Rare-earth Information Center NEWS

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

Volume XXXVI September 2001 No. 3

Double Exchange and Manganites

Yu. A. Izyumov and Yu. N. Skryabin have written a review devoted to the explanation of the physics of colossal magnetoresistance based on the double exchange (DE) model. The review, "Double exchange model and the unique properties of the manganites," was published in *Physics-Uspekhi* **44** [2] 109 – 134 (2001).

The introduction to the paper provides a short overview of manganites, and focuses on $(La,A)MnO_3$, where A is a bivalent atom in the sequence Ca, Sr, Ba, etc. The crystal structure, dependence of resistivity on temperature and concentration, magnetoresistance, and a typical magnetic phase diagram are presented, along with an introduction to electron models. The electron model employed is the DE model, which uses a two-term Hamiltonian, the first term describing the motion of an electron over lattice sites, and the second term accounting for the Hund exchange coupling. However, to describe real manganites, more terms and considerations are needed to properly interpret the Hamiltonian.

Next the effective Hamiltonian of the DE model is discussed, as well as the idea of quantum spin and its application to the exchange Hamiltonian, the properties of the DE model in the dynamical mean field approximation, especially using the classical spin model, and an analysis of the numerical results obtained using this model. The relationship between the Curie temperature and the kinetic energy, a simplified double exchange model, the coherent potential method, and a variational approach to the mean field approximation and how each specifically affects the DE model being used are explained.

The article describes how the magnetic phase diagram for manganites can be determined. Detailed information on the steps taken in applying Monte Carlo calculations and the DE model to the phase diagram are presented, along with several figures illustrating the magnetic phase assemblage. Two areas that add to the model to make it fit even better are added as well. The first is on orbital degeneracy, and the second is on the effects of electron-lattice interaction. Both topics show the modifications necessary to the model and then compare the theory to experimental results.

There are problems that remain in the physics of manganites. One is the metal-insulator transition. The problem arises in describing the paramagnetic phase at ferromagnetic compositions. Three possible mechanisms for how this can occur are presented. Another problem is that of charge ordering. The problem here is the formation of stripe domains. These domain structures have been observed experimentally, but not predicted theoretically, and their formation mechanism and impact on physical properties of the material is not yet known.

The entire work is explained carefully and the reasoning behind the theory is clearly presented. The conclusions of the authors are supported by 20 figures, 119 references, and 124 equations. For more information, Yu. A. Izyumov and Yu. N. Skryabin can be reached at the Institute of Physics of Metals, Ural Branch of the Russian Academy of Sciences, ul. S. Kovalevskoi 18, 620219 Ekaterinburg, Russian Federation, Tel: (7-3432) 74 41 93, Fax: (7-3432) 74 52 44, e-mail: Yuri.Izyumov@imp.uran.ru. Also, another article reviewed in this issue, entitled "Perovskite Oxides," is related to this topic. ▲

ASC 2002

The *Applied Superconductivity Conference, ASC 2002,* will be held at the George R. Brown Convention Center in Houston, Texas, August 4 – 9, 2002.

The *Applied Superconductivity Conference* is the premier conference on applied superconductivity held biannually in the United States. The conference will include invited talks, oral and poster presentations, and exhibitions highlighting the latest developments in the field. Workshops and tutorials are being planned for the weekend before the conference. Contributed papers are being solicited in three general areas of applied superconductivity: Large Scale, Electronics, and Materials. Abstracts must be submitted by February 15, 2002.

For more information about the conference, abstract instructions and submissions, registrations, hotel reservations, and other information, please visit www.ascinc.org. The Conference Chair is Paul C. W. Chu, and the Program Chair is Donald Gubser. ▲

In This Issue:

HTM-2001

The *Third International Conference "Hydrogen Treatment of Materials" (HTM-2001)* was held in Donetsk, Ukraine, May 14-18, 2001. More than 130 scientists, experts, and industrialists took part in the conference.

A book on the same topic, *Progress in Hydrogen Treatment of Materials*, was published this year by Donetsk-Coral Gables: Kassiopeya. The book contains contributions by world-renowned scientists and experts from ten countries, is edited by Professor V. A. Goltsov of Donetsk State Technical University, Ukraine, and is prefaced by Professor T. N. Veziroglu, President of the International Association for Hydrogen Energy, Miami University, USA.

After an introduction by V. A. Goltsov reviewing the status and development of hydrogen treatment of materials over the last 25 years, the book is organized in 4 parts. Part 1 contains 9 review papers, and includes fundamentals of hydrogen treatment of materials, the thermodynamics of hydrogen solution, diffusion and diffusive phenomena, theory of hydrogen elasticity phenomenon, hydrogen in thin films and multilayers, nature and manifestations of uphill hydrogen diffusion effects, hydride shape-memory effects, and the hydrogen phase naklep phenomenon and its use in hydrogen treatment of metallic materials.

Part 2 contains 11 review papers covering some hydrogen effects at the metals surface treatment; hydrogenation behavior, microstructure and hydrogen treatment, hydrogen as a temporary alloying element, and the achievements and prospects of hydrogen technology in production and treatment of titanium alloys; hydrogen in technologies for aluminum alloys casting; systematization and peculiarities of hydride crystal structures forming under the interaction of hydrogen with intermetallics; hydrogen induced amorphization of intermetallics, kinetics and some general features of hydrogen induced diffusive phase transformations in $Nd_2Fe_{14}B$ type alloys; surface modifications of hydrogen storage alloys and their applications in recent hydrogen technology; effects of hydrogen inclusion on electrical properties of metal oxides and nitrides; and hydrogen treatment of non-metallic catalytic materials.

Part 3 includes 2 review papers, covering hydrogen degradation of some hydride-forming metals and their alloys and hydrogen in welding processes. Part 4 is a set of appendices covering historical and scientific features of the generation and development of HTM and how a new paradigm of materials science has been formed, classification of hydrogen treatment of materials, and the status of the world-wide HTM community.

Of interest to the rare earth community is the generalized information on hydrogen interactions with rare earth intermetallic compounds, oxides, and other rare earth materials. The topics of special interest are crystal structures of hydrides, hydrogen-induced amorphization, hydrogen-induced phase transformations, and improvement of physical and catalytical properties by hydrogen treatment.

For more information, contact Professor V. A. Goltsov, e-mail: Goltsov@physics.dgtu.donetsk.ua or Goltsova@fem.dgtu.donetsk.ua, or on the Web at http://dgtu.donetsk.ua/hydrogen or http://64.177.6.116/hydrogen. Our thanks to V. A. Goltsov for contributing this story. ▲

Conference Calendar

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

September '01
Rare Earths' - 2001
São Paulo - SP, Brazil
September 22-26, 2001
Website: http://www.iq.usp.br/geral/congress.html.
RIC News **XXXIII**, [4] 3 (1998)

November '01
46th Annual conference on Magnetism and Magnetic Materials
Seattle, Washington, USA
November 12-16, 2001
*This issue

March '02
4th Bi-annual School on the Physics and Chemistry of Actinides
and
32emes Journees des Actinides (32JA)
Ein-Gedi, Israel
March 17-22, 2002
*This issue

June '02
14th International Symposium on Boron, Borides, and Related Compounds (ISBB'02)
St. Petersburg, Russia
June 9-14, 2002
*This issue

July '02
The 23rd Rare Earth Research Conference
Davis, California, USA
July 13-18, 2002
RIC News **XXXV**, [2] 4 (2000)

August '02
Applied Superconductivity Conference (ASC 2002)
Houston, Texas, USA
August 4-9, 2002
*This issue

17th Int. Workshop on Rare-Earth Magnets and their Applications
Newark, Delaware, USA
August 19-22, 2002
RIC News **XXXV**, [4] 3 (2000)

July '03
International Conference on Magnetism (ICM'2003)
Rome, Italy
July 27-August 1, 2003
RIC News **XXXVI**, [1] 4 (2001)

*denotes an article on this conference appears in this issue of the *RIC News*

The fourth bi-annual *School on the Physics and Chemistry of Actinides* and the *32emes Journees des Actinides (32JA)* will be held March 17 – 22, 2002. They will be held at the guest house of kibbutz Ein-Gedi, Israel, on the shore of the Dead Sea.

The Journees des Actinides is a series of informal conferences devoted to the physics and chemistry of the actinides. A strong emphasis is given to mixed actinide-lanthanide systems, such as compounds, solid solutions, complexes, etc. The JA series began in 1972 in Grenoble, France, as a semi-annual meeting. It has been an annual meeting since 1975. Participants are primarily from Europe, with some also coming from the USA, Japan, and Israel. The attendance this year is expected to be around 100.

The bi-annual School on the Physics and Chemistry of Actinides was begun in 1996. Its primary goal is to introduce young scientists into the field of basic properties of the actinides and mixed 4f-5f systems, possible as future support to the nuclear science and industry. The School on Physics and Chemistry of Actinides will be free of charge for lecturers and students presenting their work at the 32JA.

The first announcement for the conference will be mailed in October 2001 to past participants. Anyone else interested in receiving this information should contact Dr. Moshe Kuznietz, Chairman of the Organizing Committee, 32emes Journees des Actinides, P. O. Box 9039, 84190 Beer-Sheva, Israel, by letter or fax to +972-8-6567878, providing full address, telephone, and fax numbers, and e-mail address. ▲

E-Mail Subscription

Subscribers to the *RIC News* can request to receive their copies via e-mail. This represents a vastly improved time-of-delivery over surface and airmail. It is now available in MSWord, .pdf, HTML, or text-only formats.

To receive the *RIC News* via e-mail, please specify which format you would prefer, and send your e-mail address to RIC, 112 Wilhelm Hall, Iowa State University, Ames, IA 50011-3020 USA or ric@ameslab.gov. ▲

Magnetism and Magnetic Materials

The *46th Annual Conference on Magnetism and Magnetic Materials* will be held in Seattle, Washington, USA, November 12 – 16, 2001.

Members of the international scientific and engineering communities interested in recent developments in magnetism and associated technologies are invited to attend the conference. The conference will cover basic and applied science and technology related to the field of magnetism. The planned symposia are spin transfer torques, novel superconductivity and magnetism, spin polarization in half metals, spin injection in ferromagnetic/semiconductor materials, thermal magnetic stability of nano-sized magnetic devices, perpendicular recording, and MRAM- prototypes and feasibility.

For more information, visit http://www.magnetism.org, or contact Diandra Leslie-Pelecky, Secretary, University of Nebraska – Lincoln, Tel: 402-472-9178, Fax: 402-472-2879, e-mail: diandra2@unl.edu. ▲

New Magnetic Powder from Magnequench

Magnequench Inc. now has a new spherical isotropic powder product, MQP™-S-9-8, available for customer sampling and in commercial quantities.

The new powder is designed for plastic injection molded magnet parts and would also be suitable for calendared or extruded flexible magnets. The powder allows improved flow of polymer bonded compounds and results in an enhanced ability to make fine, sharply defined products. The powder size is approximately 50 micrometers, and helps improve dimensional tolerances, thermal stability, resistance to corrosion, and flux uniformity. It can also be used with other products to be used in hybrid NdFeB, thick film, and thin film applications.

Magnequench Inc. is headquartered in Anderson, Indiana, USA. For answers to questions on products and services, visit www.magnequench.com, e-mail infopowders@mqii.com, or call 765 648-5000. ▲

ISBB'02

The A. F. Ioffe Physical-Technical Institute and the Russian Academy of Sciences is sponsoring the *14th International Symposium on Boron, Borides, and Related Compounds* June 9 – 14, 2002, in St. Petersburg, Russia.

The scientific program will integrate both basic and applied interdisciplinary research that is centered on boron, borides, and related compounds. Oral and poster contributions are invited in the areas of preparation of new materials in normal and extreme conditions, crystal structure and chemical bonding, physical and chemical properties in a wide range of temperature and pressure, and applications and prospects. Plenary lectures are planned. The language of the symposium will be English. Registration forms are due October 1, 2001, and abstracts are due December 10, 2001.

For more information, contact Dr. Maria M. Korsukova, Symposium Secretary, Ioffe Physical-Technical Institute, Russian Academy of Sciences, 26 Polytekhnicheskaya street, 194021, St. Petersburg, Russia, Tel: +7(812) 247 99 19, Fax: +7(812) 247 89 24 or +7(812) 247 10 17, e-mail: Maria.Korsukova @pop.ioffe.rssi.ru. ▲

Consultant's Corner

To appear in our Consultant's Corner, any individual, company, or group must be involved in rare earth or rare-earth-related consulting activities. Just send us the appropriate information: contact name, company name, mailing address, Tel/Fax number(s), e-mail, web address, and areas of expertise.

We would like to update our information as much as possible, so if you have submitted your information in the past but have something that has changed, if you are new to rare-earth consulting, or if it has been a while since you have had any of your information published in the *RIC News*, please resubmit your information: Tel: (515) 294-2272, Fax: (515) 294-3709, e-mail: ric@ameslab.gov. ▲

News from Japan

Our thanks to Kensuke Shimomura for the content and translations for this section.

Toyota Motor Corp. press release, June 12, 2001: Toyota has unveiled a new hybrid system that can be applied in many vehicles, and will be used in production later this year. The new system is called Toyota Hybrid System-Mild (THS-M). The system consists of a small motor/generator, a compact 36V battery, and a control unit. This system improves fuel efficiency by 15%. The larger battery allows for thinner wires than in standard 12V systems, resulting in weight reduction and increased fuel economy. The mild hybrid system is less expensive than traditional hybrids systems, and is less dependent on electricity.

The Japan Times, June 13, 2001: Mazda Motor Corp. is working on a fuel cell electric vehicle (FC-EV) in cooperation with the Ford Motor Co. group. The fuel cell for the vehicle is supplied by an alliance of Ford, DaimlerChrysler, and Ballard Power Systems. Mazda is using methanol to make hydrogen to power the fuel cells of the vehicles, and hopes to have them in practical use by 2004.

The Asahi Shimbun, June 16, 2001: Toyota Motor Corp. has a new hybrid vehicle, the Estima, which is a minivan that is claimed to use half the fuel of comparable gas-only vehicles. The Estima is a four-wheel-drive vehicle, has a 2.4 liter gasoline engine and two electric motors, and gets about 42 mi/gal (18 km/l) of gasoline. Toyota expects to sell 1000 Estima Hybrids a month in Japan. Hopes are that the Estima will be exported someday, but no plans are made at present.

The International Herald Tribune, June 16, 2001: LM Ericsson AB has signed an $850 million agreement to supply equipment and services to Chinese telecommunications operators. Ericsson will provide network equipment and services for GSM, CDMA, and multi-service networks for three Chinese companies: Jiangsu Mobile Communications Co., China Unicom Jiangsu Branch, and China Telecom Group, Jiangsu Corp. The number of mobile phone users is expected to triple to 300 million by 2005.

The Japan Times, June 19, 2001: Toyota is developing a 63-passenger bus with Hino Motors. The bus, FCHV-BUS1, is powered by a high-pressure hydrogen fuel-cell and Ni-MH batteries. It can travel about 185 miles and reach speeds of 50 miles per hour. Toyota is also road testing its FCHV-4, a fuel cell hybrid sports utility vehicle, with direct storage of hydrogen in high-pressure tanks. These vehicles are expected to be the basis of new vehicles to be launched in 2003.

The Nikkei Weekly, July 1, 2001: Dell computer Corp. is beginning to make PCs in China for delivery to Japan. Dell is using its own original supply chain management model to produce low-cost, high-quality products in China. They maintain control over supply of parts by requiring local suppliers to have their factories within 15 minutes of Dell's factory. The management system allows customers in Japan to receive their orders within 5 days, faster even than computers made in Japan can get to them. Dell hopes these cost-saving measures will help to quadruple their world market share.

The Nikkan Kogyo Shimbun, July 25, 2001: Matsushita Electric Industrial Co. and Matsushita Battery Industrial Co. have formed a subsidiary in China to produce NiCd and NiMH rechargeable batteries. The Wuxi Matsushita Battery Industrial Co. is Matsushita's first production base for rechargeable batteries in China. NiCd batteries will be produced for use in electric tools, and NiMH batteries will be produced for use in personal computers and mobile phones.

Japanese reports on U.S. activities include the increasing popularity of hybrid vehicles in the United States (*The Nihon Keizai Shimbun* June 4, 2001), General Motors Corp.'s purchase of a 20% interest in Quantum Technologies Inc., a company that manufactures hydrogen storage tanks (*The Japan Times*, June 14, 2001), and an alliance formed between FuelCell Energy Inc. and Marubeni Corp. to generate more power through Direct Fuel Cell power plants with the eventual goal of introducing FuelCell to Japan and Asia, with long term plans for power plant to be built in Asia (*The Japan Times*, June 20, 2001). ▲

Fuel Cell Funding

The U. S. Department of Energy (DOI has selected four industrial teams to partic pate in a 10-year, $500 million program develop betterways to manufacture less e pensive and commercially acceptable sol oxide fuel cells (SOFC). The four industri teams are Honeywell, Siemens Westinghou Power Corp., Delphi Automotive Syster and Battelle, and Cummins Power Gener tion and McDermott Technology, Inc.

An article by Jeff Johnson in *C & E* **79** [34] 13 (2001) gives some details of th program.

SOFC are just one of several fuel-ce technologies that the DOE is supportin because of their commercial potential. Th particular application of SOFC has been t higher power operations, like industrial c large-scale electricity generating station SOFC can use fossil fuels as a source c hydrogen, and they can run at high tempera tures (1500°F) that can be used as a hea source for industrial applications.

The goal of the DOE program ove the next 10 years is to cut capital costs t $400 per kW through manufacturing im provements while raising efficiencies to 60 70%.

The DOE will provide approximatel $270 million over the next 10 years, and th balance of funding will come from the in dustrial teams. A related R&D program t support the industrial manufacturing project with about half the funding is expected t be announced this fall.

Specific projects included in the program include making modular 3- to 10-kW SOFC systems, 7- to 10-kW combined heat and power residential systems, and small units for vehicle applications. ▲

Newsletter on the Web

A paperless alternative to receiving ar electronic form of the *RIC News* via e-mai is to access our website: http://www.ameslab.gov/ric, where current and previous issues of the *RIC News* are available, along with general information about the Rare-earth Information Center and a list of our sponsors. ▲

Low-dimensional Cuprates

In high temperature superconducting cuprates one of the central issues is whether the two-dimensional (2-D) CuO_2 planes with strong electron correlation behave as a Fermi liquid or as a non-Fermi-liquid one-dimensional (1-D) system with electron correlation. This issue is addressed in a review article by Sadamichi Maekawa and Takami Tohyama entitled "Charge and spin in low-dimensional cuprates," *Rep. Prog. Phys.* **64** 383 – 428 (2001).

The theoretical study of spin-charge separation goes back to 1950. The charge and spin in 1-D systems do not have the same values (e and $1/2$) as they do in regular Fermi liquids, but instead are like spin and charge degrees of freedom that result from the decay of a hole or electron introduced into a 1-D system. Spin-charge separation studies have been extended to the 2-D cuprates, and advances in both 1-D and 2-D systems have helped provide clues to high-T_c superconductivity.

The body of the review is organized into three parts. The first is an introduction to the underlying electronic structure of cuprates. A discussion of the electronic structure includes basic crystallographic structure, density of states, optical conductivity, and the Hubbard model and associated Hamiltonians. This is followed by a discussion of exchange interactions, including magnetic susceptibility and the importance of bond angles.

The second section covers 1-D cuprates. The primary topics of discussion include spin-charge separation, the realization of spin-charge separation in 1-D cuprates through angle-resolved photoemission spectroscopy, charge dynamics in insulating cuprates, and spin dynamics in insulating cuprates.

The third section covers 2-D cuprates. After an introduction, phase separation versus d-wave superconductivity, electronic excitation near the Mott insulator, electronic excitation in the Mott insulator, and stripe phases are all presented.

The conclusions to be drawn from the article are that spin-charge separation has been shown to be real for 1-D cuprates, but the results are somewhat inconclusive and warrant more study in 2-D cuprates. The charge separation that seems to be seen in 2-D cuprates is dependent on momentum and connected to d-wave superconductivity. It is also concluded that stripe domains are the realization of physical spin-charge separation.

The review article has 33 insightful figures accompanying the text, along with 19 equations and 241 references. For more information, Sadamichi Maekawa can be reached by e-mail at maekawa @imr.tohoku.ac.jp, and Takami Tohyama can be reached by e-mail at tohyama@imr.tohoku.ac.jp. ▲

Gate Dielectrics

"High-κ gate dielectrics: Current status and materials properties considerations," is the title of a recent review by G. D. Wilk, R. M. Wallace, and J. M. Anthony that appeared in the *J. of Appl. Phys.* **89** [10] 5243 – 5275 (2001). The review addresses the problem of finding suitable materials for replacing SiO_2 as the gate dielectric material for sub-0.1 μm complementary metal-oxide-semiconductor (CMOS) technology.

The article gives an excellent overview of the subject. It begins by introducing metal-oxide-semiconductor field effect transistors (MOSFET) and the scaling of these based on CMOS properties. There is a short discussion on scaling and improved performance and another on the metal-insulator-semiconductor (MIS) gate stack structure that make up the MOSFET.

The scaling limits for current SiO_2 gate dielectrics are presented. The discussion is broken down into six separate areas: ultrathin SiO_2 properties, ultrathin SiO_2 reliability, boron penetration and surface preparation, SiO_xN_y and Si-N/SiO_2 dielectrics, fundamental limitations, and device structures.

Alternative (non-SiO_2) high-κ gate dielectrics that have been studied so far make up a major portion of the article. This section includes high-κ candidates from memory applications, issues for interface engineering, and recent high-κ results. This last segment contains discussions on Group IIIA and IIIB metal oxides, Group IVB metal oxides, pseudobinary alloys, and high-κ device modeling and transport. The sections on Group IIIA and IIIB metal oxides, which include Y_2O_3, La_2O_3, Pr_2O_3, and Gd_2O_3, and pseudobinary alloys, which include La-Si-O, Gd-Si-O, Y-Si-O, Sc-Si-O, and Ce-Si-O, make the most mention of rare-earth materials. If these materials proved to be particularly useful as high-κ gate dielectrics, there could be increased demand for rare earths for use in the semiconductor industry.

Finally, the review covers materials properties and considerations. The required properties for suitable dielectric replacements are presented here. They include permittivity, band gap, and band alignment to silicon, thermodynamic stability, film morphology, interface quality, compatibility with current or future materials used in processing CMOS devices, process compatibility, and reliability. While many materials meet several of these requirements, it is difficult to find one that meets all requirements. So far, the pseudobinary materials show the most promise.

The review is supported by 3 tables, 14 equations, 27 figures, and 167 references, and should prove to be an interesting starting point for anyone interested in this field.

For more information, G. D. Wilk can be reached by e-mail at gwilk@agere.com, and R. M. Wallace can be reached by e-mail at rwallace@unt.edu. ▲

Perovskite Oxides

The structure and chemistry of perovskite materials is the focus of a recent review article "Chemical Structure and Performance of Perovskite Oxides," by M. A. Peña and J. L. G. Fierro, *Chem. Rev.* **101** 1981 – 2017 (2001).

Around 90% of the naturally occurring metallic elements form stable perovskite oxides (ABO_3), thus the compounds have a wide range of properties. Since the authors have addressed physical properties in a previous review, they are not presented in this paper. The focus of this paper is instead on structures and chemical interactions of the materials, especially as catalysts. The majority of catalysts used in the chemical industry today are mixed metal oxides, and the variety available in perovskites makes them adaptable to multiple purposes. The adaptations are helped by substituting for both the A and B elements in the formula. Perovskite oxides also provide excellent models for catalytic reactions and for establishing correlations between reactivity and surface or bulk properties due to their isomorphic nature.

The review has three major sections, Structure of Perovskites, Acid-Base and Redox Properties, and Heterogeneous Catalysis, followed by a concluding section entitled Future Perspectives. Structure of Perovskites begins by covering the crystal structure, including a diagram of the ideal structure, and some deviations from the ideal structure that can occur. Non-stoichiometry, which includes oxygen non-stoichiometry and cation stoichiometry, and reasons that non-stoichiometry can occur, are discussed. Physical properties are presented, and cover magnetic properties, electrical properties, and optical properties briefly. Adsorption properties, especially for CO, NO, and O, specific surface and porosity, and thermal stability in a reducing atmosphere are also included.

Acid-Base and Redox Properties is a brief treatment of these properties, which are directly related to catalytic performance of perovskites. The surfaces of the materials are most important in producing catalytic properties, so surface sites are the main focus of this section. Acidity and basicity, redox processes, which includes discussions on kinetics and mechanisms and reduction-oxidation cycles, and ion mobility, which discusses both oxygen transport and cation transport, are all encompassed in the discussion.

The focus of the paper treats several different kinds of heterogeneous catalysis. The catalysis reactions cover a wide range of potential applications for perovskite oxides. They include oxidation reactions (like CO oxidation and oxidation of hydrocarbons), pollution abatement (such as NO_x decomposition), exhaust treatment, and a section on stability, hydrogenation and hydrogenolysis reactions (including hydrogenation of carbon oxides), photocatalysis (especially photodecomposition of water and other photocatalytic reactions), chemical sensors, electrocatalysis (specifically oxygen reduction and solid oxide fuel cells), and a section on structure-activity relationships.

Future Perspectives aims to show some possible areas for future development of perovskite oxide applications. It points out the flexibility that can be gained in using perovskites because of their isostructural nature and the degree of substitution that can be achieved. Important applications include cathode materials for solid oxide fuel cells, and the accommodating nature of the structure of perovskites should lend themselves to processes yet to be invented.

The paper is supported by 14 figures that help to illustrate the concepts presented, 27 equations, most of which illustrate chemical reactions, and 373 references. For more information, J. L. G. Fierro can be contacted by fax at +34 91 585 4760, or by e-mail at jlgfierro@icp.csic.es. Also, elsewhere in this issue of the *RIC News* is the article "Double Exchange and Manganites," which is related to this topic. ▲

Batteries and Clean Energy Sources

An excellent review, entitled "Material for rechargeable batteries and clean hydrogen energy sources," *Int. Mater. Rev.* **46** [1] – 49 (2001), written by Z. S. Wronski, covers a wide range of materials used in energ applications.

Rechargeable batteries and fuel cells ar energy sources that require functional mate rials. Development of these materials ca be challenging because multiple functions re quired of the material mean multiple require ments must be met. A combination of prop erties is possible if complex structures ar used, involving materials such as functiona composites, multi-element and multiphas intermetallics, cermets, layered insertio compounds, and nanostructured and diso dered phases. The review presents a variet of these materials used for clean energy sto age, which most often means hydrogen en ergy storage.

The introduction begins with a brief his tory starting with the invention of the firs battery in 1799. The history outlines the de velopment of automobiles and electri power sources for them, as well as the de velopment of metal-hydride storage alloy and fuel cells, and is a nice prelude to th rest of the review. The author states that th review is far from comprehensive, but at tempts to show how similar materials ar used in more than one kind of energy sto age and/or conversion.

The review is organized into three part The first introduces battery and fuel cell sy tems. The second discusses selected mater als, with particular attention to intermetallic used in gas hydrogen or electrochemical hy drogen storage. The third part discusse special topics, including nanophase mater als and processing. Some materials fit i more than one segment, and are discusse in each segment where relevance occurs.

The battery systems presented includ lead-acid systems, nickel-cadmium system nickel metal hydride systems, lithium system "other" systems, and fuel cells. The selecte materials discussed include lead alloys, nick materials for composite Ni electrodes in a kaline batteries, cadmium and zinc materia

Continued on page 7

Continued from page 6

for rechargeable alkaline cells, H insertion intermetallic alloys for gas hydrogen storage (which include rare earth-nickel alloys of the AB_5 type), H insertion intermetallics for electrochemical hydrogen storage, materials for lithium batteries, and materials for fuel cells (including ceramics and cermets that contain rare earths). Special topics include nanostructured materials, materials requirements for batteries and fuel cells to be used in portable communication and electric vehicle applications, and recyclability and life cycle analysis. There is also an appendix that defines terms from battery and fuel cell technology.

Overall this is a very informative article. To help support the information presented, 13 tables, 15 equations, 29 figures, and 457 references are employed. For more information, Z. S. Wronski can be reached at the Materials Technology Laboratory, Canada Centre for Mineral and Energy Technology, 568 Booth Street, Ottawa, ON, K1B 3B1 Canada, Tel: (613) 992-0160, e-mail: zwronski@nrcan.gc.ca. ▲

Did you know?

Promethium, element 61, was first predicted in 1903, and evidence was collected of its existence in 1926, but it was not "discovered" until 1945, when Jacob A. Marinsky, Lawrence E. Glendenin, and Charles DuBois Coryell found it in the fission products of uranium while doing nuclear research at Oak Ridge, Tennessee.

The name "promethium" comes from Greek mythology, where Prometheus stole fire from heaven and gave it to mankind. In the story, his actions brought him severe punishment from Zeus. Grace M. Coryell has been quoted as saying "This name not only symbolizes the dramatic way in which the element may be produced in quantity as a result of man's harnessing of the energy of nuclear fission, but also warns man of the impending danger of punishment by the vulture of war!"

Promethium has several isotopes with mass numbers from 134 to 155. Promethium melts at about 1042°C, boils at about 3000°C, and has a specific gravity of 7.26. It has been used in atomic batteries and as a beta-particle source in thickness gauges. ▲

Search of the Month

Ric Database Report

keywords 2000 , ***AND*** ***keywords*** Jahn-Teller-ef

Article

Epitaxial strain induced metal insulator transition in La0.9Sr0.1MnO3 and La0.88Sr0.1MnO3 thin films

(La,Sr)MnO3 2000 Debye-temp epitaxy Jahn-Teller-ef magnetization met-insulat-tr pulsed-laser-deposition resistivity SrTiO3 strain TEM temp-dependenc thin-film transition-tem

Magnetic structure evolution of Pr(1-x)MnO3 perovskite from neutron powder diffraction data

2000 crystal-struc crystallograph exchange Jahn-Teller-ef mag-moment mag-ordering mag-structure Neel-temp neutr-diffract neutr-scatter perovskite PrMnO3 spin-glass spin-ordering superexchange symmetry x-ray-diffract

Comparative study of photo-induced effect on the charge- ordered state of Pr0.65Ca0.35MnO3 in powder and thin films

(Pr,Ca)MnO3 2000 charge-order colossal DC electrotranspo EPR Jahn-Teller-ef magnetoresist met-insulat-tr oxide paramag-reson photo-induced photon-injection powder resistance thin-film x-ray-diffract

Electronic structure of LaMnO3 in the ab initio crystal Hartree-Fock approximation

2000 crystal-struc density-states electron-struc Hamiltonian Hartree-Fock Jahn-Teller-ef LaMnO3 mag-ordering mag-prop model orbital-order spin-density spin-wave

Influence of the cooperative Jahn-Teller effect on the transport and magnetic properties of La7/8Sr1/8MnO3 single crystals

(La,Sr)MnO3 2000 bibliography conductivity distortion double-exchange field-depend Jahn-Teller-ef lattice-param mag-moment mag-prop mag-suscept magnetization magnetoresist manganite orbital-order ordering oscillation perovskite phase-transiti polaron resistivity Shklovskii-Efros-hopping single-crystal spin-alignment spin-cluster SQUID structure superparamag temp-dependenc transport-prop Wigner-lattice

Wednesday, August 22, 2001 ***Page 1 of 1***

The search above satisfies a search for information on the Jahn-Teller effect contained in papers published in 2000 (Jahn-Teller-ef AND 2000). Many more citations would have been referenced if other years had been included in the search.

The preliminary search report, as shown above, which is provided when the search is requested as an evaluative tool, includes the keywords used for the search, the title of the article, and the other keywords associated with the reference, for each of the references found. A database report, whcih is sent when the search results are purchased, includes full reference information: our document number, title, authors, bibliographic reference, and keyword list..

The cost to receive the full report for this search is US$50.00. The minimum cost for any search is US$50.00, which includes the reference list for up to 25 matches, and any additional matches are available for US$2.00 each. Supporters may receive as many searches as desired for US$300.00 per year for corporate memberships, or US$100.00 for individual memberships. For other support levels available, see "September 2001 Supporters" on page 8.

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. Supporters can also have space on our website, providing additional exposure for their company and links to their own webpages.

If you would like us to conduct a search for you, please send your request to: Angela O'Connor, RIC, 112 Wilhelm Hall, Ames Laboratory, Iowa State University, Ames, IA 50011-3020 USA; Tel: 515-294-5405; Fax: 515-294-3709; e-mail: ric@ameslab.gov. If you would like to become a supporter of the RIC, send your name, address, telephone, fax, e-mail addresses, and your desired level of support to the above address or to LaVonne Treadway, RIC, 116 Wilhelm Hall, Ames Laboratory, Iowa State University, Ames, IA 50011-3020 USA, Tel: 515-294-2272; Fax: 515-294-3709; e-mail: crem_ric@ameslab.gov. ▲

Stable Binary Quasicrystal

Five Japanese researchers have found a stable binary quasicrystal. Their findings are summarized in a brief communication in *Nature* **408** [6812] 537 – 538 (2000). The article is called "A stable binary quasicrystal," and is authored by A. P. Tsai, J. Q. Guo, E. Abe, H, Takakura, and T. J. Sato.

Quasicrystals were first discovered in 1984, and since then the only stable quasicrystals contained at least three metallic elements. Thus, the discovery of a binary quasicrystal is quite a find. The Cd-Yb material represents a new class of packing of a 66-atom icosahedral cluster. The internal structure of the cluster breaks the symmetry.

The stable composition is $Cd_{5.7}Yb$, and was discovered through systematic investigation of the Cd-Yb system. The x-ray diffraction pattern of the material showed that it is a quasicrystal, and selected-area electron diffraction verified a primitive icosahedral lattice. Laue diffraction patterns clearly show 5-fold, 3-fold, and 2-fold symmetry axes, and the many sharp reflections with these symmetries are indicative of highly ordered quasiperiodicity with long range icosahedral symmetry. Another unique characteristic of this compound is its congruent melting. All other quasicrystals up to this discovery are incongruent melting compounds.

This stable binary quasicrystal is expected to be valuable for studying stability and thermodynamics in binary phase diagrams. The binary compound will simplify the analysis of experimental results by reducing the parameters for theoretical calculation. How this cluster forms remains an open question.

For more information, contact A. P. Ts at Nationals Research Institute for Metal and CREST, Japan Science ans Technolog Corporation, Tsukuba 305-0047, Japan, e mail: aptsai@tamamori.nrim.go.jp. ▲

RIC News

Vol. XXXVI, No. 3 September 2001

Published
quarterly in March, June,
September, and December
by
Rare-earth Information Center
Ames Laboratory,
Institute for Physical
Research and Technology,
Iowa State University,
Ames, Iowa 50011-3020

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.ameslab.gov/ric/

R.William McCallum ..... Editor
K. A. Gschneidner ..... Editor Emeritus
Angela S. O'Connor ..... Writer

September 2001 SUPPORTERS

Since the June issue of the RIC News, we have received support from four new family members and renewed support from 13 other organizations and individuals.

The supporters from the third quarter of the 2001 fiscal year who wish to be listed, grouped according to their appropriate category, and with the number of years that they have contributed to RIC in parentheses, are listed below.

If you would like to become a supporter of the RIC, contact LaVonne Treadway at (515) 294-2272 or crem_ric@ameslab.gov. ▲

Donor ($4000 to $9999)

Sponsor ($2000 to $3999)

Patron ($1000 to $1999)
Molycorp, Inc., USA (32)

Sustaining ($400 to $999)
AMR Technologies, Inc., Canada (12)
Atlantic Metals & Alloys, Inc., USA (13)
Electron Energy Corporation, USA (7)
Lynas Corporation Ltd., Australia (11)
Industrias Nucleares do Brasil A.A., Brazil (27)
Wheeler Associates, USA (16)

Contributor (less than $400)
CerOx Corporation, USA (1)
Custom Technical Ceramics, USA (1)
Hitachi Magnetics Corporation, USA (27)
Engelhard, USA (5)

Individual
Mel Bohlmann, USA (7)
Lawrence J. Evans, USA (1)
Andrew Gillies, Australia (1)
Laura H. Greene, USA (5)
Gary D. Sandrock, USA (7)
A. M. Tishin, Russia (4)

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