APPLICATION NOTE

ChromaLit™ Remote Phosphor for Area Lighting Applications

May 2013

Introduction: In this application brief we present a novel 20,000 lm high bay module design based on a new tempered glass product from Intematix. The combination of a single piece conical mixing chamber, LED arrays or COBs and ChromaLit tempered glass results in higher efficacy, fewer assembly parts and simple module construction. ChromaLit technology offers superior efficacy at the system level (110 lm/W DC), superior quality of light at 5000K, > 70CRI, tight color control and an appealing neutral off-state appearance. The resulting system design meets total cost of ownership requirements for this market, offers extended product lifetimes (100,000 hours) and meets IP66 requirements. This differentiated combination makes it a desirable choice for lighting designers.

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Introduction to ChromaLit Remote Phosphor

High bay applications are a subset of area lighting, as illustrated in

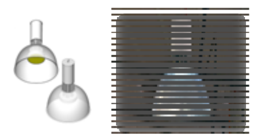
Area Lighting Applications		Performance Notes
High Bay Fixture – HID Style		•20,000 lm •5000K, 70CRI
Canopy Light		•12,000 lm •4000K, 5000K •80CRI, 70CRI
Outdoor Area Light		•20,000 lm •4000K, 80CRI

Figure 1 – Area lighting application examples.

Figure 1. All area lighting applications benefit from the use of ChromaLit technology, but the focus of this application brief is high bay applications, which are driven by efficacy and total cost of ownership. ChromaLit based solutions offer a scalable architecture and simple design rules for >20,000 lm and result in system designs with very high efficiency and uptime. Performance and cost are state of the art.

Market requirements for high bay and area lighting include a lower total cost of ownership, lower operating/ maintenance costs, maximized light output and efficacy, uniform intensity, low glare, flexible choice of CCT/CRI, use of controls at the system level, and safe and environmentally friendly materials (no mercury). ChromaLit designs offers a best-in-class solution in each of these areas.

Typical high bay systems in use today rely on either T5 or HID technologies as illustrated in

(a) (b)

Figure 2. The issue with these technologies is the lower system efficacy, the high cost of lamp replacement and disposal of old lamps.

ChromaLit-based solutions consist of arrays of blue LED sources, a reflective mixing chamber which aids in mixing and recycling the white light generated by remote phosphor, and the remote phosphor itself, which is a uniform, diffuse lambertian emitter, with minimum system glare.

(a) (b)

Figure 2 – Typical high bay fixtures based on (a) T5 industrial environment and (b) HID industrial environment.

The building blocks are illustrated in Figure 3. Remote phosphor systems offer higher efficacies when compared with white LED systems. In part this is due to thermal considerations and in part it is due to the elimination of package level losses in white LEDs. When phosphor is applied directly to blue LEDs for direct white light conversion, heat generated in the phosphor layer is removed via conduction through the LED package.

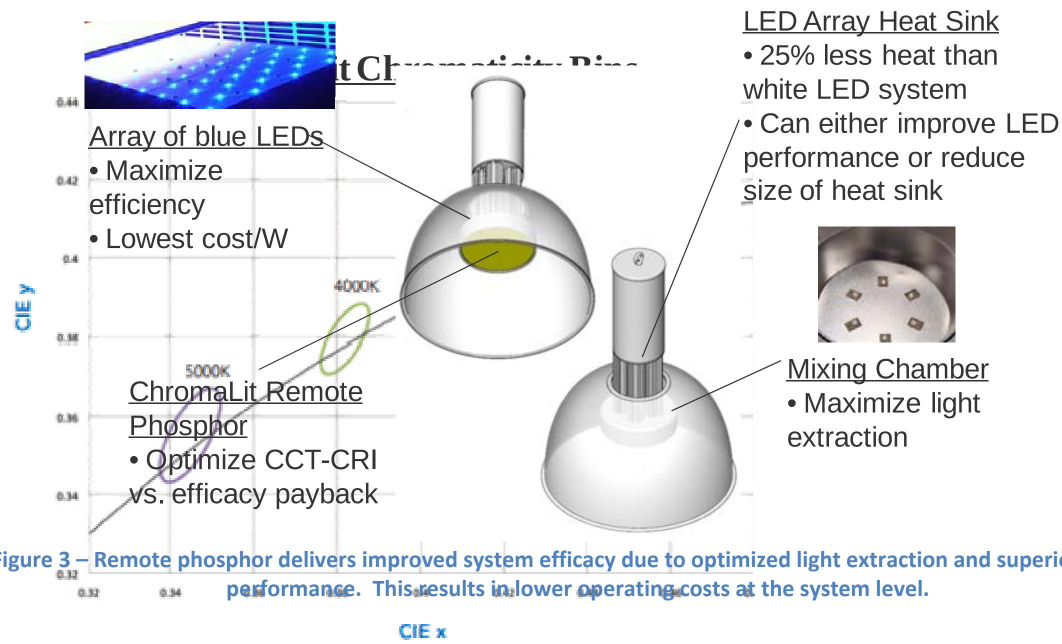


Figure 3 – Remote phosphor delivers improved system efficacy due to optimized light extraction and superior thermal performance. This results in lower operating costs at the system level.

Figure 5 – ChromaLit quality of light benefits

Temperatures in excess of 120°C are typical. This has impact on both performance and reliability of the LEDs. In remote phosphor systems, heat is removed mainly via convection (the remote phosphor is exposed to ambient air) and the thermal load on the heatsink is minimized. White phosphor-converted LEDs suffer package losses due to scattering and re-absorption of light at the package level. This can be avoided in remote phosphor systems. Lastly, most high bay systems require an outer diffuser to homogenize light. Remote phosphor acts as a diffuser plate, eliminating the additional loss of an external diffuser. All combined the efficacy benefits for remote phosphor can be as high as 30%.

One other benefit the benefit of ChromaLit is streamlined luminaire production. The use of remote phosphor reduces inventory and decreases cycle time. As shown in Figure 4, one needs to stock one blue LED engine to cover a wide range of applications. Customers can interchange ChromaLit components with different CCT and CRI combinations as needed. This also maintains the same form-factor and look at the system level throughout the product's lifecycle. White and blue LED improvements continue to occur at a very fast pace (every 6 months) which allows the product to keep the same look through obsolescence. The only changes would happen at the blue engine level (reduced LED count through performance improvements) – not noticeable to an end customer.

Figure 4 – ChromaLit streamlines luminaire production

ChromaLit offers quality of light benefits, which are summarized in Figure 5. The product assures single bin color consistency with capability of up to 2 SDCM. It works with a full range of royal blue LEDs from multiple vendors with ~455 nm average dominant blue pump distribution. The bins are centered on the black body line. Color over angle is also assured. It typically is < 3

MacAdam ellipses, while typical white LEDs have color over angle of > 6. Better white LEDs are available at a premium.

ChromaLit high bay fixtures benefit from the remote phosphor high diffusivity. Each component is a uniform Lambertian emitter with superior homogeneity. Thus, the need for diffusers is eliminated in ChromaLit-based systems.

Finally, ChromaLit is offered in tempered glass, which is a requirement for high bay applications. The robust design also assures that systems comply with IP66 requirements in terms of dust and moisture.

High Bay Requirements and Design

High bay system requirements are summarized in Figure 6.

- Up to 20,000 lumen output
- @ 5,000 to 6000K, 70 to 80 CRI
- >80lm/W
- 100,000hrs LED lifetime
- Warranty of 5 years or more for the full product
- IP66
- Possibility of integrated sensors
- -40ºC to +65ºC working temperature
- Tempered glass

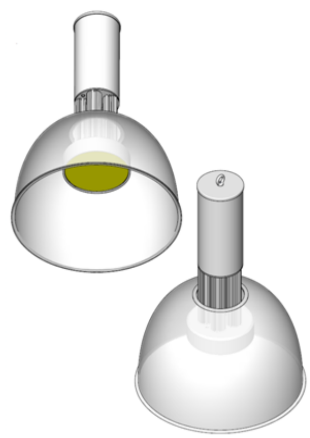


Figure 6 – High bay requirements

The 2000 lm module is based on a conical mixing chamber design with a simple construction. It uses LED arrays or COBs which are already mounted on a MCPCB board. Here we use LUXEON K16 arrays sold by Philips Lumileds.

Any number of materials can be used as reflectors for the mixing chamber, including ones from Furukawa, White Optics, Alanod and Almeco. Assembly variations are also easily eliminated by the choice of these components and the small number of components in the BOM makes it economical. The mixing chamber in this implementation is a single piece of vacuum formed material made of Furukawa poly carbonate (PC). This greatly simplifies the overall assembly and results in much improved manufacturing assembly yields.

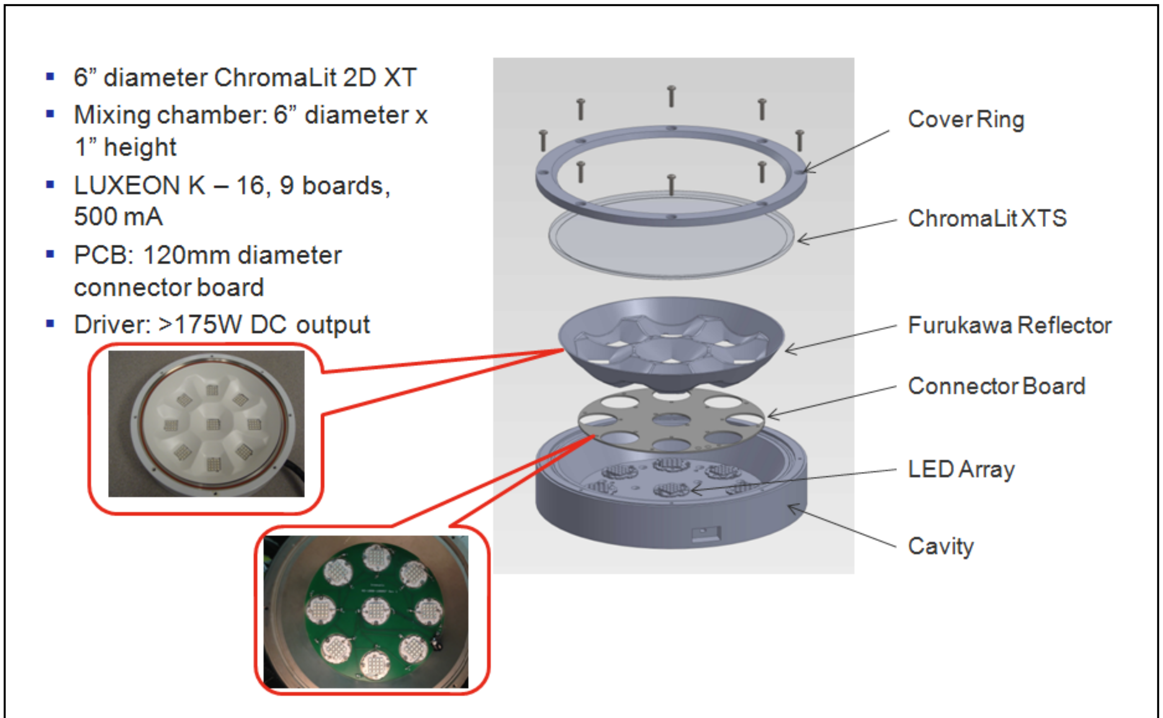


Figure 7 – 20,000 lm high bay design

The basic design is summarized in Figure 7

20,000 lm High Bay System Implementation

The key elements of our high bay system implementation are illustrated in Figure 8.


(a) (b)

Figure 8- Hardware implementation (a) heatsink, (b) completed system)

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In the next set of figures, we provide test data obtained from TUV, which is an accredited test laboratory.
Figure 9 is a summary of the test data.

TÜV SÜD America

GONIOPHOTOMETRIC TEST REPORT IES LM79-2008

Report# JI1300168-GONIO

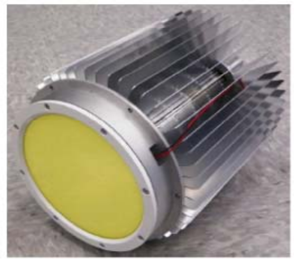
January 11, 2013

Summary of Key Test Results

Model#	High Bay
Manufacturer	Intematix
TÜV Sample#	539-1
Date of Test	January 10, 2013

Notes:

Tested in LBU orientation (Lamp-Base-Up)



Parameter	Measured Result
Luminous Flux	**22,367.7 Lumens**
Input Power	**202.84 Watts**
Efficacy	**110.3 Lumens/Watt**
Beam Angle	**113.8°**
Stabilization Time	**45 minutes**

The above results are recorded / derived from measurements in accordance with LM79-08

Figure 9 – Summary of test data

Figure 10 summarizes the photometric and electrical test parameters.

Test Results –

The following results were obtained after stabilization of the sample in accordance with the requirements set forth in section 5.0 of IES LM79-2008. Stability is achieved when the variation of 3 readings of light output and electrical power over a period of 30 minutes, taken 15 minutes apart, is less than 0.5%.

Photometric Results	High Bay Luminaire Goniophotometer
Total Luminous Flux (Lumens)	22,367.7
Luminous Efficacy (Lumens/Watt)	110.3

Electrical Results	High Bay Luminaire Goniophotometer
Input Power (Watts)	202.84
Input Voltage (Volts DC)	48.05
Input Current (Amps)	4.50
Power Factor	NA
Input Frequency (Hertz)	NA
A-THD (Current %)	NA

Additional Parameters	High Bay Luminaire Goniophotometer
Stabilization Time (Light and Power)	45 minutes
Test Geometry Configuration	Type C
Photometer	Gigahertz Optik P9801
Ambient Temperature	24.7°C
Spacing Criteria	1.28 (0° – 180°) / 1.28 (90° – 270°)

Figure 10 – Photometric and electrical parameters tested

	Illuminance at a Distance		
	Center Beam FC	Beam Width	
5.0ft	311.27 fc	15.3ft	15.3ft
10.0ft	77.82 fc	30.7ft	30.7ft
15.0ft	34.59 fc	46.0ft	46.0ft
20.0ft	19.45 fc	61.4ft	61.4ft
25.0ft	12.45 fc	76.7ft	76.7ft
30.0ft	8.65 fc	92.1ft	92.0ft
Vert. Spread: 113.8°		Horiz. Spread: 113.8°	

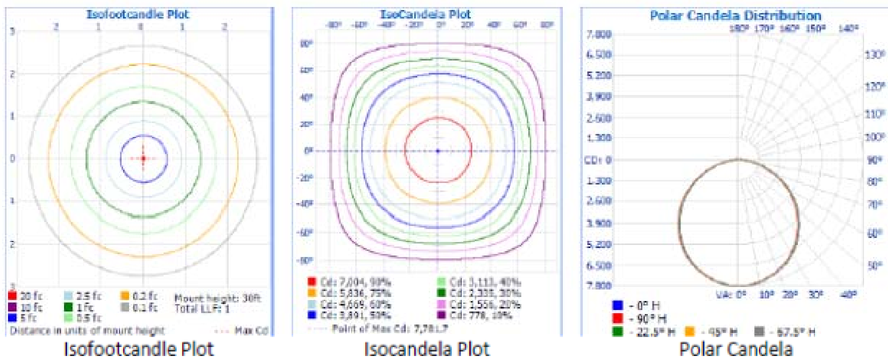
	Illuminance at a Distance	
	Center Beam FC	Field Width
5.0ft	311.27 fc	57.0ft
10.0ft	77.82 fc	114.0ft
15.0ft	34.59 fc	171.0ft
20.0ft	19.45 fc	228.0ft
25.0ft	12.45 fc	285.0ft
30.0ft	8.65 fc	342.0ft
Field Spread: 160.1°		

Beam Angle = 113.8°

Field Angle = 160.1°

Test Results – Candela Plots

The following images depict the luminous intensity distribution characteristics of the luminaire:



Finally,

Figure 11 shows the Illuminance plots for the high bay unit tested at TUV.

	Illuminance at a Distance		
	Center Beam FC	Beam Width	
5.0ft	311.27 fc	15.3ft	15.3ft
10.0ft	77.82 fc	30.7ft	30.7ft
15.0ft	34.59 fc	46.0ft	46.0ft
20.0ft	19.45 fc	61.4ft	61.4ft
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Vert. Spread: 113.8°		Horiz. Spread: 113.8°	

	Illuminance at a Distance	
	Center Beam FC	Field
5.0ft	311.27 fc	57.0ft
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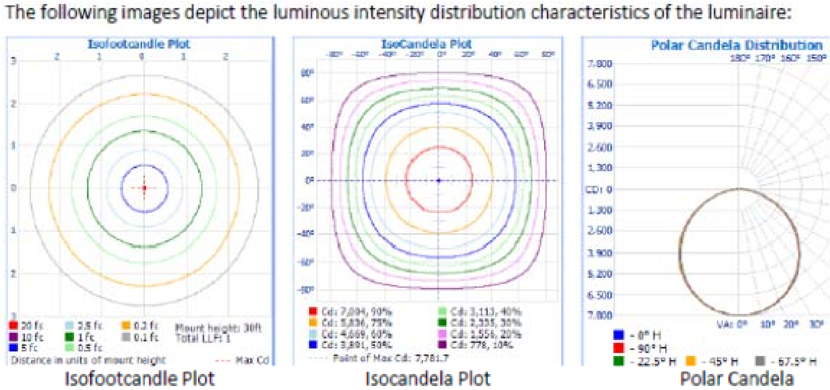

Figure 11 – Illuminance plots

Summary

We have presented a novel 20,000 lm high bay module design based on tempered ChromaLit glass and a new single piece conical mixing chamber approach. The same simple construction can be scaled down to 1000 lm and sub-1000 lm designs using smaller COB arrays. This is illustrated in
Figure 12.

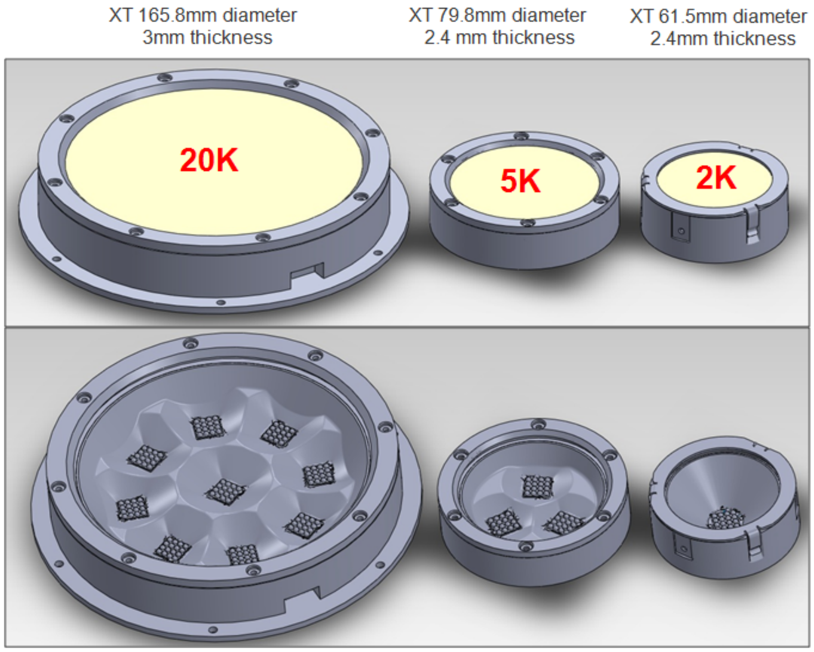

Figure 12 – Scalable downlight design allows the creation of 20,000 lm high bay designs to 5000, 2000 lm downlights and smaller downlights (<1000 lm) using the same simple assembly and a wide selection of ChromaLit CCT and CRI combinations.

The system offers superior cost of ownership and state of the art performance in terms of system efficacy, quality of light and system lifetime. Drawings for this reference design are available on request.

List of applications tools available

Intematix provides a number of application tools which are available on our website or via direct request. These include the following:

- **2D Demo kits**
  - NEW 2000 lm – Available Now
- **3D Demo kits**
- **Lumen Calculator Tool**
- **Collateral available on Intematix website (http://www.intematix.com/products/chromalit)**
  - Data sheets
  - Cut sheets

- IP Position
- Customer Case Studies
- Application notes

For more information, visit **www.intematix.com**
or contact Intematix at
phosphor@intematix.com or by phone at **+1 510.933.3300**