A study on fabrication and performance characteristics of micro fuel cell based on PCB(Printed-Circuit Board)

인쇄회로기판(Printed-Circuit Board)을 이용한 마이크로 연료전지의 제작 및 성능향상에 관한 연구

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Introduction

Direct methanol fuel cell (DMFC) that uses liquid methanol directly without reformer is considered as a competitive candidate for portable power sources because methanol has a high energy density (about 6kWh/kg). This advantage is important for portable electronic applications such as mobile phones, notebook, and other advanced mobile electronic devices, whose power requirement is increasing for its multifunctional purpose. In order to compete with conventional battery technology, it is very important to eliminate the need of some auxiliary devices such as gas compressors or fans, and reduce the weight and size of fuel cells.[1]

In this paper, the design consisted of a PCB based substrate with inlet, outlet, and flow channels to introduce alcohol as a fuel. A thin solid sheet of Nafion membrane was used as a polymer electrolyte. electrodes and catalysts were deposited as anode and cathode on both sides of this membrane by using direct spray method. Effects of channel patterns and channel width on a direct methanol fuel cell(DMFC) performance are presented.

Experimental

Micro flow channels were fabricated with photoresist using photolithography techniques. PCB - negative photoresist film was chosen for implementation in actual prototypes due to its well-established processing base and extensive usage in microfluidic devices.[2] The testing method of micro flow channel performance is similar to that used for conventional fuel cells. The membrane electrode assemblies (MEA's) were fabricated from Nafion 117 with Pt · Ru/C and Pt/C catalyst. The platinum loading was $3mg/cm^2$ and the active area was 0.5cm × 0.5cm(0.25cm^2).

During the test, the MEA was placed between two flow channel prototypes, sealed with Teflon sheet gaskets, and firmly tighten up a bolt with end plate. The metal blocks contained fuel routing paths to provide methanol and O_2 to the fuel cell. It should be noted that the same MEA was used to measure the performance of all prototypes. This eliminated any discrepancies that could have arisen due to MEA variability between tests of each prototype.

2M methanol and O_2 were supplied to the fuel cell. The inlet flow rate of Methanol and O_2 were regulated at 17ml/min and 30ml/min respectively under atmospheric pressure. Cell polarization curves were measured by DC electric load (Keithley 2000). In addition, electrochemical impedance spectroscopic measurement carried out to ohmic resistance using Auto Lab. Three types of bipolar plates having different channel width(200, 300, and 400μm) were prepared. Methanol(2M) in the anode side and pure O_2 in the cathode side were used in micro DMFC operation. The test was carried out at 1atm pressure and 80℃.

Results and discussion

Fig. 1 shows the brief process diagram. The starting material was pcb(printed circuit board) covered on copper. The masks were designed to give microreactors on a pcb. Positive photoresists were used to transfer patterns from mask to pcb. These patterns were then transferred into pcb by using wet etching process.[4]

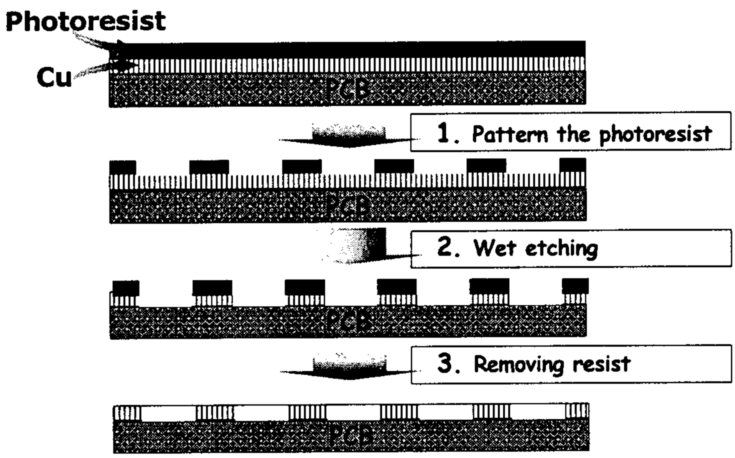

Figure. 1. PCB based FC fabrication process

The flow rate of methanol was carried at 2, 17, 52, 98 and 180ml/min. Oxygen flow rate was kept constant at 30ml/min in all cases. The best performance reveals at 17ml/min. This is also supported by the impedance spectra(Figure 2-b). The interfacial resistance decreases if the flow rate of methanol is increased from 2ml/min to 17ml/min.

Figure 3-a shows voltage-current characteristics of the bipolar plates curve for different channel width. It is clearly observed that the performance increases as the channel size of the bipolar plates decreases. At channel width of 200um, the maximum power density was obtained(figure 3-b).

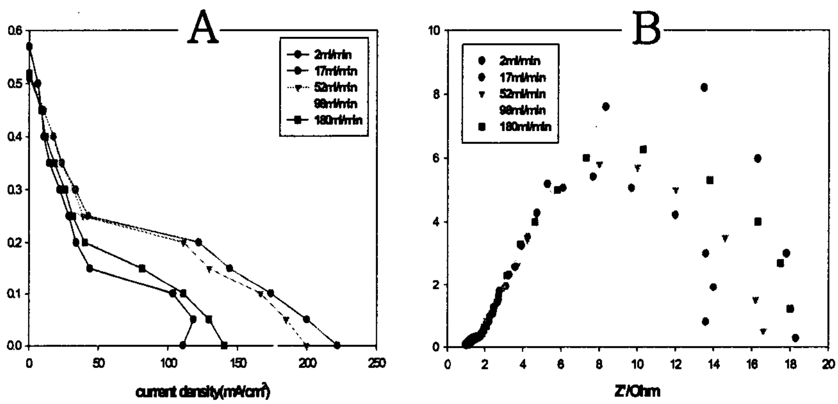

Figure 2. Polarization curves(a) and impedance spectra(b) at different methanol flow rates, air flow rate of 30ml/min, 80℃, and ambient pressure.

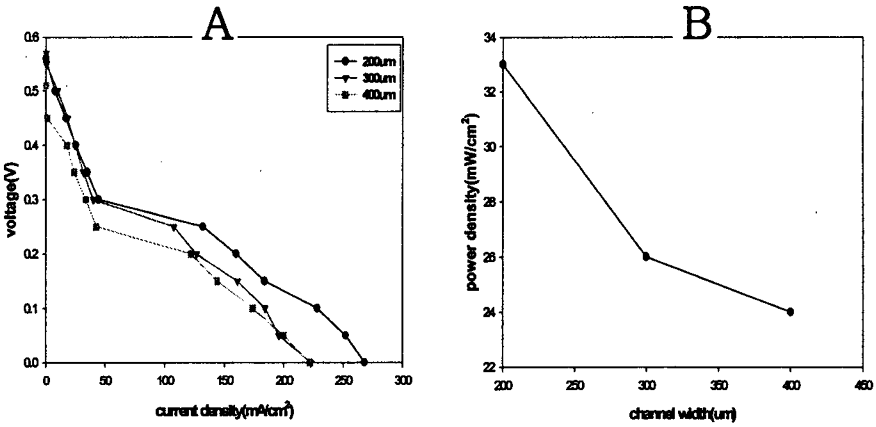

Figure. 3. IV curves of micro fuel cell with different channel width, at 200, 300, and 400μm.

conclusion

Microchannels were successfully integrated in micro fuel cells. Methanol flow rate at 17ml/min showed the best performance. Micro fuel cell performance increases with decreasing channel size due to the reduced diffusion blockage of ribs and increased convection in microchannels. The measured peak power density of $33mW/cm^2$ using a Nafion 117 and E-TEK catalyst was obtained at 80℃.

Acknowledgements

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Reference

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