Supporting information

**Band alignment of TiO$_2$ through controlling Cl content for high-efficiency perovskite solar cells**

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Figure S1 Diagram of TiO$_2$ preparation process

Figure S2 TiO$_2$ absorption and energy band changes at different growth times. (a) TiO$_2$ absorption plots at different growth times. (b) TiO$_2$ Tauc-plot plots with different growth times.
Figure S3 XPS test diagram of TiO$_2$ surface with different growth time. (a) 1.5 h. (b) 1+1 h.

Figure S4 The electron mobility of TiO$_2$ was evaluated using the SCLC model.
Figure S5 SEM images of TiO$_2$ surface at different growth times. (a) 1 h. (b) 1+0.5 h. (c) 1.5 h. (d) 1+1 h.

Figure S6 SEM images of TiO$_2$ growing at different times. (a) 1 h. (b) 1+0.5 h. (c) 1.5 h. (d) 1+1 h.
Figure S7 PH value of TiO$_2$ solution grown at different times

Table S1 Average carrier lifetime of perovskite films prepared on 1 h and 1+0.5 h TiO$_2$ films

<table>
<thead>
<tr>
<th>Growth time</th>
<th>$\tau_1$/ns ($A_1$)</th>
<th>$\tau_2$/ns ($A_2$)</th>
<th>$\tau_{ave}$/ns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 h</td>
<td>92.44 (0.092)</td>
<td>890.62 (0.876)</td>
<td>882.01</td>
</tr>
<tr>
<td>1+0.5 h</td>
<td>83.63 (0.151)</td>
<td>629.33 (0.799)</td>
<td>615.96</td>
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</tbody>
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