XI.0 Small Business Innovation Research (SBIR) Fuel Cell Technologies Office New Projects Awarded in Fiscal Year (FY) 2017

The SBIR program provides small businesses with opportunities to participate in DOE research activities by exploring new and innovative approaches to achieve research and development (R&D) objectives. The funds set aside for SBIR projects are used to support an annual competition for Phase I awards of up to $225,000 each for about nine months to explore the feasibility of innovative concepts. Phase II R&D efforts further demonstrate the technologies to move them into the marketplace, and these awards are up to $1,500,000 over a two-year period. Small Business Technology Transfer projects include substantial (at least 30%) cooperative research collaboration between the small business and a non-profit research institution.

Table 1 lists the SBIR Phase I projects and Table 2 lists the SBIR Phase II projects awarded in FY 2017 related to the Hydrogen and Fuel Cells Program. Brief descriptions of each project follow the tables.

TABLE 1. FY 2017 SBIR Phase I Projects Related to the Hydrogen and Fuel Cells Program

Report Number[1]/Title		Company	City, State
V.A.15	Highly Robust Low PGM MEAs Based upon Composite Supports[2]	Forge Nano	Louisville, CO
V.A.14	Multi-Functional Catalyst Support[2]	pH Matter LLC	Columbus, OH
V.A.13	Development of Durable Active Supports for Low Platinum Group Metal Catalysts[2]	Pajarito Powder, LLC	Albuquerque, NM
V.A.12	Mesoporous Non-Carbon Catalyst Supports of PEMFC[2]	CertainTech Inc.	Sterling, VA
V.A.11	Development of Corrosion Resistant Carbon Support for Ultra-Low Platinum Group Metal Catalysts[2]	Greenway Energy, LLC	Aiken, SC
XI.1	Metal Hydride Material Development for High Efficiency and Low Cost Hydrogen Compressors[2]	Greenway Energy, LLC	Aiken, SC
XI.2	Over-Molded Plates for Reduced Cost and Mass PEM Fuel Cells	American Fuel Cell	Rochester, NY
XI.3	Emergency Hydrogen Refueler for Individual Consumer Fuel Cell Vehicles	Reactive Innovations, LLC	Westford, MA

TABLE 2. FY 2017 SBIR Phase II Projects Related to the Hydrogen and Fuel Cells Program

Report Number[1]/Title		Company	City, State
XI.4	Novel Hydrocarbon Ionomers for Durable Proton Exchange Membranes[2]	NanoSonic, Inc.	Pembroke, VA
II.B.7	New Approaches to Improved PEM Electrolyzer Ion Exchange Membranes[2]	Tetramer Technologies, LLC	Pendleton, SC
XI.5	Flexible Barrier Coatings for Harsh Environments[2]	GVD Corp.	Cambridge, MA
XI.6	Cryogenically Flexible, Low Permeability Thoraeus Rubber H_2 Dispenser Hose	NanoSonic, Inc.	Pembroke, VA
XI.7	Low Cost Alloys for Magnetocaloric Refrigeration	General Engineering & Research, LLC	San Diego, CA

[1] Section XI titles (e.g., projects with report number XI.1, XI.2, XI.3) do not have separate entries in the Annual Progress Report. A brief description of each SBIR project listed in Tables 1 and 2 can be found below.
[2] Funded under the Basic Energy Sciences (BES) Office.

PHASE I PROJECTS

V.A.15 Highly Robust Low PGM MEAs Based upon Composite Supports

Forge Nano
1172 Century Dr., #240
Louisville, CO 80027

This project will use a recently developed low-cost atomic layer deposition technique to apply ultra-thin conductive barrier coatings onto carbon particles to prepare drop-in-ready materials suitable for use in highly robust membrane electrode assemblies (MEAs), without sacrificing cost or performance, and while extending system durability. In addition, the high-throughput atomic layer deposition technology developed by PneumatiCoat is very low cost and may even lower the cost of the electrode by enabling further reductions in platinum group metal (PGM) catalyst loading. These attributes promise to facilitate use of the current inexpensive carbon material, yet solve the durability issues experienced today, which will further accelerate commercial adoption. This project will develop high-performance, highly durable supports for low-PGM fuel cells using low-cost techniques to achieve the 2020 targets for cost ($40/kW at the system level, $14/kW at the MEA level), start-up/shutdown durability (5,000 cycles), and less than 10% loss in power after 5,000 h.

V.A.14 Multi-Functional Catalyst Support

pH Matter LLC
1275 Kinnear Rd.
Columbus, OH 43212

The overall objective of the proposed project is to develop and demonstrate a multi-functional carbon support for polymer electrolyte membrane fuel cell cathodes that is engineered to improve stability/durability and lower Pt loading requirements. The approach will be based on nitrogen- and phosphorus-doped carbon with hydrophobicity treatments to improve MEA performance.

V.A.13 Development of Durable Active Supports for Low Platinum Group Metal Catalysts

Pajarito Powder, LLC
317 Commercial Street NE
Albuquerque, NM 87102

This project aims to develop a catalyst that will combine low cost through low platinum loading with high durability through increased corrosive-resistant support. The proposed technology will be based on decoration with PGM of carbon-based metal–nitrogen–carbon materials, which intrinsically have high activity towards oxygen reduction, called active supports.

V.A.12 Mesoporous Non-Carbon Catalyst Supports of PEMFC

CertainTech Inc.
20695 Settlers Point Place
Sterling, VA 20165

This project aims to develop a new catalyst support for polymer electrolyte membrane fuel cells (PEMFCs) that will dually benefit from the support of both materials synthesis and electrochemical evaluation aspects. CertainTech will use a nano-casting route to produce mesoporous boron carbide supports. The resultant product will have a very high specific surface area, well-ordered pore structures, and narrowly distributed pore sizes, all of which will aid the even dispersion of platinum for fuel cell applications. The catalytic properties of the Pt-impregnated boron carbide mesoporous support will also be studied.

V.A.11 Development of Corrosion Resistant Carbon Support for Ultra-Low Platinum Group Metal Catalysts

Greenway Energy, LLC
301 Gateway Dr., Suite 169
Aiken, SC 29083

Carbon is used as a support material for both anode and cathode catalysts in state-of-the-art PEM fuel cells. Carbon support is susceptible to corrosion under the cathode operating conditions such as presence of oxygen and water, low pH, and high potential at the cathode interface. Corrosion of state-of-the-art carbon supports is inevitable, which leads to platinum catalyst particle detachment from the support and subsequent poor performance. Hence, modifications to the carbon supports that make them more corrosion resistant are of great importance to achieve the DOE targets. Phase I of this project will focus on the synthesis of a corrosion resistant carbon (CRC) support and Pt/CRC and Pt-alloy/CRC catalysts. A commercially available carbon will be subjected to various treatments to tailor the physical properties such as the specific surface area, pore size distribution, and hydrophilicity/hydrophobicity without sacrificing the electronic conductivity. Surface functionalization using an inexpensive bifunctional additive helps achieve uniform catalyst particle distribution and enhances catalyst/support interaction, which is critical for PEM fuel cells operating under transient conditions.

XI.1 Metal Hydride Material Development for High Efficiency and Low Cost Hydrogen Compressors

Greenway Energy, LLC
301 Gateway Dr., Suite 169
Aiken, SC 29083

Phase I of this project was awarded in FY 2017 and involved thermodynamic and technoeconomic analyses to identify key performance characteristics that metal hydride materials must achieve to be viable in cost-competitive high-pressure (875 bar) hydrogen compression. The team additionally explored the potential for cantilever beams to enable high-throughput characterization of metal hydride properties and began development of machine learning models that may predict enthalpy and entropy of metal hydride alloys that work at specified temperatures and pressures.

XI.2 Over-Molded Plates for Reduced Cost and Mass PEM Fuel Cells

American Fuel Cell
1200 Ridgeway Ave., Suite 123
Rochester, NY 14615

Development of low-cost bipolar plates for use in PEM fuel cells is critical for large-scale deployment of clean fuel cell technology. The main goal of this project is development of a low-cost bipolar plate with reduced mass by utilizing a plastic frame in the non-active regions. The development will be constrained with a design for roll-to-roll manufacturing that reduces diffusion layer stiffness constraints with narrow flow channels. The Phase I effort will focus on demonstrating the validity of the underlying concepts through design in concert with fuel cell transport and injection molding experts. Additionally, various configurations and sequences of coating all layers of the fuel cell will be investigated using the flow field as the primary carrier. Ultimately, a unitized and fully bonded fuel cell with plastic headers will result.

XI.3 Emergency Hydrogen Refueler for Individual Consumer Fuel Cell Vehicles

Reactive Innovations, LLC
2 Park Drive, Unit 4
Westford, MA 01886

Reactive Innovations, LLC, is developing an emergency hydrogen refueler to be stored in the trunk of fuel cell powered vehicles. Especially in the early stage of commercial release of hydrogen fuel cell vehicles, the sparsity of hydrogen fueling stations is expected to lead to "range anxiety." This refueler will help lessen range anxiety that consumers feel by offering them assurance of reaching a fueling station. The system will contain a hydrogen-rich solid material, which reacts with water to produce hydrogen on demand. The system will be able to be safely stored within the vehicle, to be taken out and used when needed to provide sufficient hydrogen to reach the nearest hydrogen fueling station.

PHASE II PROJECTS

XI.4 Novel Hydrocarbon Ionomers for Durable Proton Exchange Membranes

NanoSonic, Inc.
158 Wheatland Drive
Pembroke, VA 24136-3645

The objective of this project is to develop and demonstrate high-temperature hydrocarbon-based membranes with the chemical, thermal, and mechanical properties necessary to qualify for the demanding environments within a fuel cell vehicle. The approach involves the synthesis of novel high-molecular-weight aromatic hydrocarbon membranes that possess polar moieties along the polymer backbone and pendant quaternary ammonium groups. During the Phase II project, a series of novel phosphoric-acid-imbibed poly (thioether benzonitrile) copolymers shall be evaluated per DOE's 2020 technical targets for membranes for transportation applications. Specifically, the synthesized polymers will be chemically tailored to contain the ideal balance of ion exchange capacities and ionically doped phosphoric acid to demonstrate safe and reliable energy generation. The ionomers will be down-selected, transitioned from a technology readiness level of 3 to 7, and presented to PEM fuel cell manufacturers and integrators with a detailed integration design plan and cost analysis. The fully integrated PEM fuel cell system will be demonstrated as compliant with DOE's 2020 technical targets for MEAs for transportation applications, positioning the PEM fuel cells as environmentally friendly alternatives to internal combustion engines.

II.B.7 New Approaches to Improved PEM Electrolyzer Ion Exchange Membranes

Tetramer Technologies, LLC
657 S. Mechanic Street
Pendleton, SC 29670

Tetramer Technologies, LLC, has developed a new membrane molecular architecture that has demonstrated equivalent or better performance compared to the current Nafion materials at 50% lower cost. These attributes directly address the high electrolyzer cost and performance issues. Key attributes of Tetramer's technology versus the current Nafion electrolyzer membranes are improved physical performance properties, 50% lower hydrogen permeability, and equal or higher conductivity. This technology will provide thinner membranes, which can lower costs and increase performance directly through decreased ionic resistance and indirectly through the reduction of the overall cell potential. Tetramer's membranes can also provide 50% less hydrogen crossover loss, thus improving the electrolyzer yield and lowering costs.

XI.5 Flexible Barrier Coatings for Harsh Environments

GVD Corp.
45 Spinelli Place
Cambridge, MA 02138

Phase II of this project was awarded in 2016, and the project was further selected for a Phase IIA award in FY 2017. This project has focused on the development of a multi-layer vapor deposition approach to deposit coatings on top of compressor seals. These coatings are meant to enhance the resistance of seals to friction and to mitigate hydrogen ingress, therein increasing reliability. Seals are a common point of failure for reciprocating compressors, and GVD aims to enable a seal life of at least 8,000 h. In Phase IIA, they will optimize the thicknesses of their seal coatings, along with the deposition process, and test coating performance in relevant environments.

XI.6 Cryogenically Flexible, Low Permeability Thoraeus Rubber H_2 Dispenser Hose

NanoSonic, Inc.
158 Wheatland Drive
Pembroke, VA 24136

In FY 2017, NanoSonic conducted R&D to develop a low-cost, reliable hydrogen dispensing hose under an SBIR Phase II award. Dispensing hoses today fall short of DOE reliability and cost targets and are manufactured outside of the United States. NanoSonic's prototype is being designed for resistance to hydrogen embrittlement, flexibility under the low temperatures (-40°C) and high pressures (875 bar) of hydrogen dispensing, durability under consistent customer use, and manufacturability at large scales in the United States. The hose utilizes a novel polymer that is wrapped in carbon fiber and is infused with a ceramer at the ends that enables the hose to tolerate high-strength crimps. Carbon fiber winding patterns for maximum hose strength have been developed from extensive modelling and experimental testing in Phase II. In FY 2017, NanoSonic was also selected for a Phase IIB award, wherein they will develop a hose fitting that would enable evaluation of the hose›s mechanical properties and would ultimately enable integration of the hose with a dispenser.

XI.7 Low Cost Alloys for Magnetocaloric Refrigeration

General Engineering & Research LLC
10459 Roselle St. Suite A
San Diego, CA 92121

Phase I of this project was awarded in FY 2016 and evaluated the cooling capacity of low-cost rare earth alloys to assess their potential for use in hydrogen liquefaction. The team identified and filed a patent on a novel class of alloys and also determined that micro- or nano-grained structuring can lower material synthesis times, thereby reducing cost. In FY 2017, the project was selected for a Phase II award, in which they optimized the structuring approach and tune the compositions of their patent-pending alloy class for specific temperature ranges of interest to hydrogen liquefaction.