DEVELOPMENT OF H₂/O₂ GENERATION CHIP FOR MICRO FUEL CELL DEVICES

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ABSTRACT

We here report on the development of the fuel generation chip for micro fuel cell devices. In the chip, H₂ and O₂ are generated by the photocatalytic water splitting and the generated gases are separated by hydrophobic modified channels. To verify the basic concept that water splitting and the gas-liquid separation are driven solely by light energy, we prepare a chip in which electrodes (TiO₂ photoanode and Pt cathode) and partial surface modification are integrated. The photocatalytic water splitting and the gas-liquid separation were verified, respectively.

KEYWORDS: Fuel generation, Light-driven, Photocatalytic water splitting, Gas-liquid separation

INTRODUCTION

Recently micro fuel cells have been considered as a new potential power source application such as batteries for portable devices. Fuel cells require an external fuel supply system. However, the problem is that to miniaturize the system is difficult. To develop a new type of a micro fuel cell, we have to combine micro fuel cells to the micro fuel generation device (not to a fuel supplying device). Since the photocatalytic water splitting utilizes the reverse reaction of the fuel cell, it is suitable for the micro fuel generation device. The combined device can be materially closed and driven “just by solar energy”, where the separation of generated H₂, O₂ and H⁺ is required. To develop the light-driven H₂/O₂ generation chip, we propose to integrate the photocatalytic water splitting system, nano-channels as H⁺ transfer system [1] and hydrophobic modified micro channels as the gas-liquid separation system [2] together into one chip.

In this paper, we report on the method of integrating a photocatalyst electrode on the bottom of the channel and partial surface modifying on a chip. The evaluation of the photocatalytic water splitting and gas-liquid separation are also discussed.

THEORY

The structure of the H₂/O₂ generation chip is shown in Fig. 1. The TiO₂ photoanode and Pt cathode that are for photocatalytic water splitting are located in the bottom of two micro channels of a fused silica substrate and are connected with each other by nano channels (730nm wide, 230nm deep). This represents a new concept of the proton transfer system. The second shallower micro channels are parallel to the deeper micro channels and are partially modified by fluoropolymer solution for a better gas-liquid separation. TiO₂ photoanode consists of three layers. First, the adhesion layer of TiO₂ was prepared (where the concentration of O₂ component gradually changes), then Pt as contact and TiO₂ as photoanode layers were deposited, respectively.

Figure 1: The structure of the H₂/O₂ generation chip.
(A) The conceptual sketch of the H₂/O₂ generation chip, (where a=600μm, b=7μm, a’=400μm and b’=1μm).
(B) Snap shot of the H₂/O₂ generation chip.
(C) Cross-section view of a TiO₂ photoanode

978-0-9798064-4-5/µTAS 2011/$20©11CBMS-0001 653
EXPERIMENTAL

We performed two types of experiments. The first experiment was performed to confirm the photocatalytic water splitting with the help of H⁺ transfer in nano channels during UV-irradiation of a chip (Fig. 2). NaClO₄ (concentration 5 mol/L) was used as the electrolyte. We measured the photocurrent under UV light irradiation (λ=365 nm) and bias voltage (0.5 V vs Ag/AgCl reference electrode).

The second experiment was performed to confirm the gas-liquid separation. Conventional gas-liquid separation was based on the pressure flow, but we achieved it without applied pressure. As shown on Fig. 3, we measured the current between two electrodes and the behavior of the generated gas under 1.3 V potential between two electrodes. 5 mol/L NaClO₄ was used as the electrolyte.

RESULTS AND DISCUSSION

The results of the first experiment are shown on Fig. 4. Fig. 4 (A) shows the photocurrent production. Fig. 4 (B) shows the relationship between photocurrent and irradiated UV power, which is linear to the incident light power. These results proved that the photocatalytic reaction was occurring because of H⁺ transfer in nano channels.

Then, we confirmed the gas-liquid separation, whose results are shown on Fig. 5. Under 1.3V potential between two electrodes, H₂ and O₂ were generated. The current was observed and generated gas was separated to hydrophobic channel without applied pressure. The current value periodically changed depending on the gas separation.
CONCLUSION

In this study, we developed the H₂/O₂ generation chip. Photocurrent based on photocatalytic water splitting and gas-liquid separation were observed. From these results, our basic concept of water splitting and gas-liquid separation driven just by light irradiation was proved. This is the first attempt of integrating a TiO₂ photoanode and partial surface modifying of shallow micro channels in a fused silica chip, which could serve as the fundamentals of fabrication of light-driven micro fuel cells.

ACKNOWLEDGEMENTS

This work was supported by JSPS Core-to-core program.

REFERENCES


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