Effect of the membrane thickness on the over-potential behavior of the direct formic acid fuel cell

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1.Introduction

Direct formic acid fuel cells, DFAFCs, have been attracted much attention since they can generate higher power density than that of the other direct liquid fuel cells, such as direct methanol fuel cell and direct ethanol fuel cell. The intensive researches for the anode catalyst have been carried out, on the other hand, there has been little study for the cell structure and the cathode performance of the DFAFC. To generate higher power output, the optimization of the cell structure is quite important. Therefore, in this study, the effect of the membrane thickness on the power density and over potential behaviors of the anode and cathode was investigated to optimize the cell structure of the DFAFCs.

2. Experimental

The membrane electrode assembly with a 4.84 cm^2 active area was prepared. 8 mg/cm^2 of Pd black was coated on the carbon cloth for the anode and 8 mg/cm^2 Pt black was coated on the carbon paper for the cathode. 10 wt% of ionomer was contained in both electrodes. Nafion 117, 115 and NR 212 were used as an electrolyte membrane. The MEA was fabricated by sandwiching the membrane between the anode and cathode and hot pressing them at 408 K and 5 MPa for 3min.

The DFAFCs were operated with active mode. Figure 1 shows the schematic diagrams of the active cell with reference electrode. Using reference electrodes, the electrode potentials of the anode and cathode were individually measured. Current-voltage, i-v, characteristics were measured using different MEA having different membranes with 7 M formic acid solution and 1 l/min of oxygen. The cell temperature was fixed at 30 ^{o}C. The cell resistance was also measured using a digital fuel cell AC ohmic meter (FC-100R, CHINO)

3. Result and discussion

Figure 2 shows the effect of the membrane thickness on the current-power, i.e., i-p, characteristics obtained from i-v measurement. The highest power density of 301 mW/cm^2 was obtained when NR 212 was used. The ohmic resistances were 21 mΩ at NR 212, 46 mΩ at Nafion 115 and 57 mΩ at Nafion 117. Since the ohmic resistance of the NR 212 was lowest in the three membranes, the NR 212 showed highest performance. However, the performance difference between three membranes could not be explained by only the difference of the ohmic resistance. Figure 3 shows the electrode potentials during the i-v measurements when different membranes were used. A large difference in the anode potentials was observed between three membranes, and the over-potential of the anode increased with increasing the membrane thickness. From these results, NR 212 showed highest performance due to the lowest resistance and the anode over-potential in three membranes.

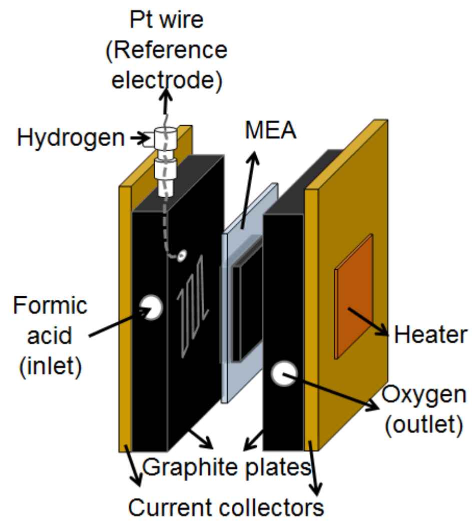

Fig.1 Schematic diagrams of the active cell with reference electrode.

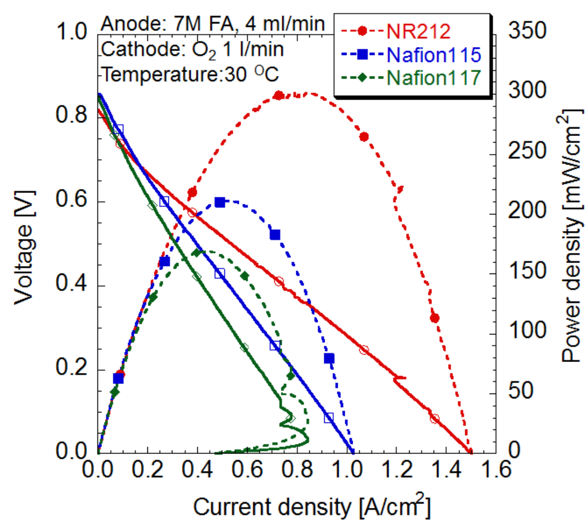

Fig. 2 Effect of the membrane thickness on the i-p characteristics.

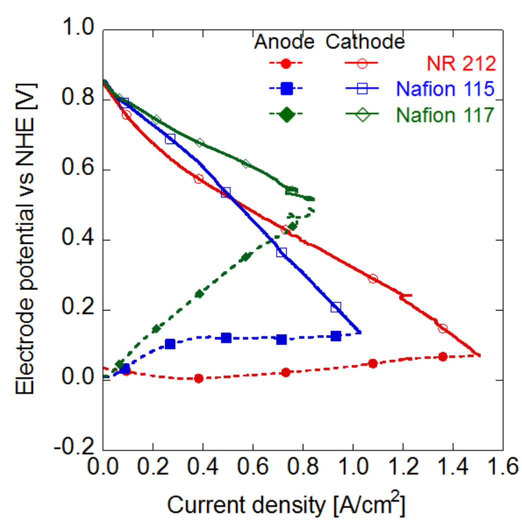

Fig. 3 Effect of the membrane thickness on the electrode potentials.

4. Conclusion

The DFAFC using NR 212 showed highest performance comparing to the DFAFC using Nafion 115 and Nafion 117 due to the low resistance and anode over potentials.

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