Controlled Porosity and Surface Coatings for Advanced Gas Diffusion Layers

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Physical Sciences Inc.

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Overview

Timeline

Project Start Date: May 28, 2019

Project End Date: May 27, 2021

Budget

FY19: $505,989

FY20 (planned): $494,008

Barriers

1) **Cost**

Partners

University of Tennessee—Knoxville

Characterization of gas diffusion layers ex-situ

University of Connecticut

Evaluation of gas diffusion layer performance in PEMFCs

Relevance

The objective of this program is to demonstrate a cost-effective, scalable method for producing gas diffusion layers (GDLs) that support equivalent performance of current GDLs at a 20% cost reduction to allow for widespread adoption of PEMFCs.

Focus Area	FY19 Impact
A. Durability	Established methods and materials to improve electrochemical stability by 95% for in-situ durability.
B. Performance	Achieved PEMFC performance equivalent to commercial GDLs at current densities 0-0.7 A/cm^2.
C. Processing	Performed initial process scale up for a production method with a projected 20% cost reduction due to reduced processing steps and energy consumption.

Approach—Overview

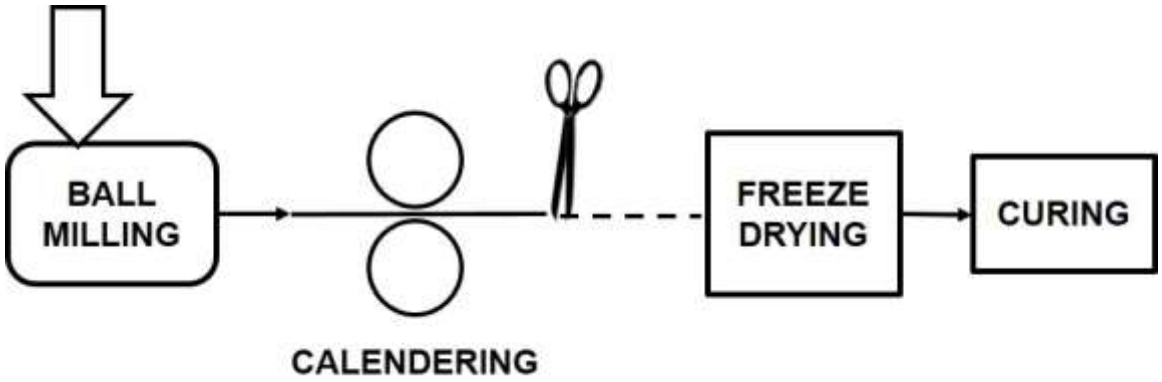
PSI's approach is focused on scaling up a versatile ice-templating method that can be used to tailor GDL properties with a reduction in processing steps compared to state of the art GDL production.

Enhanced durability and performance will be demonstrated by:

1) Use of materials that are electrochemically stable to provide enhanced durability.
2) Utilizing an ice-templating method to readily tailor transport properties of GDLs for enhanced performance.

Cost reduction will be demonstrated via:

1) Reduction in processing steps
2) Reduction in energy consumption



Block flow diagram of PSI's proposed process.

Approach—Targets

The program objectives will be achieved by reaching the milestones outlined below.

Technical Objectives	Status
Assemble PSI GDLs into PEMFCs to demonstrate necessary mechanical robustness.	Complete
Demonstrate ex-situ durability within 10% of commercial GDLs.	In Progress
Demonstrate GDLs that support equivalent (≤ 2%) PEMFC performance relative to a commercial GDL.	Complete
Utilize proposed process to produce 10 m^2 of GDL.	In Progress
Demonstrate GDLs that support equivalent (≤ 5%) PEMFC performance relative to a commercial GDL on extended operation.	Pending
Generate scale-up plans for the production of GDLs at price points representing a 20% cost reduction.	Pending

Accomplishments & Progress: Ex-Situ Electrochemical Stability

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VG-2020-55-5

PSI improved electrochemical durability of GDLs by 95% compared to first generation PSI GDLs by identifying methods and materials to minimize corrosion rates without modifying the proposed process.

- Optimization of carbon materials and formulations will be used to demonstrate electrochemical durability within 10% of commercial GDLs.
- Enhanced corrosion resistance of GDLs will provide **increased durability** of GDLs and the overall PEMFC system.

Equilibrium Current Density at 200 mV	
Commercial	0.4 μA/cm^2
PSI 1st Generation	410 μA/cm^2
PSI 2nd Generation	1.7 μA/cm^2

Accomplishments & Progress: In-Situ Performance

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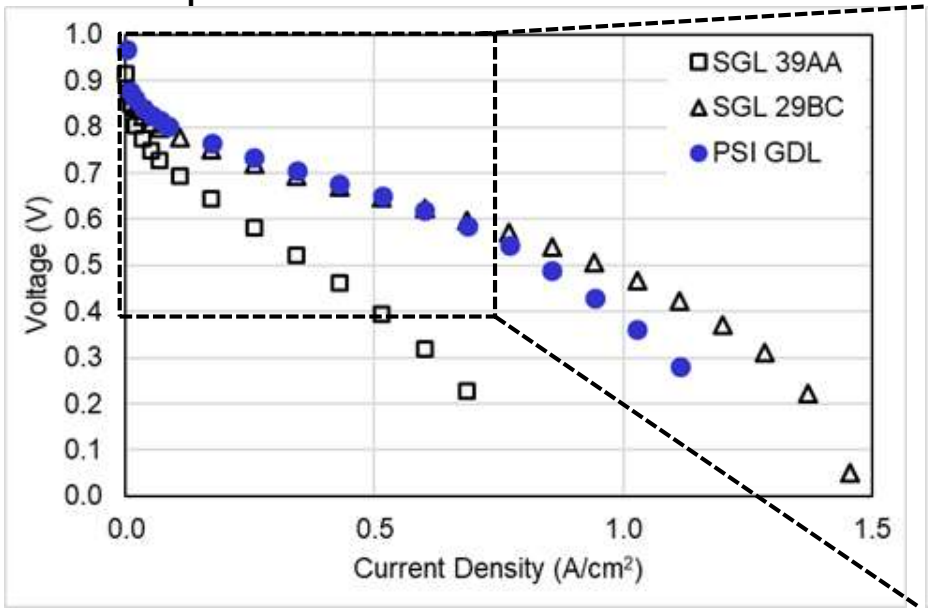
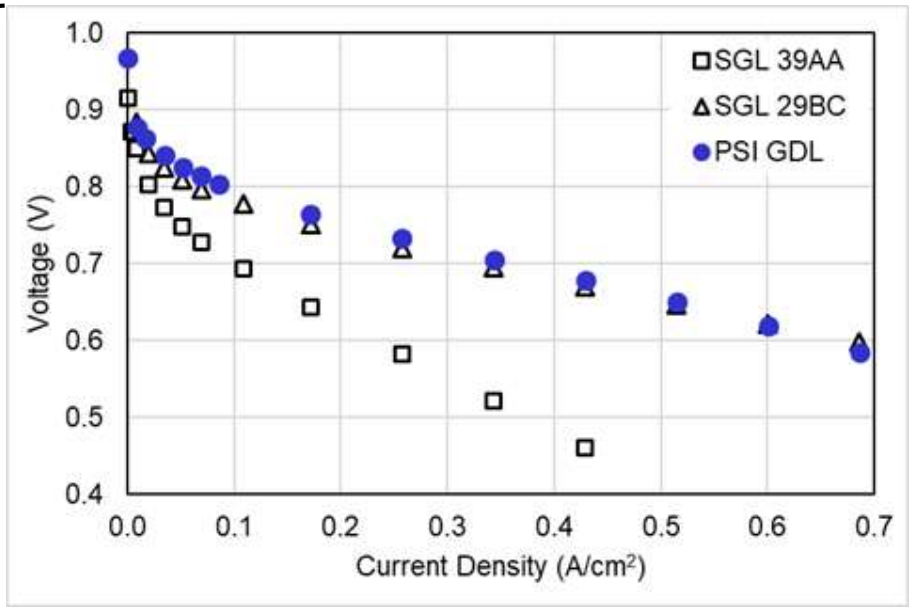
PSI GDLs supported PEMFC performance equivalent to that achieved with commercial GDLs at current densities <0.7 A/cm^2.

- PEMFC containing PSI GDLs demonstrated a limiting current density of ~1.3 A/cm^2.
- Demonstrated **enhanced performance** at current densities 0-0.7 A/cm^2 compared to commercial GDLs.



Polarization curve of PEMFC containing PSI GDLs compared to state of the art GDLs.



High voltage region of polarization curve of PEMFC containing PSI GDLs compared to commercial GDLs.

Accomplishments & Progress: Manufacturing Scale-Up

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VG-2020-55-7

PSI completed initial scale-up demonstrating scalability of the proposed process, which is estimated to be 80% of the manufacturing cost of current generation GDLs.

- PSI developed a larger-scale process and implemented equipment to manufacture GDLs with dimensions ~8.5”x11”.
- Scale-up efforts performed at PSI will be used to develop detailed cost estimates demonstrating a **cost reduction** compared to the production of current generation GDLs.

PSI GDL ~11”x8.5” produced with large scale process.

Responses to Previous Year Reviewers' Comments

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VG-2020-55-8

This project was not reviewed last year.

Program Partners/Collaborators

Electrochemical Energy Storage and Conversion Laboratories, University of Tennessee Knoxville (UTK)—Dr. Mench

UTK will lead the GDL performance characterization and evaluation efforts focusing on:

- Measurement of the thermal conductivity, thermal contact resistance, and the stress-strain relationship of GDLs as a function of compression.
- Measurement of the permeability, diffusivity, electrical conductivity, and contact resistance of selected GDLs.
- Performing durability assessment of selected GDLs.

Center for Clean Energy Engineering at University of Connecticut (UConn)—Dr. Suib

UConn will lead the efforts to characterize the performance of the GDLs in PEMFC stacks.

- Single and multi-cell stack testing will be carried out.
- UConn will characterize the performance of fuel cells with the PSI GDL upon extended cycling and after ex situ aging of the GDL.

Remaining Challenges and Barriers

To achieve the objectives of this program, the PSI-led team must:

- Further improve the electrochemical durability of GDLs to support PEMFC performance and stability.
  - Reactive components used in GDL production will be minimized to reduce corrosion of the GDLs.
  - Both ex-situ and in-situ electrochemical testing will be performed to demonstrate GDL stability.
- Demonstrate equivalent lifetime of GDLs in PEMFCs compared to commercial GDLs.
  - PEMFCs containing PSI GDLs will be tested over extended periods.
- Demonstrate a cost reduction of ~20% by developing detailed cost models and performing initial scale-up.
  - The scale-up efforts will be used to develop the cost models demonstrating the cost reduction of GDL production that will enable commercialization and wider adoption of PEMFCs.

Proposed Future Work

Future work will focus on the following:

Remainder of FY19:

- Optimize GDL formulations to demonstrate targeted transport properties, durability, and performance by minimizing reactive components of GDLs.
- Demonstrate uniformity of transport properties within larger scale samples by characterizing larger sample sets.

FY20:

- Characterize PSI GDL performance over extended operation (>1000 hrs.) of PEMFCs.
- Initial scale-up GDL production to meet 10 m^2 objective.
- Generate commercial scale plans and detailed cost models based on scale-up efforts.

*Any proposed future work is subject to change based on funding levels.

Summary

- PSI **improved the electrochemical durability** of the GDLs by 95% compared to first generation GDLs. The content of reactive materials will be optimized to **achieve equilibrium current density within 10% of commercial GDLs.**
- PSI has produced GDLs that support **PEMFC performance equivalent to commercial GDLs** at current densities 0-0.7 A/cm^2.
- PSI GDLs have demonstrated equivalent initial PEMFC performance, and will be tested for extended periods to achieve **lifetime within 5% of commercial GDLs.**
- PSI demonstrated scale-up that allows production of GDLs with a size relevant to the application. Further scale-up will be performed to **produce 10 m^2 of GDL material**.
- Commercial scale-up plans and detailed cost models will be developed based on initial scale-up at price points representing an **estimated 20% cost reduction.**