The influence of co-deposition on the performance of CuPc/C$_{60}$ heterojunction photovoltaic cells

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1. Background and Motivation

- The donor-acceptor (D-A) interface of two distinct organic semiconductor materials provides a site for efficient exciton dissociation. However, the low exciton diffusion lengths mean that light absorption must occur very close to the heterojunction.
- Co-deposition\(^1,2\) may be used to increase the interface area and hence improve the performance of the basic CuPc-C\(_{60}\) heterojunction cells.\(^3\)

References


ACKNOWLEDGEMENTS - EPSRC, BP Solar and Kurt J. Lesker Ltd
2. Experimental Methods

Organic Molecular Beam Deposition (OMBD) under high vacuum conditions (10^-8 mbar) allows for high control over layer thickness and composition.

AFM shows that the mixed layer films are smooth and amorphous, and undergo intermolecular intermixing.

**ACKNOWLEDGEMENTS** - EPSRC, BP Solar and Kurt J. Lesker Ltd
3. Results

Architectures

Co-deposition can be used to design architectures for improved device performance. (Devices not optimized with respect to substrate preparation and electrode modification)

**Solar Cell Efficiencies**

<table>
<thead>
<tr>
<th>Architecture</th>
<th>$\eta_p$ (%)</th>
<th>CuPc : C$_{60}$ Ratio</th>
<th>$\eta_p$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrete Cell</td>
<td>0.75</td>
<td>25:75</td>
<td>0.67</td>
</tr>
<tr>
<td>Fully Mixed</td>
<td>0.88</td>
<td>50:50</td>
<td>1.05</td>
</tr>
<tr>
<td>Mixed + Continuous</td>
<td>1.18</td>
<td>75:25</td>
<td>1.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>90:10</td>
<td>0.40</td>
</tr>
</tbody>
</table>

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• Mixed layer devices show a much higher $I_{sc}$ indicating that more free charges are produced due to more efficient exciton dissociation.

• The reduction of the internal field found in fully mixed cells can be avoided by adding thin continuous films of the respective materials at the electrodes.

• CuPc absorbs light more strongly than $C_{60}$ in the visible region, and consequently the $I_{sc}$ is small at low CuPc content.

The Gradient Cell

\[
\eta_p = 1.36\%
\]

A compositional gradient cell shows increased $I_{sc}$ and $FF$ due to an increased charge collection efficiency. The efficiency of this cell is nearly twice that of the discrete cell.
4. Conclusions

1) Device performance of molecular PV cells based on CuPc and C$_{60}$ can be improved by incorporation of co-deposited layers with well-defined composition ratios.

2) Further improvements in efficiency are obtained using structures where the CuPc:C$_{60}$ composition varies from pure donor to pure acceptor.

3) The improved device performance can be explained by the improved charge transport in the amorphous mixed layers and increased exciton dissociation due to intermolecular mixing.