Rare-earth Information Center Insight

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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Karl Chills Out

In case you are wondering what Karl Gschneidner Jr. is doing with all of his spare time since he turned the directorship of the RIC over to me, a recent press release will interest you. Working on a project funded by DOE's Advanced Energy Projects, he has been working on developing magnetic refrigeration. Magnetic refrigeration has been used for years by low temperature physicists to obtain temperatures below 1 K, but this project is aimed more toward freezing ice cream than keeping physicists from wandering the streets. Astronautics Corporation of America and Karl's group at Ames Laboratory have teamed up to produce a demonstration unit for near-room temperature refrigeration, which produces over 500 watts of cooling power, which has been in operatation for ten weeks. The refrigerator contains 3 kg of Gd metal spheres as the working media. Gschneidner predicts that a newly developed alloy will result in a 30% enhancement in performance. It is expected that magnetic refrigeration can compete effectively in such large scale applications as food processing, supermarket chillers, and air conditioning of large buildings.

Fatigue Resistance

Thin films of lead zirconate titanate (PZT) are ferroelectric and are being evaluated for use in such applications as nonvolatile and dynamic random access memory. Unfortunately, when the polarization of the material is cycled, the properties degrade with time. For some applications, this might not be a problem since the degradation or fatigue, as it is referred to, takes place over millions or billions of cycles. This, however, is not acceptable for memory applications. In order to address this, S. B. Majumder *et. al.* {*Appl. Phys. Lett.,* **70**, [1], 138-40 (1997)} have investigated CeO doping of lead zirconate titanate films prepared by a sol-gel route on platinum substrates. Cerium doping was found to significantly enhance the fatigue resistance of the films and improve the ferroelectric properties. While the exact cause of fatigue is still debated, it may be associated with movement of oxygen vacancies within the film during cycling. The authors suggest that the Ce substitutions may serve to pin oxygen vacancies and, hence, reduce cycle dependence.

Ten Years of High T_c

This past year marked the tenth anniversary of high temperature superconductivity. The discovery of superconductivity in the La-Ba-Cu-O system by Bednorz and Müller set off one of

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Telephone: 515-294-2272 Facsimile: 515-294-3709 Internet: RIC@AMESLAB.GOV

the most extensive research frenzies of the century. P. J. Ford and G. A. Saunders {*Contemp. Phys.*, **38**, 63-81, (1997)} have presented an overview of both the state of superconductivity in 1986 and the developments that have occurred since then. The article makes interesting reading for anyone casually interested in what has happened in this field.

Electron Emitters

Electron beam ion sources require high electron beam current densities of order $10^3 A/cm^2$. These may be achieved by focusing the beam from cathodes with lower current densities, but the more focusing that is required, the more difficult are the alignment problems associated with the large magnetic fields. R. Rao and O. Kultashev {*Meas. Sci. Technol.*, **8**, 184-8, (1997)} have demonstrated a cathode constructed from a two phase Ir-Ce alloy containing 8% Ce. From the phase diagram, this alloy is composed of Ir and $CeIr_5$. The cathode was formed by spark cutting from an arc melted button. The cathode is heated to 2100 K during operation. This temperature is 80 K below the liquidus temperature of the alloy. In operation, the material has a low work function, which is attributed to free Ce on the surface. A current density of 230 A/cm^2 was obtained. Increasing the anode voltage above that required for this maximum value resulted in a decrease in current density.

CeO_2 Sol-gel Coatings

For operation at high temperatures in an oxidizing atmosphere, passivating oxide films must be developed for metals such as nickel, chromium and nickel-based superalloys. F. Czerwinski and J. A. Szounar {*Thin Solid Films,* **289,** 213-9, (1996)} have investigated the possibility of using CeO_2 sol-gel coatings to enhance the oxidation resistance of these materials. The interesting thing about the sol-gel coating is that it is not a dense protective layer of ceramic "that protects" the metal. It appears, that under the conditions which result in the maximum enhancement of oxidation resistance, the sol-gel coating technique introduces fine particle of CeO_2 into the native oxide which forms on the material. This particulate dispersion then enhances the adherence of the native oxide and may reduce diffusion along grain boundaries. This eliminates cracking and spalling of the native film and, hence, provides significant enhancement of the oxidation resistance.

Neodymium Hydrogen Detection System

While the technique is not new, a recent paper by S. M. Toy {*J. Mater. Sci. Lett.*, **15**, 2042-43 (1996)} has focused on the reaction mechanism when Nd thin films are used for the detection of ppm quantities of hydrogen in metals. In the reported work, thin films of Nd were placed in contact with high strength steel, which had been charged with H. When the assembly is heated to 149°C, the H leaves the steel and reacts with the Nd. The current paper traces the reaction path from the initial formation of a bubble in the Nd to the formation of NdH_2. The amount of H may be quantified by either SEM or TEM analysis.

R. W. McCallum
Director CREM/RIC