Abs. 1942, 206th Meeting, © 2004 The Electrochemical Society, Inc.

Performance of Polymer Electrolyte Membrane Fuel Cell with Pressurization up to 4.0 MPa

S. Tsushima, T. Mibae, K. Teranishi and S. Hirai
Research Center for Carbon Recycling & Energy, Tokyo Institute of Technology
2-12-1, Ohokayama, Meguro-ku, Tokyo 152-8552, Japan

Fuel cell pressurizaiton has been known to show several beneficial effects on fuel cell performance, because the reactant gas partial pressure, gas solubility, and mass transfer rates are higher [1]. It is also addressed that increased pressure tends to increase system efficiencies. However, pressurization requires thicker piping and strong cell structure as well as additional expense for the compression process. Therefore, the benefits of increased pressure is in balance between the improved performance and the loss associated for high pressure operation of the system, e.g. compression loss. In this study, we evaluated performance of a polymer electrolyte membrane fuel cell with pressurization up to 4.0 MPa and examined variation of overpotential with operating pressures by means of electrochemical impedance spectroscopy and magnetic resonance imaging (MRI).

First, we examined performance of a PEM fuel cell with operating pressure up to 0.4 MPa. In the experiment, we intentionally used a rather thick membrane with 340 μm for conducting MRI study to investigate variation of water content in the membrane with operating pressure. As seen in Fig.1, pressurization up to 0.4 MPa improved cell performance. The electrochemical impedance spectroscopy we carried out revealed that the activation polarization loss indicated as R_{act} in Fig.2 as well as the ohmic loss (R_{ohm}) decreased with increasing the pressure. To examine factors for decrease of the ohmic loss with operating pressure, we measured water content distributions in the membrane under fuel cell operation by MRI technique we developed [2]. Figure 3 presents MRI results showing the membrane more hydrated with increasing pressure. Hence, we concluded that decrease of the ohmic loss with pressure was mainly caused by increase of ion-conductivity of the membrane due to membrane hydration.

We then assembled a PEM fuel cell for high pressure operation up to 4.0 MPa. Figure 4 shows polarization plots of the PEM fuel cell in changing the operating pressure from 0.1 MPa to 4.0 MPa. We can see the cell performance was improved with pressure at low current density in the entire pressure range examined. However, at higher cell current, the cell voltage was deteriorated, once the operating pressure exceeded 1.0 MPa. Because the electrochemical impedance spectroscopy measurement indicated that the drop of cell voltage observed at high current density was due to concentration polarization, it is suggested that water produced by electrochemical reaction condensed in gas diffusion layer (GDL), i.e. flooding occurred in the porous GDL. In conclusion, we pointed out that optimized operating pressure exists in PEM fuel cell system for better performance.

This study was supported by New Energy and Industrial Technology Development Organization (NEDO) of Japan. Authors gratefully thank to Asashi Kasei. Corp. and Tanaka-Kikinzoku Kogyo for supplying PEFC materials.

Reference

1. Hirschenhofer, J.H., Satuffer, D.B., Engleman, R.R., Klette, M.G., Fuel Cell Handbook 4th Edition, Parsons Corp, (1998).
2. Tsushima, S. et al., *Electrochem. Solid-State Lett.*, (2004), in press.

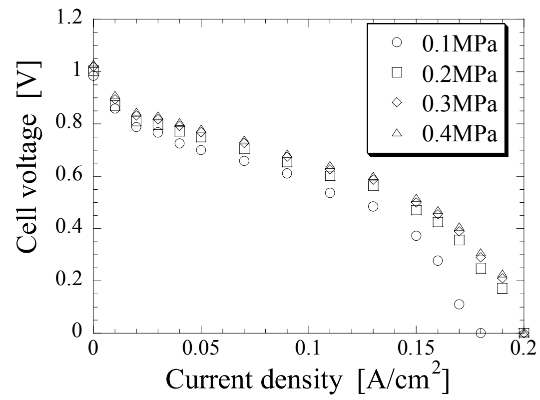

Figure1. Polarization plots of a PEM fuel cell with operating pressure up to 0.4 MPa

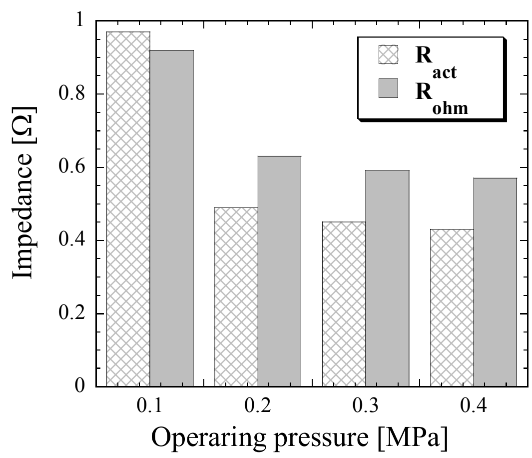

Figure 2. Variation of activation and ohmic overpotential with variation of operating pressure.

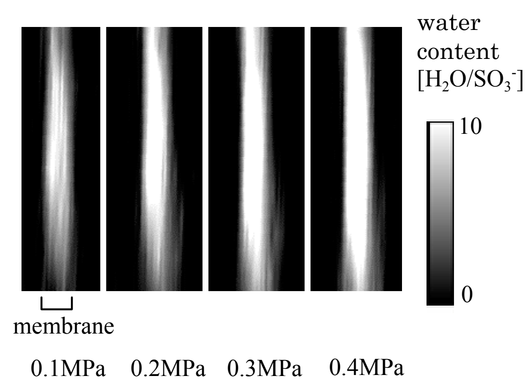

Figure 3. Water content distributions measured by MRI.

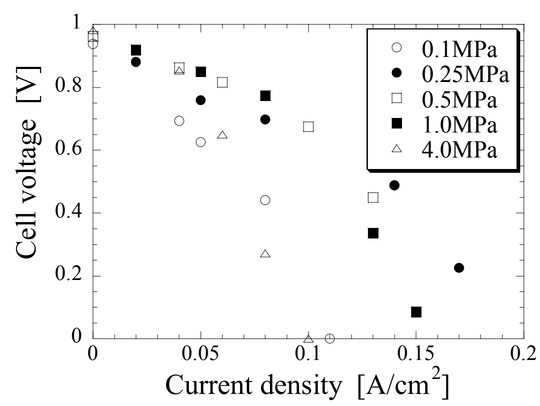

Figure4. Polarization plots of a PEM fuel cell with operating pressure up to 4.0 MPa