Improvement in Performance of ZnO based DSC Prepared by Spraying Method

Rangga Winantyo*1, Devinda Liyanage1, and Kenji Murakami2

1. Graduate School of Science and Technology, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu 432-8011, Japan
2. Research Institute of Electronics, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu 432-8011, Japan

*E-mail: f514031@ipc.shizuoka.ac.jp

Abstract

This paper reports the effect of TiCl4 on the performance of ZnO based DSC. ZnO was used due to its stability against photo-corrosion and photochemical properties similar to TiO2. Thin films of nanocrystalline ZnO were deposited on transparent conducting oxide glass using spray method. The ZnO films were treated using TiCl4. The cell’s efficiency was found to be 2.5% with TiCl4 post-treatment and 1.9% without TiCl4 post-treatment.

Keywords: DSSC, ZnO, TiCl4

1. Introduction

Zinc oxide is a semiconductor material with a band gap of 3.37 eV at room temperature, which is similar to TiO2 (3.2 eV) [1]. Most ZnO are n-type semiconductors even without the absence of dopants [2]. Several studies have been carried out on lab scale for the use of ZnO as an alternative replacement material of TiO2 nanoparticles in the dye-sensitized solar cell (DSC) applications, even though in general the effectiveness of the oxide layer of TiO2 nanoparticles is still higher [3]. This is because ZnO has many potential advantages that are not owned by other semiconductors. The only problem for the practical DSCs is lowered dye adsorption on the ZnO surface than on the TiO2 surface [4]. In the present study, we are investigating the method to enhance the dye adsorption on ZnO surface. Various strategies are being employed to improve dye adsorption. One simple approach involves post-treatment of the DSC by TiCl4.

2. Experiment

Preparation of ZnO thin film. The ZnO thin films were deposited on the fluorine doped tin oxide coated (FTO) glass substrate by using the spray method. All the substrates were cleaned with ethanol using ultrasonic cleaner. The spraying solution were made by mixing 1.5 g of ZnO, 8 drops of acetic acid (CH3COOH) and 8 drops of triton x-100 (C14H22O(C2H4O)n). The Triton X-100 was used to increase the conductivity of the film. The solution's temperature was maintained at 70 °C. The films were then rinsed with deionized water and annealed at 500 °C for 1 h to remove any residual organics and to improve the crystallinity.

TiCl4 treatment. In this report, we tried to apply a TiCl4 treatment on the ZnO surface. The solution was made by mixing 1.5 g of ZnO, 8 drops of acetic acid (CH3COOH) and 8 drops of triton x-100(C14H22O(C2H4O)n). The Triton X-100 was used to increase the conductivity of the film. The solution was stirred for 15 min using ceramic mortar. The solution was deposited on the FTO glass by using spraying gun, which can be seen in Fig. 1. During the spraying deposition, the FTO substrates were placed on the hot plate at the temperature of 150 °C. The method formed the ZnO films with thickness of around 14 μm. Finally, the films were annealed at 300 °C for 1 h.

DSC preparation. Platinum (Pt) coated glass were used as counter electrode. The ZnO film was dipped into
From the measurement that the TiCl₄ under 1.5 AM. The thickness of the film was measured from 1.9% to 2.5% is caused by the increase in the open-circuit voltage through a reduction of the charge recombinations with the TiCl₄ treatment. Further studies are needed to increase the adsorption of dye on ZnO surface. Other thin film deposition methods, such as hydrothermal and water-bath can be applied. Each of these deposition methods will form different ZnO nanostructure [6]. The effect of TiCl₄ post-treatment on each nanostructure form will be investigated on the next research.

3. Results and Discussion

Figure 3 shows the I-V characteristics of ZnO based DSCs without and with the TiCl₄ treatment. It is found from the measurement that the TiCl₄ treatment increases the open-circuit voltage.

The result indicates that the treatment introduces some blocking layer for charge recombination between ZnO and dye or electrolyte, which is same as the previous reports [5]. However, the short-circuit current density does not change through the treatment. In the present study, improvement in the energy conversion efficiency from 1.9% to 2.5% is caused by the increase in the open-circuit voltage.

4. Conclusions

It is revealed that the TiCl₄ post-treatment can improve the performance of ZnO based DSC. The treatment induces the increase of open-circuit voltage. Studies on a surface morphology and a structural property are very important to clarify effects of the treatment.

References