Rare-earth Information Center

Insight

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Erbium as a probe of everything?

This is the rather provocative title of a paper by A. Polman {*Physica B*, **300**, 78-90 (2001)}. In reality, Polman does not use Er as a probe of everything, but he demonstrates that the optical properties of rare earth ions may be used as a probe to investigate point defects, oxygen, OH, Er concentration, radiation structure, excitons, optical density of states, optical modes, and photonic bandstructure. Polman focuses on Er rather than one of the other trivalent RE ions for the same reason that I have reported numerous studies on Er-doped fibers, the energy of the transition from the first excited state of the ion to its ground state corresponds to a wavelength of 1.54 μm, which is the wavelength of maximum transmission in silica optical fibers. Our fiber optic networks would not function without Er-doped fiber amplifiers. Polman uses either the diffusion properties of Er or its optical properties as a probe. The article provides a nice introduction to the optical properties of Er when placed as an isolated 3+ impurity in a matrix, and how these properties may be used to probe the laundry list of properties given above. For those of us who like metals, Polman's everything falls short as isolated Er^{3+} ions are pretty much limited to doping in semiconductors and insulators. He has studied point defects in amorphous Si (a-Si) by using the diffusion of Er^{3+} ions. The optical properties of the Er^{3+} ions have been used to determine that the ions are trapped at the point defects in a-Si. Thus, the point defects can be studied using the diffusion of Er^{3+} through them. Luminescence properties are strongly influenced by non-radiative paths for the decay from the excited state to the ground state. For instance, the second harmonic of the stretch mode of OH has the same energy as the optical transition. Therefore, when OH is present, an excited Er^{3+} can relax to the ground state by emitting an optical photon or by transferring the energy to the OH phonon. Thus, the number of photons emitted is reduced in a predictable way by the presence of OH. The paper does not provide great detail of any of the applications, but it does provide an extensive list of original references.

Y and Corrosive Wear in 304 Stainless

Corrosive wear is a significant problem in many environments. Passivating coatings that resist corrosion are only effective if they are not removed under a wear environment. A typical application might be a bearing surface in salt water. Stainless steel is corrosion resistant, because of the formation of an adherent Cr oxide film. Under wear conditions, the mechanical properties of the film become extremely important. Additions of Y and Ce have been shown to increase the corrosion wear resistance of 304 stainless in dilute H_2SO_4 solutions. X. Y. Wang and D. Y. Li {*Mater. Sci. Eng. A*, **315**, 158-65 (2001)} have recently studied the mechanical properties of the passivating coatings formed on 304 stainless with Y additions. The critical load required to cause a failure of the passivating film was found to be higher in Y-containing 304 stainless than in the Y-free control. In addition, the electron work function of the Y-containing steel was also enhanced indicating that the film was chemically more stable.

Triboluminescence

When some materials are subject to mechanical stress, they emit light. This phenomenon has been known for hundreds of years and is referred to as

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triboluminescence. The origins of triboluminescence are not completely understood, but recently there has been considerable interest in lanthanide compounds that exhibit "brilliantly triboluminescent properties." This appears to be a rather subjective statement, as samples are crushed to obtain the luminescence spectrum, so that the peaks in the spectrum may be accurately determined, but the intensity is highly dependent on geometry. In any case, I do not expect to see a flashlight operating from a thumbscrew any time soon. It has been proposed that piezoelectricity is both a necessary and sufficient condition for a material to exhibit triboluminescence. Piezoelectricity requires that the crystal structure be non-centrosymmetric in apparent contrast to the observation of triboluminescent compounds. X-F Chen et al. {*Mater. Chem. Phys.*, **72**, 11-15 (2001)} have investigated this problem following a suggestion that impurities or disorder may play an important role in triboluminescence of centrosymmetric compounds. They investigated four Eu complexes in the $[Eu(TTA)_4]Y$ system, where TTA is 2-thenoyltrifluoroacetone, and Y is not yttrium, but rather things like 1,2 dimethylpyridinium. Both the triboluminescence and crystal structure were carefully determined, and in the complexes with centrosymmetric space groups that exhibited triboluminescence disorder was found in the thienyl rings and CF_3 groups.

Self-assembled Magnetic Nanodots

When magnetic particles are reduced in size to a scale of a few tens of nanometers, there are significant changes from bulk magnetic behavior due to the fact that thermal fluctuations become important, and the number of surface atoms becomes a significant fraction of the total structure. One might expect even more significant changes, as the conditions for periodic boundary conditions are no longer met, which should imply significant changes in the band structure. Therefore, there is considerable interest in studying systems of noninteracting magnetic nanoparticles. A major problem is to prepare such a system. P. Katiyar et al. {*Appl. Phys. Lett.*, **79**, [9], 1327-9 (2001)} have used pulsed-laser deposition (PLD) of $La_{2/3}Ca_{1/3}MnO_3$ (LCMO) and alumina to prepare a self-assembled nanoscale composite of magnetic nanodots in a non-magnetic matrix. Self-assembly makes use of such factors as diffusion rates and surface energy to produce a uniform of magnetic particles without resorting to lithographic techniques. In the current study, LCMO and alumina were alternately deposited on silicon substrates in ~100mTorr of oxygen. The size of the magnetic LCMO particles could be controlled by selecting the substrate temperature and relative deposition times for magnetic and nonmagnetic constituents. The resulting assembly of noninteracting magnetic particles was found to be superparamagnetic above a blocking temperature of 100 K. The blocking temperature is the temperature above which the magnetization of an individual particle will flip due to thermal fluctuations in less than the measurement time, while below that temperature thermal relaxation is much longer than the measurement time. Below the blocking temperature, the thermal energy is still non-negligible with respect to the energy required to overcome the anisotropy energy. Thus, the coercivity of the assembly of particles is reduced in a calculable way as the temperature approaches the blocking temperature. The temperature dependence of the coercivity for the LCMO particle is in excellent agreement with that expected for uniform nonintereacting particles.

Conference Announcements

The Japan Association of Bonded Magnet Industries will hold its "2001 BM Symposium" December 7, 2001 in Tokyo. For more information FAX 03-5811-6892 or email JDY04537@nifty.ne.jp.

23rd Rare Earth Research Conference to be held at University of California, Davis campus July 13-18, 2002. I have enclosed a letter from Prof. Susan M. Kauzlarich seeking corporate supporters for the conference.

Sincerely,

R. W. McCallum
Director of RIC