

## BODY BATTERY

by David Pescovitz

While fuel cells make front page news with the promise of non-polluting automobiles and energy efficient homes, Berkeley Mechanical Engineering professor Liwei Lin is thinking smaller. Much smaller. Lin's microbial fuel cell is just .07 centimeter square in area. Even more amazing though is that this fuel cell is built to operate inside your body.

The idea is that the microbial fuel cell would power implantable medical devices such as spinal cord stimulation devices or internal drug delivery systems. For example, an implantable drug delivery system integrated with a microbial fuel cell could be employed in Spinal Drug Infusion Therapy for pain relief applications.

"Of course, people also dream about miniature surgery systems that travel through your body," Lin says.

Fuel cells vary in design and materials, but the basic chemistry behind them remains the same. Hydrogen atoms enter at the anode, a negatively

charged electrode, where a catalyst strips them of their electrons. These electrons provide the current that powers the device that the fuel cell is connected to. In Lin's device, the fuel is nothing more than glucose, a sugar abundant in the human body. It's the catalyst that gives Lin's microbial fuel cell its name: *Saccharomyces cerevisiae*, a microorganism commonly known as Baker's Yeast.

"The fuel cell's only waste product is carbon dioxide and water," Lin says. "It's very similar in some ways to how the human body works."

The prototype microbial fuel cell contains a tiny chamber where the microbe resides. Glucose flows into the chamber, causing hydrogen protons and electrons to be generated during the fermentation process. In a June paper, Lin and graduate students Mu Chiao, Kien B. Lam, and Yu-Chuan Su reported that their tiny powerhouse cranked out 300 microvolts for two hours until the solution dried out in the open air. That kind of power is plenty for microelectromechanical systems (MEMS), tiny machines fabricated similarly to the way integrated circuits are manufactured.

MEMS, microscopic devices with biological applications, are one of Lin's specialties. In another recent effort with one of Berkeley MEMS pioneers Al Pisano and graduate student Yu-Chuan Su, Lin fabricated a drug delivery system

not much larger than a single letter on a penny. The device requires no electrical energy, instead drawing its pumping power from water flowing into an osmotic chamber filled with salt. Due to the incompressibility of the water, the diaphragm expands into a drug reservoir, pushing precise amounts of the drug through an intricate path of microfluidic channels and valves.

Lin hopes that through collaboration with industry partner Alza Corporation, acquired last year by Johnson & Johnson, research into tiny implantable drug delivery systems could improve the quality of life for individuals who require a steady flow of cancer drugs, steroids, or hormones.

"The surgeon could implant the delivery system and the patient wouldn't have to bother with it for a year or until it needed to be refilled," he says.



### Multimedia

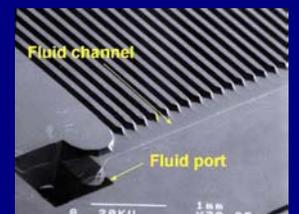
**Movie:** The diaphragm inside the drug delivery system expands to pump out precise amounts of the chemical in the reservoir. (AVI movie)

Movie courtesy Liwei Lin



Liwei Lin holds the microbial fuel cell and water-powered drug delivery system.

David Pescovitz photo



SEM microphoto of the fluid port and channel of a microfabricated fuel cell.

Photo courtesy Liwei Lin

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Editor,  
Director of Public Affairs:  
Teresa Moore

Writer, Researcher:  
David Pescovitz

Designer:  
Robyn Altman

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