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Deposition of TiO_2 Blocking layers of Photovoltaic cell Using RF Magnetron Sputtering technology

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Abstract

Dye-sensitized solar cells (DSCs) have used transparent conductive Fluorine-doped SnO_2 (FTO) glass/porous TiO_2 layer attached using dye molecules/electrolytes (I-/I_3-)/Pt-coated FTO glass configuration. In this work, prior to the coating of nanoporous TiO_2 layer on FTO glass, a dense layer of TiO_2 less than ~100nm in thickness as an electron blocking layer was deposited directly onto the FTO using radio frequency (RF) magnetron sputtering technology. Under 100 mW/cm^2 illumination at AM 1.5, the energy conversion efficiency (η) of the prepared DSC with electron blocking layer of 60nm thickness was 6.77% (V_{oc} = 0.715 V, J_{sc} = 12.932 mA/cm^2, ff = 0.74), which is increased by 1.27% compared to the general cell without electron blocking layer.

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Keywords: Blocking layer, Dye-sensitized solar cells, RF magnetron sputtering, Nanoporous films, TiO_2

1. Introduction

Dye-sensitized solar cells (DSCs) have been intensively studied since the discovery of them in 1991 [1]. There is currently considerable interest in DSCs for use in a new generation of energy harvesting devices due to the simple structure and process, low cost fabrication, transparency, color control, and applicability in flexible DSCs [2-4]. DSCs consist of a wide bandgap nanoporous metal oxide film such as TiO_2 deposited on a conductive oxide layer as an electron transport layer. Nanoporous TiO_2 is commonly used in DSCs to embed a high density of dye molecules onto the TiO_2 surface to hence enhance the photo-absorption process. A photoanode of general DSC is composed of a dye-attached nanoporous TiO_2 film coated on a transparent conductive Fluorine-doped SnO_2 (FTO) glass. The large number of dye molecules encasing the large surface area of TiO_2 nanoparticles enables efficient light

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harvesting. However, electron/charge transport has a limiting factor in the performance of the electron collecting layer of nanoparticles. The interface between the FTO glass and TiO_2 nanoparticles is almost exposed to the electrolyte due to the porous structure of the TiO_2 layer. The leakage by electron back transfer takes place from the FTO layer to the electrolyte, and thus leads to a decrease in cell efficiency. An electron blocking layer on the FTO electrode in DSCs can be adapted for minimizing the electron leakage [4, 5]. However, the optimum condition of the electron blocking layer required for high cell efficiency was not fully clarified.

In this work, prior to the coating of nanoporous TiO_2 film on FTO glass electrode, a dense TiO_2 film less than ~100nm in thickness as an electron blocking layer was deposited by RF magnetron sputtering onto the FTO to be isolated from the electrolyte. The photovoltaic characteristics of the fabricated DSCs with various blocking layer thickness were investigated experimentally. The discussion was focused on the relationship between blocking layer condition and cell efficiency obtained by analyzing the photoelectric conversion efficiency and electrochemical impedance measurements.

2. Experimental

2.1. Preparation of TiO_2 blocking layers

Figure 1 shows a schematic illustration of RF magnetron sputtering apparatus. A TiO_2 layer as a blocking layer was deposited on a FTO glass by RF magnetron sputtering following the reported method [6]. The TiO_2 thin films were deposited onto FTO glass in Ar gas pressure of 3 mTorr at the substrate temperature of 300˚C. RF power between the target and substrate was maintained at 250 W. The distance between substrate and target surfaces was 100 mm. The deposition condition of TiO_2 films with various thicknesses by RF magnetron sputtering different deposition time ranging from 5 to 20 minutes. The thickness of the TiO_2 layer was ranging from 20 to 80 nm.

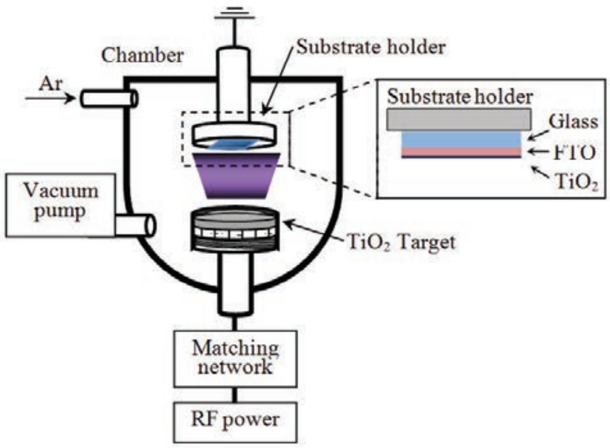

Fig.1. Schematic diagram of RF magnetron sputter system.

The microstructure and thickness of the TiO_2 thin film were observed by field emission scanning electron microscope (FE-SEM; Hitachi, S-4300). Energy Dispersive x-ray Spectroscopy (EDS) and X-ray photoelectron spectroscopy (XPS) were used to investigate the chemistry of the deposited TiO_2 layer.

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