cryogenic X-ray topography using synchrotron radiation to observe magnetic domains in various materials including terbium and $DyVO_4$ [*J. Appl. Cryst.* **10**, 91-9 (1977)]. The peculiar properties of synchrotron radiation make X-ray topography at temperatures from room to liquid helium relatively straightforward. Other apparatus, such as an electromagnet, can easily be incorporated in the set-up. Four different successful cryostat designs are described and the first observations by X-ray topography of ferromagnetic domains in terbium and Jahn-Teller domains in $DyVO_4$ are reported.

Goldschmidt

(continued from page 1)

rare earths with Co, Cu, Ti, Zr, Fe and other metals. The company has no intention to make magnets, but specializes in supplying the worldwide magnet industry. In cooperation with magnet makers, Goldschmidt's objective is to offer magnet alloys with optimum relations between raw materials availability, performance and cost.

Catalogues of rare earth products and other product lines are available from Th. Goldschmidt Products Corporation, 175 Main Street, White Plains, N.Y. 10601, or directly from Th. Goldschmidt AG, Metal Division, Postfach 17, 4300 Essen 1, Germany.

EDITOR'S NOTE:

This is one of a continuing series of features on rare earth industry. The information contained herein was supplied by the company featured and its publication should not be construed to constitute an endorsement by RIC or Iowa State University of the products or services offered by the company.

STEEL IMPROVED

Rare earth metal's ability to absorb large amounts of hydrogen has been applied by C. S. Kortovich to inhibit hydrogen embrittlement in high strength steel [AD-A-037355 (February 1977)]. Mechanical property tests showed that lanthanum or cerium additions to AISI 4340 steel in the 0.1 to 0.2 weight percent range resulted in a material which met most of the aircraft quality specification minimums. A notable exception was the Charpy impact strength which sharply decreased with increased rare earth content due to the continuous grain boundary inclusions which were formed. Delayed failure tests were employed to determine the hydrogen embrittlement resistance of the rare earth treated steel. Results indicate a substantial improvement manifested by longer time to crack initiation, longer time to failure and higher values of lower critical stress intensity. The mechanism responsible for the improved characteristics, according to the authors, is the gettering and entrapment of hydrogen by cerium and lanthanum which inhibits movement of hydrogen to the stressed area.

Chemistry Conference

The Association of Finnish Chemical Societies is sponsoring an EUCHEM Conference on the chemistry of the rare earths to be held June 12-15, 1978 in Helsinki, Finland. For more information contact Professor L. Niinistö, Department of Chemistry, Helsinki University of Technology, SF-02150 Espoo 15, Finland.

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DR ROBERT S HANSEN
Iowa State University
109 Office & Lab

RARE-EARTH INFORMATION CENTER NEWS

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

Volume XII | December 1, 1977 | No. 4

NUMBER 13

The 13th Rare Earth Research Conference, with one exception, did not support the myths often associated with the number 13. Change and progress were much more symbolic of the Conference held September 16-19, 1977 at Oglebay Park, West Virginia. Around 130 participants represented 13 countries which included Brazil, Canada, England, France, India, Israel, Italy, Japan, Sweden, Switzerland, Turkey, the U.S.S.R. and the United States. The red and gold patchwork scenery typical of late autumn in the eastern United States was enjoyed by all.

Left to right: C. Lundin, R. C. Ropp and J. R. Jackman converse during poster session.
Photo courtesy of Leon Luyckx

Approximately 100 papers were presented in the highly interdisciplinary meeting with sessions on solid state chemistry and physics, bioinorganic and general chemistry, metallurgy and spectroscopy. For the first time poster sessions were used to eliminate some of the problems caused by concurrent oral sessions and also to stimulate discussion on a one to one basis. Also for the first time in several years the proceedings of the Conference will be formally published as a book entitled *The Rare Earths in Modern Science and Technology*. Plenum is the publisher. Information concerning the availability of the proceedings will be announced in the *RIC News*. In addition, a list of the papers presented at the Conference is available from the Center upon request.

Left to right: J. B. Gruber, K. A. Gschneidner, Jr., B. Beaudry and S. Taher get together over some rare earths.
Photo courtesy of Leon Luyckx

Another first for the Conference was a paper which presented evidence to suggest that yttrium atoms in the compound $Y_6(Fe_{1-x}Mn_x)_{23}$ have a small magnetic moment. For our readers who are not magnetically inclined, yttrium has no unpaired electrons from which to derive a magnetic moment. . .or so it was thought! This is just one of the many interesting papers included in the proceedings.

Photo courtesy of Greg McCarthy

Looking ahead, the chairman, date and site for the 14th Rare Earth Research Conference have been chosen and they are, respectively, J. B. Gruber, June 25-28, 1979 and Fargo, North Dakota.

And finally, Jim Rhyne, the "unlucky" recipient of a broken leg at the 13th Rare Earth Research Conference is back on his feet now and getting around with the aid of crutches. On behalf of all the conferees we wish him a speedy recovery and perhaps a word of advice... "better watch out for black cats, too!"

CONTRIBUTORS

Three companies renewed their support of the Center during the second quarter of fiscal year 1978 bringing the total number of contributors to date to 30. Contributions were received from Indian Rare Earths Ltd., India, contributing for the ninth year, Foote Mineral Company, U.S.A. and Rare Earth Products, Ltd., United Kingdom, both six year benefactors of RIC.

Rust Inhibitor

Not only does cerium aid the mechanical properties of steel by controlling the sulfide inclusion morphology, it also provides rust prevention control according to H. Shimada, Y. Sakakibara, and H. Okada [*Corrosion* **33**, 196-9 (1977)]. It was reported elsewhere that the first step in the rust formation process is the dissolution of α (Mn,Fe)S into water. Therefore if all of these water soluble sulfides are converted to water insoluble sulfides rust formation would be greatly hindered. This study found that the best rust prevention was achieved by fixing all the sulfur in the steel as cerium manganese oxysulfides, (Ce,Mn)(O,S).

UNION OIL + MOLYCORP

Molycorp has become a wholly owned subsidiary of Union Oil as a result of Molycorp stockholder approval. Molycorp's headquarters will remain in White Plains, New York.

ICM '76

The Proceedings of the International Conference on Magnetism '76 held September 6-10, 1976 in. Amsterdam, The Netherlands are now available as a three volume set edited by P. F. de Châtel and J. J. M. Franse and published by North-Holland Publishing Co., Amsterdam, 1977. Reprinted from the journal *Physica*, volumes **86-88B**, the three books total about 1550 pages in length and cost U.S. $193.75 (Dfl. 475).

The ~ 580 articles deal with a variety of materials including rare earth metals, their alloys and compounds; 3d metals, their alloys and compounds; dilute alloys; disordered and amorphous systems; insulators and semiconductors. Topics covered include itinerant electron magnetism, transport in magnetic metals, critical phenomena, dimensionality and impurity effects, exchange, optical properties, spin dynamics, resonance and relaxation, anisotropy, domains, surface and size effects. Approximately one third of the articles deal with rare earth materials.

The Proceedings are available from Associated Scientific Publishers, Book Division, P.O. Box 211, Amsterdam-W, The Netherlands.

LaB_6 Emission Anisotropy

In an effort to gain more knowledge on the emission characteristics of LaB_6, P. H. Schmidt, D. C. Joy, L. D. Longinotti, H. J. Leamy, S. D. Ferris and Z. Fisk have measured the thermionic electron emission of various axial orientations of a LaB_6 single crystal [*Appl. Phys. Letters* **29**, 400-1 (1976)]. Maximum emission was observed for an $< 110 >$ orientation around 1600 K. Minimum values were seen with the $< 510 >$ axis. The $< 100 >$ emission was twice that of $< 510 >$ and yet 10 times less than $< 110 >$. Visual emission patterns show four spots forming a square for $< 100 >$ and for $< 110 >$ a rectangular pattern is seen. The LaB_6 thermionic emitters were designed to directly replace tungsten hairpin cathodes in scanning electron microscopes and, with proper axial orientation, seem capable of emission fluxes two orders of magnitude higher than the tungsten emitters.

1977 Nobel Prize in Physics

P. W. Anderson

J. H. Van Vleck

N. F. Mott

Three rare earthers have been named co-recipients of the 1977 Nobel Prize for physics. Dr. P. W. Anderson of Bell Telephone Laboratories and Princeton University, Dr. J. H. Van Vleck, emeritus professor at Harvard University, and Sir N. F. Mott of Cambridge University, England are cited for their work on describing electronic states in magnetic and disordered materials. "Particularly in the treatment of and emphasis on localized electronic states, they have gone far beyond the conventional theories, with direct importance for experiments and technique" according to the Nobel citation.

Van Vleck's studies have greatly aided the development of magnetic materials while Mott's and Anderson's research has been applied in the development of semiconductors and solar cells. Current research interests of both Mott and Anderson include the mixed valence question embodied by a wide range of rare earth compounds.

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Lu Diet Finally Recognized

In an effort to shed its reputation as the heaviest rare earth, checking in at 174.97, lutetium has been on a diet for some time now. Although initial progress was admittedly slow, Lu stuck with it and now even the International Union of Pure & Applied Chemistry has recognized the achievement by revising Lu's official atomic weight to 174.967 ± 0.003! Actually, rare earthers never did believe that Lu was as dense as they said. For you weight watchers, Lu attributes the loss to a high proton diet.

RE-Co WORKSHOP

The Third International Workshop on Rare-Earth Cobalt Permanent Magnets and Their Applications, sponsored by the University of Dayton and the University of California, San Diego, will take place June 27-30, 1978 on the LaJolla Campus of the University of California. The workshop will consist of prepared lectures, formal panel discussions and informal but organized topical conversations with participants representing industries, universities and governmental agencies on a world-wide basis.

A wide spectrum of topics and problems of a technological and business nature relating to the rare earth-cobalt magnets and their device applications will be discussed. Production and design problems, engineering and economic aspects, novel applications and magnetic circuit and device development head the list of topics to be covered. The commercial availability of the magnets and raw materials will be reviewed. There will be an exhibit of industrial products and developmental items and, if enough interest is expressed, a special symposium Saturday morning on the physical origins of coercivity or on the medical uses of these permanent magnets. Your comments and suggestions for the workshop content and/or organization are welcomed.

Attendance is limited to about 150. Registration is $300 and includes the printed proceedings. Submission deadlines are December 1, 1977 for abstracts and March 1, 1978 for manuscripts. For further information contact Dr. K. J. Strnat, University of Dayton (KL-365), Dayton, Ohio 45469, U.S.A.

INTERNATIONAL C.N.R.S. COLLOQUIUM ON "PHYSICS OF METALLIC RARE EARTHS"

St-Pierre de Chartreuse, France—September 4-7, 1978

As announced in a first circular, a specialized meeting on the Physics of Metallic Rare Earths is to be held next summer near Grenoble.

The following topics have been selected:

1 - Valence instabilities, theory and experiment: Kondo effect and magnetic order, phase transitions, effect of pressure and magnetic field.

2 - Exchange and crystal field: magnetization processes, magnetic structures, magnetic form factors, magnetic excitations, neutron spectroscopy, critical phenomena, magnetism of $4f$-$3d$ compounds.

3 - Physical properties: thermal properties, transport, E.P.R., hyperfine interactions.

4 - Theory and experimental determination of electronic structures: band calculation, photoemission, de Haas-van Alphen effect, magnetic order and superconductivity.

5 - Liquid and amorphous: magnetic, thermal and transport properties, neutron scattering.

Each topic will be presented in a general way in plenary sessions by one or two speakers. Particular aspects will then be developed in several shorter talks, interspersed with discussion periods. To accommodate the remaining communications, informal poster sessions will be arranged. A special session with only invited papers will be devoted to technical applications: permanent magnets, hydrogen storage, magnetostrictive devices.

The total number of participants will be limited to about one hundred. All the communications will be published in the "Journal de Physique" as a special volume in the series "Colloques internationaux du C.N.R.S.," in either of the working languages, English or French.

The registration fee has been fixed to 250 French Francs.

All the participants and accompanying persons will be lodged in St-Pierre de Chartreuse. The cost of lodging and meals per day will be between 100 F and 150 F according to the Hotel category. St.-Pierre de Chartreuse is a village resort beautifully situated at 1000 m on the western edge of the Alps in the Massif de la Chartreuse.

More detailed information concerning the registration and hotel reservations will be given in the 3rd announcement.

Deadline dates:

March 15, 1978 for the receipt of abstracts (authors of accepted abstracts will be notified by May 1st, together with instructions for the preparation of manuscripts).

June 1st, 1978 for the registration (the registration fee and pre-payment of 150 F for hotel reservation will be required at this time).

July 15, 1978 for the receipt of papers.

International Scientific Committee: J. FRIEDEL (France, Chairman), J. C. ACHARD (France), E. F. BERTAUT (France), E. BUCHER (Germany), P. DE CHATEL (Netherlands), B. R. COLES (Great Britain), B. COQBLIN (France), W. C. KOEHLER (U.S.A.), R. LEMAIRE (France), A. R. MACKINTOSH (Denmark), C. H. de NOVION (France), B. STALINSKI (Poland).

INSTRUCTIONS FOR PREPARATION OF ABSTRACTS

Authors are asked to prepare their abstracts for direct reproduction offset, without retyping. Except for reduction in size, the material will appear exactly as the authors prepare it. The following rules apply:

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3 - The title should be all in capitals, the authors' names, not underlined, and their affiliations should be in initial capitals and lower cases.
4 - The name and complete address of the author to whom further correspondence should be addressed should appear in the space below the abstract.
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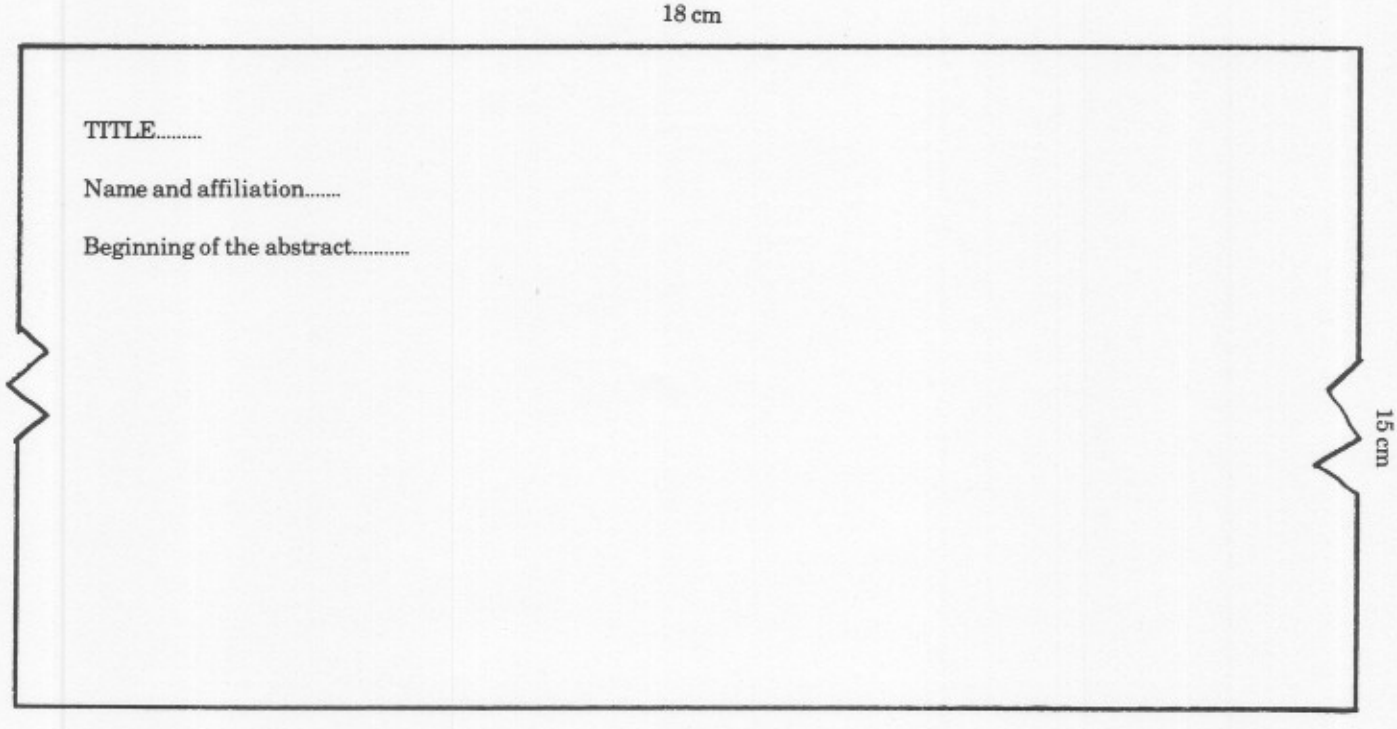
6 - The original and two copies should be submitted to the Secretary of Colloquium on "Physics of Metallic Rare Earths," Laboratoire Louis Néel, C.N.R.S., 166X, 38042-Grenoble-Cedex, France.



Name and address of the author
to whom further correspondence
should be addressed

Valence Instability

The proceedings of the International Conference on Valence Instabilities and Related Narrow Band Phenomena held at the University of Rochester, Rochester, New York November 11-13, 1976 have been published as a book entitled *Valence Instabilities and Related Narrow Band Phenomena*, R. D. Parks, ed., Plenum Press, New York (1977). The book is 562 pages long and costs $49.50.

This volume represents an excellent introduction for the uninitiated to the theoretical nightmare and experimental "paradise" of valence instability. An extremely wide range of rare earth materials is discussed. Topics range from Fermi liquids to Kondo effects. Sixty-eight papers are presented. The first half of the book consists of the oral presentations including portions of the lively discussions that followed. The last half contains the information presented at the poster sessions. A novel approach to the valence question, the elephantine version, was unveiled by Nobel laureate P. W. Anderson and should provide a large frame into which many of the problems of valence instability can be incorporated and better appreciated.

Magnetostriction

The proceedings of a workshop on magnetostrictive materials, edited by R. W. Timme, have been published in *U.S. Navy J. Underwater Acoustics* **27**, [1] 1-190 (1977). Sponsored by the Underwater Sound Advisory Group and Naval Research Laboratory, the workshop was designed to bring together various disciplines interested in the development of magnetostrictive materials and, in particular, rare earth-iron alloys. Nine of the seventeen articles deal with magnetomechanical coupling, magnetization, microstructure, mechanical properties, availability, cost and development of devices using the rare earth-iron alloys.

RIC has prepared a table of contents which includes the author's addresses. This table of contents is available by writing to RIC and is useful for obtaining reprints of articles presented at the conference since the complete proceedings are not available.

Dates Changed

The dates for the EUCHEM Conference on the chemistry of the rare earths have been changed from June 12-15, 1978 to May 30-June 2, 1978. Sponsored by the Association of Finnish Chemical Societies, the Conference will be held at the Savings Bank Institute located at Matinkylä, Espoo just 15 km west of Helsinki. The program will consist of three main topics: systematics in the properties of the rare earths, coordination and complex formation of the rare earths and rare earth nonmetallic materials. Invited speakers include J. Albertsson, Sweden, G. Blasse, Holland, P. Caro, France, I. Grenthe, Sweden, J. Loriers, France, M. A. Porai-Koshits, U.S.S.R., S. Siekierski, Poland, and S. P. Sinha, Switzerland. The official language will be English and the proceedings will not be published. Preregistration is due January 15, 1978 and final registration and submission of abstracts are due April 1, 1978. Foreign participation will be limited to around 80. For more information contact Professor L. Niinistö, Department of Chemistry, Helsinki University of Technology, SP-02150 Espoo 15, Finland.

Cerium Indicates Early Environment

Investigation of the rare earth element content in chert-type rocks of land and deep-sea origins has lead H. Shimizu and A. Masuda to portray cerium as a possible indicator of the original environment present during the formation of the rocks [*Nature* **266**, 346-8 (1977)]. Using a stable isotope dilution technique they observed a large negative cerium anomaly in all of the deep sea samples while land-exposed cherts showed either a small positive cerium anomaly or no anomaly at all. This difference is attributed to the shallower water environment in which the terrestial cherts were formed. Therefore, the presence or absence of a cerium anomaly and its extent and direction of deviation becomes a good indicator of the type of aqueous environment present during the formation of the cherty rocks. In addition, the presence or absence of a cerium anomaly would indicate whether the chert was biogenic or volcanic in origin.

Creative Invention Award

L. G. Van Uitert

Dr. L. G. Van Uitert of Bell Telephone Laboratories has been named the 1977 recipient of the American Chemical Society's Award for Creative Invention. Van Uitert is being cited for the discovery of new materials in five different areas: polycrystalline ferrites, lasers and fluorescent materials, non-linear optical materials, single crystal magnetic materials and optical fibers. His studies have contributed to advances in the fields of laser, fluorescence, magnetics and communications. Van Uitert holds over 60 U.S. patents and has authored or co-authored more than 200 papers.

FERROMAGNETISM VS SUPERCONDUCTIVITY

$ErRh_4B_4$ has been studied by W. A. Fertig, D. C. Johnston, L. E. DeLong, R. W. McCallum, M. B. Maple and B. T. Matthias to see if it is a compound where superconductivity and long range magnetic order can co-exist [*Phys. Rev. Letters* **38**, 987-90 (1977)]. Electrical resistance and ac magnetic susceptibility were measured versus temperature, and magnetization was measured versus applied magnetic field. All measurements indicate a normal- to superconducting state transition at 8.7 K, destruction of superconductivity at 0.9 K and onset of long range magnetic order at 0.9 K although at this time the type of magnetic order was indeterminate. It is noteworthy that the Er ions not only stabilize the superconducting tetragonal phase but also destroy superconductivity by long range ordering of the Er magnetic moments at low temperatures. The authors feel that this is the first evidence associating re-entrant superconductivity with magnetic structure since earlier reports dealt with matrix-impurity systems which exhibited superconductivity and the Kondo effect at the same time.

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150 years ago cerium became the first rare earth to be reduced to its metallic state.

WELDING with YTTRIUM

In an effort to improve thin sheet weld reliability of titanium alloys, R. P. Simpson has studied the controlled weld-pool solidification structure and resultant properties with yttrium inoculation of Ti-6Al-6V-2Sn welds [*Welding J.* **56,** 67s-77s (1977)]. The major stumbling block in the past has been large beta grain size in the fusion zone resulting in poor weld fracture toughness, ductility and a potential source of catastrophic failure. Yttrium was chosen because of its low solid solubility in the titanium alloy and its high affinity for oxygen. A concentration of 300 ppm yttrium in the welding rod was found to reduce the fusion zone grain size 35% and the large columnar grains in the center of the weld up to 80%. The yttrium acts as a heterogeneous nucleation site and/or restricts grain growth by pinning grain boundaries. Additions from 100 to 300 ppm yttrium were found to improve the welded structural reliability while additions greater than 300 ppm yttrium resulted in serious degradation of mechanical properties.

PLZT. . .MEET PBLN

PBLN stands for lanthanum-modified lead-barium metaniobate. M. Yokosuka has discovered that this transparent hot-pressed ceramic has some interesting optical characteristics [*Japan J. Appl. Phys.* **16,** 379-80 (1977)]. Optical transmittance spectra of PBLN were very similar to PLZT. The transverse effective birefringence as a function of electric field was measured and the linear and quadratic electrooptic coefficients were calculated. Linear coefficients are comparable while the quadratic effects for PBLN are a factor of 4 to 5 smaller than PLZT. The Curie point was found to decrease with increasing lanthanum content.

MEETING ORGANOMETALLICS

A NATO Advanced Study Institute on Organometallics of the *f*-elements has been organized for September 11-22, 1978 at the Sogesta Conference Center, Urbino, Italy. A meaningful and comprehensive picture of the chemical and physiochemical properties of lanthanide and actinide organometallic compounds will be developed via lectures, discussions, seminars and tutorials. All lectures will be in English and attendance is limited to about 80. Application deadline is March 31, 1978. For further information contact Professor T. J. Marks, Dept. of Chemistry, Northwestern University, Evanston, IL 60201, U.S.A. or Professor Dr. R. D. Fischer, Institut für Anorganische Chemie, Universität Hamburg, Martin Luther King Platz 6, 2 Hamburg 13, West Germany.

Oxygen Stabilized RE-Fe Compounds

Structural and magnetic properties of a new series of oxygen stabilized rare earth-iron intermetallic compounds have been reported by M. P. Dariel and M. R. Pickus [*J. Less-Common Metals* **50,** 125-37 (1976)]. The compounds of the formula $R_{12}Fe_{32}O_2$ are metallic in nature and have been observed for R = Gd, Tb, Dy, Ho, Er and Y. It is not known if they are thermodynamically stable or just in a metastable state. These compounds were discovered during the preparation of rare earth iron intermetallic compounds by powder metallurgy techniques. The source of oxygen is probably an adsorbed surface layer on the powder since attempts to prepare the compounds by adding oxygen or using rare earth sesquioxides proved unsuccessful.

Magnetic moment and magnetic ordering temperatures were determined for the compounds. These preliminary measurements indicate that $Y_{12}Fe_{32}O_2$ is ferromagnetic while $Dy_{12}Fe_{32}O_2$ and $Ho_{12}Fe_{32}O_2$ are ferrimagnetic.

Ni Superalloy with Y_2O_3

A mechanically alloyed, Y_2O_3 dispersion strengthened, nickel-base superalloy (MA 753) has been examined by J. H. Weber and M. J. Bomford [*Met. Trans.* **7A,** 435-41 (1976)]. The temperature dependence of fatigue properties and the role of microstructural features in deformation and failure were studied and MA 753 was compared with a conventional superalloy of similar composition.

The fatigue properties of Y_2O_3-doped MA 753 were better than the conventional Ni-base superalloy up to 1227 K, the highest test temperature. The Y_2O_3 dispersoid affected the fatigue behavior by causing more uniform deformation at all temperatures. Higher fatigue ratios in MA 753 were also related to favorable microstructural features of the dispersion strengthened alloy. In addition to good overall resistance to oxidation and sulfidation, MA 753's tensile and rupture behavior resembled thoriated nickel at high temperatures while at low temperatures these properties were similar to those of a conventional wrought Ni-base superalloy.

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DR ROBERT S HANSEN
Iowa State University
109 Office & Lab

A wish for,
Peace On Earth,
Good Will Toward All.
From RIC