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OLEDs – How Far Have They Come in Viability : A Summary of Recent SSL Reports and Findings


Photo: BlackBody


Photo: Visa Lighting


Photo: Acuity Brands

2016 DOE Solid-State Lighting Technology Workshop

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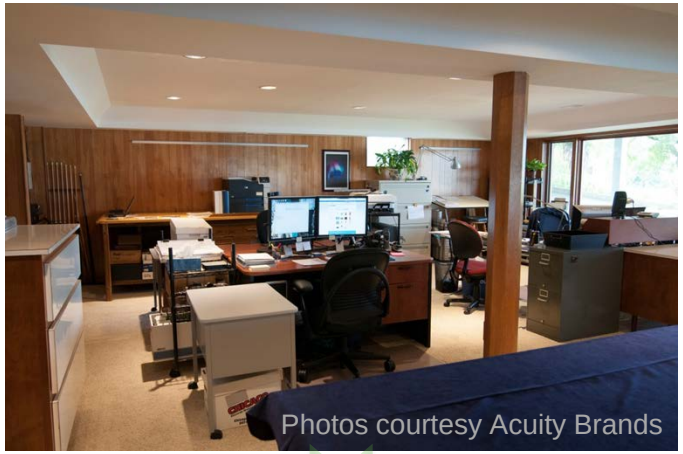
DOE Solid State Lighting Program – OLED Focus

- GATEWAY[1] (March 2016)
  - Case study of OLED lighting installed at Aurora Lighting Design offices
- OLED Lighting Products[2] (May 2016)
  - Overview report on technology and application
- CALiPER report[3] (Sept 2016)
  - Independent testing of off-the-shelf OLED architectural lighting products
  - RTI Int'l accelerated testing
  - PNNL laboratory tear-downs
- Expected additional GATEWAY studies to track future performance

[1] http://energy.gov/sites/prod/files/2016/04/f30/2016_gateway_aurora-oled.pdf
[2] http://energy.gov/sites/prod/files/2016/06/f33/ssl_oled-products_2016.pdf
[3] http://energy.gov/sites/prod/files/2016/10/f33/caliper-24_oled-luminaires.pdf

GATEWAY – OLED Lighting at Aurora Lighting Design, Inc.

- First office test site for OLEDs used in general lighting
- Before
  - 8 recessed LED PAR30 lamps
  - 27 foot-candle average (range 2 to 194 fc)
  - Funky shadows on faces, very uneven work plane illumination
- After
  - 120 OLED 4” x 4” panels
  - Designed range: around 4 to 39 fc
  - Occupants comment on almost shadow-free lighting
    - Supplementing with task and/or accent lighting improves the room appearance with visual highlights



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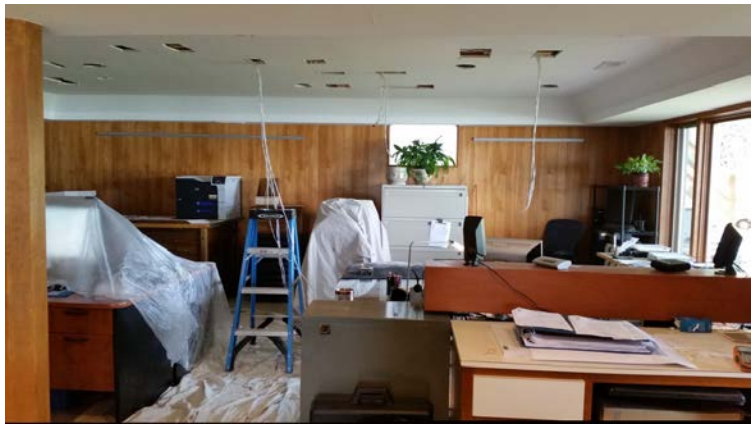
GATEWAY – OLED Lighting at Aurora Lighting Design, Inc.

- A creative and exciting light medium for architectural lighting designers
- Installation notes
  - Ceiling access constraints precluded overhead placement of drivers
  - Required 41 wires to various feed points for 7 separate assemblies
- Field findings
  - Incorrect drivers – leading to overdriving some segments
  - Driver failure and OLED panel shorting defect
  - Some noticed flicker in dimmed mode
- Some growing pains, but nothing out of the ordinary



Photos courtesy Aurora Lighting Design, Inc.

OLED Lighting Products – Capabilities

- Panels are available in various sizes
  - Typical: 100 mm x 100 mm
- Luminous flux per panel can vary
  - About 60 to 115 lm at ~3000 cd/m^2
  - Up to 300 lm at 8300 cd/m^2
- Light distribution and quality
  - "Cosine" can make spaces appear brighter, with softer shadows
  - CRI (R_a) can range from 78 to 89

3000K, 3000 cd/m^2	"Typical" OLED Panel
Panel size	100 mm square, matte appearance
Color (CCT, CRI)	3000 K, 80+ CRI
L_{70} panel life	40,000+ hrs
Panel efficacy	~50 lm/W, 3000 K
Appearance	Matte (uses light extraction layer)

DOE CALiPER Test ID	Luminaire Test Data			
	CCT (K)	Efficacy (lm/W)	Input Power (W)	Initial Output (lm)
15-13	2952	28	9.6	270
15-14 Ceiling	2946	45	7.4	332
15-14 Wall	2940	45	7.4	329
15-15 (2 panel)	2912	30	4.3	130
15-16 (1 panel)	2855	23	2.8	65

OLED Lighting Products – Challenges and Potential

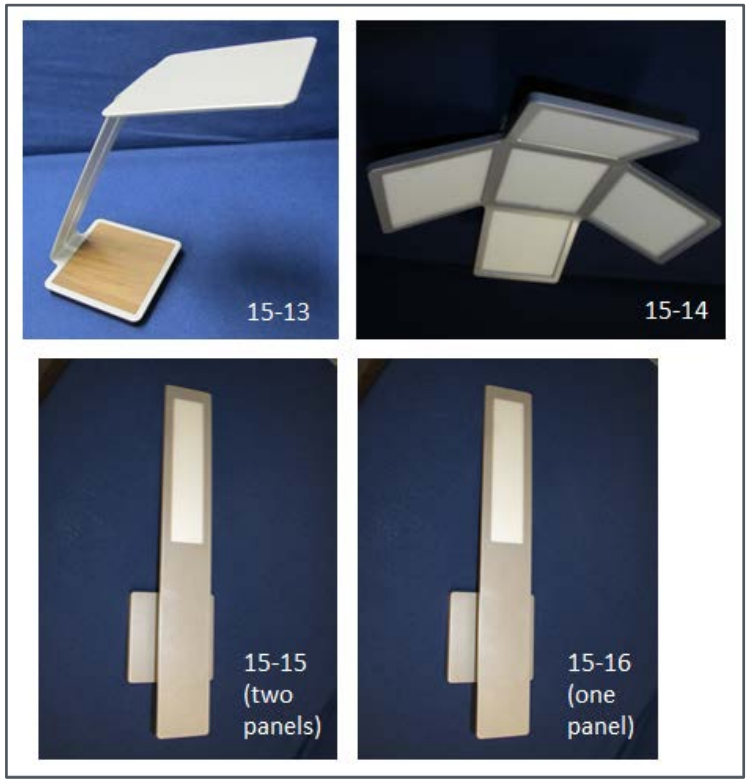
- Challenges
  - Drivers
  - Cost
  - Panel replacement
- Potential
  - Interact with lighting
  - Flexible
  - Transparent (window/light source)
  - Improved options (larger sizes, options in CCT, color bins, etc.)

Photo: Siemens

Photo: LG Chem

CALiPER – Overview

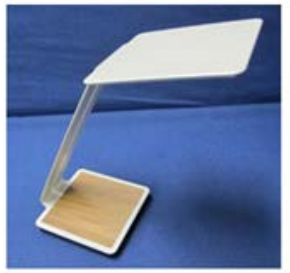
- CALiPER intended to assist:
  - manufacturers seeking to improve their products
  - buyers in making informed decisions
- OLED product testing
  - Luminaire performance (LM-79)
  - Teardown
  - Accelerated testing



CALiPER – Testing and Findings

- Photometric results

CALiPER 15-13 (task light)



CALiPER 15-14 (in ceiling-mount orientation)

CALiPER 15-15 (two panels)

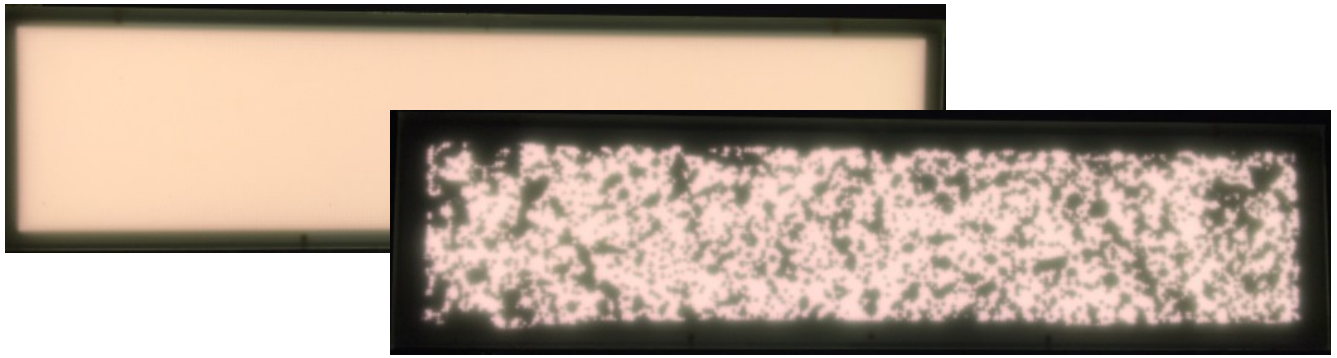
CALiPER 15-16 (one panel)

DOE CALiPER Test ID	Initial Output (lm)	Total Input Power (W)	Efficacy (lm/W)	Power Factor	CRI (R_a)	R_9	R_f	R_g	R_f -- Hue bin 1	CCT (K)	D_{uv}	THD-I (%)
15-13	270	9.6	28	0.45	78	-6	78	95	74	2952	0.0010	188.1
15-14 Ceiling	332	7.4	45	0.99	88	21	86	97	83	2946	0.0030	8.6
15-14 Wall	329	7.4	45	0.99	88	20	86	97	83	2940	0.0030	8.6
15-15	130	4.3	30	0.42	88	21	87	97	83	2912	0.0020	189.1
15-16	65	2.8	23	0.40	88	21	87	97	83	2855	0.0030	192.2

CALiPER – Testing and Findings

Teardown findings

- Dark spot
  - Break in edge seal
  - Possible reason
- Driver selection and performance
  - Efficiency ranges from 47% to 85%
- Luminaire design
  - Thinness
  - Soldering to panels



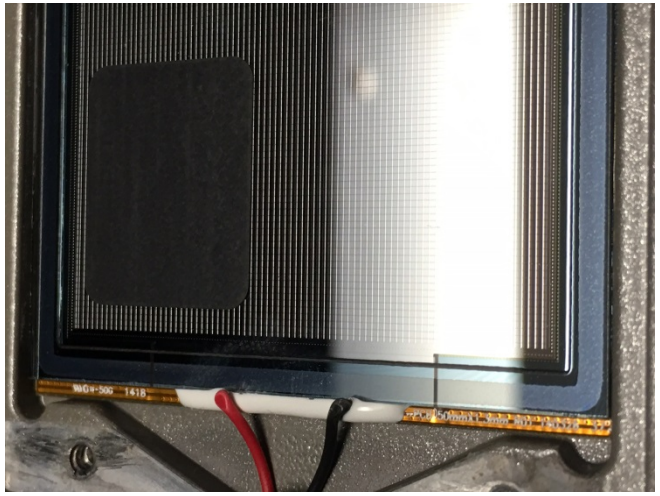


Photo: Acuity Brands

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CALiPER – Testing and Findings

- Multiple drivers
  - V_{AC} to $V_{DC} \rightarrow V_{DC}$ to I_{DC}
- OLED drivers
- Voltage overhead for V_{OLED} rise
- Dimming method options
  - **Constant current reduction (CCR)**
  - Pulse width modulation (PWM) may work – check OLED panel manufacturer specs

Photo: OLEDWorks

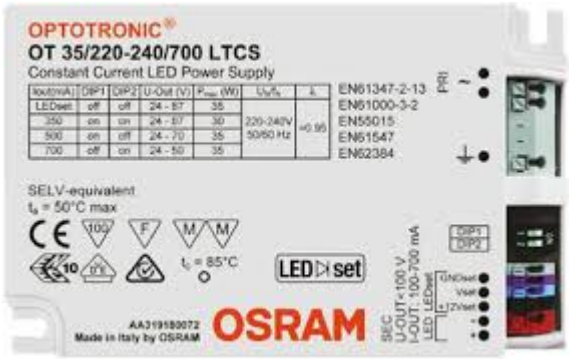
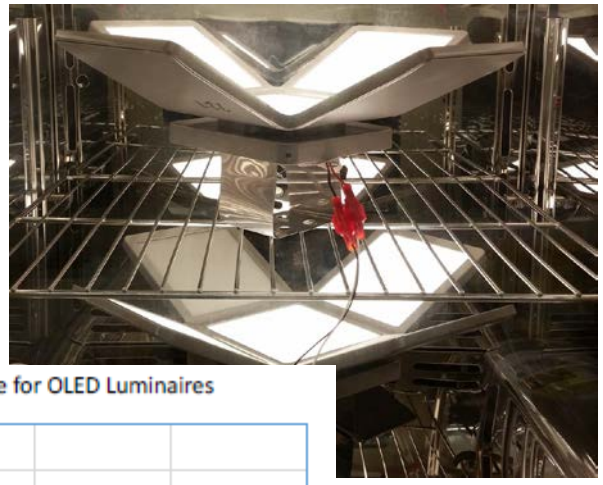
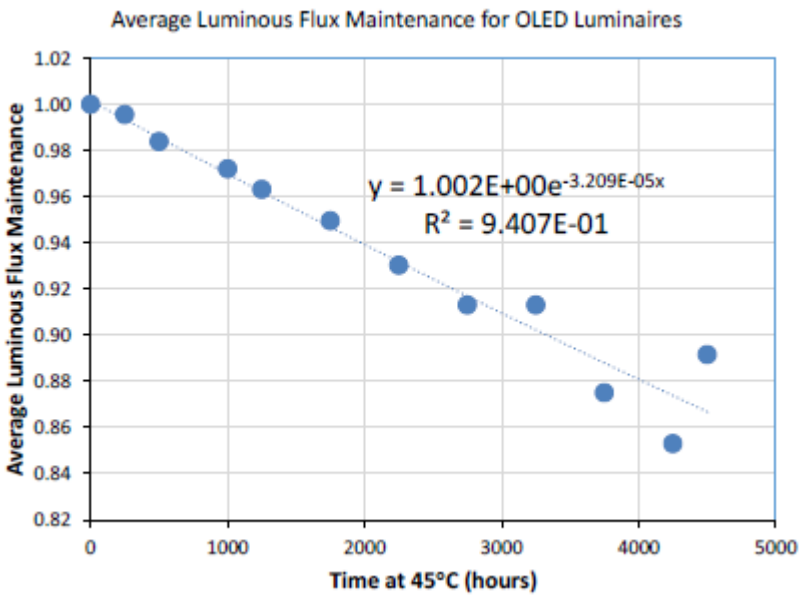


Photo: Osram

CALiPER – Testing and Findings

- Accelerated testing
  - 45°C at 150 mA (luminaire)
  - 75°C at 150 mA (panels)
  - 75°C and 75% relative humidity at 150 mA (luminaire)
  - 45°C at 200 mA (panel)
- Findings
  - Nearly linear luminous flux decay observed
  - Chromaticity shift in blue direction





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OLED's Future

- Will OLED continue to improve (performance/pricing)?
- Will OLED be a light source of choice?
  - What will be the main non-monetary driver?
- Will hybrid (LED+OLED) luminaires provide the best of both worlds?
- Other? (i.e. audience participation)

Acknowledgements

Contributors

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