Electrochemical Performance of Polymer Electrolyte Fuel Cell

Masaki Haibara, Yuki Kagawa, Kohei Ota, Kazuhiko Noda and Hachiro Imai
Department of Material Science and Engineering, Shibaura Institute of Technology,
3-7-5, Toyosu, Koto-ku, Tokyo, Japan

Introduction

Recentry, there are an environmental problem by mass consumption of a fossil fuel and an energy problem as a problem of an earth scale. Therefore, the fuel cell attracts attention as a hernative energy saving and development of a pollution-free energy system. Polymer electrolyte fuel cell (PEFC) can be especially miniaturized, and can be used widely because of easy handing at room temperature level and from the transport machine to the application. However, the many unsolved problems of fuel cell still left behind prevent the application of fuel cell to spread widely. The technology of the quality assessment method of a fuel cell and the monitoring of a battery is also very important for improvement in performance, durability, and reliability towards utilization of a future fuel cell. Some reports of research have already been carried out about degradation and the quality assessment of the solid polymer membrane[1,2].The quality assessment changing the humidity of the hydrogen supplied to the PEFC was performed in this paper, during the quality assessment method of the PEFC was also imvestigated by analyzing the difference in performance using the alternating-current impedance method in this research.

Experimental

Specimen preparation

Nafion membrane that thickness was 127μm was used as solid polymer electrolyte specimens for the measurement. Nafion is perfluorosulfonic acid membrane and the most popular material to use as electrolyte of fuel cell.

Measurement procedures

Fig.1 shows the diagram of fuel cell voltage measuring system. The fuel cell was constructed with the specimen. The cell voltage was measured using the fuel cell voltage analyzer that was the fuel cell power generation characteristic analysis machine (As-510-T, NF circuit block). As measurement conditions, the temperature of the cell was set to 300K. The hydrogen gas adjusted relative humidity (RH) to 7%RH and 80%RH using dehumidifier and humidification system was supplied as fuel. The hydrogen gas that flow rate was 200cc min^{-1} was sent to fuel electrode. The naturally-aspired oxygen gas was sent to oxygen electrode. Scanning rate of the measurement was set to 10 mA s^{-1}. The voltage of the cell and power density of the cell before measurement was taken.

Fig.2 shows the diagram of the impedance measurement. A frequency response analyzer (FRA) and Potentio / Galvanostat were connected to a computer. The impedance was measured at constant fuel cell condition. Other measurement condition was set as previously stated condition, except the flow rate of hydrogen is set to 25 cc · min^{-1} . Moreover, bias current was 5mA. The current amplitude was 3mA. The frequency range impressed sine wave alternating current as 0.01Hz to 10000Hz. The voltage to current was measured using FRA.

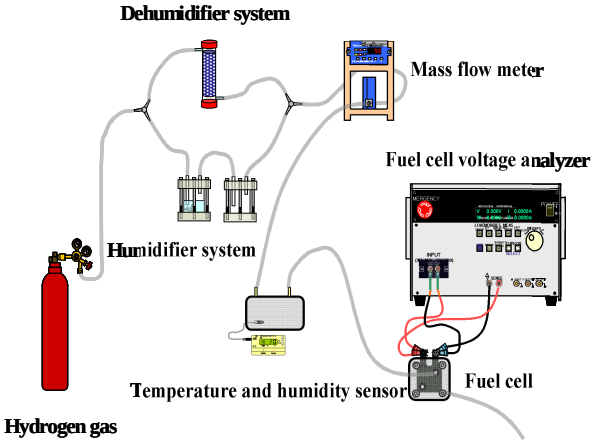

Fig.1: Schematic diagram of measurement system of the cell voltage.

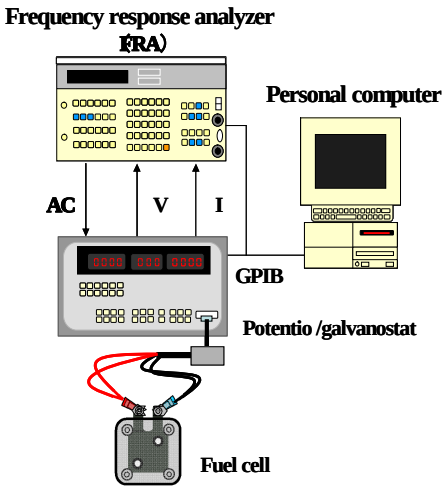

Fig.2: Schematic diagram of measurement of alternating-current impedance

Results and discussion

Fig. 3 shows the measuring results of the I-V curve by the difference humidity conditions. In the case of low humidity (7%RH), the significant decreasing of the battery performance is seen comparing with the case of high humidity. The decrease of the cell voltage at low current density is very high. The electric conduction rate of a solid polymer electrolyte membrane is greatly influenced with the quantity of the water in a membrane. The results are also conformed the decrease of the performance due to decline in electrical conductivity at low humidity. It has conformed that humidity is much required for power generation where the PEFC is more stabilized. so humidity management is very important.

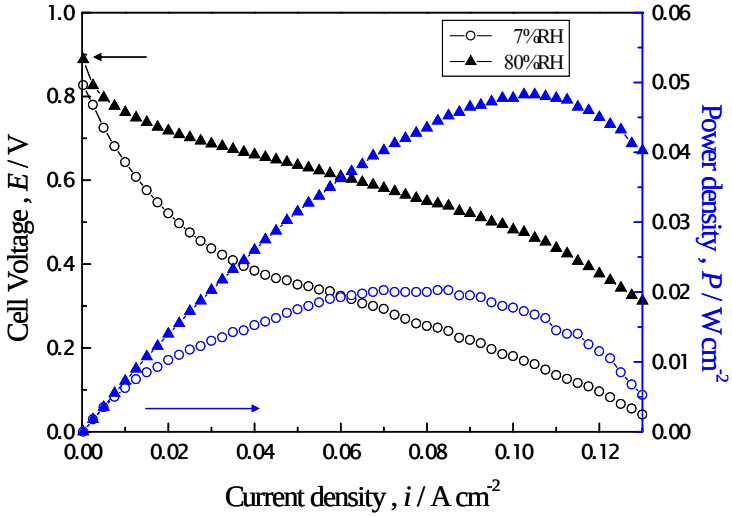

Fig.3: Influence the difference among humidification conditions has on an I-V curve

In order to investigate in detail the cause of a decrease of the cell performance seen in the I-V characteristic, alternating-current impedance measurement was performed. The Bode diagram changing humidity conditions is shown in Fig.4. In PEFC, both solution resistance and reaction resistance was measured by impedance measurement. Solution resistance is caused by the total of electrical resistance such as separator resistance and current collector resistance. The reaction resistance is caused by charge transfer resistance. The solution resistance is shown in high frequency region while in low frequency region is shown by both solutions resistance and reaction resistance. In both frequency region, the impedance result in low humidity condition shows higher resistance. It is believed that the increase of solution resistance is depended on the reduction degree of proton conductivity of a solid polymer electrolyte membrane by reduction in relative humidity. The increase of reaction resistance is considered to be caused by ion-exchange to exist in an electrode interface. Furthermore, during cell operation, the generation of water cause the membranes humidity to increase. Therefore during humidity low membranes condition, it is believed that the actual value of resistance is much higher than the measured resistance. For that reason, the use of low humidity membrane inside fuel cell caused the cell performance to greatly decrease as shown in I-V measurement.

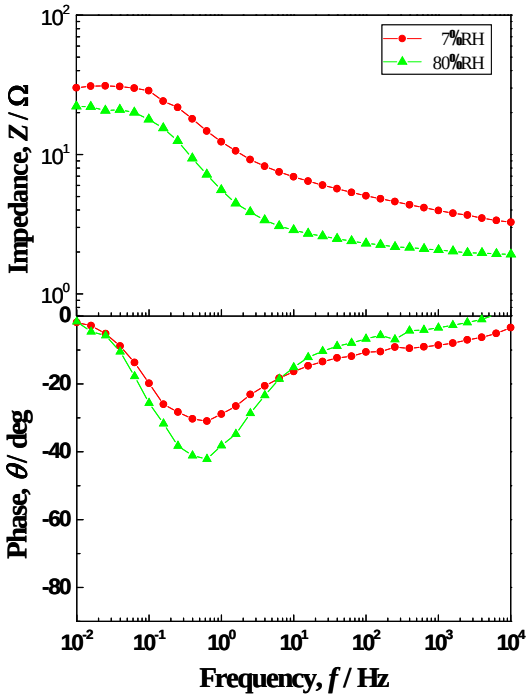

Fig.4: Influence the difference among humidification conditions has on a Bode diagram

Conclusion

1. The effect of humidity on fuel cell performance can be conformed by using I-V curve measurement.
2. As a method of evaluating the performance of a fuel cell, the performance of a fuel cell could be examined more deeply by combining I-V curve measurement and alternating-current impedance measurement.

References

1. Y.Masahira, Y.Yagi, S.Kato, K.Noda and H.Imai, The proc. 115th meeting (The surface finishing society of Japan), (2007), p263
2. S.Kato, Y.Masahira, K.Noda and H.Imai, The proc. 116th meeting (The surface finishing society of Japan), (2007), p285