Evaluation Technique of a Polymer Electrolyte Fuel Cell using 1cm^2 cell

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INTRODUCTION

To evaluate materials for the polymer electrolyte fuel cell (PEFC), such as catalysts, electrolyte membranes, gas diffusion media, FC performance tests are often carried out using single cells having various sizes and designs of the electrodes.[1] The FC performance, however, is heavily affected by the structures of the cells and, therefore, the results sometimes do not represent the characteristics of the materials and, in worst cases, can be misleading. In addition, when a cell having a large electrode is used or a high-gas-utilization condition is applied, the actual operating conditions are widely varied region by region along the gas channels.[2] Therefore the obtained cell performance is merely the average over the whole electrode area and, again, does not indicate the material properties accurately.

In the present study, we propose an evaluating technique using a small cell to solve these problems and to obtain data correctly representing the properties of used materials.

EXPERIMENTAL

Figure 1 shows the developed small cell having electrode size of 1 cm x 1 cm. The size was small enough to achieve a uniform condition along the flow but large enough to ensure the size accuracy of the active area. The flow field pattern was a cross flow / straight line. To regulate the gap between the flow fields to be parallel and precise, we employed a gap-controlling assemble process in which the gap was actually measured with a micrometer at four points during the cell assembly. The precision by 10 μm was achieved, which could not be obtained by a commonly used torque-controlling process. The gas flow rate was fixed to a value at least 10 times larger than the stoichiometric one to achieve uniform gas concentration along the flows. The composition of the cathode gas to supply, however, was varied by mixing oxygen or air and nitrogen or helium in an arbitrary ratio to examine mass transport properties.

RESULTS AND DISCUSSION

Figure 2 showed the influence of the cathode gas composition on I-V characteristics. When the O_2 concentration was 5 %, limiting current densities (I_{limit}) were clearly observed, where the cell voltage rapidly decreased with increase in current density. When the inert gas was He, I_{limit} was 1.5 times as large as that for N_2. This was due to the faster O_2 diffusion through O_2/He/H_2O than through O_2/N_2/H_2O. This 1.5-fold increase, however, is much smaller than the increase expected from the values of binary gas diffusion constants, which is as much as 3-fold. This discrepancy can be elucidated if the Knudsen diffusion plays a major role. Because the Knudsen diffusion is usually influential only in the pores of 100 nm or less, the diffusion in the catalyst layer also seems substantial.

Figure 3 shows the influence of the gap distance between the anode and the cathode on the PEFC performance. When the distance was shorter, the resistance was smaller and the IR-compensated cell voltage was higher in the lower current density range, but lower in the higher current density range. The higher IR-compensated cell voltage was obtained probably because of higher catalyst utilization achieved by the better electric contact among the catalyst layer / diffusion layer / the current collector (flow field). The lower voltage in the high current density range, on the other hand, was likely due to the lower porosity of the highly compressed diffusion layer.

It is important to notice that the gap difference of only 50 μm made the difference of this magnitude. This is why we employed the gap-controlling assemble process, with which the experimental reproducibility was also greatly enhanced.

CONCLUSION

A highly reproducible and sensitive evaluation technique of PEFCs was proposed. The importance of the gap distance control was exhibited and the usefulness of the gas composition control instead of gas stoichiometry control was demonstrated. This system can be used as a powerful tool to analyze the effect of materials and structures on the FC performance.

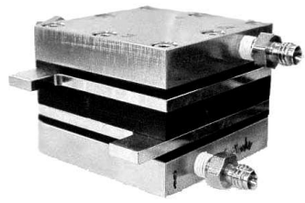

Fig. 1 Developed l cm^2 cell.

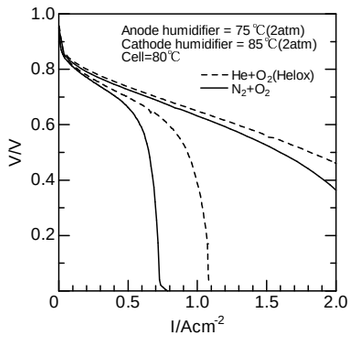

Fig. 2. Influence of the cathode gas composition on IV characteristics.

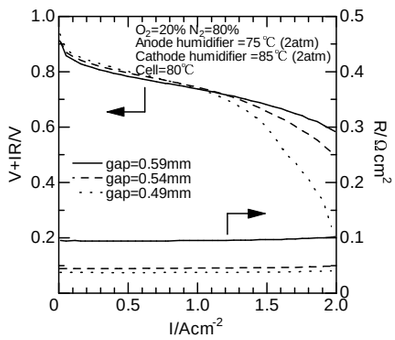

Fig. 3. Influence of the gap distance between the anode and the cathode on the cell performance.

REFERENCES

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2. Y. Morimoto, T. Suzuki, and H. Yamada, *The 9th Fuel Cell Development Information Center (FCDIC) Fuel Cell Symposium,* Tokyo, May 2002, Japan