Global LED Manufacturing

Insights from Epistar offer a global perspective on LED manufacturing, the evolution of LED technology, and the use of mid-power and high power LED in lighting

BJ LEE,
Jan 27, 2015
Outline

• Global LED Device Market
• Challenges of LED Device for TV BLU & SSL
• New Light Engine Design
• Summary
LED in Large Area BLU - less room for growth...

- Already high penetration
- Aggressive D-LED in TV BLU
  + Still growing avg. size
  + New TV Spec

2015 LA BLU \(\Delta = 0^-5\%\)

Source: DisplaySearch 2014, Epistar Marketing
Global LED Package Devices Market Trend

Main growth engine: Lighting and Automotive
Global BLU/SSL LED Demand in 2014/2015

### TV & Monitor

<table>
<thead>
<tr>
<th></th>
<th>Direct-lit TV</th>
<th>Edge-lit TV</th>
<th>Monitor</th>
<th>Smart Phone</th>
<th>Tablet</th>
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</thead>
<tbody>
<tr>
<td>‘14 M-Unit</td>
<td>119</td>
<td>98</td>
<td>162</td>
<td>1,163</td>
<td>301</td>
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<tr>
<td>TIE [M]</td>
<td>1.6</td>
<td>1.9</td>
<td>0.8</td>
<td>1.8</td>
<td>2.7</td>
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<td>‘15 M-Unit</td>
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<td>159</td>
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<td>TIE [M]</td>
<td>1.5</td>
<td>1.8</td>
<td>0.8</td>
<td>1.8</td>
<td>3.3</td>
</tr>
</tbody>
</table>

**10.3 M_TIE for 2014**

**11.0 M_TIE for 2015**

* TIE: two inch equivalent

### Lamp

<table>
<thead>
<tr>
<th></th>
<th>A-Bulb</th>
<th>T-Lamp</th>
<th>MR</th>
<th>Reflector</th>
<th>B/C/S/E</th>
<th>Street Light</th>
<th>High Bay</th>
<th>Parking</th>
<th>Down-light &amp; Ceiling</th>
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<tbody>
<tr>
<td>‘14 M-Unit</td>
<td>1,000</td>
<td>200</td>
<td>120</td>
<td>122</td>
<td>36</td>
<td>3</td>
<td>6</td>
<td>14</td>
<td>35</td>
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<tr>
<td>TIE [M]</td>
<td>13.8 M_TIE for 2014</td>
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<td></td>
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<td></td>
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<tr>
<td>‘15 M-Unit</td>
<td>2,000</td>
<td>400</td>
<td>160</td>
<td>159</td>
<td>57</td>
<td>4</td>
<td>6</td>
<td>14</td>
<td>35</td>
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<tr>
<td>TIE [M]</td>
<td>25.9 M_TIE for 2015</td>
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</tr>
</tbody>
</table>

### Luminaire

Source: DisplaySearch 2014, HIS 2013 & Epistar Marketing
Worldwide Lamp Installation

Source: IHS, Nov. 2013
Worldwide Lighting Market Trend

Light source market

End user revenue, M USD

~30%  ~50%  ~70%

Luminaire market

End user revenue, M USD

~30%  ~50%

Source: IHS, Nov. 2013
Global LED Device Major Players

Estimation by a price ratio of: Chip : Package = 1 : 2.5

- For BLU players, all Light Bar included,
- For SSL players, all lighting module included,
- For CREE, Luminaire included

2014 (est.)

Epistar 0.9B → 2.3B
0.7B → 1.8B

(Chip player)
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Revolution of LED Package Design for TV BLU

XVGA  |  HDMI  |  UHD 4K2K  |  UHD 8K4K

Edge-Lit  
- 0.2~0.5W 5630 PPA  
- 0.5~1.0W 7030 PCT  
- 1.0~1.5 W ????

Direct-view  
- 0.5~0.8W 2835 PCT  
- 0.8~1.2W 3030 EMC  
- 1.2~2.0W 3535 EMC w/ Flip-Chip

EPISTAR

LED’S BRIGHTEST LINK
From Backlighting to Lighting ... ...

- **2010**: 5630 PPA light-engine
- **2011**: 0.5W 5630 PPA
- **2012**: 0.8W 7030 PCT
- **2013**: 1.0W 3030 EMC
- **2014**: 1.5W 3535 EMC w/ Flip-Chip
- **2015**: ~3W SMC w/ Flip-Chip

What’s next?

**Edge-type BLU dominating** → **Direct-type BLU dominating**

EPISTAR

LED’S BRIGHTEST LINK
The BLU market use **Mid-power** LEDs
- Good performance, Volume production, Low cost, ... ... 

The SSL market use more and more **Mid-power** LEDs

The BLU market is trying low cost **Mid-size high power** (~2W) with **Flip chip** inside, ... ...
Packages Trend and Evolution

- **Leaded PLCC with PPA/PCT**
- **Higher T-operation**
- **miniaturization**
- **Leadless QFN with EMC/SMC**
- **Chip scale package (CSP)**
- **White chip (WC)**
Leadless QFN Become Popular ...

- Higher temperature material
- Better heat dissipation
CSP & White Chip are Advancing & Evolving … …

- Small footprint
- Wide angle
- Flip chip
- Good heat dissipation

<table>
<thead>
<tr>
<th>Size</th>
<th>Measurements</th>
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<tr>
<td>1.6x1.6 mm</td>
<td>1.6x1.6 mm</td>
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<tr>
<td>2.0x1.6 mm</td>
<td>2.0x1.6 mm</td>
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<tr>
<td>1.4x1.4 mm</td>
<td>1.4x1.4 mm</td>
</tr>
<tr>
<td>1.3x1.3 mm</td>
<td>1.3x1.3 mm</td>
</tr>
</tbody>
</table>
Low Cost Flip Chip Package – the Ultimate Solution?

Source: Lumileds, Epistar
Continuous Improvement in Efficacy, lm/W

1W device @ 350 mA/mm²
Endless Challenge of Cost Reduction, lm/$
Lm/$ Requirement for Different Applications

<table>
<thead>
<tr>
<th>Power Range</th>
<th>Lm/$ Requirement</th>
</tr>
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<tbody>
<tr>
<td>0.2W</td>
<td>Natural white</td>
</tr>
<tr>
<td>0.4-0.5W</td>
<td>0.4-0.5W</td>
</tr>
<tr>
<td>1-3W</td>
<td>1-3W</td>
</tr>
<tr>
<td>4-5W</td>
<td>4-5W</td>
</tr>
<tr>
<td>10W up</td>
<td>10W up</td>
</tr>
</tbody>
</table>

- **EMC 2016/PAA 3014**: 125lm/W
- **EMC 2016**: 110lm/W
- **PCT 3528**: 120lm/W
- **EMC 3030/PCT 5050**: 120lm/W
- **SMC 3030**: 110lm/W
- **CSP on board**: 120lm/W
- **COB**: 120lm/W
- **3535 Ceramic**: 140lm/W
- **EMC 5050**: 120lm/W
- **EMC 3030**: 140lm/W
- **PPA 5630**: 170lm/W

**COB**
- **EMC 2016**: 110lm/W
- **PCT 3528**: 120lm/W
Price-Efficacy Trade-Off for LED Package

@350 mA/mm², 25°C
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New Trend for Light Engine Design—CSP/WC on Board

**COB**

**HD COB—CSP/WC on board**

**Lateral Chip**

**Flip Chip**

EPISTAR

LED’S BRIGHTEST LINK
New Trend for Light Engine Design—Flip Chip on Board

Filament with Flip Chip on glass, may not best-fit but more reliable ...

Flip chip on board, No Wire, a lot of new application may be explored ...

EPISTAR
New Trend for Light Engine Design--Driver on Board

30ea x 3V ~ 90V

Easy to use

Fewer number of chips/pkgs

Limited space

Lower cost?

25ea x 3V ~ 75V

HV Chip

0.5 W

2S x (4*12)V ~ 96V

1.5 W

8 ea x 48V ~ 380V
High Voltage LED chip (HV LED)

Easily build up HV module for city power

Better current spreading
HV LED chips are perfect for Omni-directional bulb, candle, G9 etc..., which have limited space for drivers.
HV Light Engine for Industry & Outdoor Applications

Most of failures in LED outdoor luminaires are come from drivers ... ...

3V LED >> LV module + external driver

12~60V LED >> HV module + driver IC

Using HV module, by multiple chips or HV chips, with driver IC

better reliability & Lower system Cost
Benefits Using Driver on Board (DoB) ... ...

- Small form factor
- Lower cost compare to external drivers
- Reduce the inventory of components for various driver
- Acceptable dimmer function
- Lower cost and easy manufacturing at luminaire level
Made in USA is Feasible...

DOB + Parts >> Auto-assembly line
The growth of worldwide LED market is driven by general illumination and automotive lighting in the next few years.

Though LED BLU market has been saturated, the challenges of performance improvement and cost reduction drive innovations in chip and package design.

Mid-power LED chip and package has strong lm/$ and good lm/W, which has become a main stream in various lighting applications.

CSP and DoB are the new impacts to the market and can speed up the SSL penetration.

HV LED could be an important solution for many lighting applications.

DoB is easier to be adapted by conventional lighting fixture companies, and

Made in USA becomes feasible.
Thank You!