WO_3 as electron transport material for highly efficient $CH_3NH_3PbI_3$ perovskite Solar Cells

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Introduction:

In the past five years, perovskite solar cells have remarkably marched with the power conversion efficiency (PCE) elevating from 3.8% in 2009, 15.4% in 2013, to 19.3% in April 2014 [1, 2], which has reached a comparative performance with their counterparts—multicrystalline silicon solar cells. The perovskite solar cells are now approaching large-scale application for their properties of cost-effective production, solution processibility, sufficiency in raw material sources and capability for application in flexible substrates. TiO_2 dense-layer is usually used to transport electrons and block holes from injecting into the anode but it is necessary to obtain this layer at a very high temperature (usually about 500℃), which restricts its widespread application on flexible substrates. Moreover, TiO_2 does not possess a comparable electric contact with perovskite in contrast with WO_3. We therefore have conducted investigations with WO_3 as low-temperature ETM for highly efficient solar cells.

Results and discussion:

Experiments were conducted roughly by the prior literature [3], except the application of air flowing assisting, which enabled us to fabricate fair perovskite layers on the WO_3 based ETM layers. Another group samples with TiO_2 as ETM have also been fabricated under comparable conditions as demonstrated in our previous report [4]. Fig. 1 and Table I have demonstrated the *J-V* curves and PV parameters for two different kinds of perovskite solar cells with a geometry of FTO/TiO_2 or WO_3/ $CH_3NH_3PbI_3$/HTM/Au. It is evidently indicative that the WO_3-based solar cells have exhibited slightly inferior performance to the traditional TiO_2-based solar cells but the drawback of serious hysteresis can be greatly suppressed. It should be ascribed to the better electric contact and much higher conductivity. A comprehensive optimization for higher efficiency WO_3 solar cells with more compact ETM layers and the underlying mechanism are still under investigation.

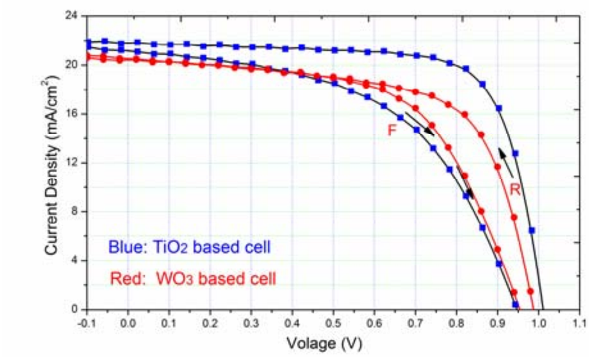

Fig. 1 J-V curves for the $CH_3NH_3PbI_3$ perovskite solar cells with WO_3 (red line) and TiO_2 (blue line) as ETM.

Table 1 PV comparison of TiO_2 (A) and WO_3 (B) as ETM for highly efficiently perovskite solar cells (the unit for J_{sc} is mA/cm^2))

Cells	J_{sc}	V_{oc} (V)	FF	PCE (%)	Ave-PCE (%)
A (F)	20.35	0.94	0.58	11.09	11.90
A (R)	20.59	0.98	0.63	12.71	
B (F)	21.80	1.01	0.74	16.32	14.82
B (R)	21.49	0.98	0.63	13.31	

Reference

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[2] Liu M, Johnston MB, Snaith HJ. Nature. 501 (2013): 395-8.

[3] Kai Wang, Yantao Shi, Qingshun Dong, Yu Li, Shufeng Wang, et al.Phys. Chem. Lett. 6 (2015): 755-59.

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