RARE-EARTH INFORMATION CENTER NEWS

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Experimentalists Gain on Theorists

The rare earth experimental physicists are slowly closing in on the elusive Fermi surfaces of the *trivalent* rare earth metals. The Fermi surface is important to scientists because it governs the nature of the transport properties of solids, in particular the electrical resistivity, thermal conductivity, Hall effect, magnetic susceptibility, etc. The most recent advance was reported in December by R. C. Young, R. G. Jordan and D. W. Jones [*Phys. Rev. Letters* **31**, 1473-6 (1973)] who measured seven different frequencies in gadolinium metal–three in the basal plane and four along the c-axis. Until now the best that experimentalists were able to do was measure a single frequency in lutetium [J. A. Hoekstra and R. A. Phillips, *Phys. Rev. A* **4**, 4184-6 (1971)].

The first of the Fermi surfaces was calculated by theorists about ten years ago, and subsequently they have been calculated for most of the rare earth metals. The results of Young and co-workers support the Fermi surface calculations in general, but there are some differences in the details. Furthermore, some of the observed low frequencies could not be explained because the band structure calculations had not been carried out in sufficient detail. But now, with some reliable data on hand, the theorists can go back to the computers and try to refine their calculations.

Two months prior to the Young, *et al.* paper, J.-P. Jan [*Phys. Rev. B* 8, 3590-4 (1973)] reported the first de Haas-van Alphen measurements of the Fermi surface of any rare earth intermetallic compound, YZn. In this case, he claims, no theoretical model can satisfactorily explain his observations.

Now it appears that the tortoise has moved ahead of the hare in the race.

The first Fermi surface measurements on any rare earth material were made in 1967 on *divalent* metallic ytterbium [*RIC News* **III** [1] 3 (1968)].

FLUORESCENT STANDARDS

Rare earth-doped glasses are promising standard reference materials for fluorescent spectroscopy according to R. Reisfeld, *J. Research NBS-A. Phys. Chem.* **76A**, 613-35 (1972). Reisfeld studied absorption, excitation and fluorescent spectra, oscillator strength, and quantum efficiency of glasses doped with Gd^{3+}, Tb^{3+}, Eu^{3+}, Sm^{3+}, Tm^{3+}, and Ce^{3+}. Other variables investigated were concentration dependence, fluorescent lifetimes, quenching by surrounding medium, and stability.

Quantum efficiency from the lowest excited fluorescing levels approaches unity for Eu^{3+}, Gd^{3+}, Tb^{3+} and Sm^{3+}. Tm^{3+} fluoresces in some of the same regions as Tb^{3+} although its quantum efficiency is

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Explosive Explanation

Dr. Fred Holtzberg has offered a different explanation for the explosive behavior of Gd-doped SmS than that proposed by A. Jayaraman *et al.* and reported in *RIC News* **VIII** [4] p. 1. Holtzberg, of IBM's Thomas J. Watson Research Center, attributes the behavior to a phase separation rather than a phase transition.

In Holtzberg's model, both the black-colored phase and the gold-colored phase are initially present. Upon cooling, differential stresses are experienced in the crystal lattice which finally gives way to an explosive phase separation. Gold crystals collected after the explosive transition became black upon cooling and regained the gold color upon heating. Thermal cycling revealed no further deterioration in the crystals.

Holtzberg concludes that the explosion is the consequence of a change in the valence state of Sm, however, the actual mechanism of the reaction is phase separation, he explains. His results were presented at the Magnetism and Magnetic Materials Conference in Boston last November.

CONTRIBUTORS

Contributions have been received from Allied Chemical, Inc., Foote Mineral Co., and GTE Laboratories, Inc., all located in the U.S.A. and contributing for the second time, and from Rhone-Progil, France, a four-time contributor. Center supporters now total 31.

ACS Southwest Region Honors John Margrave


J. L. Margrave

The 1973 American Chemical Society (ACS) Southwest Regional Award, presented annually to an outstanding Houston area chemist, has been won by John L. Margrave. He is dean of advanced studies and research at Rice University, Houston, Tex., U.S.A.

Margrave's research, some involving rare earths, has been concentrated mainly on chemistry under extreme conditions (high and low temperatures and high pressure) and fluorine chemistry.

Rare Earths In the News

A RARE MEMORY

A rare earth ceramic developed by Sandia Laboratories promises to give computer holographic memory units a boost when the image storing device is applied to data processing. The ceramic, a thin, transparent, ferroelectric PLZT plate (7% La with a 65:35 ratio of lead titanate), deforms into thousands of microscopic depressions when light is projected through a photographic negative and a voltage applied to the PLZT. The depressions, some as deep as 1300 Å, vary according to the light intensity.

LASER CRYSTAL

Yttrium vanadate, a new laser crystal host for rare earth laser materials, is undergoing intensive investigation at the newly-formed Center for Laser Studies at the University of Southern California. The material is highly transmissive in the infrared regions (cut-off point is 5μ). It is being considered for optical ranging devices and systems.

Explain Enigma

H. W. de Wijn, A. M. van Diepen and K. H. J. Buschow have explained through a series of three papers the anomalous magnetic behavior of samarium in intermetallic compounds. Ever since the first measurements of the magnetic susceptibility of samarium metal about 17 years ago, scientists have been baffled by the fact that Sm does not follow a Curie-Weiss behavior above its magnetic ordering temperature—the only rare earth metal not to do so.

Although other scientists have thought the crystal field a Sm^{3+} ion sees in a compound is important, de Wijn, van Diepen and Buschow [*Phys. Rev. B* 7, 524-33 (1973)] show it is essential to include in one's calculations 1. the higher energy multiplet level (J = 7/2) in addition to the ground state multiplet (J = 5/2), and 2. sixth-order crystal field potentials in addition

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STAFF CHANGE


Betty Verkade

RIC is pleased to announce the addition of Ms. Betty Verkade to our staff. Ms. Verkade attended the University of Illinois and Iowa State University where she received her B.S. degree in chemistry. She has taught in both high school and college. She will be working half-time answering information inquiries and working on special reports which are becoming an increasing workload for the Center.

AT NEW SOUTH WALES

K. N. R. Taylor, formerly on the faculty of the University of Durham, England, has been appointed to a Chair in Physics at the University of New South Wales, Australia. Taylor is a co-author of the book, *Physics of Rare Earth Solids.* Also joining him at Sydney is R. G. Curry from Durham.

CEF Conference

A conference on Crystalline Electric Field Effects in Metals and Alloys, with the bulk of papers centered upon the rare earths, will be held in Montreal, Canada, June 26 through 29, 1974, inclusive. Both theoretical and experimental work will be extensively covered.

Invited speakers include Prof. P. Fulde, Institut Max von Laue-Paul Langevin, Germany; Prof. R. Orbach, University of California, U.S.A.; Dr. E. Bucher, Bell Telephone Laboratories, U.S.A.; Prof. H. W. de Wijn, Rijksuniversiteit, Holland; Prof. M. Zuckermann, McGill University, Canada; Prof. W. E. Wallace, University of Pittsburgh, U.S.A.; Dr. H. Heer, Institut fur Reaktorforschung, Switzerland; and Prof. D. Goodings, McMaster University, Canada.

Authors of contributed papers should forward an abstract, 100 words maximum, to the conference organizer before May 1, 1974. The time allowance for contributed papers will be 25 minutes maximum.

Prospective conferees should notify the organizer by March 31, 1974, or as near to that date as possible. The registration fee is $20 Cdn. Contact:

Dr. R. A. Devine
CEF Conference
Departement de Physique
Université de Montréal
D.P. 6128, Montréal 101
Canada

RIC Documents Available

IS-RIC-4 *Rare Earth Metals in Steels,* Nancy Kippenhan, Karl A. Gschneidner, Jr., March 1970.

IS-RIC-5 *Thermochemistry of the Rare Earth Carbides, Nitrides, and Sulfides for Steelmaking,* Karl A. Gschneidner, Jr., Nancy Kippenhan, August 1971.

IS-RIC-6 *Thermochemistry of the Rare Earths, Part 1. Rare Earth Oxides, Part 2. Rare Earth Oxysulfides, Part 3. Rare Earth Compounds with B, Sn, Pb, P, As, Sb, Bi, Cu and Ag,* Karl A. Gschneidner, Jr., Nancy Kippenhan and O. Dale McMasters, August 1973.

Reports listed above are available without charge from the Rare-Earth Information Center, Energy and Mineral Resources Research Institute, Iowa State University, Ames, Iowa 50010 or from Molybdenum Corporation of America, Metallurgical Sales Service Office, No. 4 Gateway Center, Pittsburgh, PA 15222.

RE Abstracts

Multi-Science Publishing Co., Ltd., undertook early in 1973 the publication of an interdisciplinary abstracting journal, *Rare Earth Bulletin,* edited by Dr. R. F. Kelleher, University of Nairobi, Nairobi, Kenya, and issued bimonthly with annual subject and author indices. Subscriptions are available from Multi-Science, The Old Mill, Dorset Place, London E15 1DJ, England at £30 (about $68 U.S.) per year postpaid.

Articles abstracted include not only those from the leading chemistry and physics journals, but also from those devoted to electronics, ceramics and glass, magnetics, crystallography, optics, mineralogy, earth sciences, textiles, nuclear physics, solid-state, metallurgy, mining, and materials science. Abstracts are organized into seven major divisions—Distribution and Extraction, Chemical Properties, Crystallography, Nuclear Properties, Solid State Properties, Mechanical Properties, and Applications.

MEETING

11th RARE EARTH CONFERENCE

The 11th Rare Earth Research Conference committee has established deadlines for those wishing to present papers. Abstracts, sufficiently detailed to permit evaluation, should be sent to Dr. Harry A. Eick, Department of Chemistry, Michigan State University, East Lansing, MI 48824, U.S.A., to reach him no later than April 1, 1974. Authors of accepted papers will be notified by May 1, completed papers are due by July 1.

Sessions are planned in the areas of crystal chemistry, metals and alloys, spectroscopy, intermetallics, magnetism and physics, shift reagents, organometallics, coordination chemistry, solid state science, and catalysis, and a general session.

Pittsburgh Award To Rare Earther

W. E. Wallace

W. E. Wallace, chairman, department of chemistry, University of Pittsburgh, has received the 1973 Pittsburgh Award presented annually by the Pittsburgh Section of the American Chemical Society.

The award recognized Wallace's contributions to chemistry and to the Pittsburgh academic community. He is best known to rare earthers for his work on magnetic properties and heat capacities of rare earth metals and alloys. This has led to a much better understanding of the physics and chemistry of rare earth solids, particularly their crystal fields.

Explain Enigma

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to the fourth-order ones. This enables them to explain theoretically both the Knight shift and magnetic susceptibility of $SmAl_2$ and $SmSn_3$. Furthermore, they note that in certain crystal fields the orbital angular quantum number, L, and the spin quantum number, S, combine additively (L + S) rather than subtractively (L-S) as other light lanthanides and thus behave as a heavy lanthanide.

In their other papers they explain the change in the easy direction of magnetization in $SmFe_2$ at 175°K [van Diepen, de Wijn and Buschow—*Phys. Rev. B* 8, 1125-9 (1973)] and the reduction in the magnetic moment on the Sm^{3+} ion in several intermetallic compounds [Buschow, van Diepen and de Wijn—*Phys. Rev. B* 8, 5134-8 (1973)]. Although the authors attempted no explanation of the magnetic susceptibility of metallic Sm, it is quite likely that an extension of their method will enable theorists to calculate the correct temperature variation of Sm in the elemental form.

New Laser System

J. Stone and C. A. Burras have reported on the operation of a new Nd-doped laser system, *Appl. Phys. Letters* 23, 388-9 (1973).

Fused silica (SiO_2) is used as a noncrystalline host material because it has a minimum transmission loss in the same wavelength range in which Nd lasing occurs.

The laser system has a clad optical fiber geometry and can be end-pumped for maximum pumping efficiency. Absorbed pump power thresholds of 1-2 mW have been achieved for cores 40 μm in diameter. The laser operates at room temperature.

Fused silica, because of its high melting point, low thermal expansion, strength, favorable transmission characteristics, and ease of fabrication, warrants more investigation as a laser host, say Stone and Burras. They estimate that lasers as short as 1 to 3 cm with diameters ≤ 15 μm could be made provided a suitable pumping device is developed.

RUSSIAN ACQUISITION

The Russian book: *Fizicheskie Svoistva Khalkogenidov Redkozemelnykh Elementov (Physical Properties of Chalcogenides of the Rare Earth Elements)* by A. V. Golubkov, E. V. Goncharova, V. P. Zhuze, G. M. Loginov, V. M. Sergeeva, and I. A. Smirnov (Izdalet'stvo Nauk, Leningrad, 1973) 304 pp., has been added to RIC's collection.

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Staff Writers

End of an Era

Kerr-McGee shut down its rare earth operations Dec. 31, 1973. Economic pressures involved in complying with the Environmental Protection Agency's pollution standards were cited by management as the overriding factor in the decision.

Kerr-McGee, a relative newcomer to the rare earth industry, in its 1970 merger with American Potash and Chemical Corporation (TRONA) inherited a long legacy of pioneering going back to Lindsay Light Co., founded in 1902. Lindsay manufactured incandescent gas mantles with thorium extracted from monazite ores. Although rare earths are 5-20 times more plentiful than thorium in monazite, most of them were discarded prior to World War I. Soon after, new uses were developed for rare earths and Lindsay became a leader in the production of salts and in developing new industrial applications. Over the years the name of the company changed to Lindsay Light and Chemical Co. (1935) and then to Lindsay Chemical Co. (1952) reflecting the changing emphasis in production. In 1955 Lindsay was first to commercially produce highly pure individual salts by ion exchange. Lindsay merged with TRONA in 1958.

We acknowledge with gratitude the active support Lindsay has given RIC for the past several years.

Fluorescent Standards

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considerably lower. For this reason Tb^{3+} is preferred over Tm^{3+} as a standard reference material.

Reisfeld's investigations suggest that rare earth-doped glasses are particularly well suited as reference standards for compounds having narrow fluorescent emission spectra. For example, Eu^{3+} is an acceptable standard in the range λ = 600-700 nm, Gd^{3+} emits only in the ultraviolet region, Tb^{3+} is useful at λ = 480, 543, 587 and 624 nm, and low concentrations of Sm^{3+} are applicable at λ = 560, 602 and 640 nm.

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INITIATES MISCHMETAL BULLETINS

The Metals Division of Rare Earth Industries, Inc., has begun a series of technical bulletins devoted exclusively to mischmetal applications. The series is entitled RAREARTH 96® (with appropriate subtitles outlining specific applications).

Two bulletins have been issued so far: *Mischmetal in High Strength Low Alloy Steels,* and *Mischmetal in Vacuum Degassed Steel.* They are not numbered so requesters should order them by title.

To order the bulletins now available and to have your name placed on the permanent mailing list for the series, write to:

Rare Earth Industries, Inc.
Metals Division
P.O. Box 365, Route 168
West Pittsburg, PA 16160, U.S.A.

RECORD YEAR FOR R.E. DISCOVERY

In case there is no listing in the *Guinness Book of World Records,* we note that 1879 was a record year for the discovery of rare earth elements. Samarium, holmium, thulium and scandium were isolated that year by L. de Boisbaudran, P. T. Cleve and J. L. Soret (independently), P. T. Cleve and L. F. Nilson, respectively. There is a two-way tie for the second best year between 1843 (terbium and erbium) and 1885 (praseodymium and neodymium).

Rare Earth Use In Steelmaking

Rare earth usage in steelmaking was among the topics presented at the 31st Electric Furnace Conference held at Cincinnati, Ohio, Dec. 5-7, 1973.

Deoxidation, desulfurization, inclusion manipulation, rare earth recovery, and steel toughness and ductility were discussed with respect to rare earth additions in the manufacture of steel. Also, effects of the different methods of rare earth addition were examined.

Current trends in rare earth usage were discussed with a cost/quality emphasis. In Europe, the major innovation has been a switch from the use of rare earth silicides to mischmetal for steelmaking.

Garners Garnets

Although F. F. Y. Wang makes no claim to being comprehensive, he does cover a lot of area in the field of garnets in his recent article "Physical and Chemical Properties of Garnets", *Treatise on Materials Science and Technology* 2, 279-384 (1973).

The preparation and properties (primarily crystal data, phase equilibria, chemical, thermodynamic, magnetic and optical) of simple rare earth and substituted garnets are presented and discussed.

In the article, which contains more than 300 references, Wang attempts to illustrate the suitability of garnets as prototype compounds for materials science research.

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