— Article —

<SCJ-06>

The Effect of Platinum Deposition on the Water Photo-Reduction at p-Cu_2O Semiconductor Electrodes with Visible Light Irradiation

Ponchio CHATCHAI,[a,b] Atsuko Y. NOSAKA,[a] and Yoshio NOSAKA[a,*]

[a]Department of Materials Science and Technology, Nagaoka University of Technology, (1603-1 Kamitomioka, Nagaoka, Niigata 940-2188 Japan)

[b]Department of Chemistry, Faculty of Science and Technology Rajamangala University of Technology (Klong 6 Thanyaburi Pathumthani, 12110 Thailand)

Received April 2, 2011; Accepted May 24, 2011

The surface of a p-Cu_2O semiconductor photoelectrode was modified by electrodeposition of Pt nanoparticles and analyzed by XRD, SEM, XPS, and EIS (electrochemical impedance spectrometry) methods besides photocurrent measurements. The XRD, SEM, and XPS analyses showed the fabrication of Cu_2O film and the deposition of Pt particles. On the electrodeposition of Pt nanoparticles, cathodic photocurrent was enhanced. The EIS analysis suggested that Pt nanoparticles enhance the charge transfer process to the solution.

Key Words : Cu_2O Photoelectrode, Pt Nanoparticles, Hydrogen Evolution, Photoelectrocatalysis,

1 Introduction

Photoelectrochemical water splitting driven by solar light energy is one of the attractive targets for the development of hydrogen fuel production systems, because it is an ultimate solution for solving both the energy and environmental problems. Many metal oxide semiconductors working in a visible light region have been developed as photoelectrodes for water splitting.[1-5] Recently, we have reported $BiVO_4$ electrodes coupled with SnO_2 and WO_3 thin layers[6-7] in order to develop a photo-anode with a high activity of oxygen evolution under visible light irradiation. Moreover, gold nanoparticles were deposited on $WO_3/BiVO_4$ photoelectrode and the anodic photocurrent was increased.[8] Since these electrodes are n-type semiconductors and the potential is not enough for water reduction, p-type semiconductors have been expected as a photo-cathode for water reduction. As an efficient photo-cathode was prepared, a tandem-type photoelectrochemical cell[9] for solar water splitting can be fabricated with the photo-anode reported.

A p-type copper (I) oxide (Cu_2O) semiconductor is one of the most attractive materials because the band gap energy is so narrow (2.0-2.2 eV) enough to absorb efficiently the solar light, and the conduction band level is negative enough for the reduction of water.[10,11] Various researchers on the photocatalytic properties of Cu_2O have been reported. Hara *et al.*[12] investigated the photocatalytic water spitting to H_2 and O_2 on Cu_2O powder. However, the mechanism of the process was not clear. To clarify the mechanism, Jongh *et al.*[13] studied the electrochemical photocatalytic properties of Cu_2O electrode of water decomposition. They concluded that the Cu_2O band gap energy is suitable to reduce water to hydrogen than that the water oxidation as consider in the level of energy bands. Although p-Cu_2O is used as a photo-cathode towards hydrogen evolution under visible light irradiation, the photocatalytic activity of pure Cu_2O is unusually low because of the recombination of the photogenerated electrons and holes. This effect was studied by Nagasubramanian *et al.*[14] who confirmed the rapid recombination processes of p-Cu_2O in acetonitrile solution. There are many reports on preventing the recombination to enhance charge separation in Cu_2O semiconductor. The charge separation could be improved by trapping electrons at the conduction band of Cu_2O.[15] It may possible to improve the charge separation by combining an n-type WO_3 with the p-type Cu_2O electrode for H_2 evolution.[16] Assembling of metal nanoparticles on the semiconductor surface is one of the strategies to achieve a high catalytic activity. We found in the previous study that the modification with gold nanoparticles could improve the surface properties of a $BiVO_4$ electrode to enhance the water oxidation.[8] Therefore, metal nanoparticles were expected to modify the Cu_2O surface to promote the photocatalytic activity for water reduction.

Platinum is an attractive metal because of the high catalytic activity with a low over potential for hydrogen evolution.[17,18] Peruffo *et al.* reported an electrochemical method which enabled direct deposition of Pt nanoparticles on a fluorine-doped thin oxide (FTO) substrate, exhibiting an enhanced electrocatalytic activity.[19] Therefore, in the present study we examined the electrodeposition of Pt nanoparticles on an FTO/Cu_2O electrode and evaluated their photocatalytic activities for hydrogen evolution under visible light irradiation.

2 Experimental

2.1 Preparation of the FTO/Cu_2O film photoelectrode

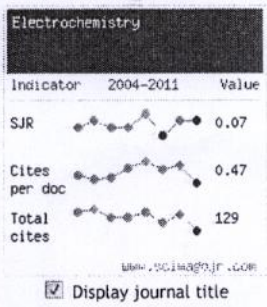
Cu_2O thin films were fabricated on a conducting FTO substrate by electrodeposition. The electrolyte was consisted of 0.1 M (M = mol dm^{-3}) of $CuSO_4$ and 0.1 M of tartaric acid,[20] and the pH was adjusted to 9.0 with 3.0 M

SJR SCImago Journal & Country Rank

EST MODUS IN REBUS
Horatio (Satire 1,1,106)

Home
Journal Rankings
Journal Search
Country Rankings
Country Search
Compare
Map Generator
Help
About Us

Show this information in your own website



Display journal title

Just copy the code below and paste within your html page:

<a href="http://www.scimagojr

How to cite this website?

SJR is developed by:

SCIMAGO LAB

Powered by SCOPUS™

Journal Search

Search query

in Journal Title Search

Exact phrase

Electrochemistry

Country: Japan

Subject Area: Chemistry

Subject Category: Electrochemistry Q4

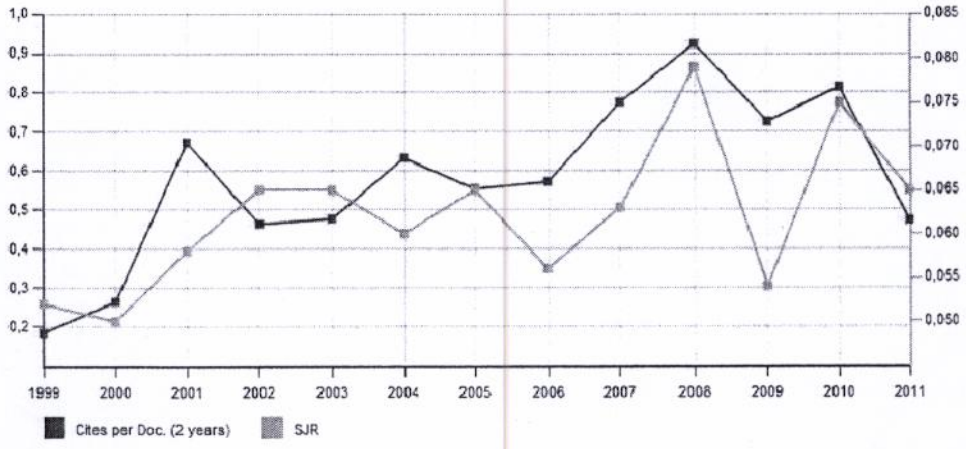
Publisher: Electrochemical Society of Japan. **Publication type:** Journals. **ISSN:** 13443542

Coverage: 1984, 1996-2011

H Index: 26

Charts Data

SJR indicator vs. Cites per Doc (2y)



The SJR indicator measures the scientific influence of the average article in a journal, it expresses how central to the global scientific discussion an average article of the journal is. Cites per Doc. (2y) measures the scientific impact of an average article published in the journal, it is computed using the same formula that journal impact factor ™ (Thomson Reuters).

Citation vs. Self-Citation