Supplementary Information

Formation of Ga double grading in submicron Cu(In,Ga)Se₂ solar cells by pre-depositing a CuGaSe₂ layer

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Fig. S1. (a) Metal flux rates and sequences for a traditional three-stage growth profile of a standard thick CIGS film. (b) The corresponding GGI curve extracted from the SIMS results.

Fig. S2. XRD spectra of submicron thick CIGS films with different growth profiles: (a) traditional profile, (b) Ga-In-Ga extreme profile, (c) Ga-In extreme profile, (d) CGS+CIGS profile.

Fig. S3. SEM cross-sectional view and top view of CGS with different Cu/Ga ratio (a-b) Cu/Ga = 1.15, (c-d) Cu/Ga =1, (e-f) Cu/Ga = 0.86.
Table S1 Parameters of Ga grading of Sample D and E.

<table>
<thead>
<tr>
<th>Sample</th>
<th>$x_b$</th>
<th>$x_f$</th>
<th>GGI$_{\text{min}}$</th>
<th>$d_n$ (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0.25</td>
<td>0.03</td>
<td>0.24</td>
<td>246</td>
</tr>
<tr>
<td>E</td>
<td>0.34</td>
<td>0.15</td>
<td>0.20</td>
<td>254</td>
</tr>
</tbody>
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