Improvement of Dye-Sensitized Solar Cells Performance using TiO_2 Nanoparticle/Nanorod Composite Photoanode

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Abstract

We successfully fabricated the TiO_2 Nanoparticle/Nanorod composite photoanode to improve the power conversion efficiency of dye-sensitized solar cells(DSSCs). The TiO_2 nanorods were synthesized using a mechanical process, in which electrospun TiO_2 nanofibers was grinded in a controlled way to obtain uniform size distribution. The conversion efficiency of the NR composite device was enhanced up to 30% compared with the pristine TiO_2 photoanode. The results demonstrate that the composite nanostructure can take advantage of both the fast electron transport of the nanorods and the high surface area of the nanoparticles
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Results and Discussion

Table. 1 shows open circuit voltage(V_{oc}), short-circuit current (J_{sc}), fill factor(FF), and energy conversion efficiency(η) of each DSSCs, which were calculated from J-V curves. According to table 1, the DSSC made using the composite with 5wt% NR achieved an energy conversion efficiency(η) of 6.1%. In comparison, the DSSC made using the TiO_2 NPs had J_{sc} and η values of 13.2 $mAcm^{-2}$ and 4.7%, respectively, for the same photoanode thickness (~ 13 μm). The efficiency increases about 30%, it can be explained that the increase of J_{sc} from 13.2 to 16.1mA/cm^2. By adding 5wt% NR, this remarkable improvement of the J_{sc} is probably due to both the light scattering caused by the NRs and good dye uptake.

The incident photon to current conversion efficiency (IPCE) spectra of the NR0 and NP/NR with NR contents of 1, 3, 5, 10 wt% are shown in Fig. 2. The maximum efficiency at the 530 nm wavelength coincides with the maximum absorption wavelength of the N719 dye. In the entire wavelength region, NP/NR reveals higher external quantum efficiency (EQE) than NR0, which is compatible with the J_{sc} value obtained by photocurrent-voltage measurement. The IPCE peak height at 530 nm for the NP/NR5 electrode with 5 wt% NR is 70.6%, which is much higher than the value of 68.3% obtained for NR0 without NR composite, and 67% for the NP/NR10 electrode with 10 wt% NR. In order to estimate the light scattering effect, the NP/NR composite electrode showed higher EQE in the long wavelength region around 600 ~ 700 nm, suggesting that the NP/NR composite electrode provides an appreciable scattering effect. The IPCE peak at 630 nm for the NP/NR5 electrode with 5 wt% NR is 51.3%, which is much higher than the value of 32.71% obtained for NR0 without NR. The stronger scattering increased light absorption by up to 57%.

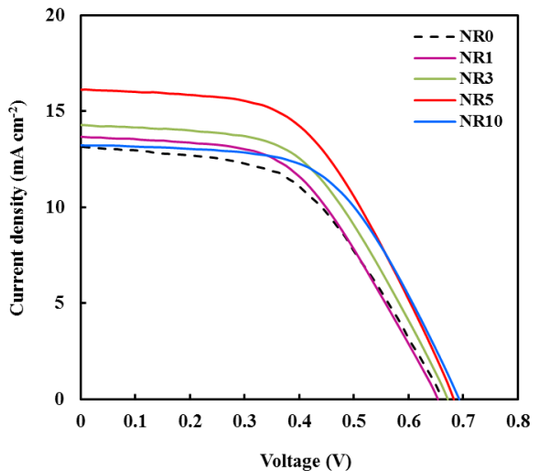

Fig.1 *J-V* curves of the analyzed DSSCs using different anode electrodes.

Table. 1 Photovoltaic performance of the DSSCs with photoanodes containing various percentages of nanorods.[a]

Photoanodes (2NP/x)	V_{oc} (V)	Jsc (mA/ cm^2)	FF	η (%)
NR0	0.66	13.2	0.51	4.7
NR1	0.66	13.7	0.52	4.9
NR3	0.67	14.3	0.53	5.3
NR5	0.68	16.1	0.52	6.1
NR10	0.69	13.2	0.54	5.4

[a] mesasured with effective incident area of 0.25 cm^2 under AM 1.5 100 mW/cm^2 simulated sunlight irradiation.

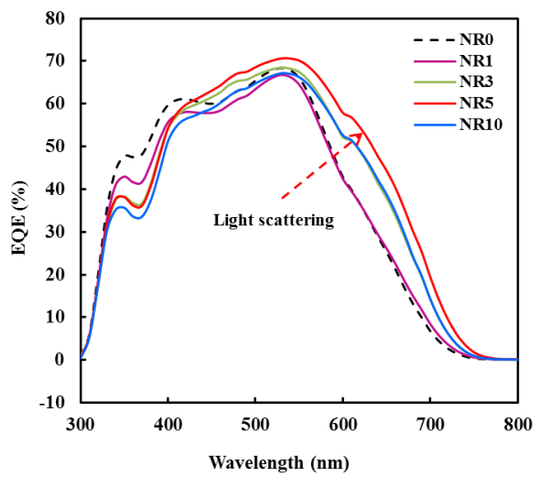

Fig. 2 Incident proton to current conversion efficiency (IPCE) curves for the DSSCs fabricated from NR/NP samples with NR percentages of 0, 1, 3, 5, and 10 wt%.

Reference

1. Grätzel M. Perspectives for dye-sensitized nanocrystalline solar cells. *Prog Photovolt Res Appl* 2000, 8:171-85.
2. Hong CK, Ko HS, Han EM, Yun JJ, Park KH. Enhanced efficiency of dye-sensitized solar cells doped with green phosphors $LaPO_4$:Ce, Tb or (Mg, Zn)$Al_{11}O_{19}$:Eu. *Nanoscale Research Letters* 2013, 8:219.

Acknowledgments

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