Rare-earth Information Center Insight

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Fracto-Luminescence

Fracto-luminescence, the luminescence which is observed when some materials are fractured, is well known. A common example is the white emission often observed due to the friction of feldspar and the cleavage of mica under low light conditions. T. Ishihara et al. {*Jpn. J. Appl. Phys.*, **63**, 781-3 (1997)} have observed "surprisingly strong luminescence", when crystals of rare-earth doped hexacelsian ($BaAl_2Si_2O_8$) are cleaved. The fact that these doped crystals give off colored light should not be entirely surprising to the rare earth community. Eu gives blue; Sm gives red; and presumably the other rare earths give appropriate colors. The authors have measured the fluorescence spectra of the compounds which they prepared, and determined that the luminescence and florescence lines are the same. They propose that the phonons, generated during fracture, excite the rare earth ions in a manner analogous to the photons during fluorescence measurements, so that the same excited states are populated. Those states then decay emitting the characteristic radiation.

High Temperature Lubrication

The temperature of operation of an engine has a direct impact on the maximum theoretical efficiency that operate at high temperature. Thus, there has been considerable interest in the development of ceramic engines. If such an engine is to operate above 300°C, liquid lubrication must be replaced by solid lubrication. Q. Xue and H. Liu {*J. Phys. D: Appl. Phys.*, **30**, 1965-71 (1997)} have extended the study of solid lubricants at high temperatures to include MoS_2, graphite, CeO_2, copper and CeF_3. In order to approximate an engine, they studied the sliding of tetragonal zirconia polycrystal (TZP) against Si_3N_4. TZP has been proposed as a cylinder-liner, and Si_3N_4 as the material for piston rings in high temperature adiabatic engine designs. The tribological properties were evaluated at temperatures up to 600°C. MoS_2 was found to perform well below 350°C, but oxidized at that temperature. Likewise, graphite was limited to 450°C for the same reason. CeO_2 and copper did not significantly influence the friction coefficient. In the studies, CeF_3 was found to exhibit good lubricating properties above 400°C, where it undergoes complete crystallization and orients along the (002) plane.

Sc Additions to Cu Vapor Lasers

A copper vapor laser (CVL) uses a discharge tube operating at between 1200 and 1700°C. Metallic Cu in the tube provides a vapor density of about 0.04 mbar at 1600°C. The Cu atoms are pumped into the resonant excited state by high voltage discharges in the tube. Attempts to increase the efficiency of CVL's by increasing the cavity length are limited by the fact that the voltage required for the discharge scales with the length, and thus, becomes unacceptably high. H. Kimura et al. {*Appl. Phys. Lett.*, **71**, 312-4 (1997)} have addressed the efficiency problem by adding Sc atoms, which effectively couple to

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the discharge. Because the excited state energy of the Sc is closely matched to that of the Cu, collisions between atoms in the vapor result in an efficient transfer of energy from the Sc to the Cu. This process resulted in a 28% increase in output power and electrical-optical conversion efficiency.

HDDR of $Sm_2Fe_{17-x}Ga_x$ for x>1

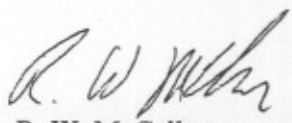
Hydrogen disproportionation desoroption recombination (HDDR) has been proven to be an effective means of producing anisotropic permanent magnet powders of $Nd_2Fe_{14}B$ based materials. It has also been applied to Sm_2Fe_{17} based materials, where the $Sm_2Fe_{17}C_y$ phase has been stabilized by the substitution of Fe by Ga, Al, or Si. In this case, the $Sm_2Fe_{17-x}Ga_x$ material is subject to the HDDR powder to produce a fine-grained textured microstructure within a given powder particle. The powder is then carburized to produce the appropriate crystal structure. The production of magnets has not been successful due to the fact that under normal HDDR conditions, the HDDR of the precursor works only up to $x = 0.5$, while a higher value of x is required to stabilize the C containing hard magnetic phase. M. Kubis et al. {J. Phys. D: Appl. Phys., **30**, L51-L54 1997)} have addressed this problem by using decidedly non-standard HDDR conditions. The $Sm_2Fe_{17-x}Ga_x$ material was ground in 0.5 MPa of H in a vibrating ball mill at elevated temperatures between 50°C and 350°C. The materials were then annealed in vacuum to H desorption and carburized at 500°C for 16 h in CH_4. Using this method, samples with $x = 1$ and 2 were successfully prepared. Coercivities of up to 1.8 T were observed in bonded magnets made from these materials. Oxidation during the process was a significant problem and will be addressed in future work.

Temperature Sensors

Last month, we discussed phosphor thermometry based on La_2O_2: Eu and Mg_4FgeO_6:Mn for cryogenic measurements. The same principles may be applied to elevated temperatures. Z. Y. Zhang et al. {*Rev. Sci. Instrum.*, **68**, 2759-63 (1997)} discusses a number of highly Nd-doped crystals and glass fibers for potential application as temperature sensors with a range up to 1000°C. Nd:YAG, which has previously been reported, was compared with Nd:YVO_4, Nd:$KGd(WO_4)_2$ and alumino-silicate fiber doped with Nd. A number of Nd concentrations were studied. In the crystalline hosts, the Nd fluorescence lifetime exhibits a nonmonotonic temperature dependence, not a desirable property for a temperature sensor. The results were also dependent on annealing, which suggests that aging will also be a problem. The fiber thermometer, on the other hand, had an approximate linear temperature dependence and shows promise.

Chinese Industrial Partners

In June of this year, a delegation of Chinese entrepreneurs led by Prof. Yu Zongsen, Vice-Chairman and Secretary of the Chinese Society for Rare Earths visited RIC and a number of U.S. companies. The delegation consisted of representatives for enterprises, which produce rare earth oxides, chlorides and metals. The purpose of the visit was to gather information on rare earth consumption and emerging requirements in terms of both the materials required and the quality required. As a result of the visit, RIC has been contacted by delegation members and asked to help identify potential industrial partners. Particular interest has been expressed in automotive catalysts and lamp phosphors. For more information, contact R. W. McCallum, Director RIC, (515) 294-4736, FAX (515) 294-3709.



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