High Power Density Solid Oxide Fuel Cell

A compact and versatile high power density energy source

Innovators at NASA’s Glenn Research Center have developed a novel solid oxide fuel cell (SOFC) with five times the specific power density of currently available SOFCs. This highly efficient SOFC can operate on a wide range of both hydrogen and hydrocarbon-based fuels including methane, diesel, or jet fuel without reformers. Glenn’s SOFC consists of a bi-electrode supported cell (BSC) manufactured with an innovative ceramic fabrication method that replaces commonly used metal interconnects (such as steel or platinum) with ceramic interconnects. This superior design reduces weight and volume by 70 percent and negates two significant challenges to traditional SOFCs: metal corrosion and metal/ceramic sealing. Furthermore, the open structure of its electrodes permits operation at high fuel utilization and enables very high electrolysis efficiencies in regenerative fuel cell applications where the fuel cell operates in a closed loop for hydrogen production and energy generation. This low-cost, high energy density SOFC has significant commercial potential for a broad range of industries.

**BENEFITS**

- **Lightweight**: Replaces metal interconnects with lightweight, low volume ceramics
- **Flexible**: Operates on a wide range of hydrocarbon fuels without a reformer or pre-reformer
- **High specific power density**: Offers five times the specific power density of traditional SOFCs
- **Efficient**: Provides direct conversion of fuel to electricity with high fuel utilization
- **Low-Cost**: Eliminates the need for expensive metal catalysts
THE TECHNOLOGY

Rather than heavy metal interconnects, Glenn’s innovative BSC uses a thin layer of electrically conductive LaCaCrO$_3$ (LCC) for current collection. To improve strength during thermal cycling and simplify stack manufacture, its design is structurally symmetrical with a thin yttria-stabilized zirconia (YSZ) electrolyte supported on either side by a porous support structure. Electrodes are made by freeze-casting, a modified tape casting technique that creates the many microchannels needed for gas diffusion in the YSZ electrode using green tape. Prior to electrode impregnation to create the anode and the cathode, the entire BSC support structure is sintered at a temperature of 1400 degrees C. This results in less internal resistance thanks to the nearly identical coefficients of thermal expansions of the YSZ electrolyte and LCC layer. This clever design is highly versatile. The anode-impregnated material can easily be changed to nearly any metal such as tin or copper without any modification to the BSC, allowing for thinner layers and better performance characteristics. Also, since the BSC cells are fabricated entirely from ceramic materials, they can operate at higher temperatures, and the formation of hermetic, ceramic-to-ceramic seals is possible. The result is a BSC SOFC that can achieve high specific power densities that are five times higher than state-of-the-art (up to 2.5kW/kg), and a volumetric power density that is eight times higher than state-of-the-art (up to 7.5kW/L). This uniquely lightweight and low volume SOFC has unprecedented performance, making Glenn’s new BSC SOFC a game changer in fuel cell technology.

APPLICATIONS

The technology has several potential applications:
- Portable power
- Unmanned and autonomous vehicles
- Aerospace auxiliary power units
- Utility power
- Distributed energy for smart grid
- Micro-combined heat and power
- Regenerative power
- Hydrogen production via electrolysis
- Electric and hybrid electric vehicles

PUBLICATIONS

Patent No: 7,534,519; 8,697,313; 8,715,886

More Information

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NP-2017-07-2426-HQ

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LEW-17630-1, LEW-17634-2, LEW-18608-1, LEW-TOPS-120