Development of the Soaking Method for Manufacturing Polymer Electrolyte Fuel Cells with a High-Aspect-Ratio Microstructure

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Better performance of micro-patterned PEFC

Efficient utilization of hydrogen energy

Polymer Electrolyte Fuel Cell (PEFC)

To increase reaction field
Introducing micro-patterns onto Nafion membranes [2]

Better Performance

Difficulties in fabricating micro-patterned electrode

- Nafion is a water-repellent material.

van der Waals forces are dominant

The soaking method

Spray pressure

Delaying the evaporation of the solvent

Fabrication of micro-patterned electrode

Fabrication process

Composition of the catalyst ink

<table>
<thead>
<tr>
<th>Pt/C [g] (TEC10V50E)</th>
<th>10 wt.% ionomer solution [g]</th>
<th>Deionized water [g]</th>
<th>Isopropyl alcohol [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.144</td>
<td>0.69</td>
<td>20.44</td>
<td>0</td>
</tr>
</tbody>
</table>

The soaking method

Two ways of spraying catalyst ink on the micro-patterned surface

(Sample A) Catalyst ink Nafion

80 °C Mask
5 s 5 s . . .

(Sample B)

30 °C
0.5 s 0.5 s . . .

The cross-sections were investigated using scanning electron microscopy (SEM).
Cross-sectional observation

Sample A

Sample B

Just after spraying

• Background
• Experiment
• Result
• Discussion
• Conclusion
Power generation test result

Power generation tests were conducted on cells with a microstructure fabricated using the soaking method.

<table>
<thead>
<tr>
<th></th>
<th>( \text{O}_2 ) [sccm]</th>
<th>( \text{H}_2 ) [sccm]</th>
<th>( \text{N}_2 ) [sccm]</th>
<th>Total flow rate [sccm]</th>
<th>Cell temp. [℃]</th>
<th>Bubbler temp. [℃]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode</td>
<td>40.0</td>
<td>0</td>
<td>92.8</td>
<td>200.0</td>
<td>80</td>
<td>72</td>
</tr>
<tr>
<td>Anode</td>
<td>0</td>
<td>80.0</td>
<td>52.8</td>
<td>200.0</td>
<td>80</td>
<td>72</td>
</tr>
</tbody>
</table>

Polarization and power density curves

※Fabricated under the same conditions
Discussion

- Background
- Experiment
- Result
- Discussion
- Conclusion

[Sample A]

[Solvent] → [Nafion] → [Pt/C] → [hydrophobic] → [Bridge]

[Sample B]

[Solvent] → [Cassie state] → [metastable] → [Transition [5]] → [Wenzel state] → [Bridge]

Driving force could be gravity or spray pressure

Conclusion

We developed the soaking method

A high-aspect-ratio microstructure was successfully arranged.

The mechanism could be explained by the Cassie-Wenzel transition.

Optimization of the soaking process parameters is required to manufacture a higher aspect ratio microstructure.
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Thank you for your attention.

Please do not hesitate to contact us!

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