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## Microstructured Cathode for Self-Regulated Oxygen Generation and Consumption

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### INVENTORS

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### OTHER INFORMATION

#### KEYWORDS

fuel cells, miniature fuel cell, micro  
fuel cell, miniature power source,  
micro power source, miniature energy  
source, micro energy source,  
batteries, self-regulating oxygen  
generation, self-regulated oxygen  
generation, self-sufficient fuel cell,  
oxygen,

#### CATEGORIZED AS

- ▶ **Energy**
  - ▶ Hydrocarbon
  - ▶ Hydrogen
  - ▶ Other
  - ▶ Storage/Battery
  - ▶ Transmission
- ▶ **Engineering**
  - ▶ Other

#### RELATED CASES

2012-408-0

## SUMMARY

UCLA researchers have developed a cathode that generates oxygen, consumes the oxygen as needed, and stops the oxygen generation when it is not consumed, all in a self-regulated fashion.

## BACKGROUND

Despite anticipated promise in high energy densities and efficiency, fuel cells have failed to reach practical applications for portable electronics primarily due to the inability to miniaturize the ancillary parts (e.g., pumps, valves, etc.) needed to operate the fuel cell and package them into a small space without eating up the volume for fuel. Removing all ancillary parts would allow a simpler design for fabrication, a more mechanically robust device, and a system with a higher energy and power density. Recent inventions have produced centimeter-sized fuel cells by removing ancillary parts, but these designs require access to ambient air and thus prevent the feasibility for stacking of the fuel cells for higher power output. In need of active oxygen supply within the fuel cell stacks, presented technology has been devised.

## INNOVATION

Researchers from the UCLA mechanical and aerospace engineering department have designed and fabricated a microstructured cathode capable of generating oxygen bubbles, consuming the oxygen bubbles as needed, and stopping the oxygen generation when it is not consumed all in a self-regulated fashion. The microstructure of the device is designed such that an electrolytic oxidant comes in contact with an electrocatalyst to generate oxygen bubbles via a reduction reaction. The cathode does not need pressurized gas tank, moving pumps or ambient air to introduce the oxygen and they can therefore be compactly stacked for higher power output. The system operates in a manner free of gravitational forces and thus may be used in non-stationary applications. The monolithic, self-regulating cathode is simple and mechanically robust, and would ideally be coupled with the recently developed monolithic anode (by the authors) that self-pumps the fuel.

## APPLICATIONS

- ▶ Complete, miniaturized fuel cell with no ancillary parts
- ▶ Portable devices such as laptops, cell phones, and global positioning systems
- ▶ Charging portable devices in the outdoor area (for soldiers or campers) to replace heavy batteries for given energy.
- ▶ Stacked system for higher power output

## ADVANTAGES

- ▶ Self-supplies oxygen onboard on-demand
- ▶ Complete fuel cell with no ancillary parts
- ▶ Does not depend on the surrounding environment and does not need to "breathe" air
- ▶ Stackable for higher power output
- ▶ Ability for sub-centimeter sizing
- ▶ Improved oxygen reduction rate balances anodic and cathodic reactions
- ▶ Membrane-less packaging and gravity-independent operation
- ▶ Monolithic, standalone system is simple and mechanically robust
- ▶ Flexibility in fuel/oxidant sources
- ▶ High energy density and high power density

## STATE OF DEVELOPMENT

Devices that generate and consume oxygen in a self-regulated manner have been fabricated and tested in electrochemical and visual experiments. Future work will focus on optimizing parameters such as hydrogen peroxide concentration, volume of stored hydrogen peroxide, and cathodic micropocket dimensions. Other future work will strive to implement the cathode into existing self-pumping fuel cells to realize a "true miniature fuel cell" that does not lack oxidant and self-regulates in both anode and cathode.

## PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,899,693	02/20/2018	2012-408

## RELATED MATERIALS

- ▶ J. I. Hur, D. D. Meng, and C.-J. Kim, "Self-Pumping Membraneless Miniature Fuel Cell with an Air-breathing Fuel-Tolerant Pt Cathode," *Journal of Microelectromechanical Systems*, Vol. 21, 2012, pp. 476-483.
- ▶ J.I. Hur and C.-J. Kim, "A Microstructured Cathode for Fuel Cell with Self-Regulated O<sub>2</sub> Bubble Creation and Consumption," *Proc. IEEE Int. Conf. MEMS*, Paris, France, Jan. 2012, pp. 35-38.
- ▶ J.I. Hur and C.-J. Kim, "Self-Contained Oxygen Supply for Self-Regulating Miniature Fuel Cell," *Proc. PowerMEMS*, Atlanta, GA, USA, Dec. 2012, pp. 191-194.

## ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ Methods of Restoring and Maintaining Gas Film on Superhydrophobic Surfaces while Underwater
- ▶ A Low-Profile Flow Shear Sensing Unit
- ▶ Complete Transfer of Liquid Drops by Modification of Nozzle Design
- ▶ Stereo Image Acquisition By Lens Translation
- ▶ Method of Fluid Manipulation By Electrowetting
- ▶ A Built-In Mechanism Of Gas Maintenance In Microfeatures On A Submerged Surface
- ▶ No-Assembly Devices for Microfluidics Inside a Cavity
- ▶ Liquid-Repellent Surfaces Made of Any Materials
- ▶ On-chip, Real-time Feedback Control for Electrical Manipulation of Droplets
- ▶ Micropumping of Liquids by Directional Growth and Selective Venting of Bubbles

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