Optimized integration of one-dimensional photonic crystals in dye solar cells

Carmen López-López,
Silvia Colodrero and Hernán Míguez

Instituto de Ciencia de Materiales de Sevilla, Consejo Superior de Investigaciones Científicas-Universidad de Sevilla, Américo Vespucio 49, 41092, Sevilla, Spain

carmen@icmse.csic.es

Dye solar cells (DSC) are photovoltaic devices in which the absorption of sunlight is realized by dye molecules attached to the surface of a titanium dioxide (TiO_2) electrode. In order to improve the light harvesting by the dye the optical design of these cells can be modify. It was already demonstrate that coupling nanoparticle one dimensional photonic crystal (1DPC) [1,2], which efficiently localize the incident light within the absorbing electrode in a targeted wavelength range, gave rise to increase of the power conversion efficiency of the cell. Such 1DPC showed no diffuse scattering, which allowed one to attain, for the first time, devices of enhanced efficiency while preserving the transparency. But the low photocurrent enhancement compared with theoretical predictions [3] and the fact that the fill factor of the cells decrease with the presence of these multilayers indicated that there may be an electrolyte diffusing problems.

New highly porous nanoparticle-based 1DPC [4] are attached to the working electrode. New porosity of these structures are the result of the incorporation of a polymeric porogen to the multilayer while being deposited and its subsequent removal by thermal annealing. In this way, not only the porosity is increase but also the pore size distribution is wider, thus the mass transport through the crystal is improved. Higher power conversion efficiency is obtained from the cells in which highly porous 1DPC are implemented [5].

References

[1] S. Colodrero, M. Ocaña, H. Míguez, Langmuir, 24 (2008) 4430.
[2] S. Colodrero, A. Mihi, L. Häggman, M. Ocaña, G. Boschloo, A. Hagfeldt, H. Míguez, Adv. Mater. 21 (2009) 764.
[3] G. Lozano, S. Colodrero, O. Caulier, M.E. Calvo, H. Míguez, J. Phys. Chem. C 114 (2010) 3681.
[4] C. López-López, S. Colodrero, S.R. Raga, H. Lindström, F. Fabregat-Santiago, J. Bisquert, H. Míguez, J. Mater. Chem., 22 (2012) 1751.
[5] S. Colodrero, A. Forneli, C. López-López, L. Pelleja, H. Míguez, E. Palomares, Adv. Funct. Mater. 22 (2012) 1303.

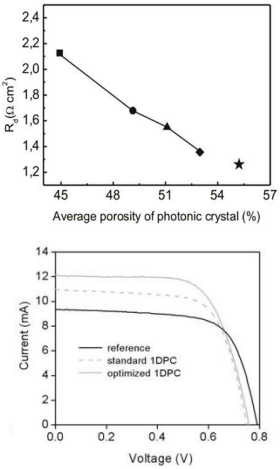

Figure 1: On the top diffusion resistance of nanoparticle based 1DPC built with different quantity of polymer porogen. At the bottom IV curves measured for DSSCs in which a non-modified 1DPC (grey dashed line), a highly porous 1DPC (grey solid line), and a reference cell (black solid line).