Supporting Information

Highly Efficient Perovskite Solar Cells with Crosslinked PCBM Interlayers

W. Qiu, a, b, † J. P. Bastos, a, c S. Dasgupta, a T. Merckx, a I. Cardinaletti, d M. V. C. Jenart, e C. B. Nielsen, e, † R. Gehlhaar, a J. Poortmans, a, c P. Heremans, a, c, † I. McCulloch, a and D. Cheyns a

a IMEC, Kapeldreef 75, Heverlee, B-3001, Belgium
b MTM, KU Leuven, Heverlee, Belgium
c ESAT, KU Leuven, Heverlee, Belgium
d Hasselt University, IMO-IMOME, Diepenbeek, 3590, Belgium
e Department of Chemistry and Centre for Plastic Electronics, Imperial College London, SW7 2AZ, UK
f Materials Research Institute and School of Biological and Chemical Sciences, Queen Mary University of London, Mile End Road, London E1 4NS, UK
g Physical Sciences and Engineering Division, King Abdullah University of Science and Technology (KAUST), Thuwal 23955-6900, Saudi Arabia

† Corresponding author: Weiming.Qiu@imec.be; Paul.Heremans@imec.be
**Fig. S1** (a) the EQE curves of PSCs without ETL, with pristine PCBM and with crosslinked PCBM as ETL; (b) The EQE curves of PSCs with TiO$_2$, TiO$_2$/crosslinked PCBM, PEIE, PEIE/crosslinked PCBM as ETL.

**Fig. S2** The $J$-$V$ curves from both reverse and forward sweep of perovskite solar cells with different ETLs.
Fig. S3 (a) The J-V curves and (b) the steady-state PCEs of PSCs with TiO$_2$/PCBM and PEIE/PCBM as the ETL, respectively

**Table S1.** The detailed photovoltaic parameters of the perovskite solar cells using TiO$_2$/PCBM and PEIE/PCBM as the ETL, respectively, with the data extracted from Fig. S3.

<table>
<thead>
<tr>
<th>ETLs</th>
<th>$J_{sc}$ (mA/cm$^2$)</th>
<th>$V_{oc}$ (V)</th>
<th>FF (%)</th>
<th>PCE$_{jv}$ (%)</th>
<th>PCE$_{bias}$ (%)</th>
<th>Irradiance (mW/cm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiO$_2$/PCBM</td>
<td>21.5</td>
<td>0.9</td>
<td>73.2</td>
<td>15.4</td>
<td>13.3</td>
<td>100</td>
</tr>
<tr>
<td>PEIE/PCBM</td>
<td>18.9</td>
<td>0.9</td>
<td>33.0</td>
<td>6.0</td>
<td>0.9</td>
<td>100</td>
</tr>
</tbody>
</table>
**Fig. S4** Top-view SEM images of CH$_3$NH$_3$PbI$_3$ films deposited on (a) ITO, (b) TiO$_2$, (c) PEIE, (d) crosslinked PCBM, (e) TiO$_2$/crosslinked PCBM, (f) PEIE/crosslinked PCBM.

**Fig. S5** Difference between the tip work function and that of different ETLs on ITO substrates: (a) ITO; (b) Crosslinked PCBM; (c) TiO$_2$; (d) TiO$_2$/crosslinked PCBM; (e) PEIE; (f) PEIE/crosslinked PCBM. The work function of the different tips used was not perfectly matching, therefore whenever the tip needed to be changed, we would re-acquire the potential for the last measured layer, as to be able to fix the offsets to the same scale. This explains eventual incongruences between the data in **Fig. 3d** and that in the scan images.
Fig. S6  Top-view SEM images of the \((\text{HC(NH}_2\text{)}_2)_{0.66}(\text{CH}_3\text{NH}_3)_{0.34}\text{PbI}_2.85\text{Br}_{0.15}\) film deposited on TiO\(_2\)/crosslinked PCBM ETL.

Fig. S7  XRD patterns of the CH\(_3\)NH\(_3\)PbI\(_3\) and \((\text{HC(NH}_2\text{)}_2)_{0.66}(\text{CH}_3\text{NH}_3)_{0.34}\text{PbI}_2.85\text{Br}_{0.15}\) films deposited on TiO\(_2\)/crosslinked PCBM ETL.
Fig. S8 Digital images of our perovskite module taken from (a) the metal electrode side and (b) the ITO side. It has a total aperture area of 4 cm$^2$, with 4 sub-cells.

Fig. S9 (a) the J-V curves and (b) the steady-state PCE of the perovskite solar module.