RARE-EARTH INFORMATION CENTER NEWS

INSTITUTE FOR PHYSICAL RESEARCH AND TECHNOLOGY
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Far East Visit

On November 6-9, 1988, the editor was privileged to take part in the First International Conference on the Metallurgy and Materials of Tungsten, Titanium, Rare Earth, and Antimony (W-Ti-RE-Sb'88) in Changsha (Hunan Province), People's Republic of China (PRC). While in the Far East he also visited a number of research institutes and one university.

W-Ti-Re-Sb'88 Conference

The conference was organized by the Non-ferrous Metals Society of China. There were about 400 participants, with about 110 from outside of the PRC, including 50 from Japan. A total of 231 oral and poster presentations were given.

The first day's talks consisted of 10 plenary lectures reviewing the major areas within the central theme of the conference. The editor presented the only talk that dealt exclusively with the rare earths, but two other plenary lectures included some information about the rare earths. There were four half-day oral sessions, two poster sessions, and a closing discussion session involving the rare earths. Unfortunately, the two oral sessions on extractive metallurgy were held parallel to the two oral sessions on materials science and applications of rare earths.

Professor Peter Wachter from ETH-Zürich presented an invited talk on his model for high temperature superconductivity in ceramic oxide materials to lead off the rare earth materials science and applications oral sessions. He also mentioned that he and his co-workers have prepared *kilometers* of the $YBa_2Cu_3O_{7-x}$ (1:2:3) superconductor in wire form. They prepared the wire by arranging silver alloy tubes containing the 1:2:3 ceramic in a hexagonal array of 19 "cores" (strands). Then 19 of these arrays are stacked together before the total composite is drawn down to a 361 multistrand wire of an outside diameter of 0.1 mm. The individual strands are about 1 μm in diameter. The current carrying capacity is quite low, 500 A/cm^2.

During the discussion session at the end of the conference, Professor Emeritus S. Goto (University of Tokyo) mentioned that a number of Japanese firms are involved in the development of rare earth (Gd and Tb)-transition metal (Fe

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ACS Award Organometallic Chemistry

Tobin J. Marks, Charles E. and Emma H. Morrison Professor of Chemistry and professor of materials science and engineering at Northwestern University, was presented the ACS Award in Organometallic Chemistry. He received the award, sponsored by Dow Chemical Company, in recognition of research that has had a major impact on contemporary organometallic chemistry. Especially active in the actinide field, he is well known also for his work with the rare earths. Marks' research in synthetic studies has resulted in a wide array of novel compounds: alkyls, hydrides, acyls, formyls, metallacycles, and compounds with metal-metal bonds. He also has studied the structure, bonding, molecular dynamics, kinetics, reaction mechanisms, and thermodynamics of many of these systems. Tobin earned his B.S. degree at the University of Maryland and his Ph.D. at the Massachusetts Institute of Technology. He joined the faculty at Northwestern University in 1970.

Rare Earths Enter the Dragon

M. O'Driscoll has written a survey of the rare earth field [*Indus. Miner.* [254], 21-55 (November 1988)]. This is the latest in the series that includes the earlier surveys of 1979 and 1984. A copy of this report can be ordered for 9.8 £ (~U.S.$17) from Mr. J. Fea, Subscriptions Manager, Industrial Minerals, Park House, 3 Park Terrace, Worchester Park, Surrey KT4 7H7, United Kingdom.

The survey starts with a discussion of some of the minerals and their occurrence. A listing of the make-up of two bastnasites, five monazites, and a xenotime is given in the table.

The next section is on production and exploration. He lists world reserves and production in tables, then discusses present and potential areas of production, their reserves and outputs, and the companies involved for Australia, the United States, China, India, Brazil, Malaysia, and Thailand/Sri Lanka. Other areas of present or future production discussed are Canada, Greenland, Mozambique, Madagascar, West Germany, USSR, Venezuela, and Zaire. These sources could prove to be important in the future, along with other areas of Africa, South America, and Mexico.

In the section on processing and producers he discusses Rhône-Poulenc; Molycorp; other U.S. processors; and processors in China, Japan, and Europe.

In the Applications and Market Overview section, the discussion centers on market trends, current users, and new uses. The uses of rare earths in catalysts, autocatalysts, metallurgy and glass, phosphors and ceramics, magnets, and superconductors are given special mention.

A section on the Chinese market

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CONFERENCE CALENDAR

International Symposium on Magnetoelasticity and Electron Structure of Transition Metals, Alloys and Films (ISOMES '89)
Duisburg, West Germany
March 20-22, 1989
RIC News, **XXIII**, [2] 2 (1988)

10th International Workshop on Rare-Earth Magnets and Their Applications
Kyoto, Japan
May 17-19, 1989
RIC News, **XXIII**, [4] 4 (1988)

International Conference on Materials and Mechanisms of Superconductivity and High-Temperature Superconductors M²S-HTSC
Stanford, California, U.S.A.
July 23-28, 1989
RIC News, **XXIII**, [4] 4-5 (1988)

2nd International Symposium on Rare Earth Spectroscopy (RES-89)
Changchun, Jilin, China
September 9-14, 1989
RIC News, **XXIII**, [3] 2 (1988)

International Conference on the Physics of Highly Correlated Electron Systems (ICPHCES)
Santa Fe, New Mexico, U.S.A.
September 11-15, 1989
RIC News, **XXIII**, [4] 4 (1988) and **This Issue*

XI Simposia Latino Americano Fisica del Estado Solido (XI SLAFES)
Caracas, Venezuela
October 23-27, 1989
RIC News, **XXIII**, [4] 4 (1988)

1st International Conference on f-Elements (ICFE)
Leuven, Belgium
September 17-21, 1990
RIC News, **XXIII**, [4] 4 (1988)

*New Information

Other conferences approved at a meeting of the Board of Directors of the International Steering Committee for Conferences on *f*-Elements, held at the 18th Rare Earth Research Conference are as follows:

Actinide Conf.	Tashkent, U.S.S.R.	1989
19th RERC	Kentucky, U.S.A.	1991
	Japan	1992
20th RERC	California, U.S.A.	1993
2nd ICFE	Finland	1994
	Asia?	1995

ICPHCES

This is an update to the announcement in the last issue of the *RIC News*. The deadline for the abstracts, in camera ready form, is March 8, 1989. The abstracts should fit in a 12 cm wide by 10 cm high space. The abstracts should be mailed to Dr. B. R. Cooper, Program Committee

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Chairperson, Department of Physics, West Virginia University, Morgantown, WV 26506, U.S.A.

Participation in the *International Conference on the Physics of Highly Correlated Electron Systems* will be limited to 250 attendees. Preregistration is suggested and the fee is U.S.$160.00 before July 14, 1989 and $175 after that date.

PROCEEDINGS

Rare Earths Applications and Technology

The Proceedings of an International Symposium on Rare Earths—Applications and Technology, held in Bombay, India, September 25-26, 1986, were published as Volume **30** of *Materials Science Forum* (1988) by Trans Tech Publications.

In this book, the applications and technology of rare earths were reviewed extensively with emphases on processing, production, and marketing. Several new research results were also given. The 25 papers were compiled into seven sections: Resources and Supply, Processing and Separation, Metallurgy, Catalysis Studies, Metallurgical and Hi-tech Applications, Magnetic Applications, and Chemical and Other Applications.

The first section contains three papers, two concerned with the world reserves, resources, and deposits and with production and marketing of rare earths. Included are discussions on the geological environment, compositions, physical properties, and mining of rare earth minerals from different sources. One paper describes the beneficiation of monazite from Indian beach sands.

In the second section, there are two articles. One discusses processing of monazite at Indian Rare Earth Limited and the other is on photochemical reduction of europium in aqueous lanthanide mixtures.

In the third section, there are two papers related to electrowinning of the individual rare earth metals and alloys, and one on the development of rare earth-magnesium alloys.

There are two papers in section four with one on the decomposition of isopropanol over RE oxides and the other on catalytic materials with particular emphasis on perovskite. Vari-

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ous applications of the perovskite catalysts are discussed.

In section five there are three papers, two on the applications of rare earths in titanium alloys, superalloys, chromium alloys, rapidly solidified alloys, intermetallic compounds, structural ceramics, metal hydrides, magnetostrictive alloys, and garnets. Some applications include magnets, energy storage systems, transducers, magneto-optical recording, stronger high tech materials, and corrosion. The other paper deals with applications of lasers, their purification, and their preparation.

Section six contains six papers, five dealing with preparation of Nd-Fe-B alloys and on research and development of Nd-Fe-B and RCo_5 (R = Sm, Pr, and MM) permanent magnets. One article reviews rare earth substituted garnet films for magnetic bubble memory applications.

The last section contains six papers with one reviewing industrial applications of rare earths in Japan. The other five are devoted to the applications of rare earths in paints, pigments, cinema arc carbons, hydrogen storage materials, and Y_2O_2Si:Eu and CaS:Ce,Nd phosphors.

Edited by C. K. Gupta and T. S. Krishnan, the 320-page book costs SFR 110.00 (~U.S.$70) and may be ordered from Trans Tech Publications Limited, P.O. Box 10, CH-4711 Aedermannsdorf, Switzerland.

HTSC-M²S

An international conference on High Temperature Superconductors and Materials and Mechanisms of Superconductivity was held at Interlaken, Switzerland, on February 28-March 4, 1988. The proceedings were published by the North-Holland Physics Publishing division of Elsevier Science Publishers B.V. in 1988 in Volumes **153-155** of *Physica C*. The 1,801-page proceedings are also available as two hard-bound books. The proceedings were refereed under the direction of editors J. Müller and J. L. Olsen and cost Dfl. 450 (~U.S.$215). It is available from The Netherlands office of Elsevier Science Publishers B.V., at P.O. Box 103, 1000 AC Amsterdam, The Netherlands. Prepayment is required.

This international conference was

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RIC Insight

It has been a year since the RIC started publishing *RIC Insight* [*RIC News*, **XXIII** [2] 5 (1988)]. The first volume had 10 issues since it started with the March 1, 1988, issue. From now on each volume will have 12 issues. The reaction to the new publication has been favorable and has resulted in several new sponsors. New sponsors of RIC have received or will receive the 10 issues of Volume 1, plus the first seven issues of Volume 2 (through the July 1 issue). Regular sponsors will receive the publication regularly as long as they renew their support.

The subject matter of the first volume of *RIC Insight* was as listed below:

No. 1—"RIC Inaugurates a New Service," "Corrosion," "A New Rare-earth Permanent Magnet Material?," and "Non-rare-earth High T_c Superconducting Competitor."

No. 2—"High Temperature Superconductivity" and "Meeting Announcements."

No. 3—"Heavy Metal Fluoride Glass Optical Fibers" and "Chinese Become Largest RE Producer!"

No. 4—"Competition is Heating Up—"information on new deposits and sources of rare earths and "RE Geochemistry for the Layman."

No. 5—"Large Pore Size Molecular Sieves," "New Laser Host," and "Multilayer Magnetic Structures."

No. 6—"Inexpensive RE-Fe-B Permanent Magnets," "More Magentic News"—information about a review on $SmCo_5$-Sm_2Co_{17} magnets and testing of Nd-Fe-B magnets for an x-ray light source, and "New Optical Materials"—electroluminescent film, blue emitting CRT phosphor, and short wavelength laser.

No. 7—"High T_c 1:2:3 Films" and "High T_c 1:2:3 Flexible Tapes."

No. 8—"Highlights from the 18th Rare Earth Research Conference. (a) U.S.A. Still Largest Producer of Rare Earths, (b) Egyptian Rare Earths, (c) 1:2:3 High Temperature Superconducting Powders, and (d) Mid-Infrared Laser Diode."

No. 9—"High Strength, Low Density Glassy Alloys," "High T_c Update—How Do J_c's Stack Up!," "Rhône-Poulenc to Acquire Research Chemicals," "S. X. to Treat Rare Earths," "Nuclemon to Separate Rare Earths," and "Highlights from the 18 RERC—Mid-

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Infrared Laser Diode—continued."

No. 10—"W-Ti-RE-Sb'88 Conference Highlights. (a) 1:2:3 Superconducting Wire, (b) Optical Storage Disks, (c) Extractive Metallurgy, (d) Electrowinning, and (e) Miscellaneous."

All back issues, future issues, and privileges of being a sponsor are included in the subscription price of U.S.$300.00 for new subscribers to *RIC Insight*. Payment may be sent to RIC, 225 Spedding Hall, Iowa State University, Ames, IA 50011-3020, U.S.A. For more information contact Dr. Karl A. Gschneidner, Jr., at the above address. Any issue of special interest may be obtained by sending U.S.$30.00 to the RIC at the above address. Please specify which issue(s) you are ordering.

Business News

Renison Goldfields

Renison Goldfields Consolidated Limited has announced a definitive engineering study of an ore body of its wholly-owned subsidiary, Associated Minerals Consolidated Limited (AMC). The AMC ore body, Eneabba West prospect, is located 5 km west of AMC's existing operation at Eneabba. The new ore body contains an estimated 150 million metric tons (mt) of ore grading about 4% heavy minerals. It should be capable of producing 2,500 mt/yr of monazite for at least 12 years. The deposit could turn out to be even larger and further studies are under way. A feasibility study under way should enable production to begin in late 1990 if the feasibility study is favorable. The expected capital cost of the project is A$55 million.

SX Holdings

In December, SX Holdings Limited announced it had reached an agreement with the China National Non-Ferrous Import Export Corporation and the Center for Rare Earth Agriculture Technique of the China National Non-Ferrous Metal Industry Corporation. The agreement provides for the transfer to SX of technology and marketing rights covering the rare earth trace element fertilizer "Nongle," on an exclusive basis in Australia and New Zealand for 13 years.

SX, with help from Chinese scientists and in association with a number of agricultural institutions,

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will test the fertilizer throughout Australia. Application to wheat, sugar cane, grapes, and pasture has yielded impressive results in China and will have special significance to Australian agriculture if testing is successful in that country.

Following the trials, SX will import its initial requirements of "Nongle" from China but expects to build a plant at Port Pirie in conjunction with their planned rare earth processing plant [*RIC News*, **XXIII**, [4] 2 (1988)].

The world will be watching the tests with keen interest. If the tests are successful and rare earths are added to fertilizers around the world, the consumption of rare earths could easily double.

Cooljarloo Sands

TI02 Corporation NL and Kerr-McGee Chemical Corporation, joint venture partners in the Cooljarloo mineral sands project, will commence premining development in the near future. Located near Cataby, 170 km north of Perth, Australia, the deposit has reserves of 569 million tons grading 3.2% heavy minerals and a high grade orebody of 57 million tons grading 6.7%. The heavy sands contain 1% monazite. Mining is scheduled to start in 1989 with a projected output of 1,000 tpa of monazite.

Johnson Matthey

Johnson Matthey/AESAR has agreed to purchase the Alfa Catalog Chemicals Division of Morton Thiokol. A spokesman said that Alfa did not fit in with Morton Thiokol's long-term plans. The two Johnson Matthey divisions will, at present, continue to put out their own catalogs. The purchase will make AESAR/Alfa one of the largest catalog chemical sales companies and supposedly the largest specializing in inorganic chemicals.

Neomet

Mr. Tatsuo Arima became executive vice president of Neomet Corporation on September 1, 1988. He replaced Mr. Yuzo Yamamoto who was transferred to Mitsubishi Metal Corporation in Baltimore, Maryland. Neomet, located in West Pittsburg, Pennsylvania, is a joint venture of Mitsubishi and Reactive Metals and Alloys.

CEAM II

Concerted European Action on Magnets Group (CEAM) has been granted a two-year extension of funding of 25,000 ECU. It is a unique experiment in interdisciplinary collaborative research and development effort sponsored by the European Commission [*RIC News,* **XXI,** [1] 3-5 (1986)]. Founded in 1986, the emphasis of research and development is on materials, magnet processing, and applications of Nd-Fe-B magnets. The CEAM Scientific Project Director is Dr. I. V. Mitchell while Dr. L. Bellemin is the CEAM Administrative Project Manager.

The research on materials, which is led by Dr. D. Givord and Professor J. M. D. Coey, aims to achieve a fuller understanding of the magnetic properties of $Nd_2Fe_{14}B$ and related phases; to improve the magnetic properties by controlling the microstructure and chemical composition; and to search for new rare earth-iron rich phases that might have potential as permanent magnets.

The research on magnet processing is under the direction of Dr. I. R. Harris, and is concerned with the characterization of the microstructure of cast ingots; development of economical powder production routes such as hydrogen decrepitation; measurement of physical properties and characterization of microstructure of sintered magnets; study of corrosion behavior of and development of corrosion protection strategies for sintered magnets; study of production, characterization, and magnet fabrication of melt-spun material; and development of processing techniques for new materials developed by the material groups.

The application research, under the direction of Professor R. Hanitsch, is centered on magnets made from Nd-Fe-B, related materials, or any newly developed materials. Technical achievements can be divided into the following broad areas: new and improved design and engineering capabilities; design and construction of a range of electrical machines; and design and construction of prototypes of static devices such as hexapoles, wigglers, undulators, clamping devices, and magnetic resonance image scanners.

Nearly 60 companies, institutes,

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Honors

Inventor of the Year

Dieter Gruen, associate director of the Materials Science Division of the Argonne National Laboratory, has been named Inventor of the Year by the Patent Law Association of Chicago. Gruen is the inventor of the process for making high T_c wire that was recently licensed to American Superconductor [*RIC News,* **XXIII,** [4] 2 (1988)].

National Medal of Science

On July 15, President Reagan awarded the National Medal of Science to 19 scientists, including Paul C. W. Chu and Walter Kohn.

Paul Chu, of the University of Houston, was recognized for his contributions in achieving stable superconductivity in high T_c oxides at temperatures above the temperature of liquid nitrogen.

Walter Kohn, of the University of California, Santa Barbara, was recognized for his pioneering contributions to the theory of the electronic structure of solids, including the effective mass approach to defects in semiconductors, the KKK method of band structure, and most importantly, the density functional approach to the many-electron problem. SmS is one of the compounds he studied.

Hewlett-Packard

J. Georg Bednorz and K. Alex Müller of the IBM Zurich Research Laboratory received the Hewlett-Packard Europhysics Prize at a conference held in Budapest in April. Given for their discovery of high T_c superconductivity, the prize consists of 20,000 Swiss francs (~U.S.$13,300). Bednorz has been at IBM since 1982 while Müller has been there since 1963.

ACA Awards

The American Crystallographic Association presented Paul M. Horn and Robert Birgeneau with the Bertram Eugene Warren Diffraction Physics Award, in June of 1988, for their contributions to solid-state physics. They both have worked with high T_c superconductors; Horn exploring the relationship between their crystalline structure and the mechanism of superconductivity, and Birgeneau using neutron-scattering to observe two-dimensional dynamical spin fluctuations. Birgeneau has been associated with rare earths since 1967, first at Bell Laboratories and since 1975 at the Massachusetts Institute of Technology.

High T_c Superconductor Market Survey

Recent advances in the field of superconductivity are stimulating major commercial developments that could have a profound impact on many industries according to a 397-page market survey completed in August 1988 by Falmouth Associates Inc. of Falmouth, Maine. The full title of the market survey is *High-Temperature Superconductors: Raw Materials, Synthesis, Fabrication and Applications. An appraisal of the technology, market potential and new business opportunities, 1988-2000.*

According to the prospectus, significant near-term opportunities exist to supply raw materials; synthesize superconducting oxides; and fabricate superconducting powders, films, wires, and other shapes for a wide range of applications. The report attempts to predict when these various applications will become commercially viable.

Falmouth Associates predict a $375 million market for high-temperature superconductor components by the year 2000 and that it could reach $3.2 billion by 2000 if current attempts to synthesize 150-300°K superconductors were successful. Sales of equipment and devices incorporating these components would be considerably larger than this.

In addition to market projections, the report focuses on the raw materials and synthesis routes used to make high T_c superconductors, as well as the various methods for fabricating these materials into useful components.

A key section of the report deals with the rare earths used in synthesizing the high-temperature superconductors that have been developed to date. Various rare earth ores are described along with separation routes, purity requirements, reserves, production, consumption, and commercial information. Other elements similarly treated are Cu, Ba, Ca, Sr, Bi, Tl, and Nb.

The price of the report is U.S.$10,000. For more information contact Dr. Hugh Olmstead, Falmouth Associates, 170 U.S. Route One, Falmouth, ME 04105, U.S.A.

* Contributors *

As usual, the third quarter of fiscal 1989 was fairly quiet. We are quite happy with the continued growth in the number of new sponsors. Of the 30 benefactors sending their support, eight are new additions to our family. For the year we now have 94 sponsors and our fourth quarter is usually the best of the year.

The 30 additions to our list of benefactors during the third quarter, with the number of years they have been sponsors in parentheses, are listed below.

Allied-Signal Incorporated, U.S.A. (17)
Aran Isles Chemicals Incorporated, U.S.A. (5)
Auer-Remy GmBH, West Germany (2)
BOSE Corporation, U.S.A. (12)
Companhia Industrial Fluminence, Brazil (16)
Dow Chemical U.S.A., Texas Division, U.S.A. (3)
Ergenics Incorporated, U.S.A. (5)
General Research Institute for Non-ferrous Metals, People's Republic of China (1)
GTE Products Corporation, U.S.A. (17)
Guangzhou Nonferrous Metal Institute, People's Republic of China (1)
Hanbridge Developments Limited, England (1)
Haynes International Incorporated, U.S.A. (6)
Hunan Research Institute of Rare Earth Metals, People's Republic of China (1)
Institute of Materials Processing, Michigan Technical University, U.S.A. (2)
London & Scandinavian Metallurgical Company, Limited, England (5)
Metal Mining Agency of Japan, U.S.A. (1)
Mitsui & Company (U.S.A.) Incorporated, U.S.A. (4)
Muswellbrook Energy and Minerals Limited, Australia (2)
Neomet Corporation, U.S.A. (3)
OREMCO Incorporated, U.S.A. (1)
Reactor Experiments Incorporated, U.S.A. (19)
Ronson Metals Corporation, U.S.A. (21)
Silicon Metaltech, U.S.A. (1)

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Gorham Magnet Study

The present market for permanent magnets is estimated to be U.S.$1 billion. Now growing at a 10 percent rate, many experts expect to see the market hit $3 billion by the year 2000. According to Dr. Andrew C. Nyce, president of Gorham Advanced Materials Institute (GAMI), the fastest growing share of the market is owned by NdFeB magnets. He claims their share of the market, which is expanding at a 50 percent pace, could reach $1 billion by then.

A study by GAMI, "The Global Permanent Magnet Industry: Market Forecasts, Business Opportunities, and Technoeconomic Assessments to 2000," is scheduled to be completed in October 1989. The report, as described in the news release, will generate detailed, consumption-based market forecasts of demand, in units, kilograms, and dollars, by specific end use market and applications for NdFeB, rare earth-cobalt, Alnico, and ferrite permanent magnets. In addition, the report will critically analyze the advantages and disadvantages of these magnets and assess the possible impact of NdFeB materials and technologies on each. According to Nyce the report will also discuss how the availability and pricing of raw materials will affect the market.

The report will consist of four volumes. Volume **I,** *Technoeconomic Assessment of Potential Applications and Emerging Manufacturing Technology,* costs U.S.$5,000. Volume **II,** *North American Markets for Permanent Magnet Materials to 2000,* costs $7,500. Volumes **III** and **IV,** which cover markets for permanent magnet materials in Western Europe and the Pacific Rim, respectively, will also cost $7,500 each. A prospectus may be obtained from Dr. Andrew C. Nyce, president, Gorham Advanced Materials Institute, P.O. Box 250, Gorham, ME 04038-0250, U.S.A.

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Tam Ceramics Incorporated, U.S.A. (2)
Tosoh SMD Incorporated (formerly Special Metals Division of Varian Associates, Incorporated), U.S.A. (2)
UGIMAG RECOMA AG, Switzerland (5)
Vollbrecht Associates, U.S.A. (5)
Wako Bussan Company, Limited, Japan (20)

TITANIUM

The preceedings for the four-session symposium on rapidly solidified titanium alloys, which was held at the 1986 TSM-AIME annual meeting in New Orleans, Louisiana, was published in 1986 by The Metallurgical Society, Incorporated under the title *Titanium, Rapid Solidification Technology.* The book contains 28 papers and is 331 pages long, was edited by F. H. Froes and D. Eylon, and costs U.S.$96.00 (TMS members $48.00, students $23.00). It may be ordered from The Metallurgical Society, 420 Commonwealth Drive, Warrendale, PA 15086, U.S.A.

Fifteen of the papers deal with rare earth additions to both alpha and beta Ti-base alloys. The rare earths studied the most are Er and La but Ce, Dy, Gd, Nd, and Y were also investigated. The rare earths are usually present as dispersoids but are also present in solution. The dispersoids are normally oxides but can be sulfides or oxysulfides. The dispersoids produced by rapid solidification are ultrafine and affect the behavior of the alloy in a number of ways. First, the dispersoid produces hardening due to the Orowan effect and indirectly affects the alloy due to grain size reduction. The papers deal with alloy design, production methods, processing and fabrication, microstructures, and mechanical properties of rapidly solidified titanium.

The ability of rapid solidification to circumvent many of the restrictions placed by equilibrium phase diagrams combined with the microstructural refinement inherent to this technology omens well for development of new titanium alloys that can be used in higher stressed components, at increased temperatures, in conjunction with reduced density.

CEAM II

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and universities in 10 European countries are involved. So far the magnets being produced are comparable in quality to any produced elsewhere in the world. Industrial economic returns are already being realized in the European Common Market. For more information write to Dr. I. V. Mitchell, DG XII-C4 EURAM, or Dr. L. Bellemin, DG XII-HI STIMULATION, both at 200-rue-de la Loi, B-1049 Brussels, Belgium.

Far East Visit

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and Co) amorphous alloys for magneto-optical storage. The advantage of these amorphous alloys is that the stored information can be erased and written over using a laser beam.

Several papers were presented by the Chinese on the separation of the bastnasite and monazite in the Baiyunebo ore by flotation methods. One of the difficulties with the Baiyunebo ore is that the alkaline digestion of the two unseparated minerals (bastnasite and monazite) has presented some problems, which an efficient, low-cost physical separation process could eliminate. From the information presented at the conference, it appears that some success has been realized.

A number of papers were presented on the electrowinning of rare earth metals by fused salt electrolysis of their chlorides or fluorides. Because of the extensive use of the metals in the metallurgical field in China (additives to steels and Al base alloys, Nd for permanent magnets, etc.) there is a large emphasis on this topic.

Central Research Institute, Mitsubishi Metal Corporation

The Central Research Institute of Mitsubishi Metal Corporation (MMC) is located in Omiya, Japan, just outside of Tokyo. The Central Research Institute's role is to develop new products, improve on existing ones, and furnish assistance when needed at the 13 manufacturing plants of the corporation. MMC is involved in a variety of products, such as semiconductor grade silicon single crystals, silicon wafers, semiconductor compounds (e.g. GaAs), sputtering targets, inorganic compounds and pigments, hard metals, powder metallurgy parts and bearings, copper tubing, aluminum cans, precious metals, nuclear energy (uranium refining, fuel fabrication, reprocessing, and waste management technology), and geothermal energy.

My host was Dr. T. Takeshita, who is the manager of the Powder Metallurgy Division. His group's efforts are about equally divided between $Nd_2Fe_{14}B$ permanent magnets and the high temperature superconductors. The main emphasis on the $Nd_2Fe_{14}B$ permanent magnets is to develop plastic bonded magnets. The

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superconductivity work involves making $YBa_2Cu_3O_7$ (1:2:3) wire coils by explosive compacting, and thin films of both the 1:2:3 and the Bi-Sr-Ca-Cu-O materials. The 1:2:3 wires are made by packing the superconducting oxide powders in a silver tube, cold rolling to a wire, winding a coil on a steel mandrel, explosively compacting the coil, and then sintering at 925°C in a flowing O_2 atmosphere. They claim their material has a critical current density of 13,000 A/cm^2 at 77 K. They have prepared films by both an organometallic deposition technique and by reactive sputtering. The materials have been deposited on yttria partially stabilized ZrO_2 (Y-PSZ), Y-PSZ coated Si, and MgO single crystals. They have been able to etch small intricate designs in the 1:2:3 on an MgO single crystal by a conventional lithography technique, but have not yet measured the critical current density.

In the Metallurgy Division (headed by Dr. E. Kimura) they are making high purity Sc_2O_3, which is used to improve the emission characteristics and brightness of the electron emitter of TV picture tubes. They are also trying to improve the process for making Sc metal, which is used in halogen lamps, via the Ca reduction of ScF_3.

Institute of Physics, Academia Sinica

At the Institute of Physics of the Chinese Academy of Science, located in Beijing, I visited Professor Z. X. Zhao's low temperature research group. In the past year the Chinese Academy of Sciences set up a high temperature superconducting research project which is headed by Dr. Zhao. Not surprising most of his group efforts are focused on these materials. One aspect of this research is concerned with the growth of high T_c single crystals, especially the Bi-based Cu-oxide materials, and their characterization, some of which is being carried out collaboratively with scientists throughout the world. The crystals are about 1 mm on an edge. Dr. S. Xie, who heads a group studying phase relationships, has done a lot of work on the phase relationships and magnetic properties in the iron-rich corner of the Fe-Nd-B system.

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General Research Institute for Non-Ferrous Metals

The General Research Institute for Non-Ferrous Metals (GRINM), which is located in Beijing, is one of the major research institutes of the China National Nonferrous Metals Industry Corporation. GRINM has 21 laboratories staffed by 1,400 technical employees and is concerned with all aspects of nonferrous metallurgy from ore dressing and smelting to producing nonferrous metal products, designing and manufacturing equipment, plus providing a variety of technical services. The rare earth research group at GRINM is working on $SmCo_5$ and $Nd_2Fe_{14}B$ permanent magnets, $LaNi_5$ hydrogen storage materials, rare earth phosphors, and rare earth fertilizers. This institute also designed and built a rotary kiln roaster and solvent extraction lines for processing the rare earth ore from the Baiyunebo iron-rare earth mine near Baotou in Inner Mongolia.

University of Science and Technology-Beijing

The University of Science and Technology-Beijing (USTB) is one of the top universities in the fields of metallurgy, material science, and mineral engineering in the People's Republic of China. At USTB I visited with Professors R. Zhu, Y. Xu, and Z. Qiao. The first two are involved in surface science and corrosion, and the latter in the physical chemistry of molten salts. Some of Professor Zhu's research involves high temperature corrosion coating materials, including AlNi and Ni_3Al that are doped with yttrium, which unfortunately gives only marginal improvement in the corrosion resistance. Professor Qiao is working on rare earth oxide and halide phase diagrams. One diagram (Y_2O_3-CuO) was discussed for some time and is of particular interest for work on high temperature superconducting materials.

Epilogue

It was an interesting and exciting trip visiting old friends and making new ones, and learning about the rare earth science and technology that is occurring not only at the places visited but at other institutions, companies, and universities. As usual, the Japanese and Chinese were wonderful hosts.

$YBa_2Cu_4O_8$ Synthesis

The superconducting phase $YBa_2Cu_4O_8$ (1:2:4) differs from $YBa_2Cu_3O_7$ (1:2:3) in having a double instead of single Cu-O chain running parallel to the *b* axis. It was first observed as a lattice defect in partly decomposed 1:2:3 powders and then as an ordered defect structure in inhomogeneous 1:2:3 thin films. J. Karpinski, E. Kaldis, E. Jilek, S. Rusiecki, and B. Bucher report on the synthesis of the 1:2:4 phase in bulk at 400 bar O_2 and 1,040°C [*Nature*, **336**, 660-2 (1988)]. The superconducting transition temperature is 81 K and unlike the 1:2:3 compounds, the oxygen content in 1:2:4 is thermally stable up to 850°C. This may prove important for applications.

Leopold Gmelin

Leopold Gmelin is hardly a household name. But the chances of its becoming one are enhanced, at least in some parts of the world, by the issuance of the West German postage stamp bearing his likeness and signature. The special issue marks the anniversary of the noted chemist's birth in Göttingen 200 years ago.

Although Leopold Gmelin may not be very well known worldwide, the handbooks bearing his name, *Gmelin Handbook of Inorganic Chemistry*, now in its eighth edition, are well known. The set contains some 570 volumes and occupies about 50 feet of shelf space. Thirty-seven of these volumes are devoted to the rare earths.

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High Coercivity Nd-Fe-O Phase

G. Schneider, G. Martinek, H. H. Stadelmaier, and G. Petzow [*Mater. Lett.* **7**, 215-8 (1988)] report that arc melted 80 at% Nd-20 at% Fe and similar alloys develop intrinsic coercivities of up to 5000 Oe in the as-cast condition. This is attributed to a fine-grained eutecic microstructure stabilized by oxygen. The alloy has a Curie temperature of 235°C. According to the authors, the high coercivity of these alloys confirm the 1935 work of V. Drozzina and R. Janus [*Nature*, **135**, 36-7 (1935)] who found that Nd containing 7% Fe (presumably weight %) had a coercive field of 4300 Oe. The authors' study may also explain why the Nd-Fe melt-spun materials studied by J. J. Croat in the early 1980s were able to achieve their high coercivities. The 1935 alloy and the melt-spun materials probably contain oxygen to some degree.

The authors studied Nd-Fe alloys containing 70, 80, and 90 at% Nd that were arc-melted under argon. The oxygen content ranged from 0.1 to 0.3 at%. They also studied two Nd-Fe-O alloys and two Nd-Fe-B alloys. In all cases they observed a phase identified as $NdFe_4O_x$, which helped stabilize the systems. This finding supports the observation of a second magnetically hard phase in Nd-Fe-B magnets. The second phase had been observed to have a Curie temperature 50 to 80 K below that of $Nd_2Fe_{14}B$.

The possible utilization of $NdFe_4O_x$ as the only magnetically hard phase in a permanent magnet requires more accurate determination of its formation conditions. In any case, the role of oxygen in rare earth permanent magnets needs further study.

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The total consumption of rare earth products in China in 1987 was about 5,000 metric tons.

Enter the Dragon

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puzzle and a discussion of prices ends the survey.

This survey will give a person a good place to start for acquiring a picture of the rare earth field. It does not, however, give a very clear picture of the Russian efforts in the rare earth field. Overall it contains a lot of information which is rarely found in one paper.

Lanthanide Oxysulfides

A review covering the oxysulfides of the rare earths, written by Yu L. Suponitskii, G. M. Kuz'micheva, and A. A. Eliseev, appears in *Uspekhi Khim.*, **57**, 367-84 (1988) [Engl. Transl. *Russ. Chem. Rev.*, **57**, 209-20 (1988)]. Devoted mostly to lanthanides, especially lanthanum; some data on yttrium and scandium oxysulfides are also included. Following a short introduction sections are devoted to methods of synthesis, crystal-chemical properties, solid solutions, and thermal and thermodynamic properties.

The section on synthesis considers three methods: (1) sulfiding the oxides; (2) reducing sulfates and sulfites; and (3) oxidizing the sulfides. The same procedures can be used to produce double rare earth oxysulfides $[(R,R')_2O_2S]$ and other metal-rare earth oxysulfides $[(R,M)_2O_2S]$ where M includes: Ga and In; monovalent Cu and Ag; divalent Pb; trivalent As, Bi, Cr, Sb, and V; and tetravalent Ge and Sn.

The section on crystal-chemical properties discusses the crystal structure and region of homogeneity. The structure is governed by close packing principles and includes vacancy studies of all three elements present (R,O,S). The homogeneity discussion involves the La_2S_3-La_2O_3 system. The liquidus temperature of 0-100 mol % La_2O_3 is given, as is the lattice periods in the 50-78 mol % range and the density for 60-70 mol % La_2O_3.

The solid solution section includes data on lattice parameters of $(Eu,Y)_2O_2S$ and $(Nd,Y)_2O_2S$ for the 0-100 mol % range. Other systems are also discussed.

The section on thermal and thermodynamic properties include the oxidation temperatures of most of the rare earth oxysulfides as well as their enthalpy of oxidation. Also included are melting points, enthalpies of formation, entropies, and Gibbs energy for some of the oxysulfides, and the relationship between the crystal lattice energies of the oxides and oxysulfides. A discussion of the La-O-S phase diagram is included.

The review includes a bibliography with 117 entries with three other references added as footnotes in the main text.

PREMO CHIOTTI

One of the friendliest, most humble men we have known passed away January 5, 1989, when Premo Chiotti died of cancer in Sun City, Florida, at the age of 77. He was born in Cuba, Illinois, on February 18, 1911. He attended Joliet Junior College from 1933 to 1936 and received his bachelor's degree in chemical engineering from the University of Illinois in 1938.

He enlisted in the Army Signal Corps during World War II and within months he began working on the Manhattan Project's uranium preparation program headed by Dr. F. H. Spedding at Iowa State College, Ames, Iowa.

In 1946, he went to graduate school at Iowa State and received his Ph.D. in 1950. He stayed at the Ames Laboratory and Iowa State University until his retirement in 1978. In 1976, he was awarded a Faculty Citation from the ISU Alumni Association in recognition of his long, outstanding, and inspiring service on the university faculty. He was named professor emeritus in 1978.

His professional interests included the determination of phase relationships and thermodynamic properties of salt and metal systems, particularly lanthanide and actinide alloys, including the rare earth-zinc systems. He also worked on the design and development of fused salt and liquid metal systems for reprocessing nuclear reactor fuels.

Proceedings

(Continued from page 2)

originally conceived as a merger of the Materials and Mechanisms of Superconductivity Conference and the new subject of high T_c superconductors. However, over 90 percent of the 720+ contributed papers belonged to the high T_c field and it seems more logical to think of it as a take-over rather than a merger. The 99 invited papers were divided among heavy-electron materials, localization and interactions, superconductivity and magnetism, binary and multinary components, thin films and superlattices, and organic superconductors.

Originally planned for 800 participants, the conference drew 1,150 scientists from 39 countries and all five continents. The next conference in this series is to be held July 23-28, 1989, at Stanford University in Stanford, California.

Metallic Glasses

We reported that Y. He, S. J. Poon, and G. J. Shiflet [*RIC News,* **XXIII,** [4] 3 (1988)] had developed new aluminum-rich metallic glasses containing rare earths, which had some unusual qualities. The RIC has since learned that Japanese scientists from the Institute for Materials Research, Tohohu University, had developed similar materials. Indeed the first paper by A. Inoue *et al.* was published about five months before the *Science* report cited in our earlier story. The first paper and three subsequent papers by Inone and his coworkers were published in *Jap. J. Appl. Phys.,* **27,** L479, L1579, L1583, and L1796 (1988). The first paper's title did not contain any reference to rare earths and was initially missed. The others did have rare earths listed in the title and were duly noted when RIC received the journal. It appears that these unusual alloys were discovered independently but the Japanese published first. The latest results still support the contention that this discovery could have a strong impact on the rare earth market.

Nd-Fe-B Bibliography

A new report, number PB88-864012, *Neodymium-Iron-Boron (Nd-Fe-B) Permanent Magnets,* is available from National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA 22151, U.S.A. It is a bibliography containing citations from the Information Services for the Physics and Engineering Communities (INSPEC) database. It covers the period from January 1984 to May 1988. The 204 citations are a great addition to ISRIC-9, "Source Book On Neodymium-Iron-Boron Permanent Magnets," which was published by the RIC in 1986.

Congratulations Globe Metallurgical

On November 14, 1988, Arden Sims, president of Globe Metallurgical, accepted the first Malcolm Baldridge National Quality Award from President Ronald Reagan. This award, for small businesses, established by an Act of Congress, salutes companies that "improve the quality of their goods and services, thus enhancing productivity, lowering costs, and increasing profitability." It recognizes the relationship between quality goods and services and the economic necessity for American producers to succeed in domestic and international market places. Globe is an RIC sponsor and we wish to extend our hearty congratulations.

Safety Note

In a letter-to-the-editor [*C & E News,* **66,** 2 (August 1, 1988)] Peter Gradeff reports the following explosion, which could be life threatening.

Ceric ammonium nitrate (CAN) was being reacted with sodium cyclopentadienyl (NaCp) under inert conditions in an appropriate solvent. The products are $CeCp_3$ and $NaNO_3$. The nitrates are normally filtered off before the solvent is removed but this time the solvent was removed first. A violent explosion occurred when the solid reaction mixture was heated to 75°C. Fortunately, the damage was minor since only a small quantity of material was involved and no one was in the vicinity.

In view of the advantages of using nitrates as starting materials for preparative organolanthanide chemistry, those who use this route should be aware of the dangers that might be present. It should also be kept in mind that the danger may not be restricted to cerium but extend to other rare earths or to other elements.

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