# Cree® XLamp® ML and MX LED Breakdown Voltage

**Breakdown voltage demonstration of two different materials conducting through an insulating medium, here, air[1]**

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## INTRODUCTION

Breakdown voltage is the minimum voltage that causes a portion of an insulating material to become electrically conductive and allow current to flow through the insulating material. This failure causes an irreversible effect, permanently damaging the component. The breakdown voltage paths within an LED can be complex, are heavily dependent on the material utilized in the LED package and often are not definitive. Therefore the LED breakdown voltage is most accurately presented as the mean breakdown voltage derived from a large sample set.

During the initial design phase of a lighting product using Cree XLamp® ML and MX LEDs, designers often want to know the minimum LED breakdown voltage that can be safely designed into their lighting product. In the study described in this application note, Cree's application support team tested the forward breakdown voltage of XLamp ML and MX LEDs to determine the voltage at which a breakdown occurs through the packaging material from the anode to the thermal pad.

The majority of XLamp MX LEDs tested showed breakdown voltages greater than 80 V. The majority of XLamp ML LEDs tested showed breakdown voltages greater than 90 V.

1 Copyright 2012 Aspen Labs, LLC, www.eeweb.com/electronics-quiz/what-is-the-breakdown-voltage-of-dry-air/





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## ML/MX PACKAGE DESCRIPTION

An ML/MX series package is a flat-top plastic leaded chip carrier (PLCC) package made up of a white polyphthalamide (PPA) reflector and a metal frame with an isolated thermal pad. LED chips are attached to the thermal pad. Unlike other XLamp LED products whose LED chips are attached to a ceramic-based substrate, the ML/MX series packages directly attach the LED chips to the metal thermal (heat sink) pad.

When designing a circuit board for XLamp ML/MX LEDs, it is critical to ensure that the thermal pad connections are electrically isolated from both the anode and cathode connections in the fixture circuit. If the isolated thermal pad on an XLamp ML/MX LED package is tied to either the anode or cathode pad in the LED board, breakdown of the insulation material would occur at much lower voltage than for other XLamp LED packages that have ceramic substrate material between the thermal pad and the back side of the LED chip.

The side view comparison of the XLamp ML/MX LED package to the XLamp XP LED package in Figure 1 shows the ML/MX LED directly connected to a heat sink, whereas the ceramic substrate of the XP LED separates the LED from a heat sink.

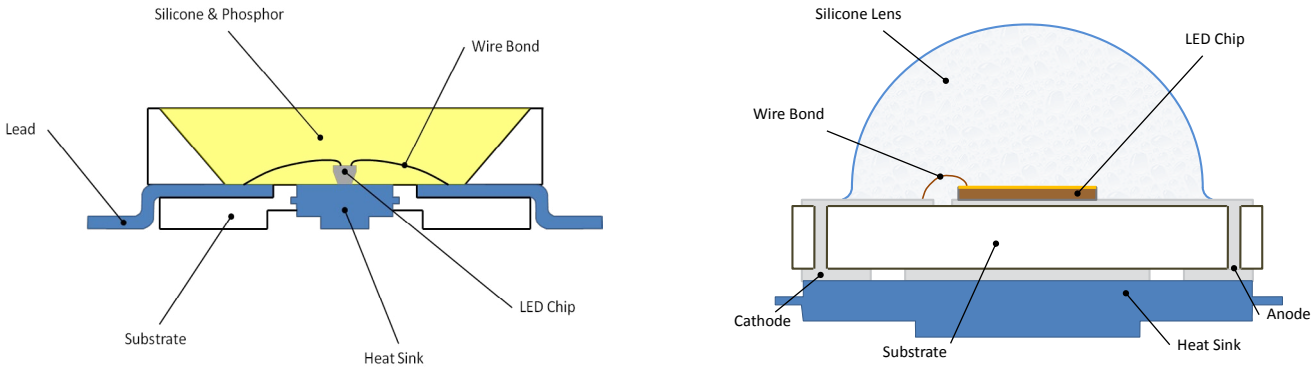



**Figure 1: Side view comparison of XLamp ML/MX LED (left) to XLamp XP LED (right)**

Figure 2 shows the thermal pad on the bottom of XLamp ML/MX LEDs.

Bottom view of ML LED

Bottom view of MX LED

**Figure 2: Bottom view of XLamp ML (left) and MX (right) LEDs**

## TEST METHOD

The basic concept of breakdown voltage testing is to apply a current-limited high voltage to an insulator and raise the voltage until the desired voltage level is reached or until a small amount (1 to 2 microamps) of leakage current flows. This small amount of leakage current is the point at which voltage breakdown is starting to occur for the LED device.

Using a similar concept, each XLamp LED tested for this study was connected to a Chroma Programmable AC Source Model 61503, which has a maximum DC voltage of 424 V. An input voltage ramping up from 10 V to 250 V and back down to 10 V was applied. A 610 k ohm resistor was connected in series with the XLamp LED under test to monitor the current flow, as shown in Figure 3.

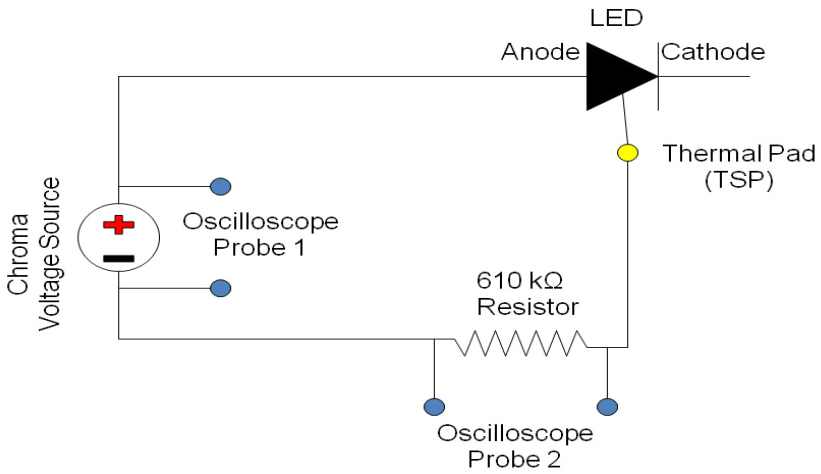



**Figure 3: Breakdown voltage test schematic**

The input voltage from the DC power source was represented on an oscilloscope as Channel 1 voltage and the voltage across the 610 k ohm resistor was represented as Channel 2 voltage. The breakdown voltage across the anode and thermal pad of the XLamp LED under test was determined as the cross point of these two voltages, as shown in Figure 4.

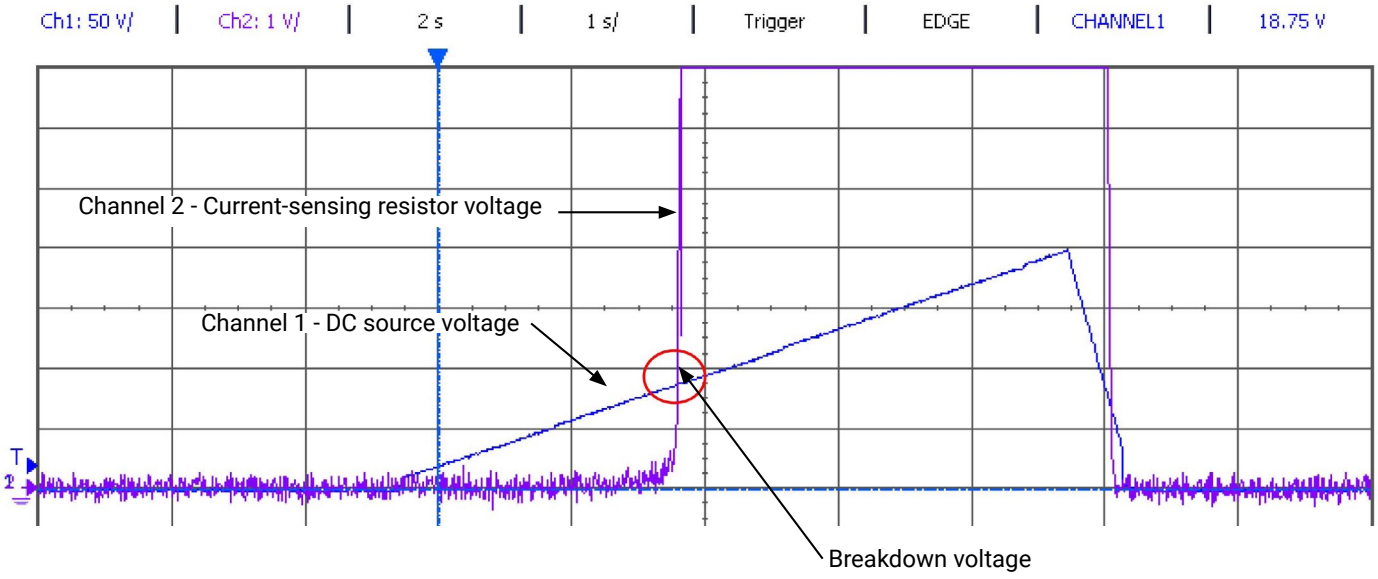
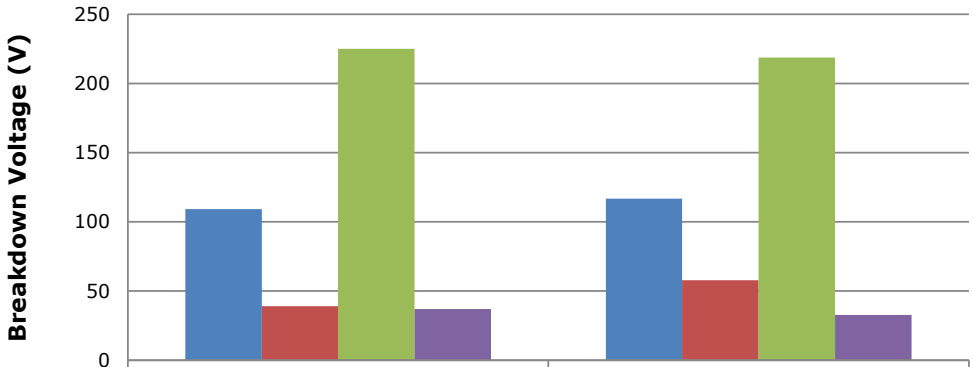



**Figure 4: Waveform capture of input voltage and breakdown voltage**

## TEST RESULTS

### MX Packages

Fifty LEDs of each product in the XLamp MX LED family (MX-6 and MX-3) were tested. The average, minimum and maximum breakdown voltages observed for these products are shown in Figure 5, along with the standard deviation for the breakdown voltages for each product.




| | MX-6 | MX-3 |
|---|---|---|
| Avg | 109.25 | 116.71 |
| Min | 39.06 | 57.81 |
| Max | 225 | 218.75 |
| Std Dev | 36.94 | 32.66 |

**Figure 5: Breakdown voltage comparison of XLamp MX LEDs**

### ML Packages

Thirty-one XLamp ML-E parallel white LEDs were tested. Breakdown voltages similar to those seen on XLamp MX LEDs were observed, as shown in Figure 6.

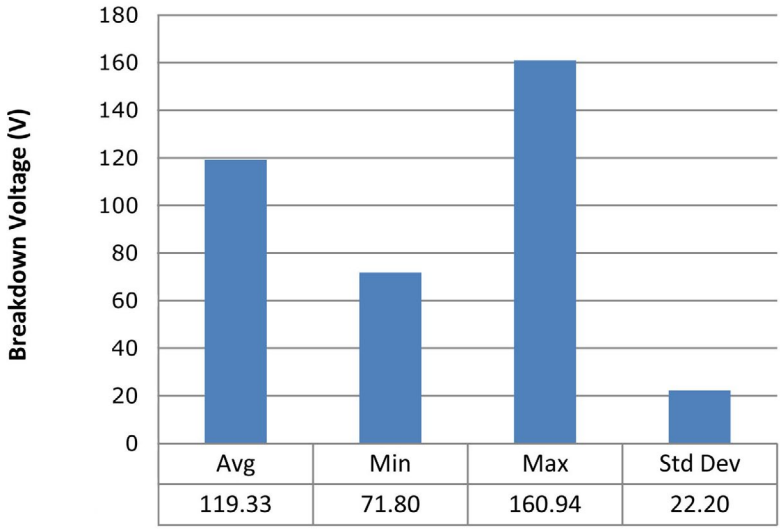



**Figure 6: Breakdown voltage of XLamp ML-E white LEDs**

## SUMMARY

The breakdown voltages observed for both XLamp ML and MX LEDs are much lower than the breakdown voltages observed for the ceramic-substrate based XLamp XP, XR, XM and XT LED families, typically greater than 1000 V. This is due to the ML and MX LED design configuration; the LED chip is directly connected to the metal thermal (heat sink) pad.

For this reason, electrically isolating the thermal pad connection from both the anode and cathode connections is one of the most important design criteria to follow when designing an LED board with products from the XLamp ML and MX LED families.

The average breakdown voltage for XLamp MX LEDs was tested to be in the range of 93 V to 118 V. The lowest minimum breakdown voltage was 39 V and the highest maximum breakdown voltage was 225 V. More than 84% of the LEDs tested showed a breakdown voltage greater than 80 V with close to 50% showing a breakdown voltage greater than that of the average observed for each product type.

XLamp ML-E LEDs were tested using the same test set-up and were found to have similar breakdown voltage ranges as the XLamp MX LEDs. The average breakdown voltage for the ML package was 119 V with minimum and maximum breakdown voltages being 71 V and 161 V respectively. More than 90% of the LEDs tested showed a breakdown voltage of greater than 90 V with 55% exhibiting greater than the average breakdown voltage of 119 V.

Although the majority of the LEDs tested showed breakdown voltages greater than 80 V for MX- and 90 V for ML-type packages, a helpful recommendation to follow when designing a robust LED circuit is to connect no more than 12 MX LEDs or 20 ML LEDs in series.