JESD51-14 Thermal Resistance Calculation Method

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INTRODUCTION

The thermal resistance (R_{th}) value reported on an LED data sheet is a critical parameter for developing and evaluating the design of any lighting system, especially for high-power applications or cases where long-term reliability is a focus. Building a thermal model using an incorrect R_{th} value can understate the expectation for LED junction temperature (T_j) causing worse performance or may overstate the T_j and lead to overdesigned fixtures at unnecessary cost or selection of a lower than optimal drive current.

To better serve our customers and allow for more accurate thermal models, Cree LED has updated R_{th} values for XLamp® LEDs, using the JESD51-1 test method together with the JESD51-14 Transient Dual Interface Test Measurement analysis method. This additional testing and analysis procedure improves the accuracy of the LED component R_{th} value, which is ideal for constructing a thermal model in any end-user fixture.

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JESD51-1 TEST METHOD

The JESD51-1 method for measuring thermal resistance of LED components is a simple dynamic test method that holds an LED at a low measurement current before applying a higher heating current for a period, then switching back to the measurement current. Heat generated by the LED during the high-current period causes the forward voltage (V_F) to decrease.

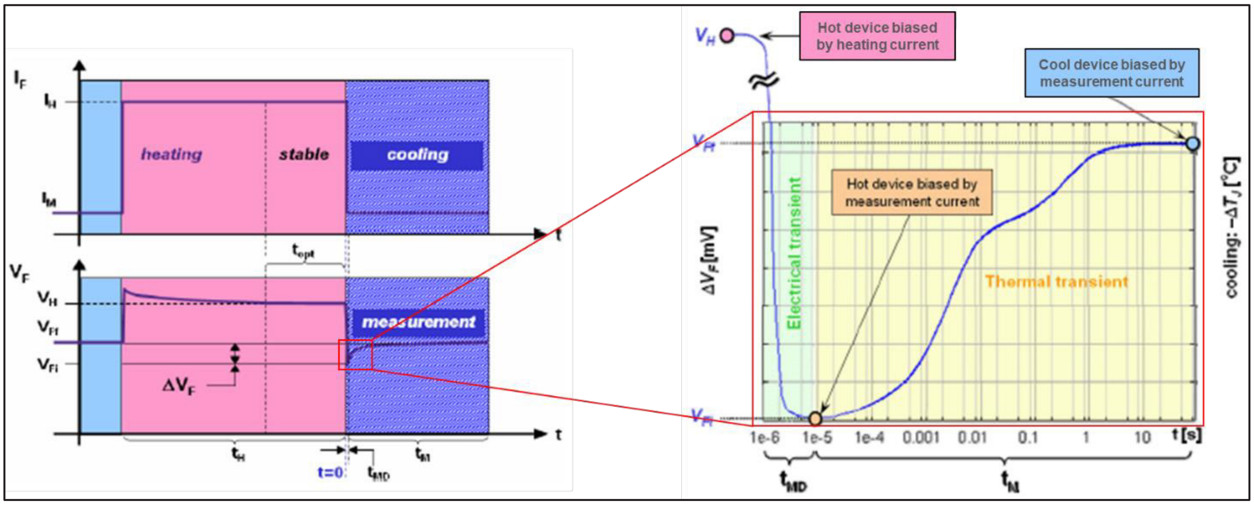

Figure 1: Forward current and voltage response of an LED during the JESD51-1 dynamic measurement

The difference in voltage at the measurement current immediately following the heating period, V_{Fi}, and once the component returns to thermal equilibrium, V_{Ff}, represents a measurable electrical analog for the temperature change of the LED itself. This voltage change is converted to a temperature change by dividing the ΔV_F value by the Temperature Coefficient of Voltage (TCOV). The change in temperature can then be divided by the input power during the heating period, yielding the system thermal resistance, as follows.

$$Rj,a = \frac{V_{Ff} - V_{Fi}}{TCOV \times I_H \times V_H}$$

This simple calculation provides a measure of the thermal resistance between the LED junction and the ambient environment, denoted $R_{j,a}$, which includes contributions from all equipment shown in Figure 2.

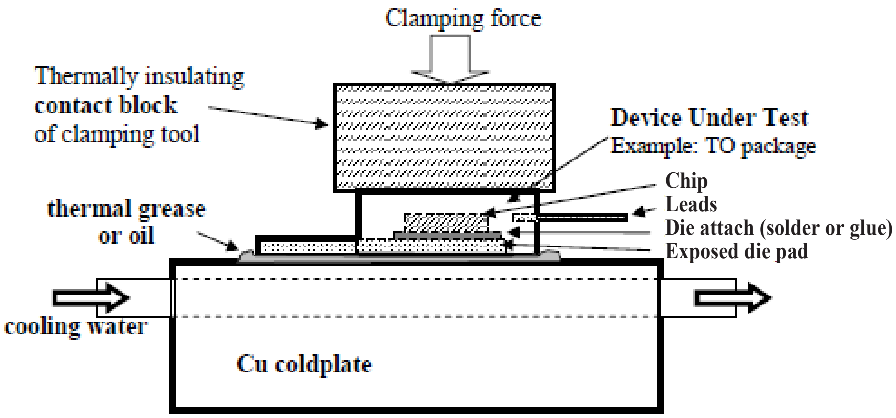

Figure 2: Typical measurement apparatus as depicted in JESD51-14

JESD51-14 ANALYSIS METHOD

The updated test method according to JESD51-14 uses the same testing apparatus and electrical measurement method as explained in the previous section. The new method differs by requiring the LED component be tested with both a "good" attach method (such as a standard solder or thermal grease) and a "bad" attach method (typically an electrically conductive adhesive), then performing some more complex data processing.

This processing results in a plot of thermal capacitance vs. thermal resistance that helps visualize layers of higher and lower thermal conductivity along the heat-flow path from the LED junction towards the cold plate. As the component is measured with both the "good" and "bad" attach materials, the curves are identical up to the interface between the solder pads of the component package and the attach material. This divergence point then denotes the LED component thermal resistance from junction to solder point, $R_{j,sp}$.

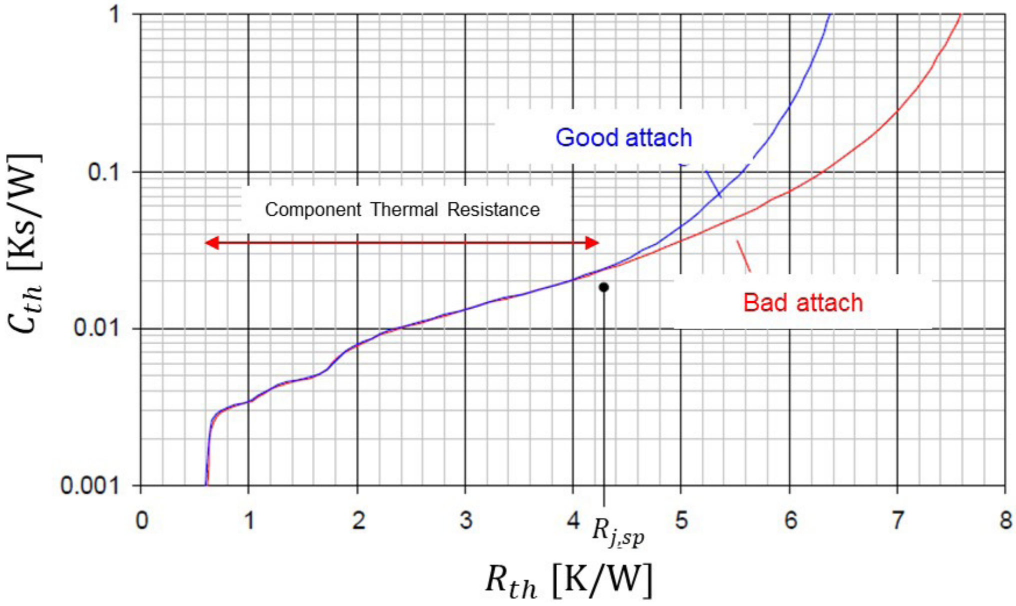

Figure 3: Thermal capacitance vs. thermal resistance curves for an LED component with "good" and "bad" attach materials

CONCLUSION

This R_{th} value derived through the JESD51-14 Transient Dual Interface Measurement method analysis of JESD51-1 testing is now the standard for Cree LED XLamp® LEDs, providing a significantly more accurate measure of the typical intrinsic component thermal resistance at binning conditions. This improved accuracy enables more sophisticated and representative thermal models of luminaires or other LED systems, providing additional confidence in a manufacturer's assessment of their design and system functionality.

Thermal resistance values listed on Cree LED data sheets that were derived through the newer JESD51-14 method will be denoted with the following footnote: "Thermal resistance measurement was performed per the JEDEC JESD51-14 standard."