National Aeronautics and
Space Administration

High-Power Density Solid Oxide Fuel Cells

A lightweight, compact, zero emissions energy source

TECHNOLOGY OPPORTUNITY

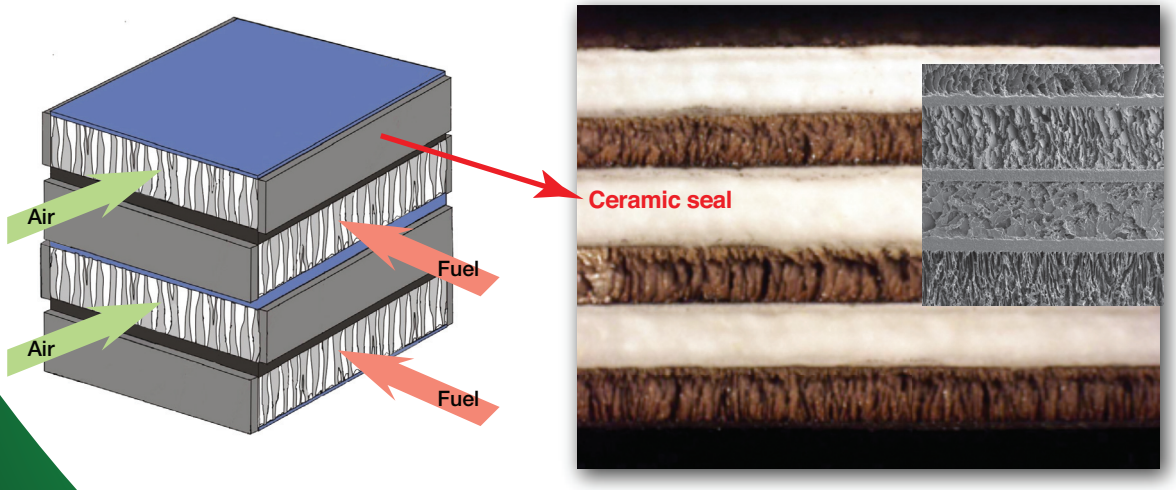
Innovators at NASA's Glenn Research Center have developed a low-cost solid oxide fuel cell (SOFC) that provides five times the power density of currently available SOFCs. Because this novel SOFC replaces the commonly used metal interconnects, such as steel and platinum, with lightweight ceramic interconnects, they are 70 percent lower in weight and volume than conventional SOFCs. NASA is looking for partners to commercialize this technology and further develop the next generation of SOFCs for both automotive and aerospace applications.

BENEFITS

- **Compact:** Lightweight and low volume
- **Fast:** Rapid startup and peak load management for battery SOFC hybrid systems
- **Efficient:** Direct conversion of fuel to electricity
- **Flexible:** Not restricted to pure hydrogen fuel
- **Robust:** Tolerant of impurities and poisons (as compared to proton-exchange-membrane (PEM) fuel cells)

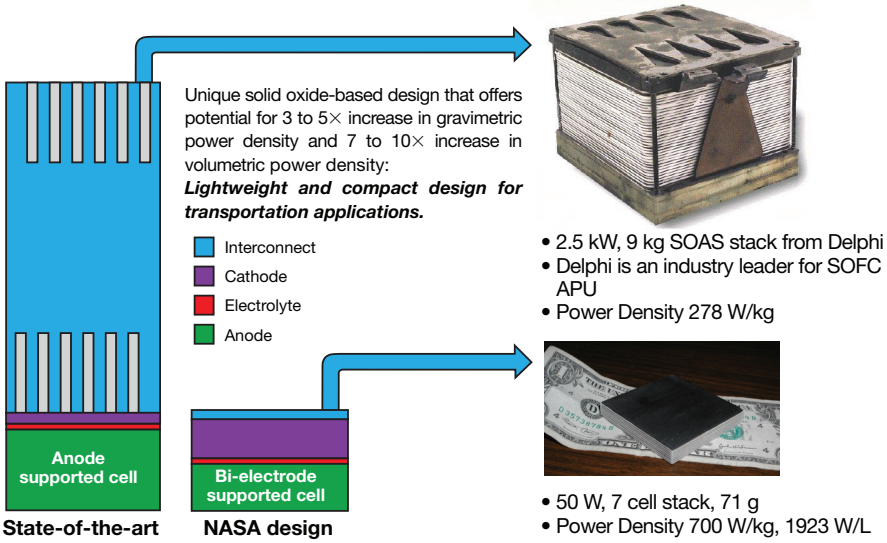
APPLICATIONS

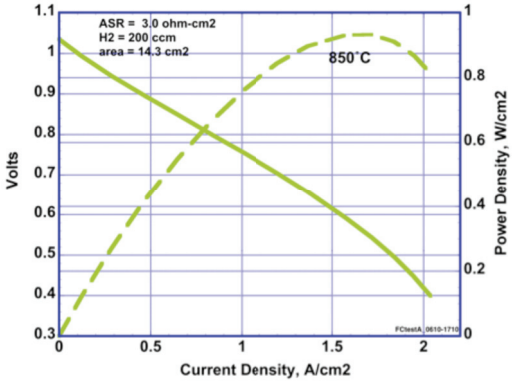
- Electric vehicles (EVs)
- Hybrid electric vehicles (HEVs)
- Plug-in hybrid electric vehicles (PHEVs)
- Auxiliary power units to support "hotel loads" for long-haul trucks and recreation vehicles



HOW IT WORKS

The cell is structurally symmetrical, with both electrodes supporting the thin electrolyte and containing microchannels for gas diffusion, creating a bi-electrode supported cell (BSC). The electrodes are made by freeze-casting, a modified tape casting technique, which creates the many microchannels in the yttria-stabilized zirconia (YSZ) electrode green tape. Since the 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 high-temperature fusing of structural elements leads to strong bonding of interfaces and hermetic sealing. NASA's novel cell design replaces heavy, expensive metal interconnects with a thin, flat layer of Ca-doped $LaCrO_3$ (LCC) approximately 30 to 60 microns thick. Removal of the metal interconnects, which alone account for up to 70 percent of the weight and volume in many planar designs, provides a dramatic improvement in both the specific power density and volume density. The resulting BSC is both low volume and low weight. The BSC and interconnect repeat unit weighs only 36 g and has a volume of 10 cm^3, as compared to a standard anode-supported cell and repeat unit, which weighs approximately 199 g and has a volume of 85 cm^3. The BSC design has the potential to improve the power density by a factor of five, increasing the specific power from 0.2 to 1.1 kW/kg.





Single cell data demonstrates the power density characteristics needed to achieve >1000 W/kg.

WHY IT IS BETTER

The SOFC provides a fivefold increase in power density over comparable SOFCs, and it is anticipated that NASA's next-generation SOFC will double that figure (providing a tenfold increase in power density). The use of ceramic interconnects, rather than metal, not only lowers weight and volume but it also removes two significant challenges encountered with metal-based SOFCs: metal corrosion and metal/ceramic sealing. The uniquely lightweight and low volume design is well suited for automotive applications, as it enhances vehicle fuel efficiency and produces zero emissions. The open structure of NASA's electrodes permits operation at high fuel utilization and enables very high electrolysis efficiencies in applications where regenerative fuel cells are of interest. NASA's fuel cells can operate on a wide range of fuels, including hydrocarbon, diesel, gasoline, natural gas, propane, and hydrogen.

PATENTS

Glenn has patented this technology (U.S. Patent No. 7,534,519 B2).

LICENSING AND PARTNERING OPPORTUNITIES

Glenn's Office of Technology Partnerships and Planning seeks to transfer technology to and from NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the High-Power Density Solid Oxide Fuel Cells (LEW–17630–1).

FOR MORE INFORMATION

For more information about this and other technology licensing opportunities, please contact

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