Rare-earth Information Center

Insight

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Advances in Fuel Cells

Hydrogen fuel cells were first demonstrated in 1839 by Sir William Grove. Over the years, there have been significant developments, and now polymer electrolyte fuel cells exhibit high power densities at temperatures only slightly above room temperature. Unfortunately, the generation and storage of hydrogen has significant safety problems, as was demonstrated by the spectacular destruction of the Hindenberg zeppelin. There is not a lot of interest in having large storage vessels for liquid hydrogen, and unfortunately, while there are a number of hydrogen storage alloys, the cost and weight associated with these materials causes a significant hurdle to their application. There is considerable interest in fuel cells that work with fuels that are compatible with the current infrastructure for distribution. These include natural gas, ethane, and other fossil fuels. There are two approaches to realizing this goal. The first is an external reformer that uses a catalyst to convert the fuel into hydrogen, and the second is a fuel cell that converts the fuel internally. Solid oxide fuel cells have many desirable characteristics, but until recently, they operated only at high temperatures in order to achieve the required high ion conductivity in the solid electrode. High temperature operation carries with it a number of disadvantages, including the requirement for relatively expensive materials and a tendency to become contaminated with carbon. Recent developments have dropped the temperature of operation significantly. T. Hibino et al. {*Science*, **288**, 2031-3 (2000)} have just reported a single-chamber solid oxide fuel cell, which operates below 500°C. In traditional fuel cell designs, a thin membrane separates the two sides of the cell. If this membrane is ceramic, there are significant problems of mechanical robustness. The new cell uses a Sm doped CeO_2 disk as the electrolyte. Currently, the disk is 0.15 to 0.5 mm thick. Electrodes of 10 wt% Sm doped CeO_2 with Ni and $Sm_{0.5}Sr_{0.5}CoO_3$ are formed on the opposing surfaces of the disk by coating the appropriate pastes on the disk and then firing. These electrodes are the anode and cathode, respectively. While the paper is quite interesting, the commentary by R. F. Service, which appeared in the *News Focus* portion of the same journal as a result of the publication of the paper, is probably of more general interest. The commentary discuses the various types of fuel cells and outlines their current status, including major industrial size developments.

A Ceramic Nd:YAG Laser

Nd:YVO_4 has a large absorption cross section, which has made it a popular material for highly efficient microchip lasers. However, the power density of these lasers is limited by the low thermal conductivity of the material, which is half that of Nd:$Y_3Al_5O_{12}$ (Nd:YAG). Nd:YAG is limited in efficiency by the fact that for doping concentrations in excess of about 1.5 at.%, there is a segregation of the Nd dopant during standard Czochralski growth of single crystals. Recently, high quality ceramic Nd:YAG samples have been prepared by simple sintering of high purity powders of Al_2O_3, Y_2O_3 and Nd_2O_3. Uniform doping of up to 8.2 at.% Nd was obtained with thermal conductivities of 80% of the single crystal value, and the samples were comparable in transparency to single crystals. Using 3.4 at.% Nd:YAG ceramic, the authors demonstrated a 230% increase in laser power over that of a conventional Nd:YAG single crystal when used in the same laser. While the application addressed in the paper is high power microchip lasers, the use of ceramics instead of single crystals in other lasers,would seem to be attractive. {*Appl. Phys. Lett.*, 77, [7], 939-41 (2000).

Gd_2O_3 and Y_2O_3 Gate Dielectrics for Si

The quantum tunneling limit for SiO_2 is 10 Å. This means that electrons can pass through an insulating barrier of this thickness without significant loss. This, of course, means that there is an inherent limit to the gate layer thickness in microelectronics using Si-SiO_2 techniques. The requirement for a thin layer of SiO_2 is a result of the relatively low dielectric constant, ε. SiO_2 is, of course, inherently compatible with Si, but other candidates, such as Al_2O_3, Ta_2O_5 and TiO_2, form interfacial layers of unacceptable thickness at the required processing temperature of 1000 K. Given the thermodynamic stability of rare earth oxides and their high dielectric constants, they are attractive alternatives for dielectric layers, if they can be successfully grown on Si. J. Kwo et al. {*Appl. Phys. Lett.*, 77, [1], 130-2 (2000)} report that the key to growing epitaxial Gd_2O_3 and Y_2O_3 layers on Si is to keep the oxygen partial pressure during growth below 10^{-9} Torr. This avoids the oxidation of the Si surface during deposition. The properties of the dielectric layers obtained are claimed to be comparable to that of state-of-the-art SiO_2 gate oxides layers 15 Å thick with a layer which has the same coupling as a 10 Å thick layer.

Company Notes

Magnequench, Inc. has announced agreements for the purchase of two businesses related to the production of rare earth magnets. It will purchase Ugimag's rare earth business from Carbone Lorraine Group and Widia's Magnet Engineering from Milacron Inc. The Ugimag acquisition adds sintered Sm-Co and Nd-Fe-B magnets to the Magnequench magnets and powders, while the Widia acquisition, located in Essen, Germany, produces injection molded bonded magnets.

As mentioned previously, TradeTech L.L.C has sold its rare earth and specialty metals business, including the monthly newsletter, *Elements,* to High Tech Materials and has resumed the publication of *Elements*, which covers rare earths, specialty metals, and applied technology. The *Elements* newsletter will be sent by e-mail each month to subscribers. High Tech Materials now has a new website. Contact: richvito@RareEarthsMarketPlace.com (http://www.RareEarthsMarketPlace.com).

Conferences

The RIC is a media sponsor of Permanent Magnet Systems: from Concept Thorough Commercialization, September 25-27, Atlanta, Georgia, USA, www.goradv.com.

Intertech is organizing a conference "China's Magnet Industry, Challenges and Opportunity for the Global Economy." The conference will be held October 23-26, 2000 in Hanzhou, China, www.intertechusa.com

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