Vertically-aligned Semiconductor Oxides for Dye sensitized solar cells

Irene Gonzalez-Valls[a], Lola Gonzalez-Garcia[b], Belén Ballesteros[a], Frank Güell[c], Angel Barranco[b], Youhai Yu, Agustín R. Gonzalez-Elipe[b] and Mónica Lira-Cantu[a*]

a, Centre d'Investigació en Nanociència i Nanotecnologia, Campus UAB, Edifici ETSE, Bellaterra (SPAIN), 08193.
b, Instituto de Ciencia de Materiales de Sevilla (CSIC-Univ. Sevilla), Avda. Americo Vespucio 49, 41092 Sevilla, Spain.
c, M-2E, IN2UB, Departament d'Electrònica, Universitat de Barcelona, *C/Martí I Franquès 1. Barcelona (SPAIN), 08028.*
monica.lira@cin2.es

Vertycal-aligned oxide nanostructures are interesting semiconductors for their electronic properties, they are thought to improve contact between the donor and acceptor material in organic solar cells (OSCs), or improve electron injection in Dye sensitized solar cells (DSCs) [1-5]. In this work we present the application of different aligned semiconductor oxides, like TiO_2 and ZnO, in Dye sensitized solar cells (DSC). The efficiency of DSC applying vertically-aligned ZnO nanorods (NRs) is still lower than DSCs with hierarchical ZnO nanoplates, nanosheets, disk-like nanostructures or aggregates that can achieve more than 6% efficiency [6]. In an effort to understand the factors that limit power conversion efficiency, we report in this work a slight modification of the hydrothermal synthesis technique for the obtention of vertically-aligned ZnO NRs. Our initial results show that, for the same NR growth time, shorter NR length but higher power conversion efficiencies are obtained with the modified method (Figure 1). For example, the same solar cell efficiency can be obtained for a 5 µm ZnO NR thickness obtained by the hydrothermal method and for 1 µm thick ZnO NR electrode applying the new method. The latter is attributed to the higher dye loading capacity of the ZnO NRs obtained with the modified synthesis methodology. Our work also encompasses the synthesis of transparent thin film electrodes made of vertically aligned nanocolumns of TiO_2 with well-controlled oblique angles. These electrodes were grown by physical vapor deposition at glancing incidence (PVD-GLAD). For an electrode thickness of 500 nm, we report a 40% variation on solar cell efficiency (from 0.6% to 1.04%) when the deposition angle was modified between 60º and 85º. Transparent thicker films with higher surface area deposited at the optimal angle of 70º were grown with a zigzag morphology which confers high mechanical strength to the thin films. Using this topology, the application of an electrode thickness of 3 µm in a DSC resulted in a power conversion efficiency of 2.78% maintaining electrode transparency [7].

References

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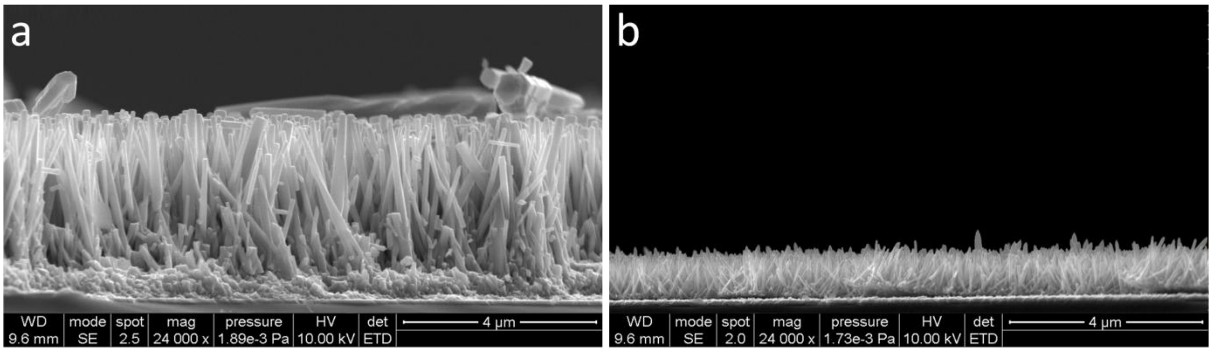
Figures 1



SEM pictures of the vertically-aligned ZnO nanorods grown for 12h by: a) standard hydrothermal synthesis and b) new synthesis.