Panel | OLEDs – How Far Have They Come in Viability?

OLED Luminaire and Driver Development

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Horizon Group, Acuity Brands Lighting
Presentation Overview

1. Introduction to OLED Technology and Panels
2. OLED Luminaire and Lighting Design
3. OLED Installation Case Studies
4. Drivers for OLED Luminaires
Introduction to OLED Technology and Panels

OLED Device Structure and Properties

- Substrate (e.g. glass)
- Anode (ITO)
- Electron transport
- Hole injection
- Hole transport
- Emissive
- Hole blocking
- Cathode (e.g. Al)

Actively layers are 100’s of nanometers thick

- Typical Bottom-Emitting OLED
- Rigid glass substrate
Introduction to OLED Technology and Panels

OLED Panel Suppliers

Current Gen: 55-60 LPW; Next Gen: 75-90 LPW
2700, 3000, 3500, 4000K
3000 cd/m², $L_{70} = 30-40$Khrs
Rigid and bendable/flexible substrates

Brite2: 57-63 LPW
3000, 4000K
$L_{70} = 50$Khrs @ 2800 cd/m², 10 khrs @ 8300 cd/m²
Rigid substrate
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OLED Luminaire and Lighting Design

Acuity’s OLED Development Timeline

- Glimpse™
- Revel*™
- Trilia™
- Modelo™
- Chalina™
- Aedan™
- Olessence™
- LightFacet
- Kindred™
- Canvis™
- Lumen Being
- Nomi™
- AR14
- Sundial

*Most Innovative Product LFI’11
OLED Luminaire and Lighting Design

Application Efficiency – from more precise placement of luminaires

TYPICAL “STANDARD” LAYOUT
Rectilinear Layout with uniform illumination

“APPLICATION EFFICIENT” LAYOUT – VARYING LOCATIONS & HEIGHTS
OLED Luminaire and Lighting Design

Task-Ambient-Surround

- Task-Surround-Ambient has advantages in both facial modeling and energy consumption
- The prototype used OLED/LED for the task component and a back LED for surround.

OLED Luminaire and Lighting Design

Olessence™: DuetSSL™ Technology (Hybrid OLED/LED)

- Majority LED up-light and OLED down-light
- Combine efficacy, functional luminance and aesthetics

Imoni
Single
2015
Prototype

Olessence
Curve
2015
Prototype

Olessence Commercial Launch
October 2016

- Up to 100 LPW, 1620 LMF
- 4’, 6’, and 8’ sections
- Optional integrated sensors
OLED Luminaire and Lighting Design

What Does the Future Hold?

Cost reduction with Gen 5 plant and beyond
- Source: LG Chem

LGD to build Gen 5 plant
- Source: LG Display, Mar’16

Thin and Flexible
Other unique properties

Luminaire as a capsule of other technology
- Design and user interface are paramount
- Illumination is secondary
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OLED Installation Case Studies
Cammisa + Wipf Consulting Engineers, San Francisco, CA

“Everybody loves it,” he explains. “They find it to be a real, eye-catching experience that is unlike anything they have ever seen before.”

48 fc average, 0.70 W/ft²
OLED Installation Case Studies
Irondequoit Public Library, Rochester, NY

“Most people have never seen anything like it. People love the fixtures. These fixtures are here for art’s sake as much as for light.”

– Terry Buford, Library Director

**DETAILS**

**Project:**
Irondequoit Public Library, Rochester, New York

**Project Size:**
38,700 square feet

**Lighting Specifier:**
Peter Wehner, AIA LEED-AP, Passero Associates

**Lighting Contractor:**
Concord Electric

**Lighting Manufacturers:**
Acuity Brands/Winoa® Lighting

**Products:**
Trilia™ OLED
OLED Installation Case Studies
Meissner Filtration Products, Inc. Camarillo, CA

“This is exactly what we were looking for in the lounge,” he noted. “An elegant look that is also functional.”
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OLED Driver Challenges

- UL Class 2 limit is 60VDC (most drivers max out at 55 VDC)
- Panel voltages are approximately 3V/stack
- Panel voltage will increase due to aging
- Limited number of serially connected panels
- Paralleling panels need to account for possible shorts
Additional Driver Requirements

- PF < 0.9 for commercial, < 0.7 for residential; THD < 20%
- Driver efficiency, PF and THD tend to deteriorate with higher input voltage and lower loading
- Deep dimming, 1% or even 0.1% are becoming industry standard
- Lower wattage drivers will have lower efficiency

Typical PF and THD vs. driver load and input voltage, source: Phihong
Flicker

![Image: Figure 1: Periodic Waveform Reference for Traditional Flicker Metrics]

Source: IES Lighting Handbook, 10th Edition

Percent Flicker = 100% x (Max-Min) / (Max + Min) = 100% x (A-B) / (A+B)  Eq.1

Flicker Index = Area above Mean / Total Area = Area 1 / (Area 1 + Area 2)  Eq.2

Source: Poplawski and Miller

Also see IEEE PAR 1789, June 2015
Current Acuity Driver Solutions for OLED Luminaires

- Used in LED luminaires, equally applicable to OLED luminaires 7-100 W
- eldoLED programmable drivers (150-1400mA), 55V max, up to 87% efficient, Hybrid HydraDrive

- For low wattage OLED luminaires <5W
  - 0-10V, phase cut dual dimming, CCR
  - PF > 0.9, THD < 20%, 120-277V input
  - Fits in a 2” x 4” single gang switch box
Hybrid HydraDrive

<table>
<thead>
<tr>
<th>Driver</th>
<th>Dim Level</th>
<th>Percent Flicker</th>
<th>Flicker Index</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>eldoLED</td>
<td>100%</td>
<td>3.9%</td>
<td>0.01</td>
<td>305 Hz</td>
</tr>
<tr>
<td>eldoLED</td>
<td>80%</td>
<td>9.2%</td>
<td>0.03</td>
<td>306 Hz</td>
</tr>
<tr>
<td>eldoLED</td>
<td>50%</td>
<td>4.0%</td>
<td>0.01</td>
<td>307 Hz</td>
</tr>
<tr>
<td>eldoLED</td>
<td>30%</td>
<td>11%</td>
<td>0.03</td>
<td>2450 Hz</td>
</tr>
<tr>
<td>eldoLED</td>
<td>20%</td>
<td>4.0%</td>
<td>0.01</td>
<td>832 Hz</td>
</tr>
</tbody>
</table>

As measured by VISO Systems Flicker Checker App

Trilia driven by eldoLED drivers, dimmed to 2.5%

Flicker checker
DOE Project

- DE-EE0007073 “OLED Luminaire with Panel Integrated Drivers and Advanced Controls”
- Work spans 9/1/2015-10/31/2016, with OLEDWorks as subcontractor
- The proposed architecture is to have a base station that performs AC/DC voltage conversion and integrated driver at each panel that performs DC/DC current regulation.
- But how about dimming?

<table>
<thead>
<tr>
<th>Proposed Deliverable</th>
<th>Luminaire Platform: Canvis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel CCT</td>
<td>3000K (3500/4000K optional)</td>
</tr>
<tr>
<td>Panel Luminance</td>
<td>2500-3000 cd/m²</td>
</tr>
<tr>
<td>Panel CRI</td>
<td>&gt;85</td>
</tr>
<tr>
<td>Panel Lifetime (L₇₀)</td>
<td>&gt;25,000 hrs</td>
</tr>
<tr>
<td>Panel Efficacy</td>
<td>80 lm/W</td>
</tr>
<tr>
<td>Total Luminous Output</td>
<td>4000-5000 lm</td>
</tr>
<tr>
<td>Luminaire Efficacy</td>
<td>65 lm/W</td>
</tr>
<tr>
<td>Luminaire Control (option 1)</td>
<td>0-10V dimming, global</td>
</tr>
<tr>
<td>Luminaire Control (option 2)</td>
<td>DMX or other protocols, individual panel addressable</td>
</tr>
</tbody>
</table>
System Architecture

Original proposal, options for wired control and PLC (power line communication)

Current system architecture: PLC communication, with strand controllers to expand the number of panels in the system
Hardware Development

- Gen 1 base station transceiver
- Gen 2 base station transceiver
- Strand controller
- Gen 1 panel transceiver and driver
- Gen 2 panel integrated driver (next to a 4” square panel)
- Gen 3 panel integrated driver (~0.25” total thickness)
Individually Addressable Dimming

- 2 strands x 11 panels
- 3 dimming patterns
  - Sequential
  - Checker board
  - Random
Thank You!

http://www.acuitybrands.com/oled