Rare-earth Information Center

Insight

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Theoretical Route to High Performance Low Temperature Thermoelectric Junctions

Efficient thermoelectric coolers and power generators have been the subject of intensive research for many years. Recently, there have been attempts to use the interface energy in a metal/ superconductor junction to enhance performance. This idea has been extended to junctions between a metal and an electronic ferroelectric. An electronic ferroelectric (FE) is a mixed valent semiconductor that exhibits a small energy gap and is typified by SmB_6 and Sm_2Se_3. Theoretical calculations by M. Rontani and L. J. Sham {*Appl. Phys.Lett.*,77, [19], 3033-5 (2000)} produce a rather interesting result. If the interface is dirty, with a layer of rare earth atoms different from those in the FE between the FE and the metal, very high values for the figure of merit for the junction are obtained at low temperatures. It will be interesting to see if this effect can be observed experimentally.

Simultaneous Three Color Continuous-wave Laser

In April of last year, I reported on a single laser crystal capable of simultaneously generating two colors. Now, one of the authors {*Appl. Phys. Lett.*, **78**, [2], 144-6 (2001)} has succeeded in producing a crystal that simultaneously generates red, green, and blue continuous-wave laser radiation. The crystal is an aperiodically poled Nd^{3+}-doped lithium niobate. As with the previous work, the ferroelectric $LiNbO_3$ has highly nonlinear polarization versus voltage coefficients. This allows the simultaneous phase matching of the different nonlinear processes involved. Red and green are obtained by self-frequency-doubling of fundamental infrared lines, while blue is obtained by self-sum-frequency doubling.

OLP-based OLEDs

Organic light emitting diodes (OLEDs) have generated a considerable amount of interest for possible use in flat panel displays. However, in order to fabricate a viable display, the emission color, emission efficiency, and device lifetime must all meet stringent requirements. Most OLEDs are made using conjugated organic polymers or molecular species, where these properties are all interrelated, which makes it difficult to simultaneously optimize all three. Organolanthanide phosphors (OLPs) offer the normal lanthanide advantage. The color and efficiency of emission are a properties of the lanthanide and can be changed without changing the chemical properties of the polymer. A recent report by S. Capecchi et al. {*Adv. Mater.*, **12**, [21], 1591-94 (2000)} reports the fabrication of a high-efficiency organic electroluminescent device using an organoterbium emitter. The device produces green light with peak luminance of more than 2000cd/m². In order to obtain this efficiency, a multilayer structure was used.

Improved Tensile Creep Properties in Alumina

The thermodynamic efficiency of an engine is limited by its maximum operating temperature, and hence there is a continuing drive for higher operating temperatures. The operating temperature is, of course, limited by the materials available. (This is a problem that has existed throughout history and is clearly demonstrated in the design of early steam engines.) There is considerable interest in ceramic matrix composites for applications such as hot exhaust components in advanced jet engines. Unfortunately, high temperature tensile creep of aluminum oxide (α-Al_2O_3) is fairly high. Interestingly, there is a limited (<1000 PPM) solubility of rare-earth ions in α-Al_2O_3. Recent experiments by J.

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Cho et al. {*J. Mater. Res.*, **16**, [2], 425-9 (2001)} have shown that 100 PPM of Y or La can reduce the tensile creep rate of α-Al_2O_3 by about two orders of magnitude. Doping α-Al_2O_3 particles at this level is accomplished by dispersing fine α-Al_2O_3 powders in an equal mass of methanol and adding a lanthanide nitrate methanol solution. After drying and hot pressing, sintered bodies with ~1.5 μm grain size and density exceeding 99% are obtained. While a solid solution is obtained, it is believed that the composition is not uniform throughout the grains. The larger rare-earth ions are believed to segregate to the surfaces near the grain boundaries. The solubility limit is defined by the presence of detectable second phases. As creep processes involve either grain boundary diffusion or grain boundary sliding, the segregation of the very small level of dopant to that region helps account for the tremendous effect of the low level of doping.

Transparent Conducting Films

There appears to be considerable interest in transparent films that are either metallic or semiconducting for use in devices. In December, I reported on a transparent *p*-type semiconductor. Now, T. Minami et al. {*Thin Solid Films*, **366**, 63-8 (2000)} have produced a highly transparent and conductive film by doping ZnO with Sc or Y. The films were prepared by magnetron sputtering. There has been considerable research on impurity-doped ZnO films since the materials are inexpensive and readily available. Al- and In- doped ZnO films are already in commercial use in flat-panel displays and organic light emitting diodes. The rare earth doped films were found to be comparable with Al- doped films prepared by the same process. Interestingly, there was a considerable difference in the optimal doping levels 2 wt% for Sc and 4wt% for Y.

Road & Track

In the April issue of *Road & Track*, a popular magazine for automotive enthusiasts, there is an extensive article on catalytic converters that provides a reasonable introduction for the non-technical person. Unfortunately, the article deals mainly with the role of noble metals and only briefly mentions the lanthanides, which it refers to as elements that do not come readily to mind when you say periodic table. Attention is given to the potential to significantly reduce the amount of noble metal required in a converter though the use of rare earths.

Louis Néel

Néel temperature, Néel wall, antiferromagnets, ferrimagnets which are all concepts, we learned when we first studied magnetism, are the basis for much of modern technology. Thus, I was somewhat surprised to learn that the man responsible for these concepts was preparing a TV program last November. Unfortunately, Louis Néel died November 17, 2000 at the age of 95. While we all recognize the vast changes in technology that have occurred recently, it is somewhat shocking to think that the understanding of even the most basic concepts is only a lifetime old.

Double HDDR

Perhaps based on the theory that if one is good two is better, H-W Kwon {*J. Phys. D: Appl. Phys.*, **34**, 36-40 (2001)} has investigated the effect on repeated HDDR treatments of Sm-Fe-N and Nd-Fe-B. As you may recall, HDDR (hydrogenation, disproportionation, desorption and recombination) is a process that reduces the grain size of the magnet. In this process large single grains of the magnet material are proportionated into rare earth hydride and other phases. However, the disproportionation is not quite complete so that a dispersion of aligned nuclei remain. When the material is recombined, the new magnet grains form around these nuclei so that a very fine-grained structure is achieved. Kwon notes that after a single HDDR treatment the resulting material is somewhat inhomogeneous with local regions containing large recombined magnetic grains and some un-recombined Fe. These two features contribute to low coercivities in the HDDR powders. Kwon reports the effect of repeating the HDDR process up to five times and finds that in both Sm-Fe-N and Nd-Fe-B, the coercivity of the material increases on the second cycle and then decreases. The effect on energy product is not reported, but there is a considerable amount of thermal and x-ray analysis data presented.

Sincerely,

R. W. McCallum
Director of RIC