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Investigation of liquid water behavior in PEFC porous media

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1. Introduction Polymer Electrolyte Fuel Cell (PEFC) is a kind of electrochemical device which combines hydrogen and oxygen to produce electricity. It is expected to play a significant role in the next generation energy systems because of its environmental advantages, wide applications and high energy efficiency. On the other hand, the problems of PEFC like high price and short life still disturb its development and popularization. It's well recognized that the management of water in PEFC is very important. Therefore, the aim of this work is to investigate the liquid water behavior in GDL, balance between membrane dehydration and water flooding to ensure the high performance and durability of PEFC.

2. Experiment PEFC visualized single cell (Fig.1) was used in this experiment. As a result, the flow channel of cathode side could be observed through the acrylic plate and the liquid water generated phenomenon could be recorded by microscope. Membrane Electrode Assembly (MEA) of this single cell is PRIMEA5510 (Japan Gore Tex) which has 1cm^2 electrode area and the Gas Diffusion Layer (GDL) type of both cathode side and anode side was CARBEL-CFP (Japan Gore Tex) which was coated with Micro Porous Layer (MPL) at the catalyst layer and had water repellency at the channel side. We experimented with two different channels of 1mm and 3mm in width under the same conditions. Operating conditions are as follows: cell temperature: 40ºC, 50ºC, 60ºC; relative humidity (RH): 70%, 80%, 90%; Current density: 1.0A/cm^2. The liquid water condition was captured by video camera of microscope for 30 min under each condition and then the droplets distribution was obtained by image process (Fig.2). In order to comparing the effect of each part, we divided this channel from rib to center into five areas (Fig.3).

3. Results and discussions Fig.4 and Fig.5 show the number of droplets at each area in 3mm channel and 1mm channel respectively. Cell temperature was 40ºC and RH was changed. For all the cases generated droplets are less in the center of the channel and increase in the area close to the edge of the rib. It is noted that the rib hinders vapor diffusion and that it is a reason of this phenomenon. On the other hand, high thermal conductivity of the rib leads to the low temperature, therefore the more liquid water appears at the area which near the rib. Comparing the data of experiments with different gas channel sizes, one can see the droplets distribution is more symmetrical in Fig.5 (1mm). A possible reason for this is that the temperature of GDL surface appears to be more heterogeneous uneven due to the wider gas channel. Results of droplets number in 3mm gas channel under the conditions relative humidity 80%, 90%; cell temperature 40ºC, 60 ºC are shown in Fig.6. A remarkable uneven distribution is seen when the cell temperature is high under the condition RH 80%, however in the case RH 90% this phenomenon is not evident. It is possible that for the low RH cases, cell temperature makes great influence on the state of water. When the cell temperature gets higher, water exists in gas more easily. But under the high RH condition, water remains liquid state no matter how high or low cell temperature is. Hence, the cell temperature has larger effects on droplets generating with the lower RH condition.

4. Conclusions In this study, the analysis focuses on the behavior of liquid water in the PEFC. It is observed that RH and cell temperature have a significant impact on two-phase condition in GDL. Droplets generate more easily in the area nearby the rib due to the uneven distribution of GDL surface temperature.

5. Acknowledgements This research was financially supported by PEFC program of new energy and industrial technology development organization (NEDO), Japan.

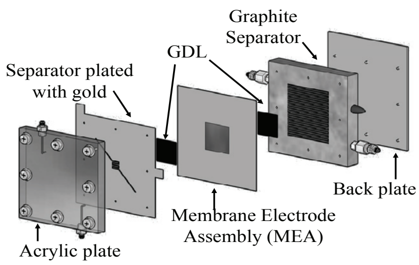

Fig.1 Structure of visualized cell

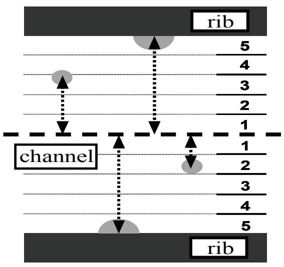

Fig.3 Channel areas

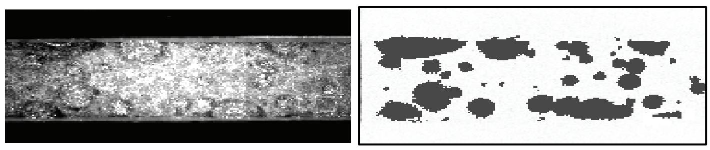

Fig.2 Droplets distribution and the result of image processing

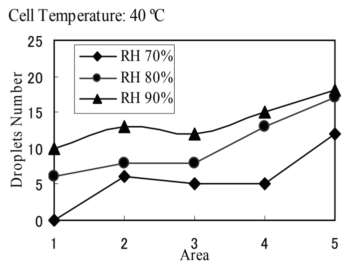

Fig.4 Droplets distribution (3mm)

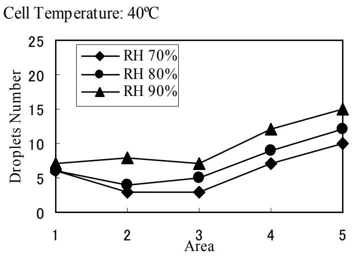

Fig.5 Droplets distribution (1mm)

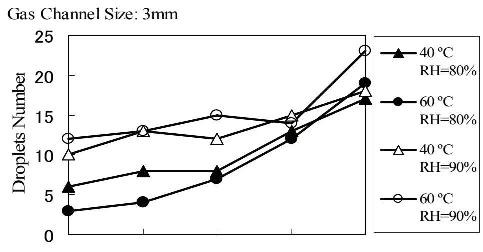

Fig.6 Droplets distribution (40ºC, 60 ºC)

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