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Nano-Embedded High Performance Non-Toxic Solar Cell

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ABSTRACT

Dye-sensitized solar cell (DSSC) is a new type of solar cell that is environmentally friendly and proven clean that can bring advantages for photovoltaic technology development. The optimization of photoanode layer is fundamental for conversion of visible light-irradiation into electricity in DSSC device. In this investigation, nanoflowers structure of TiO_2-Ag embedded with $SrSnO_3$ is employed as a photoanode layer of DSSC by using hydrothermal technique and RF sputtering to create a larger surface area for anchoring dye.

Keywords: *DSSC; TiO_2; Hydrothermal*

Introduction

Solar energy is one of the readily available renewable energy sources for electric conversion from light irradiation. Until now, dye-sensitized solar cell (DSSC) still an on-going third-generation solar cell development in discovering optimum properties for DSSC fabrication. This is due to the friendly eco-system and the flexibility of DSSC structured compared to the conventional solar cell (1-3). DSSC is principally as and which type photoelectrochemical cell with two electrodes of photoanode and counter electrode imbedded on transparent conductive substrate. Other than that, DSSC also composed of dye-sensitizer and an electrolyte layer. Dye-sensitized solar cell (DSSC) is among line of solar cell evolution.

The essence component of DSSC is photoanode electrode layer as it is providing surface area for dye adsorption of photon incident. Most prominent material used for photoanode layer is Titanium Dioxide, TiO_2 due to the core criteria of non-toxicity material and possess highly photocatalytic behaviour (1, 4). However, physicochemical characteristic of TiO_2 based photoanode often shows discouraging performance improvement. With the advancement of nanomaterials structure, the five-layer of DSSC architecture can be modified with refinement fabrication strategies such as noble metal ion doping (1. 5, 6) and implementing noble metal with various fabrication method of multilayer material. In this present study, we synthesized pure TiO_2 nanoflower and Ag-TiO_2 nanoflower by hydrothermal method with SrSnO3 embedded using RF sputtering. Both samples were characterized by XRD, FESEM, EDX and Solar Simulator (AM1.5G) analysis.

Material and Methods

The flourine-doped oxide (FTO) glass was cut into 1.0 cm (L) X 0.5 cm (W) and clean with Deionized (DI) water, Acetone and Ethanol. The nanoflower TiO_2 was growth using titanium (IV) butoxide (TBOT) and $AgNO_3$ (QRëC,USA) in hydrothermal solution for 10 hours. $SrSnO_3$ was embedded using RF sputtering with 100W for 10 minutes. Veloronitrile, Butyl Pyridine (TBP), Iodolyte AN50, DMPII and Guanidine Thiocyanate (GT) were used as precursor of an electrolyte. N719 (Ruthenizer 535-bis TBA), (Solaranix, Switzerland) was used as dye-sensitizer solution. The successfully fabricated photoanode substrate was immersed in prepared dye solution for 24 hours before assembled as a solar cell module.

Results and Discussion

Both samples were categorized as Table 1. S1 is a pure sample of TiO_2 nanoflower while S2 is sample of TiO_2 NF doped with 0.25 wt% Ag and have been sputtered with $SrSnO_3$.

Table 1. Sample Details

Sample	Details
S1	Pure TiO_2 Nanoflower (NF)
S2	0.25 wt% Ag-TiO_2 NF

The crystal structure of S1 and S2 samples were compared using XRD diffractogram shown in Fig.1. It can be observed that the characteristic of TiO_2 in both samples were tetragonal rutile phase (ICSD 98-0039167) and (ICSD 98-008-1123). High-intensity peaks were confirmed at scattering angles of 2θ = 27.29°, 36.15°, 41.23°, 54.23°, 56.45°, 62.91°, and 69.13° corresponded to Bragg planes of (110), (101), (111), (211), (220), (002) and (112) respectively. Srontium, Sr were slightly found at (112) and (421) crystallographic plane. From XRD analysis of sample S2, no diffraction peak of silver (Ag) dopant is found because Ag doped is not covalently anchored into the crystal lattice of rutile TiO_2, it is merely well dispersed at interfacial TiO2 surface.

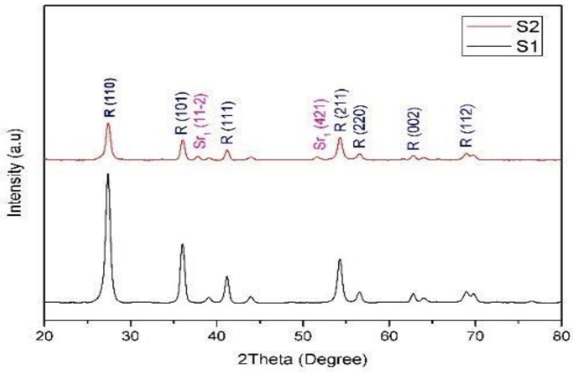

Fig. 1. XRD Analysis

The observation morphology of nanoflower growth on TiO_2 substrate were confirmed using JSM7600F FESEM (JOEL, Tokyo, Japan). It can be observed that there was different surface structure between S1 and S2. The bunch of nanorod petal in S1 look more smoother than S2. Roughness surface is advantageous for DSSC as it can prompt oxidation active surface of the tip petal of nanoflower. Nanoflower morphology also can enhance more surface area for dye loading and scattering effect where reducing reflected out of photon at the interfacial TiO_2 surface.

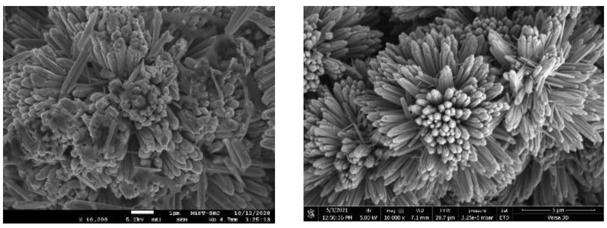

Fig. 2. (a) Pure TiO2 NF (b) 0.25 wt% Ag-TiO_2 NF sputtered with $SrSnO_3$

To strengthen the observation of XRD and FESEM analysis, Energy Dispersive X-ray Spectroscopy (EDX) was performed to validate the elemental composition as Table 2.

Table 2. EDX Analysis

S1		S2	
Element	**Atomic%**	**Element**	**Atomic%**
O K	80.200	O K	62.880
Ti K	15.090	Ti K	36.760
		Sr K	0.040
		Sn K	0.310

Performance of DSSC module was inferred by Newport Oriel solar simulator (AM1.5G) measurement with Keithley 2400 under xenon lamp radiation as Table 3. Efficiency, ŋ% of S2 is higher than S1. SrSnO3 embedded on Ag-TiO_2 is influenced the current density of DSSC. This is attributed to the increment of electron injection from excited dye to the conduction band of TiO_2. Other than that, Ag material able to stimulate electrical conductivity on TiO_2 surface (6).

Table 3. Solar Simulator AM1.5G Analysis

Voc, Jsc	**Fill Sample (V)**	**(mA/cm2)**	**Isc, (A)**	**Factor**	**Ŋ %**
S1	0.632	3.000	2.407	0.450	0.590
S2	0.669	3.230	0.002	58.080	1.250

Conclusions

Pure TiO_2 and 0.25 wt% Ag-TiO_2 embedded with $SrSnO_3$ were successfully fabricated on photoanode substrate of DSSC. TiO_2 NF sample with nano-embedded shown higher performance than pure TiO_2 NF due to enhancement of electron injection. Hence, this study successfully reveals that improvement of DSSC performance with deposition of nanomaterial.

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