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Pulse Laser Deposition and Sputtering of Carbon-free Pt/SnO_2 Electrocatalysts for PEFC

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Introduction

Polymer electrolyte fuel cells (PEFCs) are promising power sources for vehicles, co-generation systems, and mobile devices. However, the durability of their electrocatalysts is one of the most important technological issues. Especially, Pt electrocatalysts supported on carbon black suffer from carbon corrosion on the cathode side under the start-up and shut-down condition. To solve this problem, we have developed carbon-free Pt electrocatalysts using SnO_2 as the electrocatalyst support material. The use of SnO_2 as an alternative support improves durability under the start/stop voltage cycling, as SnO_2 is thermochemically stable under such operational conditions. We have reported that the durability test with voltage cycles between 0.9 and 1.3 V revealed that the Pt electrocatalyst supported on SnO_2 maintained electrochemical surface area (ECSA) even after 60,000 voltage cycles [1]. However, the SnO_2-supported electrocatalyst has a tendency to show lower power generation characteristics, comparing to conventional carbon materials, mainly due to relatively high contact resistance between SnO_2 particles. Therefore, the aim of this study is to develop alternative preparation procedures to lower contact resistance between the particles of SnO_2 and to obtain SnO_2-supported PEFC electrocatalysts with higher performance.

Experimental

Conventionally, we prepare SnO_2 powder by the co-precipitation method and Pt nano-particles are then impregnated on SnO_2 by e.g. the colloidal method. The prepared electrocatalysts are coated with Nafion using the spray printing method. However, as described above, in this way, contact resistance of the SnO_2 powder becomes a technical problem. Therefore, in this study, we used pulse laser deposition (PLD) and sputtering technique to prepare SnO_2 layer and Pt particles, respectively.

To examine the interface between SnO_2 particles and the particle size of both SnO_2 and Pt, field emission scanning electron microscopy (FE-SEM) was applied.

To evaluate power generation characteristics, we prepare single cells. Prepared Pt-sputtered SnO_2 layer was used as the cathode, and the anode was made of Pt-deposited carbon catalysts by the conventional spray printing method. Then, current-voltage characteristics were measured.

To evaluate their durability, the single cells were subjected to the potential cycling between 1.0 and 1.5 V_{RHE} at a scan rate of 0.5 V/sec up to 60,000 cycles, recommended by Fuel Cell Commercialization Conference of Japan (FCCJ) [2].

Results and Discussion

Fig. 1 shows an FE-SEM image of SnO_2 layer on the the micro porous layer (MPL) of carbon paper, prepared by the PLD method. SnO_2 layer is relatively dense, and each particle has better contact, suitable for lower contact resistance.

Fig. 2 shows the current-voltage characteristics of the cell with the electrocatalysts evaluated in this study. This PLD method leads to higher power performance than the conventional preparation method. However, it is still lower than that using Pt/C, so that we have to optimize preparation conditions in order to get higher power performance.

Fig. 3 shows that the PLD method can realize similar durability, compared to the conventional preparation method, resulting in 70% of the initial cell voltage maintained even after 60,000 cycles.

References

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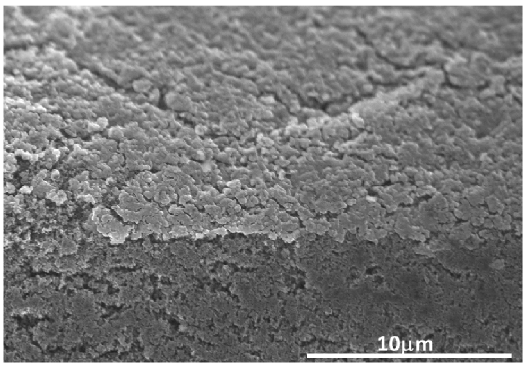

Fig. 1 FE-SEM micrograph of SnO_2 on carbon paper (MPL)

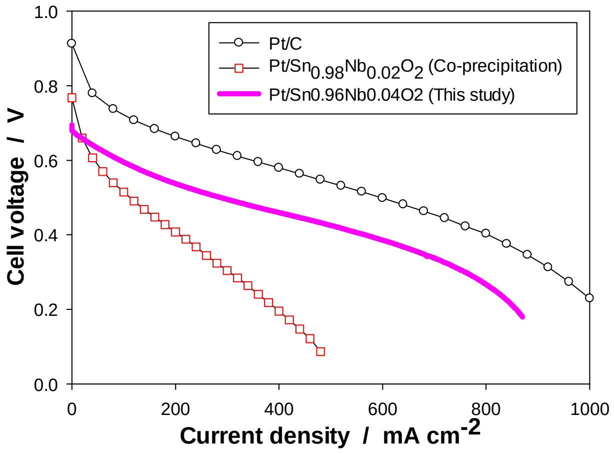

Fig. 2 Current-voltage characteristics (80^{0}C)

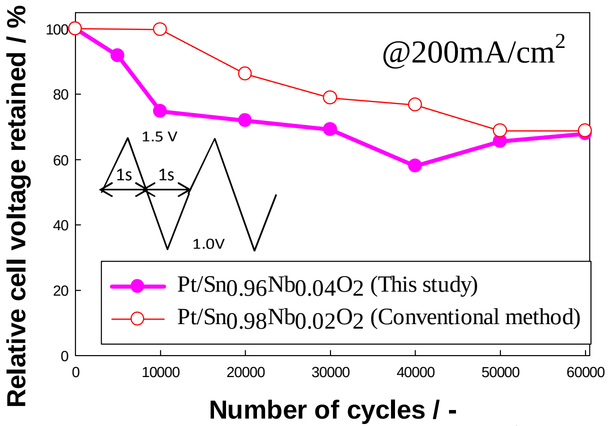

Fig. 3 Cell voltage change with cycles (80^{0}C)