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Improvement in Performance of ZnO based DSC Prepared by Spraying Method

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Abstract

This paper reports the effect of $TiCl_4$ on the performance of ZnO based DSC. ZnO was used due to its stability against photo-corrosion and photochemical properties similar to TiO_2. Thin films of nanocrystalline ZnO were deposited on transparent conducting oxide glass using spray method. The ZnO films were treated using $TiCl_4$. The cell's efficiency was found to be 2.5% with $TiCl_4$ post-treatment and 1.9% without $TiCl_4$ post-treatment.

Abstrak

Peningkatan Kinerja DSC Berbasis ZnO yang Dihasilkan dengan Metode Semprot. Makalah ini membahas efek $TiCl_4$ pada kinerja DSC berbasis ZnO. ZnO dimanfaatkan karena stabilitasnya ketika berhadapan dengan korosi-cahaya (*photo-corrosion*) dan elemen-elemen fotokimiawi yang serupa dengan TiO_2. Saput-saput tipis ZnO nanokristalin ditumpuk pada kaca oksida-konduksi transparan menggunakan metode semprot. Saput-saput ZnO itu diproses dengan $TiCl_4$. Terbukti bahwa sel-sel itu memiliki efisiensi sebesar 2,5% dengan proses akhir $TiCl_4$ dan 1,9% tanpa proses akhir $TiCl_4$.

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 TiO_2 (3.2eV) [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 TiO_2 nanoparticles in the dye-sensitized solar cell (DSC) applications, even though in general the effectiveness of the oxide layer of TiO_2 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 lowerdye adsorption on the ZnO surface than on the TiO_2 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 $TiCl_4$.

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 (CH_3COOH) and 8 drops of triton x-100($C_{14}H_{22}O(C_2H_4O)_n$). 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 $^{\circ}$C. The method formed the ZnO films with thickness of around 14μm. Finally, the films were annealed at 300 $^{\circ}$C for 1 h.

$TiCl_4$ treatment. In this report, we tried to apply a $TiCl_4$ treatment on the ZnO surface. The solution was made by mixing 0.548 ml of $TiCl_4$ with 100 ml of water. The solution was stirred for 15 min. The ZnO films were then dipped into the $TiCl_4$ solution for 30 min. The solution's temperature was maintained at 70 $^{\circ}$C. The films were then rinsed with deionized water and annealed at 500 $^{\circ}$C for 1 h to remove any residual organics and to improve the crystallinity.

DSC preparation. Platinum (Pt) coated glass were used as counter electrode. The ZnO film was dipped into

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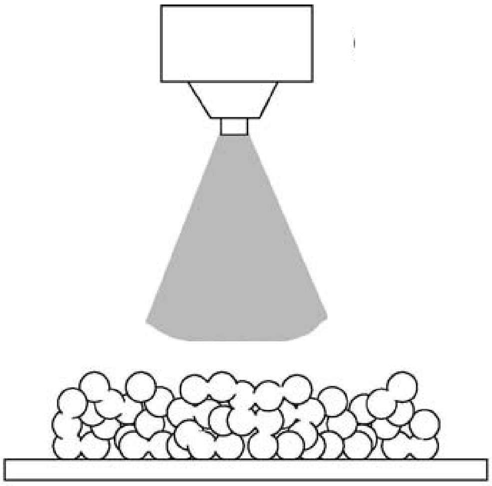

Fig.1. Spraying Method

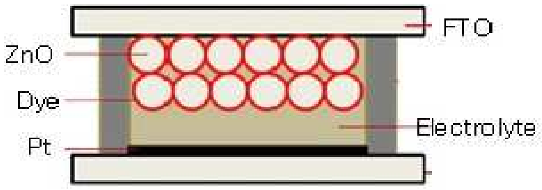

Fig. 2. DSC Structure

ruthenium dye (N719) solution for 24 h. DMPII based liquid electrolyte was used in the present experiment. This electrolyte contained 0.85 ml of acetonenitrile, 0.1 M LiI, 0.6 M of 1,2-dimethyl-3-propylimidazolium iodide, 0.5 M of 4-tert-butylpyridine, 0.1 M of guanidine thiocyanate, 0.5 ml of valeronitrile and 0.05 M of I_2. The cell was assembled according to Fig. 2

Characterization. I-V characteristics of the prepared DSCs were measured by using the solar simulator (CEP-25 BX, JASCO). The measurement was done under 1.5 AM. The thickness of the film was measured using the surface profiler (DEKTAK 3).

3. Results and Discussion

Figure3 shows the I-V characteristics of ZnO based DSCs without and with the $TiCl_4$ treatment. It is found from the measurement that the $TiCl_4$ 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

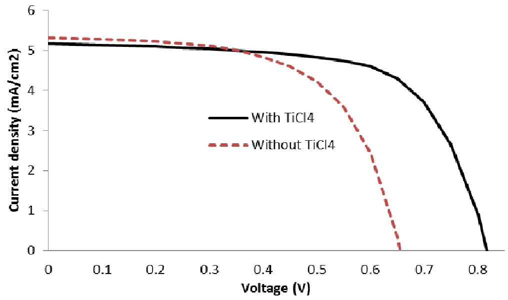

Fig.3. I-V Measurement of ZnO based DSC with and without $TiCl_4$ Treatment

open-circuit voltage through a reduction of the charge recombinations with the $TiCl_4$ 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 $TiCl_4$ post-treatment on each nanostructure form will be investigated on the next research.

4. Conclusions

It is revealed that the $TiCl_4$ 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.

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