



# 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 ideally suited to power small unmanned systems that will be increasingly important when competing against near-peer adversaries, especially for isolated forces in the INDOPACOM region. A key facet of small unmanned systems is their attritability relative to expensive weapons systems. Attritable fuel cell powered unmanned systems require that the cost of fuel cells decrease so that their loss is acceptable in an exchange. This cost decrease can be traded against durability and performance, but ideally, both performance and durability would remain relatively constant. This is a unique DoD problem whose materials challenges are not being addressed by the broader fuel cell industry or academia.

The objective of this project is to perform material research combined with simulation to propose a conceptual design for a fuel cell with laminate construction to realize a 5x cost decrease over state-of-the-art (SOA) small fuel cells (0.5-5 kW) while retaining performance.

**BACKGROUND:** Hydrogen fuel cells have the ability to store energy efficiently, produce electric power with low 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 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. The objective of this work is to move fuel cell 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:** Under this work, HNEI is investigating simpler system architectures to enable

reduced cost of construction for high temperature proton exchange membrane fuel cells (HT-PEM). The use of HT-PEM also has the potential to reduce the costs of precious metal catalysts and polymer membrane substrates, further supporting the lower cost targets. The higher operating temperatures of HT-PEM (120-200°C) directly address heat rejection challenges. Volumetric storage challenges of hydrogen are indirectly addressed in this project through a simpler fuel cell system architecture and increased heat rejection that leads to volume savings in the fuel cell system that can be applied to hydrogen storage space claim.

To date, HNEI has successfully demonstrated the use of flexible PCB based materials for planar current collection in a single cell without any performance loss vs standard configurations. Fabrication of 2-cell prototype (Figure 1) has also begun. In 2024, ONR awarded a three year program extension to continue this work.

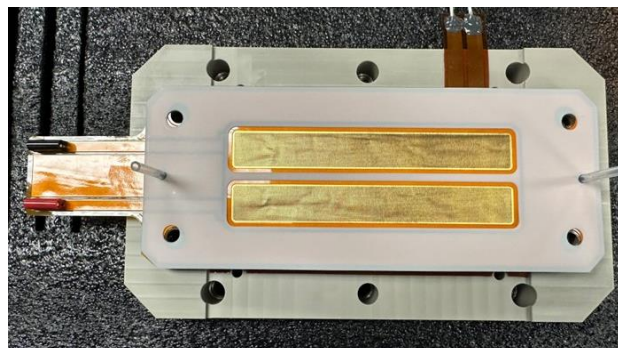


Figure 1. 2-cell prototype fuel cell using 1 cm x 10 cm electrodes with planar current collection assembly in progress. Clearly visible are the flexible PCB based-current collectors.

Results of this work has been presented at the Electrochemical Society meetings in 2023 and 2024: [Investigating the Suitability of Printed Circuit Components for Fuel Cells](#) and [Investigating the Suitability of Printing Metal Current Collectors Directly Onto the GDMs of PEMFCs](#).

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