Hawai‘i Natural Energy Institute Research Highlights

Electrochemical Power Systems

Materials Enablers for Advanced Manufacturing of Attritable Fuel Cells

OBJECTIVE AND SIGNIFICANCE: Hydrogen fuel cell systems are well suited to power small unmanned systems. Since cost remains an issue for these small systems, our focus is to develop design simplification that leads to cost reductions, while retaining the best possible performance. Hence, the concept of an attritable fuel cell, with "attritable" effectively being defined by the degree to which a product's performance is intentionally reduced to achieve lower cost. More specifically, the objective of this project is to eliminate the bipolar plate in the stack assembly and replace it with an embedded current collector in each cell with a unitized assembly incorporating the electrodes, current collectors, and flow path and gas manifolding.

BACKGROUND: Hydrogen fuel cells can produce electric power with a low thermal signature and operate with minimum maintenance, providing an important complement to battery electric systems and internal combustion engines. The key advantage over the incumbent technologies is the 4-8x gravimetric energy storage density of the hydrogen fuel over batteries, which translates into 4-8x endurance/range for systems and low signature DC power with improved start times over internal combustion engines. Key technical challenges remain for hydrogen fuel cells, namely cost, heat rejection, and volumetric storage density of hydrogen as compared to logistic fuels.

A large fraction of cost of system fabrication for small-scale fuel cells is associated with the bipolar plates and the labor costs associated with building the device because of the large part count. We are seeking to move fuel cell (FC) manufacturing closer to battery manufacturing, in which continuous reel-to-reel process are used to manufacture the electrode, which are then rolled or stacked into containers that require very little handwork or parts registration.

PROJECT STATUS/RESULTS: To meet our goals, a new lamination processes leveraging the latest advances in flexible electronics manufacturing is being developed. This proposed process preserves electrochemical activity, uses new methods to simplify fabrication and assembly, and incorporates new materials enablers to achieve a significant cost decrease over state-of-the-art FCs. The approach allows for multiple cells to be connected on a single plane and aggregated into one unitized FC produced continuously.

To date, a successful demonstration of a multi-cell planar array FC was completed—validating the ability to use flexible printed circuit boards (PCB) as a current collector in a laminated structure for development of multi-cell planar arrays of FCs. The demonstration was completed with a 2-cell prototype with 1 cm x 10 cm high temperature (HT) FCs using flexible PCB-based current collectors. The flexible PCBs were produced with 2 oz copper and a Dupont HN polyimide coverlay, validating the materials further usage assembling planar arrays of HT proton exchange membrane FCs operating at 160°C with free phosphoric acid in contact with the current collectors. Future work will expand upon past year successes scaling up to a 100 W demonstration module.

Figure 1. Demonstrated ability to fabricate a 2-cell membrane electrode assembly using flexible PCB technology.

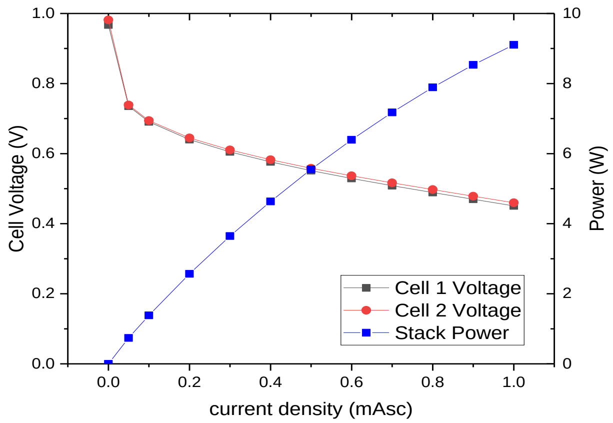

Figure 2. 2-cell performance curves from successful demonstration of planar current collector designs laminated with 2-cell membrane electrode assembly.

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