Rare-earth Information Center NEWS

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Correlated Electrons in India

Correlated electrons are not indigenous to India – they are everywhere! But they took center stage in India during the last four days of September, when scientists from all over the world gathered together to tell each other what we know about them. The editor (and his wife) were part of the attendees.

Tata Institute of Fundamental Research

The first stop in India was the Tata Institute of Fundamental Research (TIFR), which is celebrating its 50th birthday this year. There is a lot of excellent work going on in the Solid State division of TIFR on heavy fermions, anomalous *f* systems, and high temperature superconductivity. Most of our discussions at TIFR were in groups of two to four foreign scientists, who were on their way to the strongly correlated electron systems conference, and one or two Indian scientists. It is impossible to cite all of the work going on, so only a few highlights will be mentioned below. Discussion with Dr. S. Ramakrishnan and his student, K. Ghosh, centered on their work on the coexistence of superconductivity and magnetism in the $Sc_{5-x}Dy_xIr_4Si_{10}$, $Y_{5-x}Dy_xOs_4Ge_{10}$, $La_{(2-x)}Nd_xRh_3Si_5$, $R_3Ru_4Ge_{13}$ family of alloys and the $TlSr_2Ca_{1-x}R_xCu_2O_7$ (R = Pr and Tb) high temperature superconductors. Dr. E. V. Sampathkumaran presented his work on the magnetization, heat capacity and magnetoresistance of $Gd_{1-x}Y_xNi_2Si_2$ and $Gd_{0.2}La_{0.8}Cu_2Si_2$ alloys. The Gd magnetic contribution to the heat capacity of these compounds was found to extend to a much higher temperature above the Néel temperature (by more than one order of magnitude) than the usual factor of two. He believes this is due a to a magnetic precursor effect and transition metal band spin fluctuations. Dr. S. K. Dhar and I talked about his work on Yb and Sm, containing com-

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pounds which exhibit unusual magnetic and electronic properties. This latter work is of special interest to me because Dr. Dhar is collaborating with Dr. P. Manfrinetti (Genova, Italy) on this work, both of whom were post-doctoral associates of mine in 1983 - 1984. The most exciting thing is that Dr. Manfrinetti has developed a technique for making the Yb and Sm intermetallic phases by induction melting, using water-cooled copper hearth under a 1 kbar argon atmosphere without the loss of any Yb or Sm, both of which are quite volatile.

The writer also spent some time talking with Dr. S. K. Malik about our joint research project on the influence of crystalline electric field (CEF) effect on magnetic ordering and spin reorientation effects in the $(Dy_{1-x}Er_x)Al_2$ system.

The other foreign scientists visiting TIFR at the same time were Brian Coles (retired from Imperial College, London, England), C. Godart (Chemical Metallurgy of Rare Earths, Meudon, France), H. Fujii (Hiroshima University, Japan), H. von Lohneysen (University of Karlsruhe, Germany), and Y. Onki (Osaka University, Japan) and two of his associates.

International Conference on Strongly Correlated Electron Systems

The International Conference on Strongly Correlated Electron Systems (SCES'95) (September 27-30, 1995) was held at a beautiful beach hotel, the Goa Renaissance Resort, located on the Arabian Sea about 30 km (18 miles) from the Goa airport. Goa is about 500 km (300 miles) south of Bombay. The main themes of SCES'95 were: heavy Fermion superconductivity; borocarbides; superconductivity/Kondo effect/magnetism-interplay; Kondo effect and Kondo insulators; heavy Fermion compounds-magnetic ordering; non-Fermi-liquid behavior/multichannel Kondo effect; new features in f-electron systems; Hubbard model and hopping transport; high T_c superconductors; photoemission and absorption; and correlations in transition metal systems. The conference started out with an overview by the father of heavy electron systems, Frank Steglich, Technische Hochshule, Darmstadt, Germany. Each oral session had several invited speakers plus contributed papers. There were three such sessions plus a poster session every day, except Saturday morning, which consisted of one oral session and two conference summaries. The first conference summary on experimental aspects was given by J. T. Thompson (Los Alamos National Laboratory, New Mexico, USA), and the second one, on theory, was presented by G. Baskaran (Institute of Mathematical Sciences, Madras, India). In addition to the plenary lecture and the two conference summaries, there were 33 invited lectures, 27 oral presentations and about 175 poster presentations.

The more exciting areas of interest and papers (to the editor) were concerned with: (1) Non-fermi liquid behavior in $CeCu_{6-x}Au_x$, $U_{1-x}Th_xPd_2Al_3$, $M_{1-x}U_xPd_3$ (M = Sc or Y), $U_{1-x}Th_xBe_{13}$ and $UCu_{5-x}Pd_x$. The behaviors of these materials were discussed

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21st RERC

The 21st Rare Earth Research Conference (RERC) will be held July 7-12, 1996 at the Duluth Entertainment and Convention Center in Duluth, Minnesota, and will be hosted by the University of Minnesota. The Program Chair for the meeting is Dr. Lynda Soderholm of Argonne National Laboratory and the General Chair is Prof. Larry Thompson of the University of Minnesota.

For more information, contact Prof. Larry C. Thompson, Department of Chemistry, University of Minnesota, Duluth, MN 55812 USA; Tel:218 726 8716; E-mail:"lthompso @d.umn.edu". ▲

RERC '93 Proceedings

The Twentieth Rare Earth Research Conference was held September 12-17, 1993 in Monterey, California, USA. The conference was attended by almost 200 scientists, with a majority coming from outside the United States.

The Proceedings contain the presentations of eight oral symposia and seven poster sessions. Oral symposia deal with the most recent research directions, innovative concepts, and contemporary applications in rare earth and actinide research. Topics included advances in lanthanides in biochemistry and medical diagnostics; optical spectroscopic probes of electronic excited-state structure dynamics in lanthanide systems; characterization of rare earth energy-level structures in optically opaque materials; molecular lanthanide chemistry in the development of new materials and reaction catalysts; recent developments in the characterization, understanding and applications of magnetic and superconducting properties in rare earth-based materials; synthesis and properties of light metal glasses which utilize the rare earths; industrial applications of rare earths; emerging technologies; and comparative aspects of lanthanide and actinide behavior including solid state and coordination chemistry of these compounds.

The papers that appear in the Proceedings are grouped into the same areas as the conference symposia. Invited papers are followed by contributed papers. Subject and author indices are included. The 496-page soft-bound book *Rare Earths 1993* was published as *J. Alloys and Compds.*, Vol. 207/208 in 1994 and was edited by L.R. Morss,

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RERC '93 Proceedings/*Continued* ⇨

L.E. DeLong, M.F. Reid, and H.B. Silber. The cost of the Proceedings is $299.00 US and can be ordered from Elsevier Science S.A., P.O. Box 564, 1001 Lausanne, Switzerland; Tel: 41 21 320 73 81; Fax: 41 21 323 54 44. Customers in the United States and Canada may order from: Elsevier Science Inc., 655 Avenue of the Americas, New York, NY 10010 USA; Tel: 212 633 3750; Fax: 212 633 3764. ▲

Conference Calendar

*** A NEWS STORY THIS ISSUE**

April '96

1996 MRS Spring Meeting, Symposium D: Rare Earth Doped Semiconductors
San Francisco, California, USA
April 8-12, 1996
*This issue

MORIS '96
Noordwijkerhout, The Netherlands
April 29 - May 2, 1996
RIC News XXX, [3] 2 (1995)

July '96

Twenty First Rare Earth Research Conference (21st RERC)
Duluth, Minnesota, USA
July 7-12, 1996
RIC News, XXX, [2] 1 (1995)

September '96

Fourteenth International Workshop on Rare-Earth Magnets and Their Applications and Ninth International Symposium on Magnetic Anisotropy and Coercivity in Rare-Earth Transition Metal Alloys
São Paulo, SP, Brazil
September 1-5, 1996
RIC News, XXX, [1] 2 (1995)

International Conference on Substrate Crystals and HTSC Thin Films (ICSC-F '96)
Szczyrk, Poland
September 16-20, 1996
RIC News XXX, [3] 2 (1995)

October '96

Solidification and Powder Processing of Rare Earth-Based Materials
Cincinnati, OH, USA
October 6-10, 1996
RIC News XXX, [3] 2 (1995)

RE-Doped Semiconductors Symposium

Rare earth-doped semiconductors hold great potential for a variety of opto-electronic applications, including lasers, light-emitting diodes and optical amplifiers. The field has been growing rapidly in the past few years as commercial interest in the field increases. Symposium D: Rare Earth Doped Semiconductors will be a part of the 1996 Spring Meeting of the Materials Research Society. The Spring Meeting will be held April 8-12, 1996, in San Francisco, California, USA with Symposium D scheduled to last three days.

Symposium D will bring together scientists that have conducted research on: rare earth-doped semiconductors group VI, III-V, II-VI; structural aspects, chemical vapor deposition, ion implantation, rare earth precursors, co-doping and novel growth techniques; electrical properties in relation to optical properties; excitation and de-excitation mechanisms; theoretical calculations of electronic properties; electroluminescent devices such as light emitting diodes, lasers and optical amplifiers; and opto-electronic integration and novel device concepts.

For more information, contact Symposium D organizer Albert Polman, FOM-Institute AMOLF, Kruislaan 407, NL-1098 SJ Amsterdam, The Netherlands; Tel: 31 20 608 1234; Fax: 31 20 668 4106; E-mail: polman@amolf.nl. In the USA contact: Robert N. Schwartz, Hughes Research Laboratories, 3011 Malibu Canyon Road, Malibu, CA 90265; Tel: 310 317 5595; Fax: 310 317 5679; E-mail: rschwartz@msmail4.hac.com. ▲

LETTERS TO THE EDITOR

The following is excerpted from a letter we received in response to our "filler" which appeared on page 5 of the March 1, 1995 issue of the RIC News - "Solar neutrinos can be detected by using the radioactive isotope Dysprosium-163."

An article by C.L. Bennett "^{163}Dy as a Solar Neutrino Detector", which appeared on pages 212-215 in the book *Solar Neutrinos and Neutrinos Astronomy*, M.L. Cherry, K. Lande and W.A. Fowler, eds., AIP Conference Proceedings Number 126, American Institute of Physics, New York, 1985, explains the huge stumbling block that has prevented the application of the reaction dysprosium 163 with neutrinos to the detection of solar neutrinos. The cross section of the reaction of neutrinos with dysprosium 163 is so minute that in order for Dy_2O_3 to be used as a detector, 17 tons would be required to obtain one atom of holmium per day (neutrinos transform dysprosium 163 into holmium 163).

Current experiments detect solar neutrinos by using chlorine 37 or gallium 71, the atoms of argon 37 or germanium 71 result from the reaction of solar neutrinos and parent materials. Chlorine and gallium are stored in liquid form (CCl_4 and $GaCl_3$, respectively), and in both cases, the few nuclei produced by the nuclear reaction may be flushed with a flow of carrier gas.

However, since homologous compounds of dysprosium and holmium exhibit very similar chemical properties, the extraction of a few atoms of holmium from tons of a dysprosium compound poses a formidable challenge, which still has to be taken up. Another problem would have to be addressed; namely how to discriminate between holmium 163 atoms created by neutrinos and those created by protons.

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in separate papers by F. G. Aliev, L. Degiorgi, M. B. Maple and H. von Löhneysen; (2) The interplay of magnetism and superconductivity in the rare earth borocarbides was discussed in several of papers, both oral and posters. An overview by L. C. Gupta brought the audience up to speed on this subject, while new information was given in individual presentations by C. V. Tomy, J. W. Lynn and S. F. J. Cox. In particular, the report of a superconducting transition temperature of about 6.5K in $DyNi_2B_2C$ was of interest because, heretofore, others had *not* been able to detect the superconducting state. Now the Dy compound's behavior is consistent with that of the other lanthanides; and (3) Kondo insulators, which according to M. B. Maple might be better called hybridization gap semiconductors, were reviewed by T. Kasuya from the theory side, and by Z. Fisk from the experimentalist's viewpoint. The presentation by T. Takabatake brought out the point that high quality samples are essential in understanding these materials. His results showed that a clean CeNiSn sample is a semi-metal (exhibiting metallic conduction) while impurer ones are semi-conductors (i.e. Kondo insulators). This is the first case we are aware of, where *an increase in purity changes a semiconductor to a metallic conductor* — usually it is the other way. The influence of purity on these anomalous *f*-materials was evident in other talks; as noted above for the $DyNi_2B_2C$, and also the paper by J. L. Smith on SmB_6. The importance of purity in these materials goes back to the earliest days of the subject starting with the allotropes of pure Ce metal, which took ~25 years from the time of discovery to the day that allotropically pure α-Ce and β-Ce were finally prepared in the early 1970's; the TmX (X = S, Se and Te) problem in the 1960's and 70's; and more recently the influence of the Cu stoichiometry on the superconductivity, or its absence, in $CeCu_{2-x}Si_2$. This was so well put in J. D. Thompson's concluding summary: "we need to make the best measurements possible on the best possible materials if meaningful progress is to be made, and the theorist needs to present his theory in meaningful units so the theory can be compared to experiment".

The Conference proceedings will be published in *Physica B*, and its availability will be

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Permanent Magnet Short Course Available on Videocassette

The Metal Powder Industries Foundation (MPIF) sponsored the P/M Magnetic Materials & Applications Short Course on June 27-28, 1995, in Philadelphia, Pennsylvania, USA. The course was recorded on videotape and these tapes are now available. The course is available in eight VHS (NTSC North American and PAL) standard cassettes. The eight volumes include presentations with the following titles: Nomenclature, D.C. Theory; Testing Magnetic Materials; P/M Materials for Today's Soft Magnetic Applications; High Temperature Sintering: Its Importance in Manufacture of P/M Structure Sensitive Parts; How to Engineer P/M Parts of Magnetic Devices; The Present and Future Trends for Quality P/M Magnetic Parts; The Emerging of the MIM Process in Design of Newer Magnetic Parts; Parts Fabrication of Iron and Phosphorous Iron Alloys; The Emerging Market for P/M Ferritic Stainless Steels Requiring Corrosion Resistance for P/M Magnetic Parts; Permanent Magnet Materials and Their Impact on Today's Magnetic Devices; Applications for P/M Parts Within the Automotive Industry for Now to the Year 2000; and The Future of P/M Materials.

The complete videotape record of the 1995 P/M Magnetic Materials & Applications Short Course is available for $900.00 US plus $15.00 US for shipping and handling. The 8 VHS cassettes come with a complete set of handouts. For more information or to order your Short Course video tapes, contact: Metal Powder Industries Federation, 105 College Road East, Princeton, NJ 08540-6692 USA; Tel: 609 452 7700; Fax: 609 987 8523. ▲

***Correlated Electrons in India**/Continued* ➪

announced in the *RIC News* as soon as it is published. The Indian organizers and hosts were most gracious – we had a wonderful time. Many thanks.

After the conference, Melba and I, and Jim and Carol Smith (from Los Alamos, New Mexico), spent six incredible days touring the golden triangle in Central Northern India (Jaipur, Agra and Dehli). Needless to say (at least to the editor), the Taj Mahal (Agra) is more beautiful when seen in person, than it is in all the photographs ever taken of it. ▲

Electroluminescence in Rare Earth Phosphors

Since the first powder electroluminescent phosphor was produced in 1936, there have been many developments and uses of phosphors for a multitude of industrial, commercial and consumer applications. Currently, there is a large portion of the worldwide rare earth market that is related to phosphors and electroluminescent materials, which generates considerable interest in this field.

The electroluminescence of rare earth doped materials are reviewed in a paper by M. Godlewski and M. Leskelä entitled "Excitation and Recombination Processes During Electroluminescence of Rare Earth-Activated Materials". The review appeared in *Crit. Rev. Solid State Mater. Sci.*, 19, [4], 199-239 (1994) and places emphasis on the basic physics of electroluminescence processes by the direct and indirect excitation of nonradiative and radiative recombination of rare earth ions. The structures of various electroluminescent structures are reviewed as well.

Although the basic physics of high-field electroluminescence is not very well known, the physical processes that are responsible for generating electroluminescence in a device are: 1) generation of charge carriers, 2) acceleration of charge carriers in the electric field, 3) excitation of the activator ions by various mechanisms, 4) relaxation of the excited state toward the ground state, and 5) outcoupling of the emitted light from the device. A common configuration for electroluminescent thin films is the layering of materials to form a miniature "sandwich" to make a metal-insulator-semiconductor-insulator-metal structure. This sandwich is then deposited on a glass substrate. Although there are many phenomena occurring in these structures, such as electric fields in semiconductors, tunnel emission, avalanche, etc., the authors in this review have concentrated on excitation and relaxation processes.

The paper describes the general properties of rare earth ions, selection rules for rare earth excitation and recombination, phosphor materials used in electroluminescence, emission spectra of blue phosphors, heating and impact excitation mechanisms and processes, lumocens (complex centers that are essential for impact excitation in electroluminescent structures), ionization processes and transitions, carrier trapping and bind-

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Electroluminescent Phosphors/Continued ⇨

ing, and photoluminescence excitation mechanisms. Nonradiative recombination processes such as one-center Auger recombination and thermal and electric field-induced deactivation are covered as well.

The paper includes two tables which contain information on the electronic configuration of the ground state of the lanthanides as well as the emission, luminance, lumi-

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Electroluminescent Phosphors/Continued ⇨

nous efficiency, and color coordinates of rare earth thin film electroluminescent phosphors. Twenty-three figures illustrate various properties, structures, and processes of electroluminescence that the authors thoughtfully included in the review. The paper includes 167 references. ▲

Consortium for Advanced Magnets

In an attempt to revitalize and support the United States permanent magnet research and development activities, a new consortium based on university, national laboratory, and industrial collaboration has been formed. The Consortium for Advanced Magnets (CAM) will have an active involvement of several industrial institutions. The role of the industry groups will be threefold: to help define the research agenda by identifying problems of importance to industry; to use the research findings to prepare final products of commercial value; and to assist end-users to develop new applications. CAM will endeavor to transfer the knowledge and techniques by facilitating collaboration between scientists and engineers.

The objectives of CAM include: drawing roadmaps to the year 2000 and beyond for materials, technologies, and products that will lead to improving the magnetic properties of existing magnets and to discovering better and less expensive magnets; establish guidelines to assist funding efforts by Consortium members and seek funds, through joint proposals, to support collaboration and visits to participating institutions; promote educational and employment opportunities for members, and prepare a new generation of researchers and engineers in permanent magnets; provide early access to scientific and technological advances in permanent magnets and to distribute information regarding facilities, expertise, and needs among participating institutions; and to sponsor think-tank sessions and annual workshops to review the latest progress in permanent magnets and discuss future directions.

For more information, contact George C. Hadjipanayis, Department of Physics and Astronomy, University of Delaware, Newark, DE 19716-2570 USA; Tel: 302 831 2736; Fax: 302 831 1637; E-mail: hadji@udel.edu. ▲

Permanent Magnets 1995 Update

Did you know that...

- China has become the #2 producer and user of Alnico, ferrite, and Nd-B-Fe permanent magnet materials in the world?
- Global permanent magnet sales have grown historically at an average 10% per year, in 1994 they grew at a rate of 12.6% with sales exceeding $3.2 billion US?
- Permanent magnet sales are projected to be $10 billion US by 2005?
- The global "Information Highway" is creating exceptional new demand for rare earth permanent magnets?
- Anisotropic Bonded Rare Earth magnets, introduced in 1994, will accelerate the market expansion as major new applications emerge in the appliance and automotive fields?

If you answered "no" to any of the above, then the latest report that reviews the worldwide permanent magnet industry *Permanent Magnets-1995 Update* will interest you. The report is the seventh publication in the past 26 years of international permanent magnet studies prepared by Wheeler Associates.

The report contains information on the following topics: industry structure such as leaders, mergers, joint ventures and technical alliances; permanent magnet technologies; raw materials; markets and applications; activity in developing countries; and the current status of Nd-B-Fe permanent magnet manufacturing. The report also predicts the market through 2005, and production value by producer, geographic area, by magnet type and by market. Whether your company is relatively new to the arena of permanent magnets, including rare earth types, or a well-established producer of these materials, this report will be a guiding force that will assist you in making correct decisions in this field for years to come.

The 478-page *Permanent Magnets-1995 Update* is available by contacting Wheeler Associates, Permanent Magnet Consultants, P.O. Box 825, Elizabethtown, KY 42701 USA; Tel: 502 765 6773; Fax: 502 765 2137. ▲

Recent Developments

The utility, application and influence that rare earths have on various materials continues to be explored. Three recent developments in materials science illustrate the important contributions that rare earths have made in making materials better, stronger, and more durable. Researchers in Japan have developed a steel that has the highest Young's modulus on record, the strongest magnesium alloy, and better electron and plasma guns {*Japan New Mater. Rep.*, IX, [6] 1-10 (1994)}.

Steel with Highest Young's Modulus

Researchers at Sumitomo Metal Industries, Ltd., Osaka, announced that they have developed a steel material that features a Young's modulus of 29,000 kgf mm^{-1}. This is close to the theoretical limit for steel and represents a 35 to 40% increase in the previous maximum for steel which was 21,000 kgf mm^{-1}. This new material was produced while conducting research on distributed alloys produced through a mechanical alloying process. The procedure utilizes an advanced powder metallurgy process and a steel process.

The production process has three major steps: 1) mechanical alloying fine dispersed Y_2O_3 particles in a ferrite alloy; 2) formation and processing of an alloy powder using a heat extrusion process; and 3) recrystallization heat processing that allows the alloy to attain a 111 crystal orientation. The Young's modulus of the steel is determined by the crystal structure and crystal orientation. The composition of the steel is 13-16% chromium, 1-3% aluminum, 0.5% Y_2O_3 (yttria), and the remainder iron.

This increased Young's modulus reduces elastic deformation, making it possible to reduce the width of machine parts and to reduce vibration. Possible applications include the automobile industry where a 10% decrease in weight may be realized, in industrial robotics, and the leisure sports industry.

Strong Magnesium Alloy

A consortium between a mining company and a research institute has produced a magnesium alloy that has high tensile strength at high temperatures. Mitsui Mining Company, Ltd., Tokyo, and Nagaoka University of Technology and Science have developed a magnesium alloy that not only can be heat forged, but has a tensile strength of 298 KPa at 250°C.

It has been difficult to produce magne-

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Recent Developments/Continued ⇨

sium alloys that are strong at high temperatures, yet are easy to shape. One version of the alloy contains 10% gadolinium and 3% neodymium, and another alloy contains 10% dysprosium and 3% neodymium. The alloy is produced in a vacuum furnace with high frequency heating and an argon gas atmosphere. Zirconium is added to reduce grain size to 30 to 50μm but also increases toughness.

Tough Cathodes

Vacuum deposition is widely used to improve the surfaces of metals, non-metals, optical lenses, and a host of other materials and products. One method is to use electron guns which discharge electrons to heat the cathode. In the past, some of these cathodes have been made of high melting point metals such as tungsten, but life expectancy of the cathode was less than 100 operating hours.

Ishikawa Harima Heavy Industries Company, Ltd., Tokyo, has developed a new electron gun and a new plasma gun which both feature a three-fold increase in life expectancy. The new gun uses a ceramic cathode composed of lanthanum tetraborate which allows a large electrical discharge at low temperatures. The lanthanum borate cathode has an operating lifetime of up to 300 hours of continuous operation. This new development will make it commercially feasible to use electron guns for film formation on optical lenses. ▲

Chalcogenide Optical Materials

In recent years, there has been increasing interest in infrared (IR) materials for use in surveillance equipment. In order for this equipment to function effectively, optical materials that operate efficiently in the infrared region must be employed. Sulphide compounds are well known for their optical and electronic properties which allow them to transmit in the IR region and to be useful semiconductors. Recently, crystalline and amorphous rare earth sulphides have emerged as a class of materials that show promise for use as IR detectors and semiconductors in electronic circuits because of their unique optical and electronic properties.

P.N. Kumta and S.H. Risbud provide a general background on the research and science of this field in their review paper

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Optical Materials/Continued ⇨

"Rare-Earth Chalcogenides-an Emerging Class of Optical Materials" {*J. Mater. Sci.*, 29, 1135-58 (1994)}. The review covers the status of these amorphous and polycrystalline rare earth-sulfide materials, the techniques to process these materials, and their structural, thermal, mechanical and optical properties. Conventional and emergent chemical processing techniques that are used in synthesizing rare earth sulphides are reviewed in detail.

Since most chalcogenides form glasses rather easily, they are prime candidates for use as optical materials. However, rare earth sulphides are refractory solids and the cubic forms of these compounds exhibit long-wavelength transmissions. They are thermally stable with high melting points and are mechanically strong with moderate coefficients of expansion. The rare earth sulphides are not glass formers, but form stable glasses when mixed with other chalcogenide glass-forming sulphides such as gallium sulphide, germanium sulphide, and arsenic sulphide.

The authors cover some of the rare earth oxide and oxysulphide systems, including the glass-forming domain of the La_2O_2S-Ga_2S_3 pseudo-binary system, and the optical and thermal properties of various rare earth glasses. Other potential infrared window materials and their properties are included as well. A table listing the properties and preparation techniques of rare earth and non-rare earth IR window and dome materials, along with a timetable of predicted commercial application lends credence to the research being conducted in this area.

The authors illustrate that the use of metallorganic precursors and the modification of their chemistry to tailor the composition of the final ceramic sulphide is an important consideration in forming these materials. The potential of these chemical techniques and their advantages over conventional solid state techniques that are used for processing sulphide ceramics is also discussed, particularly in light of their successful applications in processing novel electronic and optical oxide ceramics.

To keep up-to-date on the recent developments in this field, or for general information of rare earth chalcogenides as optical materials, this paper is recommended reading. The paper contains 13 tables, 31 figures, and 153 references. ▲

N.I.S.T. High T_c Database

The National Institute of Standards and Technology (N.I.S.T.) has established a database that contains property data for oxide superconductors, including those derived from Y-Ba-Cu-O. The database, referred to as NIST Standard Reference Database 62, provides the user with material properties such as superconducting characteristics (T_c, j_c, H_{c2}, etc.), thermal properties (conductivity, expansion, specific heat), mechanical properties (elasticity, strength, toughness), and crystallography (cell parameters, atomic coordinates), methods, procedures, and conditions of oxide superconductors. Data has been collected from published sources from 1987-1993 and has been evaluated in terms of materials characterization and how experimental conditions have been controlled. In all cases, the sources of the data are fully documented in a comprehensive bibliography.

The computer hardware requirements include: MS-DOS 5.0 or higher; 386, 486 or Pentium®; 7.5 MB disk space; 4MB RAM; and Windows™ 3.1 or higher. The cost to receive the database is $265.00 US but the per-copy price decreases for multiple-copy purchases. For more information contact: Standard Reference Data Program, NIST, 221/A320, Gaithersburg, MD 20899-0001 USA; Tel: 301 975 2208; Fax: 301 926 0416; E-mail:srdata@enh.nist.gov; HTTP://www.srd.nist.gov:8231. ▲

Neomet Dedicates New Plant

Neomet Corporation, a subsidiary of Mitsubishi Materials Corporation, Tokyo, Japan, recently opened their new rare earth permanent magnet alloy plant in Edinburg, Pennsylvania. The plant will produce anisotropic magnetic powder using the hydrogenation-decomposition-desorption-recombination (HDDR) method. Neomet was granted authority to produce HDDR powder through an agreement between Mitsubishi Materials Corporation, Sumitomo Special Metals Co., and Magnequench. The development of the HDDR process and commercialization of anisotropic resin-bonded magnet materials is expected to expand the rare earth permanent magnet market. ▲

U.S. H-Storage Alloy Factory

Japan Metals and Chemicals Company, Ltd. (JMC), recently announced plans to build a factory in the U.S. for producing hydrogen storage alloys {*Japan New Mater. Rept.*, **10** [3] (1995)}. The new facility will be operated by JMC (USA) Inc., which is a wholly owned subsidiary that was established in 1993. The plant is to be located on a 15 to 20 acre site in Durham County, North Carolina. Construction should be completed in early 1997.

Rare earth and mischmetal-hydrogen storage alloys, also known as metal hydrides, have experienced rapid growth during the past few years. By far, the largest application of the nickel-based metal hydrides are rechargeable batteries that find uses in portable electronic products. In 1994 Japan produced about 200 million batteries that used the hydrogen storage alloy. The total use of hydride alloys in the same year was about 2000 mt.

The company will invest about $17 million US in the plant, and is expecting sales of about $35.3 million US per year when the plant opens. Japan Metals and Chemicals Company, Ltd. expects that the plant will initially produce 1000 mt of hydrogen storage alloy per year. ▲

Rare Earth Minerals

A mineral sand deposit that is unconcentrated and that has been screened through #30 mesh is available. The mineral contains 20 oz/ton cerium, 12 oz/ton neodymium, and about 9 oz/ton lanthanum, as well as other rare earths in lesser quantities. For more information, contact Edward Behymer, Rt. 1, Stockport, OH 43787-9801 USA; Tel:614 559 2476. ▲

ISO-9002

Shin-Etsu Chemical Co., Ltd., Takefu Plant, Takefu City, Japan, has been awarded the ISO-9002 certificate of the international standard of quality assurance. In March, 1995, the company was screened by the "Japan Quality Assurance Organization" and granted the accreditation. The company was found to be in compliance with the wide range of demands of a quality assurance system where the supplier manufactures and installs their products. ▲

Arris International Corporation

Arris International Corp. of West Bloomfield, MI is offering an extensive selection of high purity rare earth metals, materials, and alloys. Additional metals such as niobium, tantalum and other items are also available. A complete chemical analysis of each material can be provided, or samples for independent analysis can be obtained from the company. Arris can fill orders for small quantities as well as for large tonnages. For more information, contact the company at: Tel: 810 851 0004; Fax: 810 851 8294; E-mail: arris1@aol.com. ▲

RE Metals and Oxides Available

Charlotte Square Capital Ventures announces the availability of rare earth metals and rare earth oxides. For a complete listing of rare earth metals and compounds for sale, contact the company at the following address: 1300 Bristol Street North, Suite 200, Newport Beach, CA 92660 USA; Tel: 714 252 0400; Fax: 714 252 1405. ▲

New Position

Mr. Dudley J. Kingsnorth, formerly with Ashton Mining Limited, Western Australia, has resigned and accepted a new position as Chief Executive Officer of the Materials Institute of Western Australia, 133 Salvado Road, Wembley, WA 6014, Australia. He is retained as a consultant to Ashton Mining Limited. ▲

Liuzhou Foreign Goodwill Service

The International Technology and Development Department of Liuzhou Foreign Goodwill Service is offering scandium metal and scandium oxide powder to industrial users. For more information, contact Hong Ke Chang, Senior Engineer, Liuzhou Foreign Goodwill Service, International Technology Development Department, 10/F Wenhui Palace, 80, Wenhui Road, Liuzhou City, Guangxi 545001, China; Tel/Fax: 772 282 6104. ▲

Harley A. Wilhelm (1900-1995)

Harley A. Wilhelm, 95, died October 7, 1995, in Story City, Iowa from a heart attack. Dr. Wilhelm is best known for his outstanding contributions in devising a process to prepare inexpensive uranium metal that was used in the Manhattan Project during the 1940's, including the first atomic pile which had been constructed under the stands of the University of Chicago's football stadium. He was known to rare earthers from his work on spectrographic analyses of rare earth elements, the production of rare earth metals, and the separation of rare earths by liquid-liquid extraction.

After accepting a graduate assistantship at Iowa State College, now Iowa State University, at Ames, Iowa in 1927, he went on to earn his Doctorate in Physical Chemistry in 1931. He developed new courses in the curriculum at the university in the 1930's and in 1942 set up the small group which developed a large-scale process to prepare uranium that was used to make atomic bombs and nuclear power reactors. Prof. Wilhelm went on to become Associate Director of Ames Laboratory and worked full time until 1966, then part time until his retirement in 1971. However, he continued to work in the laboratory until just a few years ago. ▲

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$d_{x^2-y^2}$ Pairing in Cuprate Superconductors

Since Bednorz and Muller's paper was published on the discovery of the high T_c superconducting Ba-La-Cu-O system, the transition temperature of superconducting materials has increased to 134 K. In that time, there have been many studies on the properties of these materials and many differing views to explain the "why" of both the normal and superconducting states as well as the origin of the pairing mechanism. The nature of the orbital pairs in the superconducting phase of the high-T_c superconducting cuprates remains one of the central questions in this field.

In a recent review entitled "The Case for $d_{x^2-y^2}$ Pairing in the Cuprate Superconductors" by D.J. Scalapino {*Phys. Repts.*, **250** [6] 329-375 (1995)}, the author examines the possibility that the superconducting state of these materials is characterized by $d_{x^2-y^2}$ pairing. This is discussed in two questions about the possibility of $d_{x^2-y^2}$ pairing: (1) Why might it happen? and (2) How would we know? These questions are considered by first looking theoretically at why this type of pairing might be favored in a strongly correlated system with a short-range Coulomb interaction, then what the evidence would be if $d_{x^2-y^2}$ pairing were present.

The review is recommended for both students in high-T_c superconductors as well as those who have been interested in this field for some time. The paper includes 24 figures, 1 table, 42 equations and 170 references. A copy of the paper is available from Elsevier Science B.V., P.O. Box 211, 1000 AE Amsterdam, The Netherlands; Tel: 31204853653; Fax: 31204853432. Cost is $34.00 US. ▲

Workshop and Symposium on Permanent Magnets

The Rare-earth Information Center still has a limited supply of the proceedings of both the *Twelfth International Workshop on Rare Earth Magnets and Their Applications*, and the *Seventh International Symposium on Magnetic Anisotropy and Coercivity in Rare Earth Transition Metal Alloys*.

The cost of the two-volume set is $150.00 US, or $75.00 US for either volume alone For ordering information check page 7 of the September 1, 1993 issue of the *RIC News*, or contact the Rare-earth Information

Continued in next column ⇨

CeO_2 Insulator

With the development of the ultralarge-scale integration (ULSI) of electronic circuitry, the utilization of a suitable thin-film material for miniaturized capacitors is required. The capacitor must have appropriate dielectric properties while operating at low voltages to be useful for this application. Previously, SiO_2 was used for this purpose, but it is expected that this material will no longer satisfy the basic requirements of ULSI technology in the future. Other high-dielectric-constant thin film insulating materials such as Ta_2O_5 can be used in ULSI's, but preparation of the polycrystalline film has been problematic. The recent application of CeO_2 as a thin-film insulating material has been explored and the electrical characteristics of the material reported by T. Nakazawa *et al.* in *Jpn. J. Appl. Phys.*, 34, [2A], Part 1, 548-53 (1995).

Cerium dioxide is one of the most attractive insulating materials because it is chemically stable and it exhibits a high dielectric constant ($\in_r$=26). It can be deposited onto silicon by electron-beam evaporation to form a high-quality film, and so is expected to be used in silicon-on-insulator structures, stable capacitors for ULSI and buffer layers of superconducting materials.

The deposition of CeO_2 was conducted after the Si substrate was etched in a solution of HCl, H_2O_2, HF and H_2O. The CeO_2/Si layers were then topped with a gold film, forming a Au/CeO_2/Si structure. The composite was then tested for electrical characteristics by utilizing capacitance-voltage and conductance-voltage methods. The dielectric constant of the structure was determined to be around 20 from the accumulation capacitance at 1 MHz and the film thickness, which is close to the bulk value of 26. These results were obtained regardless of the orientation and conduction type of the Si substrate. It is further reported that the CeO_2 film samples were free from the undesirable properties caused by the negative charge and carrier injection, such as flat-band voltage shift and hysteresis of the conduction-voltage curve. The authors believe that CeO_2 can be used as high-quality and highly stable insulating thin films. ▲

Workshop/Continued ⇨

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Lanthanide Macrocyclic Ligands and Complexes

Coordination chemistry of macrocyclic ligands is a fascinating area of current research interest to organic chemists around the world. The interest in designing new macrocyclic ligands lies in their applications as models for protein-metal binding sites in a substantial array of metalloproteins in biological systems; as synthetic ionophores; as models to study magnetic exchange phenomenon and as therapeutic reagents in chelate therapy for the treatment of metal intoxication; as cyclic antibiotics that owe their antibiotic action to specific metal complexation; to study guest-host interactions; and in catalysis. Therefore, much research in new synthetic routes in preparing these compounds is being conducted. A review by V. Alexander entitled "Design and Synthesis of Macrocyclic Ligands and Their Complexes of Lanthanides and Actinides" appeared in *Chem. Rev.*, **95** [2], 273-342 (1995) and addresses this issue.

Among the 22 sections in the paper are topics which explain the design of macrocyclic ligands by coordination template effect; the anion template effect in the synthesis of macrocycles; template potential of lanthanides; dinuclear and trinuclear macrocyclic complexes of lanthanides; thermal stability of lanthanide macrocyclic compounds; structural features of lanthanide complexes of higher coordination numbers; use of lanthanide macrocyclic complexes in radioimmunotherapy; lanthanide extraction using ionizable macrocyclic ligands; lanthanide complexes as nuclear magnetic resonance (NMR) shift reagents; and luminescence quenching of lanthanide ions in macrocyclic complexes.

"Design and Synthesis of Macrocyclic Ligands and Their Complexes of Lanthanides and Actinides" is one of the most comprehensive reviews that we have seen on this subject. The author did not hesitate to include as much information as was available to back up his claims, and the paper contains 506 references as a result. A glossary explains the meaning of the acronyms and abbreviations used in this discipline - an essential addition for a review of this type. The paper also includes 42 figures, 160 chemical structures, 10 tables, 8 schemes, and 17 chemical equations. ▲

Supporters 1996

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Since the September issue of the RIC News went to press, RIC has received support from 10 new family members, and renewed support from 30 other organizations and individuals. The supporters from the second quarter of fiscal year 1996 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 parenthesis, are listed below.

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