Rare-earth Information Center

Insight

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Upconversion Fluorescence and Lasing

Normally, when you think about fluorescence of an element, the excited photon is at a shorter wavelength than the emitted photon. In fact, for processes which involve the absorption of a single photon, this is required by the law of the convervation of energy. Under favorable conditions it is possible for an atom to absorb one photon, and then before it has a chance to relax either radiatively or non radiatively, absorb a second photon exciting it to a high level state that relaxes by the emission of a photon of shorter wavelength than either of the absorbed photons. This process is called upconversion. This process is of interest due to the possibility of infrared-pumped lasers which emit in the visible range. The desire for solid state lasers at short wavelength is driven by the fact that the optical data storage is limited by the minimum diffraction limited spot size of the laser. Therefore, a shorter wavelength means higher bit density. The conditions for upconversion are that the atom must have the appropriate optical transitions and that the lifetime of the intermediate transitions be sufficiently long for there to be a reasonable probability of absorbing a second photon before decaying. Upconversion has been observed in many rare earth doped glasses including those doped with Er^{3+}, Ho^{3+}, Pr^{3+}, and Tm^{3+}. As there is often more than one allowed decay path from the final excited state, a single pumping wavelength may be converted into emissions at two higher wavelengths. While the energy levels for each ion are determined by atomic parameters, the splitting between levels is determined by the crystal field splitting due to the host lattice and the non-radiative lifetimes are determined by the phonon spectrum of the host. For this reason, the host is typically a glass with small maximum phonon energy which reduces the losses to non-radiative decay via multiphonon processes. Recently, S. Kishimoto and K. Hirao {*J. Appl. Phys.*, **80**, [4], 1965-69 (1996)} reported intense ultraviolet and blue upconversion fluorescence in Tm^{3+}-doped fluoroindate glasses. The observed intensities are much larger than that observed in other fluoride or oxide glass hosts when pumped by 650 nm red light at room temperature. While the phonon energy of the host glass was found to play a major role in the upconversion intensity, other factors were also found to be important and are currently being investigated.

In an interesting application of upconversion, D. M. Baney *et. al.* {*Appl. Phys. Lett.*, **69**, [12], 1662-64 (1996)} reported an upconversion laser pumped by an infrared semiconductor and lasing simultaneously at two different visible wavelengths. The laser is based on ZBLAN fluorozirconate glass doped with Pr^{3+} and Yb^{3+}. The authors claim that upconversion lasers have a much broader pump wavelength and polarization tolerance than other candidates for compact visible lasers using optical doubling schemes. In the reported laser, the emission comes from the excited states of the Pr^{3+}. The Yb^{3+} is used as a sensitizer. Yb^{3+} has a single excited state which limits the possibilities for decay, while at the same time phonon mediated energy transfer activates the desire Pr^{3+} intermediate state. The laser was in the form of a fiber laser. The authors note that there are no

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previously published reports of a single device simultaneously lasing at two widely spaced wavelengths.

$Y_{0.9}Ca_{0.1}FeO_3$ Cathode for Solid Oxide Fuel Cells

A rare earth material, $Y_{0.9}Ca_{0.1}FeO_3$, has been suggested as a candidate for the cathode material in solid oxide fuel cells. Undoped $YFeO_3$ does not have the required conductivity but doping with CaO results in p-type conductivity sufficient for cathode applications. C.-S. Kim and H.-I. Yoo {*J. Electrochem. Soc.*, **143**, [9], 2863-70 (1996)} report that the ionic conductivity is due to oxygen anions. They have studied the ionic conductivity over six orders of magnitude and determined the activation energy for ionic conduction. The defects responsible for conductivity are discussed and the limits of stability for the material are determined.

Thick-film Based Position Sensors

The giant magnetoresistance (GMR) or colossal magnetoresistance (CMR) of manganese perovskites has been of considerable interest over the last few years. Recently, L. I. Balcells *et. al.* {*Appl. Phys. Lett.*, **69**, [10], 1486-88 (1996)} have extended this interest from the strictly scientific to the applied with the fabrication of a thick film position sensor. The sensor is based on thick films of $La_{2/3}Sr_{1/3}MnO_3$ which were prepared using a simple spray printing technique. Submicron powders of the perovskite material were suspended in a solvent and sprayed onto an alumina substrate with an airbrush. Following a three-step heat treatment, the films exhibit a variation of about 1.2% in resistivity at room temperature with the application of a 4 kOe field. The films were incorporated into a position detector which included a permanent magnet as a bias field generator. Successful operation of the sensor was demonstrated.

Short Notes

Japan New Materials Report, **11**, [4], 7 (1996) reports that Sumitomo Special Metals Co. Ltd. has developed a Nd based magnet that can be used at temperatures up to 200°C. The materials designation is "Neomax EH". The higher temperature performance is said to be made possible by a new powder production process which improves the uniformity of the grain size within the material and restricts it to five microns or less. Also reported (p. 12) is the commercial availability of a 4KW YAG laser welding machine from Sumitomo Heavy Industries Ltd. This is claimed to be the largest commercially available machine. A report on the National Research Council study to be conducted into the feasibility of tagging explosives {*C&EN*, **74**, [37], 10 (1996)} contains an interesting note that the Swiss company, Plast Labor, produces a product containing rare earth elements embedded in synthetic granules. The tagging code is based on the melting point of the matrix and the composition of the embedded elements.

The Department of Energy program on Tailored Microstructures in Permanent Magnets, a multilaboratory program in advanced materials, will be having an open meeting to report research results in conjunction with the 41st Magnetism & Magnetic Materials Conference. The DOE Meeting will be held at the Atlanta Hilton and Towers on Monday, November 11th at 2:00 p.m. The meeting is in the Henry Room on the 2nd floor. For more information contact Bob Dunlap, Argonne National Laboratory, Tel: 630-252-4925, Fax: 630-252-4798, bddunlap@anl.gov.

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