



# Rare-earth Information Center NEWS

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Institute for Physical Research and Technology  
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## 19<sup>th</sup> RERC

The 19<sup>th</sup> Rare Earth Research Conference (RERC) was held July 14-19, 1991, in Lexington, Kentucky. General Conference Chair Lance De Long and Program Chair Herbert Silber deserve acclaim for a successful conference. Thanks are also awarded to all those individuals who helped make the conference run smoothly. The proceedings are to be published in the *Journal of Alloys and Compounds* (formerly the *Journal of Less-Common Metals*) and is scheduled to appear in print in early 1992.

The 19<sup>th</sup> RERC was truly an international conference as nearly half of the 177 participants were from other countries. Oral sessions of the conference included topics on: Applied Science and Technology, Spectroscopy, Rare Earth and Actinide Magnetism, Coordination Chemistry, Magnetism and Superconductivity, Low-Dimensional Magnetism, High-Temperature Superconductors, Metal-Insulator Transitions, and Actinide Physics and Chemistry. Poster sessions allowed discussion opportunities between participants. Among the highlights of the conference were the following.

Karl A. Gschneidner, Jr., was presented the Frank H. Spedding award Tuesday evening by LeRoy Eyring, who substituted for William Carnall, chair of the selection committee, and Pierre Falconnet of Rhone-Poulenc, sponsor of the award. Dr. Gschneidner then presented an informative acceptance speech entitled: "An Odyssey Through the Rare Earths. A Quest for Knowledge" (copies available from RIC upon request).

Dr. Tetsuo Sakai of Government Industrial Research Institute, Osaka, Japan, discussed the development and commercialization of rechargeable hydrogen storage batteries using rare earth-based hydrogen storage alloys. He reported that  $\text{LaNi}_5\text{-H}$

*Continued in next column* ⇨

## National Academy of Science

Herbert B. Callen, professor of Physics at the University of Pennsylvania, is one of the 59 newly elected members of the U.S. National Academy of Sciences. Among the 15 new foreign associates is C.N.R. Rao, director of the Indian Institute of Technology in Bangalore. Nomination for membership in either of these academies is made by an incumbent member, reviewed by a topical committee, then put to a vote of the full membership. The foreign associates are nonvoting members who are not U.S. citizens. H. B. Callen worked on rare earth compounds early in his career, especially chalcogenides. C.N.R. Rao has been active in the rare earth field for 25 years working with oxides, sulfides, perovskites, and other inorganic structures. ▲

### 19<sup>th</sup> RERC/Continued ⇨

batteries have 1.5-2 times the energy density of nickel-cadmium batteries while being much less toxic as well. The development of low cost mischmetal-based alloys ensures the commercial production of this energy source. The electrode properties of the alloys such as capacity, cycle life, rate-capability, and self-discharge are greatly affected by chemical composition, stoichiometric composition, and casting conditions. Included in his report was that the control of grain size and precipitated compounds were also important for getting useful metal-hydride electrodes. The Institute has constructed a small cylindrical battery with a high energy density (210 wh/liter, 65 wh/kg) and also a large 30Ah, 12V stacked battery.

Officers of the Rare Earth Research Conference, Inc. gave their approval for the 20<sup>th</sup> Rare Earth Research Conference to be held in September, 1993, in Monterey, California. The 20<sup>th</sup> RERC will either precede or be held as a sequel to the Actinides-93 International Conference in Santa Fe, New Mexico, September 19-24, 1993. ▲

## 1991 Shiokawa Award

The Shiokawa Award of the Rare Earth Society of Japan was made in May to Professor Emeritus Akira Ouchi of the University of Tokyo, College of Arts and Sciences, Department of Chemistry. He received his B.S. and D.Sc. from the University of Tokyo, and worked at the college from 1952 to 1989.



Akira Ouchi

He received the award for his studies on the synthesis and the structure determination of rare earth metal complexes. He has presented substantial data about the structures of many rare earth complexes using single crystal x-ray diffraction techniques.

Professor Ouchi has also examined the relation between each preparative condition and the structures of the obtained lanthanide complexes using many different kinds of ligands. He found that the complexes of a complete lanthanide series are not isomorphous; i.e. a given structure for one type of complex was found for a limited number of adjacent lanthanides, while for another region a different structure was observed. The lanthanides at which this structure change occurred varied with the type of complex.

He plans to study in more detail the relation between the coordination structure and the size of the central metal ion of lanthanide complexes. ▲

## New Fax Number

The Rare-earth Information Center has obtained a separate facsimile line so that we may more readily process information requests. Our new fax number is (515)294-3709. ▲

## Distinguished Materials Scientist

The Distinguished Materials Scientist of the Year Award was presented to Prof. E. C. Subbarao at the Second Annual General Meeting of the Materials Research Society of India meeting in New Delhi on February 9-10, 1991, according to *MRS Bulletin* 16, [4] 67 (1991). He also delivered the honor lecture, "A Second Ceramic Age — A New Materials Frontier". Subbarao, from Tata Research, Design and Development Centre, Pune, India, is co-author of several papers dealing with such subjects as phase transformations, electrical and ionic conduction, phase relations, phase equilibria and other properties of rare earth materials. ▲

## Journées des Actinides

The 22<sup>nd</sup> International Conference on the Physics and Chemistry of the Actinides will be held in Dieulefit, France on April 26-29, 1992. This meeting aims to promote discussion and scientific exchange between participants on all aspects of basic and applied chemistry and physics of the actinides. To receive an announcement or further information write: Professeur J.M. Fournier, DRFMC/SPSMS/MDN, C.E.N.G. 85X, 38041 Grenoble Cedex, France. ▲

## Actinides-93

Actinides-93 is an international conference providing a forum for communication of recent research results on the physics, chemistry, and technology of the actinide elements. In addition, Actinides-93 is extending the scope of the conference to include the physics, chemistry, and thermodynamic properties of the heaviest elements, the transactinides. The scientific program will consist of a series of invited plenary and keynote lectures followed by presentations of invited and contributed papers in poster sessions. English is the official language of the conference.

The conference will be held in Santa Fe, New Mexico, USA September 19-24, 1993. To receive the first announcement or more information contact: Actinides-93, Mail Stop P366, Los Alamos National Laboratory, Los Alamos, New Mexico 87545 USA Telephone:(505)667-9313 Fax:(505)665-4624. ▲

**GADOLINIUM**, atomic number 64, was named after the Finnish chemist Johan Gadolin by J.C.G. Marignac, who discovered it in 1880. ▲

## Conference Calendar

### \* A NEWS STORY THIS ISSUE

#### March '92

*Joint TMS-Australasian IMM Rare Earth Symposium: Sources Science, Technology and Applications*  
San Diego, California, U.S.A.

March 2-5, 1992  
*RIC News*, XXVI, [2] 2 (1991)

#### April '92

*22<sup>nd</sup> Journées des Actinides*  
Dieulefit, France  
April 26-29, 1992

\*This issue

#### June '92

*Rare Earths '92 International Conference*

Kyoto, Japan  
June 1-5, 1992  
*RIC News*, XXV, [3] 2 (1990)

#### July '92

*2<sup>nd</sup> International Symposium on Physics of Magnetic Materials (ISPM'92)*

Beijing, People's Republic of China  
July 3-8, 1992  
*RIC News*, XXV, [2] 2 (1991)

*12<sup>th</sup> International Workshop on Rare Earth Magnets and Their Applications and 7<sup>th</sup> International Symposium on Anisotropy and Coercivity in Rare Earth Metal Alloys*

Canberra, Australia  
July 12-16, 1992  
*RIC News*, XXVI, [2] 2 (1991)

*Third International Symposium on Magnetic Bearings*

Alexandria, Virginia, U.S.A.  
July 29-31, 1992  
\*This issue

#### April '93

*Rare Earth Minerals: Chemistry, Origin, and Ore Deposits*

London, England  
April 1-2, 1993  
*RIC News*, XXVI, [2] 2 (1991)

#### September '93

*Actinides-93*  
Santa Fe, New Mexico, USA

September 19-24, 1993  
\*This issue

## Third International Symposium on Magnetic Bearings

The Third International Conference on Magnetic Bearings will be held July 29-31, 1992 in Alexandria, Virginia. Magnetic bearings have become increasingly important in industry for the support of shafts subject to forces. They can provide the advantages of oil free operation, no friction losses, long life and enhanced vibration control. The conference will be held jointly with MAG '92, which is an industrial conference on applications of magnetic bearings, magnetic drives and dry gas seals. A one day short course entitled, "Introduction to Magnetic Bearings" will be held July 28. If you are interested in participating in the Symposium contact: Mrs. Sandy Maslen, Conference Coordinator, Mechanical & Aerospace Engineering Department, McCormick Road/MEC 105/ROMAC Laboratories, University of Virginia, Charlottesville, Virginia, 22903 USA Telephone:(804)924-3292 Fax:(804)982-2037. ▲

## Materials Awareness Bulletin

RIC has received the May, 1990 issue of *Materials Awareness Bulletin* entitled "A Special Issue on Applications of Rare Earths". This publication focuses on the industrial uses of rare earth materials worldwide. The issue contains nearly 330 abstracts, complete with references, which cover topics such as: Technology News/Novel Applications, Nonferrous Alloys, Ferrous Alloys, Ceramics, Components for Engineering Applications, Nd-Fe-B Permanent Magnets, Cutting Tools and Dies, Processing Aspects, and Surface Modification and Coatings.

The 144-page issue is a comprehensive review of the technological and industrial uses of rare earth materials. It was compiled and edited by Y.R. Mahajan and can be ordered by contacting Dr. P. Rama Rao, General Secretary (MRSI) & Director, Defence Metallurgical Research Laboratory, PO Kanchanbagh, Hyderabad-500 258, India. Telephone:239365 Fax:842-239683 Telex:0425-6457 DMRL IN. The cost of the book is \$35.00 US. ▲

## People's Republic of China News Item

A clipping from *China Daily* states that for the first time in the history of the People's Republic, the rare earth industry will be placed under State planning. The new policies apply to three rare earth ores, namely rare earth concentrate minerals from Baotou, Inner Mongolia, and rare earth chlorides and ion absorption type rare earth minerals from south China. The article quotes Ye Qing, vice-minister of the State Planning Commission, as saying that China will not approve any new extracting plants, but will support the development of just one or two key projects during the Eighth Five-year Plan (1991-95).

According to the state plan, as presented by Ye Qing at a recent national meeting on the rare earth industry, the output of ion adsorption rare earth minerals in South China will be cut by 2000 tons by 1995. The state plan also includes control of the export of rare earth minerals and the extracting technology. Ye said China has also ruled out the possibility of Sino-foreign cooperation on research, mining, and extracting ion absorbing mineral. The state will not approve solely foreign-funded or solely Taiwan, Hong Kong, or Macao-invested projects on exploration and mining of this mineral. The mineral is to be listed as China's special resource under protection, will not be open to foreign visitors. Apart from mining and extraction projects, foreign businesses will be encouraged to invest in projects using rare earth minerals.

Another spokesman from the State Planning Commission Bai Jie, said that during the coming six years, China will strengthen the domestic use of rare earth metals, especially in agricultural production, energy saving and high-tech projects.

The news item claims that China's rare earth exports are holding firm at 20 per cent of the world's total. It also lists the country's verified rare earth reserves at 36 million tons which account for 80 per cent of the world's reserves. ▲

### Direct Overwrite Possibility

Research scientists at IBM Japan, Tokyo, report on the feasibility of a new method for direct overwrite with a power-modulated laser beam under a constant external bias field fixed in the same direction as an initializing bias field [*Appl. Phys. Lett.* 56, 2690-92].

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### Rare Earths. A Recollection

Fathi Habashi  
Laval University, Quebec City  
Canada G1K 7P4

I first started working on the rare earths in 1956 during my graduate studies at the Institut für Chemische Technologie Anorganischer Stoffe, Technische Hochschule Wien (now Technical University, Vienna). While I was investigating the recovery of uranium from phosphate rock, I learned that the black sands at Rosetta in Egypt (my home country) were being exploited for the recovery of the mineral monazite. I extended my project to include the extraction of uranium from this source. In this part of the project I was inspired by Professor Kurt Peters (1897-1974) whose father was director of Carl Auer von Welsbach's rare earths plant at Atzgersdorf near Vienna. This was the first rare earths plant in the world for the separation from monazite sand of thorium, cerium, and other rare earths for use in the preparation of the gas mantles.

Prof. Peters was born in Atzgersdorf and had access to the Welsbach Archives. In his personal laboratory attached to his office on Getreidemarkt 9 he kept numerous bottles of rare earths that he inherited from Welsbach. Two of these bottles, each about one gallon in size, were quite interesting: one contained a yellowish green praseodymium salt and the other contained a red violet neodymium salt. He was kind enough to let me fill a bottle with a sample of Indian monazite sand he had in his laboratory. Later, he also gave me a sample of thorium nitrate from the Welsbach collection for radioactivity measurements when I moved to the Chemisches Institut of the University of Vienna on Währingerstrasse.

During my stay at the Technische Hochschule in Vienna, I met Fraulein Helga Auer who was also a graduate student at that time; she was a grand-daughter of Auer von Welsbach. She worked at the Inorganic Chemistry Department of the University of Vienna on Währingerstrasse. This is the same building where Carl Auer had done some of his research. Also, in this building the chemistry journal *Monatshefte für Chemie* was founded and edited. This is the journal

in which Carl Auer published most of his work.

Auer invented the *Gasglühlicht*, i.e., glowing gaslight in which he applied the incandescence principle, the osmium filament lamp; and Cereisen, i.e. the iron-cerium alloy used as a lighter flint. At that time the twenty schillings banknote carried a picture of Welsbach; it was then worth one dollar—now it is no longer in circulation. I also heard lectures by Prof. Anton Brukl of the same institute who specialized in the rare earths.

In 1958, the Austrian Chemical Society celebrated the 100th anniversary of Carl Auer's birth. On this occasion, the Society invited Frank H. Spedding (1902-1984) from Iowa State University in Ames, Iowa, to deliver the Plenary Lecture on the Separation of the Rare Earths. The lecture was given in English and a German translation was available at the meeting as a typewritten brochure. I had the privilege of hearing Prof. Spedding's lecture and talked with him briefly afterwards. Prof. Spedding was awarded on that day the Honorary Membership of the Verein Österreichischer Chemiker.

I moved around a lot, became busy with other things, and finally settled down in Quebec City in 1970. In 1981 I gave an intensive graduate course on hydrometallurgy at the Department of Applied Process Metallurgy, Royal Institute of Technology, in Stockholm where I visited the Berzelius Museum. Jacob Berzelius (1779-1848) discovered, among other things, cerium in 1803 and thorium in 1829. It was interesting to see the samples of chemicals he had prepared and stored in numerous drawers, the equipment he had used, and the numerous pictures.

In 1982, I benefited from my mission to Brazil with a visit to the monazite treatment plant in San Paulo, operated by Empersas Nucleares Brasileiras. On my return from Brazil, I again became interested in the rare earths when I learned that they were present in phosphate rock. Having a project underway on the recovery of uranium from phosphate rock, I extended it to include the recovery of rare earths as well. Finally, in the summer of 1990, I was a guest lecturer in China and Sweden. My host in China arranged for me to visit the rare earths plant near Guangzhou (known in the West as Canton). This was an interesting visit because I learned about the recovery of rare earths from clays. In Stockholm, I visited the Ytterby Mine on Resaro Island near Vaxholm a suburb of Stockholm. It was

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**Rare Earths and I** (Continued from page 3) ◊ there Lieutenant Carl Axel Arrhenius (1757-1824), the Swedish chemist and mineralogist, found in 1787 a black rock which he named Ytterbite. Seven years later, Johan Gadolin (1760-1852), professor of Chemistry at the University of Abo in Finland, at that time a part of Sweden, discovered the complex earth "Ytria" in this mineral. This mineral was later named gadolinite in his honor.

The Ytterby Mine is unique not only because the four metals yttrium, terbium, erbium, and ytterbium were discovered there and given names derived from the name of the mine, but also three other metals that existed in the mine were discovered by the Swedish chemists, Lars Fredrik Nilson (1840-1899) and Per Teodor Cleve (1840-1905). Nilson discovered scandium in 1879 (named after Scandinavia), and Cleve discovered holmium (named after an old name for Stockholm) and thulium (named after Thule, a Roman name of a Nordic god) — both in 1879. That is why in 1989 the ASM International (American Society of Metals) designated the mine as a historical landmark.

Thus, while the science of rare earths is considered to have started with the discovery of the mineral gadolinite in Ytterby Mine in 1787 by Carl Axel Arrhenius, the rare earths industry started one hundred years later in 1887 when Carl Auer von Welsbach bought Fabrik Chemisch - pharmazeutischer Präparate Wurth & Co. in Atzgersdorf and transformed it for the treatment of monazite sand to separate the rare earths on a commercial scale. Thanks to the Swedish chemist Johan Fridrik Bahr who went to Robert Bunsen in Heidelberg with samples of gadolinite which Carl Auer later studied when he went, also to Heidelberg, a few years later. ▲

**Direct Overwrite** (Continued from page 3) ◊ (1990)]. S. Takayama et al. employed TbFeCoCr amorphous films with a compensation temperature for below room temperature in the study. Coercivity fell to below 200 Oe at 200°C while saturation magnetization remained high. By using a power modulation between 9 and 5 mW, under a constant field of 100 Oe, these researchers were able to demonstrate direct overwrite. The readout carrier-to-noise ratio under those conditions was low - 18dB but efforts are underway to achieve a higher carrier-to-noise ratio, hopefully, by optimizing the magnetic properties of the medium itself. ▲

## Summary of Magnet Development in the Past Two Years

A review article entitled "Summary of Magnet Development in the Past Two Years" by H. H. Stadelmaier appeared in *J. Magn. Eng.* 12, 185-93 (1990). This paper was presented at the "Seminar on Hard and Soft Magnetic Materials", a part of "ASM Materials Week" at Indianapolis, Indiana on October 3, 1989.

As stated in the abstract, Stadelmaier points out that recent permanent magnet research has proceeded along four lines (a) improvement of the properties of Fe-Nd-B by alloying additions and processing; (b) exploration of other alloy systems that feature the tetragonal compounds of the  $Fe_{14}Nd_2B$  type; (c) systematic studies of new magnetic compounds such as those based on the  $Mn_{12}Th$  structure, and (d) characterization of phases that are present in the known systems and which contribute to coercivity.

Sections a and b, dealing with  $T_{14}R_2X$  ( $T = Fe$  or  $Co$ ,  $R =$  rare earths, and  $X = B$  or  $C$ ), discuss the improvements and developments based on this tetragonal phase. One development is the substitution of Pr for Nd, along with the addition or substitution of other elements. These elements include Al, Cu, Ga, and Nb. Also discussed are various methods of processing the magnets and the phases that stabilize out in the finished product.

Among the magnets with the  $Mn_{12}Th$  type structure that are discussed are  $Fe_{10}V_2R$ ,  $Fe_{11}TiSm$ ,  $Al_8T_4R$  ( $T = Cr, Mn, Fe, Cu$ ),  $Fe_8Mn_3Y$ , and some variations of these. The  $Al_8T_4R$ , because of their high Al content are not serious contenders in the field. Also discussed is the oxygen stabilization of some of these transition metal-rare earth phases.

Stadelmaier cites 88 references, many of which were published in the last five years. ▲

## Chinese Translations

The December 1, 1990 issue of the *RIC News* contained a story in "The Rare Earths and I" column which was written by J.P. Liu, who is now at the University of Amsterdam, The Netherlands. Mr. Liu has also furnished us with translations of three Chinese articles dealing with the development of a "Rare-Earth Valley" in China. The three papers (in English) are; "Rare-Earth Valley" (Continued in next column) ◊

## Er-doped III-V Semiconductors

Interest has been growing in recent years in the properties of rare earth doped III-V semiconductors. This is partly due to the possibility of electrically exciting the internal  $4f-4f$  emission bands of the rare earth center to produce efficient light-emitting diodes (LEDs) or lasers with emission wavelengths that are insensitive to temperature variations. Erbium is of particular interest since the characteristic emission at  $1.54 \mu m$  is well matched to the low-loss region of silica-based optical fibers. Two papers have recently been published concerning Er doped III-V semiconductors.

The effects of post-implantation annealing of MeV Er-implanted GaAs by monitoring the  $Er^{3+}$  electron paramagnetic resonance (EPR) signal as well as the  $Er^{3+}$  and near-band-edge photoluminescence (PL) spectra as a function of anneal temperature has been reported by P. B. Klein et al. [*Appl. Phys. Lett.* 58, 502-04 (1991)]. The  $Er^{3+}$  photoluminescence was observed from several distinct Er sites in the annealed material. The observed dependences upon anneal temperature suggest that the  $Er^{3+}$  PL is emitted from centers that are not in the  $Er^{3+}$  state at equilibrium. Absolute electron paramagnetic measurements of  $Er^{3+}$  concentration indicate that only a small fraction (<0.1%) of the Er in the sample exists as  $Er^{3+}$ .

H. Isshiki et al. report that the erbium-related  $1.54 \mu m$  luminescence peak has been observed in erbium-doped InP layers by impact excitation of Er atoms with energetic carriers accelerated by an electric field [*Appl. Phys. Lett.* 58 484-6 (1991)]. Au/Sn ohmic contacts were formed on the surface after Er ions were implanted into n-type InP. The sharp Er-related peak at  $1.543 \mu m$  was observed when dc voltages were applied between the electrodes over the temperature range 77 to 360 K. Although band-edge emission and impurity-related emission was intense in the photoluminescence spectra of the sample, neither was observed in these tests. ▲

**Chinese Translations** (Continued) ◊ Earth Valley - A New High-tech Industry of the 21<sup>st</sup> Century", by J.P. Liu, "Symposium on Rare-Earth Valley Held in Inner Mongolia", and "Construction of China's First Rare-Earth Valley Outlined" [*Sci. & Tech. Daily*, January 22 and July 25, 1990, respectively].

Copies of these articles can be obtained by writing RIC. ▲

## TMS Awards

Three noted scientists with long time rare earth connections were among those honored by The Minerals, Metals and Materials Society (TMS) at the annual meeting held February 19, 1991 in New Orleans.

Erwin Parthé received the William Hume-Rothery Award which honors a scientific leader for exceptional scholarly contributions to the science of alloys. Dr. Parthé has been professor of structural crystallography at the University of Geneva, Switzerland since 1970. Previously, he held positions at MIT, the University of Pennsylvania and the University of Grenoble, France. He has authored over 185 publications on crystal chemistry and structures of inorganic and intermetallic compounds, many containing rare earths.

Thomas J. O'Keefe received The Extractive Metallurgy Lecturer Award which honors an outstanding scientific leader in the field of nonferrous extractive metallurgy. Dr. O'Keefe is director of the Institute for Chemical and Extractive Metallurgy at the University of Missouri-Rolla. He is also the curators' professor of metallurgical engineering and a senior research investigator at UMR's Graduate Center for Materials Research. His research interests include electrolytic processing and the simultaneous roles of mass transport effects.

Leo Brewer received The Extractive Metallurgy Science Award which recognizes a paper or series of papers which represents a notable contribution to the scientific understanding of extractive metallurgy, particularly nonferrous metals. Dr. Brewer is professor emeritus of chemistry at the University of California-Berkeley and is senior scientist with the Chemical and Materials Research Division of Lawrence Berkeley Laboratory. Dr Brewer's characterization of the thermodynamic properties at high temperatures and critical evaluations of the thermodynamic properties of the elements, halides, oxides and other compounds have been updated periodically for more than four decades. The paper for which he received the award was co-authored by Michael J. Cima. ▲

## Change of Address

Denison Mines, Ltd. has announced that their address has changed to: National Bank Building, 150 York Street, Suite 1508, Toronto, Ontario M5H 3S5 Canada Tel:(416)865-1991 Fax:(416)865-0632. ▲

## Erasable CD's?

Scientists in Sydney are on the verge of commercializing a new technique which, they claim, will result in practical read/write optical data recording. Optical discs for music and some data have been around for 15 years but exist, for the most part, in a read only format. For 10 years it has been known that the rare earth alloy terbium iron has both the magnetic and optical properties necessary for a read/write disk. The process usually involves a two-stage laser. In the high power condition the laser heats the terbium iron above its magnetic transition point in a magnetic field. The optical properties of the cooled alloy depend on the field direction which can be discerned by reading with a laser in a low intensity mode. The problem has been that the optical properties of the terbium iron degrade when exposed to air.

Efforts at providing a protective film on the terbium iron are difficult due to the special requirements of extreme thinness and optical purity that high data storage densities and high access speeds place on a film. Dr. Phil Martin and colleagues from the CSIRO's Division of Applied Physics, have applied a technique they pioneered, ion assisted deposition (IAD), to the problem and have come up with a thin layer, transparent to the laser light, that stabilizes the alloy. The current effort is concentrated on a commercially viable machine that will be capable of using IAD to make dense layers routinely.

The potential market according to Chief Scientist with IBM Australia, Mr. Greg Clark, is worth somewhere between \$1-2 billion per year. The work is being supported by the Australian government and through a licensing and royalties deal with IBM, who will do the marketing.

At about the same time, research scientists at IBM Japan, Tokyo, have published two reports dealing with improving CD technology. The first was a study of the feasibility of a new method for direct overwrite with a power-modulated laser beam under a constant external bias field fixed in the same direction as an initializing bias field (*Appl. Phys. Lett.* 56, 2690-92 (1990)). S. Takayama et al. employed TbFeCoCr amorphous films with a compensation temperature far below room temperature in the study. Coercivity fell to below 200 Oe at 200°C while saturation magnetization remained high. By using a power modulation between 9 and 5 mW, under a constant field of -100 Oe, these researchers were able to

demonstrate direct overwrite. The readout carrier-to-noise ratio under those conditions was low — 18dB but efforts are underway to achieve a higher carrier-to-noise ratio, hopefully by optimizing the magnetic properties of the medium itself.

A second publication by S. Takayama et al. [*J. Magn. Magn. Mat.* 94, 357-361 (1991)] reports on their work on increasing the corrosion resistance of amorphous TbFeCo films by the addition of Cr in amounts greater than 5 at.%. The addition of elements such as Pt, Cr, Ta, Ti and Nb are known to increase the corrosion resistance but in amounts in excess of 2-3 at.% they normally deteriorate the magnetic and magneto-optical properties of the film. In conventional TbFeCo amorphous films the Co content is approximately 10 at.% in order to maintain a low Curie temperature. It is also known that high magnetic moments can be realized by increasing the Co content to the 30-40 at.% range.

Takayama's group investigated the possibility of compensating for the degradation of the magnetic and magneto-optical properties by optimizing the content ratio of Co to Fe in TbFeCoX films, (X = added non-magnetic elements). As a result, they found that Tb<sub>10</sub>Fe<sub>85</sub>Co<sub>20</sub>Cr<sub>x</sub> films have high corrosion resistance with good magnetic and magneto-optical properties and a high readout carrier to noise ratio of 51dB. ▲

## Lanthanide Complexes

M. Kodama et al. have synthesized the macrocyclic pentaamino pentacarboxylate ligand (PEPA) and the hexamino hexacarboxylate (HEHA) and have investigated their complexation with lanthanides [*Inorganic Chemistry*, 30, 1270-73 (1991)]. Titrations of the pH were used for the equilibrium study and ligand-exchange reactions of M(III) - Arsenazo III with macrocyclic ligands were employed for the kinetic study. The results were compared with those for known lanthanide chelating agents, linear DTPA and macrocyclic DOTA and TETA. The stability trends of PEPA and HEHA complexes relative to the lanthanide +3 ion size are almost parallel to those of DTPA and TETA. ΔS was found to be the major contributor to complex stability. HEHA complexes generally yielded more stable 1:1 complexes than DTPA at pH~7. The relative complexation rates for HEHA were 10 times slower than those of DTPA but about 100 times faster than those of DOTA. ▲

## Review of Chevrel Phases

"Rare Earth Based Chevrel Phases  $REMO_6X_8$ : Crystal Growth, Physical and Superconducting Properties" is the title of a review article by Octavia Peña and Marcel Sergent published in *Prog. Solid St. Chem.*, 19, 165-281 (1989). A short introduction points out that ferromagnetism and superconductivity are two different phenomena, unlikely to occur simultaneously within the same material: for some time it was believed that the two phenomena excluded each other. The discovery in 1971 of Chevrel phases  $M_xMo_6X_8$  ( $M = 3d$  elements, In, Sn, Pb, alkali, alkaline earths, etc.;  $X =$  chalcogen) and then, in 1975, of rare-earth based  $RMo_6S_8$  and in 1976 of  $RMo_6Se_8$  brought a new situation. Experimental and theoretical research devoted to the interplay of superconductivity and magnetism showed for the first time that a system containing a regular lattice of magnetic ions could be superconducting.

In chapter 2, the authors survey Chevrel phases, discussing generalities, chemistry, structure, electronic properties, and the upper critical field,  $H_{c2}$ . In chapter 3, the authors consider the preparation and characterization of  $RMo_6X_8$  ( $X = S, Se$ ) compounds and state that the most convenient way to synthesize these materials is by solid-state reaction of molybdenum powder with an already made binary chalcogenide. Some details of the preparation by solid state reaction and precautions to be taken are presented. Phase characterization and lattice parameter determinations have been carried out by both x-ray powder and single-crystal techniques. Lattice parameters obtained from sintered powders of both sulfides and selenides are presented in the tables, as well as single crystal parameters of the sulfides. The authors present structural and positional parameters of  $RMo_6S_8$  and state that not much work has been reported on structural refinements of the rare earth molybdenum selenides with the exception of  $La_{0.85}Mo_6Se_8$ .

In chapter 4, Peña and Sergent review the superconductivity and magnetic order found in measurements on bulk samples of the magnetic Chevrel-phase superconductors. Chapter 5 deals with pseudo ternary systems wherein a trivalent rare earth replaced some  $M$  (Pb or Sn) in  $MMo_6S_8$ . The next chapter considers problems in the crystal growth of Chevrel phases, discusses difficulties encountered in growing single crystals from a liquid phase and details the research program at the University of Rennes. Chapter 7 reviews the results of single crystal studies of normal state physical properties of  $RMo_6X_8$

( $R = Ho, Eu, Ce, Er, Yb, Lu$ ) phases. This is followed by a discussion of studies of the superconducting-state physical properties of  $HoMo_6S_8$  and  $EuMo_6S_8$ . Results on single crystal studies in quaternary systems  $(R,M)Mo_6X_8$  are reviewed in Chapter 8. In the final chapter, the authors make comparison between Chevrel phases and the recently discovered high- $T_c$  (HTSC) cuprates.

This review article lists 250 references, 98 figures, 8 photographs, and 17 tables. ▲

## Permanent Magnets Research and Applications

A paper entitled "Modern Permanent Magnets for Applications in Electro-Technology" by K. J. Strnat appeared in *Proceedings of IEEE*, 78, 923-46 (1990). This paper describes the range of magnetic materials and properties that are now available to design engineers, and the place of different magnets in electro-technology with attention to economic and engineering factors.

According to Dr. Strnat, revolutionary developments have recently occurred in the field of permanent magnetism. Hard ferrites have become an inexpensive magnetic material, while rare earth magnets have raised the highest available energy products 4- to 5-fold and coercivity by an order of magnitude. Consequently, a rapid broadening of magnet uses is occurring. Traditional devices are being miniaturized and new uses and design concepts are evolving. The author discusses trends, gives examples, and assesses currently evolving permanent magnet materials, production processes, prospects for even better magnets and the ultimate upper limits for permanent magnet properties.

This paper includes 23 figures, six tables and 59 references. In addition to the references, Dr. Strnat includes a bibliography that lists seven general texts and reference books on permanent magnets; six magnetism books, conference proceedings, and periodicals which devote major sections to permanent magnets and their uses; and nine books, conference proceedings and special journal issues on rare earth-transition metal permanent magnets. ▲

**THULIUM**, atomic number 69, was discovered in 1879 by P.T. Cleve and was named for Thule, the ancient name for Scandinavia. ▲

## Bibliographic Database

*High- $T_c$  Superconductivity in 1990* is a supplement to the bibliographic database that contains a list of key words, general and chemical indices, and a reference list on the latest papers dealing with superconductor research. The first two parts of the bibliography appeared in *J. Superconductivity* 2(1), 1-210 (1989) and *J. Superconductivity* 3(1), 1-153 (1990). Together with the previous reference lists covering 1987-88 and 1989, respectively, the Bibliography of *High- $T_c$  Superconductivity in 1990* covers the entire history of high-temperature superconductivity. It appeared in *J. Superconductivity*, 4(2), 75-169 (1991).

With each annual update the bibliography is becoming more narrowly focussed with a growing emphasis on applied superconductivity. The entire database, containing source information for all 8500 references and search software for IBM compatible or Macintosh computers, can be downloaded from Ames Laboratory at Iowa State University. Instructions appear in the June 1, 1991 issue of *High- $T_c$  Update* (Vol. 5, No. 11). For a hard copy of the three listings, contact the *Journal of Superconductivity*, Plenum Publishing Company, Dept. JCA, 233 Spring Street, New York NY 10013-1578 USA Telephone: (800)221-9369. ▲

## Laboratory Directory

The RIC recently received the 1990-1991 Directory from the American Council of Independent Laboratories, Incorporated (ACIL). The ACIL is an association of independent, engineering and scientific laboratories conducting operations in the United States and around the world.

The 415-page directory, "A Guide to the Leading Independent Testing, Research, and Inspection Laboratories of America" gives the scope of services of ACIL member companies in the engineering and scientific disciplines. Comprehensive indices cross-reference product and service categories and test methods to more than 1,000 facilities across the United States and abroad. Some of these companies have the ability to analyze for the rare earths in various matrices.

The directory is published biennially and costs ACIL members \$5.00 U.S. It costs non-members \$25.00 U.S. It may be ordered from ACIL, 1725 K Street NW, Washington, DC 20006 U.S.A. Postage and handling is \$5.00 for United States orders and \$10.00 for international orders. ▲

## Luminescence of Wideband Semiconductors

Luminescence of Wideband Semiconductors is Volume 182 of Proceedings of the Lebedev Physics Institute, Academy of Sciences of the USSR. This volume, edited by M. D. Galanin, is divided into four sections which have the following headings: Infrared Photoluminescence of Zinc Sulfide; Luminescence and Photoelectric Properties of  $\text{La}_2\text{S}_3$  and  $\text{La}_2\text{O}_2\text{S}$  Single Crystal Semiconductors Doped with Rare Earth Ions; Investigation of Radiative Recombination Channels in Indium Phosphide; Luminescence of Single Crystal Layers of n- and p-Type Zinc Oxide. Only the second section deals with rare earth materials. It is 66 pages long and has 119 references. It has 4 chapters that contain a literature review, the methods of measurement utilized, the photoelectric and luminescence properties of  $\text{Nd}^{3+}$  and  $\text{Ce}^{3+}$  doped  $\text{La}_2\text{S}_3$ , and the photoelectric and luminescence properties of  $\text{Nd}^{3+}$ ,  $\text{Eu}^{3+}$ , and  $\text{Tb}^{3+}$  doped  $\text{La}_2\text{O}_2\text{S}$ . This section is written by A. N. Georgobiani, V.I. Demin, and Ye. S. Logozinskaya.

The book was published in the Russian language by Nauka Publishing House in 1988. Exclusive English language rights, copyright 1990, are held by Nova Science Publishers, Inc. This 234 page English version is available from Nova Science Publishers, Inc., 283 Commack Road, Suite 300, Commack, NY 11725-3401, U.S.A. at a cost of \$93.00 U.S. in the U.S.A. and Canada and \$111.00 U.S. elsewhere. ▲

## Gilbert Y. Chin

Dr. Gilbert Y. Chin, 56, passed away May 5, 1991. He recently retired as director of the Passive Components Research Laboratory at AT&T Bell Laboratories. His laboratory was responsible for a large part of the materials research and development in metals and ceramics at Bell Labs, and also developing optical fibers. Dr. Chin was granted 11 patents and authored or co-authored 140 papers and three books. He was known to rare earthers for his fine work on rare earth magnets and magnetic materials. We convey our condolences to the family of Dr. Chin. ▲

## Charlotte Moore Sitterly

RIC has learned that Charlotte Moore Sitterly died of heart failure at her home in Washington D.C. Her publications appear under her maiden name, Charlotte E. Moore. She made significant contributions to the description and interpretation of the solar spectrum, including: "The Atomic Spectra of the Rare Earths: Their Presence in the Sun". However, she was more widely known for her critical compilations of atomic spectroscopic data obtained from laboratory observations. Her classic three-volume reference, "Atomic Energy Levels" (1949-58) remains one of the most highly respected and frequently cited sources of basic atomic data ever published. It includes data for 485 atomic species including many rare earth ions and is organized in a uniform, clear format with standardized notation.

Moore graduated from Swarthmore College in 1920. She then went to Princeton University Observatory where she began an association with H.N. Russell. In the 1920's she worked with Russell and others to update the solar-spectrum wavelengths and used solar line strengths to make the first major determination of the Sun's chemical composition. After earning her PhD from the University of California in 1931, Moore returned to Princeton, where she worked on energy-level analysis of several complex atomic spectra. In 1945, she joined the National Bureau of Standards (NBS) where she was put in charge of an atomic energy levels program. She continued there until her official retirement in 1968 but later joined the Naval Research Laboratory in 1971 while continuing her work at NBS. ▲

In 1912 X-ray spectra confirm that only 15 lanthanides are to be expected plus the two closely related metals Sc and Y. ▲

## CONCORD Trading Corporation

CONCORD Trading Corporation (CTC) is the international trade development unit of the CONCORD group of companies, headquartered in Denver, Colorado, USA. CTC's business interests include isotopes, rare earths and specialty metals, gemstones, food packaging equipment, computer chip design and manufacture, radiometric imaging services for the mining and petroleum industries, industrial lasers, and advanced materials which utilize ultra fine powders.

Certain of these business interests, including rare earths, are an outgrowth of the established trading relationships by its affiliate, NUEXCO, throughout the world including the Soviet Union and China. CTC maintains offices in Denver, New York, Washington, D.C., San Francisco, London, Zurich, Hong Kong, and Sydney.

For more information contact: Lisa Vogelsong, 520 Madison Avenue, 40<sup>th</sup> Floor, New York, NY 10022 Tel:(212)486-4890 Fax:(212)752-5369 or Bob Alexander, 11 Dupont Circle, Suite 505, Washington, D.C. 20036 Tel:(202)328-9250 Fax(202)328-6699. ▲

## Ceracon-Argonne

A cost-shared research agreement to develop and test electrical leads made from high-temperature superconductors has been announced by Ceracon, Inc., of Sacramento, California and the U.S. Department of Energy's Argonne National Laboratory near Chicago, Illinois. Ceracon is a materials research and product development company that focuses on using and licensing its patented processes to fabricate ceramics, metals, alloys and composites. Argonne has the nation's largest publicly funded superconductivity research program with over 200 different programs underway in basic and applied science.

The electrical leads are to be used to conduct current from room temperature devices to machines, experiments and instruments at temperatures as low as 4K. Argonne will supply Ceracon with Ca-doped yttrium-barium-copper oxide. Ceracon will then form the material into wires, cylinders and other commercial shapes suitable for leads. Argonne will then measure the ability of Ceracon's leads to carry current at different temperatures in the presence of various magnetic fields. Results will help scientists develop shapes best suited for the leads. ▲

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## Rare Earther

RIC News has received word that Mr. Warren J. Heiman, president of Reactor Experiments, Incorporated of Sunnyvale, California has retired. His successor is Mr. Donald Heiman. Reactor Experiments, a long time RIC supporter, sells radiation shielding and other nuclear reactor or nuclear activation materials including foils of rare earth metals and alloys. ▲

## HECLA Celebrates Centennial in 1991

HECLA Mining Company of Coeur d'Alene, Idaho is celebrating its 100th year of incorporation this year. In celebrating its Centennial year, it has adopted a new Centennial logo and will be holding events throughout the year at its properties across North America. Arthur Brown, HECLA's chairman and CEO, states that the main event of the year will be the unveiling of a specially commissioned, original bronze sculpture commemorating the contribution of their employees to the Company's success. The company employs nearly 1000 people in operations in 14 states and several Canadian provinces. It is a leading domestic supplier of newly mined silver and gold and a major supplier of ball clay, kaolin, feldspar and specialty aggregates. ▲

## Battery Grade Mischmetal

Tricoastal Lanthanides Company is announcing the availability of battery grade mischmetal in North America from their Baotou Plant in China. The product development work was begun in 1989 and is now completed. This plant can produce over 210 metric tons/year of 99% purity battery grade mischmetal.

This new mischmetal is not expected to interfere with production of the regular metallurgical grade mischmetal. For further information contact: Ray Rumer, Tricoastal Lanthanides Company, 16 Knight Street, Norwalk, CT 06851 Telephone:(203)838-5124 Fax:(203)854-0893 Telex:(42)7070 TRI COST. ▲

## Errata

We erred in spelling the name of Mr. K. Subramanian of Indian Rare Earths in the story on page 6 of the June 1991 issue of *RIC News*. Mr. K. Subramanian has retired from the company as of May 31, 1991. We apologize for our oversight. ▲

## Supporters

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Since the June issue of the RIC News went to press, RIC has received support from only 1 new family member, and renewed support from 36 other organizations.

The supporters for the first quarter who wish to be listed, grouped according to their appropriate category, and with the number of years that they have contributed to the Center in parentheses, are listed below.

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