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Fabrication of Polymer Electrolyte Fuel Cell Using Carbon Nanowalls

カーボンナノウォールを用いた固体高分子燃料電池の作製

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Polymer electrolyte fuel cell (PEFC) is expected to be a power source for vehicles and cogeneration systems to realize downsizing and weight-saving. We propose a novel structure of PEFC using carbon nanowalls (CNWs), which possess large surface area and high electric conductivity. CNWs were grown directly on the carbon fiber cloth (CFC). PEFC unit using Pt-supported CNW/CFC as catalyst layer was constructed, and its voltage-current (V-I) and power-current (P-I) characteristics were measured. V-I and P-I curves showed the power generation similar to the conventional PEFC.

1. Introduction

Polymer electrolyte fuel cell (PEFC) is expected to be a power source for vehicles and cogeneration systems to realize downsizing and weight-saving. Carbon black has been conventionally used as the catalyst support of the PEFC. Carbon nanowalls (CNWs) have a potential as alternative materials for the catalyst support to improve the durability and catalytic activity, owing to their large surface area and high electric conductivity. CNWs have been grown using various chemical vapor deposition (CVD) methods and several applications such as batteries, fuel cell, electrochemical sensors and biosensors using CNWs have been reported [1-2].

In this study, we propose a novel structure of PEFC using CNWs. CNWs were grown directly on the carbon fiber cloth (CFC) using inductively coupled plasma-enhanced CVD (ICP-CVD). PEFC unit employing platinum (Pt)-supported CNW/CFC as catalyst layer was constructed, and its voltage-current (V-I) and power-current (P-I) characteristics were measured. Power generation characteristics of the PEFC using CNWs were evaluated.

2. Experimental

Fig. 1 shows a schematic of ICP reactor used for the growth of CNWs. The ICP reactor was 16 cm in diameter and 30 cm in height. A one-turn coil antenna with a diameter of 10 cm was set on a quartz window at the top of the reactor. RF (13.56 MHz) power was applied to the coil antenna and plasma was generated in the reactor. RF power was 500 W, Ar/CH_4 gas flow rates were 100/50 sccm, total pressure was 20 mTorr, a growth temperature was 720 °C. Pt nanoparticles were supported on the surface of CNW on CFC by using the pulsed arc plasma deposition method.

Fig. 2 shows a schematic of the membrane / electrode assembly (MEA) of the PEFC. The MEA of the PEFC was assembled with the Pt-supported CNW, separators and proton exchange membrane. The power generation characteristics of the PEFC were evaluated with the fuel cell test system.

3. Results and discussion

Fig. 3 shows SEM image of CNWs grown on CFC. This image indicates that CNWs were successfully grown on the CFC. The Raman spectra of the CFC and CNWs grown on the CFC and SiO_2 substrate are shown in Fig. 4. The Raman spectrum of the CFC has a strong G band peak (1590 cm^{-1}) indicating the formation of a graphitized structure. Typical Raman spectrum of the CNWs grown on the SiO_2 substrate has a G band peak and a D band peak (1350 cm^{-1}). The G band peak is accompanied by a shoulder peak at 1620 cm^{-1} (D' band). The D band peak and D' band peaks are arising from a nanocrystalline structure and the presence of graphene edges and defects. The Raman spectrum of the CNWs grown on the CFC was similar to that of the CNWs grown on SiO_2. These results indicate that CNWs were successfully grown on the CFC.

Fig. 5 shows a voltage–current density (V-I) and a power-current density (P-I) curves for the PEFC

using Pt-supported CNWs on CFC as catalyst layer. The measurement was carried out at 80 °C. The power density increased up to 0.186 W/cm^2 with increasing the current density, and the voltage decreased. The slope of voltage can be classified roughly three phases. These behaviors indicate that the power generation of the fuel cell using CNWs was successfully performed.

4. Conclusion

We have proposed a novel structure of PEFC using Pt-supported CNWs as catalyst layer. CNWs were directly grown on the CFC using ICP-CVD. The membrane / electrode assembly of the PEFC was assembled using the Pt-supported CNW and the power generation characteristics of the PEFC were evaluated with the fuel cell test system. It is confirmed that the power generation of the fuel cell using CNWs was successfully performed.

References

[1] M. Hiramatsu and M. Hori. *Carbon Nanowalls*, Springer. 2010.

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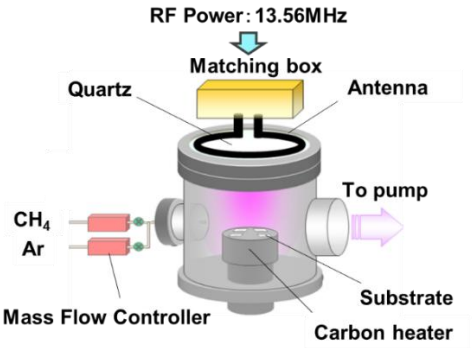

Fig. 1 Schematic of ICP system used for the growth of CNWs.

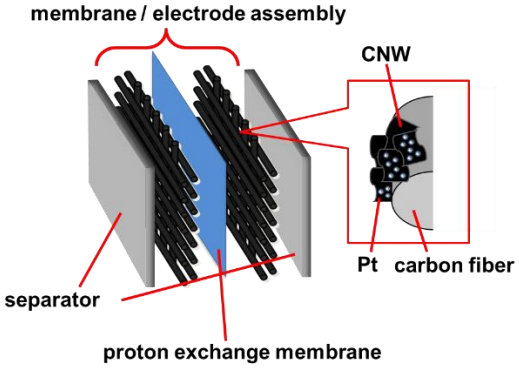

Fig. 2 Schematic of the membrane / electrode assembly of the PEFC.

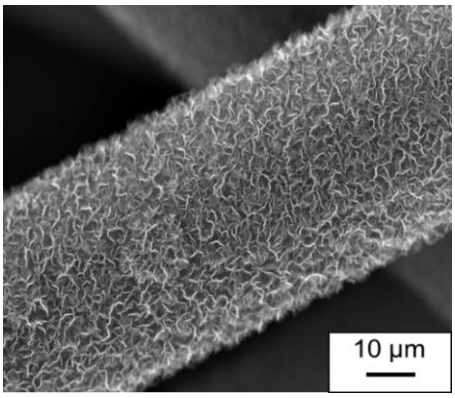

Fig. 3 SEM image of CNWs grown on carbon fiber.

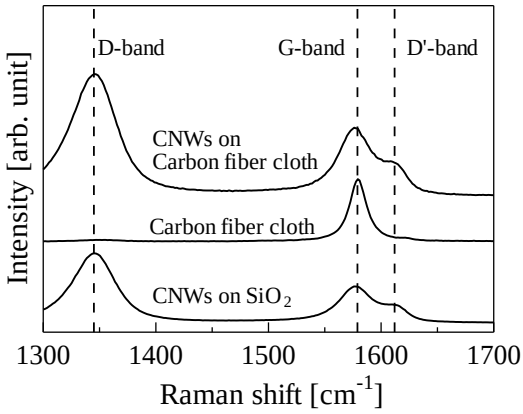

Fig. 4 Raman spectra of CFC and CNWs grown on CFC and SiO_2.

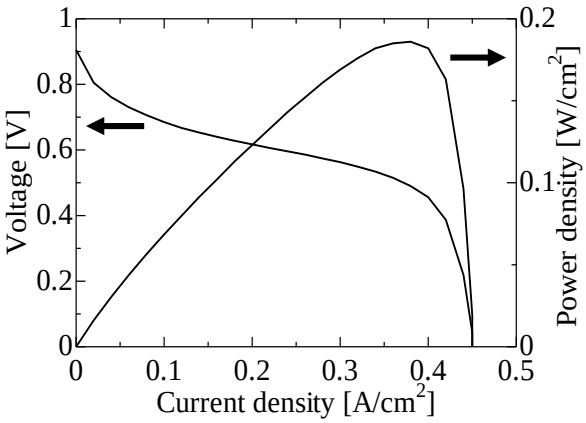

Fig. 5 V-I and P-I curves of the PEFC using Pt-supported CNWs on CFC as a catalyst layer.