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Effect of interfacial structure between micro-porous layer and catalyst layer on water transport in PEFC

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Although a number of studies have reported that micro-porous layers (MPLs) play an important role in preventing water flooding, the actual mechanism of this role has not been fully understood. Especially, the impact of interfacial structure between the MPL and the catalyst layer (CL) on water transport in the polymer electrolyte fuel cell (PEFC) is one of the most controversial topics. It was reported by the authors that the interfacial gaps at the MPL/CL interface act as water pooling sites and prevents the reactant gases from reaching active sites in the CL (1). In this paper, we observed the cross-sectional distribution of condensed water inside the cathode side membrane electrode assemblies (MEAs) which are made by two different methods. By comparing the two observations, we discuss the effect of interfacial structure between the MPL and the CL on water transport phenomena in the vicinity of the MPL.

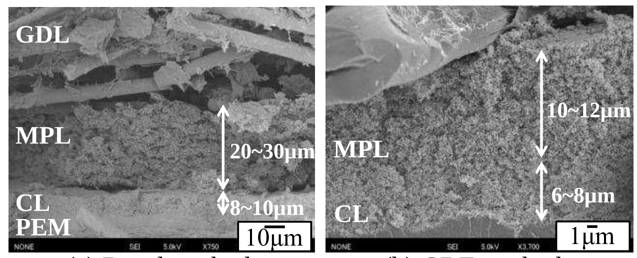
The single cell was composed of the MEA whose active area was 1.8 cm^2 and two bipolar plates with straight flow channels. Pure hydrogen and air were used for the anode and the cathode side gases, respectively. In the experiments, the cell was set in a thermostatic chamber to keep the cell temperature constant.

The MEA made by two different methods were used. One is made by conventional method called decal transfer method whose MPL/CL interface is combined by hot-press. Other is made by GDE method which improves interfacial adhesion by directly coating the catalyst ink on the MPL. A Gore PRIMEA®5570/CNW20B was used as the MEA made by the decal method, and the MEA made by the GDE method was produced experimentally by Asahi Glass Co., Ltd. Note that GDE method was only used to the cathode side MPL.

In this study, the experiment consists of measurement of cell performance and observation of condensed water by freezing method (2). The operating condition was set so that the condensed water accumulates in the vicinity of the MPL. The current density was 0.7 A/cm^2 and kept constant through the operation. The cell temperature was 5 ºC, and dry gas was supplied.

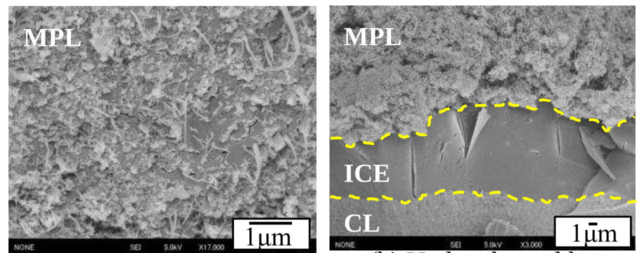
The freezing method immobilizes the condensed water as ice by rapidly freezing the cell just after stopping the operation and enables to directly observe the distribution of condensed water in the MPL. After measuring the cell performance, the cell was rapidly cooled in a thermostatic chamber to hold on the condensed water where it exists at the instant of shutdown. Next, the MEA extracted from the cell and was cut into the several pieces to set the sample holder in liquefied nitrogen. Then, the sample was moved to the vacuum chamber of cryo-SEM whose inner temperature is –150 °C. Finally, the sample was observed by the cryo-SEM.

Figure 1 is the cryo-SEM image before operation: (a) and (b) are the images of MEA made by the decal method and GDE method, respectively. Comparing these images, the interfacial adhesion of the MEA made by GDE method is much higher than that made by decal method, and the former's interface is difficult to discriminate.

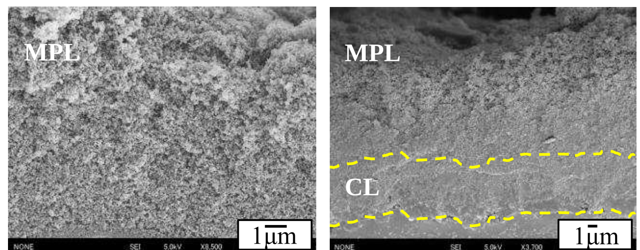


(a) Decal method (b) GDE method

Figure 1. Cryo-SEM image of MPL before operation



(a) Under land by decal method (b) Under channel by decal method



(c) Under land by GDE method (d) Under channel by GDE method

Figure 2. Cryo-SEM images after operation

Figure 2 is the cryo-SEM image after operation: (a) and (b) are the images of MPL made by the decal method, and (c) and (d) are those made by GDE method. (a) and (c) are the images under the lands, and (b) and (d) are those under the channels. In the decal method, ice distribution is different between under the lands and the channels. In Fig. 2(a), corresponding to the point under the land, the porous structure of the MPL is filled with ice. On the other hand, in Fig. 2(b), corresponding to the point under the channel, no ice can be found inside the MPL, and a large block of ice exists in the MPL/CL interface. In contrast, such a difference in the ice distribution depending on the observation points cannot be found in the vicinity of the MPL made by GDE method. In Fig. 2(c), corresponding to the point under a land, ice exists within pores of the MPL as well as ice distribution in the decal method. However, in Fig. 2(d), corresponding to the point under channels, block of ice does not exist in the MPL/CL interface, and the pores of the MPL are filled with ice. Such a difference in the distribution of ice can be explained by the difference in the interfacial structure between the MPL and the CL. In the case of MEA made by decal method, the condensed water easily accumulates inside the interfacial gaps because the clamping pressure under the channel is relatively low compared with that under the land. On the other hand, in the case of the MEA made by the GDE method, a firm interface is formed between the CL and the MPL, and condensed water cannot accumulate in the interface.

References

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