Rare-earth Information Center

Insight

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SO_2 Sensor

The monitoring of sulfur oxides in combustion exhausts is becoming increasingly important in order to meet environmental requirements to reduce acid rain. Currently, most monitoring are performed with spectroscopic instruments, which are both bulky and expensive. Small solid-state sensors, similar to YSZ oxygen analyzers, are highly desirable. Recently, S. Suganuma et al. {*Solid State Ionics,* **126**, 175-9 (1999)} have demonstrated such a sensor utilizing YSZ and sulfate salts. As in the YSZ oxygen analyzer, the YSZ is an O^+ ion conductor. In order to detect SO_2, the SO_2 is first oxidized to SO_3 at a Pt grid. The sensor itself is a sandwich with an Ag coated Pt grid, a layer of Ag_2SO_4-based sulfate salts, the YSZ and finally a Pt reference electrode. In the presence of SO_3, O_2 is dissociated at the reference electrode interface, and the O^{2-} is conducted through the YSZ. At the sensing electrode auxiliary phase interface, the reaction $2Ag + O^{2-} + SO_3 = Ag_2SO_4 + 2e^-$ takes place. Since we have extra electrons on the sensing electrode side and are short electrons on the reference electrode side, and EMF appears across the cell. The EMF is linear in the logarithm of the SO_2 concentration following the Nernst equation with a slope of 85.6 mV/decade. The sensor, which operates over the range 1 – 1000 ppm, has a 90% response time of ~40 s when operated at 600°C. Preliminary field tests in the exhaust pipe of a boiler indicate that the sensor is stable under those operating conditions.

Polar Kerr Rotation in Amorphous Nd-Fe-B Films

Conventional magneto-optical recording uses red laser beams ($\lambda \approx 700$ nm) and amorphous heavy rare earth – transition metal alloy films, which have an easy axis perpendicular to the film plane. The maximum bit density that can be obtained in these devices is limited by the minimum optical spot size: the diffraction limited spot size, which is determined by λ. With the development of blue ($\lambda \approx 700$ nm) laser diodes based on GaN single crystals, the diffraction limited spot size is significantly reduced. Unfortunately, the Kerr rotation angle for the conventional medium is also significantly reduced at the shorter wavelength. While light rare earth transition metal alloys have large Kerr rotations for the blue wavelength, sputtered amorphous films of these materials lack the perpendicular magnetic anisotropy required for optimum performance. In an attempt to increase the perpendicular anisotropy of sputtered films, J.-Y. Kim et al. {*J. Appl. Phys.,* **86**, [8], 4544-7 (1999)} have investigated the effect of boron in amorphous NdFe films. Starting with the binary composition $Nd_{0.38}Fe_{0.62}$, which yields optimum Kerr rotation, they systematically added B. Unfortunately, the B addition reduces the Fe moment so there is a substantial reduction in magnetization. In addition, the perpendicular anisotropy is reduced.

Interestingly, the Kerr rotation angle, which increases with decreasing wavelength for all concentrations of B, is systematically enhanced by the addition of B. This reflects the fact that the Kerr rotation is determined by the energy levels in Fe and Nd. As B is added to the alloy, one electron per B atom is transferred to the 3*d* band of Fe, which changes the Fermi level changing both the Fe moment and the Kerr rotation. The results are discouraging from the point of view of magnetic recording, but provide interesting information on the factors involved in the Kerr rotation.

Travel Notes

In late October, I attended "The International Symposium on Magnets and Applications (SOMMA '99)" held at Chungnam National University, Taejon, Korea. The symposium celebrated the opening of the Research Center for Advanced Magnetic Materials (ReCAMM) at Chungnam National University, which has been recently funded by the Korean Science and Engineering Foundation. ReCAMM brings together 25 professors and researchers from 15 different universities, research institutes and industry to advance the state-of-the-art technology in magnetic recording, MEMS (Micro Electro-Mechanical Systems) and magnetic devices. The center is to play a major role in educating students and researchers for Korea's magnetic industries. Collaborative international partnerships are sought. Contact: Prof. Chong-Oh Kim, magnet@web.cnu.ac.kr.

Immediately following the Korean symposium, I traveled to Hanoi, Vietnam. In Hanoi, I visited the National University of Hanoi as part of a National Science Foundation sponsored program to enhance international collaborations with Vietnamese scientists. The trip was time to correspond with the Third International Workshop on Materials Science (iWOMS'99). The workshop brought an impressive array of international scientists, including strong groups from the Netherlands, to Hanoi, and provided extensive interactions between scientists.

Center for Rare Earths and Magnetics (CREM) MRSEC Proposal

The NSF Materials Research Science and Engineering Center (MRSEC) program supports interdisciplinary university based group research and educational activities in the areas of materials science and engineering, condensed matter physics, solid state and materials chemistry, and related areas of science and engineering. Following a preproposal evaluation, CREM, the parent of the RIC, will be submitting a full proposal for the ***Center for Integrated Structural Imaging and Modeling of New Materials***. If selected, this center will receive approximately $8,000,000 over a five-year period. The center will thus focus on the development of an integrated microstructural imaging and modeling approach to new materials. The goal of the proposed center is to develop models so that new materials can be developed through accurate theoretical modeling that can be coupled with high speed computing to explore a wide range of new materials in a highly systematic manner. These models will be validated through experimental studies that use state-of-the-art three-dimensional imaging techniques.

Part of the role of a MRSEC involves active cooperation with industry, to stimulate and facilitate knowledge transfer among the participants and strengthen the links between university-based research and its application. In our tentative model, industrial affiliates would participate in the educational programs of the center that will be based around short courses on microstrucutral development and advanced characterization techniques. Collaborators may be themselves involved in research, which compliments the research in the center, or may be actively involved in the research through the exchange of materials, ideas and if appropriate, researchers. The basic research at ISU and UW, which is the core of a MRSEC, will be fully supported by NSF and University funding, as will be the educational programs.

Company Notes

On November 1, 1999, Moltech Corporation announced the completion of its acquisition of Energizer Power Systems from Eveready Battery Company and has formed Moltech Power Systems, a wholly owned subsidiary. Ralston Purina, the parent company of Eveready, announced its plans to exit the OEM rechargeable battery business in April 1999 and reached an agreement to sell the division to Moltech on September 28, 1999. Moltech Corporation was founded in 1988 as a spin-off from Brookhaven National Laboratory and since 1994 has focused on Lithium-Sulfur rechargeable batteries. Of interest to the rare earth community, the new subsidiary, Moltech Power Systems, produces NiMH rechargeable batteries. (http://www.moltechpower.com/)

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