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Hybrid and tandem dye sensitized solar cells aiming at high efficiency

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Abstract – Dye-sensitized solar cells consisting of tandem and hybrid structures are reported. It was proved that these new structures have a potential to harvest light with wide range of wavelength and increase open circuit voltage. In addition, modification of charge separation interfaces with organic molecules and dyes are discussed in terms of trap passivations which bring about high efficiency.

Efficiency of dye sensitized solar cells (DSC) [1] has reached 11%. In order to increase the efficiency, we propose 3D DSCs (Figures 1-3) consisting of tandem and hybrid DSCs to cover wide ranges of wavelengths and collect electrons effectively.

1)Improvement of charge collections by surface state passivation of nano-porous TiO_2 layers with dye and organic molecules [2].: We found that surface states of nano-porous TiO_2 layers can be passivated with various organic dye molecules which stained titania surfaces under a pressurized CO_2 condition. This process realized long electron life time, high electron diffusion coefficient and suppression of unfavorable dye aggregations. 10.4 % efficiency is reported.

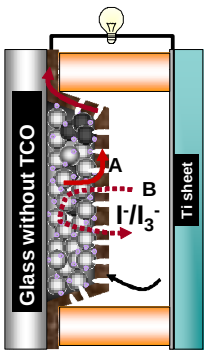

Figure 1. TCO-less-all-metal-DSC having 8% efficiency

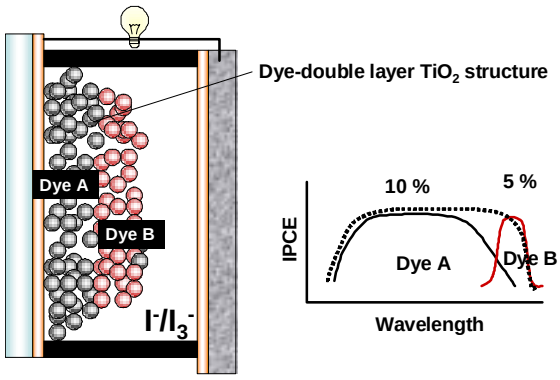

Figure 2. DSC consisting of dye double layer structure

2) Transparent conductive layer less-DSC (TCO-less-DSC). [3,4]: We report two kind of TCO-less-DSCs with all-metal electrodes. One consists of nano-porous Ti electrodes (Fig. 1) and the other consists of a floating electrode. 8% efficiency is reported

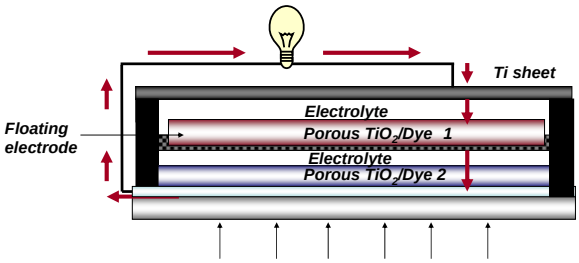

Figure 3. 3D-tandem DSC consisting of floating electrode

3) Hybrid and tandem DSC. DSC consisting of a dye-double layer titania structure (Fig.2), tandem DSCs consisnting of a floating electrode (Fig. 3) and fiber DSCs consisting of hybrid and tandem structures (Fig. 4) are reported. The preliminary results of whether or not they work properly as tandem and hybrid cells are presented.

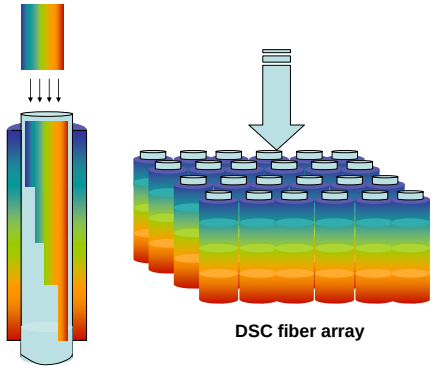

Figure 4 DSC fibers consisting of tandem and hybrid structures

References
[1] B. O'Regan, M. Grätzel, Nature, 353, 737 (1991). [2] Y. Ogomi, S. Hayase, et.al., J.Electrochem. Soc., 153, A2294 (2006). [3] Y. Kashiwa, S. Hayase et al., Appl. Phys. Lett., 92, 033308 (2008). [4] Y. Yoshida, S. Hayase, et. al., Appl. Phys. Lett., 94, 093301 (2009). [5]F. Inakazu, Y. Noma, Y. Ogomi and S. Hayase, Appl. Phys. Lett., 92, 093304 (2008).