Application of CdS nanostructured layers in dye-sensitized solar cells: Effect of the layer morphology and sensitizer on photovoltaic performance

O.P. Dimitriev[1], D.O. Grynko[1], O.M. Fedoryak[1], P.S. Smertenko[1], N. A. Ogurtsov[2], A.A. Pud[2], Yu.V. Noskov[2], R.B. Laghumavarapu[3], D.L. Huffaker[3]

[1]V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, pr. Nauki 41, Kyiv 03028, Ukraine, e-mail: dimitr@isp.kiev.ua
[2]Institute of Bioorganic Chemistry and Petrochemistry, NAS of Ukraine, 50 Kharkivske Shose, Kyiv 02160, Ukraine
[3]University of California Los Angeles, 420 Westwood Plaza, Los Angeles, USA

CdS semiconductor is one of the materials for photovoltaics which has been attracted attention due to its stability, relative cheapness and ability to form thin films and nanocrystals[1]. Use of semiconductor nanowires (NWs) instead of planar films, textured surfaces, or even quantum dot semiconductor nanoparticles is one of the perspective directions to achieve higher performances of hybrid solar cells[2]. Application of semiconductor NW arrays in solar cells has potential advantages, such as better light absorption due to the reduced reflection and light trapping (shadow effect) and better charge collection from the active layer, since charge carriers move straight to the respective electrode through a NW crystal[3]. Hybrid solar cells based on CdS crystals of different morphology, such as single crystals[4], polycrystalline films[5,6], quantum dots[7,8] and NW crystals[9,10] have been investigated in the last decade.

In this work, CdS nanostructured layers of different morphologies, such as nano-textured films, NW arrays and branched core-shell NW structures have been prepared by vapor-liquid-solid (VLS) and vapor-solid (VS) condensation techniques. This contribution is just devoted to demonstration for the first time of applicability of these layers as the prospective acceptor semiconductor basis for formation of hybrid organic-inorganic solar cells. No optimization has been done at this stage. Three types of solar cells have been prepared and compared, namely: (i) CdS – poly(3-hexylthiophene) (P3HT) cells, (ii) CdS - dye sensitized solar cells and (iii) CdS - perovskite sensitized solar cells, with P3HT as the hole-transporting layer in cells (ii) and (iii). It has been found that introduction of a sensitizer in CdS-P3HT structure improves photovoltaic performance of the cells by more than one order of magnitude with the best results obtained in the case of the CdS - perovskite $CH_3NH_3PbI_3$ sensitized solar cells (Fig.1). By changing morphology of the CdS layer from a nano-textured continuous film to a NW array we demonstrate an improved efficiency of collection of charge carriers due to the increased organic-CdS interface area in all types of the cells. Solar cells based on the branched core-shell morphology demonstrated a promising performance as

compared with their planar analogs. Mechanisms of the cell efficiency improvement depending on the cell morphology are discussed.

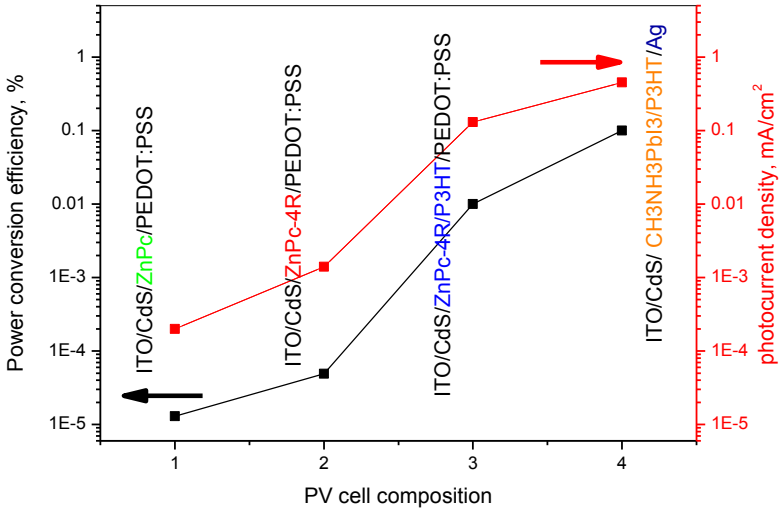

Fig.1. Progress in photovoltaic performance of CdS based solar cells due to selection of sensitizer and structure optimization.

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