SOLID STATE LIGHTING: STATUS & PROSPECTS

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Disclosure: Forward-Looking Statements

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How Do We Produce White Light with LEDs?

- Blue LED Chip
  - Determines raw brightness and efficacy
- Phosphor system
  - Determines color point and color point stability
- Package
  - Protects the chip and phosphor
  - Helps with light and heat extraction
  - Primary in determining LED lifetime
In a typical, well-designed lighting fixture, discount component efficacy by ~20% (~10% driver, ~10% optics)
Driving Lumens Affordability with Technology

$/lm, normalized (Cool White, 6500K)

Annual Improvement in $/lm @ 100 LPW

<table>
<thead>
<tr>
<th>Year</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>43%</td>
</tr>
<tr>
<td>2006</td>
<td>45%</td>
</tr>
<tr>
<td>2007</td>
<td>35%</td>
</tr>
<tr>
<td>2008</td>
<td>29%</td>
</tr>
<tr>
<td>2009</td>
<td>45%</td>
</tr>
<tr>
<td>2010</td>
<td>40%</td>
</tr>
</tbody>
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Efficacy (LPW)

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Real-life Example of Value-Adding Innovations Driving Adoption

2008
• 3200 lm, 90 CRI
• 65 LPW
• Lots of LEDs
• ~$400

2013
• 3200 lm, 90 CRI
• 100 LPW
• 30 LEDs
• $159
• Payback <1y
Key LED Lighting Applications

- Healthcare
- Petroleum & Convenience Store
- Airports
- Restaurants & Hospitality
- Residential
- Education
- Government
- Municipal
- Retail & Grocery
- Auto Dealerships
Light Bulb – RIP?

Low initial cost
High quality white light
Terrible efficiency
Short lifetime

Extra Challenges for LEDs
• Legacy form factor
• Omni-directional
• Customer familiarity

$9.97 (450 lm)
$12.97 (800 lm)
80 CRI
75-85 lm/W (6x)
25,000 hour life (25x)

Looks like a light bulb, lit & unlit

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A Few Thoughts on What’s Coming

CONVENTIONAL SSL VALUE

• Recent system efficacy gains and cost reduction trends should continue
  – 200lm/W, 100lm/$ systems (but not together for a while)
  – Proliferation across most lighting segments – when and how, not if

NEW VALUE PROPOSITIONS

• Spectral engineering
  – Raise efficacy limits
  – Tailor to physiology
• Novel form factors
• Sophisticated integrated controls
  – Dynamic color tuning