NASA SBIR 2011 Phase I Solicitation

X8.01 Fuel Cells and Electrolyzers

Lead Center: GRC

Participating Center(s): JPL, JSC

Advanced primary fuel cell and regenerative fuel cell energy storage systems are enabling for various aspects of future Exploration missions. Proposals that address technology advances related to the following issues for PEM fuel cell, electrolysis, and regenerative fuel cell systems are desired.

Proton Exchange Membrane (PEM) Fuel Cells and Electrolyzers

Proposals that address technology advances related to the following issues for PEM fuel cell, electrolysis, and regenerative fuel cell systems are desired.

Oxidation Resistant Gas Diffusion Layer (GDL)

GDLs are integral to PEM fuel cell membrane-electrode-assemblies (MEAs). Traditional carbon or graphite based GDLs are very susceptible to oxidation under certain operating conditions in the pure oxygen environment of space fuel cell systems. This results in MEA degradation and shortened life. Proposals addressing the development of oxidation resistant GDLs that remain stable to oxidation in a pure oxygen environment, and provide improved performance and longer life are desired.

Deionizing Water Treatment for High Pressure, High Temperature Water Electrolyzers

Ultra high purity water is needed for NASA's high pressure, high temperature water electrolyzers. Technology is needed to remove ions within the water that is circulated over the catalyzed electrodes of the electrolyzer. Ions need to be reduced below TBD ppm prior to entering the water electrolyzer. The deionizer must function in flowing water at 2000 psi and 80Â°C.

High System Pressure water Pump

A water pump is needed to circulate water through a high-pressure water electrolyzer. The pump must meet the following criteria:

- Operating System pressure of >2000 psia.
- Minimum developed differential pressure of 30 psid.
- Operating temperature 20-90Â°C.
- Minimum liquid flow rate of 30 LPM.
- Chemically tolerant to water saturated with dissolved oxygen at 2000 psia, 90Â°C.
- Tolerant to two-phase mixtures of gaseous oxygen and liquid water without losing pumping effectiveness.
- Mass â‰¤ 2 kg.
- Volume â‰¤ 0.75 liters.
- Power Consumption â‰¤ 120 watts.

Instrumentation, Control, Health Monitoring, and Data Handling

Highly reliable voltage monitors for batteries, fuel cells, electrolyzers, and regenerative fuel cells are needed having low mass and low parasitic power consumption. Up to 48 differential voltages (0-5 VDC) with a minimum of 120 VDC common mode rejection must be monitored for system health management over an operating temperature range of -20 to +40Â°C, and the system must be capable of being upgraded to meet a Grade-1 EEE reliability

Solid Oxide Fuel Cells and Electrolyzers

Advanced primary Solid Oxide Fuel Cells (SOFC) and Electrolyzers offer notable advantages in certain space applications when integrated with, respectively, CH_4/O_2 propulsion systems and systems for producing oxygen from planetary resources. In contrast to most terrestrial/commercial applications, solid oxide devices for spacecraft will operate on pure oxygen and clean fuel streams (e.g., pure methane.) New materials are required to enable their use in these applications. These devices typically operate at high temperatures (800-1000Â°C) and are expected to undergo on/off cycling in aerospace applications. Technology advances are sought that reduce the time required to get to operating temperature, enable hundreds of rapid start-up/shut-down cycles, and enable systems to accommodate large load swings without leakage or deposition of elemental carbon. Spacecraft solid oxide devices that operate with minimal active cooling are needed. Low recurring costs are not a priority for spacecraft fuel cell materials. Technology advances that reduce the weight and volume, improve the efficiency, life, safety, system simplicity and reliability of Solid Oxide Fuel Cells and Electrolyzers are desired. Proposals are sought which address the following areas:

Advanced Primary SOFC Systems

Their high temperature heat rejection and high efficiency power generation from methane and oxygen make primary SOFC's attractive for application to spacecraft with CH_4/O_2 propulsion systems. Research directed towards improving the durability, efficiency, and reliability of SOFC systems fed by propellant-grade methane and oxygen is desired. Primary SOFC components and systems of interest:

- Have power outputs in the 1 to 3 kW range.
- Offer thermodynamic efficiencies of at least 70% (fuel source-to-DC output) when operating at the current draw corresponding to optimized specific power.
- Operate as specified after at least 300 start-up cycles (from cold to operating temperature within 5 minutes) and 300 shut-down cycles (from operating temperature to cold within 5 minutes).
- Operate as specified after at least 2500 hours of steady state operation on propellant-grade methane and oxygen.
- Are cooled by way of conduction through the stack to a radiator exposed to space and/or by anode exhaust flow.

Advanced Solid Oxide Electrolyzers

Their high temperature heat rejection and operation, along with high efficiency, make solid oxide electrolyzers attractive as the final step of producing oxygen from Lunar or Martian regolith by way of hydrogen or carbothermal reduction. They are also attractive components for Sabatier reactors producing methane from the Martian atmosphere. Research directed towards improving the durability, efficiency, and reliability of solid oxide electrolyzers is desired. Solid oxide electrolysis systems of interest:

- Require power inputs in the 1 to 3 kW range.
- Operate as specified after 10,000 hours of operation fed by water with mild contamination.
- Operate as specified after 100 start-up cycles (from cold to operating temperature within 5 minutes) and 100 shut-down cycles (from operating temperature to cold within 5 minutes).
- Offer thermodynamic efficiencies of at least 70% (DC-input to Lower Heating Value H_2 output) when operating at the current feed corresponding to rated power.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract.