Experimental diagnosis on the effect of water in the cold operating condition of PEFCs

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Fuel Cell cars in winter season !

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Water management issues in PEFCs

2

Water Management

At temp. > 0 °C

- **Performance degradation by Dry or Flooding of Cells (Stack)**
  - Understand the main driving forces of water transportation in the PEFC cells.
  - Suggest the most effective water management measures in the components

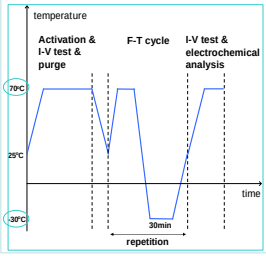
Commercial Level PEFC System

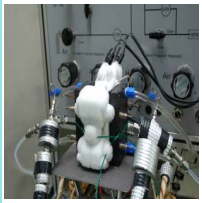
At temp. < 0 °C

- **Cold Start-up Performance degradation**
  - Suggest the tolerable amount of remained water for the freeze start-up of stacks
  - Comprehend the phase change effects of water during the Freeze start-up of stacks
- **Freeze/Thaw durability**
  - Observe the property changes during Freeze/Thaw cycles

Freeze/Thaw cycle test

3





Purge (water removal) test

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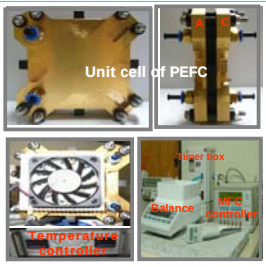
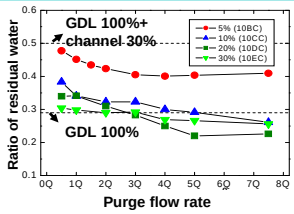


Cell component	
MEA	Commercial (Pt/C, 50cm²)
GDL	SGL 10BC
Bipolar plates	Graphite

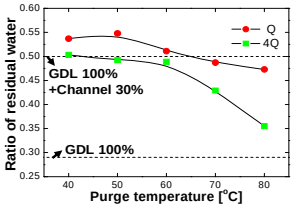
Purge test	
Gas	Air
Hydration condition	80°C, 1hr
Flow rate [ml/min] Q=83.4(A), 345.4 (C)	0.5Q, 1Q, 1.5Q, 2Q, 3Q, 4Q, 5Q, 7Q
Temperature [°C]	40, 50, 60, 70, 80
Purge time [sec]	2.5, 5, 10, 20, 30, 40. 50, 60
PTFE contents of GDL [%]	3, 5, 10, 20, 30

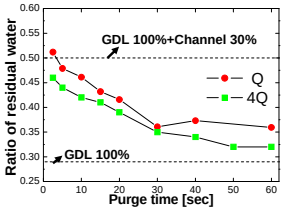
Residual water with purge conditions (Flow rate, temperature, time) after shut-down

5



[1Q(anode)=83.4 ml/min, 1Q(cathode)=345.4 ml/min]





Freeze/Thaw cycle test for the felt type GDL : Remained water effect on freeze durability

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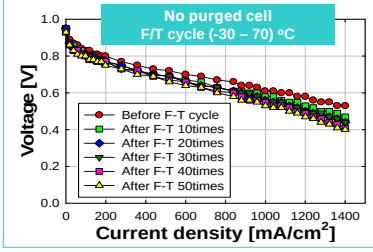
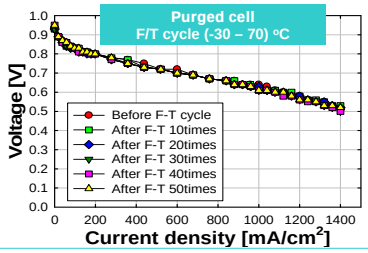
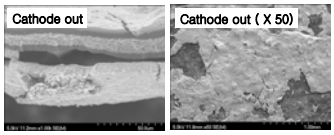




SEM Images of MEA after 400 times F/T Cycles (-30 – 70) °C



Introduction

Guarantee of durability at sub-zero temperature condition is one of the most challenging tasks for the commercialization of fuel cell systems. The technical targets of DOE (Department of Energy : USA) on the freezing condition of vehicles until FY 2015 are as following.

- Cold start-up time @ -20 °C : 30 s
- Survivability (Min.Temp.) : -40 °C

In this work, freeze/thaw cycle test for the different kinds of GDLs (Gas Diffusion Layer) were experimentally conducted to suggest the optimum design conditions of them.

Description

5 The amount of residual water can be reduced in the condition of high flow rate, high temperature, long purge time

6 The results reveal that the remained water can accelerated the cell degradation and the weakened adhesive strength between the membrane and electrode interface is the main degradation reason at sub-zero temperature operation.

7 Three distinctive GDLs with different bending stiffness were investigated.

8 Felt type GDL which has highest bending stiffness showed the best durability and performance distributions.

9 No significant changes between GDLs in metal surface area, membrane destroy were observed.

10 Ohmic resistance drastically increased with F/T cycles.

11 Degradation mechanisms in F/T condition were suggested for the several type of GDLs.

Summary

Felt type of GDLs can be recommended for the durable material for PEFCs when considering sub-zero temperature operations.

GDL effect on the Freeze/Thaw durability

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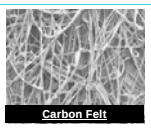
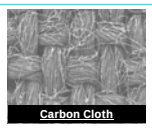
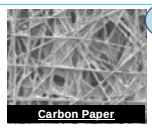

Carbon Felt


Carbon Cloth


Carbon Paper

Diffusion media type	Thickness [㎛]	PTFE content [wt%]	Existence of MPL	Porosity [%]	Areal weight [g/m²]	Bending stiffness [g cm]
Cloth	350	5	Yes	80	166.01	0.4
Felt	400	5	Yes	84	140.23	78.4
Paper	230	5	Yes	80	85.08	5.4

Changes in current density with F/T cycles

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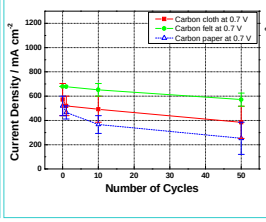

Changes in ECSA & H_2 cross-over current with F/T cycles

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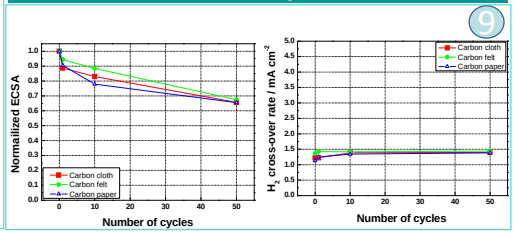

Changes in cell resistance with F/T cycles

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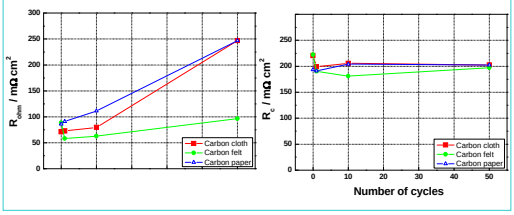

Suggestion of cell degradation mechanisms for the different type of GDLs

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