The goal? Cooler, smaller, fuel cells

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Fuel cells that use hydrogen or methane to generate electricity in chemical reactions while shedding only harmless byproducts like water are dream products for engineers, environmentalists and business leaders searching for clean, alternative ways to power tomorrow's vehicles.

While high hurdles stand before the cheap manufacturing of fuel cells, engineers and scientists at the University of Illinois at Chicago and nearby Argonne National Laboratory are starting a tightly focused research project to develop solid oxide fuel cells that may meet this goal.

"Solid oxide fuel cells offer the potential to scale down to very small dimensions," said Christos Takoudis, professor of bio- and chemical engineering at UIC, and lead investigator in a new $475,000 National Science Foundation grant to investigate ways to synthesize and characterize this type of fuel cell in a temperature range lower than what most currently operate.

SOFCs oxidize fuels by electrochemical conversion to create electricity, using a solid oxide as the electrolyte between an anode and cathode circuit. While their small size and solid state are attractive attributes, the higher operating temperatures that SOFCs' need -- currently as high as 1,800 degrees Fahrenheit -- are a big drawback.

Takoudis and his colleagues hope they can lower the operating temperatures to what is considered the "intermediate range" of between 1,100 and 1,500 degrees.

They also want to see if such fuel cells can be created at the "nano" level, measuring thickness in mere single-digit layers of atoms.

"We're trying to come up with new materials and processes to make these fuel cells very efficient at lower temperatures. Material and design demands for higher temperatures are much more severe and require additional precautionary measures," Takoudis said.

A key research focus is how well the main elements -- the anode, electrolyte and cathode -- work at interface junctions and what contamination problems exist, if any.

"As dimensions shrink, it becomes even more important, because the actual contact area is much greater with respect to the total volume than it is in bigger systems," Takoudis said.

UIC researchers will grow the materials to test as potential solid anodes, cathodes and electrolytes for their SOFCs, and then use Takoudis' lab and Argonne's Advanced Photon Source for a close probe of the materials as they generate electricity.

Jeffrey Miller, leader of Argonne's heterogeneous catalysis group, will oversee that part of the work. Other project investigators working with Takoudis include UIC engineering adjunct professors Gregory Jursich and Alan Zdunek, who will study the process of atomic layer and chemical vapor deposition methods to create fuel cell components and ways to maximize efficiency. Robert Klie, UIC associate professor of physics, will supervise electron microscopy study and analysis of material interfaces.

Creation of microscopic-sized, cooler-operating, highly efficient solid oxide fuel cells may open up a world of possible applications that offer the twin benefits of being ecologically benign and cheap.

"Today's cost of fuel cells is prohibitive," Takoudis said. "Our group wants to push the technology envelope to help make the costs reasonable and create a power source that does little harm to the environment."

Provided by University of Illinois at Chicago