**Improved Performance of Dye-sensitized Solar Cells by Hybridization of Nano-sized Metal Oxides**

Akinori Konno,[†] G. R. Asoka Kumara,[†] and Kirthi Tennakone[‡]
[†]Faculty of Engineering, Shizuoka University,
3-5-1 Johoku, Hamamatsu, 432-8561 Japan.
[‡]Institute of Fundamental Studies,
Hantana road, Kandy, Sri Lanka.

The dye-sensitized solar cell developed by Grätzel et al is well known and the optimized system is reported have practically viable energy efficiencies.[1] The only other reported dye-sensitized solar cell having a comparable efficiency is the device based on $SnO_2$/ZnO composite films which the author devised in Sri Lanka (the reported efficiency ~ 8 %).[2] It was found that the recombination in dye-sensitized photoelectrochemical cells could be suppressed by coating an insulating shell on the $SnO_2$ and as a consequence increase of the efficiencies was noted. The insulating shell effectively suppresses recombinations of the geminate pair (i.e., $e^-$, $D^+$) and also recombinations of injected electrons with the acceptors in the electrolyte. We also reported that improved efficiency of the cell based on $SnO_2/Al_2O_3$ or $SnO_2$/MgO composite films.[3,4] In this paper, improved performance of the cell made from several types of thin shell covered $SnO_2$ nanoporous films, is reported.

On coating the $SnO_2$ crystallites with a thin film of MgO, the voltage and efficiency are increased to 650-700 mV and ~6.5%, respectively (Figure 1). Evidence is presented to show that the photoexcited dye on the outer MgO shell could tunnel electrons to $SnO_2$ and that the low probability of reverse tunneling suppresses recombinations, thus increasing the efficiency.

Two types of composite systems with $SnO_2$ and ZnO are possible. In the first type $SnO_2$ crystallites are covered with an ultra-thin (< 1nm) outer shell of ZnO (Table 1: ($SnO_2$)ZnO) and in the second type the film comprises of $SnO_2$ crystallites (~10 nm) with a thin ZnO outer shell and larger ZnO particles (~ 100 nm) (Table 1: ($SnO_2$)ZnO/ZnO). The short-circuit photocurrent and efficiency of these cells are ~ 17 $mAcm^{-2}$, 19 $mAcm^{-2}$ and 7%, 8% respectively. Paper explains in detail how a thin shell of ZnO on $SnO_2$ could effectively counteract recombinations of electrons with acceptors in the electrolyte (e.g., $I_3^-$) and increase the efficiency although $SnO_2$, ZnO individually are not good materials for dye sensitized solar cells. In the second type larger ZnO crystallites reduces the rate of geminate recombinations, in addition to the effect of the outer shell.

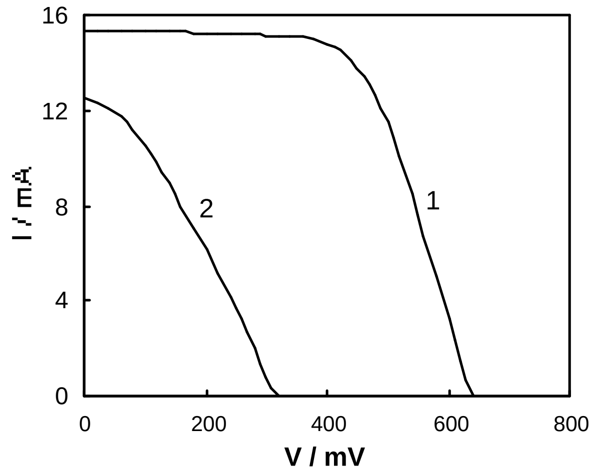


Figure 1. I-V characteristics of the DS cells made from (1) $SnO_2$/MgO(4.1%) and (2) $SnO_2$.

Table 1 Short-circuit photocurrent (Isc), open-circuit voltage (Voc), fill factor (FF), and efficiency (η) of the cells made from $SnO_2$ and $SnO_2$/ZnO composite nanoporous electrode.

| electrode | Isc $mAcm^{-2}$ | Voc mV | FF | η % |
|---|---|---|---|---|
| $SnO_2$ | 12.0 | 330 | 0.31 | 1.3 |
| ($SnO_2$)ZnO | 16.9 | 660 | 0.65 | 7.0 |
| ($SnO_2$)ZnO/ZnO | 18.8 | 650 | 0.63 | 8.0 |

**References**

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