Rare-earth Information Center NEWS

Center for Rare Earths and Magnetics
Ames Laboratory
Institute for Physical Research and Technology
Iowa State University, Ames, Iowa 50011-3020 U.S.A.

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Doped Optical Fibers

The rapid growth of the internet and land-based telecommunications depends to a large extent on achieving higher bandwidth for the transmission of data at minimum cost. This, in turn, requires the use of optical fibers, which can transmit light signals with very little signal loss due to absorption, reflection, and impurity effects. *Properties, Processing and Applications of Glass and Rare Earth-Doped Glasses for Optical Fibres* details the essential, up-to-date knowledge on the properties of silica, oxide, halide and chalcogenide glasses together with their use in fabricating state-of-the-art optical fiber devices. The book is made up of 65 contributions from 56 researchers from Brazil, Europe, Japan, Korea and North America.

The contents are presented in a highly structured format in four parts (silica, oxide glass, halide glass, and chalcogenide glass), each containing five sections on the optical properties, thermal and mechanical properties, rare-earth spectroscopy, optical fiber manufacture, and applications of rare earth-doped glasses. Erbium-doped glasses have received most of the attention recently because the Er^{3+} ion improves transmission in these materials. Of the papers included on Er-doped optical fibers and glasses, various important properties are presented, including optical absorption of oxide glass, compositional dependence in borate glass, the isomer shift in fluoride glass, and fluorescence of Er-doped oxide glass materials.

The sections on the preparation and production methods of high-quality rare earth-doped glass, such as melting and drawing, should be interesting to those involved in the commercial production of optical fibers. The finished product should also represent claims of consistency and performance, and an important review of quality assessment is not omitted.

Glass and Rare Earth-Doped Glasses for Optical Fibres is edited by D. Hewak and its 376-pages were published in 1998. In the Americas, the book can be ordered for US$195.00 from Institution of Electrical Engineers, c/o Whitehurst & Clark, 100 Newfield Ave., Edison, NJ 08837 USA; Tel: 888 438 2517; Fax: 732 225 1562; wcbooksiee@aol.com; elsewhere, P.O. Box 96, Stevenage, Herts SG1 2SD, UK; Tel: 44 1438 313311; Fax: 44 1438 742792; sales@iee.org.uk. ▲

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Search of the Month

The sample search below satisfies a request for information on rare earths perovskite compounds that exhibit magnetoresistivity.

RIC searches utilize the Boolean operand system with "+" = (or), "*" = (and), and "*^" = (and not). Many more citations would have been referenced had we included specific compound/alloys.

RARE-EARTH INFORMATION CENTER LITERATURE SEARCH REPORT
Magnetoresistivity in REE Perovskites Since 1998

MAGNETORESIST * PEROVSKITE * (1998 + 1999)

TERM	KEYWORDS INDEXED	NUMBER IN REQUESTS
MAGNETORESIST	843	46
PEROVSKITE	1029	46
1998	3162	36
1999	1053	10
***************	46 DOCUMENTS HAVE SATISFIED THIS REQUEST**	

The above Literature Search Report shows the key words used in the search, the number of times each appears in the data base, and that 46 documents that contain information on magnetoresistivity in rare earth perovskites since 1998 were referenced in the search. More papers can be referenced by requesting specific compounds.

The cost to receive the Literature Search List from this search, which is a complete listing of all 46 referenced documents, is available for US$95.00. Supporters can receive as many searches as needed for US$300.00 per year (corporate) or US$100.00 (individual).

As an added benefit, supporters receive the 2-page monthly newsletter *RIC Insight* that reports on late-breaking news of rare earths and how these developments may impact the rare earth industry.

If you would like us to conduct a search for you, please send your request to: Joel Calhoun, RIC, 112 Wilhelm Hall, Ames Laboratory, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515 294 5405; Fax: 515 294 3709; ric@ameslab.gov. ▲

Conference Calendar

* A NEWS STORY THIS ISSUE

Note: Reach as many potential conference attendees as possible! us your conference announcement and we will publish it here. ▲

January '00
Rare-Earth-Doped Materials and Devices IV
San Jose, California, USA
January 22-28, 2000
RIC News **XXXIV**, [3] 2 (1999)

March '00
Rare Earths and Actinides: Science, Technology, and Applications IV
Nashville, Tennessee, USA
March 12-16, 2000
RIC News **XXXIV**, [2] 2 (1999)

May '00
NATO ASI: Modern Trends in Magnetostriction Study and Application
Crimea, Ukraine
May, 2000
RIC News **XXXIV**, [3] 3 (1999)

June '00
NATO ASI: Magnetic Storage Systems BEYOND 2000
Rhodes, Greece
June 12-23, 2000
RIC News **XXXIV**, [3] 2 (1999)
*See "*Date Change*" Col. 1

September '00
The Third International Conference "Noble and Rare Metals" (NRM-2000)
Donetsk, Ukraine
September 19-22, 2000
RIC News **XXXIV**, [1] 3 (1999)

September '01
Rare Earths - 2001
São Paulo - SP, Brazil
September, 2001
RIC News **XXXIII**, [4] 3 (1998)

Date Change!

The NATO-ASI conference "Magnetic Storage Systems Beyond 2000", Rhodes, Greece, will now be held June 12-23, 2000. Contact Dr. Hadjipanayis, University of Delaware, Dept. of Physics and Astronomy, Newark, DE 19716 USA; Tel: 302 831 2736; Fax: 302 831 1637; hadji@udel.edu. ▲

High T_c Superconductors

Microstructural Studies of High Tc Superconductors and More on Quaternary Borocarbides is Volume **28** of Studies of High Temperature Superconductors (Advances in Research and Applications), series of reviews. Although the book deals primarily with the microstructural aspects of high temperature superconductivity, it contains two chapters on superconducting borocarbides.

Of the eight chapters that deal with superconductors, seven contain information on rare earth-based high-Tc compounds. The first two chapters report on the microstructure of melt-grown $REBa_2Cu_3O_{7-x}$ superconductors, and defects and microstructural engineering in melt textured RE-123 superconductors. Chapter 3 deals with the refinement of Y_2BaCuO_5 and distribution on microstructural inhomogeneities in melt-processed YBCO superconductors, followed by a review of the real domain structure originating in (110) Mechanic twinning in $YBa_2Cu_3O_{7-y}$ and microstructure studies in ramp type high T_c Josephson junctions. The final two overdue chapters contribute to literature on transport properties in RNi_2B_2C, and superconductivity and magnetism in quaternary borocarbides and boronitrides.

Microstructural Studies of High Temperature Superconductors (and more on Quaternary Borocarbides) is edited by A. Narlikar, National Physical Laboratory, New Delhi, India, and is published by Nova Science Publishers, Inc., 6080 Jericho Turnike, Suite 207, Commack, NY 11725 USA; Tel: 516 499 3103; Fax: 516 499 3146; Novascience@Earthlink.net; www.nexusworld.com/nova. The 290-page hardcover book was published in 1999 and is available for US$93.00. ▲

Colossal Magnetoresistance

Since 1993, there has been intense activity in the study of colossal magnetoresistance (CMR) in manganese oxides and related systems $(La_{1-x}A_x)MnO_3$ (Ln= rare-earth; A= divalent ion). This interest has been driven by the potential technological applications of these materials. Work in this area, and on these materials, has led to the discovery of many other new phenomena and properties such as charge-ordering and orbital ordering in perovskite manganese oxides. *Colossal Magnetoresistance, Charge Ordering and Related Properties of Manganese Oxides* contains eleven contributed articles that represent a cross-section of these topics, from review to current status.

Topics covered in the book include the role of crystal chemistry upon the

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CMR properties of manganites, magnetotransport, and magnetoelastic effects in manganese oxide perovskites. Research on low field magnetoresistance, including work on grain boundaries in doped manganese perovskites is reported. Other properties of manganese oxide perovskites such as: double-exchange, first-order insulator-metal transitions, striped charge and orbital ordering, electronic structure, and the spin-valve effect on CMR are covered. The final contribution deals with the theory of CMR.

Colossal Magnetoresistance, Charge Ordering and Related Properties of Manganese Oxides, a 345-page hardcover book, is available for US$64.00. It was edited by C.N.R. Rao and B. Raveau and was published in 1998 by World Scientific Publishing Co. Pte. Ltd., P.O. Box 128, Farrer Road, Singapore 912805. ▲

Scandium Deposit

Unexpectedly high grades of scandium have been discovered in drill cores from the Syerston prospect in New South Wales, Australia {*Australian Rare Earth Newsletter*, 3 Jan. 1999 [www.ozemail.com.au/~marcusr/aren/scandium.htm#syerston]}. Syerston is primarily a nickel/cobalt deposit that is located 70 km northwest of Parkes, west-central NSW. The deposit could contain 3,000 – 6,000 mt of scandium, which could be recovered as a byproduct of the nickel/cobalt operations should a mine be developed. According to the prospecting concern, Black Range Minerals NL, the economically-recoverable scandium resources could be the world's largest.

Black Range Minerals NL conducted the assays from ten exploratory drill holes at the site, which were taken over an area of 1 square km. Three assays included measurements of 136, 147, 371g of scandium per mt, while others ranged between 12-68 g/mt. The company's next step is to conduct a pre-feasibility study for the nickel-cobalt operation, and that a mine at Syerston could be operational within three years. The production of cobalt from this mining operation would have a positive impact on the Sm-Co permanent magnet industry by making the alloying components of this material more readily available. ▲

ERES Newsletter

The *ERES Newsletter* is a forum for the European Rare earth and Actinide Society, which is a non-profit organization that has its headquarters in Lausanne, Switzerland. The *ERES Newsletter* contains reports on rare earth and actinide research, conference notifications and reports, and general rare earth news with a particular focus on scientific research. It is published 2-4 times per year, and has a circulation of over 350 and is partly supported by donations. The Editor is Jean-Claude Bünzli, Université de Lausanne, Institute de chimie minérale et analytique, BCH 1402, CH-1015 Lausanne, Switzerland; Tel: 41 21 692 3821; Fax: 41 21 692 3825; Jean-Claude.Bunzli@icma.unil.c. ▲

RIC Database

The total number of documents referenced in our system is now over 100,000. The documents are stored as citations in the RIC data base and represent books, journal articles, government, company, and laboratory reports, patents and theses, all of which contain information on rare earth metals, their alloys and compounds. A typical citation from a search contains the author(s) name(s), title of paper or contribution, reference line, and keywords that we have assigned to the citation after we have reviewed the document (see below).

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199911740
          KAWAMURA;Y          WADA;Y              HASEGAWA;Y
          IWAMURO;M           KITAMURA;T          YANAGIDA;S
          Observation of neodymium electroluminescence
          Appl. Phys. Lett., 74, [22], 3245-7 (1999)
          1999         ELECTROLUMINES LUMINESCENCE   ND
          APPARATUS    ND-            COMPLEX        LAYERED
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The minimum cost to receive the results of a computer search is US$50.00 (for 25 citations and US$2.00 for each citation over 25 per search). However, many organizations become supporters which allows them to not only receive as many searches as needed for one year, but as an added benefit, they receive the monthly two-page newsletter *RIC Insight*. *RIC Insight* provides a provocative view into recent developments of rare earth science and technology and how these may impact the rare earth industry. The cost to become a supporter is US$100.00 for an individual, or US$300.00 for a corporate membership.

Send requests to: Rare-earth Information Center, 112 Wilhelm Hall, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515 294 5405; Fax: 515 294 3709; ric@ameslab.gov; www.external.ameslab.gov/ric/ ▲

Yttria/Ceria Electrolyte

The recent research and interest in fuel cells is resulting in new electrode designs that operate directly on hydrocarbons instead of hydrogen {*C&EN*, **77**, [33], 7 (1999)}. Since fuel cells are electrochemical devices that produce electricity via chemical oxidation of hydrogen, an intermediate stage, a "reformer" is needed in order for electrical generation from a fuel cell from hydrocarbon fuel. Reformers are reactors that convert carbon-based fuels to hydrogen and carbon monoxide. However, reformers that operate above 800°C causes carbon deposits that decrease the performance of the fuel cells, while operating temperatures below 800°C decrease power output.

Fuel cells that can function on hydrocarbon fuels offer advantages over those that require hydrogen only, since the energy transportation, delivery, and storage infrastructure for hydrocarbon fuels such as methane is already in place. When a conversion

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step is be removed from the conversion process, efficiency is increased.

To improve the operation of solid oxide fuel cells, the direct oxidation of methane by incorporating Y_2O_3-doped CeO_2 in nickel-based anodes results in high power densities at 650°C, a temperature that avoids carbon deposition. The high ionic conductivity of CeO_2 in the cathode enables oxygen ions to be transported more readily from the electrolyte to the anode, where they are needed for hydrocarbon oxidation. This is an improvement over current solid oxide fuel cells, most of which use ceramic-nickel composites that contain yttria-stabilized zirconia (Y_2O_3-doped ZrO_2).

Further improvement may be realized by replacing the nickel in the anode with copper. Fuel cells that directly oxidize methane on materials that utilize nickel enable the formation of carbon soot, so when nickel is replaced by copper in the electrode, increased electrical power production efficiency results. Yttria-doped ceria-copper anodes appear to be a viable material alternative for use in fuel cells. ▲

High Creep Resistant Magnesium Alloys

Magnesium-based alloys with their high strength-to-density ratios work well in applications where weight reduction is required. Magnesium alloys that are used in automotive, aerospace, and mass transit systems meet the demand for reduction in fuel consumption, emissions and the ability to be recycled. However, there are only a few current magnesium alloys that have adequate creep-properties at elevated temperatures to fulfill the requirements for high-temperature applications. Due to the low melting temperature (between 743 and 923 K, depending on composition) the desired creep properties of magnesium alloys are restricted. Therefore, research on Mg-alloy development is needed to enable them to compete with Al-alloys, and to improve the temperature range of application of possible Mg-alloy components. Elements to be alloyed with Mg should have the following characteristics:

- ▲ Solubility in magnesium, which will fall sharply with decreasing temperature. This results in high supersaturation with subsequent precipitation, which allows hardening to be possible.
- ▲ The existing precipitates should show a high content of magnesium in order to get a high volume content of the second phase(s) and a short distance between the precipitates.
- ▲ Have high melting points.
- ▲ A combination of different alloying elements should lead to a higher concentration of precipitates or to different precipitates containing the alloying elements themselves.
- ▲ The alloying elements should show a low diffusivity in magnesium to prevent the tendency of over-aging.

The alloys of the WE-series (Y, Nd, Tb, Er, Dy and Gd containing alloys) are highly creep resistant and can be used at temperatures up to about 573 K. Magnesium-Scandium alloys seem to work well because:

- ▲ Alloying with scandium raises the melting point of the Mg-Sc solid solution (peritectic system).
- ▲ The high melting point of scandium (TM=1541°C) indicates a low

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diffusivity of scandium in magnesium.

- ▲ The density of scandium (3 g/cm≈) is lower than the density of comparable alloying elements.
- ▲ The addition of La, Ce and Mn may increase both room temperature and high-temperature properties.

The aim of our research is to develop high creep resistant magnesium cast alloys containing Sc in a range of 6-12 wt.%. We plan to expand the investigations to the systems Mg-Gd ☛ and Mg-Tb in the near future. Our research deals with the composition, mechanical properties, and the creep resistance of the alloys up to 623 K.

Contact Prof. Dr.-phil. Barry L. Mordike, Technische Universität Clausthal, Institut für Werkstoffkunde und Werkstoff-technik, Agricolastr. 6, 38678 Clausthal-Zellerfeld, Germany; Tel: 05323 / 72 – 2120; Fax: 05323 / 72 –3148; http://www.iw.uni-hannover.de/sfb/sfb390/englisch/a2_e.html. ▲

Electron Density of $RFeO_3$

A part of a series of studies that focus on the effects of Fe-Fe and R-Fe interactions on the electron density distributions in rare earth-iron perovskite orthoferrites appears in *Acta Cryst.* **B55**, 1-7 (1999). Since the deformation electron densities (Dr) of $RFeO_3$ perovskites are thought to be determined by cation-cation interactions, the study emphasizes on the cation array geometry and its effect on Dr images for $NdFeO_3$ and $DyFeO_3$. These orthoferrites were selected because, containing paramagnetic rare earth atoms such as Nd and Dy, they assist in determining the magnetic properties of this class of compound.

The Nd-Dy FeO_3 compounds used in the study were prepared by hydrothermal precipitation from a solution of R_2O_3 + Fe_2O_3 (0.2 wt%) – NaOH (53 wt%) in H_2O contained in a platinum tube that was placed in an autoclave for 2 days at 650 K. The orthoferrites from the tube appeared as small dark red crystals (11 x 11 x 17 mm for $NdFeO_3$ and 11.8 x 12.4 x 12.6 mm for $DyFeO_3$). Diffraction studies were carried out at room temperature with 0.84 Å synchrotron X-radiation using a four-circle diffractometer, which was used in determining lattice constants and internal crystal structure.

The rare earth electron densities are highly polarized due to the proximity of their unfilled *d* and *f* states to their filled states. The symmetry and similarity of the topographies around the Fe, Dy and Nd magnetic atoms, supports conventional thinking that the overlapping atomic electron densities are deformed mainly by interactions involving cations. Although cation-cation interactions affect the electron density and determine the structural geometries and magnetic properties of these perovskites, their role does not have the effect that nearest-neighbor cation-anion interactions have. The magnetic exchange interactions in these materials must originate in indirect super exchange mechanisms that invoke O-atom *p* orbitals as intermediates. However, since the interference between the cation wavefunctions seems to be more significant and the *p* orbitals are relatively unimportant, the exchange mechanism should include direct exchange terms that modify the cation localized-orbital model of indirect exchange interactions.

The authors conclude that the exchange mechanism based on the interactions via highly polarized rare earth $4f - 5d$ and Fe $3d$ orbitals for rare earth iron intermetallic compounds, as proposed in *J. Phys. F.*, **2**, L47-L49 (1972), are relevant for rare earth orthoferrites. They also point out that the strong magnetic effects are due primarily to electron spin density. The spin density and the charge density are related by the effect of uncompensated spins on the electron probability density. There is a different spatial distribution of charge density, depending on the spin correlation. They show that accurate synchrotron radiation diffraction imaging of the electron density can provide supplementary information on magnetic materials and for testing models of magnetic interactions. Victor A. Streltsov, Crystallography Centre, The Univ. of Western Australia, Nedlands 6907, Australia; strel@crystal.uwa.edu.au. ▲

Gd_2O_3 Dielectric

Gallium arsenide (GaAs) has several properties that make it superior to silicon for use in optoelectronic devices. The advantages of GaAs include higher charge carrier mobility and a wider, direct band gap that allows high-temperature operation. Even with these advantages, GaAs-based materials are used less than Si devices because it is difficult to fabricate defect-free insulating oxide barriers on gallium arsenide. Recently, M. Hong *et al.* {*Science*, **283**, 1897-1900 (1999), Bell Laboratories, Lucent Technologies, Murray Hill, NJ 07974 USA; mwh@lucent.com} describe the epitaxial growth of single-crystal Gd_2O_3 dielectric thin films. These Gd oxide films were grown by molecular beam epitaxy and reportedly have a low density of interface states and exhibit low leakage currents across the interface, and are stable against mechanical stresses.

The growth of these Gd_2O_3-GaAs heterostructures was carried out in a multichamber ultrahigh vacuum system. A powder-packed Gd_2O_3 source was used for electron beam evaporation. The GaAs substrate was held between 200°C and 550°C and the growth process were monitored in situ by reflective high-energy electron diffraction (RHEED). Resulting film thickness was determined by ellipsometry and x-ray reflectivity, and the crystal structure was examined by x-ray diffraction. In order to conduct electrical property tests, electrical contacts were deposited on the surface oxide layer by evaporating Au/Pt dots that were 75, 100, and 150mm in diameter.

The Gd_2O_3 film had a cubic structure isomorphic to manganese oxide and was (110)-oriented in single domain on the (100) GaAs surface. The oxide film exhibited a dielectric constant of ~10, and a leakage current of 10^{-9} to 10^{-10} A/cm^2 at zero bias. The typical breakdown field was discovered to be 4 MV/cm for a film 185 Å thick and 10 MV/cm when the oxide film was 45 Å thick. Both accumulation and inversion layers were observed in the Gd_2O_3-GaAs metal oxide semiconductor diodes. ▲

New High-Temp Permanent Magnet Materials

Sponsored by the US Air Force and DARPA and cooperated with Electron Energy Corporation, new sintered high-temperature rare earth permanent magnet materials have been developed by the University of Dayton Magnetics Laboratory, Dayton, Ohio, USA.

Permanent magnet materials capable of operating at high temperatures (~ 400°C) are required for future advanced power systems. Currently, the best existing high temperature permanent magnets can be operated up to 300°C. The problem for a higher temperature (>300°C) operation has been that the intrinsic coercivity (MHc) of these magnets drops sharply upon heating. For example, the MHc of the best conventional Sm-Co 2:17 magnets drops from 20 – 30 kOe at room temperature to only 2 - 6 kOe at 400°C. This also results in non-linear second-quadrant induction demagnetization curves (B curves) at above 200 - 300°C. A linear second-quadrant B curve is critical in all dynamic applications, such as in generators and motors.

The intrinsic coercivity (MHc) of the new Sm-Co based magnets reached 13 kOe (2 to 6 times higher than the current materials). The second-quadrant B curves of the new magnets remain linear up to as high as 550°C (250 to 350°C higher than the current materials). The new magnets possess small negative (-0.1%/°C), or near-zero (-0.03 to +0.03%/°C), or even large positive (up to +0.27%/°C) temperature coefficients of MHc, as compared with -0.3%/°C for conventional 2:17 and 1:5 and -0.9%/°C for Nd-Fe-B magnets. In a long-term aging test the new magnets show a flux density loss less than 1/10 of the best conventional 2:17 magnets after being aged at 500°C in air for 92 hours. In a dynamic characterization at 400°C after being cycled between 0 and -6 kOe, the new magnet displays an energy product more than 20 times higher than the best conventional 2:17 magnet. In addition, a new model of coercivity mechanism has been proposed to ex-

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plain the abnormal temperature dependence of MHc in some of the new magnet compositions.

For more information, contact Sam Liu or Ed Kuhl, University of Dayton Magnetics Laboratory, 300 College Park Avenue, Dayton, OH 45469-0170 USA; Tel: 937 229 3527; Fax: 937 229-3433; lius@udri.udayton.edu or kuhl@udri.udayton.edu. ▲

New Gd Chelate

Metal chelates that contain paramagnetic Gd ions have been used effectively in clinical medicine as a diagnostic tool used in magnetic resonance imaging (MRI). These chelates are nonspecific contrast agents that are introduced into the human body via intravenous injection and are distributed in the extracellular water space in the body. The development and use of a tissue-specific contrast agent has been somewhat elusive until the discovery of a new MRI Gd-contrast agent Gd-EOB-DTPA {*Inorg. Chem.*, **38**, 1134-44 (1999), M. Brehm, Research Laboratories of Schering AG, D-13342 Berlin, Germany}. However, the large-scale production of this agent has been inhibited by the limiting factor of the established synthesis route, the diborane procedure.

The new synthesis route was accomplished by following a series of chemical reactions between esters, amines, amino acids, other organic chemical species, catalytic hydrogenation, and other steps. The diborane procedure was replaced with a new alkylating protocol that allows much larger production batches to be synthesized for clinical use. The resulting Gadolinium complex contrast agent was then studied by the researchers, and physiochemical characterization was carried out.

Gd-EOB-DTPA is a water-soluble liver tissue-specific contrast agent that is currently undergoing clinical trials and may be accepted as an industry standard in the health care field. The new agent allows detection and differentiation of hepatic tumors due to specific uptake by healthy liver tissue, but not by tumors in the affected organ. ▲

Nanostructured Y_2O_3 Powders

Yttria is one of the most widely-used rare earths because of its applications in refractory compounds (Y_2O_3 coatings), ceramics (oxygen sensors, electronics), laser crystals, phosphors, super alloys, and catalysts. New and improved rare earth catalysts and phosphors depend on high surface-area powders that increase reaction and luminescence, since surface area per unit mass is increased as size decreases.

The preparation of yttria powders can be accomplished by colloidal processes, solution and polymeric routes, and by sol-gel techniques. A recent paper by S. Roy *et al.* {*J. Mater. Res.*, **14**, [4], 1524-31 (1999)} (Max-Planck-Institut für Metallforschung, Universität Stuttgart, Institut für Nichtmetallische Anarganische Materialien, Pulvermetallurgisches Laboratorium, 70569 Stuttgart, Germany) describes a process of producing nanostructured yttria powders via gel combustion. Powders with an average particle size of 25 nm were produced in this procedure and are claimed by the authors to meet the requirements for catalysts where high surface area of the catalyst is essential.

Gel combustion directly yields decomposed-intermediate powders, thereby overcoming problems associated with chemical gelation, such as premature drying due to hygroscopy of the gels, adherence of the gels to glass surfaces, and repeated calcination due to swelling. Hydrated $Y(NO_3)_3$ and anhydrous citric acid crystals were mixed in a glass beaker with 50 mL H_2O. The mixture was then heated to 125°C while stirring until a clear solution was formed. Subsequent dehydration of the solution yielded a transparent gel which, upon further heating, underwent precipitation, and ultimately combustion when the temperature was increased to 200°C. Calcination was carried out at 750°C in air.

Varying agglomerate structures of the powder can be made by altering the citrate-nitrate ratio in the combus-

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tion reaction. The gel with a nitrate-citrate ratio of 0.098 in situ yields nanostructured yttria powder with an average particle size of 25 nm and with a specific surface area of 55 m^2/g. In addition, porosity of the powders can be tailored for specific catalytic applications. ▲

Gd/Si Thin Film

Rare earth silicide films have potential uses in infrared sensors because of their unique formation properties and electrical conductivity. They form the lowest Schottky barriers an *n*-type silicon at ~0.4 eV, and Schottky contacts on *p*-type silicon. Silicon is the dominant-diffusing component in the formation reaction, but the control mechanism of the reaction remains undetermined. G.L. Molnár, MTA Research Institute for Technical Physics and Materials Science, H-1525 Budapest, P.O. Box 49, Hungary; molargy@mfa.kfki.hu {*Appl. Phys. Lett.*, **74**, [12] 1672-4 (1999)} demonstrated the pattern formation of Gd silicide in conventional thin film geometry.

The scientists showed that the solid phase reaction of Gd thin film and Si single crystal substrate consists of nonplanar, explosive, selective growth of two silicide phases, hexagonal $GdSi_{1.7}$ and orthorhombic $GdSi_2$. The Gd/Si formation reaction must be slowed down, using an intermediate layer, because the formation is very abrupt. To test their theory, they vapor deposited a Ti layer via electron gun onto the Si layer. The Ti layer was then removed by HF chemical etching techniques, which prepared the surface for the Gd reaction. Gd ingots of 99.99% purity were then evaporated at 3×10^{-6} Pa and at a rate of 0.3 – 0.5 nm/s. After Gd deposition, the wafers were annealed at 360°C by radiation for 30 min.

The surface of the reacted film showed patterned in separate spots. The resulting fractal-like development of this Gd silicide indicate that it was produced by a kinetic type process. This process is believed to be the result of modification by the structure of the Gd thin film and by the emerging stresses of pressure effects rather than by nucleation-controlled growth. ▲

Liquor Magnetization

A novel application for Nd-Fe-B permanent magnets is being explored in Mongolia {*China Rare Earth Information*, **5**, [2], 3 (1999)}. The use of strong rare earth permanent magnets at Wulanhote Liquor Plant involves magnetizing alcoholic beverages during processing to decrease the harmful effects of alcohol.

Equipment that employs Nd-Fe-B permanent magnets subjects the liquor to the correct magnetic field, for the correct amount of time, which is reported to be beneficial to the production process. Non-optimum treatment of the liquor may actually increase the alcohol content. The magnetization mechanism of the liquor is not fully understood and the plant is collaborating with several universities to determine how the process actually works.

For more information, contact Junxi Yan, China Rare Earth Information Center, P.O. Box 131, Baotou, Inner Mongolia 014010, People's Republic of China; Tel/Fax: 86 472 515 6773; yancreic@public.hh.nm.cn. ▲

Rare Earth Consultants

We receive referral requests from interested clients from time to time about consultants in the rare earth field. Several years ago we kept a list but it now needs updating. If you would like us to refer prospective customers to you for consulting services, just send us the following information:

- Contact Name
- Company Name
- Mailing Address
- Telephone Number
- Facsimile Number
- Electronic Mail Address
- URL
- Area(s) of Expertise

This listing is provided at no cost as part of the RIC's service to the worldwide rare earth community.

The information should be sent to: LaVonne Treadway, 116 Wilhelm Hall, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515 294 2272; Fax: 515 294 3709; RIC@ameslab.gov. ▲

Industry Happenings in 1999

Ashton Mining Limited is interested in developing the Mt. Weld rare earth deposit, located near Laverton, Western Australia, and will bring a pilot plant on-line in the near future.

Atlantic Metals & Alloys, Inc., moved their offices to Stratford, CT.

Bokan Mountain, Alaska, USA, was discovered to contain significant amounts of recoverable rare earths.

Dr. Peter Campbell announced that he is discontinuing his consulting activities.

ETREMA announced a US$16 million expansion plan to increase its production of TERFENOL-D.

Ferro Electronic Materials is now the new name for the Transelco Division of Ferro Corporation.

Intertech Corporation moved to: 19 Northbrook Drive, Portland, ME 04105 USA.

International Specialty Alloys (I.S.A.) purchased Neomet Corp.

Jade Magnetics Ltd., Shenzhen, People's Republic of China, started operations after being formed by Arnold Engineering Company, a subsidiary of SPS Technologies.

Jervois Mining NL discovered a major Scandium deposit near Port Macquarie, New South Wales, Australia.

Magnequench International, Inc., announced the opening of a 32,000 sq. ft. technology center located at Research Triangle Park, North Carolina.

Magnequench International, Inc. opened a European office in Tübingen Germany.

Metal Mining Agency of Japan moved their New York office to: 120 W. 45th St., Suite 901, New York, NY 10036 USA.

Morgan Crucible Company plc., UK, purchased Crumax Magnetics, Inc., from YBM Magnex International, Inc. and purchased the rights to the Vacuumschmelze GmbH plants from Siemens AG.

Rhodia Rare Earths started construction of a separation facility at its subsidiary Baotou Rhodia Rare Earths plant. Separation activities at Freeport, Texas, ended.

Continued in next column ☛

Santoku America Incorporated (SAI) has acquired the rare earth metals and alloys activities of Rhodia Rare Earths, Inc. The Phoenix plant located in Arizona, will be transferred to SAI.

Santoku Metal Industry, Japan, opened a branch office, Santoku America, in Chicago, USA.

University of Birmingham, UK, opened a Net Shape Laboratory to develop the production of Nd-Fe-B permanent magnets.

Vacuumschmelze GmbH developed a process for manufacturing thin, flexible magnetic films using rare earth permanent magnets.

Industry News

▲ **Arris International Corporation**, 7071 Orchard Lake Road, MS 235, West Bloomfield, MI 48322 USA; Tel: 248 851 0004; Fax: 248 851 8294; info@arris-intl.com; www.arris-intl.com, offers a broad selection of rare earth metals, oxides, and alloys. They also offer custom fabrication, single-crystals, and stable isotopes. Services include chemical analysis of 72 elemental impurities, nanometer particle size measurement and homogeneity analysis, statistical analysis, x-ray, and ultrasound testing.

▲ **Morgan Crucible plc.**, Windsor, UK, has purchased rights to the Vacuumschmelze plants in Hanau, Germany, Oklahoma City, USA, Horná Streda, Slovakia, and Pontian, Malaysia from Siemens AG. Morgan Crucible has manufacturing locations in over 40 countries with more than 15,000 employees. Matthias Marquardt, Vacuumschmelze GmbH, Postfach 22 53, D-63412 Hanau, Germany; Tel: 49 61 81/38-26 29; Fax: 49 61 81/38-8 26 29; www.vacuumschmelze.de. **Morgan Crucible** also recently purchased **Crumax Magnetics** from YBM Magnex International, Inc. 101 Magnet Drive, Elizabethtown, KY 42701; Tel: 502 769 1333; Fax: 502 765 3118; crusales @crumaxmagnetics.com.

▲ **Parkans International, L.L.C.**, 5521 Armour Drive, Houston, TX 77020-8002 USA; Tel: 713 675 9141; Fax: 713 675 4771; www.parkans.com, recycles residues containing rare earth oxides and markets pure rare earth oxides. Contact Jeff Tange.

▲ **Santoku America, Inc.**, Two Continental Towers, 1701 Golf Road, Suite 605, Rolling Meadows, IL 60008 USA; Tel: 847 437 5520; Fax: 847 437 5521, announced on October 5th that their parent company, Santoku Metal Industry Co., Ltd., Japan, have acquired Rhodia Rare Earths rare earth metals and alloys activities in the USA. Santoku America, Inc., will accept the assets and employees of Rhodia's plant located in Phoenix, Arizona, USA. The main products at the Phoenix plant are Nd-Fe-B and Sm-Co permanent magnet alloys, and alloys for nickel metal hydride batteries.

▲ **Santoku Metal Industry Co., Ltd.**, 14-34, Fukae-Kitamachi 4-chome, Higashi-nada-ku, Kobe-city Hyogo 658-0013, Japan; Tel: 81 78 431 0531; Fax: 81 78 451 3208, is a comprehensive rare earth manufacturer that offers a range of rare earth metals, compounds, and alloys, including mischmetal, Nd-Fe-B and Sm-Co permanent magnet materials, and metal hydride alloys. The company also offers phosphors, catalysts, ceramics, polishing powder, optical lenses, and ultraviolet-absorbing glass and ceramics.

▲ **Tianjiao International Trading Co. (USA) Inc.** has established two warehouses located on the east and west coast of the USA to ensure delivery of products to customers. Contact Weiji Cui, Tianjiao International Trading Co., 1818 Gilbreath Rd., Suite 223, Burlingame, CA 94010 USA; Tel: 650 259 9618; Fax: 650 259 9608; baotoure@aol.com; www.baotou.com.

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Scandia Stabilized Zirconia

Toho Gas Company and Daiichi Kigenso Kagaku Kogyo Co., Japan, have teamed up to develop a new scandia-stabilzed zirconia (Sc_2O_3-doped ZrO_2, ScSZ) ceramic {*Nikkan Kogyo Shinbun*, July 15, 1999}. The new material is to be used as an electrolyte for solid oxide fuel cells (SOFC). The new ScSZ ceramic is made by adding Sc_2O_3 to zirconium oxide ZrO_2 to optimize the crystal structure, then sintering. The new ScSZ exhibits improved electric conductivity and mechanical strength while its coefficient of thermal expansion is about the same as YSZ.

The advantage of ScSZ over YSZ in solid oxide fuel cells is that it will help increase power generating characteristics of the devices, while decreasing size and cost. Daiichi Kigenso manufactures and markets the ceramic powder, which has been commercially available since this summer.

There are currently four types of fuel cells: Solid Oxide Fuel cells (SOFC), Molten Carbonate Fuel Cells (MCFC), Phosphoric Acid Fuel Cells (PAFC), and Polymer Electrolyte Fuel Cells (PEFC). The SOFC type will be used in regional electrical cogeneration systems. ▲

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Since the September issue of the RIC News went to press, we have received support from two new family members and renewed support from 26 other organizations and individuals.

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Postmaster: Send address changes to: *RIC News*, Rare-earth Information Center, Ames Laboratory, Institute for Physical Research and Technology, Iowa State University, Ames, IA 50011-3020
Telephone: 515 294 2272
Facsimile: 515 294 3709
INTERNET: ric@ameslab.gov
http://www.external.ameslab.gov/ric/
R.William McCallum .... Editor
Karl A. Gschneidner, Jr. .... Editor Emeritus
Joel Calhoun .... Writer

Rare-earth Information Center
Ames Laboratory
Institute for Physical Research and Technology
Iowa State University
Ames, Iowa 50011-3020