Refined life-cycle assessment of polymer solar cells

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Summary

Comprehensive sketch of full environmental potential of polymer-PV by embedded energy analysis (EE).

Focus on critical components:
• transparent conductive ITO layer
• encapsulation

On a m² basis environmental characteristics of polymer OPV are very promising.

Spotlight of near-term R&D efforts of OPV community from environmental/sustainability point of view should be on:
• replacement of ITO layer
• optimization of encapsulation concepts

General device structure with design variables

1. Encapsulation (design variable)
   - Contact 2 (screen-printed Ag-grid from “PV410”)
   - Charge-selective layer 2 (Pedot:PSS or ZnO)
   - Photo-active layer (PCBM:P3HT blend)
   - Charge-selective layer 1 (Pedot:PSS or ZnO)
   - Contact 1 (design variable)
   - PET substrate

Choices for design variables

2. Contact 1:
   a) ITO
   b) Pedot:PSS/Ag-grid
   c) Al/Cr

Encapsulation:
   d) PET + moisture barrier, adhesive
   e) Steel, EVA, ETFE
   f) Glass, EVA
   - Indoor
   - Outdoor

Embedded energy analysis*

3.

<table>
<thead>
<tr>
<th></th>
<th>EE (MJ/m²)</th>
<th>EE (MJ/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET/contact 1</td>
<td>35-50</td>
<td>35-50</td>
</tr>
<tr>
<td>Charge select. layer 1</td>
<td>5-10</td>
<td>5-10</td>
</tr>
<tr>
<td>Photoactive layer</td>
<td>5-10</td>
<td>5-10</td>
</tr>
<tr>
<td>Charge select layer 2</td>
<td>5-35</td>
<td>5-35</td>
</tr>
<tr>
<td>Contact 2</td>
<td>20-30</td>
<td>20-30</td>
</tr>
<tr>
<td>Encapsulation</td>
<td>10-15</td>
<td>200-380</td>
</tr>
<tr>
<td>Totals</td>
<td>~80-150</td>
<td>~300-500</td>
</tr>
</tbody>
</table>

* Study based on 50 kWp roll-based pilot line facility at Risø

Conclusions

4. • Embedded energy of polymer-OPV modules is ~ 80-150 MJ/m² for indoor mobile electronics and ~ 300-500 MJ/m² for outdoor power-generation applications (which differ on the level of encapsulation).
• Encapsulation is the dominant environmental load factor (at least for outdoor power applications).
• ITO replacement is required due to indium scarcity.

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