

Solid Oxide Fuel Cells Enable Direct Oxidation of Common Liquid Fuels

Fuel cells can produce power in the same way that combustion engines can, but with higher efficiencies and environmentally friendly and predictable by-products. However, a major difficulty in the implementation of fuel cells is the requirement that most fuels must first be converted to hydrogen. Current research in this field focuses on creating materials that electrochemically oxidize and draw power from readily available fuels, such as gasoline and diesel fuel, without first reforming these fuels to hydrogen. To this end, researchers at the University of Pennsylvania, led by Raymond J. Gorte, have revealed that Cu-cermet anodes are capable of electrochemically oxidizing toluene, *n*-decane, and synthetic diesel fuel directly, without first reforming them to hydrogen.

As reported in the *Journal of The Electrochemical Society* 148 (7) (2001), model solid-oxide fuel cells were used. The fuel cells were prepared by first fabricating an yttria-stabilized zirconia (YSZ) wafer with a 400- μm porous layer and a 60- μm dense layer. After attaching the cathode material (50:50 YSZ and $\text{La}_{0.8}\text{Sr}_{0.2}\text{MnO}_2$) on the dense side of the YSZ wafer, the porous side was made into a composite anode by impregnation with nitrate solutions of Cu and ceria and subsequent oxidation and reduction to form the Cu-ceria-YSZ cermet. Electrochemical characterization was then performed while injecting liquid hydrocarbons (toluene, *n*-decane, and synthetic diesel fuel) directly into the cell. A flow of dry N_2 gas was included in most, but not all, of the experiments to maintain flow. Fuel conversions were less than 1%, conditions that are most likely to cause coking (i.e., the formation of tar-like substances) because insignificant amounts of water are formed. The cathode was left open to air.

Results for Cu-ceria-YSZ cermets showed positive characteristics, according to the researchers. First, the fuel cell was stable. The cell was operated at 973 K and a potential of 0.5 V for 12 h in a 40 wt% hydrocarbon- N_2 mixture for each of the three fuels. The anode was also stable in pure *n*-decane for at least 1.5 h. By comparison, the researchers reported, a fuel cell made with a traditional Ni-based anode was rapidly destroyed at 973 K in the 40% toluene- N_2 mixture. Even without optimization or the use of a thin electrolyte, a reasonable power density of 0.1 W/cm^2 was observed for each of the fuels with a 40 wt% hydrocarbon- N_2 feed. Analysis of the effluent gas using gas chromatography for the toluene feed showed that the fuel was completely ox-

dized to CO_2 and water.

The researchers said that this report is important to the materials community in the search for cost-effective, environmentally friendly ways to use hydrocarbon fuels to produce electrical power, especially for transportation and portable power devices.

MATHEW M. MAYE

2D Nanopatterns Observed in Lead Films Indicate Potential for Nanotemplating

Researchers from Sandia National Laboratories in Albuquerque and Livermore have observed two-dimensional nanopatterns, indicating that nanotemplates

can be formed to fine-tune device characteristics of self-assembling nanostructures. In the August 30 issue of *Nature*, the researchers show a sequence of low-energy electron microscope images of lead deposited on a Cu(111) substrate followed by a lead overlayer phase. The pattern evolved from circular islands with an average diameter of 67 nm, to stripes, and then to vacancy islands within the lead-overlayer matrix. The researchers account for this sequence due to the high mobility of the islands containing thousands of atoms. The researchers furthermore suggest that the stabilization of domain patterns is a result of the elastic interactions that come from a surface-stress difference

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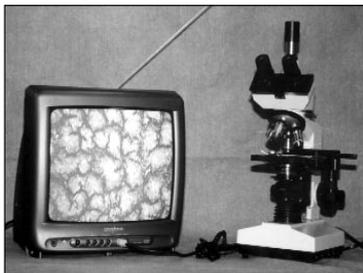
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between the alloy and overlayer structures. The behavior of the patterns also responds to temperature changes.

Specific Chemical Reactions Induce Reorientation of Nanoscale Liquid Crystals

Nicholas L. Abbott of the University of Wisconsin—Madison and Rahul R. Shah of the 3M Corp. (formerly of University of Wisconsin) have devised a portable chemical sensor that relies on liquid crystals formed from molecules weakly tethered to a nanotextured surface. As reported in the August 17 issue of *Science*, the device consists of an ultrathin gold film with nanoscale corrugation. The surface of the gold film is then dotted with protruding chemical receptors that weakly anchor the liquid crystal in a well-defined orientation along the film's surface. When these receptors are exposed to the specific chemical that is the object of detection, however, they bond more strongly with that target chemical than they do with the liquid crystal. The liquid crystal is then displaced into a new orientation that is controlled by the underlying surface texture, changing the sensor's color or brightness. On a surface with car-

boxylic acid receptors, for example, exposure to a vapor of the chemical hexylamine caused the liquid crystal to shift from an orientation perpendicular to the gold film's corrugations to an orientation that was parallel with the corrugations. According to the researchers, the "competitive binding" mechanism also allows the sensor to tolerate nontargeted compounds, such as water, which can interfere with detection in other types of sensors. In this case, the nontarget forms an even weaker bond with the receptor than the liquid crystal, and is unable to dislodge it.

Elasticity of Hexagonal Close-Packed Iron at Earth's Inner Core Characterized

Researchers have been puzzled as to why, based on seismological measurements, elastic waves generated by earthquakes travel through the inner core faster along directions parallel to Earth's polar axis than in other directions. The cause of this difference has not been well understood, partly because the elastic properties of iron at the high pressure and temperature of Earth's center are not known. A research team from the Uni-

versity of Michigan, Carnegie Institution of Washington, California Institute of Technology, National Institute of Standards and Technology, and the University of Pennsylvania has used supercomputer simulations to study changes in the crystal structure of iron at high pressure and very high temperatures of 4000–7000 K. As reported in the September 6 issue of *Nature*, their results support the hypothesis that the directional behavior in seismic wave propagation reflects the alignment of crystals in the inner core. The strong temperature-dependence of the average seismic wave velocity in iron and an almost perfect agreement of such properties with those of the inner core at a temperature of 5700 K have also led the researchers to infer that this is the temperature in the center of the Earth.

Developing a method that uses a first-principles treatment of the electronic structure with an efficient model of the lattice vibrations, the researchers were able to characterize the structure and elasticity of dense hexagonal close-packed (hcp) iron at high temperatures. They calculated the elastic-constant tensor by applying small magnitude finite strains to

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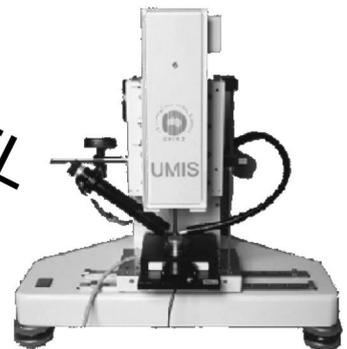
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