Degradation and Durability of SOFC Materials by the Impurities

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Introduction and Purpose

● The degradation and durability of SOFC cell-stacks have been a major concern for commercialization. Among many factors associated to degradation of SOFCs, chemical degradation due to impurities is one of the key issues.
● The impurities can react with the component materials and condense at the electrochemical active sites, affecting their properties and reducing the performance of stacks (In Figure 1 left) [1-3]. Such impurities come from gases or diffusion in the solids (fuels, air, and stack components) and they are usually present in very low concentration levels (lower than several tens ppm in weight).
● Secondary Ion Mass Spectrometry (SIMS) technique is being applied to evaluate the concentration levels of impurities in practical stack/modules components under the NEDO project; “Development of system and elemental technology on SOFCs” (2008-2012).
● The purpose of this report are; 1) recent durability and reliability for five different kinds of stacks with detected impurities, and 2) Clarification of degradation mechanism analysis at cathodes and anodes.

Impurity concentrations and cathode degradations
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Summary

● The effects of impurities on degradation of stacks were examined for 5 different kinds of stacks.
● Very low concentration levels of impurities in the stack components were successfully detected by the SIMS technique.
● The voltage degradation data and impurity related factors were presented; the degradation rates in FY2009 were improved than those of FY2008.
● For impurity affected degradation, some degradation mechanisms were considered associate with chemical reaction of impurities.

Acknowledgements:
This work was financially supported by the NEDO, Japan

Results and Discussion

Durability of five different stacks

<table>
<thead>
<tr>
<th>Type</th>
<th>SOFC (developers)</th>
<th>FY2008 degradation rate (stack)</th>
<th>FY2009 degradation rate (stack)</th>
<th>FY2008 degradation rate (cell)</th>
<th>FY2009 degradation rate (cell)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHI</td>
<td>TOTO</td>
<td>1.7</td>
<td>1.1</td>
<td>0.83</td>
<td>0.73</td>
</tr>
<tr>
<td>MHI</td>
<td>MMFF-KEPCO</td>
<td>1.1</td>
<td>1.3</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>MHI</td>
<td>KEPCO</td>
<td>0.33</td>
<td>0.30</td>
<td>0.37</td>
<td>0.35</td>
</tr>
<tr>
<td>MHI</td>
<td>Kansai Electric</td>
<td>0.31</td>
<td>0.30</td>
<td>0.37</td>
<td>0.35</td>
</tr>
<tr>
<td>MHI</td>
<td>Mitsubishi Heavy</td>
<td>0.21(5000-5600h, modified stack)</td>
<td>0.21(5000-5600h, stack)</td>
<td>0.21(5000-5600h, stack)</td>
<td>0.21(5000-5600h, stack)</td>
</tr>
</tbody>
</table>

Table 1. Durability of Examined Stacks and Observed Impurities

The concentration levels of some elements increase with operation time: Condensation of impurities with time. Source of Cr: evaporation of metallic components

Cr-Poisoning at Cathodes: difference of degradation behaviors and Cr concentration

Impurity concentration levels of practical stack components: Application of SIMS technique

Improvements of cell-stack

Anti Cr-poisoning in MHI cell

Demonstrative cells

Analysis of demonstrative cell-stack

Impurity concentration levels of practical stack components: Application of SIMS technique

Fig. 1 Schematic diagram showing the degradation mechanism and estimation of lifetime of SOFCs.