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Decal Method with High Catalyst Transfer Ratio and Its Performance in PEMFC

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Key words : Polymer electrolyte membrane fuel cell, Membrane electrode assembly, Decal method, Catalyst layer, Thin electrode

Abstract : A breaking layer was introduced to conventional decal transfer method in membrane electrolyte assembly fabrication for high catalyst transfer ratio. In this study, the modified decal transfer method with high catalyst transfer ratio was introduced and its performance is studied. The structural features of electrodes made by decal method were investigated using scanning electron microscopy and current-voltage polarization measurement.

1. Introduction

Polymer membrane fuel cell (PEMFC) has been garnered attention as reliable alternative power sources in these days for its high efficiency and low emission of pollutant. However, the commercialization of fuel cell is not realized in these days and the expense of its components is considered the most important barrier to its commercialization. Therefore, more high utilization of rare metals inside the fuel cell is required to reduce the cost of fuel cell.

In order to fabricate more efficient membrane-electrode assembly (MEA), several methods have been used and studied. These includes a discovering new electrocatalyst rather than platinum[1-2)], introducing a new MEA fabrication method[3)], and improving the MEA fabrication process[4-5)] to maximize the platinum activity.

In this study, we used a decal transfer method to achieve a catalyst coated membrane (CCM). Moreover, the structure of membrane electrolyte assembly (MEA) was experimentally optimized to get a high single cell performance. The features of MEA were characterized using field-emission scanning electron microscopy and current-voltage polarization measurements.

2. Experimental

The catalyst coated membrane was fabricated as below. A substrate was prepared in proper size to be used in a decal method. The powder particles for breaking layer was also prepared. The particles were mixed with perfluorosulfonic acid (PFSA), then dropped into solvent. The powder ink was fully mixed ultrasonically. After then, the ink was coated on dried decal substrate. The Catalyst ink was prepared with a electrocatalyst, polymer ionomer and solvent. The catalyst used for fuel-cell electrodes was a carbon supported platinum (40 wt.%, Johnson Matthey). In order to make the catalyst ink, the solvent and polymer ionomer solution (5 wt.% Nafion in water and alcohol, Sigma-Aldrich) were added to the catalyst powder in a vial. The prepared catalyst ink was ultrasonically mixed and physically stirred until they form a well mixed slurry.

The prepared catalyst ink was brushed on

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the decal substrate which already has a breaking layer. The temperature of the substrate was carefully controlled during the coating process. The amount of polymer ionomer solution and solvent was also carefully determined to make the proper catalyst layer and easy the MEA fabrication process. Moreover, the microporous layer with proper structure was introduced.

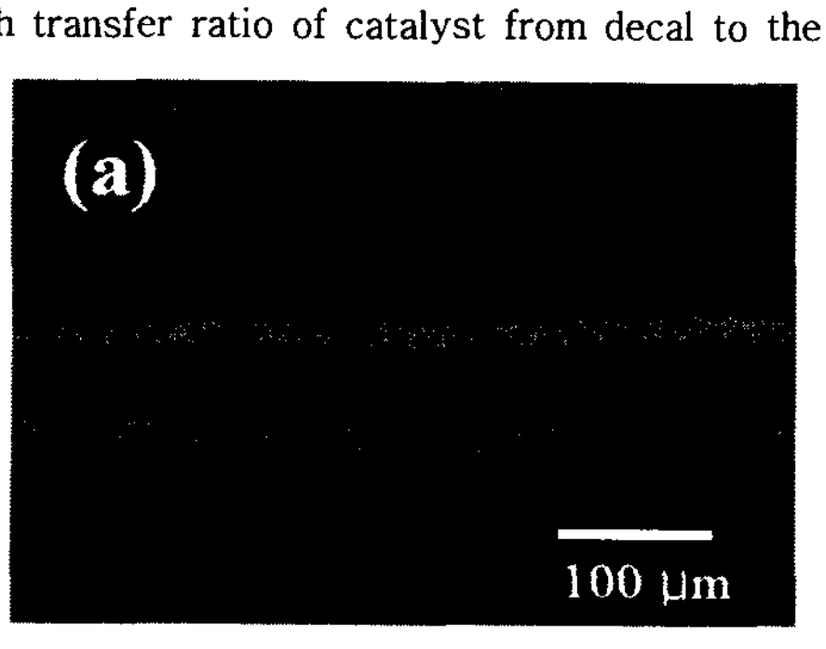
The current-voltage characterization curves revealed the performance of PEMFC. The performance of fabricated MEA was evaluated using a single cell (CNL-PEM005-01, CNL Energy) and fuel cell testing system (WFCTS, WonAtech). The cell temperature during the test was maintained at 70 ℃ and ambient pressure. The single-cell performance was characterized using humidified hydrogen / oxygen and hydrogen /air gases at 75 / 70 ℃ for anode / cathode feed.

Field emission scanning electron microscopy (FE-SEM) analysis was conducted to determine the electrode character with a JSM 6700F (JEOL Ltd.).

The amount of platinum catalyst used in this study was carefully controlled to 0.30 mg cm^{-2}.

3. Results and Discussion

In this study, the breaking layer is introduced to decal transfer method. The breaking layer is coated on decal substrate before the catalyst layer formed on it. In conventional decal transfer method, the catalyst layer has been directly applied to the decal substrate and it makes difficult to realize a high transfer ratio of catalyst from decal to the



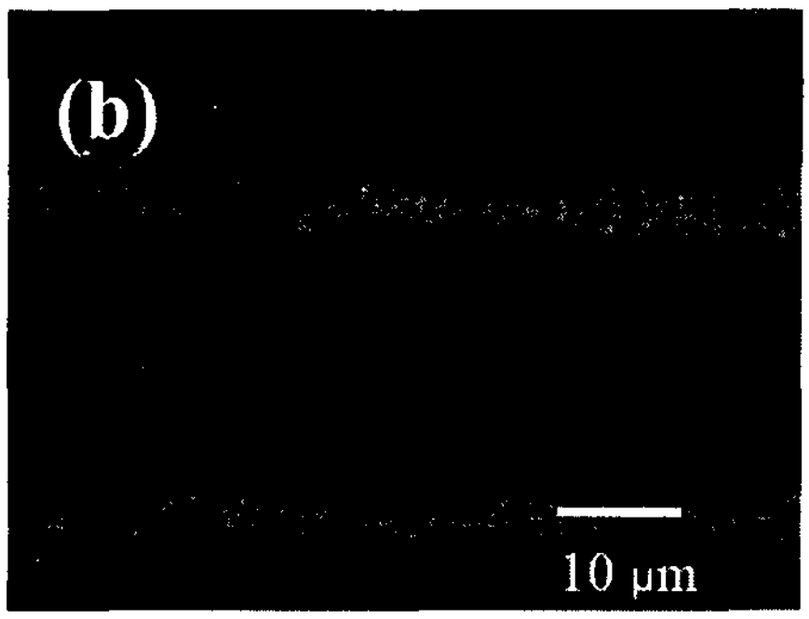


Figure 1. Scanning electron microscopy images of membrane electrolyte assembly made by (a) conventional spraying method and (b) modified decal method.

polymer membrane. However, there is no catalyst loss during MEA fabrication process in this modified decal method by introducing such breaking layer. In results, the modified decal method could confirm its complete catalyst transfer from decal substrate to the polymer electrolyte membrane.

Field emission scanning electron microscopy micrographs of the catalyst layer are shown in figure 1. The bright layers on both side of membrane are the platinum catalyst layer. The micrograph shows that the MEA formed by the modified decal method shows more continuous interface and good adhesion between the MPL and catalyst layer (Fig. 1(b)) than the one from the conventional spraying method (Fig. 1(a)). The smooth interface may decrease the interface resistance.

The performance of single fuel-cell is also studied using fuel cell testing machine. The current density is 1890 mA cm^{-2} at the voltage of 0.6 V with oxygen gas feed (Fig. 2(a)). The current density with air feed is 962 mA cm^{-2} at 0.6 V (Fig. 2(b)).

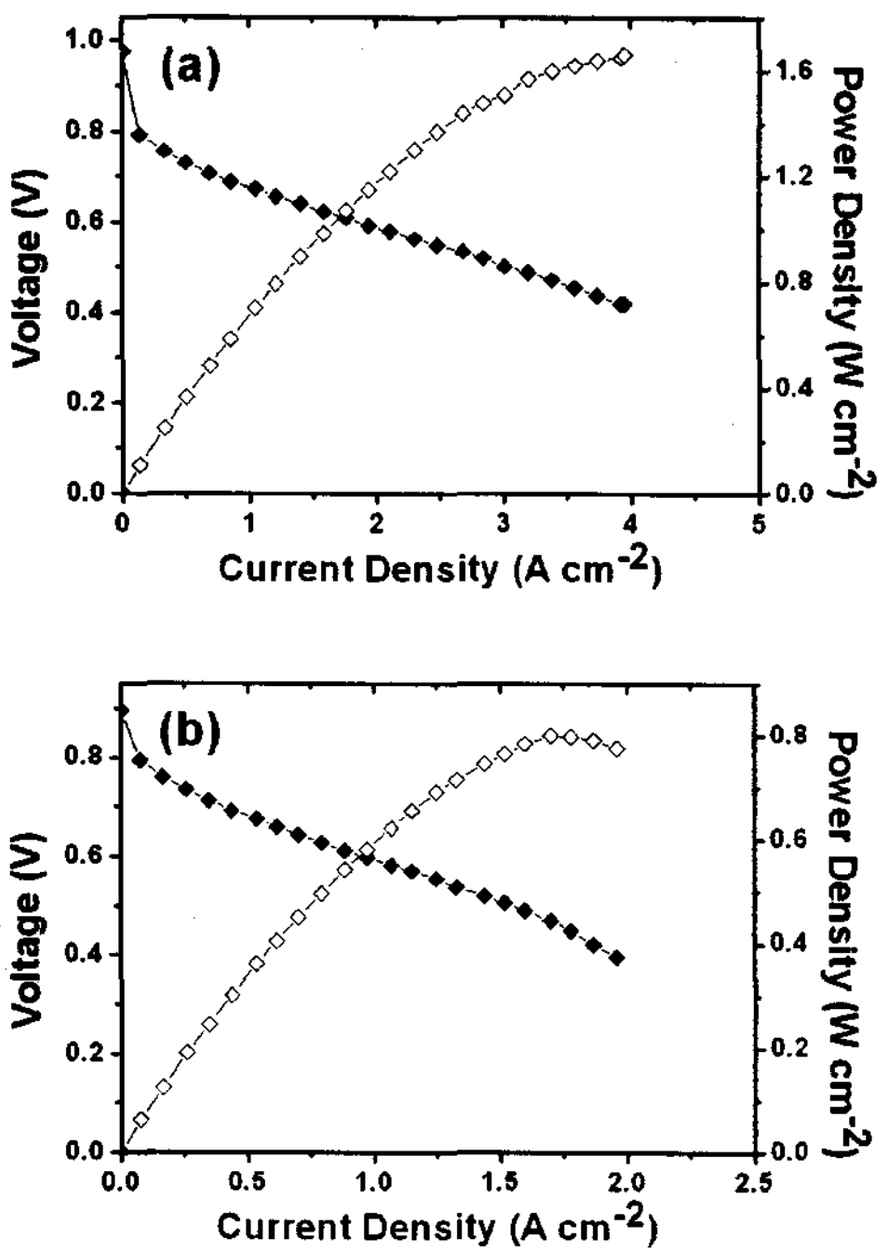


Figure 2. Current-voltage polarization curves of the electrodes made by modified decal method. Feed (a) oxygen and (b) air as a cathode fuel.

4. Conclusion

The modified decal method could confirm its complete catalyst transfer from decal substrate to the polymer electrolyte membrane by introducing breaking layer. Moreover, the structure of MEA is experimentally optimized. As a result, fuel cell with a high power density of ca. 1.7 W cm^{-2} and 0.8 W cm^{-2} in oxygen and air operation is achieved.

Acknowledgments

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