CrayoNano®

Temperature Derating of LEDs

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Temperature Derating of LEDs

Introduction:
This document will cover methods for measuring and managing thermal properties of an LED. Thermal management and proper heat dissipation are extremely important for the design and the use of LEDs. Proper thermal design and management will greatly affect the performance and reliability of the UV-C LED package and must be considered for product design with proper lifetime considerations for the LED.

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1. Measuring LED Temperature and Power Output

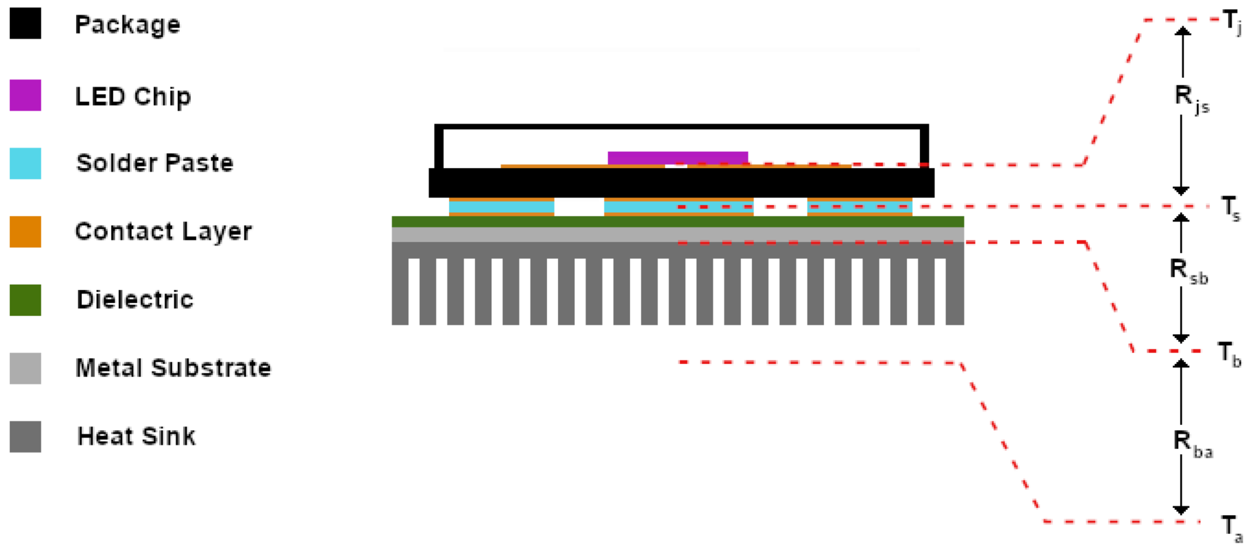
There are many factors that influence UV-C LED power output, with a primary factor being temperature. During operation of a UV-C LED, both light and heat are generated. With continued operation, the temperature of the device will increase based on the thermal management design. A critical parameter for operational power is the junction temperature, T_J, which is the temperature of the active region between the p-n junction of the LED chip. This active region is where carrier recombination generates light. When the junction temperature rises, the light output from the LED will decrease, which is defined as thermal derating.

When measuring the LED power output, proper thermal management design methods need to be used to achieve the best performance. For CrayoLED™ (CLH-N3S) H-series UV-C LED, from ambient operation at 25 ^{o}C, there is a 0.27 mW/^{o}C reduction in power as T_J increases. This means that at 35 ^{o}C, which is 10 ^{o}C hotter, there is a 2.7 mW reduction in light output for any given device.

2. Temperature Measurement Method

Measuring T_j directly is not feasible. Understanding the different measurement points and how they can be measured is important. There is more than one method to determine T_j. Before explaining the calculation methods, first the parts of an LED and cooling system need to be defined.

T_j – Temperature of the active region at the p-n junction within the LED chip
T_s – Temperature of the solder joint between the LED contacts and board contacts
T_b – Temperature of the PCB substrate layer
T_a – Ambient temperature outside of heatsink or cooling system
$R_{\theta js}$ – Thermal resistance of heat transfer in the LED between the junction to solder point (T_j => T_s)
$R_{\theta sb}$ – Thermal resistance of heat transfer in the PCB from the solder point to board (T_s => T_b)
$R_{\theta ba}$ – Thermal resistance of heat transfer in the cooling system from the board to ambient (T_b => T_a)



The Absolute Maximum Junction Temperature (T_J) as specified in the Product Specification must not be exceeded.

1. The LED's junction temperature may vary while in operation and is dependent on the module/system design, including but not limited to: PCB thermal resistance, the density of LEDs on the PCB assembly, thermal interface material specification, circuit material, PCB structure, ambient temperature and condition, etc.
2. Ensure that when using LEDs for a chosen application, heat is not concentrated in any one area and is properly distributed and transferred away from the LED in the complete system design.
3. The operating current should be determined by considering the temperature conditions surrounding the LED (i.e. T_a) to ensure sufficient heat is being dissipated.
    a. Power in the system is defined with this formula: W = Input Power (I_f x V_f)
4. To calculate the LED's junction temperature, the following two formulas can be used:
    a. $T_j = T_a + R_{\theta ja} \times W$
    b. $T_j = T_s + R_{\theta js} \times W$

3. CrayoNano Power Measurement Method

The packaged LED is first mounted to a starboard, details in chart below. The temperature of the board is regulated to the control temperature. For initial testing of devices, it is best to target a regulated temperature of 25 °C for with a temperature control fixture. The starboard is mounted to a control fixture to regulate T_b and T_a. Power is applied to the LED. The light output is measured in an integrating sphere to capture all the radiant flux that is emitted from the LED package. The control temperature is then varied to measure radiant flux, wavelength, and voltage at different temperatures to identify the de-rating characteristics.

Aluminium Metal Core Printed Circuit Board (MCPCB) is designed as below:

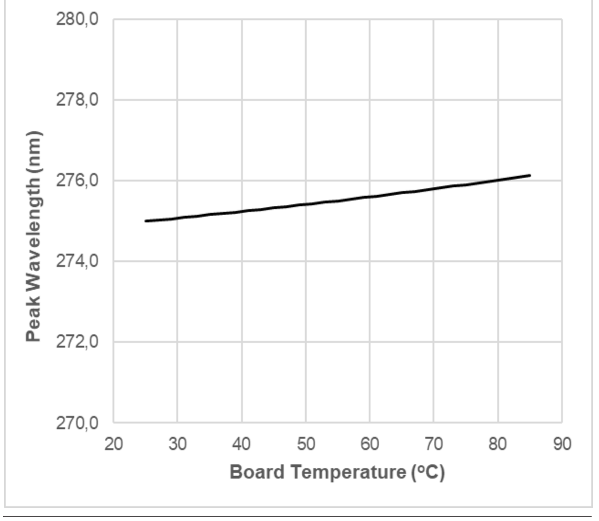
Circuit Layer	Copper 35 µm
Dielectric layer	Prepreg polymer Glass free 25 µm
Base layer	Aluminum 6061 1.57 mm

4. Temperature Derating

Below are the results of temperature derating based on how the effects are seen in radiant flux, wavelength, and voltage. The allowable forward current chart is based on the thermal design of the system with an assumed $R_{\theta JA}$ value of 20 °C/W.

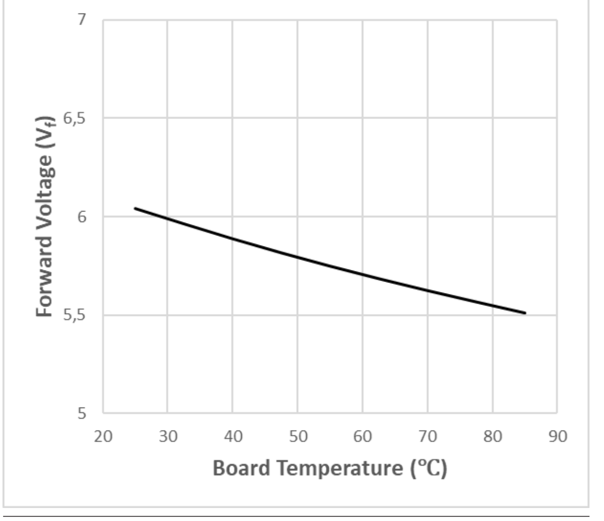
Typical Characteristic Curves for CrayoLED™ (CLH-N3S)

PEAK WAVELENGTH VS BOARD TEMPERATURE



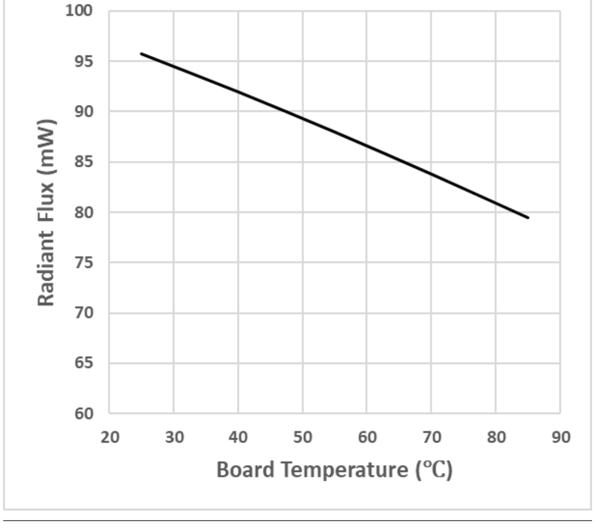
Test Conditions:
I_{FP} = 350 mA
$R_{\Theta JB}$ = 12 °C/W

FORWARD VOLTAGE VS BOARD TEMPERATURE



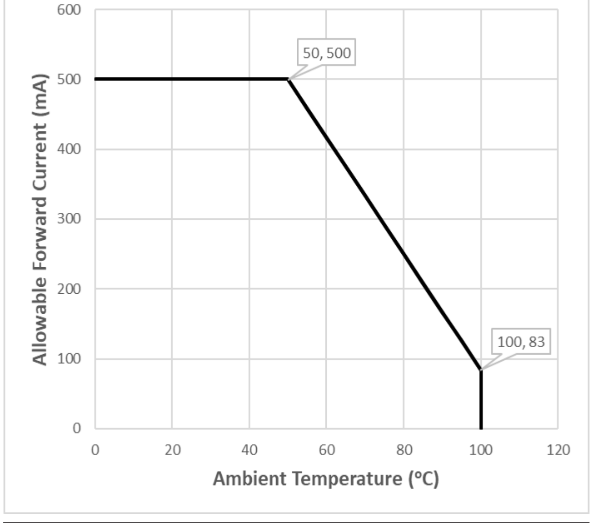
Test Conditions:
I_{FP} = 350 mA
$R_{\Theta JB}$ = 12 °C/W

RADIANT FLUX VS BOARD TEMPERATURE



Test Conditions:
I_{FP} = 350 mA
$R_{\Theta JB}$ = 12 °C/W
Bin AC

ALLOWABLE FORWARD CURRENT VS AMBIENT TEMPERATURE ($R_{\Theta JA}$ = 20 °C/W)



$R_{\Theta JS}$ = 6 °C/W (CrayoLED CLH-N3S)
$R_{\Theta SA}$ = 14 °C/W (value dependent on thermal design)

5. Summary

Junction temperature and thermal management need to be a focus for UV-C LED design to achieve optimal performance and reliability. The design is the first step to achieve good thermal management, which also needs to be verified and measured through prototyping phases. Thermal simulations and calculations are important starting points. Actual measurements of the solder, board, and ambient temperatures of a completed design are essential steps to implement an LED design successfully.

Optical measurements are most accurately measured on individual LEDs with an integrating sphere. Practical measurements of LEDs in a device commonly require the use of less accurate measurements. Understanding the benefits and limitations of different light measurements is critical for identifying best practices based of the design of a system. Proper measurement methods and techniques will lead to more accurate results in UV-C LED applications and longer lifetimes.

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