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PEM Fuel Cell Freeze Durability and Cold Start Project

UTC Fuel Cells

May 16, 2006

FCP 21

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Overview

Timeline

- January 1, 2006
- December 31, 2006
- 40% complete

Barriers

- Barriers addressed
  - Cold Start Durability
  - Cold Survivability
  - Cold Start Capability
- Targets
  - 90% rated power in 30 sec from -20 ºC
  - Survivability to -40 ºC

Budget

- Total project funding
  - DOE - $990,000
  - Contractor - $247,600

Partners

- UTC Research Center

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Objectives

- To characterize PEM fuel cell durability and performance under freezing conditions

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Approach

- Task 1: Cold Start Decay Studies
  - Investigate the effect of freeze and cold start procedures on performance decay
  - Alternative cell materials will be evaluated for their resistance to performance loss with repeated cycles.

60% complete

- Task 2: Cold Survivability
  - Conduct freeze/thaw cycling of short stack to -40 ºC
  - Conduct teardown analysis to characterize failure modes

0% complete

- Task 3: Rapid Cold Start Characterization
  - Investigate the effect of freeze and cold start procedures on cold start capability
  - Investigate effect of alternate cell materials on cold start capability

60% complete

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Technical Accomplishments/ Progress/Results

- Conducted cold start testing of baseline cell configuration
- Evaluated effect of procedural variables on cold start decay and start time
- Developed understanding of key factors related to performance loss after cold start
- Developed alternate cell configuration which reduced cold start performance losses and improved cold start capability

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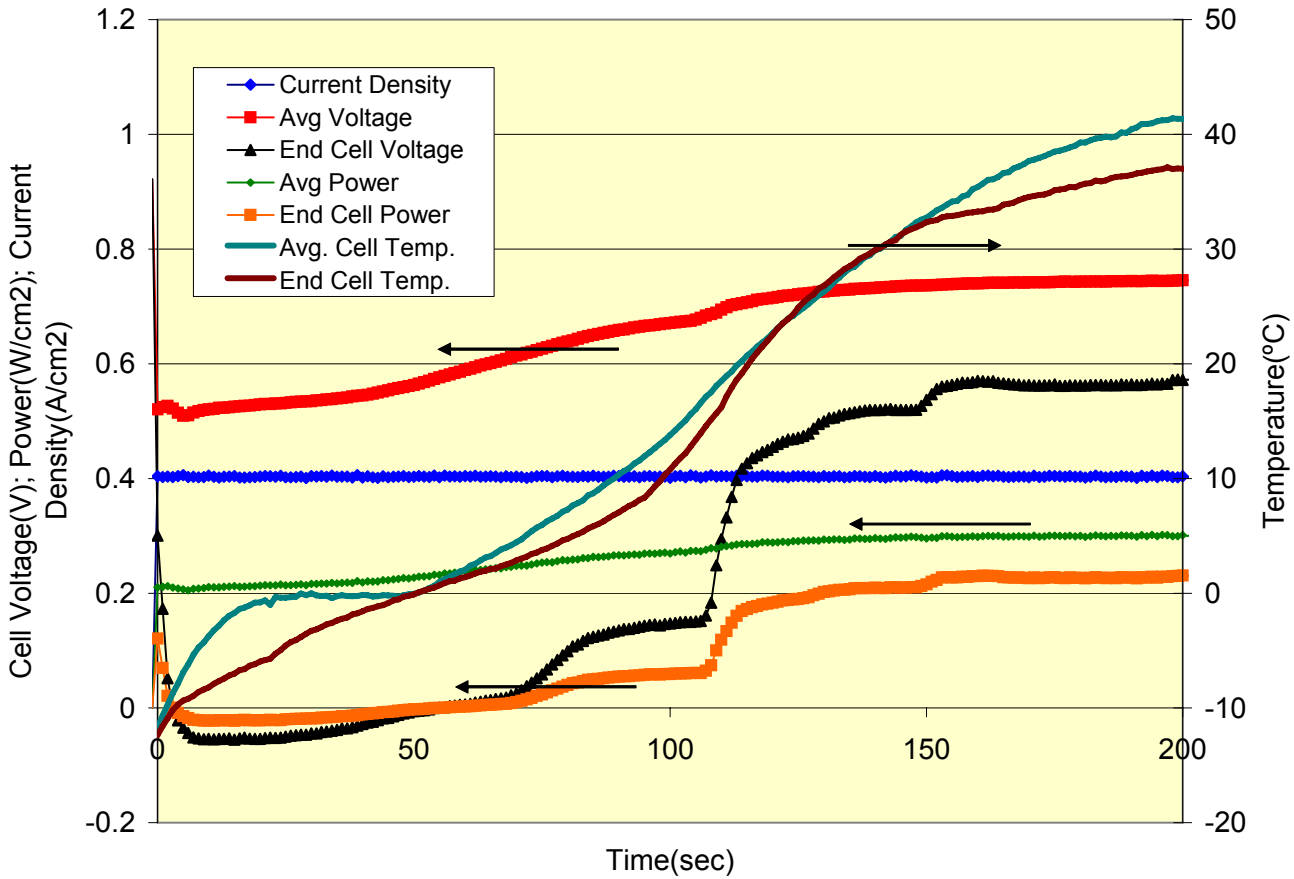
Short Stack Cold Start Testing

End cells perform worse than middle cells during cold start from -15 ºC



Data from cold start from -15 ºC

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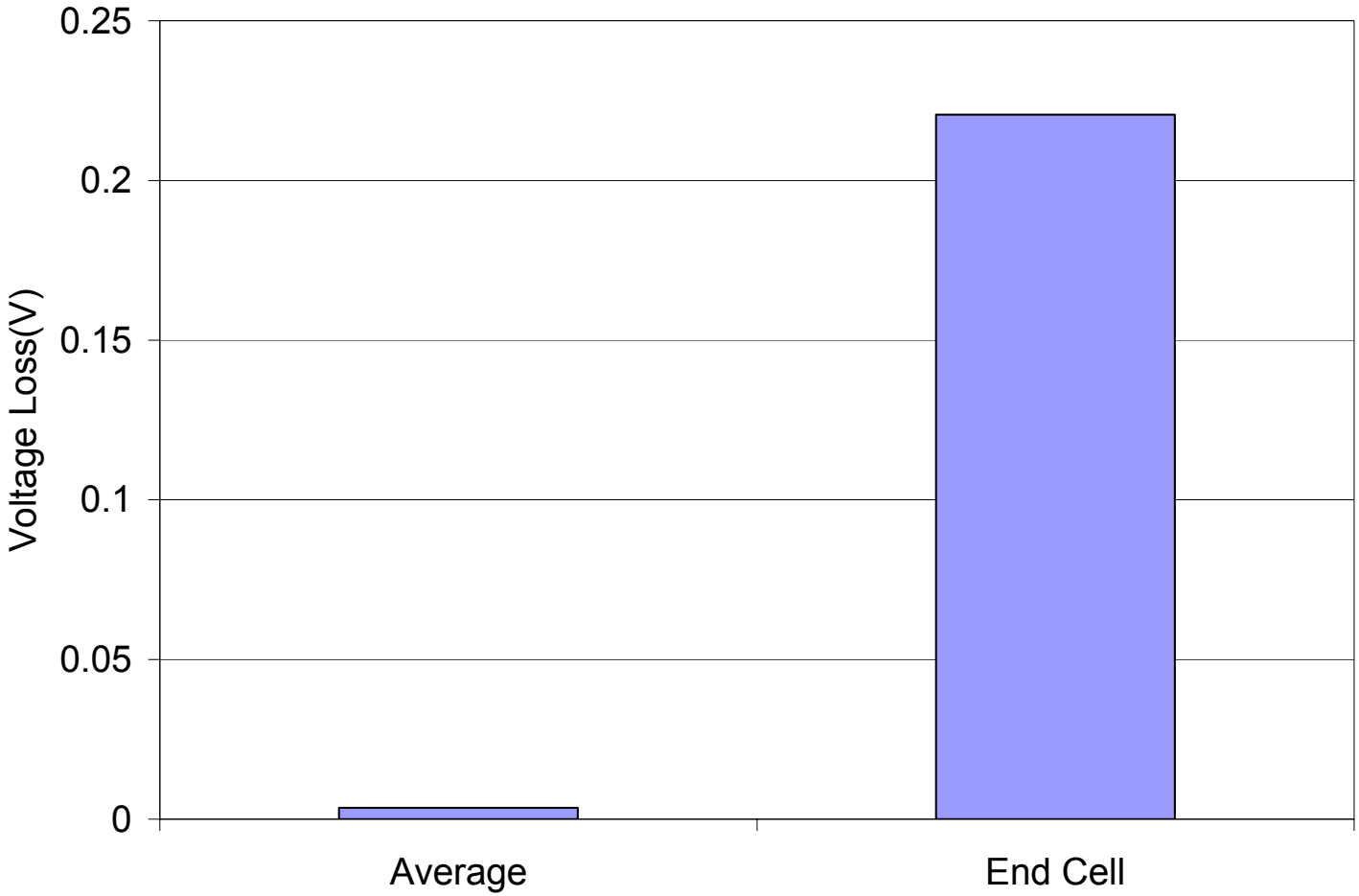
Short Stack Cold Start Testing

End cells suffer performance loss after cold start from -15 ºC



Voltage loss at 1000 mA/cm^2 after cold start from -15 ºC

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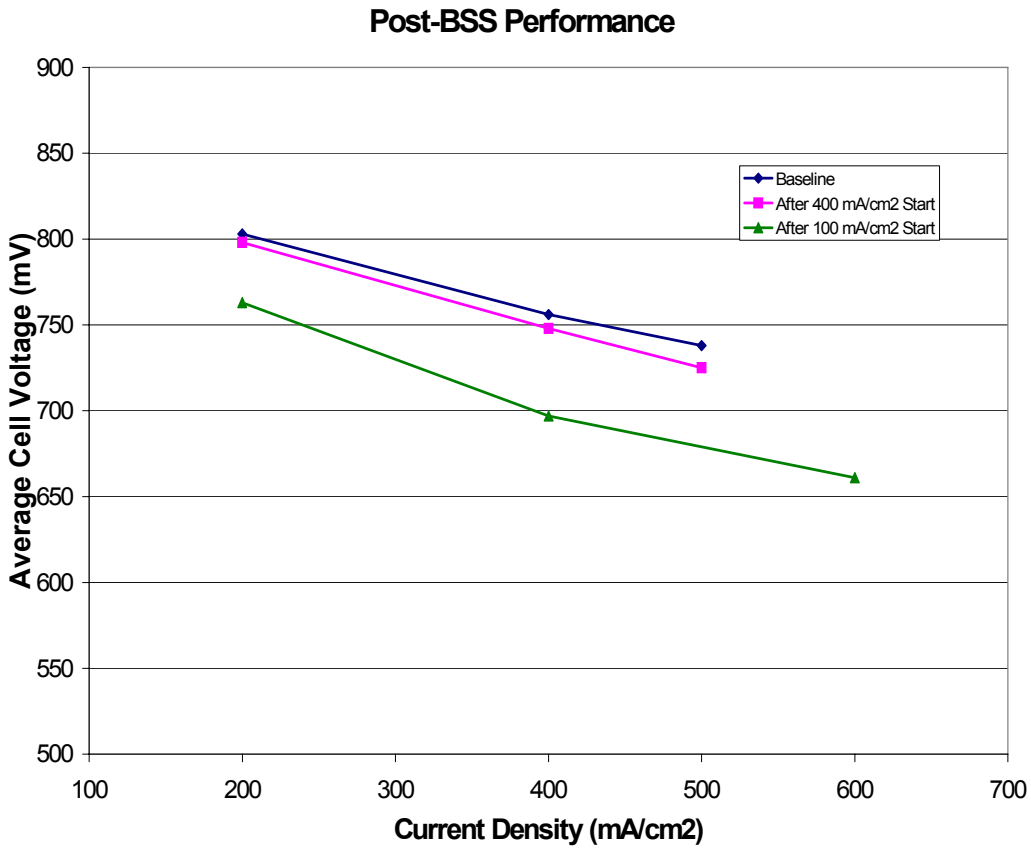
Influence of Start Current Density on Decay after Cold Start

Low current density start induces performance decay after cold start



Comparison of effect of start current density on performance decay after cold start from -15 ºC

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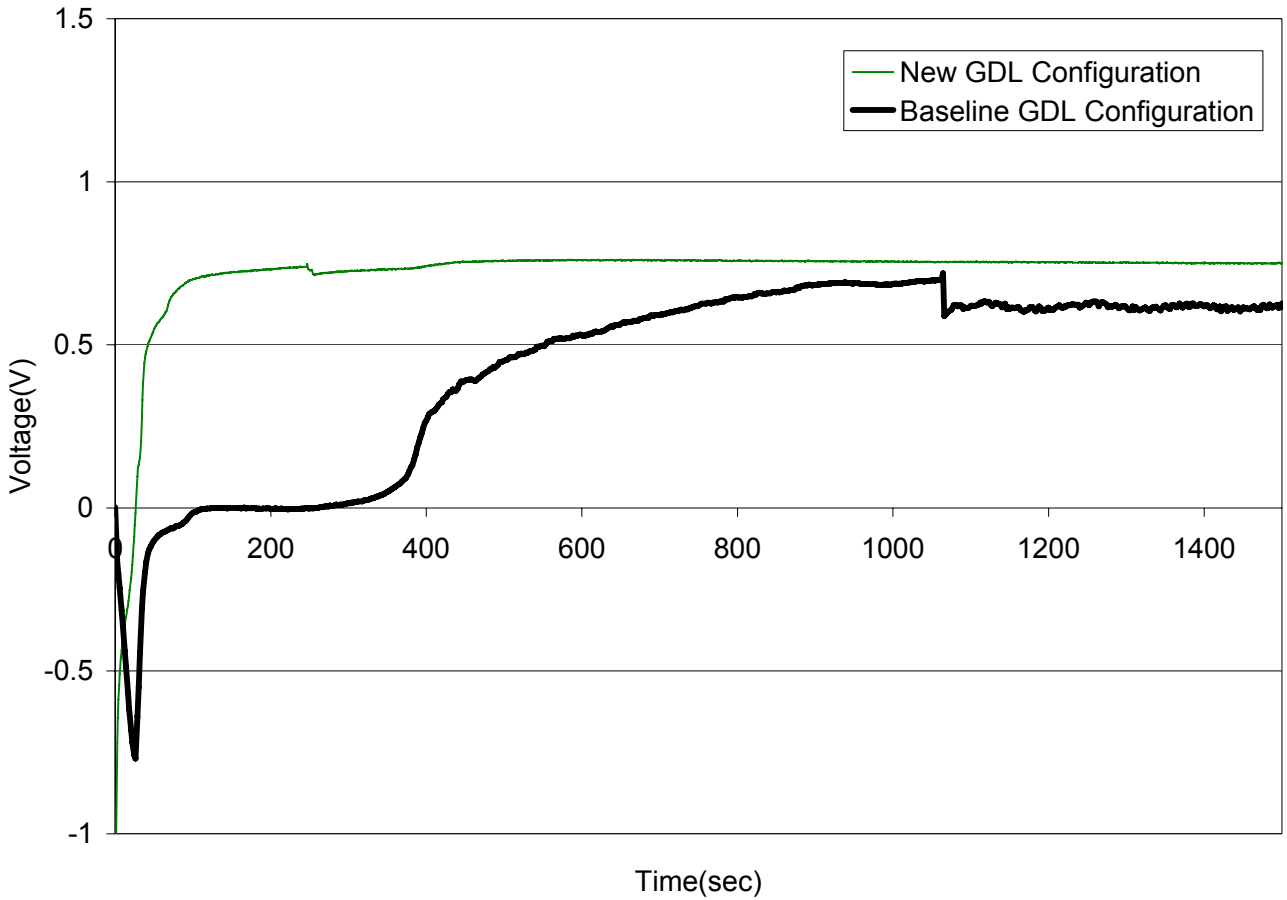
Single Cell Cold Start Testing

New GDL configuration improves cold start performance



Comparison of voltage profile for new GDL configuration during cold start from -15 ºC

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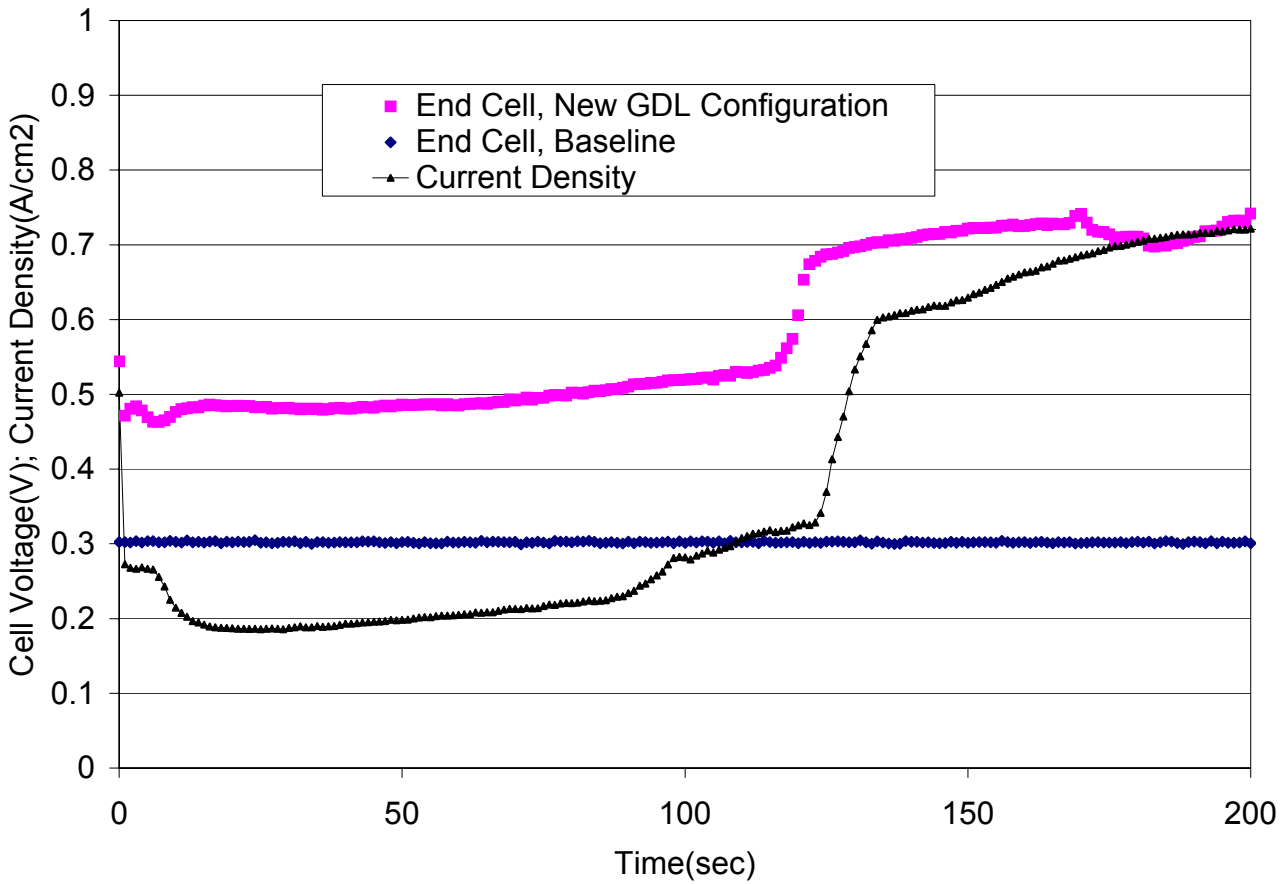
Short Stack Cold Start Testing

New GDL configuration improves cold start performance of end cells



Comparison of end cell performance for new GDL configuration during cold start from -15 ºC

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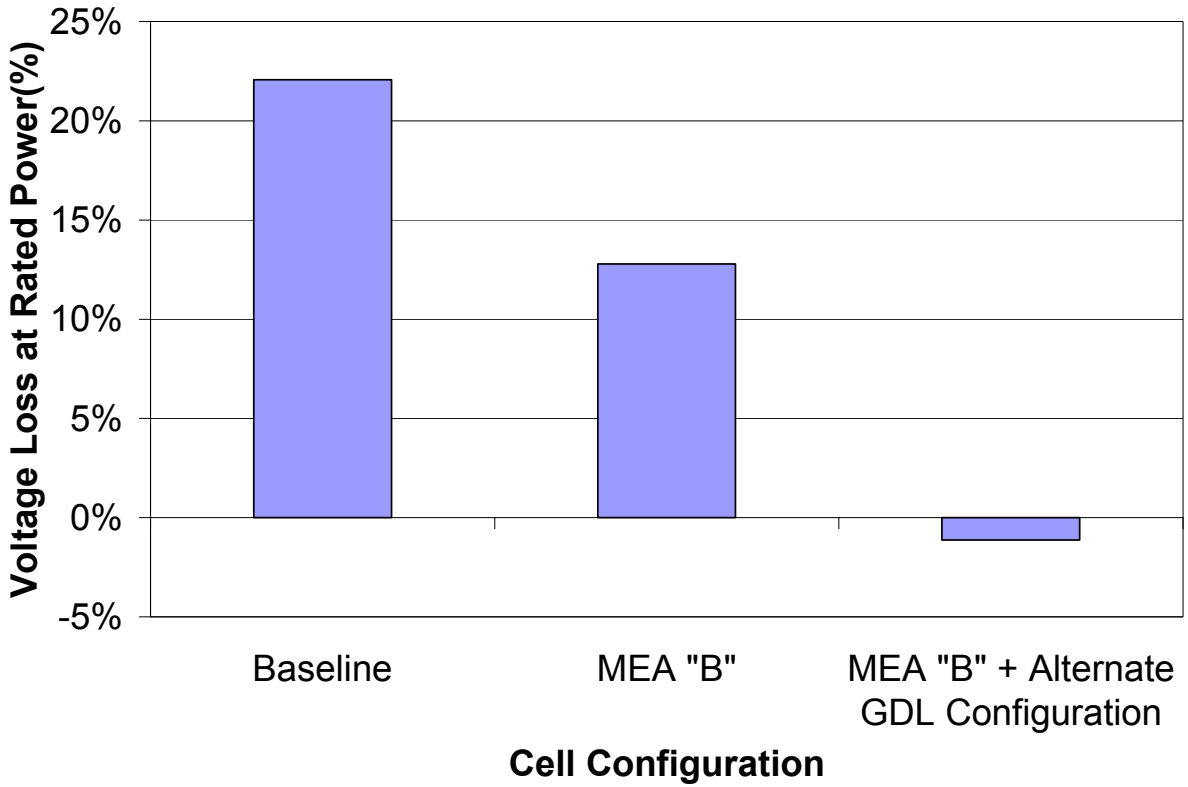
Short Stack Cold Start Testing

Cell material properties play strong role in performance degradation after cold start

- Different MEA decreased performance losses of end cells after cold start by 42%
- Different gas diffusion layer configuration eliminated performance losses of end cells after cold start



Performance loss of end cells at rated power after start from -15 ºC

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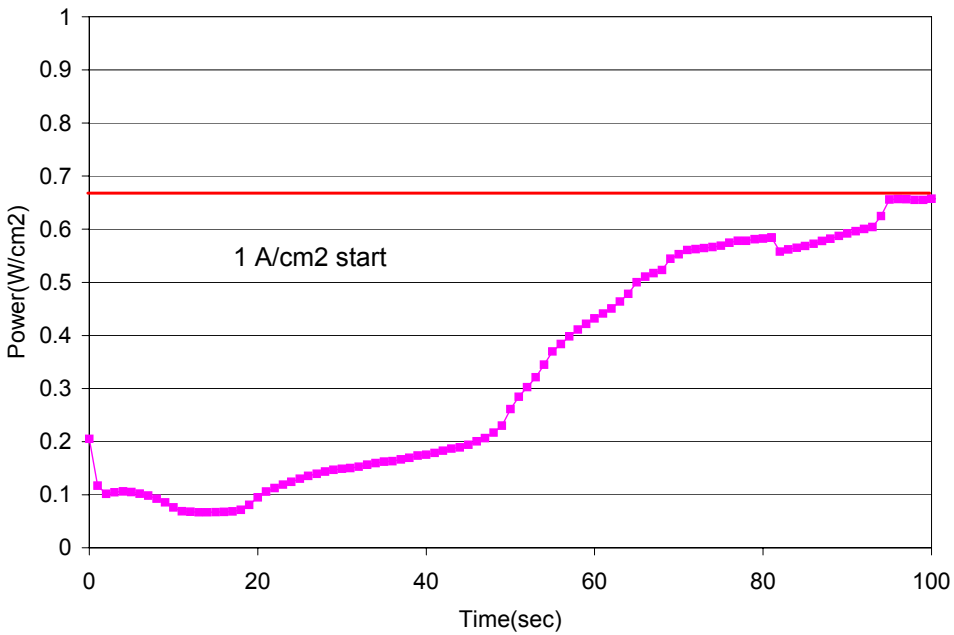
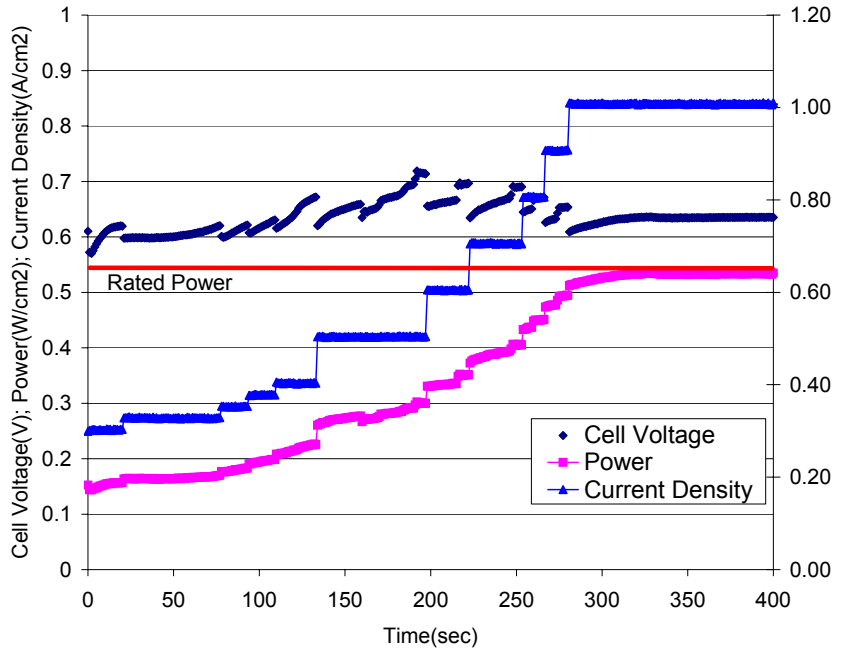
Short Stack Cold Start Testing

- With no voltage limit, 50% rated power reached in ~55 sec; 90% in 70 sec;



Start data from -15 ºC with no lower voltage limit

- With 0.6 V lower limit, 50% rated power reached in 200 sec; 90% in 270 sec;



Start data from -15 ºC using 0.6 V lower limit

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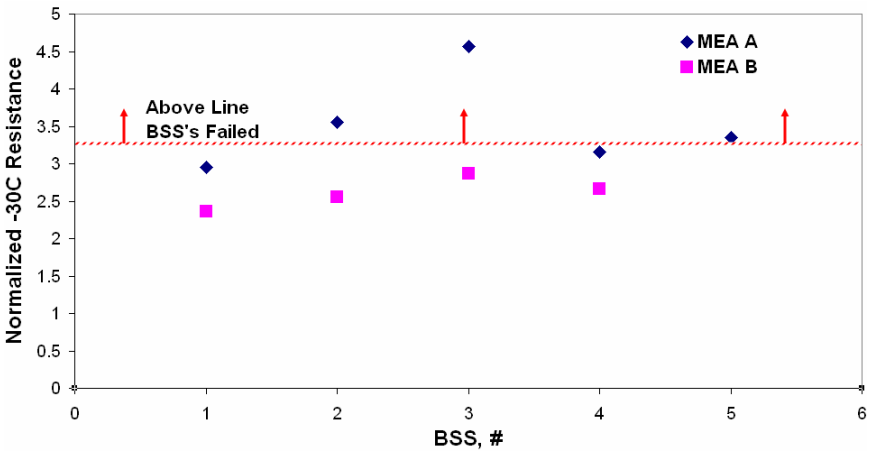
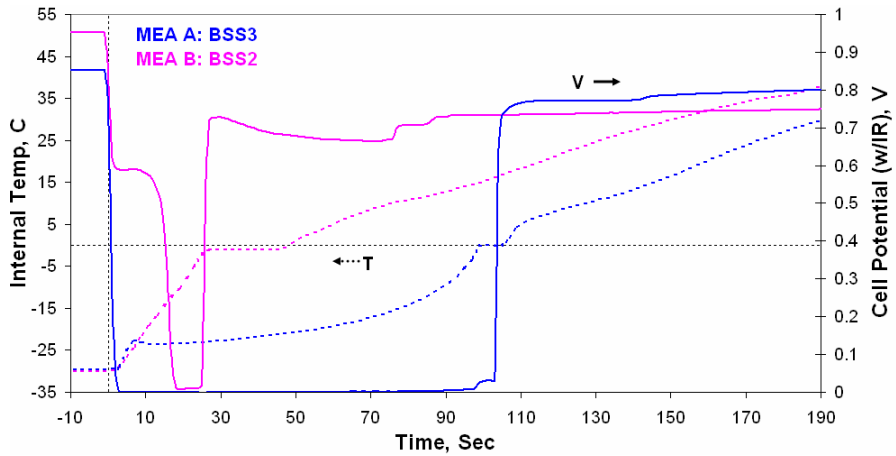
Subscale Single Cell Cold Start Testing

- Frozen to -30˚C under a thermal profile equivalent to stack center cell

- Cold start from -30˚C
- Applied initial load of 200 mA/cm^2





- Cold start ability depends critically on final frozen cell resistance: higher resistance = poor performance

- All **MEA B** cold starts were successful
- **MEA A** cold start ability was sporadic

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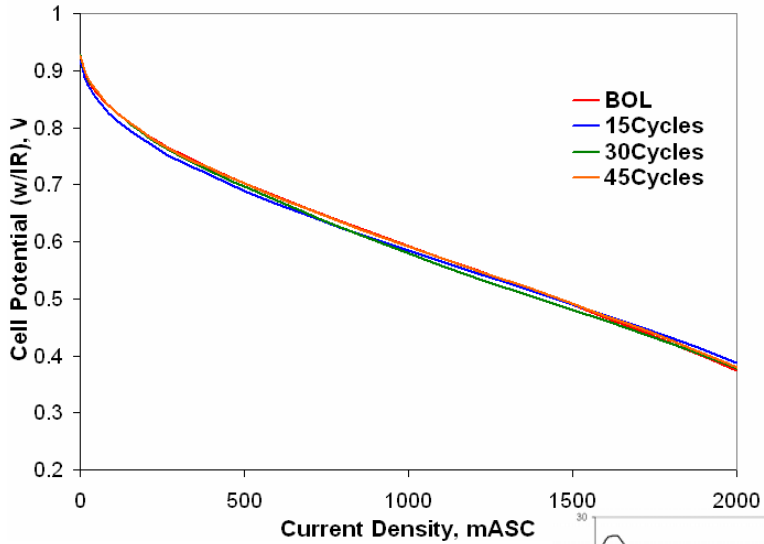
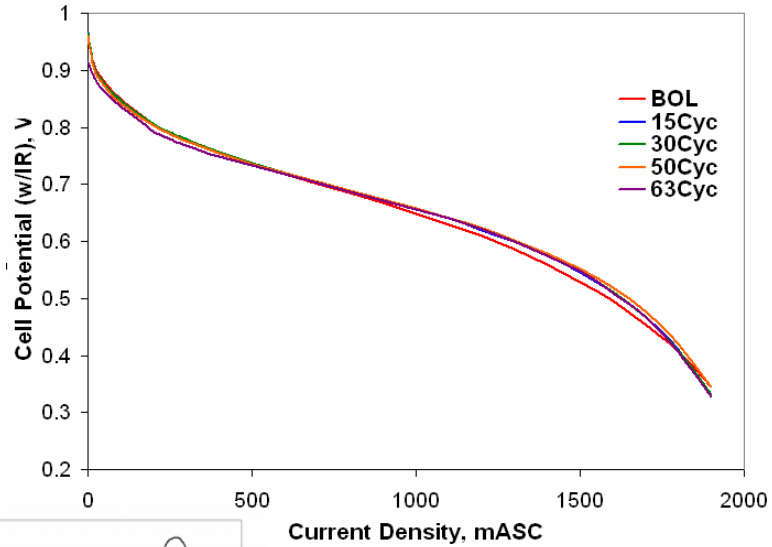
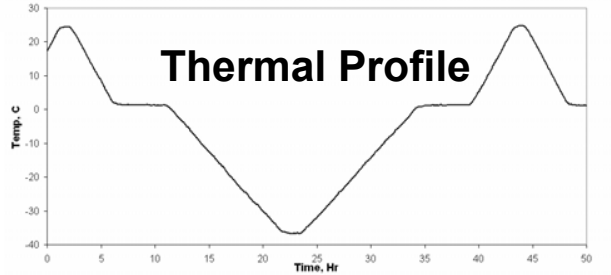
Survivability to -40˚C

- MEA A w/GDL-1



- MEA A w/GDL-2





- Performance under normal operating conditions was measured every ~15 freeze/thaw cycles
- No freeze/thaw cycling induced decay was observed

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Future Work

- Complete investigation of effect of material properties and procedural variables on cold start performance degradation and cold start capabilities
- Conduct -40 ºC freeze/thaw cycling of short stack and complete teardown analysis

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Project Summary

- Relevance
  - Understand key factors related to operation of PEM fuel cells in freezing environment
- Approach
  - Conduct single cell and short stack fuel cell testing under freezing conditions to characterize fuel cell performance and degradation
- Technical Accomplishments and Progress
  - Reduced performance degradation and decreased start time of end cells
- Proposed Future Research
  - Complete investigation of effect of material properties and procedural variables on performance of fuel cell in freezing condition