



Hawai'i Natural Energy Institute Research Highlights

Electrochemical Power Systems

Enabling Durable Fuel Cell Operation via Contaminant Mitigation

OBJECTIVE AND SIGNIFICANCE: Fuel cells offer the opportunity to significantly increase the flight duration of electric powered unmanned aerial vehicles (UAVs). With fuel cell power systems, increases of 5-10x in flight duration are possible for the same volume and weight constraints as high energy lithium batteries. Under this project, HNEI continued support to Naval Research Laboratory (NRL) efforts to develop lightweight, high efficiency fuel cell systems for UAVs including developing components that enhance contaminant tolerance. Contamination mechanisms in proton exchange membrane (PEM) fuel cells can become quite complex with many sources (air, fuel, system materials) and problems can be compounded by the contaminant reaction products that impact many key fuel cell materials.

BACKGROUND: The partnership between HNEI and NRL began in 2009 and HNEI continues to support NRL's fuel cell (FC) development effort via diagnostic testing, evaluation of needs, and design recommendations. More recently, HNEI has shifted focus from testing support to working on the design, development, and demonstration of PEMFC components that enhance contaminant tolerance at elevated operating temperatures. Most industry efforts to address contamination have focused on low temperature (60-90°C) PEMFCs. High temperature (140-200°C) PEM (HTPEM) fuel cells, while not as fully developed, offer the benefits of higher contaminant tolerance and lower cost membranes compared to low temperature PEMFCs. Additionally,

the higher operating temperatures can help reduce system complexity and provide opportunities for volume reduction, e.g. heat exchanger size reduction, a major consideration for use of FCs for small UAVs (0.5-5 kW).

PROJECT STATUS/RESULTS: Under prior work, HNEI established an electrode fabrication system similar to one originally developed by NRL allowing the fabrication of custom catalyst coated membranes for small UAV-scale FCs. HNEI's fabrication is based on ultrasonic spray deposition and is adapted from the NRL protocol to work with high temperature materials with improved contamination resistance.

Within the past year, we began in-house production of gas diffusion electrodes with varying catalysts and other materials. Several modifications were made to the spray coating system, improving the reproducibility. Testing of these electrodes was conducted and a literature review was completed, identifying specific contaminants and concentration levels for further examination. Due to federal funding cuts in May 2025, this work was halted prior to initiating contaminant screening, however, work has now resumed under new funding from the Office of Naval Research.

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Contact: Edward Bruffey, ebruffey@hawaii.edu

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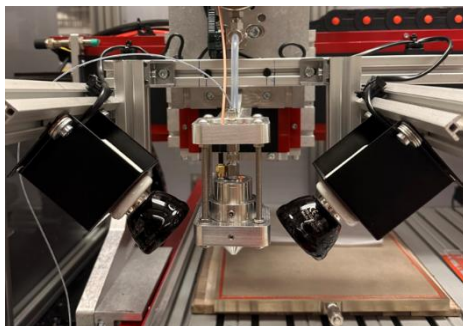


Figure 1. Radiant heater modification to ultrasonic spray coating system (left).

Histogram showing improvements to electrode catalyst loading reproducibility of spray coated decreased from $\pm 15\%$ to $\pm 2.5\%$ with spray coated modifications (right).

