VI.0 Manufacturing R&D Sub-Program Overview

INTRODUCTION

The Manufacturing Research and Development (R&D) sub-program supports activities needed to reduce the cost of manufacturing hydrogen and fuel cell systems and components. Manufacturing R&D will enable the mass production of components in parallel with technology development and will foster a strong domestic supplier base. The sub-program's R&D activities address the challenges of moving today's technologies from the laboratory to high-volume, pre-commercial manufacturing to drive down the cost of hydrogen and fuel cell systems. The sub-program focuses on the manufacturing of components and systems that will be needed in the early stages of commercialization. Research investments are focused on reducing the cost of components currently used or planned for use, as well as reducing overall processing times. Progress toward targets is measured in terms of reductions in the cost of producing fuel cells, increased manufacturing processing rates, and growth of manufacturing capacity.

In Fiscal Year (FY) 2015, manufacturing projects continued in the following areas: use of rolled goods quality control to detect defects in membrane electrode assembly materials; modeling of the effect of defects on fuel cell material properties.

GOAL

Develop innovative technologies and processes that reduce the cost of manufacturing fuel cells and systems for hydrogen production, delivery, and storage.

OBJECTIVES[1]

Key objectives for Manufacturing R&D include the following.

- Develop manufacturing techniques to reduce the cost of automotive fuel cell stacks at high volume (500,000 units per year) from the 2008 value of $38/kW to $20/kW by 2020
- Develop fabrication and assembly processes to produce onboard vehicle hydrogen storage systems achieving 1.8 kWh/kg (5.5 wt% H_2) and 1.3 kWh/L (40 g H_2/L) at a cost of $12/kWh ($400/kg H_2 stored) or less by 2017
- Support efforts to reduce the cost of manufacturing components and systems to produce hydrogen at <$4/gge (gallons gasoline equivalent; 2007 dollars; untaxed, delivered, and dispensed) by 2020

FY 2015 TECHNOLOGY STATUS

Presently, fuel cell systems are fabricated in small quantities. The cost of a 10-kW, low temperature polymer electrolyte membrane (PEM) fuel cell system for backup power is projected to be ~$3,700/$kW_{net}$ at a volume of 100 systems per year[2]. For automotive applications using today's technology, the cost of an 80-kW PEM fuel cell system is projected to be $55/kW for high volume manufacturing (500,000 systems per year)[3]. Projected costs include labor, materials, and related expenditures, but do not account for manufacturing R&D investment.

FY 2015 KEY ACCOMPLISHMENTS

FY 2015 saw a number of advancements in the manufacture of fuel cells and hydrogen storage systems.

- New algorithms for automated defect detection: National Renewable Energy Laboratory (NREL) expanded on its previous demonstration of optical inspection for fuel cell electrodes by developing algorithms that can automatically detect defects of various types from the real-time inspection data (Figure 1). The algorithms were shown to have no false positives on sample materials from General Motors. This work supports improved technology transfer to industry and addresses Manufacturing R&D sub-program milestones for membrane electrode assembly inspection.

[1] Note: Targets and milestones were recently revised; therefore, individual project progress reports may reference prior targets.
[2] http://www.hydrogen.energy.gov/pdfs/review14/fc098_wei_2014_o.pdf
[3] http://www.hydrogen.energy.gov/pdfs/review15/fc018_james_2015_o.pdf

- Component quality control measurement: In FY 2014, NREL demonstrated its reactive impinging flow (RIF) technique in which the reactive gas ($H_2/O_2/N_2$) flows onto conductive fuel cell roll goods; heat from the chemical reaction is then detected. In FY 2015, Lawrence Berkeley National Laboratory (LBNL) modeled the RIF process with gas diffusion electrode material. LBNL predicted the change in temperature of the material (due to the reactive excitation and heat generation) as a function of the width of the defect for three different defect depths, and results can be seen in Figure 2. Clearly at any defect width, the more the catalyst layer thickness is reduced, the higher the temperature change from the bulk material. If the lines are extrapolated down to $\Delta T = 1$ K or 2 K, the width of the minimum detectable defect can be determined.

Funding Opportunity Announcement (FOA): On March 3, 2015, the Office of Energy Efficiency and Renewable Energy (EERE) Fuel Cell Technologies Office (FCTO) released an FOA entitled "Hydrogen and Fuel Cell Technologies Research, Development, and Demonstrations." The FOA included a topic on innovative hydrogen delivery pipeline manufacturing with funding up to $1.5 million. The organizations selected for negotiation will be announced soon.

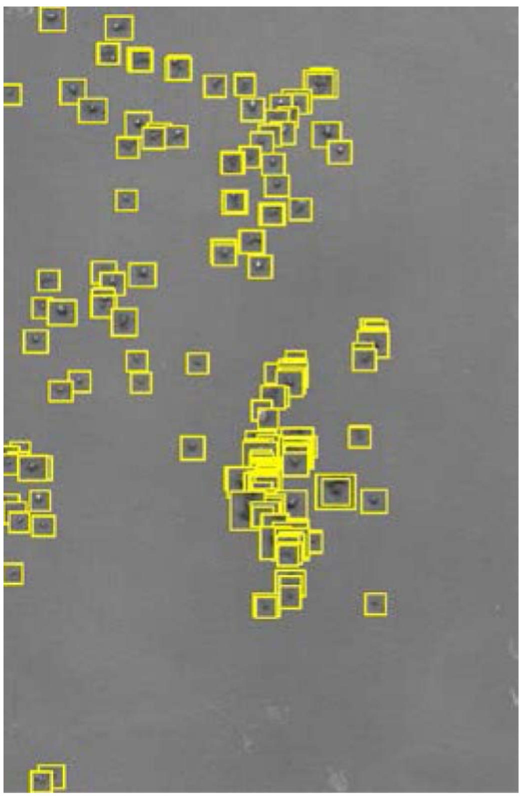

FIGURE 1. Image of intentionally created scuffs and scratches on fuel cell membrane. Defects were detected using optical reflectance. The scanning system operated on sheet materials at 10 fpm. Algorithms were developed and demonstrated for automated detection as illustrated by the yellow boxes. The debris images (dots) were magnified 10x for ease of viewing.

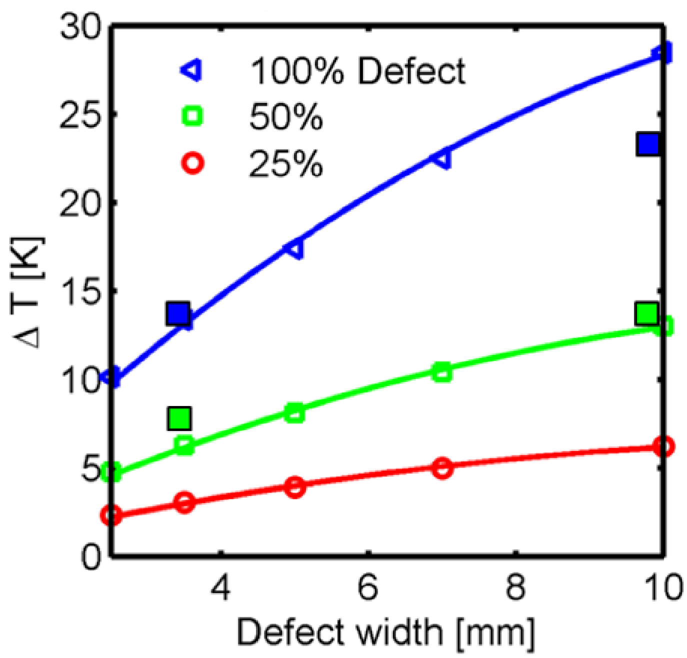

FIGURE 2. Change in temperature of gas diffusion layer material as a function of defect width following reactive excitation for three different defect thicknesses. 100% defect means that all the reactive material is gone and only a bare spot is left. 50% means that the thickness of catalyst layer is reduced by one half, and 25% means the thickness is reduced by one quarter. The solid symbols represent experimental data while the hollow symbols are model predictions. The solid lines were drawn to guide the eye through the modelled data points.

BUDGET

The President's FY 2016 budget request for FCTO includes $4 million for Manufacturing R&D. The FY 2015 appropriation for Manufacturing R&D was $3 million (Figure 3).

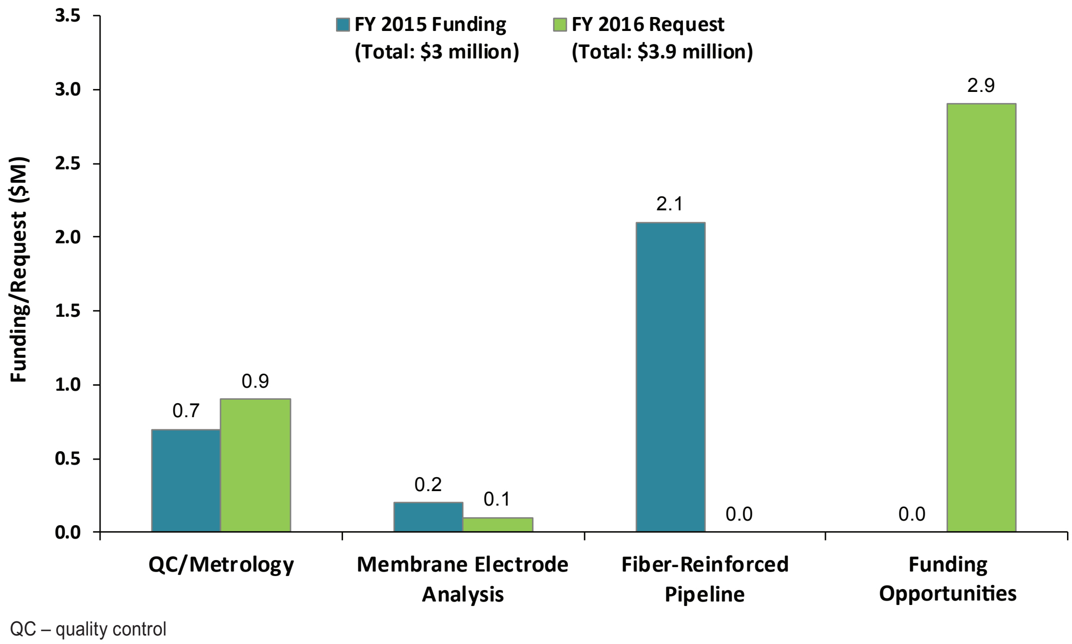

FIGURE 3. Manufacturing R&D Funding. Subject to appropriations, project go/no-go decisions, and competitive selections. Exact amounts will be determined based on research and development progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements.

FY 2016 PLANS

In FY 2016, the Manufacturing R&D sub-program will:

- Continue projects on supply chain development (Ohio Fuel Cell Coalition and Virginia Clean Cities at James Madison University) and global manufacturing competitiveness analysis (GLWN - Westside Industrial Retention & Expansion Network) in collaboration with DOE's Clean Energy Manufacturing Initiative and NREL's Clean Energy Manufacturing Analysis Center.
- Initiate a project to manufacture reliable joints (with very low leak rates) that connect fiber-reinforced pipeline for hydrogen delivery at 100 bar.
- Correlate the size of defects generated during membrane and/or membrane electrode assembly fabrication to loss of fuel cell performance.
- Continue to use predictive modeling and single and segmented cell test methods to assist diagnostic development.
- Develop novel defect detection via infrared detection of the thermal response of material.
- Expand implementation of defect diagnostic techniques on industry production lines to original equipment manufacturers.

FCTO plans to release an FOA that includes topics on hydrogen and fuel cell manufacturing R&D in FY 2016, with awards subject to appropriation and announced later in the fiscal year. FCTO will continue to coordinate with other agencies (including the National Institute of Standards and Technology and the U.S. Department of Defense) and with other technology offices within EERE to identify synergies and leverage efforts.

Nancy Garland
Manufacturing R&D Project Manager
Fuel Cell Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, D.C. 20585-0121
Phone: (202) 586-5673
Email: Nancy.Garland@ee.doe.gov