Hawaiʻi 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 uniquely 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 compliment to battery electric systems and internal combustion engines. Key advantages over the incumbent technologies are 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.

Under this work, HNEI is investigating the potential of high temperature proton exchange membrane fuel cells (HT-PEM) to develop materials enablers that will allow for the construction fuel cells with cheaper assembly costs through a simpler system architecture to reduce components. HT-PEM also has the potential to reduce the costs of precious metal catalysts and polymer membrane substrates to achieve the target cost reduction. The higher operating temperatures of HT-PEM directly addresses heat rejection challenges through higher temperature operation (120-200°C). 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.

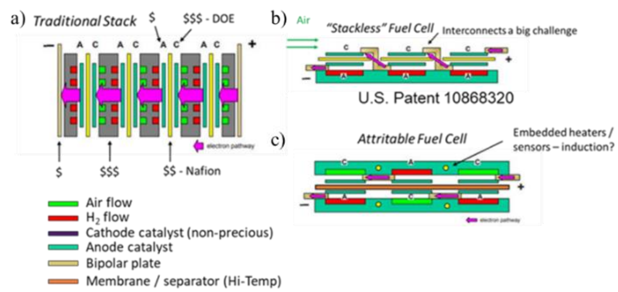

Figure 1. a) Traditional fuel cell stack with bipolar plate interconnects, b) previous demonstrated "Stackless Fuel Cell" by ONR, c) concept for a closed-cathode air-cooled fuel cell that would be attritable.

PROJECT STATUS/RESULTS: To date, we have down-selected components and fabrication protocols that yield peak power representative of the current art and began evaluating electrode fabrication techniques. Researchers have also designed and produced current collectors based on flexible circuit board technology and began planning for demonstrating operation with OEM and HNEI produced electrodes in a single cell. The year 1 results **Investigating the Suitability of Printed Circuit Components for Fuel Cells** were presented at the 244th Electrochemical Society meeting in October 2023.

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