WO3 as electron transport material for highly efficient CH3NH3PbI3 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. TiO2 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°C), which restricts its widespread application on flexible substrates. Moreover, TiO2 does not possess a comparable electric contact with perovskite in contrast with WO3. We therefore have conducted investigations with WO3 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 WO3 based ETM layers. Another group samples with TiO2 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/TiO2 or WO3/CH3NH3PbI3/HTM/Au. It is evidently indicative that the WO3-based solar cells have exhibited slightly inferior performance to the traditional TiO2-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 WO3 solar cells with more compact ETM layers and the underlying mechanism are still under investigation.

Reference

Fig. 1 J-V curves for the CH3NH3PbI3 perovskite solar cells with WO3 (red line) and TiO2 (blue line) as ETM.

Table 1 PV comparison of TiO2 (A) and WO3 (B) as ETM for highly efficiently perovskite solar cells (the unit for Jsc is mA/cm²)

<table>
<thead>
<tr>
<th>Cells</th>
<th>Jsc (mA/cm²)</th>
<th>Voc (V)</th>
<th>FF</th>
<th>PCE (%)</th>
<th>Ave-PCE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (F)</td>
<td>20.35</td>
<td>0.94</td>
<td>0.58</td>
<td>11.09</td>
<td>11.90</td>
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<tr>
<td>A (R)</td>
<td>20.59</td>
<td>0.98</td>
<td>0.63</td>
<td>12.71</td>
<td>14.82</td>
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<tr>
<td>B (F)</td>
<td>21.80</td>
<td>1.01</td>
<td>0.74</td>
<td>16.32</td>
<td></td>
</tr>
<tr>
<td>B (R)</td>
<td>21.49</td>
<td>0.98</td>
<td>0.63</td>
<td>13.31</td>
<td></td>
</tr>
</tbody>
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