Creation of a U.S. Phosphorescent OLED Lighting Panel Manufacturing Facility

Universal Display Corporation

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Barry Young (consultant)
Project Objectives

- Establish a U.S. pilot phosphorescent OLED (PHOLED) manufacturing line

- Provide prototype lighting panels to U.S. luminaire manufacturers for incorporation into products to facilitate testing of design concepts and to gauge customer acceptance.

- Provide a cost of ownership analysis to quantify production costs including OLED performance metrics such as yield, materials usage, cycle time, substrate area, and capital depreciation.
Technical Approach and Current Status

- U.S. OLED lighting pilot manufacturing facility, based on UDC’s PHOLED technology, is being established by MBT.

- Proposed “micro-factory” approach based on high throughput processing of 150 mm x 150 mm glass substrates uses known and proven production methods. All building block elements have now been developed and ready for implementation.

- Low cost integrated substrates (with light extraction) are critical for low cost OLED lighting. MBT plans to combine its independently developed integrated substrate technology with the U.S. pilot manufacturing capabilities for high performance PHOLED lighting.

- Extensive cost modeling has been completed and prospects for achieving DOE roadmap targets look promising.

- Pilot facility requires >$10M third party funding; in progress.
### UDC White PHOLED 15 x 15 cm² Panel – 70 lm/W

<table>
<thead>
<tr>
<th>Panel 15 cm x 15 cm</th>
<th>At 1,000 cd/m²</th>
<th>At 3,000 cd/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Efficacy [lm/W]</strong></td>
<td>70</td>
<td>57</td>
</tr>
<tr>
<td><strong>CRI</strong></td>
<td>85</td>
<td>86</td>
</tr>
<tr>
<td>Luminous Emittance (LE) [lm/m²]</td>
<td>2,580</td>
<td>7,740</td>
</tr>
<tr>
<td><strong>Voltage [V]</strong></td>
<td>3.8</td>
<td>4.3</td>
</tr>
<tr>
<td><strong>Duv</strong></td>
<td>0.008</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>CCT [K]</strong></td>
<td>3030</td>
<td>2880</td>
</tr>
<tr>
<td><strong>Temperature [°C]</strong></td>
<td>22.2</td>
<td>26.9</td>
</tr>
<tr>
<td><strong>LT70 [hrs]</strong></td>
<td>30,000</td>
<td>4,000</td>
</tr>
</tbody>
</table>

*1.75x Efficacy Outcoupling Enhancement*

![Diagram of Non-stacked Simple Structure]

**UDC White PHOLED**

- Panel 15 x 15 cm
- At 1,000 cd/m²
- At 3,000 cd/m²
- Efficacy [lm/W]: 70, 57
- CRI: 85, 86
- Luminous Emittance (LE) [lm/m²]: 2,580, 7,740
- Voltage [V]: 3.8, 4.3
- Duv: 0.008, 0.007
- CCT [K]: 3030, 2880
- Temperature [°C]: 22.2, 26.9
- LT70 [hrs]: 30,000, 4,000

**Non-stacked Simple Structure**

- Cathode
- ETL
- BL
- Blue EML
- R:G EML
- HTL
- HIL
- ITO
The OLED Lighting Microfactory

- MBT’s patented manufacturing concept - capacity scale with market growth
- Small form-factor, fast-throughput, product-size microfactories
- Highly differentiated from display industry; uniquely suitable for US industry

- Integrated substrate technology, developed by MBT in parallel with the DOE program, is ready for integration with the US PHOLED pilot facility

<table>
<thead>
<tr>
<th>Substrate</th>
<th>OLED Deposition</th>
<th>Encapsulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Substrate</td>
<td>Single Substrate or Batch</td>
<td>Single Substrate</td>
</tr>
<tr>
<td>150mm x 150mm</td>
<td>150mm x 150mm or &lt; “multi-up” deposition platform</td>
<td>150mm x 150mm</td>
</tr>
<tr>
<td>High Throughput, Low Cost cost structure &lt;$50/m²</td>
<td>State-of-the-Art Proven OLED Deposition Technology &amp; Phosphorescent OLED Devices</td>
<td>High Throughput, Low Cost</td>
</tr>
<tr>
<td>Product Size Manufacturing; Capex reduction</td>
<td>Gen 2 manufacturing platform sufficient to achieve &gt; 2 Mn panels per year</td>
<td>Product Size Manufacturing; Capex reduction</td>
</tr>
</tbody>
</table>
MBT US OLED Pilot Line (Canandaigua/New York)
OLED Lighting Cost Roadmap

*MBT’s OLED “micro-factory” concept can meet DoE cost target
Plan Forward -

- Complete “Facility Implementation” activities
  - Commission production equipment
  - Implement UDC PHOLED technology and best integrated substrate technology available
  - First prototype panels

- Continue “Commercial Implementation” activities
  - Provide prototype lighting panels to luminaire makers
  - Final report of status of pilot facility
  - Commercial roadmap