Chip Scale Package UV LED Enables the Highest Power Density Applications

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Feb 17, 2014
UV LED Major Challenges
Limited by package and spacing

- Achieving higher power density
- Maintain longer Life time
  - Silicone cracking
  - Wire bonding breaking
- Achieve tighter beam control
- Thermal management
- Reduce cost
LUXEON FlipChip UV in 380-410 nm
Unique UV LED enabling limitless design freedom

**Features**
- Industry leading optical power >650mW min at 395nm (500mA, T_{25C}) up to 45+% WPE
- High current and packaging densities for high lm output and lm/$ at high lm/W
- Chip-Scale-Package LED for surface mount
- Excellent reliability without wire bonds and encapsulation
- 1.0 mm² (1.0 mm x 1.0 mm five sided emitter
- Two large, widely spaced bond pads finished with UBM
- Low R_{th} 2.5K/W (395 nm)

**Benefits**
- LUXEON FlipChip is the at heart of new Lumileds products
- Customers now have complete design flexibility to access Lumileds’ industry leading performance at the die level and customize the phosphor and packaging to best suit their lighting application.
Typical LED Chip Structures

FlipChip eliminate wire bonds

**Lateral Chip**
- classical
- lowest cost
- limited driving current
- higher Vf
- 4 wire bond (1mm² die)

**FlipChip**
- good thermal
- higher light extraction
- higher driving current
- lower Vf
- **no wire bond** (1mm² die)

**Vertical Thin Chip**
- best light extraction
- higher driving current
- complex manufacturing
- no side wall light
- 2 wire bond (1mm² die)

Die cost is getting higher
LUXEON Flip Chip
Advantaged flip chip architecture -> chip scale package

- 1 mm x 1 mm chip size
- Sapphire on top, Epi junction at bottom
- Two large bond pads with 200 um spacing
- 5 sided emitter
- Under bump metallization for various solder paste and substrate options
Building Block For High Density Package
Small footprint enables highest power density

- Small footprint enable high flux, high density package
- Compact LED architecture enables light system BOM cost savings

1 x 1 mm² chip scale package vs. 3.5 x 3.5 mm² common packaged LED footprint

Chip on board high lumen compact LED solutions

Flip chip + Remote Phosphor Film

vs.

- No wire bond → less spacing
- compact light source
- Add remote phosphor film for color control
LUXEON UV Die Size Benchmarking
Comparison of 395nm Array Irradiance – LUXEON UV vs. UV Die

1X View

<table>
<thead>
<tr>
<th>Company A Die</th>
<th>LUXEON UV</th>
<th>LUXEON Flip Chip UV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2 mm</td>
<td>2.2 mm</td>
<td>0.2 mm</td>
</tr>
<tr>
<td>5.2 mm²</td>
<td>2.9 mm²</td>
<td>200 microns between die</td>
</tr>
<tr>
<td>Spacing reserved for wire bonding</td>
<td>200 microns between LED’s</td>
<td></td>
</tr>
<tr>
<td>1.1 mm² UV die footprint</td>
<td>2.2 mm² LUXEON UV footprint</td>
<td></td>
</tr>
</tbody>
</table>

10X10 View

<table>
<thead>
<tr>
<th>mW/LED</th>
<th>Array W/cm²</th>
<th>Assembly Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,180</td>
<td>23</td>
<td>High</td>
</tr>
<tr>
<td>1,300</td>
<td>46</td>
<td>Medium</td>
</tr>
<tr>
<td>1,300</td>
<td>108 or 86*</td>
<td>High</td>
</tr>
</tbody>
</table>

* Includes 20% interference penalty
Array Density in Proof Concepts

Test Results

395-400nm
48up LUXEON UV Array

UV Array - Radiometric flux density vs If

- UV Flip Chip 92 W/cm² *
- Gen2 LUXEON UV 46 W/cm² *
- Gen 1 LUXEON UV 33 W/cm² *

Industry’s highest 395nm irradiance today = 20 W/cm²

Flip Chip UV Interference Penalty

- Interference between Flip Chip UV from side light emission
- 3 tests at 1.5mm pitch
- 1st test with center LED only, no surrounding LED’s
- 2nd test after mounting surrounding LED’s, only lighting up same center LED
- 6-19% penalty observed

* To be confirmed with Array tests. UV Flip Chip includes 20% interference assumption
LUXEON UV Portfolio Summary
Smallest, highest flux density, UV LED

- Micro footprint enabling highest array irradiances (W/cm²)
- 380-430 nm UV range
- 1A max drive current enabling more flux per LED
- $R_{th}$ as low as 5 K/W (packaged), 2.5 K/W (chip scale package) at 395 nm
- Up to 45+% efficiency, reducing heat management
- Undomed for precise optical control
- Robust surface mount device for UV source/system

Enables highest array irradiances and superior design freedom due to 1.0-2.2mm² micro footprint. Available from 380nm to 430nm
Thank you