RARE-EARTH INFORMATION CENTER NEWS

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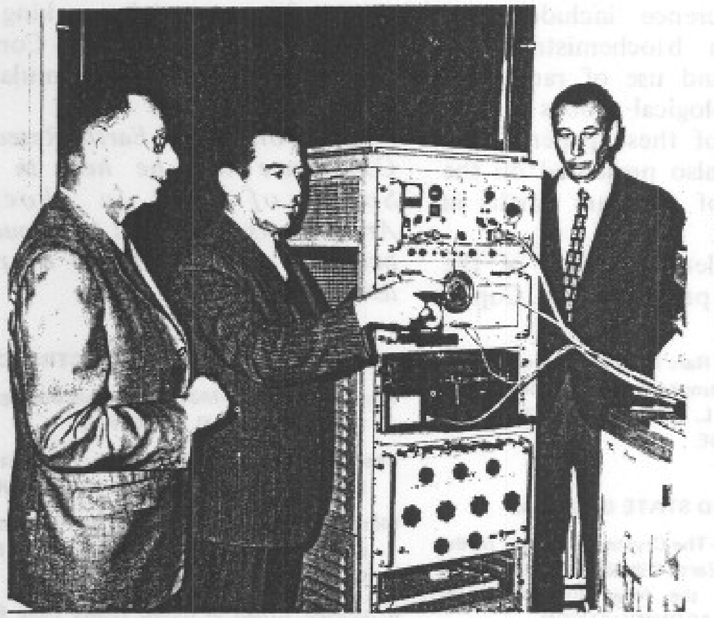
FRENCH SCIENTISTS HONORED FOR GARNET WORK



Pictured here are the recipients of the 1970 French Academy of Science Award of the Crédit Lyonnais. From left are Erwin-Félix Lewy-Bertaut, René Pauthenet and Francis Forrat.

Word has been received that three French scientists have received the Award of the Crédit Lyonnais from the French Academy of Science for their 1955 discovery of the rare earth garnet ferrites. The award, in the amount of 150,000 F (about $27,000 U.S.), was shared equally by Erwin-Félix Lewy-Bertaut, research director at the National Center of Scientific Research (C.N.R.S.); René Pauthenet, professor at the Faculty of Sciences, Grenoble; and Francis Forrat, engineer at the French Atomic Energy Commission (C.E.A.).

The trio was cited by the Academy specifically for developing the rare earth garnet ferrites, establishing their structure and determining their major properties, particularly their magnetic properties. In its citation of the French scientists the Academy noted that their work had given "impulsion not only to science and technology," but had also contributed to the industrialization and commercialism of rare earths.

Rare earth garnets are now used extensively in many electronic high frequency devices such as filters, transducers, harmonic generators, spectral analyzers, tuned oscillators, modulators and delay lines. They are currently being studied as possible components in computer memory devices.

Ho, Ho, Ho, Ho, Ho

For those of you who find it tiresome handling Ho, there's a good reason for it—Ho is heavier than you thought. IUPAC has recently adopted a new atomic weight for this rarity, 164.9304 instead of the older value of 164.9303. One part in 1.6 million may seem insignificant, but our rare earthers are a sensitive lot and we thought you would like to know. Of course, many of you suspected that Ho was heavier than reported anyway, didn't you? You didn't?

Holiday Greetings

from RIC

9th Rare Earth Research Conference

The lovely autumn campus of Virginia Polytechnic Institute and State University, Blacksburg, Va., was the setting for the 9th Rare Earth Research Conference held Oct. 10-14, 1971. The conference was attended by about 150 rare earthers who represented 11 countries and 25 states, 49 industrial companies and government installations (15 non-U.S.), and 37 universities (9 non-U.S.). Between sessions the warm weather enabled the conferees to enjoy the VPI campus and the beauty of the Virginia countryside in the special trips which were planned to the various scenic attractions near Blacksburg.

Rare earth-containing auto exhaust catalysts [see *RIC News* VI (2) 2 (1971)] was the topic of the Plenary Address presented by W. F. Libby, Nobel laureate from the University of California, Los Angeles. Dr. Libby is screening RE transition metal oxides and offers to test any samples which are sent to him. About 20-25 grams of the oxide in as finely divided a state as possible is required for testing.

Besides the traditional sessions on solid state physics, chemistry, metallurgy and spectroscopy, this year's conference included two sessions on biochemistry. The importance and use of rare earth cations as biological probes formed the nucleus of these papers. Two papers were also presented on the metabolism of the rare earths in these sessions.

The complete program of the conference is printed below. Copies of the *Proceedings of the 9th Rare Earth Research Conference* are still available at a cost of $20 for the two-volume set from:

Dr. Allan F. Clifford
Department of Chemistry
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

We would like to thank Dr. Clifford and his co-workers for the hard work involved in organizing the conference and for making the 9th Rare Earth Research Conference a pleasant and stimulating experience.

The 10th Rare Earth Research Conference will be held in the Spring of 1973 in Phoenix, Arizona. As additional information becomes available it will be published in RIC News.

PLENARY SESSION

Plenary Session—Auto Exhaust Catalysis by Rare Earth—Transition Metal Oxides. WILLARD F. LIBBY

SESSION A, SOLID STATE I (General)

Keynote Address—J. BEVAN. Studies in Rare Earth Oxides-Fluorides.

Effects of Pressure on the Electronic Structure of the Samarium Monochalcogenides—H. L. DAVIS

Luminescent Properties of Rare Earth Oxysulfide Films—R. V. ALVES, T. G. MAPLE, L. E. SOBON, and R. A. BUCHANAN

Preparation and Luminescence Properties of Tetragonal Cerium Disilicate $Ce_2Si_2O_7$ and Its Terbium Activated Derivatives. R. HEINDL, N. JONKIERRE, and I. A. LORIERS

SESSION B, CHEMISTRY I

Theoretical Treatment of the Energy Differences Between $f^{q+1}s^2$ and $f^qd^1s^2$ Electron Configurations for Lanthanide and Actinide Atomic Vapors. L. J. NUGENT and K. L. VANDER SLUIS

Electroluminescence of Trivalent Rare Earth Ions in Liquid Phosphorous Oxychloride Solutions: Formation of Electronically Excited Ions in Electrode Processes. A. HELLER, K. W. FRENCH, and P. O. HAUGSJAA

Infrared Spectra of Rare Earth β-Diketonates. P. C. MEHTA and S. P. TANDON

Metal Chelates of Rare Earths in Aqueous Solution: A Spectrophotometric Study. S. P. SANGAL, V. L. SHAH, S. C. PANDE, and S. B. DEBHADE

SESSION C, SOLID STATE II (General)

Keynote Address—The Crystal Chemistry of the Salt-like Rare Earth Dihalides and the Determination of the New Structure Type Ln_3O_4Br. H. BAERNIGHAUSEN

Growth and X-ray Studies of Single Crystals of Higher Oxides of Praseodymium and Terbium. J. M. HASCHKE, M. Z. LOWENSTEIN, L. KIHLBORN, and L. EYRING

The Crystal Structure of the Intermetallic Compounds $Pr_2Co_{1.7}$ and $Nd_2Co_{1.7}$. J. SCHWEIZER, K. J. STRNAT, and J. B. Y. TSUI

Synthesis and Physical Properties of Eu_3SiO_5. G. BUSCH, E. KALDIS, P. STREIT, C. VACCANI and P. WACHTER

Some $Ln_2Ti_2O_7$ Compounds (Ln=Rare Earth) and Their Modification Under Pressure. M. F. QUEYROUX, M. G. BOCQUILLON, M. C. SUSSE, M. R. COLLONGUES, and A. REVCOLEVSCHI

The β-Form of the L_2S_3 Rare Earth Sulfides. P. BESANCON, D. CARRE, P. LARUELLE, and J. FLAHAUT

A Non Destructive Method for the Determination Ce^{4+}/Ce^{3+} in Borate Glasses. R. REISFELD and J. HORMODALY

Soft X-Ray Spectroscopy Applied to the Study of 4f State Distributions in Rare Earth Metals and Their Oxides. R. C. KARNATAK and C. BONNELLE

SESSION D, MÖSSBAUER SPECTROSCOPY

Keynote Address—Mössbauer Spectroscopy in the Rare Earths. R. L. COHEN

The Mössbauer Effect of Europium Chelates. J. LINN MACKEY and N. N. GREENWOOD

Mössbauer Spectroscopy of Eu (III) Compounds. S. Z. ALI, S. CHANDRA and M. L. GOOD

Mössbauer Effect in Mixed Heavy Rare Earth Garnets. E. L. LOH and J. C. WALKER

Crystallographic and Mössbauer Study of HoPtSn and Related Intermetallic Compounds. A. E. DWIGHT, W. C. HARPER and C. W. KIMBALL

Hyperfine Interaction of ^{151}Eu in Eu_2TiO_4. C. L. CHIEN and F. de S. BARROS

SESSION E, SOLID STATE III (Magnetics)

Keynote Address—Magnetism in the Rare Earth Metals—A Review. R. J. ELLIOTT

A Magnetic Study of the Transition Metal Moment in the Systems $Gd(Co_{1-x}Ni_x)_3$ and $Gd(Fe_{1-x}Ni_x)_3$. J. E. GREEDAN

Magnetic Properties of $RT'_{3-x}T''_x$ (R=Dy or Ho, T'=Fe or Co, T''=Ni) K. S. V. L. NARASIMHAN, R. A. BUTERA, and R. S. CRAIG

Pulsed Field Magnetization Measurements of Rare Earth Transition Metal Compounds. K. N. R. TAYLOR, C. POLDY, and G. J. PRIMAVESI

Magnetic and Electrical Properties of Dysprosium-Neodymium Alloys. K. N. R. TAYLOR, D. CHATTERJEE, and H. KRIZKOVA

Magnetic Structure of $HoFe_3$. M. SIMMONS, J. M. MOREAU, and W. J. JAMES

The Effects of Composition on the Magnetic Properties of Sm-Co Alloys. J. W. WALKIEWICZ, J. S. WINSTON, and M. W. WONG

Liquid-Phase Sintering of $PrCo_5$ Magnets With A Sm-Co Additive. K. J. STRNAT, J. B. Y. TSUI, and J. SCHWEIZER

SESSION F, BIOCHEMISTRY I

Keynote Address—J. A. GLASEL. Studies of Lanthanides in Biological Systems.

The Lanthanide Cations as Nuclear Magnetic Resonance Probes of Biological Systems: Studies of Lysozyme and Staphylococcal Nuclease. E. NIEBOER

The Lanthanide Cations as NMR Conformational Probes. C. D. BARRY, J. A. GLASEL, A. C. T. NORTH, R. J. P. WILLIAMS and A. V. XAVIER

Investigations of Amino Acid Complexes of Nd(III). E. R. BIRNBAUM, C. YOSHIDA and D. W. DARNALL

Rare Earth Metal Ions as Probes of Calcium Ion Binding Sites of Proteins. D. W. DARNALL and E. R. BIRNBAUM

SESSION G, CHEMISTRY II

Keynote Address—Solvent Extraction of the Rare Earths. H. A. C. McKAY

Thermodynamic Systematics Among the Members of the Lanthanide and Actinide Series. L. J. NUGENT, J. L. BURNETT, and L. R. MORSS

Samarium Separation by a Selective Stripping Sequence. D. J. BAUER, L. E. SCHULTZE, and R. E. LINDSTROM

Electrochemical Reduction of Europium at a Porous Carbon Cathode with Flowing Electrolyte. E. I. ONSTOTT and C. R. McCLENAHAN

Potentiometric Titrations of Ytterbium (II) in Liquid Ammonia at Room Temperature. R. N. KRISHNAN and J. C. WARF

Relative Basicities of Trivalent Actinides and Lanthanides and Comparison of Stoichiometries of Their Hydroxide Formation. B. WEAVER and R. R. SHOUN

Lanthanide Oxalates and Some of Their Derivatives. F. WEIGEL, W. OLLENDORFF, R. MERZ, A. M. MULOKOZI, and S. YIN-TSANG

Investigation at Tracer Scale of Some Lanthanide Chemical Properties. G. BOUISSIERES, F. DAVID, J. FOOS, R. GUILLAUMONT, Y. LEGOUX, J. MERINIS, NGUYEN-LONG-DEN and M. de SAINT-SIMON

Occurence and Extraction of Rare Earth Minerals in Norway. B. GAUDERNACK and O. BRAATEN

SESSION H, METALLURGY I

Keynote Address—Rare Earth Permanent Magnets and Related Compounds. H. ZIJLSTRA

Pressure—Induced Electronic and Structural Transformations in Rare Earth Monochalcogenides. A. K. SINGH, A. JAYARAMAN, A. CHATTERJEE and S. RAMASESHAN

Samarium-Gold and Dysprosium-Gold Alloy Systems. O. D. McMASTERS

Lattice Constants for Mixed Intermetallic Phases of the Type $R_2(Co_{1-x}Fe_x)_{17}$. A. E. RAY and R. S. HARMER

Phase Transformations in Ytterbium Metal Thin Films. C. BOULESTEIX, P. E. CARO, M. GASGNIER, CH. H. La BLANCHETAIS, and G. SCHIFFMACHER

Thermal Conductivity of Cerium at High Temperature. L. J. WITTENBERG

The Oxidation of Erbium Metal. D. H. LOESCHER

Sulfur Removal from Super Alloys by Cerium Metal. J. G. CANNON and R. CREMISIO

Determination of Low Concentrations of Rare Earths in Aluminum. I. S. HIRSCHHORN and S. TANNENBAUM

Electronic Structure of Samarium Chalcogenides as Derived from the Optical and Magneto-Optical Properties. C. PAPARODITIS and R. SURYANARAYANAN

SESSION I, SOLID STATE IV (Spectroscopy)

Keynote Address—Laser Pumped 10μ Photon Quantum Counter Up-Conversion in Rare Earth Doped Crystals: Theory and Experiment. F. K. FONG, M. M. MILLER, and J. C. WRIGHT

Fluorescence Efficiency of Lanthanum-Cerium-Terbium-Phosphates. J. C. BOURCET, J. GRAFEMEYER, J. JANIN, and F. GAUME-MAHN

Flame Excited Luminescence in Terbium and Europium Doped Rare Earth Oxides. J. R. SWEET and W. B. WHITE

Two Photon Spectroscopy Applied to Rare Earth and Actinide Ions in Crystals. J. B. GRUBER

Spectra and Energy Levels of Eu^{3+} in $LnLiO_2$ Compounds. F. GAUME-MAHN, C. LINARES, and M. BLANCHARD

Quantum Yields and Transition Probabilities of Eu^{3+} in Silicate Glasses. R. VELAPOLDI, R. REISFELD, and L. BOEHN

Sensitization Processes of Eu^{3+} Luminescence by a Trace of Pr^{3+} and Tb^{3+} in Y_2O_2S. H. YAMAMOTO, T. KANO, Y. OTOMO and KOICHI URABE

SESSION J, BIOCHEMISTRY II

Keynote Address—Gadolinium (III) as a Paramagnetic Probe for Magnetic Resonance Studies of Biological Macromolecules. J. REUBEN

Molecular Conformation Determinations of Inhibitor/Enzyme Complexes with Respect to the Gd(III) Reporter Site. R. A. DWEK, K. G. MORALLEE, E. NIEBOER, R. E. RICHARDS, R. J. P. WILLIAMS and A. V. XAVIER

Physico-Chemical and Biological Interactions in Rare Earth Metabolism. D. D. MAHLUM and M. R. SIKOV

Metabolism of Monomeric and Polymeric Plutonium in Mice Following Intravenous Injection. A. LINDENBAUM

SESSION K, CHEMISTRY III

Pulse Radiolysis in Lanthanides Aqueous Solutions I: Formation Spectrum and Chemical Properties of Divalent Europium, Ytterbium and Samarium Ions. M. FARAGGI and Y. TENDLER

Solubility of $Er(OH)_3$ at Hydrothermal Conditions. S. MROCZKOWSKI and J. ECKERT

Vaporization Thermodynamics of Europium (II) Chloride and Europium (III) Oxidechloride. A. V. HARIHARAN and H. A. EICK

High Temperature, High Pressure Chemical Transport of EuS. G. BUSCH and E. KALDIS

The Nonstoichiometry of Rare Earth Hexaborides. S. YAJIMA and K. NIIHARA

Decolorizing Soda-Lime Glasses with Cerium Concentrate. G. A. BARLOW

SESSION L, METALLURGY II

Keynote Address—Valance Bond Formation in the Rare Earth Compounds Having the $CaCu_5$ Structure. F. L. CARTER

Relative Stability of Definite Compounds in the Samarium Tin System. A. PERCHERON and J. C. ACHARD

Phase Relationships in the Ternary System ZrO_2-PrO_x. G. BRAUER and B. WILLAREDT

Formation of Metastable Low Temperature Allotropic Solid Solutions in Rare Earth-Zirconium Systems. R. WANG

Thermal Mechanical Treatments on Magnesium-10.8 per cent Yttrium Alloy. A. SAIA and R. E. EDELMAN

Growth of Large Single Crystals of Rare Earth Metal Isotopes. R. E. REED

SESSION M, SOLID STATE V (General)

Keynote Address—Low Temperature Heat Capacity of Rare Earth Intermetallic Compounds. K. A. GSCHNEIDNER, JR.

Magnetic Susceptibility of Thorium Cerium Alloys Between 10 and 300°K. M. FRANCILLON and O. GOROCHOV

Studies of Kondo Phenomenon in $Ce_xLa_{1-x}Pd_3$ Ternary Alloys. R. D. HUTCHENS, V. U. S. RAO, J. E. GREEDAN, and R. S. CRAIG

Electrical Resistivities of Some Palladium-Rare Earth Intermetallic Compounds. R. O. ELLIOTT and H. H. HILL

Energy Levels and Crystal-Field Splittings of Er^{3+} in Y_2O_2S. J. C. SOUILLAT, J. ROSSAT-MIGNAD, C. LINARES, and C. QUEZEL

(Continued on Page 4)

Anisotropy of Exchange and Its Variation with Lattice Parameters for Rare Earths in the Paramagnetic State. P. BOUTRON, J. L. FERON, G. HUG, and P. MORIN

Magnetic and Thermal Properties of $Yb(C_2H_5SO_4)_3 \cdot 9H_2O$. S. P. TANEJA

On the Behavior of Er^{3+} Ion in $SrMoO_4$ and $LiYF_4$. VISHWAMITTAR, S. P. TANEJA, and S. P. PURI

SESSION N, CHEMISTRY IV

Keynote Address—The $L_6B_2C_2X_{14}$ Family. J. FLAHAUT

Rare Earth Formates: Decomposition, Infrared, and Single Crystal Data. F. L. CARTER, F. VON BATCHELDER, J. MURRAY and P. H. KLEIN

The Problem of the Stability of Eu^{2+}-Transition Metal Oxides as Illustrated by the System Eu-Fe-O. G. J. McCARTHY and R. D. FISCHER

Crystal Chemistry and Phase Relations in the System Eu-W-O. G. J. McCARTHY, J. SANZGIRI, G. G. JOHNSON, JR., and R. D. FISCHER

The Use of a Rare-Earth-Hydrogen System as a Gas Pressure Standard. C. E. LUNDIN

Phase Transformations in Rare Earth Oxide Thin Films. C. BOULESTEIX, P. E. CARO, M. GASGNIER, CH. H. La BLANCHETAIS and G. SCHIFFMACHER

Solid Solutions of $YbMnO_3$-$YbCrO_3$. A. E. AUSTIN, J. F. MILLER, V. E. WOOD, E. W. COLLINGS, R. BAUXTER, and K. C. BROG

The Dissociation Energies of Scandium and Yttrium Monoaurides. K. A. GINGERICH and H. C. FINKBEINER

Yttria Capacitor

The use of yttrium oxide thin films as capacitors has been described by T. Tsutsumi in the *Jap J. Appl. Phys.* 9, 735-739 (1970). A capacitor with an Al-Y_2O_3-Al configuration was prepared on a glass substrate by vacuum evaporation. The capacitor exhibited excellent dielectric stability with respect to temperature (changes of 300 ppm/°C) and to frequency (less than 0.5% variation from 10^3 to 10^6 Hz).

The author noted Y_2O_3 films are easily and reproducibly fabricated by vacuum evaporation. The Y_2O_3 films were found to have the cubic C-form structure. Other properties determined were the dielectric constant (13), dissipation factor (tan $\delta = 0.003$) and the breakdown field strength (3×10^6 V/cm^2).

RE Oxysulfides

Two recent papers have indicated possible new uses for the luminescent properties of rare earth-doped oxysulfides. Yb-Er- and Tm-activated oxysulfides have been reported to emit visible radiation when excited by infrared light from a GaAs diode, P. N. Yocom, J. P. Wittke, I. Ladany, *Met. Trans.* 2, 763-766 (1971), while Nd-doped La_2O_2S has been shown to be a highly efficient laser material, R. V. Alves, R. A. Buchanan, K. A. Wickersheim and E. A. C. Yates, *J. Appl. Phys.* 42, 3043-3048 (1971).

Yocom and co-workers prepared a $(Y_{.86}Yb_{.08}Er_{.06})_2O_2S$ phosphor which, when coated on a GaAs:Si diode and driven at a power density compatible with long diode lifetime, gave a higher output than any other phosphor composition previously reported. The visible emission of this phosphor is in a group of lines near 5500Å, the peak of the eye sensitivity for green. A blue, but less efficient, phosphor was obtained by using Tm^{3+} as the activator in Y_2O_2S. The authors reported over-all power efficiencies in the green of 1 to 2×10^{-4} and of 4.5×10^{-6} in the blue.

Alves and co-workers reported the lasing action of Nd in La_2O_2S. This material has a larger pumping cross section, a larger lasing cross section and a lower lasing threshold than YAG:Nd. Projecting from the pulsed-mode data, the authors predicted that La_2O_2S:Nd will show an 8-12 times greater continuous wave slope efficiency than YAG:Nd as soon as high optical quality crystals become available. Although the preparation and properties of fairly large (1 X 1½ in.) single crystals of La_2O_2S have been reported by L. E. Sobon, K. A. Wickersheim, R. A. Buchanan and R. V. Alves, *J. Appl. Phys.* 42,3049-3053 (1971), these crystals were not of high enough optical quality for lasers.

C. F. Auer von Welsbach discoverer of praseodymium and neodymium appears on the Austrian 20 schilling note.

PNICTIDES

Almost 600 references arranged according to the non-RE element are cited in *Pnictides of the Rare Earth Metals (Compounds of Scandium, Yttrium and Lanthanum with the Nitrogen Group Elements), Bibliographical Catalog (1828-1967),* K. E. Mironov and T. G. Pritchina (Academy of Sciences, USSR, Siberian Division, Novosibirsk, 1969).

Although the book is in Russian, the majority of the references are to non-Russian publications and are cited in the language of the original publication.

This pnictide bibliography is available for a price of 69 Kopecks from the following source:

K. E. Mironov
90-Novosibirsk
Science Prospect
Bldg. 3, Siberia
USSR

ORDNANCE

The pyrophoric and incendiary properties of mischmetal (a mixture of rare earth metals) are being utilized in a new application of this material in munitions as projectile linings. The pyrophoric nature of mischmetal has been employed for many years as cigarette lighter flints and other sparking tools. The incendiary nature is not as well known, except for those persons who might be involved in machining or grinding mischmetal or some of the light lanthanide metals, especially cerium.

Studies in the last few years have shown that mischmetal can be ignited in ordnance devices either by firing these projectiles at high velocity against steel or by an explosive charge contained in the projectile itself.

The mischmetal requirement for these shell linings is expected to be quite large. This major application is only the second, the other being lighter flints, in which the rare earth material is the major component of a product rather than an additive.

RCA Laboratories–

Luminescence and Electro-Optics

Staff of the RCA Laboratories Luminescent and Electro-Optic Materials Research Group are from left W.M. Yim, W. H. Fonger, R. E. Shrader, C. W. Struck, S. Larach (RCA Laboratories Fellow), J. P. Dismukes, P. N. Yocom (Group Head), I. Shidlovsky and S. A. Lipp.

Located at the David Sarnoff Research Center in Princeton, N.J., the RCA Laboratories Luminescent and Electro-Optic Materials Research Group under Dr. P. N. Yocom has been conducting studies in the luminescence and semiconduction of rare earth materials among its research activities.

In the area of luminescence, the main activity is the development and understanding of cathodoluminescent materials. This area of activity is supported by three interacting activities. One of these programs is basic studies which explore the areas of excitation, energy transfer, radiative emission and nonradiative energy dissipation.

The second is the synthesis effort which is responsible for the preparation of new and improved luminescent materials. An important aspect of the synthesis work is the characterization of materials from the compositional aspect.

The third of these interacting activities is the measurement program which can be considered a characterization from the physical point of view. Many of the materials studied in the luminescence program are either activated by rare earth ions or are in the main rare earth compounds with added activators.

(Continued on Page 6)

New RE Publication

A new publication concerning rare earths has been published by Reaction Metals, a subsidiary of Rare Earth Industries, Inc., under the title *Tech Bulletin.* Three issues have been published to date.

The first issue deals with mischmetal (a mixture of rare earth metals containing primarily the light lanthanides in the same relative proportions as found in the ore) and its mechanical properties, and some general background information on the rare earths. The second issue deals with the pyrophoric and incendiary behavior of mischmetal and some manufacturing techniques. The third issue deals with alloying mischmetal and the effects these alloying elements (Mg, Fe, Cu, Sn, etc.) have on its properties.

This publication is available free from Reaction Metals, Inc., 6239 Edgewater Drive, Orlando, FL 32810.

Applied Solid State Reviews

Two excellent review chapters on photochromic materials and on laser materials appear in *Applied Solid State Science. Advances in Materials and Device Research*, R. Wolfe and C. J. Kriessman, eds. (Academic Press, New York, 1971) 319 pp., $16.

"Inorganic Photochromic Materials," B. W. Faughnan, D. L. Staebler and Z. J. Kiss, 65 pp., 88 references, is a detailed study of the photochromic materials, which have received recent attention, with emphasis on a fundamental understanding of the basic processes involved. After a short review of the characteristics of inorganic photochromic materials, the properties of specific compounds are discussed including the mechanisms of oxidation-reduction of rare earth ions in CaF_2, of charge transfer between rare earths, and of charge transfer in singly-doped CaF_2 and transition metal-doped $SrTiO_3$. Applications and the direction of future photochromic research are also presented.

In "The Chemistry of Laser Crystals," 126 pp., 413 references, K. Nassau discusses the crystal chemistry, growth and substitution of laser materials. Because there are a large number of crystalline host-active ion combinations used in lasers, the author reviews in detail only a few of the better understood laser materials in order to cover the full range of phenomena observed. The garnets and rare earth-doped compounds are among those materials discussed in detail. A large section of the chapter is devoted to the growth of laser crystals.

BOOKS

The 1961 edition of *The Rare Earths*, edited by F. H. Spedding and A. H. Daane has been reprinted. It is available from the R. E. Krieger Publishing Co., Inc., P.O. Box 542, Huntington, NY 11743, U.S.A. for $16.50.

Luminescence and Electro-Optics
(Continued from Page 5)

The other area of the group's work has been the synthesis and characterization of rare earth, yttrium, and scandium nitrides and sulfides as semiconductor materials with particular emphasis on the electroluminescent aspects of semiconductors.

In recent years the group's efforts, together with the efforts of its corresponding group at the RCA Entertainment Tube Division at Lancaster, Pa., have been responsible for the development and introduction of europium activated yttrium oxysulfide as a commercial red phosphor in color television.

Rare Earther, Drobnick, Dies

James L. Drobnick, director of process research for Molycorp, died Aug. 28, 1971, following surgery. Drobnick joined Molycorp in 1966 after 14 years with the Colorado School of Mines Research Foundation where he had been manager of the chemical division. At Molycorp he was associated with successful projects involving sophisticated rare earth solvent extraction systems. At his death he was co-author of patent applications for separation processes for Nb, Mo and the rare earths.

PROMOTED AT DAYTON

Al Ray has been promoted to the post of director of Materials Science in the Engineering Department at the University of Dayton, Dayton, Ohio.

EXPLORE MERGER

Molybdenum Corp. of America and Kawecki Berylco Industries, Inc., both headquartered in New York, N.Y., are presently exploring the possibilities of merging or consolidating. The outcome of the possible merger or consolidation will be decided by the boards of directors and shareholders of both firms. Preliminary plans indicate that one share of common stock of the merged company will be issued for every outstanding share of common stock of each of the companies.

Pu in Nature

Plutonium-244 has been isolated from bastnasite ore from Molycorp's Mountain Pass, Calif., mine. This is the first time that this isotope has been identified in nature. Only 8×10^{-15} gram of ^{244}Pu was obtained from 85 kg of bastnasite by Darleane Hoffman and Francine Lawrence of the Los Alamos Scientific Laboratory and Jack Mewherter and Frank Rourke of Knolls Atomic Power Laboratory.

The detection of ^{244}Pu, which has a half-life of 80 million years, may indicate that the synthesis of heavy elements was still occurring when the solar system was formed.

Pm in Nature

A promethium content of $7.3 \times 10^{-17}\%$ has been found in the naturally occurring lanthanide oxides of gadolinite by H. Meier and co-workers, *Z. Naturforschung* 25A, 1945-1953 (1970).

A beta-emitting fraction between samarium and neodymium was separated from 200 kg of gadolinite in one- and two-stage cation exchanges by using nitrilotriacetic acid as the eluant and Cu^{+2} as the barrier ion. The beta-activity source in this fraction was identified as ^{147}Pm on the basis of chemical behavior and the energy of its activity.

The authors concluded that the ^{147}Pm was the result of the short lived neodymium isotope

$$^{146}Nd\,(n,\gamma)^{147}Nd \xrightarrow{11.1\text{ days}} {}^{147}Pm \xrightarrow{2.62\text{ years}} {}^{147}Sm$$

and not the result of fallout, the actinium anomaly or spontaneous fission of ^{238}U.

The ^{147}Pm content found in this study agrees well with the $4.5 \times 10^{-17}\%$ value reported in 1965 by O. Erämetsä in a study of the lanthanide oxides of apatite.

RARE, EARTHLY GOOFS

Vol. VI, No. 3, September 1971

In the story about F. C. Palilla receiving the second Annual Award from the Electronics Division of the Electrochemical Society, his name was consistently misspelled Pallila. *RIC News* regrets this error.

Surface Laser

A new type laser which contains a high density of active ions (25%) has been successfully operated by F. Varsanyi, *Appl. Phys. Letters* 19, 169-171 (1971). Using 100% $PrCl_3$ or $PrBr_3$ single crystals, Varsanyi has been able to generate laser action in the ionic layers near the surface and, because of the high density of active ions, the beam travels freely to the edge of the crystal. The exciting radiation, generated by a turnable dye laser or an argon laser with a wavelength of 4880Å, penetrates the crystals to a depth of about 1μ.

The high ion density and essentially 100% efficiency permits a large gain per unit length and makes a very compact device. If the exciting radiation impinges on the $PrCl_3$ crystal in the form of a rectangular slit, the initial laser action occurs along an axis which is parallel to the longest dimension of the slit. This output is called the "surface mode." When the excitation energy density is increased, a second threshold is reached and the surface laser action abruptly ceases but at the same time a laser beam of the same wavelength as the surface one excites the crystal in both the forward and backward direction—the so-called "penetration mode."

Varsanyi points out several useful properties which make these surface lasers attractive as active elements in integrated optical networks. Their small size would permit packing densities of 10^6 independent lasers per square inch. Since the surface mode of operation is dependent on the slit direction, the output beam is steerable. The dual mode of operation permits the use of these crystals as memory cells. Finally, the ease of preparing these materials by vapor deposition should permit the preparation of devices by the masking techniques developed in integrated electrical-circuit technology.

(Continued on Page 7)

Surface Laser
(Continued from Page 6)

When a tiny $PrCl_3$ or $PrBr_3$ crystal, which was barely visible to the eye, reached the threshold energy density the "dust" particle lit up with a brilliant red glow. A dispersion of these crystals in an appropriate carrier could be used in display technology.

MEETING

The Russian Academy of Sciences has announced an international conference on the physics and chemistry of the rare earth metals, alloys and compounds to be held in September 1972. As more information becomes available, it will be published in future issues of the *RIC News.* The conference chairman is Prof. E. M. Savitskii, Institute of Metallurgy, Academy of Sciences of the USSR, Leninskii Prospekt 49, Moscow V-334, USSR.

Rare Earths In the News

R-Fe MAGNETOSTRICTION

Room temperature magnetostrictions, which are several orders of magnitude larger than have ever been observed in typical polycrystalline materials, were found to occur in some rare earth-iron compounds by scientists at the Naval Ordnance Laboratory, Silver Springs, Maryland.

CERIUM SAVINGS

Manufacturers of ductile iron can save up to \$1/ton simply by increasing their use of Ce and other rare earths and reducing the amount of Mg used in their nodularizing additions, according to a study completed last year by the Illinois Institute of Technology Research Institute. Another plus is that strength, ductility and machineability all can be increased by doubling or tripling present rates of Ce addition.

Crystal Fields

The recent progress in understanding the origin of the lanthanide crystal fields has been summarized by D. J. Newman in *Advan. Phys.* 20, 197-256 (1971). An attempt was made to examine the theory and explain some new conceptual developments, but all the experimental data published in the literature was not collected.

Newman finds the most intriguing questions are: 1. why is the phenomenological parametrization method so effective, 2. how can deviations from this method be explained, and 3. what is the underlying electronic mechanism which produces the crystal field splitting.

The questions are answered in seven subsections. These deal with the parametrization of the crystal field; determination of crystal field parameters from experimental data; the superposition model; correlation induced by crystalline environment; *ab initio* calculation of crystal field parameters; topics related to crystal field theory; and perturbation theory for nonorthogonal states.

An appendix briefly outlines the history of lanthanide crystal field theory.

FREE

Copies of *Rare-Earth Metals in Steels*, IS-RIC-4, and *Thermo-Chemistry of the Rare Earth Carbides, Nitrides and Sulfides for Steelmaking*, IS-RIC-5, are available from RIC.

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Telephone: Area Code 515 294-2272
K. A. Gschneidner, Jr. . . . . Editor
Nancy Kippenhan and W. H. Smith
Staff Writers

Hydrogen Detector

Neodymium films evaporated onto a polished and etched metal or alloy surface have been used to detect the hydrogen emanated from the substrate according to S. M. Toy and A. Phillips, *Corrosion* 26, 200-207 (1970). Since the neodymium film is optically transparent except at the sites where hydrogen is emanated to form NdH_2, the microstructural features of the metal surface are directly correlated to the hydrogen emitting sites.

Toy and Phillips estimate that an NdH_2 site 1μ diam corresponds to about 4 ppm H_2 emitted from a maraging steel or 30 ppm from a Ti-6Al-4V alloy. For the maraging steel the hydrogen is found to be emitted from austenite islands in the steel, and for the Ti-6Al-4V it was emitted from the α/β (hcp/bcc) titanium alloy interface.

Supporters Up 50%

Nine more rare earth firms have joined the ranks of those who provide financial support for RIC. Newest contributors for this year are:

American Metallurgical Products Co., U.S.A. (3)*
Kerr-McGee Chemical Corp., U.S.A. (4)
Lunex Co., U.S.A. (2)
Nuclear Corporation of America, Research Chemicals Division, U.S.A. (4)
Pechiney-Saint Gobain, France (2)
Rare Earth Corporation of Australia, Ltd., Australia (2)
Santoku Metal Industry Co., Ltd., Japan (2)
Sawyer-Adecor International, Inc., U.S.A. (2)
Wako Bussan Co., Ltd., Japan (3)

*The number in parenthesis behind each contributor's name indicates the number of years of RIC support including Fiscal Year 1972.

With the addition of these nine firms to the list of RIC supporters, the Center is now receiving aid from 25 rare earth producers and manufacturers of rare earth products.

Zap R E Separation

Rapid, high resolution separations of Yb, Lu, Er and Tm have been achieved through the use of electromolecular propulsion (EMP), a new technique developed by N. Haber, Haber Instruments, Inc., Palisades Park, N.J., according to the developer.

EMP employs high electrical voltages to effect rapid molecular migration. By using the appropriate amount of electrical energy, charge transport can be controlled between molecular species as they interact with one another and with their environment. Thus, a mixture can be separated by exploiting the electromolecular character of each species. Although voltages as high as 22,000 V are used, only a small amount of heat is generated.

EMP is applicable to both organic and inorganic, polar and nonpolar materials.

The details of the EMP process and the instrument are proprietary pending patent coverage.

Laser Properties

The optical and mechanical properties of five commercially available Nd-doped laser glasses have been measured by R. M. Waxler and co-workers of the National Bureau of Standards, Washington, DC, J. Res. NBS 75A [3], 163-174 (1971).

The study includes data on the transmittance, refractive index, thermal expansion, thermal change in refractive index, photoelastic constants, elastic constants, thermal conductivity in the temperature range 0-100°C, Knoop hardness, density and chemical composition. The thermal change in refractive index at constant volume was also calculated because this value is important in the self-focusing of laser light.

The measurement and compilation of these properties should be a valuable aid in laser design and in calculating corrections for optical distortions produced by thermal effects in laser operation.

Thermomagnetic Writing on EuO

An improved method has been developed for measuring the temperature in a thermomagnetically written bit, H. Wieder, S. S. Lavenberg, G. J. Fan and R. A. Burn, *J. Appl. Phys.* 42, 3458-3462 (1971).

Basically, thermomagnetic writing consists of focusing a pulsed laser beam on the storage plane of a medium, thereby raising the local temperature to a point where the coercive force of the medium can be overcome by a magnetic field. The spot is then "read" by its effect on the polarization state of a laser beam. Previous attempts to estimate the critical amount of energy necessary to raise the temperature were only partially successful.

The authors have developed a method which utilizes the red shift of the *4f* to *5d* transition in EuO with increasing temperature. This shift appears as a change in transmission which can be calibrated against temperature when the shift is monitored at 0.85μ, the wavelength of the GaAs laser.

The temperature excursion necessary to write a bit was found to be about 50°K. It was reported that energy losses from thermal relaxation processes were at a minimum with short, high-powered pulses. Short pulses should also achieve high data rates. One of the possible uses for thermomagnetic writing on EuO is for beam-addressable files.

Analyze Magnetic Materials By Nuclear Spectrometry

An excellent review of the application of the Mössbauer effect (ME) and nuclear magnetic resonance (NMR) methods to the study of magnetic materials has been written by D. Feldman, H. R. Kirchmayr, A. Schmolz and M. Velicescu, *IEEE Trans. Magnetics*, MAG-7, 61-91 (1971). The authors first present a brief summary of the basic properties of atomic nuclei and their interactions with magnetic and electric fields. Experimental techniques are described in some detail. This is followed by a discussion of the properties of the materials which are suitable for investigation and the special features of Mössbauer effect and nuclear magnetic resonance for studying magnetically ordered substances. The last portion of the paper deals with specific applications and a review of recent NMR results on magnetic materials and references concerning ME results on the same materials. More than 275 references are cited.

Of the 17 rare earth elements, only Y, Ce, Pm, Sm and Er do *not* have isotopes suitable for NMR studies, and for ME studies there are six which are *not* suitable: Sc, Y, La, Ce, Nd and Lu. Although Y and Ce isotopes cannot be used in either ME or NMR studies, compounds or alloys may still be investigated depending upon what other elements are present. For example, in rare earth-iron garnets, the ^{57}Fe isotope may be used in either ME or NMR experiments.

Rare-Earth Information Center
Institute for Atomic Research
Iowa State University
Ames, Iowa 50010