SLAC's Shou-Cheng Zhang

Page 2

Research Highlights . . .

DOE Pulse

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New catalyst for ethanol-powered fuel cells

A major hurdle to the commercial use of fuel cells that run on ethanol — an easy-to-produce, renewable, high-energy-density fuel — is the molecule's slow, inefficient oxidation. Scientists have been unable to find a catalyst capable of breaking the bonds between ethanol's carbon atoms. Now, at Brookhaven Lab, scientists have found a winner. Made of platinum and rhodium on carbon-supported tin dioxide nanoparticles, the electrocatalyst can break carbon bonds at room temperature to efficiently oxidize ethanol. This catalyst paves the path toward an alternative fuel system for automobiles that, with minor modifications, could even make use of the infrastructure currently in place to store and distribute gasoline.

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Trapping light to constrain dark energy

Using recycled parts and a shoe-string budget, physicists working on the GammeV experiment at DOE's Fermi National Accelerator Laboratory became the first group to set constraints on the chameleon particle, a candidate for explaining the dark energy of the universe. The chameleon particle may cause the dark energy's repulsive force, which causes the universe to expand at an accelerating rate. The particle's name reflects the fact that its properties, particularly its mass, change depending upon its environment. GammeV collaborators used lasers and a magnetic field to attempt to produce and trap chameleons, looking for their glow as they convert back to photons. The GammeV collaboration published its results in Physical Review Letters.

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Nano-material removes arsenic from drinking water

A new technology from DOE's Idaho National Laboratory can remove arsenic from drinking water seven times more effectively than current methods. The Nano-Composite Arsenic Sorbent (N-CAS) contains high concentrations of arsenic-absorbing nanoparticle metal oxides embedded in a strong composite polymer matrix. It may ease an expensive dilemma created when the Environmental Protection Agency reduced the maximum allowable arsenic concentration from 50 parts per billion (ppb) to 10 ppb, which meant water resources for 4,000 American municipalities and nearly 14 million homeowners now exceed allowable limits. Harvard, Mass.-based Water Technology Group, Inc. recently licensed the technology.

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Solar cell improvement

A team of researchers at DOE's Los Alamos National Laboratory led by Victor Klimov has shown that carrier multiplication--when a photon creates multiple electrons--is a real phenomenon in tiny semiconductor crystals and not a false observation born of extraneous effects that mimic carrier multiplication. The research, explained in a recent issue of Accounts of Chemical Research, shows the possibility of solar cells that create more than one unit of energy per photon. Klimov and colleagues have shown that nanocrystals of certain semiconductor materials can generate more than one electron after absorbing a photon.

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DOE Pulse highlights work being done at the Department of Energy's national laboratories. DOE's laboratories house world-class facilities where more than 30,000 scientists and engineers perform cutting-edge research spanning DOE's science, energy, national security and environmental quality missions. *DOE Pulse* (www.ornl.gov/news/pulse/) is distributed every two weeks. For more information, please contact Jeff Sherwood (jeff.sherwood@hq.doe.gov, 202-586-5806).

Advanced vehicles on verge of a market breakthrough

At DOE's National Renewable Energy Laboratory's Advanced Vehicles Systems Program, researchers are exploring several ways to improve hybrid systems so they will achieve 100 mpg or more. Of special interest is the performance and reliability of the vehicles' microelectronics.

"About one-third of the incremental cost of hybrids is in its power electronics," said NREL senior engineer Ken Kelly. "We need to process that electricity in ways that are reliable and extend the range of the vehicle."

The Toyota Prius hybrid system drive already works at 90 percent efficiency. But heat is its enemy; efficiency dips as the coolant temperature increases.

NREL senior engineer Ken Kelly watches a heat transfer test on a Toyota Prius hybrid system drive.

If it could run cooler, it would run longer. And it could be manufactured using less expensive materials.

Kelly's group is experimenting with heat exchangers made of different layers, including graphite and indium.

"One third of your radiator's capacity is used to cool the vehicle's electronics," Kelly said. "People want to package things smaller and powerfully. That means there is more heat in a small space. So the challenge is growing to get heat from the device to the coolant."

In a separate experiment, senior engineer Sreekant Narumanchi is developing an advanced gel to spread between power electronics components.

Silicon chips typically rest on a metal base plate that conducts heat away from the chip. This heat transfer is aided by a very thin gel layer spread between the parts. The conventional gel's performance suffers under the high heat and pressure generated in a car engine.

Narumanchi's new gels include metals, graphite and advanced ingredients such as carbon nanotubes. His equipment simulates years of high-temperature conditions and temperature cycling over weeks.

"Our target is a material that will perform for 15 years," he said.

Submitted by DOE's National Renewable Energy Laboratory

SHOU-CHENG ZHANG'S PRACTICAL PHILOSOPHY

Shou-Cheng Zhang

Shou-Cheng Zhang says he likes looking for good analogies to explain science and make it accessible. And that's a very good thing, because as a condensed matter theorist with the Stanford Institute for Materials and Energy Science at SLAC National Accelerator Laboratory and Stanford University, Zhang has a lot of explaining to do.

Zhang recently used the spin of electrons to predict a semi-conducting material that dissipates less energy, giving it powerful applications in the computing industry.

When a solid transports current, says Zhang, on the atomic level it looks like a Berlin nightclub around 3:00 a.m. "It's totally disordered. You're the electron, trying to move from one side of the room to the other, but you keep bumping into people and losing energy."

Zhang's goal is to get the electrons to dance more coherently. He imagines the interior of a solid as a dance floor, with some pairs of electrons spinning clockwise while moving clockwise around the room, and other couples spinning counterclockwise while moving counterclockwise. No one bumps into each other, so they don't dissipate energy. Part of this "dance," the electrons' movement, was previously understood. It's called the quantum Hall effect, and occurs when a solid is placed in a strong magnetic field.

But by adding the spinning motion in his calculations, Zhang removed the theoretical need for a magnet. In a 2006 paper, he pointed to a real-world material—mercury telluride—in which this dancing pattern, known as the quantum spin Hall effect,such a phenomenon could occur. One year later, collaborators at the University of Würzberg confirmed the theory experimentally. The discovery of this new state of matter was lauded by Science as a runner-up breakthrough of 2007.

However, Zhang's material needs to be cooled to a few degrees Kelvin to work. So nNow Zhang is busy dreaming up the material that could exhibit the quantum spin Hall effect at room temperature. If he succeeds, the theoretical could meet the practical in a very powerful way. "There are physicists who dream things up, and others who make things happen," he addssays. "Even though we dreamers don't seem to do anything, we contribute in our way. "

Submitted by DOE's SLAC National Accelerator Laboratory