Sealed dye-sensitized solar cells based on ZnO and ZnO:Ga porous nanostructured electrode.

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Introdução

Dye-sensitized solar cells (DSSCs) are typically based on thick nanostructured films of TiO_2, SnO_2, or ZnO sintered to yield a mesoporous network endowed with a huge internal surface area able to absorb most of the light-harvesting dye molecules. Even though ZnO and TiO_2 have similar band positions, DSSCs based on the former present lower efficiencies and the reason is still a topic of current research[1]. ZnO has received recently great attention in DSSCs as a core-shell material and since it can be grown anisotropically it is possible to assemble DSSCs based on nanowires, which might improve electron transport. In this work we report on gallium-doped ZnO (ZnO:Ga) in order to enhance electron transport and this way the DSSCs performance.

Resultados e Discussão

ZnO and ZnO:Ga nanoparticles were prepared in an aqueous solution of zinc nitrate and/or gallium in the presence of triethanolamine[2]. A commercial source of ZnO (Wako, 95%, particle size 20 nm) was used for the sake of comparison. The porous films were sensitized in ethanolic solution 0.5 mM of the complex $RuL_2(NCS)_2$:2 TBA, in which L stands for the ligand 4,4'-dicarboxy-2,2'-bipyridine and TBA for tetrabutylammonium, during 3h. The liquid electrolyte was composed of 0.5M 4-*tert*-butylpyridine, 0.8M tetrabutylammonium iodide, 0.1M LiI, 0.05M I_2 in methoxypropionitrile:acetonitrile (50:50 v/v). The counter electrode was a Pt-sputtered conductive glass substrate (Asahi Glass, fluorine-doped SnO_2). Film thickness was 6 µm, measured by a profiler (Dektak3). The cells were sealed by Himilan (Mitsui-Dupont Polychemicals). The porosity, surface area and pore size distribution were estimated by the BET method based on nitrogen adsorption isotherm (Quantachrome, Autosorb-1) after scratching the film off the substrate. Current-voltage (*J-V*) curves were carried out under the irradiance of 100 $mWcm^{-2}$ (AM 1.5) using a simulated light source. The incident photon to current conversion efficiency (IPCE) was measured using a commercial setup (PV-25DYE, JASCO). The electrode morphology was observed by field emission scanning electron microscopy (SEM, JSM-6700FE, JEOL). Table 1 summarizes the *J-V* features along with the porosity data.

Table 1. *J-V* features of DSSCs based on ZnO ZnO:Ga under 100 $mWcm^{-2}$ and porosity data.

DSSC	J_{sc} ($mAcm^{-2}$)	V_{oc} (V)	FF	η (%)	Porosity
ZnO (Wako)	5.72	0.80	0.36	1.63	0.68
ZnO	1.81	0.85	0.44	0.68	0.16
ZnO:Ga 1%	6.51	0.80	0.33	1.72	0.39
ZnO:Ga 3%	5.82	0.76	0.38	1.85	0.55
ZnO:Ga 5%	6.40	0.76	0.38	1.88	0.58

The presence of gallium ions gave rise to a higher porosity, evidenced also by the SEM images due to the smaller particle size of ZnO:Ga samples. Despite the high V_{oc} values, the low values of FF and J_{sc} reported here might be due to a poor dye uptake. It is believed that the dye adsorbs mainly at the outermost layer of the porous electrode, which explains the poor J_{sc}, FF and IPCE values. However, in all cases the ZnO:Ga electrodes provided a higher performance than both ZnO samples studied here, partly due to the smaller size of ZnO:Ga samples. It is also observed that V_{oc} decreases from ZnO to ZnO:Ga in view of a higher trap density (ZnO:Ga samples have a higher surface area).

Conclusões

ZnO:Ga-based DSSCs provided a better performance than both ZnO DSSCs studied here, partly due to the smaller particle size of ZnO:Ga samples and their higher porosity (higher dye uptake).

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