RARE-EARTH INFORMATION CENTER NEWS

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STICKY SCALE

The fact that small additions of yttrium or hafnium, or their oxides, improve the adherence of the protective oxide coating of high temperature alloys is undisputed. How they accomplish this phenomenon is subject to debate. Among the mechanisms proposed to account for the improved adherence have been: (1) the formation of oxide pegs that anchor the scale to the substrate; (2) the prevention of vacancy coalescence at the scale-metal interface by providing alternate sites; (3) the enhancement of scale plasticity by altering its structure; (4) the alteration of scale growth processes; and (5) the formation of a graded oxide layer.

A. W. Funkenbusch, J. G. Smeggil, and N. S. Bornstein have proposed a new mechanism in *Metallurgical Transactions*, **16A**, 1164-6 (1985). They present the results of their surface analyses of an alloy with and without yttrium additions. They also present weight loss curves for thermally cycled alloys with different dopants. The addition of elemental yttrium improved the adherence even if some Y_2S_3 was also added. If Y_2S_3 was added by itself, the weight loss became high. The authors think the Y_2S_3 reduces to YS releasing sulfur to the main body of the alloy. Unless elemental yttrium is present to form YS with the sulfur it migrates under thermal cycling to the oxide-metal interface along with any other sulfur not tied up in stable sulfides.

They propose that the oxide coating is weakened by the segregation of sulfur at the oxide-metal interface under the action of thermal cycling. To support their view they report 20 atom percent sulfur in the top layers of the NiCrAl alloy that has a bulk concentration of only 50 ppm sulfur by weight. When 0.1 weight percent

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RE's in the News

New Magnet Facility

General Motors Corporation is building a 160,000 sq. ft. plant in Anderson, Indiana to produce neodymium-iron-boron magnets. The plant will require an initial investment of ~$70 million. General Motors will produce their super magnets under the trade name "MagneQuench" for use, initially, in starter motors. They hope to expand and make other magnets designed for use in other applications, not necessarily limited to the automotive field.

Turbine Blade Failures

In experiments at Sandia National Laboratories, Albuquerque, New Mexico, sodium and vanadium have been identified as the culprits in the failure of yttria-stabilized zirconia coatings on gas turbine blades. When clean fuel was used the blades could endure 10,000 cycles from room temperature to 1325 K and back. Too often in actual practice they would fail much earlier. It was discovered if only 5 ppm (parts per million) of sodium and 2 ppm of vanadium were added to the fuel, the coatings would peel from the blades with less than 100 cycles. Molten vanadate salts, formed in the combustion, leach the Y_2O_3 out and cause the ZrO_2 to change structure and peel.

Sneaky Subs

Submarines may not be able to sneak around undetected much longer, according to a story in *Popular Science*, **227**, [1] 72-75 (1985). Among the many schemes proposed for better detection of the subs are sonar systems operating at lower frequencies and with higher power out-

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Response to Open Letter

RIC has received several responses to the article "An Open Letter to the Rare Earth Community" concerning the proliferation of meetings. In summary: (1) there is a desire to include rare earths in biology and environmental sciences as a topic in future conferences *(Editor's note—there are two poster sessions on this topic at the Intl. Conf. on RE Development and Application being held in September 1985 in Beijing)*, and (2) a desire to coordinate some of the physics oriented conferences on "Crystal Fields" and on "Anomalous Rare Earth and Actinides." The editor also suggests that the "Valence Fluctuation" conferences should be considered along with the other two since many papers overlap all three themes.

MEETINGS

ISPAMH V

The 5th International Symposium on the Properties and Applications of Metal Hydrides will be held May 25-30, 1986 in Maubuisson, France. The symposium will cover experimental and theoretical aspects of hydride materials including the following: crystal structures and phase relationships, dynamics and kinetics, physical and mechanical properties, electronic structures, surface effects, and novel hydride systems. Applications covered include hydrogen storage, gas purification, catalysis, isotope separation, heat pumps, magnets and technical systems.

For more information write to Dr. A. Percheron-Guegan, Laboratoire de Chimie Metallurgique des Terres Rares, C.N.R.S., 1 place Aristide Briand, 92190 Meudon, France.

Pr-Nd

1885

Carl Gustav Mosander, in 1841, treated lanthana (La_2O_3) with dilute nitric acid and produced a rose-colored oxide. He thought it was the oxide of a new element, which he named didymium because, as he said, it seemed to be "... an inseparable twin brother of lanthanum." Although many scientists thought that didymium was really more than one element, no one could separate them and it was accepted as an element until 1885 when Carl Auer, Baron von Welsbach, managed to unlock the secret.

On June 18, 1885, Auer von Welsbach announced to the Vienna Academy of Sciences that he had succeeded in splitting didymia into two new elements. He had used repeated crystallizations of ammonium didymium nitrate to accomplish the separation. The lightest rare earth was named praseodymium from Latin for green twin, and the other neodymium from Latin for new twin. Baron Auer von Welsbach is better remembered for inventing the gas mantle that uses thorium and cerium to produce incandescent light and is named after him.

Praseodymium is used in electronics, magnets, lasers, steels, and catalysts. Probably its most unique application, from a scientist's point of view, is in nuclear adiabatic refrigeration where $PrNi_5$ has been used to achieve record low temperatures of only a few microkelvin (millionth of a kelvin).

Neodymium is used in many laser applications. It is usually the lasing ion in a different host but some of its compounds are also used as the laser body. Some other applications are in catalysts, electronics, and metallurgy. The newest and most promising application is in the new Nd-Fe-B magnetic material that has recently been developed.

Belated Thanks

We wish to thank Ergenics, Incorporated for their support during the 1985 fiscal year. We inadvertently omitted them from our list of contributors at the time we received their support.

CONFERENCE CALENDAR

Intl. Conf. on Rare Earths Development and Applications and Intl. Fair for Rare Earths and Their Application Products
Beijing, People's Republic of China
September 10-14, 1985
RIC News **XIX** [2] 2 (1984)

Chemistry of Lanthanides and Actinides at X Annual Symposium of São Paulo Academy
São Paulo, Brazil
November 6-8, 1985
RIC News **XX** [2] 2 (1985)

*5th Intl. Symposium on the Properties and Applications of Metal Hydrides
Maubuisson, France
May 25-30, 1986
This issue

17th Rare Earth Research Conference (RERC)
Hamilton, Ontario, Canada
June 8-12, 1986
RIC News **XIX** [2] 3 (1984) and **XX** [1] 3 (1985)

Intl. Conf. on Anomalous Rare Earths and Actinides (I.C.A.R.E.A.)
Grenoble, France
July 7-11, 1986
RIC News **XX** [2] 2 (1985)

2nd Intl. Conf. on the Basic and Applied Chemistry of the *f*-Transition (Lanthanide and Actinide) and Related Elements (2nd I.C.L.A.)
Lisbon, Portugal
April 6-10, 1987
RIC News **XIX** [4] 3 (1984) and **XX** [2] 2 (1985)

JOE BECKER

The Rare-Earth Information Center recently learned of the death of Joseph J. Becker on October 13, 1984, at the age of 61. He was born in Germany and came to the United States as a young boy. He received his bachelor's, master's, and doctor's degrees in 1943, 1947, and 1950, respectively, in physical metallurgy at Harvard University in Cambridge, Massachusetts. He worked for General Electric as a metallurgist and during his 34-year career became a world renowned scientist in the field of magnetism and magnetic materials. Becker was a pioneer in the study of cobalt-rare earth permanent magnets, amorphous metallic alloys, and recently was active in the study of rare earth-boron-iron alloys. In May of 1985 he was honored posthumously at the 8th International Workshop on Rare Earth Magnets in Dayton, Ohio. A certificate attesting to his pioneering work and contributions in the field of rare earth magnets was prepared and signed by the organizing committee of the workshop. His numerous review articles will keep his name alive in the literature for many years.

MEMORIAL SCHOLARSHIPS

In honor of their accomplishments and to perpetuate their memories, memorial scholarship funds have been started for Drs. Spedding and Legvold. For the news of their passing see *RIC News*, **XX**, No. 1, 1 (1985).

The Frank H. Spedding Memorial Fund will provide scholarships for science students at Iowa State University. Donations may be sent to the Frank H. Spedding Memorial Fund, First National Bank, Fifth and Burnett, Ames, Iowa 50011, U.S.A.

The Sam Legvold Memorial Fund will be used for scholarships for undergraduate physics majors at Iowa State University. The fund will recognize outstanding juniors by providing them with scholarships for their senior year. Donations may be sent to the Sam Legvold Memorial Fund (account no. 79M), ISU Achievement Foundation, Alumni Suite, Memorial Union, Iowa State University, Ames, Iowa 50011, U.S.A.

SOLID MOMENTS

The proceedings of a NATO Advanced Study Institute on Moment Formation in Solids, held August 21 to September 2, 1983, on Vancouver Island, Canada, has been published by Plenum Press in 1984 as volume 117 of the NATO ASI Series. Entitled *Moment Formation in Solids*, the 336-page book costs U.S. $49.50 and is available from Plenum Press, 233 Spring Street, New York, New York 10013, U.S.A. The editor is W. J. L. Buyers and the book contains 23 papers written by 31 authors.

The following quote from the preface best introduces the book. "The problem of moment formation in metallic systems lies at the interface of localized and itinerant magnetism. The phenomena observed correspond to destruction rather than to formation of spin-correlations. They give rise to the progression from localized ground states through Kondo and mixed-valence behaviour to itinerant magnetic or nonmagnetic systems. Somewhere in the progression superconductivity can occur in the presence of *f*-moments."

This book should provide a summary for research scientists and graduate students on the state-of-the-art for Kondo and intermediate-valence systems up through 1983.

Surface Purity

According to the developers, a new two-laser system has the potential to be the most accurate and sensitive way known to measure surface impurities. Being developed by D. M. Gruen and his team at the Argonne National Laboratory, Argonne, Illinois, the technique is known as Surface Analysis by Resonance Ionization of Sputtered Atoms (SARISA). Other team members are M. J. Pellin, C. E. Young, and W. F. Callaway. The system includes an ion gun, a pulsed Nd:YAG pumped dye laser, a XeCl excimer laser, and suitable extraction and detection systems.

The ion gun is used to bombard the surface of the target sample, thus creating a flux of charged and neutral atoms, molecules, and clusters. The output of the Nd:YAG pumped dye laser is tuned to a frequency resonant with one of the electronic transitions of the impurity of interest. This excites these atoms, which are then ionized by a burst of energy from the XeCl excimer laser. Gruen says, "In theory we should be able to detect the presence of only a few atoms of any element by properly tuning the lasers."

While not quite at this stage yet, the present setup can detect iron in silicon at the 300 ppb atomic level with an accuracy of 1 part in 10^6.

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Russian Acquisitions

The RIC has just received a copy of the Russian book *Vvedenie v Strukturnuyu Fiziku Redkozemel'nykh Intermetallicheskikh Soedinenii (Science of the Structural Physics of Rare Earth Intermetallic Compounds)* from its author, A. S. Ilyushin. The book contains 100 pages and was published in 1984 by Izdatelstov: Moskovskogo Universiteta, Moscow.

The RIC has also received numbers 19, 20, and 21 of *Redkozemel'nye Poluprovodniki i Drugie Soedineniya RZM. Ukazatel' Otechestvennoi i Inostrannoi Literatury (Rare Earth Semiconductors and Related REM Compounds. Index of Russian and Foreign Literature)* edited by V. P. Zhuze. The bibliographies are published by the Fiziko-Teknicheskii Institut im A. F. Ioffe, Akademii Nauk SSSR, Leningrad. Number 19 was published in 1983 while 20 and 21 were published in 1984. They contain 480, 571, and 515 citations, respectively. The references are printed in their original languages. Foreign references have a Russian translation while Russian references have an English translation. The bibliographies have both an English and Russian Table of Contents and an Author Index.

Magnetic Superconductors

K. N. Shrivastava and K. P. Sinha have published a review with 173 references on rare earth compounds that display superconductivity and/or magnetic ordering. Published in *Physics Reports,* **115,** 93-149 (1984), the review can be obtained from Elsevier Science Publishers B.V., Reprint Department, P.O. Box 211, 1000 AE Amsterdam, The Netherlands. The price, including postage, is Dfl. 35.00 (~U.S. $9.50).

The first half of the review is devoted to the development of the theoretical models and theories that have been advanced to predict some of the properties of the magnetic superconductors. Some of these models predict reentrant behavior in some systems (ferromagnetic superconductors) and coexistence regions in others (particularly antiferromagnetic superconductors). Among the parameters for which values are predicted are the upper and lower critical fields and temperatures.

(Continued in next column)

Most of the experimental data reviewed are for the ternary borides and molychalcogenides RRh_4B_4 and RMo_6S_8. Among the other compounds discussed are RRu_2, $NdRh_6B_6$, ROs_xSn_y, RRh_xSn_y and $YbPd_2Ge_2$.

LASER CRYSTALS

A. A. Kaminskii has authored an informative review article entitled, "Achievements in the Field of Physics and Spectroscopy of Activated Laser Crystals." The review was published in *Phys. Stat. Solidi (a),* **87,** 11-57 (1985) and includes a bibliography with 184 entries.

Ionic laser crystals bring together many disciplines, including solid state physics, spectroscopy, quantum chemistry, crystallography, and inorganic synthesis. High success rates in the search for new lasing systems are not to be expected, nevertheless, 7 to 10 reports of new lasing crystals and their physical and spectoscopic investigations are reported each year.

According to the review, 204 crystalline hosts used for activation by lasing ions have been reported and 319 laser crystals different in structure and/or composition have been created using these hosts. Of the 204 host crystals, 161 contain rare earth elements. The laser crystals are mainly fluoride or oxide compounds and most of them (291) are doped with trivalent rare earth (R^{3+}) ions, including 143 involving the Nd^{3+} ion, 56 the Ho^{3+} ion, and 36 the Er^{3+} ion. The wave lengths of the stimulated emission of the lasers range from 0.172 to ~ 5.15μm.

The review has sections dealing with the following topics: (1) laser garnets, (2) disordered laser crystals for stimulated-emission excitation of Nd^{3+} ions, (3) low-threshold laser crystals with Nd^{3+} ions, (4) crystals with R^{3+} ions for lasing in the visible, (5) tunable laser emission of activated crystals, (6) laser crystals with high concentrations of R^{3+} ions, and (7) real intensity of R^{3+} ion laser channels in crystals.

A. A. Kaminskii's interesting review is well put together. It should prove valuable to those groups looking for new laser systems and informative to people using the lasers based on the ionic crystals described in the review.

$$ 1986 $$

Fiscal year 1986 is under way and the number of companies sending in their pledges of support is a little behind last year's pace. A good second quarter will quickly make up the difference. We received pledges from 13 sponsors renewing their support and added 2 new members to our supporting cast. The 15 companies on our early list for fiscal 1986, with the number of years they have been supporting the RIC in parentheses, are listed below.

Aran Isles Chemicals, Incorporated, U.S.A. (2)
A/T Products Corporation, U.S.A. (6)
Companhia Industrial Fluminense, Brazil (13)
Denison Mines Limited, Canada (14)
Gesellschaft für Elektrometallurgie, West Germany (1)
Lanthanide Research Corporation, U.S.A. (2)
Mitsubishi Metal Corporation, Japan (2)
Nissho Iwai American Corporation, U.S.A. (5)
NUCLEMON—Nuclebrás de Monazita e Associados Ltda., Brazil (12)
Rare Earth Products Limited, England (14)
Reactive Metals and Alloys Corporation, U.S.A. (10)
Reactor Experiments, Incorporated, U.S.A. (16)
SCI Incorporated, U.S.A. (1)
Treibacher Chemische Werke AG, Austria (14)
Wako Bussan Company, Limited, Japan (17)

In the News

(Continued from page 1)

puts. Sonar experts at Gould Defense Electronics Division in Glen Burnie, Maryland are working on a high-powered, low-frequency transducer using "Terfenol D", a rare earth alloy of terbium, dysprosium, and iron. Terfenol was developed by A. E. Clark and coworkers at the Naval Surface Weapons Center, Silver Spring, Maryland and by O. D. McMasters of the Ames Laboratory at Iowa State University. It has 10 times the power of an equal sized ceramic type transducer and resonates at 1.35 kilohertz compared to normal sonar frequencies of 3 to 15 kilohertz.

Rare Earth Data Cards

North-Holland Physics Publishing, a division of Elsevier Science Publishers B.V., has made available a 6 cm x 8 cm plastic card on which many of the electronic and physical properties of the rare earths are listed. The free cards may be obtained from the publishers of the *Handbook on the Physics and Chemistry of Rare Earths* by writing to Ms. C. Schilpp, marketing manager, North-Holland Physics Publishers, P.O. Box 103, 1000 AC Amsterdam, The Netherlands. This handy pocket card lists the electronic properties, including number of 4*f* electrons; quantum numbers S, L, and J; spectroscopic ground-state symbol; g; μ; and μ_{eff} on one side. On the other side are the physical properties including crystal structure, metallic radius, atomic volume, density, melting and boiling points, and heat of sublimation at 298 K.

Scale

(Continued from page 1)

yttrium was added, the surface concentration dropped to about 5 atom percent. While still quite a bit higher than the bulk concentration the adherence of the oxide coating was improved.

The authors suggest that other impurities such as phosphorus, chlorine, etc. may also adversely affect the scale adherence. The complex interplay between these minor impurities, added reactive elements, and processing variables would therefore be important. They state that the recognition of such an interplay has been absent in the past and that additional research is warranted in this area due to the technological importance of oxidation resistant high temperature alloys.

RE Magnet Workshop

The *Proceedings of the 8th International Workshop on Rare-Earth Magnets and Their Applications and the 4th International Symposium on Magnetic Anisotropy and Coercivity in Rare Earth-Transition Metal Alloys* has been published by the University of Dayton's School of Engineering. The workshop and symposium were held May 6-9, 1985 in Dayton, Ohio. Edited by Karl J. Strnat, the Proceedings, containing 793 pages, may be obtained from the Magnetics Laboratory (KL-365), University of Dayton, Dayton, Ohio 45469, U.S.A. The price is U.S. $45.00 plus a $5.00 mailing charge. For overseas orders the mailing charge is $12.00 if airmail shipment is desired.

The three sessions dealing with the applications of permanent magnets were entitled, (1) magneto-mechanical devices and electric motors, (2) electronic devices and mechanical design, and (3) medical and dental uses of magnets. Three sessions on permanent magnetic materials were held with the papers almost equally divided between those on rare earth-cobalt magnetic material and those on rare earth-iron-boron alloys. One session was held on raw materials and one on testing of magnets.

The symposium dealt with the phases, structure, anisotropy, coercivity, and domains of permanent magnets made from rare earth alloys. One paper discussed the use of $R_2Fe_{14}B$ for magnetic recording.

Business News

Rhone-Poulenc Inc., Special Products Division, Monmouth Junction, N. J. announced the appointment of Barbara Gan as Venture Analyst, Commercial Department.

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