MEA for PEMFC Prepared by Sputter Deposition in Low Pressure Air and Transfer Method

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The deposition of thin film catalyst layers on the surface of electrolyte membranes has been reported previously as a way to improve the mass-transportation and to obtain a more active catalyst layer. Sputter deposition was sometimes used to obtain thin catalyst layers. However, the sputter-deposited catalyst layer cracks up when the layer gets thicker (approximately more than 10 nm) because the electrolyte membrane absorbs water in the air and swells after the vacuum process (Fig. 1(a)) [1-3]. Therefore, the performance of the cell with sputtered catalyst cannot overtake the commercial cells because the amount of catalyst is too little although the cell performances are superior to conventional cells with the same catalyst amount. It has also been tried to form the catalyst layer on a carbon electrode by direct sputter deposition for the reduction of platinum loading amount [4-7].

In this paper, a thin film catalyst layer of low electrical resistance without using carbon support was prepared by a novel method using sputter deposition. A continuous uniform catalyst layer has been obtained by the following method (Fig. 1(b)). First, gold and platinum have been sputter-deposited on a PTFE blank sheet. Ionomer was brushed on the sputtered layer. The catalyst layer was then transferred to a polymer electrolyte membrane by hot press. The platinum loading amount was about 0.7mg/cm^2 after 90 minute of sputtering.

After structure analysis, it became clear that the platinum layer was oxidized and its structure made porous by sputtering in low pressure air instead of an inert gas such as argon gas or nitrogen gas. This platinum layer is suitable for the catalyst of the proton exchange membrane fuel cell (PEMFC) because its porous structure helps gas diffusion and supplies a large active surface area.

The dependence of fuel cell performances on various parameters, platinum thickness, amount of ionomer, and gold thickness was measured. As a result, the performances have been improved as the platinum layer gets thicker. By brushing the electrolyte solution on the surface of the catalyst layer before the transferring process, the ionic connection between the electrolyte membrane and catalyst layer was improved. Gold was sputtered before platinum deposition to improve the electrical connection between the catalyst layer and the electrodes. Sputtering gold was also effective to support the catalyst structure and to collect current.

It is clear that the MEA produced by the method proposed in this paper has higher performances than other conventional MEAs (Fig. 3).

REFERENCES

1. S. Y. Cha and W. M. Lee, *J. Electrochem. Soc.*, **146**, 4055 (1999).
2. R. O'Hayre, S. Lee, S. Cha and F. B. Prinz, *J. Power Sources*, **109**, 483 (2002).
3. T. A. Zavodzinski, C. Derouin, S. Radizinski, R. J. Sherman, V. T. Smith, T. E. Springer and S. Gottesfield, *J. Electrochem. Soc.*, **140**, 1041 (1993).
4. S. Hirano, J. Kim and S. Srinivasan, *Electrochim. Acta*, **42**, 1587 (1997).
5. S. Mukerjee and S. Srinvasan, *Electrochim. Acta*, **38**, 1661 (1993).
6. E. A. Ticianelli, C. R. Derouin and A. Srinvasan, *J. Electroanal Chem.*, **251**, 275 (1988).
7. E. J. Taylor, E. B. Anderson and N. R. K. Vilambi, *J. Electrochem. Soc.*, **139**, L45 (1992).

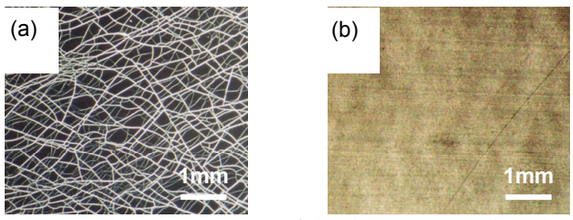

Fig. 1. Microscope images of (a) direct sputter-deposited Pt on a polymer electrolyte membrane and (b) transferred Pt and Au to the surface of a polymer electrolyte membrane after sputtering it on a PTFE sheet.

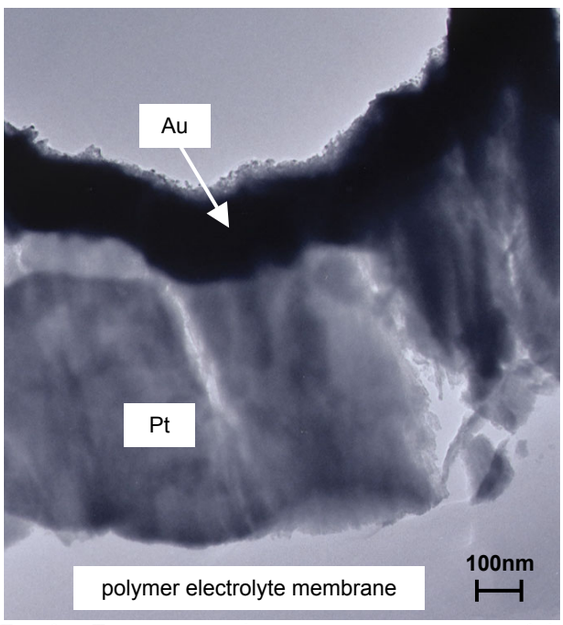

Fig. 2. Transmission electron microscope image of the cross-section of a MEA with sputter-deposited and transferred catalyst layer. 600 nm thick Pt layer was deposited on the electrolyte membrane and 200 nm thick Au layer was deposited on it.

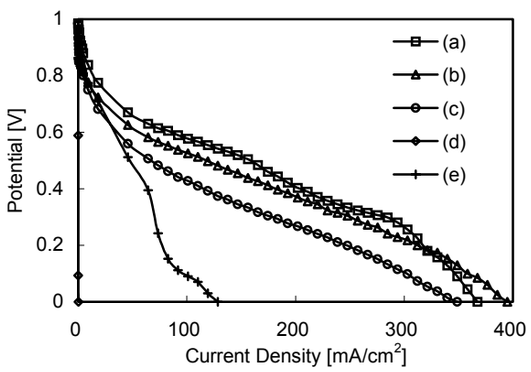

Fig. 3. Comparison of the cell performances fabricated by various methods. The Pt loading amount for each of them is approximately 0.7mg/cm^2. (a) transfer of sputtered Pt (b) Pt black powder, (c) 40wt% Pt/C powder, (d) direct Pt sputtered on a electrolyte membrane, (e) direct Pt sputtered on carbon clothes.