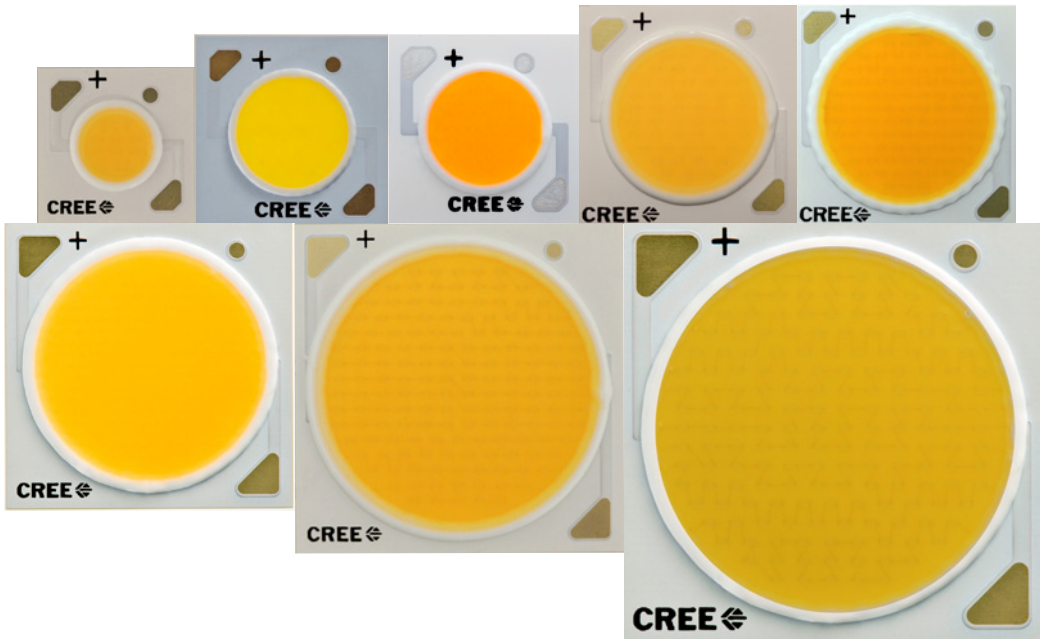
Cree® XLamp® CXA LED Design Guide



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INTRODUCTION

This guide simplifies the CXA luminaire design effort by providing basic information on the requirements to use Cree XLamp CXA LEDs successfully in luminaire designs, with appropriate consideration for mechanical, electrical, thermal and optical design and chemical compatibility. In addition, the Cree Solution Provider (CSP) program assists lighting manufacturers in identifying components and materials that work with Cree LEDs.[1]

In this document, the term CXA LEDs refers to Cree's ceramic substrate CXA LEDs, i.e., all the CXA LEDs except for the CXA2011.

Cree's CXA LEDs deliver high lumen output and efficacy in a family of single, easy-to-use components. CXA LEDs enable lighting manufacturers to quickly add LED products to their product portfolio. With Cree's CXA LEDs, lighting manufacturers can have performance, reliability and ease-of-use in a single LED.

This design guide explains how CXA LEDs and assemblies containing these LEDs should be handled during manufacturing. Please read this entire document to understand how to properly design with and handle CXA LEDs.

ABOUT THIS DESIGN GUIDE

This design guide provides critical design guidelines, principles and best practices for successfully integrating the XLamp CXA LED into new and existing luminaire designs.

- For additional product information or samples, please contact your Cree sales representative.
- For technical information and support, please e-mail us at productsupport@cree.com.

Consult the CXA family soldering and handling document for additional information on the proper procedures to solder and handle CXA LEDs.[2]

THANK YOU

Thank you for choosing to incorporate the XLamp CXA LED into your luminaire designs.

If you need assistance, Cree will support you with thermal testing assistance for lifetime analysis, available from Cree's Thermal, Electrical, Mechanical, Photometric and Optical tests (TEMPO) for LED luminaires.[3]

1 Cree Solution Provider Program, www.cree.com/LED-Components-and-Modules/Tools-and-Support/Solution-Providers
2 Cree XLamp CXA Family LEDs Soldering & Handling, AP74, www.cree.com/xlamp_app_notes/CXA_SH
3 Cree Services, www.cree.com/led-components-and-modules/cree-services

CXA FAMILY PRODUCT CAUTIONS

- XLamp CXA LEDs must be electrically connected to an unenergized driver before applying power. "Hot plugging," i.e., making a connection from a CXA LED to an energized driver, may cause irreparable damage and will void the product warranty.
- All installations and applications of CXA-based luminaires are subject to the electrical, construction and building codes in effect in the final installation location. Installation by professionals having experience in the area of electrical lighting and formal inspection by the Authorities Having Jurisdiction (AHJ) is strongly recommended.
- Thermal characteristics of CXA LEDs are affected by the luminaire and by the conditions in which the luminaire is installed. All final luminaire products should be evaluated in actual worst case installation conditions. Thermal limits of the CXA LED must be maintained for warranty consideration.

⚠ CXA LED surfaces may be hot during operation. Take care during handling to avoid burns.

⚠ Do not look directly at an energized CXA LED without proper eye safety precautions or diffusive shielding.

Failure to follow the design guidelines in this document may void the product warranty.

STORAGE & HANDLING

Store XLamp CXA LEDs in their original packaging to minimize potential for unintended contact and contamination.

CXA LEDs must be handled with proper electrostatic discharge (ESD) handling protocols. Remove CXA LEDs from their package at an ESD-safe workstation and use appropriate handling protocols and precautions when handling and soldering connections to the CXA LED.

- Handle CXA LEDs in a clean environment, i.e., free from particulates, oil residues, etc.
- Do not touch the light emitting surface (LES) of a CXA LED with tools or fingers. The LES is the part of the LED from which light is emitted. In the pictures on page 1 of this guide, the yellow or orange circle on each CXA LED is the LES.
- Do not allow foreign material to touch the LES of a CXA LED.
- Do not assemble CXA LED-based luminaires in an environment in which foreign material can come in contact with the LED
- Material should be cleaned from a CXA LED by gently blowing the material off the LED with air or by wiping the LED with isopropyl alcohol (IPA).

MECHANICAL DESIGN

Typical Assembly

CXA LEDs are generally attached directly to a heat sink and discrete wires are used to deliver power to the LED, as illustrated in Figure 1. A thermal interface material (TIM) must be applied between the CXA LED and the heat sink to properly maintain thermal performance.

Without the use of a connector to attach a CXA LED to a heat sink, apply thermal adhesive or thermal tape between the CXA LED and the heat sink.

With a connector, apply thermal adhesive, thermal tape, a thermal pad, thermal grease, gel, gap filler or heat spreader between the CXA LED and the heat sink.

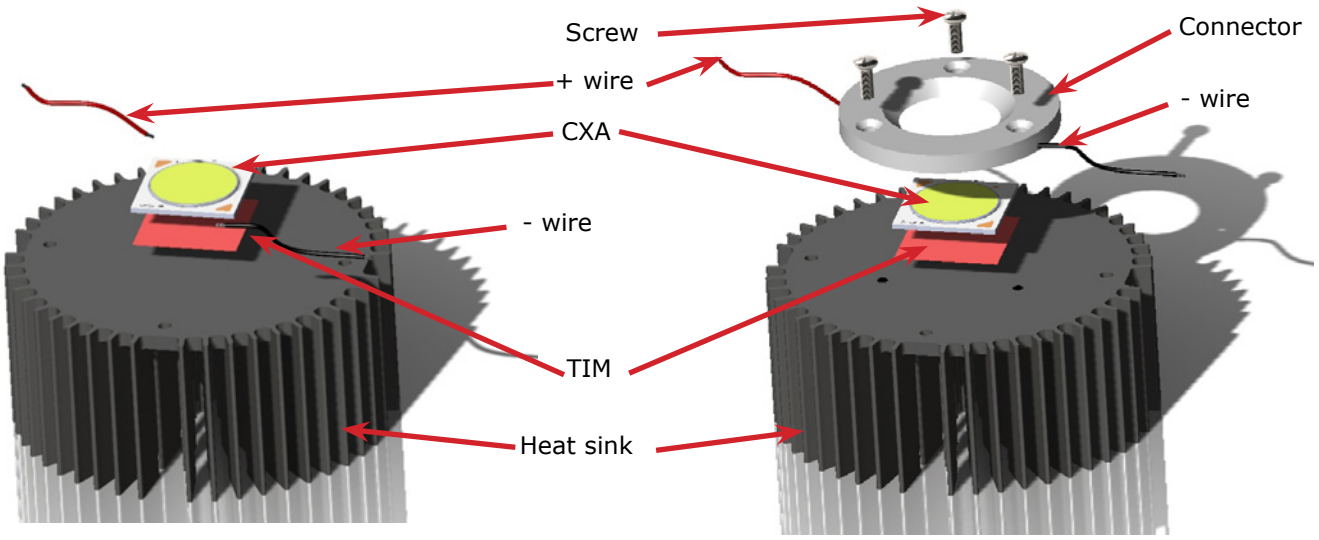

Figure 1: CXA LED connected to heat sink, left: without a connector, right: with a connector

Connectors

The use of a connector to attach a CXA LED to a heat sink simplifies aligning a secondary optic with the LES. Additionally, because a connector covers the LED's electrical connections, use of a connector simplifies the process of safety and regulatory certification.

Connector Resources

Table 1 contains model numbers and characteristics for connectors available from Interconnect Solution Providers that participate in the CSP program.[4] Each supplier name and model number is a link to additional information on the connector. These suppliers can provide assistance with connectors and connector information.

4 Interconnect Solution Providers, www.cree.com/LED-Components-and-Modules/Tools-and-Support/Solution-Providers/Interconnect

CXA LED/Characteristic	Supplier				
	BJB	Ideal	Molex	SMK	TE Connectivity
CXA13XX	47.319.6120.50	50-2000CR			2-2154857-2
CXA15XX	47.319.6101.50	50-2001CR	180560-0001		2-2154857-3 5-2154874-2 Z50 Z50 LP
CXA18XX	47.319.2130.50	50-2101CR			2-2154857-2 Z50 Z50 LP
CXA25XX	47.319.2140.50	50-2102CR	180720-0001	CLE9902-0791F	2-2154857-2 5-2154874-3 Z50 Z50 LP
CXA3050	47.319.2150.50	50-2234C			2-2154857-2
CXA35XX		50-2303CR			
Screw size	M3	#5-40 (M3)	M2.5, M3	M3	No. 4 or M3x6-mm (minimum)
Maximum torque for screw (Nm)	0.5	0.3-0.5	0.4-0.8	0.3 ±10%	0.28-0.45
Reflectivity	97%				
Zhaga Book 3 compliant	Yes	Yes	No	No	No

Table 1: CXA connector model numbers

Cree recommends following the connector manufacturer's recommendations for both the amount of torque to apply to the connector and the TIM thickness.

Table 2 shows some of the optics available for CXA LED connectors. For more optics solutions, see Table 8.

CXA LED	Connector Vendor	Connector Part Number	Optic			
			Carclo Part Number	Khatod Part Number	LediL Part Number	Ideal LediL Adaptor Part Number
CXA13XX	BJB	47.319.6120.50				
	Ideal	50-2000CR				
	Molex					
	SMK					
	TE Connectivity	2-2154857-2				
CXA15XX	BJB	47.319.6101.50				
	Ideal	50-2001CR			Mirella	
	Molex					
	SMK					
	TE Connectivity	Z50, Z50 LP	Newton-12684 et al.	KCLP1683ST KCLP1682CR		

CXA LED	Connector Vendor	Connector Part Number	Optic			
			Carclo Part Number	Khatod Part Number	LediL Part Number	Ideal LediL Adaptor Part Number
CXA18XX	BJB	47.319.2130.50			F13659_ANGELINA-S-B F13660_ANGELINA-M-B F13661_ANGELINA-W-B F13662_ANGELA-S-B F13663_ANGELA-M-B F13664_ANGELA-W-B	
	Ideal	50-2101CR			Mirella-PF Lena Angela	50-2100MR 50-2100LN 50-2100AN
	Molex					
	SMK					
	TE Connectivity	Z50, Z50 LP	Newton-12684 et al.	KCLP1691ST KCLP1691CR		
CXA1830	BJB					
	Ideal					
	Molex					
	SMK					
	TE Connectivity					
CXA25XX	BJB	47.319.2140.50			F13659_ANGELINA-S-B F13660_ANGELINA-M-B F13661_ANGELINA-W-B F13662_ANGELA-S-B F13663_ANGELA-M-B F13664_ANGELA-W-B	
	Ideal	50-2102CR			Lena Angelina	50-2100LN 50-2100AN
	Molex					
	SMK					
	TE Connectivity	Z50, Z50 LP	Newton-12684 et al.	KCLP1691ST KCLP1691CR		
CXA3050	BJB	47.319.2150.50			F13659_ANGELINA-S-B F13660_ANGELINA-M-B F13661_ANGELINA-W-B F13662_ANGELA-S-B F13663_ANGELA-M-B F13664_ANGELA-W-B	
	Ideal	50-2234C			Lena Angelina	50-2100LN 50-2100AN
	Molex					
	SMK					
	TE Connectivity	Z50, Z50 LP	Newton-12684 et al.	KCLP1713ST KCLP1713CR		
CXA35XX	BJB					
	Ideal	50-2303CR			Angelina	
	Molex					
	SMK					
	TE Connectivity					

Table 2: CXA LED connectors and optics

Mechanical Damage to Light Emitting Surface

At no time should anything (tools, optics, hands) come in contact with the LES of a CXA LED. Such contact will damage the LED.

Cree performed tests to replicate handling that can damage the CXA LED LES. Figure 2 shows downward force being applied to a CXA LED LES. Figure 3 shows bent (blue arrows) and broken (red arrows) bond wires in a CXA LED due to force applied to the LES. Figure 4 shows a CXA LED that is only partially illuminated due to handling that damaged bond wires in the LED.

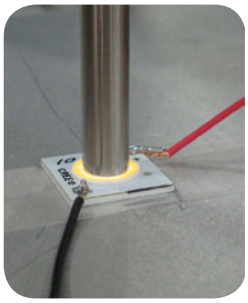

Figure 2: Force applied to CXA LED

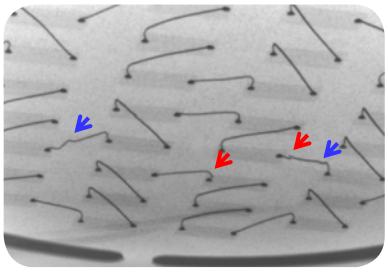

Figure 3: Damaged bond wires due to improper handling of CXA LED

Figure 4: Partially illuminated CXA LED due to damaged bond wires

Handling/Assembly

Do not attach screws directly to a CXA LED. Doing so will damage the LED. Figure 5 is an example of improperly attaching a CXA LED to a heat sink.

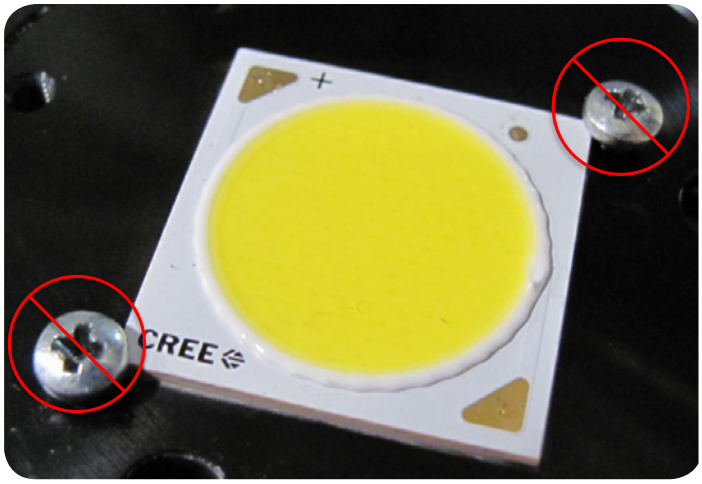

Figure 5: Do not attach CXA LED with screws

Figure 6 shows proper and improper handling of CXA LEDs with fingers and tweezers. Wear latex gloves when handling CXA LEDs. Doing so helps to keep the LES clean. Do not touch the LES with fingers, gloved fingers or tools.

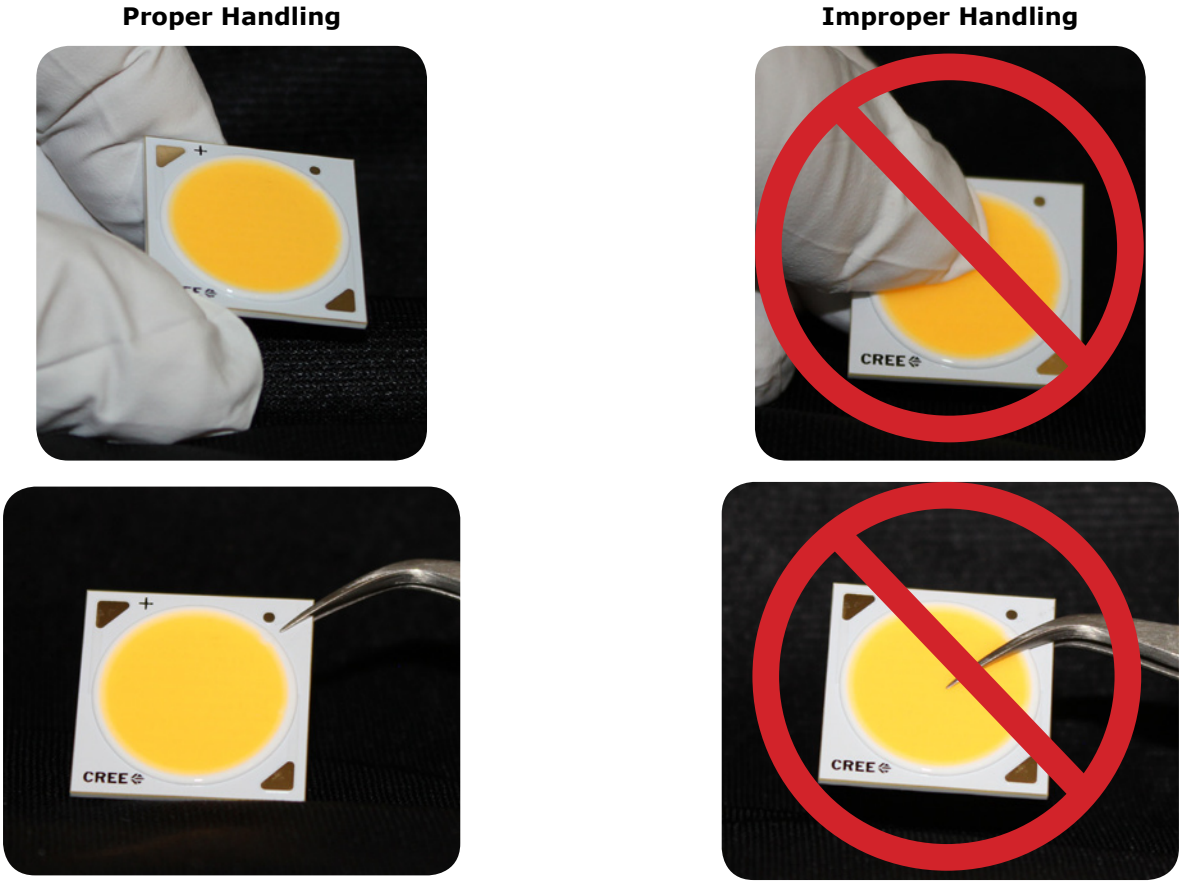

Figure 6: Correct and incorrect handling of CXA LED with fingers and tweezers

If wires are to be manually soldered to a CXA LED, Cree recommends using wire of the gauge shown in Table 3. These gauges apply when operating the CXA LED at its maximum current. If a lower current is used, a smaller gauge wire can be used. The wire strip length depends on the size of the CXA LED and should be no longer than the length of the solder pad, as shown in Table 3, .

LED	Wire Gauge		Wire Strip Length	
	AWG	mm²	in	mm
CXA1304	21	0.41	0.075	1.9
CXA1507	25	0.162	0.075	1.9
CXA1512	23	0.258	0.075	1.9
CXA1520	22	0.326	0.075	1.9
CXA1816	22	0.326	0.075	1.9
CXA1820	21	0.41	0.075	1.9
CXA1830	20	0.518	0.075	1.9
CXA2520	20	0.518	0.106	2.7
CXA2530	19	0.653	0.106	2.7
CXA2540	18	0.823	0.106	2.7
CXA3050	17	1.04	0.106	2.7
CXA3070	17	1.04	0.106	2.7
CXA3590	19	0.653	0.126	3.2

Table 3: CXA manual soldering wire gauge and wire strip length

Wire should not protrude outside the contact pad to minimize the potential to damage the LES or short around the ceramic dielectric. Any residual flux should be cleaned with IPA to minimize the potential for contamination or degradation of the silicone.

Figure 7: Left: Wires improperly attached to CXA LED, center: wires should not protrude beyond solder pads, right: excessive solder flux should be cleaned

THERMAL DESIGN

Heat & Lifetime

XLamp CXA LEDs are designed to perform over a range of operating temperatures. As with all LEDs, their expected lifetimes depend on their operating temperature. The acceptable case temperature (Tc) operating range for the CXA LEDs is 0 - 150 °C. When designing a luminaire that incorporates CXA LEDs, careful consideration must be taken to ensure a sufficient thermal path to ambient is provided. Verification of a proper thermal path is done on the finished

luminaire in the intended application by attaching a thermocouple at the Tc measurement point indicated in Figure 8 for each CXA LED.

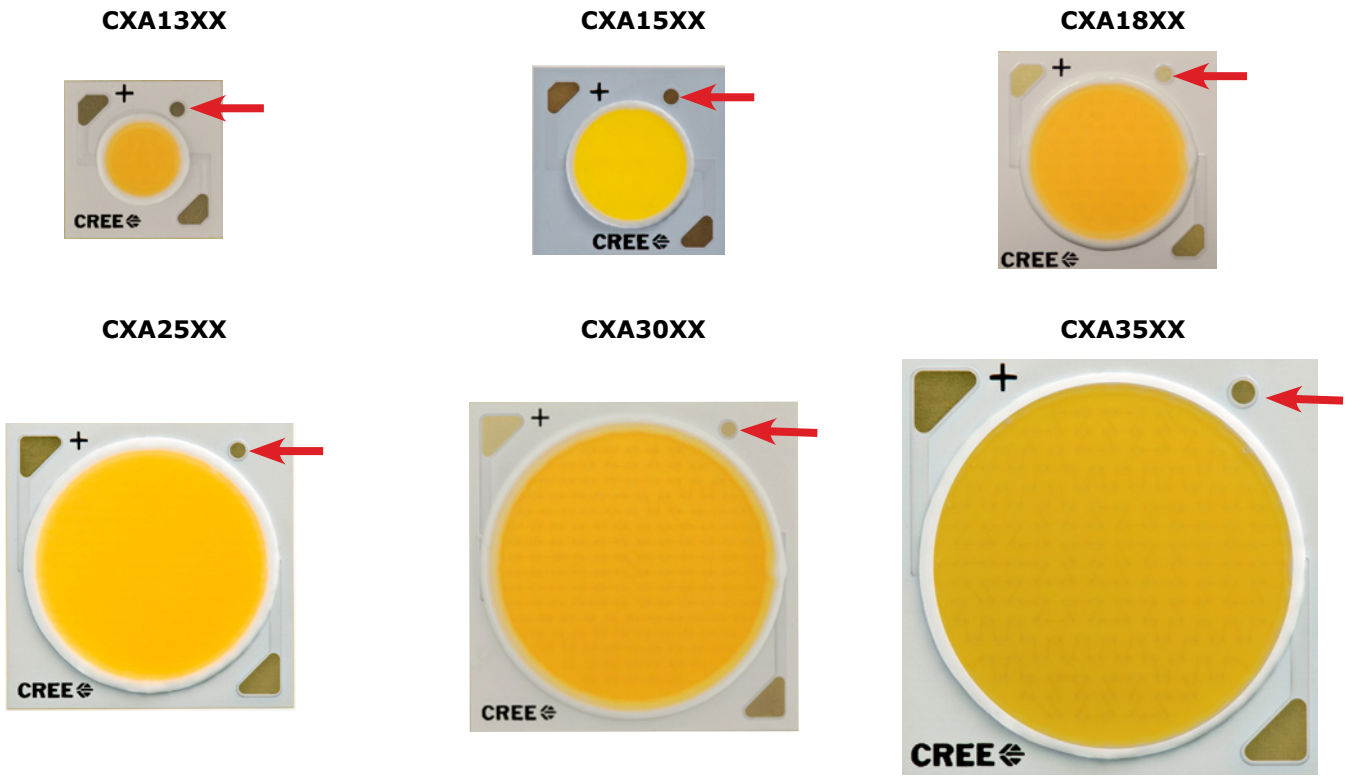

Figure 8: Tc measurement point for CXA LEDs

A summary of the LM-80 test results summary with reported TM-21 lifetimes is available on the Cree website.[5] Contact your Cree sales representative to request an LM-80 report for a CXA LED. Contact your Cree Field Applications Engineer (FAE) to request TM-21 projections.

Heat & Light Output

All CXA LEDs are rated for their nominal lumen output at a Tc of 85 °C. Temperature change from this point inversely affects the lumen output of the CXA.

The Operating Limits section of each CXA LED's data sheet gives the maximum current and Tc conditions under which the LED operates successfully. At operating temperatures above a certain point, different for different LEDs, the current level must be de-rated, i.e., lowered, to allow the LED to operate at peak effectiveness. See the Operating Limits section of this document for more information.

5 Cree LED Components IES LM-80-2008 Testing Results Application Note, AP57, www.cree.com/xlamp_app_notes/LM80_results

Ambient Temperature Measurement

The ambient temperature of the test environment must be monitored and recorded with the required data during a temperature test. The preferred ambient temperature measurement apparatus is described in UL1598-2008 Rev January 11, 2010, Section 19.5. The intent of this requirement is to ensure that the temperature monitored does not fluctuate. The ambient temperature of the space must be 25 °C ± 5 °C. Note that bare thermocouple wires in open air is not an acceptable method of recording the ambient temperature.

Thermocouple Attachment

Attach a thermocouple to the Tc point indicated in Figure 8. The attachment method described in UL1598-2008 Rev January 11, 2010, Section 19.7.4 is preferred; using silver-filled thermal epoxy is an acceptable alternative. Ensuring that the tip of the thermocouple properly contacts the LED at the Tc location and that the attachment method does not add thermal resistance to the test is critical to correct and acceptable testing. A thin (>30 AWG, 0.05 mm^2) Type-T thermocouple can be easily and quickly soldered directly to the Tc point. Type J and K thermocouples are also very popular. A temperature measured at the LES will be inaccurate and taking a measurement this way can damage the LED. Figure 9 shows a thermocouple properly attached to a CXA LED.

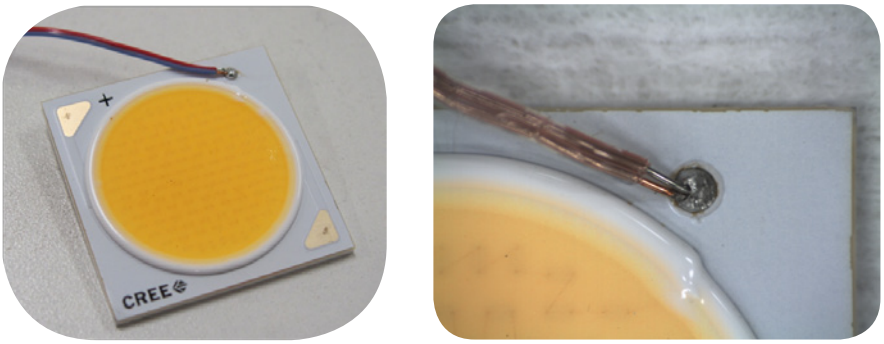

Figure 9: Thermocouple properly attached to CXA LED, left: thermocouple wire does not cross the LES, right: thermocouple attachment in close-up

> **Note** - Quick-drying adhesives and other cyanoacrylate-based products are known to be destructive, over time, to the components and adhesives used in solid-state lighting products. The use of cyanoacrylate-based products is at the discretion of the testing organization. Cyanoacrylate adhesives should not be used in any luminaire design or for any long-term testing.

Luminaire Case Temperature Measurement

Once the thermocouple is properly attached at the Tc location, assemble the CXA LED into the luminaire. The luminaire must then be tested in its intended environment or that environment which will result in the highest recorded temperature. Take care during assembly to ensure that the thermocouple remains properly attached and that the thermocouple wire is not in the light output from the LED. Energize the luminaire and allow the assembly to reach thermal equilibrium. Thermal stabilization may require several hours, depending on the mechanical design. Once thermal equilibrium is achieved, record the room ambient and case temperatures. Measure the CXA LED case temperature at the designated case temperature measurement point, adjacent to the anode or plus (+) solder pad. This measurement point is shown in Figure 8.

Cree has measured the temperature at the bottom of the CXA LED package, commonly referred to as the solder point (T_{SP}), and found this value to be equivalent to the temperature at the Tc location at the top of the package once the LED has reached thermal equilibrium. There is no need to calculate for T_J inside the package, as the thermal management design process, specifically from T_{SP} to ambient (T_a), remains identical to any other LED component. For additional information on Tc measurement, refer to the Solder-Point Temperature Measurement application note.[6]

Operating Limits

The Operating Limits section of each CXA LED data sheet has a graph similar to Figure 10. The plotted line is the maximum operating condition for the LED. The operating conditions, i.e., LED drive current and Tc, must be below the line. In the example graph in Figure 10, the CXA LED can be operated at 375 mA as long as the Tc remains at or below 100 °C. When the Tc exceeds 100 °C, the CXA LED must be operated at a lower drive current level and Tc, i.e., a drive current level and Tc in the green area below the plotted line in the graph.

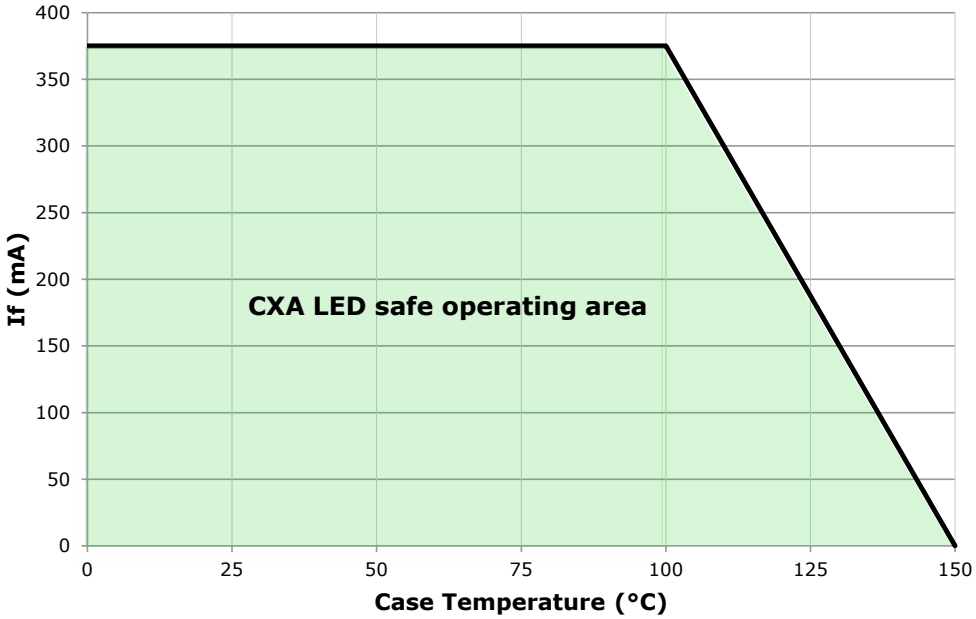

Figure 10: Example CXA LED operating limit graph

Heat Sink Flatness and Cleanliness

The use of an appropriate heat sink will improve thermal performance in LED-based luminaire designs and help maximize the LED lifetime. A heat dissipation path is required; CXA LEDs should not be operated without a properly tested heat dissipation path. Luminaire designs with a direct thermal path to ambient are desired and will provide the best results. Attaching a CXA LED to a clean, flat, smooth heat sink is required for good thermal transfer. The use of a TIM between the CXA LED and the heat sink is required.

The back of a ceramic substrate CXA LED is ten times smoother than the back of the aluminum substrate often used by other types of LEDs A ceramic substrate enables a better thermal contact with a flat, clean heat sink.

6 Solder-Point Temperature Measurement of Cree XLamp LEDs Application Note, AP157, www.cree.com/xlamp_app_notes/solder_point_temp

A quick way to check the flatness of a heat sink is to use a razorblade as a straight edge and touch the edge to the heat sink. Look for any gaps between the razorblade edge and heat sink. Figure 11 shows the procedure.

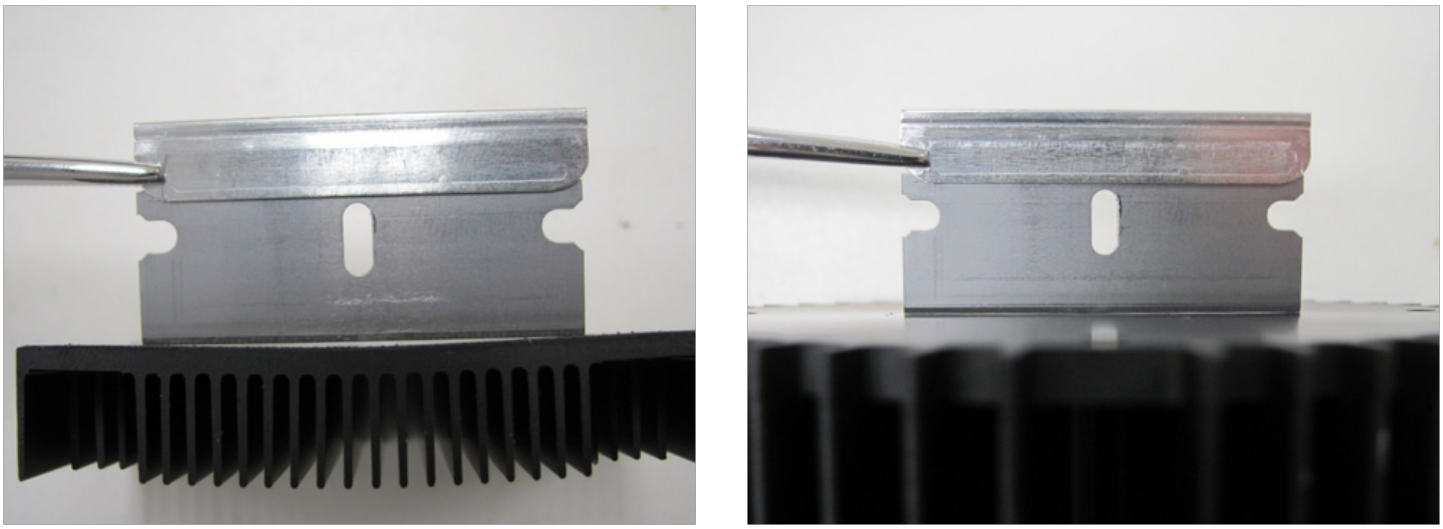

Figure 11: Checking heat sink flatness, left: a gap below the razorblade edge, right: no gap below the razorblade edge

Thermal Interface Materials

A good thermal connection between the CXA LED and the heat sink is critical for successful designs. A TIM is required for optimal performance. Air is a thermal insulator so a TIM is needed to fill any voids between the CXA LED and the heat sink as shown in Figure 12.[7]

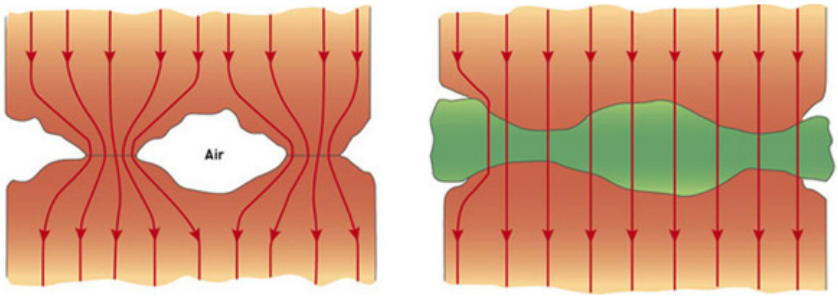

Figure 12: TIM fills the void between the CXA LED and the heat sink

Electrically isolated TIMs are not needed with CXA LEDs because the ceramic substrate acts as electrical isolation.

Make sure the TIM does not come into contact with the LES. There is a risk of failure of the CXA LED if this occurs.

The thermal resistance calculation is as shown in Equation 1. Cree's Thermal Management application note provides additional information.[8]

7 Copyright Dennis Publishing Limited. under licence from Felix Dennis, www.bit-tech.net/hardware/2009/02/16/all-about-tim/
8 Thermal Management of Cree XLamp LEDs Application Note, AP05, www.cree.com/xlamp_app_notes/thermal_management

$$\Theta_{TIM} = \frac{L}{k\ A}$$

Equation 1: TIM thermal resistance calculation

where:

Θ_{TIM} is the thermal resistance of the TIM

L is the thickness of the TIM (m)

k is the thermal conductivity of the TIM (W/m K)

A is the contact area (m^2)

At the high power levels that many of the CXA LEDs operate, it is necessary to use a TIM to ensure proper thermal operating conditions. The higher the power, the more critical this interface is. If the Tc is too high, i.e., above the CXA LED's operating limit, a better thermal solution needs to be found. Cree recommends thermal grease or thermal pads as the first choice for a TIM, with other TIMs as an alternative when circumstances make the use of thermal grease or thermal pads not viable.

Figure 13 shows the Tc of a CXA2540 LED connected to a Cree heat sink designed for use with the LMH2 LED module[9] for various power levels with several TIMs. Note that thermal grease and a thermal pad allow the LED to operate well within its operating limit. With other TIMs, the LED's Tc rises to beyond the LED's operating limit.

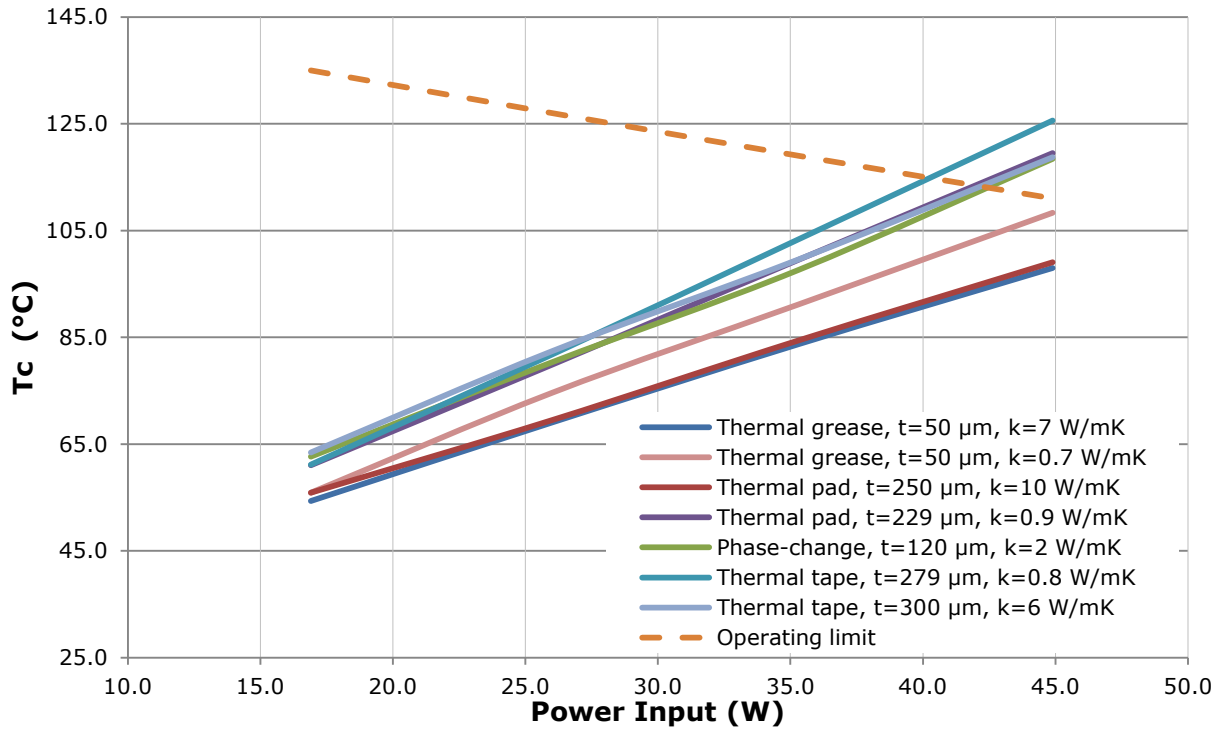

Figure 13: CXA2540 Tc vs. power

9 Order code LMH020-HS00-0000-0000001

Figure 14 shows the relative lumen output from a CXA2540 LED connected to the same Cree heat sink and operated at various power levels with various TIMs. The lumen output percentages are calculated relative to the output with thermal grease as the TIM. Note that a thermal pad allow the LED to operate at nearly the same lumen level as with thermal grease, but with the other TIMs the lumen level is initially lower than with thermal grease and decreases as the power increases.

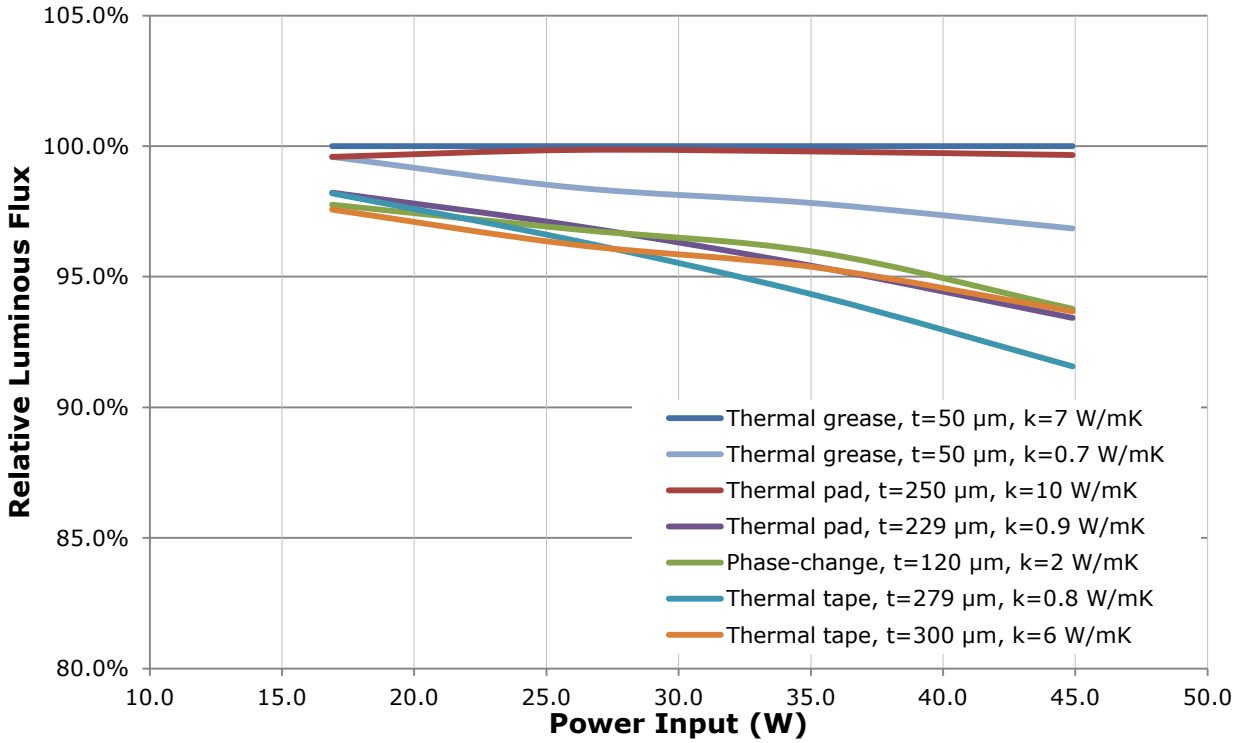

Figure 14: CXA2540 relative luminous flux vs. power

Using a TIM helps deal with process variations in heat sink manufacturing and ensures that differences in heat sink flatness/roughness can be accommodated. Figure 15 shows examples of the change in Tc when various TIMs are used on heat sinks with varying roughness.

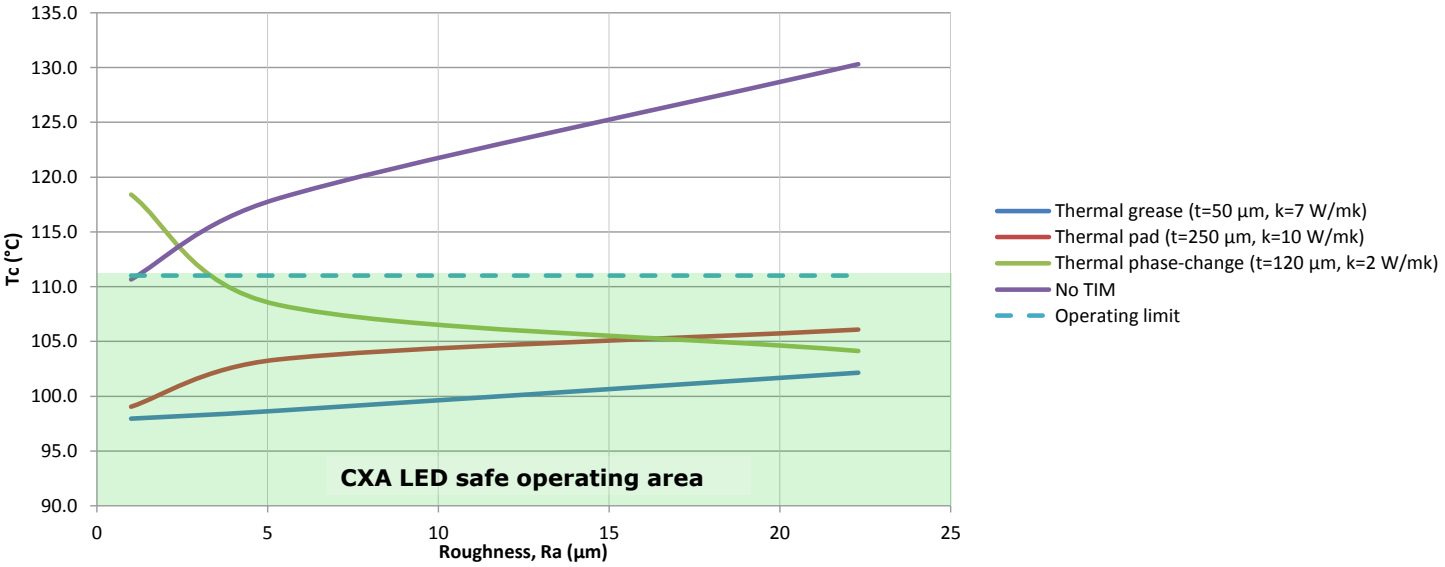

Figure 15: Tc vs. roughness

Cree recommends that the heat sink used with a CXA LED has an average roughness value (Ra) less than 10 µm. The following chart shows typical roughness values resulting from various manufacturing processes.[10] Once a heat sink is manufactured, finishing the heat sink by polishing or milling, for example, is important to achieve a smooth, flat surface. For comparison purposes, Table 4 contains size measurements for several grit sizes in several standards systems.[11]

10 E. Paul DeGarmo, J.T. Black and Ronald A. Kohser, *DeGarmo's Materials and Processes in Manufacturing,* Ninth Edition, John Wiley & Sons, Inc. (2003)

11 Orivs, Kenneth H. and Grissino-Mayer, Henri D., *Standardizing the Reporting of Abrasive Papers Used to Surface Tree-Ring Samples*, Tree-Ring Bulletin, Volume 58 (2002)

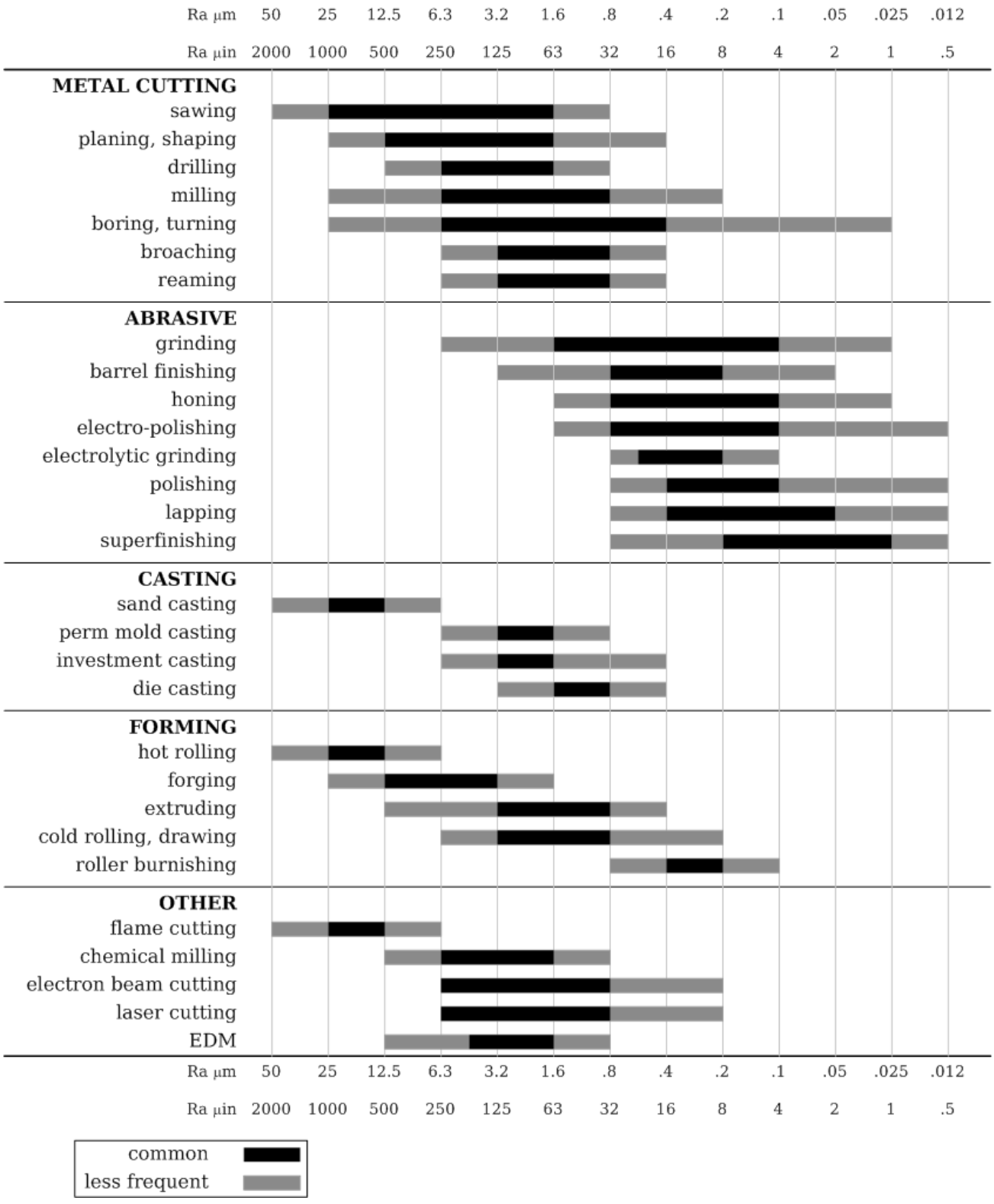

Figure 16: Roughness values from various manufacturing processes

International		US		Europe		Japan		China	
ISO (86)	µm	ANSI (74)	µm	FEPA (93)	µm	JIS (87)	µm	GB2478 (96)	µm
P100	125-150	100	125-149	P100	162	100	125-150	100	125-150
P220	53-75	220	53-74	P220	68	220	53-75	220	53-75
P400	33.5-36.5	320	32.5-36.0	P400	33.5-36.5	400	32.0-36.0	W40	28.0-40.0
P1000	17.3-19.3	500	16.7-19.7	P1000	17.3-19.3	800	17.0-19.0	W20	14.0-20.0
P2500	7.9-9.1	1000	6.8-9.3	P2500	7.9-8.9	2000	7.8-9.2	W10	7.0-10.0

Table 4: Sandpaper grit sizes

Thermal Design Resources

The Thermal Solution Providers listed on the Cree website[12] can provide assistance in designing a thermal system.

Table 5 contains examples of recommended TIMs from several suppliers. This is not an all-inclusive list of available TIMs. The presence of a TIM in the table is not a guarantee or warranty of the TIM's performance in any particular installation. The absence of a TIM from the table does not necessarily imply non-performance. Contact your Cree Field Applications Engineer or the TIM supplier for help with specific case-by-case recommendations.

Supplier	Thermal Grease	Thermal Pad	Thermal Phase-Change	Thermal Tape	Thermal Adhesive	Thermal Gap Filler
3M	TCG-2035 Grease	5590H		8810	TC-2810 Epoxy	
Bergquist	TIC1000A	Q-Pad II	Hi-Flow 565UT	Bond-Ply 100	Luiqi-Bond SA 3505	Gap Filler 4000
GrafTech		HITHERM 1205/1210				
Lord	TC-426				MD-140SP	

Table 5: TIM examples

ELECTRICAL CONSIDERATIONS

Multiple CXA LEDs

If multiple CXA LEDs are used in a luminaire, it is best to configure the LEDs in series, not parallel, or use a multi-channel driver.

Electrical Overstress/Hot-Plugging

Electrical overstress (EOS) occurs when an LED is exposed to any current exceeding the maximum current specified in the LED's data sheet. The effect on the LED varies in severity depending on the duration and amplitude of the exposure however, any single EOS event has the potential to damage an LED. This damage can result in an immediate failure or in a gradual failure many hours after the event. A number of EOS protection devices are available to absorb electrical energy that would otherwise be dissipated in the LED or to block current from flowing in the reverse direction if the load is connected backwards. A good way to avoid EOS is to use a good quality driver, such as one from a Driver Solution Provider listed on the Cree website[13] or from a supplier that participates in the Driver Compatibility Program (DCP).[14]

12 Thermal Solution Providers, www.cree.com/led-components-and-modules/tools-and-support/solution-providers/thermal-solution-providers
13 Driver Solution Providers, www.cree.com/LED-Components-and-Modules/Tools-and-Support/Solution-Providers/Driver-Solution-Providers
14 Driver Compatibility Program, www.cree.com/drivercompatibility

Cree recommends adding EOS protection to luminaires that do not include an on-board power supply. The use of a simple, low-cost protection circuit can dramatically reduce the rate of returns from lighting customers. EOS, and hot-plugging in particular, is the most common problem Cree has observed in returned LEDs. In addition, Cree recommends extensive testing of LED luminaires that includes surge immunity, power cycling and electromagnetic compliance.

Some steps to prevent EOS events at a work station or assembly line include:

- Connecting a metal table to a common ground point
- Anti-static wrist straps for personnel
- ESD table mats
- ESD floor mats

Additional information on EOS can be found in the EOS and Pulsed Overcurrent application notes.[15]

Dielectric Voltage Withstand Testing

CXA LEDs do not require special handling for luminaire assembly line dielectric voltage withstand testing. The ceramic substrate of the CXA LED provides a high level of electrical isolation. Cree conducted dielectric voltage withstand testing to confirm this. Figure 17 shows the test setup. With two leads connected to the CXA LED and separated to prevent arcing and a dielectric voltage withstand tester set to 1 second and 5 mA limit, voltages starting at 1000 V and increasing to 5000 V in 1000-V increments were applied.

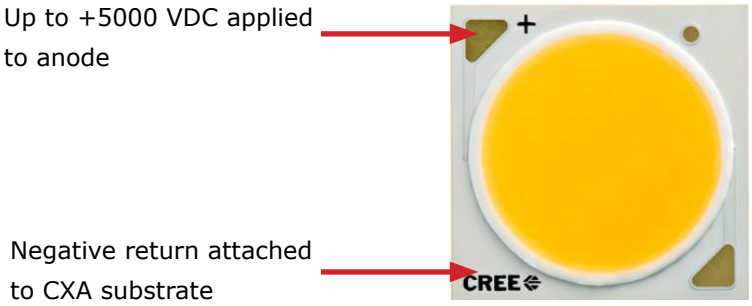

Figure 17: CXA dielectric voltage withstand test setup

The test results are shown in Table 6. Five individual LEDs of each model were tested. A check mark indicates the test passed.

15 Cree XLamp LED Electrical Overstress Application Note, AP29, www.cree.com/xlamp_app_notes/electrical_overstress
Pulsed Over-Current Driving of Cree XLamp LEDs: Information and Cautions Application Note, AP-29, www.cree.com/xlamp_app_notes/overcurrent_driving

LED	Test Results				
	1000 V	2000 V	3000 V	4000 V	5000 V
CXA1507	√	√	√	√	√
CXA1512	√	√	√	√	√
CXA2520	√	√	√	√	√
CXA2530	√	√	√	√	√

Table 6: CXA dielectric voltage withstand test results

The results of this testing gives luminaire manufacturers confidence.

- Electrically isolating thermal materials are not required.
- The CXA LED will comply with any testing to UL8750 section 8.4 Dielectric Voltage Withstand Test standards.
- The CXA will pass production system-level dielectric voltage withstand testing.

Reverse Voltage

CXA LEDs must not be energized with reverse voltage or catastrophic damage will occur. The LED can be protected by placing a barrier diode in series with the LED. Observe correct polarity when connecting a CXA LED to a driver.

CHEMICAL COMPATIBILITY

Consult Cree's Chemical Compatibility application note[16] for lists of recommended chemicals, conformal coatings and harmful chemicals and materials to be used or avoided in LED manufacturing activities. Consult your regional Cree Field Applications Engineer for assistance in determining the compatibility of materials considered for use in a particular application.

Avoid getting material, e.g., thermal grease, thermal adhesive or solder, on the LES of the CXA LED. Material contacting the LES will compromise the lumen output and can negatively react with the materials in the CXA LED to shorten the component's lifetime.

Chemical Resources

The Cree solution providers listed on the Cree website[17] can provide assistance with chemicals and conformal coatings.

OPTICAL CONSIDERATIONS

Optical Design

All CXA LEDs have a lambertian light distribution. The optical center and mechanical center is same on CXA LEDs. The small LES allows for easier optical control, particularly for narrow beam applications. The small LES and high luminous flux of the CXA HD series LEDs provide unrivaled lumen density for spotlight applications.

16 Cree XLamp LEDs Chemical Compatibility Application Note, AP63, www.cree.com/xlamp_app_notes/chemical_compatibility
17 Chemical Solution Providers, www.cree.com/LED-Components-and-Modules/Tools-and-Support/Solution-Providers/Chemical

Cree provides optical source models and ray files for CXA LEDs on the Cree website. All rays are originated on a plane. As shown in Figure 18, the Z = 0 point is on top of the LED substrate.

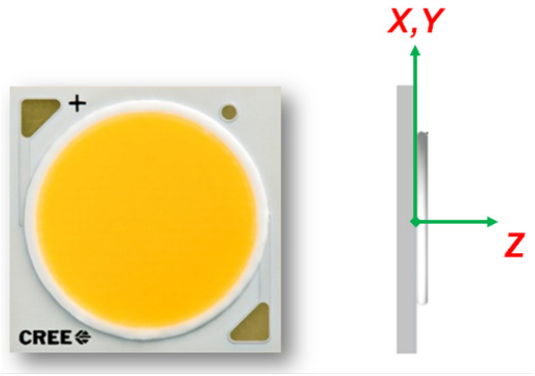

Figure 18: X, Y and Z axes in CXA LED ray files

When applying secondary optics to CXA LEDs, make sure the optics opening matches the LES. All light coming from the CXA LED needs to be collected by optics. Be sure there are no gaps between the optic and the LES that allow light to not be collected by the optics and that the optic does not obstruct the LES.

There are several ways to add secondary optics to CXA LEDs:

- Incorporate optics with the luminaire housing and directly add optics on top of the CXA LED.
- Connect the optics on the top of a connector and use the connector lock feature to attach the optics.
- Some optics are supplied with the connector and the optics and connector can be directly applied to the CXA LED.

Figure 19 shows examples of secondary optics and connectors.

Ideal Chip-Lok™ connector

Khatod LYRA reflector system

LEDiL reflector with connector

Figure 19: Secondary optics and connectors

CXA LES Comparison

Table 7 shows simulated performance data for CXA LEDs with the same reflector. This shows that the small LES size of CXA LEDs enables small beam angles and intense light. Note that the beam angle increases and the cd/lm decreases as the LES size increases.

Characteristic	CXA13XX	CXA15XX	CXA18XX	CXA25XX	CXA30XX
LES (mm)	6	9	12	19	23
Optics size - depth X height (mm)	120 x 60	120 x 60	120 x 60	120 x 60	120 x 60
Beam angle - full width half maximum (degrees)	5.6	6.7	7.1	13.2	13.8
cd/lm	38.0	26.0	23.0	10.3	9.5
Intensity at 400 lm (cd)	15,200	10,400	9,200	4,120	3,800
Intensity at 700 lm (cd)	26,600	18,200	16,100	7,210	6,650
Intensity at 1000 lm (cd)	39,000	26,000	23,000	10,300	9,500
Intensity at 2000 lm (cd)		52,000	46,000	20,600	19,000
Intensity at 5000 lm (cd)			115,000	51,500	47,500

Table 7: CXA LES Comparison

Optical Design Resources

Cree works with all major LED optical companies around the world to offer different types of optics for CXA LEDs. The secondary optics solution providers listed on the Cree website[18] can provide assistance in designing an optical system. The check marks (√) Table 8 show the optics available from secondary optics solution providers.

Optics Solution Provider	LED	Beam Angle			Web Link
		< 15 °	15 - 30°	> 30°	
Bicom	CXA 13XX				en.baikang.cn
	CXA 15XX		√	√	
	CXA 18XX				
	CXA 25XX		√	√	
	CXA 30XX		√	√	
Carclo	CXA 13XX				www.carclo-optics.com/optics-for-leds/cree/
	CXA 15XX		√	√	
	CXA 18XX				
	CXA 25XX				
	CXA 30XX				
DBM Reflex	CXA 13XX				www.dbmlighting.com/cree-optics/
	CXA 15XX	√	√	√	
	CXA 18XX				
	CXA 25XX				
	CXA 30XX				

18 Secondary Optics Solution Providers, www.cree.com/LED-Components-and-Modules/Tools-and-Support/Solution-Providers/Secondary-Optics-Solution-Providers

Optics Solution Provider	LED	Beam Angle			Web Link
		< 15 °	15 - 30°	> 30°	
Gaggione	CXA 13XX	√	√	√	www.lednlight.com
	CXA 15XX		√	√	
	CXA 18XX		√	√	
	CXA 25XX				
	CXA 30XX		√	√	
Kathod	CXA 13XX				www.khatod.com/Khatod/Search.aspx?4
	CXA 15XX	√	√	√	
	CXA 18XX				
	CXA 25XX		√	√	
	CXA 30XX		√	√	
LediL	CXA 13XX	√	√	√	ledil.fi/cree
	CXA 15XX	√	√	√	
	CXA 18XX		√	√	
	CXA 25XX	√	√	√	
	CXA 30XX		√	√	
Ledlink	CXA 13XX	√	√	√	www.ledlink-optics.com/ProductsHomeLED.aspx
	CXA 15XX	√	√	√	
	CXA 18XX	√	√	√	
	CXA 25XX		√	√	
	CXA 30XX		√	√	

Table 8: Optics for CXA LEDs

SAFETY & COMPLIANCE

As a matter of course, CXA LEDs are submitted for safety and compliance testing to standards such as European Union (EU) Registration, Evaluation, Authorisation and Restriction of Chemicals (REACh) and restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) and such organizations as UL.

CXA LEDs that have completed UL testing have a Level 4 enclosure consideration. The LED package or a portion thereof has been investigated as a fire and electrical enclosure per ANSI/UL 8750 so a luminaire based on a CXA LED does not need to cover the LED. Level 4 CXA LEDs are recognized to be able to operate in damp environments and with non-isolated or isolated LED drivers. Information on UL certification of CXA LEDs is available on the UL website.[19] Contact your Cree sales representative for the UL Conditions of Acceptability (COA) document for a CXA LED.

19 OOQL2: database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=OOQL2.E349212&ccnshorttitle=Light-emitting-diode+Packages+-+Component&objid=1082121000&cfgid=1073741824&version=versionless&parent_id=1081631557&sequence=1
OOQL8: database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=OOQL8.E349212&ccnshorttitle=Light-emitting-diode+Packages+Certified+for+Canada+-+Component&objid=1082121005&cfgid=1073741824&version=versionless&parent_id=1081631571&sequence=1

SUMMARY

Observe the following practices to maximize the performance of CXA LEDs.

- Work with CXA LEDs in a clean environment, free from any foreign material that could come into contact with and damage the LED.
- Do not touch the LES of a CXA LED.
- Wear latex gloves when handling CXA LEDs.
- Use a connector to attach the CXA LED to a flat, smooth and clean heat sink.
- Apply a TIM, preferably thermal grease or thermal pad, between the CXA LED and the heat sink.
- Operate a CXA LED within its operating limits, as shown in the LED's data sheet, to maximize light output and LED lifetime.
- If multiple CXA LEDs are being used, connect them in series.
- Cree Solution Providers can provide components that work well with CXA LEDs and guidance on best practices to use the components.

DESIGN EXAMPLES

This section contains design proposals for luminaires that incorporate CXA LEDs and are suggestive of luminaires that can be produced using CXA LEDs.

> Note - The examples depicted below are conceptual only. The inclusion of a concept in this group does not imply agency approval. The exclusion of any concept from this group should not be seen as a limitation. These examples are not proprietary or protected and may be reproduced wholly or in part as desired by a luminaire manufacturer. Final agency approval(s) and confirmation of acceptable operating parameters is solely the responsibility of the luminaire manufacturer.

A number of reference designs based on CXA LEDs are available on the Cree website.[20]

Decorative

20 XLamp LED Reference Designs, www.cree.com/ref

Downlight

Pendant

Track