Rare-earth Information Center

Insight

Ames Laboratory
Institute for Physical Research and Technology
Iowa State University, Ames, Iowa 50011-3020 U.S.A.

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Thermophotovoltaic Emitters

The thermophotovoltaic method of producing electricity seems like a highly inefficient process. Thermal energy from a heat source, such as a gas burner, is used to cause an appropriate thermal emitter to emit photons that are captured by a photovoltaic cell to produce electricity. Estimates for the maximum efficiency that can be realized for such a system are about 10%. Clearly, this is not a route that one would use to produce large quantities of power. The process, however, may have extensive applications in systems whose primary purpose is to produce heat. In particular, residential heating systems that operate on propane or butane, where electrical power is not available, can use such a system to power the control electronics. Since the production of heat is the goal of the system, a low efficiency conversion of some of that heat to electricity does not effect the overall efficiency of the system. Unfortunately, the combustion of most fuels produces a light spectrum, which is not well matched to the needs of photovoltaic cells. The process of photothermal emission has been in use for over a century in the form of lantern mantels that result in a high output of visible light from gas lamps. For illuminating photovoltaics, a white spectrum is undesirable, as wavelengths which are not matched to the band gap of the photocell result in the production of heat, not light. This is, of course, detrimental to the lifetime of the photocell. B. Bitnar et al. {*Solar Energy Mater. Solar Cells*, **73**, 221-34 (2002)} have studied the use of Yb_2O_3 and Er_2O_3 as selective emitters for thermophotovoltaic applications. The emission band of Yb_2O_3 is matched to the bandgap of Si while the Er_2O_3 would be used with cells based on GaSb or SiGe. The authors started with Y_2O_3 mantles and coated them with Yb_2O_3 or Er_2O_3. The coating method was rather simple. Oxide powders were suspended in alcohol, and the mantel was dipped into the solution. Following immersion, the mantle was "enkindled", burning off the alcohol. I assume this means they set it on fire. The process was apparently repeated numerous times. The mantel was heated with butane – air flames with the air fuel mixture adjusted for maximum generated current in the reference photocell. The emission spectrum was measured and consisted of the selective emission lines of the rare earth, characteristic combustion lines and blackbody radiation. The temperature of the emitter was determined from the blackbody radiation. Based on the measured values, the authors calculated that an efficiency of around 2% can be obtained with a simple mantel. However, it should be possible to introduce a selective filter that would reflect the IR part of the spectrum back on the emitter while passing the desired wavelengths. This should increase efficiency to around 10%. An efficiency of greater than 1% is considered adequate for the intended application.

Cracking *n*-butane

Ethylene and propylene, which are extensively used as starting materials for many plastics, are commercially produced by the steam cracking of ethane or other higher hydrocarbons. This process requires a temperature of over 800°C. If an appropriate catalyst can be found to reduce this temperature, there is the potential for considerable energy savings. If cracking catalysts are to be effective, they must not result in the creation of light alkanes such as methane, ethane and propane. K. Wakui et al. {*Appl. Catalysis A: General*, **230**, 195-202 (2002)} have studied the loading of MFI type zeolites with rare earth oxides in an attempt to control the cracking of the hydrocarbons. Both La and Pr oxides were investigated. The loadings investigated were 10 wt% as metal. A two-stage process was used where the *n*-butane was first dehydrogenated over a Pt-Sn catalyst and then converted to ethylene and propylene over the loaded catalyst. A yield of 58% was obtained at 650°C. The rare earth elements played a significant role in reducing the bimolecular reactions that normally increase the percentage of undesirable phases.

Barocaloric Effect

The magnetocaloric effect is well known and is of considerable current interest. In the magnetocaloric effect, a magnetic field is used to bias the Curie temperature of a ferromagnet so that it can be transformed from a ferromagnetic to paramagnetic state adiabatically. Due to the fact that many rare earth materials undergo large volume magnetostrictons at their magnetic transition, it is also possible to use pressure to bias the Curie temperature and hence produce magnetic refrigeration using the barocaloric effect. The barocalcoric effect has been observed in systems with both pressure-induced structural phase transition and pressure-induced magnetic phase transitions. Now the barocaloric effect has been observed in a Kondo system. In a Kondo system, there are local magnetic moments at high temperature. As the temperature is lowered, the conduction electrons interact with the local moments so that the local moment is compensated, screened by the spins of the conduction electrons. Normally in a metallic system, the conduction electrons can be treated as a fermi gas of electrons. The deviation from an ideal gas is treated as a change in the mass of the electrons so that electrons in a normal metal have an effective mass that is somewhat larger than their true mass. In a Kondo system, the interactions are so strong that the effective mass may be orders of magnitude larger than the true electron mass, hence, these systems are called heavy-fermion systems. Th. Strassle et al. {*J. Appl. Phys.*, **91**, 8543-5 (2002)} have looked at the Kondo system $Ce_3Pd_{20}Ge_6$. Due to the fact that Ce may be either 3+ or 4+, there is frequently a strong interaction between the local moment and the conduction electrons in Ce compounds when the valance states are close together in energy. Pd is also a good bet for these systems, because while it normally has no magnetic moment of its own, a large moment may be induced by neighboring moments. In Ce_3Pd_{20}Ge6, uniaxial pressure may result in a distortion of the crystal that increases the interaction of the Ce 4*f* electrons and the *sd* conduction electrons. This increases the temperature at which the moments are screened, the Kondo temperature. Thus, the application of pressure near the Kondo temperature can change the magnetic moment of the material. The result is that at 4.4 K a cooling of 0.75 K per 0.3 GPa released is observed.

Company Notes

Treibacher Auermet Produktions Gesellschaft mbH, part of the Austrian-based Group Treibacher Industrie AG has acquired the rare earth assets of Meldform Rare Earths Limited. Treibacher Auermet has been in rare earth materials for over 100 years and sells approximately 6000 metric tons of rare earth content per year. Meldform Rare Earths has been supplying rare earth materials for over 25 years.

Conference Notes

"Rare Earth Research Conference" will be held July 13-18, 2002, at the University of California, Davis (www.chem.ucdavis.edu/rerc/). "Seventeenth International Workshop on Rare-earth Magnets and Their Applications" will be held August 18-22, 2002, in Newark, Delaware (http://rem02.physics.udel.edu/) "Permanent Magnet Systems and Power Electronics for Motion Control" will be held September 9-12, 2002, at a location to be announced. (www.goradv.com.).

Sincerely,

R. W. McCallum
Director of RIC