Electrochemical Evaluation of Bipolar Plate for Polymer Electrolyte Fuel Cell

1. Introduction

With heightened concern about environmental problems in recent years, higher expectations have also been placed on fuel cells as an alternative energy source for petroleum. The features of fuel cells include high power generating efficiency and low environmental impacts, as fuel cells do not emit atmospheric pollutants (sulfur oxides, nitrogen oxides, etc.) during cell operation. As shown in **Table 1**, the features and applications of fuel cells differ depending on the type of electrolyte used [1]. Among these, polymer electrolyte fuel cells (PEFCs) operate at a low temperature and display high power generating efficiency, and therefore are considered a promising source of clean electric power for automotive drive systems. The unit cell of a PEFC consists of one membrane electrode assembly (MEA) between two bipolar plates. Because the voltage output of a unit cell is on the order of 0.7 V, unit cells are actually used in fuel-cell stacks consisting of a large number of stacked cells. For example, the MIRAI, which was first marketed by Toyota Motor Corporation in 2014, is equipped with a stack consisting of 370 unit cells (maximum output: 114 kW) [2]. Since the bipolar plates occupy a large percentage of the total weight and volume of the stack, it is important to

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[3, 4].
Therefore, in addition to the cell operation tests performed in evaluations of candidate bipolar plate materials, polarization tests in a simulated PEFC environment are also conducted. One distinctive feature of the corrosion resistance test in a simulated PEFC environment is evaluation of the corrosion resistance of the stainless steel bipolar plate in a short period of time.

2. Electrochemical Evaluation of Bipolar Plates for PEFC

2.1 Cell for Evaluation of Corrosion Resistance of PEFC Bipolar Plates

Acidic solutions with different concentrations of F^- and pH values are used as aqueous solutions simulating the bipolar plate/GDL [5]. A glass cell is generally used in evaluations of corrosion resistance under a simulated PEFC environment. However, the silicon (Si) which is the main component of the glass cell used in the test dissolves into the test solution as a contaminant owing to the high test-temperature of 353 K and F^- content of the solution, and this Si contamination can have harmful effects on the quantitative analysis of the metals dissolved from the bipolar plate in subsequent measurements of the interfacial contact resistance (ICR) and analysis by inductively coupled plasma-mass spectrometry (ICP-MS). To avoid this problem, JFE Techno-Research Corporation developed an electrochemical cell to evaluate corrosion resistance of PEFC dissolved from the respective cells was determined by an analysis by inductively coupled plasma-atomic emission spectrometry (ICP-AES). The amount of Si dissolved from the developed cell was approximately 1/10 of that dissolved from the glass cell, clearly showing that dissolution of Si can be suppressed by using the developed cell.

2.3 Evaluation of Stainless Steel Bipolar Plates for PEFC

2.3.1 Electrochemical measurements of candidate bipolar plate materials

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Fig. 3 ICR between as-polished type 304 and Au plated type 304 stainless steels and carbon paper before and after the polarization

In addition to these techniques, JFE Techno-Research Corporation has also created a complete system which is capable of conducting various types of evaluations of PEFCs, including observation of bipolar plates by ultra-low accelerating voltage-scanning electron microscopy (ULV-SEM) and transmission electron microscopy (TEM), evaluation of the oxidation state of the substrate material or the surface-treated layer and the composition distribution in the depth direction by X-ray photoelectron spectroscopy (XPS), evaluation of wettability of the bipolar plate surface by the measurement of contact angle, etc. Utilizing these technologies, we hope to provide even stronger support for PEFC development in the future.

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