Stepped light-induced transient measurements of photocurrent and voltage in sealed dye-sensitized solar cells based on ZnO and ZnO:Ga.

Agnaldo S. Goncalves[1,*] (PG), Marian R. Davolos[1] (PQ), Ana F. Nogueira[2] (PQ), Naruhiko Masaki[3] (PG), Shogo Mori[4] (PQ), Shozo Yanagida[3] (PQ). [*] agnaldo@iq.unesp.br

1. *Instituto de Quimica – UNESP, 14800-900, Araraquara/SP, Brazil*
2. *Instituto de Quimica – UNICAMP, 13083-970, Campinas/SP, Brazil*
3. *Center for Advanced Science and Innovation, Osaka University, 565-0871, Osaka, Japan*
4. *Department of Fine Materials Engineering, Shinshu University, Ueda, 386-8567, Japan.*

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Introdução

Dye-sensitized solar cells (DSSCs) have received great attention all over the world in the last decades due to their respectable efficiency and low cost. These cells are based on dye-adsorbed nanoporous semiconductor electrode soaked in an electrolyte, sandwiched by a Pt counter electrode. After light absorption by the dye, electron injection into the conduction band of the semiconductor takes place. The electrons then diffuse into the semiconductor and are finally collected by the TCO. Even though much information is available on electron diffusion coefficient (D) and electron lifetime (τ) for electrodes based on TiO_2, little is known about ZnO. The aim of this work is to measure D and τ for sealed DSSC based on ZnO and ZnO:Ga 1, 3 and 5 at.% by stepped light-induced transient measurements of photocurrent and voltage (SLIM-PCV).

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[1]. The porous films were sensitized in an ethanolic solution 0.5 mM of the complex $RuL_2(NCS)_2$: 2 TBA, where L is the ligand 4,4'-dicarboxy-2,2'-bipyridine and TBA for tetrabutylammonium, during 3h. The electrolyte was 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 TCO (Asahi, SnO_2:F). The cells were sealed by Himilan (Mitsui-Dupont Polychemicals). Film thickness was 6 µm and typical cell areas were 0.2 cm^2. For SLIM-PCV measurements, a diode laser (Coherent, LabLaser, λ = 635 nm) was used for both photocurrent and voltage transients[2]. Figure 1 shows the behavior of D and τ observed under increasing gallium content. D decreases almost to half the value measured for ZnO in DSSCs based on ZnO:Ga, probably due to a higher trap density in ZnO:Ga electrodes since they have a higher surface area than the ZnO electrode. Since electrons spend more time in traps, D becomes smaller. However, a smaller dye loading in the ZnO electrode compared to ZnO:Ga might also play a role.

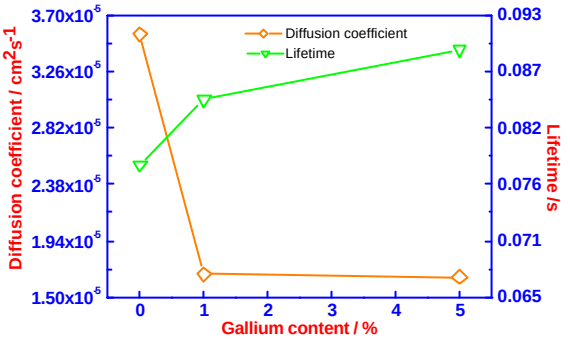

Figure 1. D and τ behavior against gallium content in ZnO and ZnO:Ga-based DSSCs measured by SLIM-PCV.

The electron density increased almost linearly from ZnO to ZnO:Ga 5 at.% which is an evidence that gallium ions contribute electrons to the ZnO conduction band. This is exactly what should be expected, since Ga^{3+} will give rise to shallow trap sites in ZnO. In all DSSCs studied the calculated electron diffusion lengths were greater than film thickness, which means that most of the photogenerated carriers would be collected.

Conclusões

The electron diffusion coefficients and lifetimes reported here are in the same range to the ones reported for ZnO and TiO_2 measured by other techniques. The smaller D in ZnO:Ga-based DSSCs might be related to a higher trap density. The electron density increased almost linearly under increasing gallium level, as expected since Ga^{3+} gives rise to shallow trap sites in ZnO.

Agradecimentos

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