Electronic Supplementary Information

Silver bismuth iodides in various compositions as potential Pb-free light absorber for hybrid solar cells

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Fig. S1  Plan-view and cross-sectional-view SEM images of the Ag$_2$BiI$_5$ (a), and SBI-55:45 (b) and CH$_3$NH$_3$PbI$_3$ (c) films used for obtaining UV-visible absorption spectra. For the preparation of Ag$_2$BiI$_5$ and SBI-55:45 films, each of 0.3 M solution in DMSO/DMF/HI was spin-coated on the 200 nm-thick mesoporous TiO$_2$ layer, followed by heat-treatment at 120 °C. The film thicknesses of these films over TiO$_2$ surface were estimated to ~60 nm. CH$_3$NH$_3$PbI$_3$ films were coated by using a 0.6 M solution, consisting of PbI$_2$ and methylammonium iodide, 600 mg DMF and 78 mg DMSO. After spin-coating at 4000 rpm for 20 s, the coated film was heat-treated at 100 °C for 5 min. The thickness of CH$_3$NH$_3$PbI$_3$ film was also estimated to be ~60 nm. Thus the prepared Ag$_2$BiI$_5$, SBI-55:45 and CH$_3$NH$_3$PbI$_3$ films have quite similar thicknesses.
Fig. S2  $J-V$ curves and photovoltaic parameters of the SC-SBI-67:33 (SC-Ag$_2$BiI$_3$) measured under various light intensities.
<table>
<thead>
<tr>
<th>Preparation method</th>
<th>$V_{OC}$ (mV)</th>
<th>$J_{SC}$ (mA/cm$^2$)</th>
<th>FF (%)</th>
<th>PCE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>from SBI-55:45</td>
<td>614</td>
<td>6.329</td>
<td>59.34</td>
<td>2.31</td>
</tr>
<tr>
<td>from AgI and BiI$_3$</td>
<td>510</td>
<td>4.202</td>
<td>51.63</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Fig. S3  $J$-$V$ curves of SBI-55:45 solar cells derived from two different coating solutions. That is, in preparing SBI-55:45 films, 0.3 M coating solution was prepared by dissolving the Ag$_2$BiI$_5$ powder in the mixed solvent of DMF/DMSO/HI. In comparison, a 0.3 M coating solution was prepared by dissolving the stoichiometric amounts of AgI and BiI$_3$ in the DMF/DMSO/HI. To form the SBI-55:45 layer, the prepared each solution was spin-coated and heat-treated at the same condition.
Fig. S4  Photographic images for the HTM-coated Ag$_2$BiI$_5$ films employing pristine spiro-OMETAD (a) and TBP-added spiro-OMETAD.