Technical Assistance in Fabrication and Testing of MEAs

Cooperative Research and Development Final Report

CRADA Number: CRD-16-00638

NREL Technical Contact: Michael Ulsh

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Technical Report
NREL/TP-5900-71425
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Report Date: 1/12/2018

In accordance with Requirements set forth in the terms of the CRADA agreement, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the DOE Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: Altergy Systems

CRADA number: CRD-16-00638

CRADA Title: Technical Assistance in Fabrication and Testing of MEAs

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind
Year 1	$130,000.00
TOTALS	$130,000.00

Abstract of CRADA Work:

Altergy's fuel cell cost is highly dependent on expensive purchased membrane electrode assemblies (MEAs), which amount to $0.42/watt in a 5kW system. In order to better compete with other power solutions, the company has identified an MEA breakthrough cost of $0.20/watt to unlock new, major markets for its fuel cell products. Since Altergy presently does not have an accurate cost model for the real costs of these MEAs, it is difficult to know whether the company goal is achievable.

Altergy seeks to leverage NREL expertise to reduce cost and improve performance for Altergy's fuel cell products. The objective of this Small Business Voucher (SBV) project therefore will be for NREL and Altergy to work together in three major task areas: 1) demonstrating the fabrication of MEAs at NREL using NREL non-proprietary methods, to the intent of potentially fabricating MEAs at Altergy to reduce product costs; and, 2) creating a cost model to assist Altergy in manufacturing decisions.

Summary of Research Results:

Task 1: Fabricate baseline CCM-based MEAs (March, 2017)

At present, NREL fabrication of MEAs centers on multiple passes over a heated Nafion substrate with a small ultrasonic applicator nozzle. A mixture of 1% solids (the balance being evaporated), is applied. While this works well for fabrication of small MEAs on a time insensitive basis, part of the work at NREL in this task will be to increase the solids content closer to 10%, improve the stability of the ink (e.g. via different solvents), and utilize the larger Sonotek "Impact" spray head to explore high-throughput fabrication of CCM MEAs, suitable for industrial application. At least 4 batches of (5) MEAs each will be produced to allow for mild, non-proprietary optimization. These initial MEAs are expected to utilize standard Pt/C catalyst materials for a comparative baseline. The MEA size will be for the 377 cm2 existing Altergy product. NREL will transfer procedural and equipment and material cost information to Altergy, including cataloging the equipment and level of effort needed to produce the MEAs with this technique.

Task 2: Fabricate baseline GDE-based MEAs (September, 2017)

The above activity will be repeated for a set of GDE-based MEAs. Based on the CCM coating method results, the NREL team may choose to use the ultrasonic coating technique applied to gas diffusion electrodes, or may alternatively utilize the previously mentioned roll-to-roll coating method if desired.

Results for Tasks 1 & 2

- We completed the operational setup and verification of a second ultrasonic spray system in our MEA fabrication lab, using a spray head on this system that is different than our standard system, to pursue higher throughput.
- With this head, and by exploration of several process parameters including ink flowrate, head speed, and number of passes, **we demonstrated an improvement in area sprayed per unit time, at a given nominal loading, by two orders of magnitude**. As measured with spatial XRF, these high-throughput (HT) CCM electrodes are less uniform than those using our standard process.
- We evaluated an ultrasonic spray head with a different excitation frequency than those that we've previously used, which resulted in additional increases in throughput.
- We performed studies of high-throughput spraying of GDEs to see if we can replicate the performance we obtained in CCMs. We also studied spraying of the ionomer overcoat necessary for GDE performance.
- We sprayed several 377 cm^2 CCM electrodes and assembled MEAs for Altergy to test full-sized cells in their unique open-cathode system.
- In final exploratory studies, we fabricated electrodes with (a) higher loading, (b) Vulcan support instead of HSC, and (c) I:C ratios higher than those considered optimal for automotive conditions.

Task 3. Assist Altergy in performing in situ testing of MEAs fabricated in tasks 1-2 (September, 2017)

With its extensive testing capabilities, NREL will also perform testing as needed to provide additional insight to Altergy into specific behavior of the different catalyst compositions and constructions as it functions in the MEA.

<u>Results for Task 3</u>

- In situ testing showed only minor loss of performance of the HT CCM electrodes compared to our lab baseline, at both high temperature/high humidity and lower temperature/lower humidity (which is of more interest to Altergy for their open-cathode design) testing conditions.
- In situ testing of the sprayed GDEs showed that performance was not quite as good as the CCMs, though power output was almost the same.
- Altergy sent us a sample of their commercially sourced MEA (we don't know the source), which we tested and showed that, at least on our test station, at both high temperature/high humidity (automotive) and low temperature/low humidity (closer to Altergy's operating conditions), our high-throughput sprayed MEA performs better than their commercial MEA.
- Altergy completed testing of two 377 cm^2 NREL-sprayed CCM MEAs in a 12 cell stack with 10 of their standard MEAs on their open-cathode test-bench. The NREL cells did not perform as well in their system, but they considered the performance encouraging considering that these were lab MEAs with materials and structures focused on automotive performance.
- In situ testing of electrodes with higher loading and higher I:C ratio did not result in performance improvement. In situ testing of electrodes using Vulcan support instead of HSC resulted in moderate improvement in high current density performance at high humidification and high temperature, and minor improvement at the very dry conditions that are more typical for Altergy's system.

Task 4. Assist Altergy in developing a cost model for volume MEA manufacturing (December, 2017)

NREL will assist Altergy in developing a cost model. This will be used, in combination with the data from MEA fabrication and testing, to yield a "make-vs-buy" decision for Altergy with respect to MEA fabrication.

<u>Results for Task 4</u>

- We hosted the Altergy PI for several days to fully transfer knowledge developed during the project related to the equipment used, and mixing and spraying procedures used for the electrode coating, in order to support Altergy's development of a cost model.

Subject Inventions Listing:

None

ROI #:

None

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DOE Program Office:

Office of Energy Efficiency and Renewable Energy (EERE), Fuel Cell Technologies Program