Photoelectrochemical Cell Using Hydrothermally-Synthesized TiO_2 Thin Film as Photoelectrode to Split Water

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1. Introduction

Photoelectrochemical (PEC) cell contains a semiconductor electrode, which has a sufficiently positive valence band-edge for water oxidation to oxygen, coupled with a platinum black counter electrode for proton reduction to hydrogen [1-3]. Metal-oxide semiconductors such as TiO_2, ZnO, $SrTiO_3$, and $CaTiO_3$ have been extensively studied because these materials satisfy the requirement as an electrode of PEC cells [4]. In the present work, we focus mainly on the fabrication of special TiO_2 powder that is processed into thin film electrode for photoelectrochemical characterization.

2. Experimental

A commercial TiO_2 (P25, Degussa AG, Germany, ca. 30% rutile and 70% anatase) was hydrothermally treated to prepare high surface area powders. In preparation, the P25 powder was mixed with 70 ml of a 10 N NaOH aqueous solution, followed by hydrothermal treatment of the mixture at 130 °C in a Telfon-lined autoclave for 24 h. After the treatment, the product was rinsed by mixing with 0.1 N HNO_3 aqueous solutions for several times until the pH value of the rinsing solution was less than 7. The sample was hydrothermally treated again in 100 ml water at 180 °C for 12 h to obtain a colloidal solution.

The colloidal solution was mixed with poly(ethylene glycol) and Triton X-100 to become slurry, which was then spin-coated on conducting fluorine-doped SnO_2-coated glass substrate to become a semiconductor electrode.

Photoelectrochemical characterization of the electrode was performed by measuring photocurrent measurement in a three-electrode cell configuration with 3 M KOH solution as the electrolyte. Pt black and Ag/AgCl electrodes were used as counter and reference electrodes, respectively.

3. Results and Discussion

The size of the particles gained from hydrothermal treatment is smaller than that of P25, as shown in Fig. 1. The hydrothermally-synthesized TiO_2 is fully composed of anatase structure, as shown in the XRD pattern (Fig. 2). The photocurrent density as a function of potential at TiO_2 film electrodes under illumination is shown in Fig. 3. The results show that the hydrothermal treatment improved the photo-conversion efficiency in splitting water.

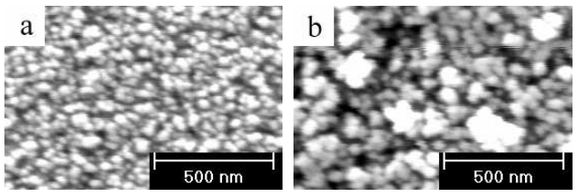

Fig. 1. SEM micrographs of TiO_2 thin film electrodes coated with (a) hydrothermally-synthesized TiO_2 (b) commercial P25 TiO_2.

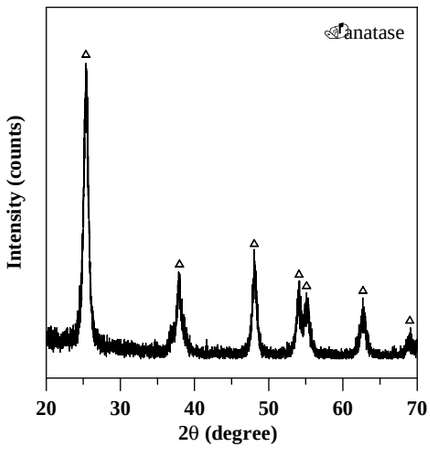

Fig. 2. XRD patterns of the hydrothermally-synthesized TiO_2 powders.

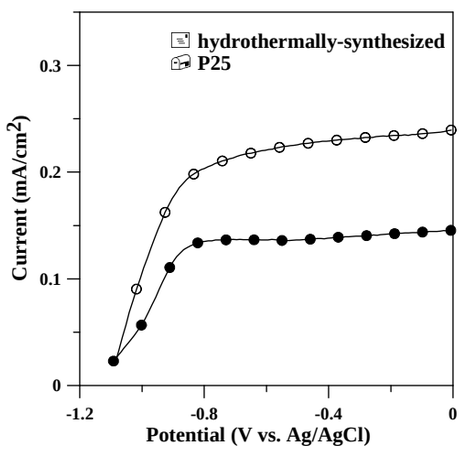

Fig. 3. Photocurrent density as a function of potential under illumination of 88 $mWcm^{-2}$ in 3 M KOH. The potential sweep rate is 10 $mV\ s^{-1}$.

Acknowledgement: Financial support from National Science Council of Taiwan is gratefully acknowledged.

References

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