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Thin Film ZnO Coated on FTO/TiO_2 as an Anti Reflection Coatingfor EnhancingVisible Light Harversting in Dye Sensitized Solar Cells System

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Abstract

ZnOmaterial has unique electrical and optical properties that many important applications, including as an anti-reflection coating in dye sensitized solar cells. Flat anti-reflective coatings (ARC) made of ZnO on top to improve the optical properties of the coating.In this study, ZnO nanoparticle were coated with TiO_2 nanolayers by a simple wet chemical route. TiO_2 nanorods coated ZnO nanoparticle was synthesized by two step i.e. (1) base hydrolysis and polymerization of TiO_2 (2) ZnO nanoparticle were coated with a TiO_2 layer. The TiO_2 coated ZnO prepared was characterized by X-ray diffraction (XRD), Reflectance spectroscopy, SEM and TEM. ZnO annealed at a temperature of 400^{o}C have the greatest crystal size than annealedat a temperature of 500°C and 600°C. While, the Reflectance (%R)properties shows that the higher annealing temperature of ZnO preparations, the higher of %R value of ZnO thin layer.The ZnO prepared by annealed at 400^{o}Cgain a good performance of the lowest reflectance value. The difference properties are due to differences of light scattering resulting from the crystal size effect.The crystals size that have a good performance as an anti-reflection is around 20 nm, result study of ZnOannealed at 400°C. TEM nanograph shows that the synthesized ZnO have spherical morphology. The optimum performance ofDSSCs was conducted using the photoanode ZnO-coated TiO_2at present 10%APTMS as surface modifier anchor dye group. Bythe addition of ARC we have been capable improve cell performance so that cells achieve an efficiency of 1.13%.

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1. Introduction

As another photocatalyst, ZnO has unique electrical and optical properties that many important applications, such as for transparent conducting films, waveguides, the ultraviolet laser, solar cells, photocatalysts, and varistors[1]. It has played an important role as a semiconductor for the photoelectrochemical cell because its photocatalytic performance has been shown to be similar to that TiO_2[2]. ZnO has a similar bandgap to that of TiO_2approximately 3.2 eV.It is expected to exhibit similar photocatalyst capacity to that of TiO_2, provided that this property is largely dependent on the energy level of CB and VB. Therefore, it has been comparatively studied with TiO_2 in terms of its photocatalytic performance.ZnO electron mobility at about 2000 $cm^2/(Vs)$ while the hole mobility is a relatively low range of 5-30 $cm^2/(Vs)$. Most of ZnO has the characteristics of n -type semiconductor, even without the presence of dopant. This is because of the natural crystal defects such as oxygen excess ZnO, and interstitial atom of Zinc. The basic properties of ZnO support applications in thin film technology such as the use of ZnO as a thin film solar cell.The efficiency of DSSC based on ZnO material, which is still low is not known clearly, but some research has shown that this may be due to the stability of the oxide surface and surface density. ZnO crystallizes in the Wurtzite structure which does not have a center of inversion. A possible mechanism for the stability of these systems is a rearrangement of the electronic structure resulting in an effective charge transfer between the polar surfaces removing the macroscopic field which would otherwise be present. Besides control of process parameters such as dyes, pH, and a sensitizer also affects the efficiency of DSSC based on ZnO[3].

The main drawback of particulate ZnO in an aqueous environment is, however, its chemical instability:

$$ZnO + 2H^+_{aq} \rightarrow Zn^{2+} + H_2O \quad (1)$$

$$ZnO + H_2O \rightarrow Zn(OH)_2 \quad (2)$$

Hence, the pH range in which ZnO is found to be stable is very limited.

ZnO nanoparticles better in excitonic recombination. The freeexciton can easily ionize by the scattering of longitudinal optical photons. The strength of these phonons can be reduced along with the size reduction of ZnO. ZnO is able to absorb powerful photons with energies greater than the band gap energy[4].

Flat anti-reflective coatings (ARC) made of ZnO on top to improve the optical properties of the coating. A thickness of 30 nm has been considered for the ITO layer in the case of a hybrid coating. Reducing the ITO thickness down to 30nm, compared to a more standard value around 50-70 nm, yields a lower useless absorption in the TCO layer. This reduction is made possible in the case of our hybrid design, since the top ZnO layer will also contribute to the lateral conduction of electrical charges.

In this study, ZnO nanoparticle was coated with TiO_2 nanolayers by a simple wet chemical route. In order to gain high-efficiency DSSCs, the inorganic semiconductor particle should be small and highly distributed uniformly with a spherical particle morphology. TiO_2 nanorods coated ZnO nanoparticle were synthesized by two-step i.e. (1) base hydrolysis and polymerization of TiO_2 (2) ZnO nanoparticle were coated with TiO_2 layer. The TiO_2 coated ZnO prepared was characterized by means of X-ray diffraction (XRD), Reflectance spectroscopy, SEM and TEM.

2. Method and Characterization

2.1 Synthesis of TiO_2 NRs –ZnO

Treated TiO_2 ball mill was refluxed under NaOH solution of 8, 10, and 12M for 24 hours. Then the mixture was filtered and neutralized to pH 7 using 0.1 M HCl to obtain a solid after dried at 60°C for 12 hours. While, the ZnO nanoparticles synthesized from the precursor $ZnSO_4.7H_2O$ and NaOH at a mole ratio of 1: 2 in ethanol. Those mixtures were refluxed for 2 hours at 60°C. Then the solids obtained dried at a temperature of 60 – 70°C. Composites of TiO_2 NRs - ZnO were prepared at ratio of TiO_2 NRs:ZnO = 1: 1, 1: 2 and 2: 1 (w/w) in ethanol. Then, it was stirred for 10 minutes at room temperature. TiO_2 NR_S-ZnO composites were annealed at a temperature of 400°C. Material characterization was done by XRD, Reflectance spectroscopy, SEM and TEM.