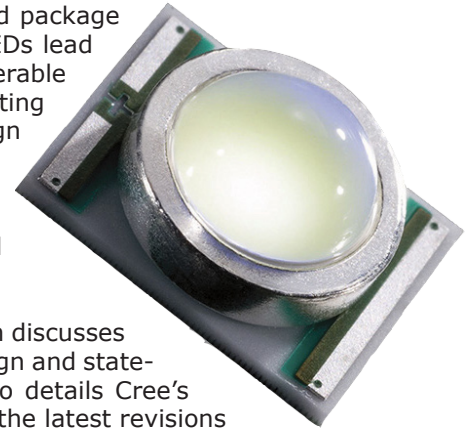


Cree® XLamp® LED Reliability

Cree XLamp LEDs combine the brightness of power LED chips with a rugged package capable of operating from a half watt to in excess of three watts. XLamp LEDs lead the solid-state lighting industry in brightness while providing a reflow-solderable design that is optimized for ease-of-use and thermal management. Lighting applications featuring XLamp LEDs maximize light output and increase design flexibility, while minimizing environmental impact.

Cree's approach to reliability starts at design and is carried over through product qualification, production-lot surveillance, incoming-material qualification and inspection and long-term-aging testing.

This application note describes the types of failures common to LEDs and then discusses Cree's approach to minimizing these failures through innovative package design and state-of-the-art, high-volume manufacturing processes. This application note also details Cree's rigorous qualification procedure for XLamp LED products in accordance with the latest revisions of Joint Electron Device Engineering Council (JEDEC) standards and provides a basis for projecting the long-term lumen maintenance of XLamp LEDs.



LED Failure

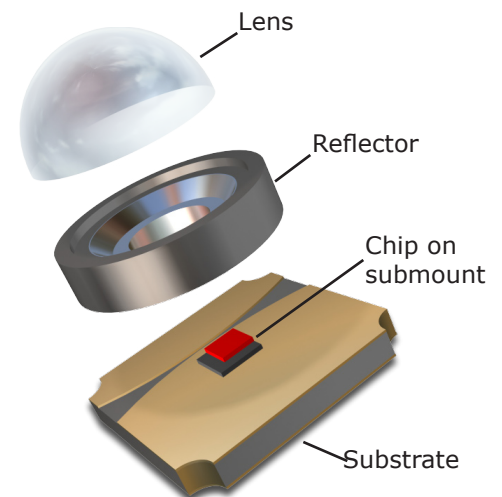
Light source failures can be divided into two categories, catastrophic and parametric. Catastrophic failures are failures that result in the cessation of light output from the source. Parametric failures are failures that result in changes that shift key characteristics outside of acceptable bounds. For LEDs the most important parameters are: light output, forward voltage, forward or reverse leakage, and color shift.

While it is rare for LEDs to experience catastrophic failure, all light sources see some level of parametric shift over time. For LEDs, this can be minimized by adhering to recommended junction temperature and current limits in circuit design.

Cree XLamp LEDs

As one of the world leaders in the production of gallium nitride (GaN) LED chips, Cree has coupled its strengths in manufacturing with its expertise in high-power packaging to create the XLamp LED product line. The XLamp LED platform was designed for volume production and is ideally suited for high power and long life-time applications due to its superior thermal conductivity and part-to-part consistency. In order to realize these advantages, XLamp LEDs must be mounted in a manner consistent with Application Note: Soldering & Handling, AP-04.

This unique platform features a thermally conductive and electrically neutral thermal path optimized to transfer heat away from the LED chip to the heat sink contact. The package also incorporates a durable metal reflector and a glass lens in a surface-mount design that does not rely on external leads for electrical contact. XLamp LEDs are designed to be used with standard surface-mount technologies such as pick-and-place and lead-free reflow solder. The ease-of-use of XLamp LEDs ensures lighting manufacturers that they can use standard, repeatable processes when designing XLamp LEDs into their products.



Qualification Test List

Before a product is released to production, representative samples must pass the following standard tests.

Test	Applicable Standards	Test Description
Room Temperature Operating Life Test (RTOL)	JESD22 Method A108-B	Temp = 25°C I _f = 350mA (7090), I _r = 125mA (4550) Time = 1008 hours Failure Criteria: <ul style="list-style-type: none"> Forward Voltage shift > 200mV between 0 and 1008 hours. Luminous Flux degradation > 10% on any lamp between 0 and 1008 hours. Forward or Reverse Leakage above maximum values specified in product data sheet. Catastrophic failures causing the lamp to become non-functional.
High Temperature Operating Life Test (HTOL)	JESD22 Method A108-B	Temp = 85°C I _f = 350mA (7090), I _r = 125mA (4550) Time = 1008 hours Failure Criteria: <ul style="list-style-type: none"> Forward Voltage shift > 200mV between 0 and 1008 hours. Luminous Flux degradation > 10% on any lamp between 0 and 1008 hours. Forward or Reverse Leakage above maximum values specified in product data sheet. Catastrophic failures causing the lamp to become non-functional.
Wet High Temperature Operating Life Test (WHTOL)	JESD22 Method A101-B	Temp = 85°C Humidity = 85% relative humidity (RH) I _f = 350mA (7090), I _r = 125mA (4550) Time = 1008 hours Failure Criteria: <ul style="list-style-type: none"> Forward Voltage shift > 200mV between 0 and 1008 hours. Luminous Flux degradation > 15% on any lamp between 0 and 1008 hours. Forward or Reverse Leakage above maximum values specified in product data sheet. Catastrophic failures causing the lamp to become non-functional.
Low Temperature Operating Life Test (LTOL)	JESD22 Method A108-B	Temp = -40°C I _f = 350mA (7090), I _r = 125mA (4550) Time = 1008 hours Failure Criteria: <ul style="list-style-type: none"> Forward Voltage shift > 200mV between 0 and 1008 hours. Luminous Flux degradation > 10% on any lamp between 0 and 1008 hours. Forward or Reverse Leakage above maximum values specified in product data sheet. Catastrophic failures causing the lamp to become non-functional.
Thermal Shock	MIL-STD-202G Method 107G	-40°C to 125°C 15 minute dwell time < 20 second transfer time , 200 cycles
Mechanical Shock	JESD22 Method B104-C	1500G 0.3ms pulse width 5 shocks each 6 axis (30 total)
Salt Atmosphere (Corrosion Test)	JESD22 Method A107-B Condition C	Temp = 35°C Salt deposit 30g/sq.m/day Time = 48 hours

In addition to pre-release testing, samples from each production lot of XLamp LEDs are tested according to RTOL, HTOL, and WHTOL procedures.

Procedures for RTOL, HTOL, WHTOL and LTOL

The following procedures are followed for RTOL, HTOL, WHTOL, and LTOL tests:

- Lamps are reflow soldered onto metal-core printed circuit boards (reference Application Note: Soldering & Handling, AP-04).
- PC boards are mounted onto heat sinks within reliability test chambers.
- While the LEDs are powered off, internal conditions within the test chambers are brought to those specified for the individual tests (i.e., 85°C/85% RH).
- Heat-sink temperature is maintained at the test-chamber temperature during the test.
- Power is applied to the lamps. In the case of WHTOL, power is applied in one-hour intervals that are followed by one-hour intervals without power in order to let the moisture penetrate the package as much as possible. This procedure results in a test that is more rigorous than one that calls for applying continuous power.
- At regular intervals power is turned off and the chamber conditions are brought to ambient conditions.
 - The boards are removed from the test chambers and the lamps are characterized according to reliability test criteria and inspected for visual defects.
 - The boards are placed back into the test chambers and the procedure is repeated until the test has concluded.

Lumen Maintenance Projections

Cree has accumulated operating data in excess of 18,000 hours. Using this data, long-term lumen maintenance can be projected. The method used for extrapolation is an exponential fit of the data from 1,000 hours until the end of the data set. Based on this method, XLamp LEDs are projected to have lumen maintenance of greater than 70% on average after 50,000 hours when used in accordance with published guidelines.

Summary

LEDs, like all light sources, experience parametric shifts over time. The XLamp platform was designed to minimize the mechanisms that cause these shifts. All Cree XLamp LED product lines undergo a rigorous qualification procedure before release. In addition, Cree continuously tests production lots under extreme conditions at the maximum rated currents. These methodologies conform with the latest JEDEC revisions.

XLamp LEDs are projected to have lumen maintenance of greater than 70% on average after 50,000 hours when used in accordance with published guidelines.

This document is provided for informational purposes only and is not a warranty or a specification. For product specifications, please see the data sheets available at www.cree.com/xlamp. For warranty information please contact Cree Sales at XLampSales@cree.com.