Light Emitting Diode

Thermal Design Considerations for the Nichia E11A Series LEDs

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NFSWE11A, NFSWE11A-V1, NFSGE11A-V1, NFSRE11A-V1, NFSBE11A-V1L1, and NFSW757H refer to Nichia part numbers. These Nichia part numbers within this document are merely Nichia's part numbers for those Nichia products and are not related nor bear resemblance to any other company's product that might bear a trademark.

1. Overview

When an LED is operated, if the heat is not appropriately dissipated it may cause the components and/or materials to deteriorate due to the self-heating of the LED leading to a performance/reliability degradation of the LED (e.g. reduction in the brightness, shorter lifetime, etc.). Proper thermal design is necessary to achieve the performance that is specified in the applicable specification of the LED.
The Nichia E11A Series are intended for general lighting applications and have a package that is compact, low-profile, and light; these LEDs are perfect for smaller luminaires that could not use larger sized LEDs. Note that the smaller the chosen luminaire is, the more challenging the thermal design and thermal evaluation will be.
This application note provides the thermal design considerations for the Nichia E11A Series LEDs, the results of the thermal evaluations Nichia performed, and how to evaluate the junction temperature (T_J) of the LEDs in the chosen application.

2. Features of the Nichia E11A Series LEDs

2.1 Color Options for the Nichia E11A Series LEDs

Table 1 shows representative color options for the series. For detailed information, contact a local Nichia sales representative.

Table 1. Representative Color Options for the Nichia E11A Series LEDs

Part Number	NFSWE11A NFSWE11A-V1	NFSGE11A-V1	NFSRE11A-V1	NFSBE11A-V1L1
Appearance (for reference)				
Color of the Light	White / Warm White	Green	Red	Blue

2.2 Outline Dimensions

Figure 1 provides the outline dimensions of the Nichia E11A Series LEDs. Figure 2 provides comparison images that show the difference in outline dimensions between the Nichia E11A Series LEDs and the NFSW757H LED[1]; the NFSW757H LED is an existing Nichia LED whose output power is equivalent to that of the Nichia E11A Series LEDs. From Figure 2, it is obvious that the Nichia E11A Series LEDs are much smaller than existing LEDs that have an equivalent output power; with the Nichia E11A Series LEDs, it is possible to design very compact, low-profile luminaires.

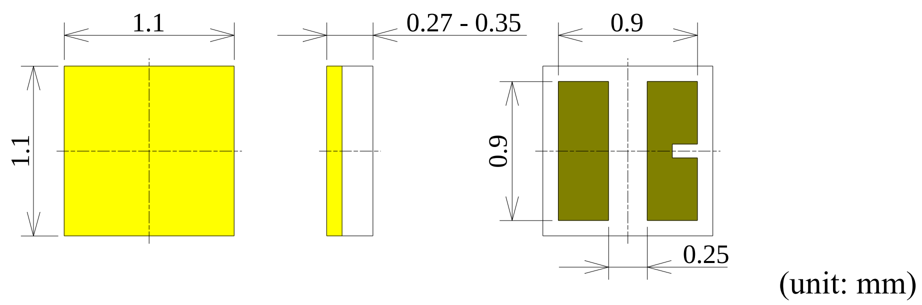


Figure 1. Outline Dimensions of the Nichia E11A Series LEDs

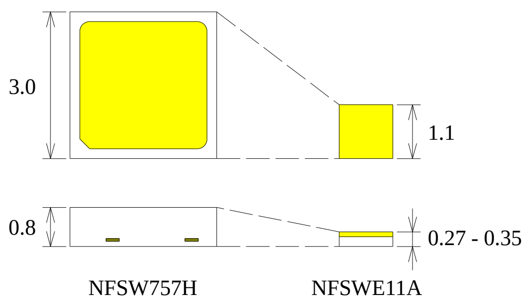


Figure 2. Size Comparison with an Existing LED with an Equivalent Output Power

2.3 Structure

For a typical LED, the chip is mounted on the lead frame, submount, etc.; in the process when the heat generated from the chip is dissipated to the PCB, the heat goes through the adhesive (e.g. chip bonding adhesive) and the lead frame, submount, etc. For the Nichia E11A Series LEDs, the chip is soldered directly to the PCB; the heat generated from the chip can be effectively dissipated to the PCB. See Figure 3. Note that although the Nichia E11A Series LEDs have good heat dissipation performance, proper thermal design is necessary since the LEDs themselves and their electrodes, which are in the thermal path, are too small compared to the amount of the heat generated.

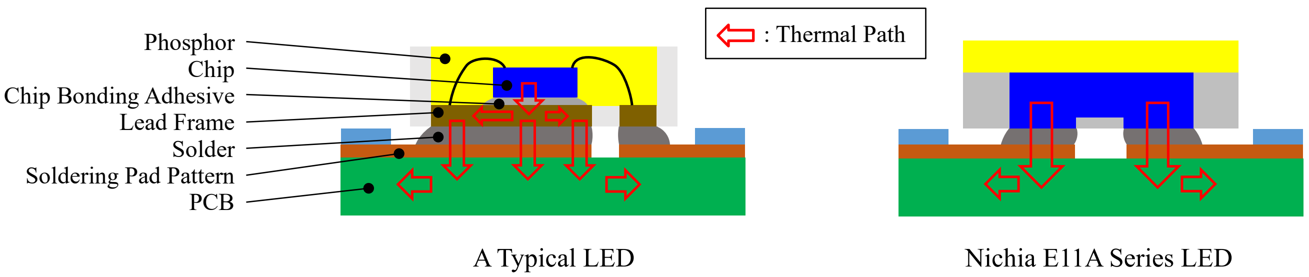


Figure 3. LED Heat Dissipation Reference Images

[1] The sorting current for the NFSW757H LEDs is the same as that for the Nichia E11A Series LEDs: 65mA.

2.4 Precautions when Soldering the Electrodes

The Nichia E11A Series LEDs have large electrodes to improve the placement accuracy (see Figure 4); if solder paste is not applied to a sufficient area between the electrodes and soldering pad pattern, it may cause the heat dissipation performance of the LEDs to be reduced resulting in reduced reliability (see Figure 5). To achieve the performance that is specified in the applicable specification for each LED part number, ensure that the electrodes are soldered to the PCB properly.

To achieve the specification's performance for the LEDs, Nichia recommends each of the electrodes is soldered to the PCB with solder paste covering ≥75% of the electrode. Ensure that an adequate area is covered by solder paste using an X-ray examination, etc. The ratio of the solder joint area to the area of the electrode is calculated using Equation 1.

Equation 1:

Area of the solder joint except for non-bonding area (e.g. voids)/Area of the electrode×100

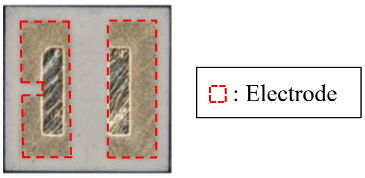


Figure 4. Appearance of the Back of the Nichia E11A Series LEDs

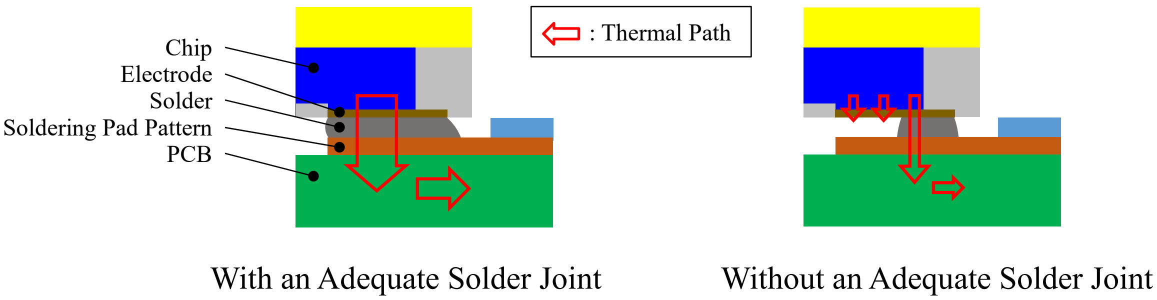


Figure 5. LED Heat Dissipation Reference Images for the Nichia E11A Series LEDs

3. Thermal Design Considerations

3.1 Thermal Resistance Model and Descriptions of the Terms

Figures 6 and 7 show a thermal resistance model for the Nichia E11A Series LEDs. Table 2 shows the terms and descriptions that are used herein. When performing a thermal evaluation with the chosen application, ensure that the T_B is measured adjacent to the LEDs.

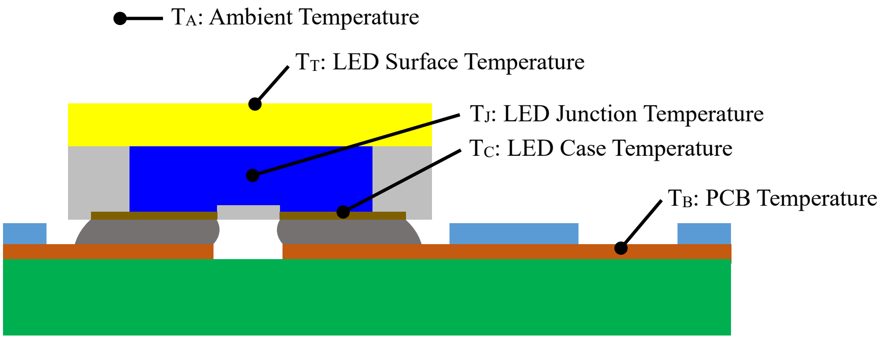


Figure 6. Cross-sectional View of the Nichia E11A Series LEDs

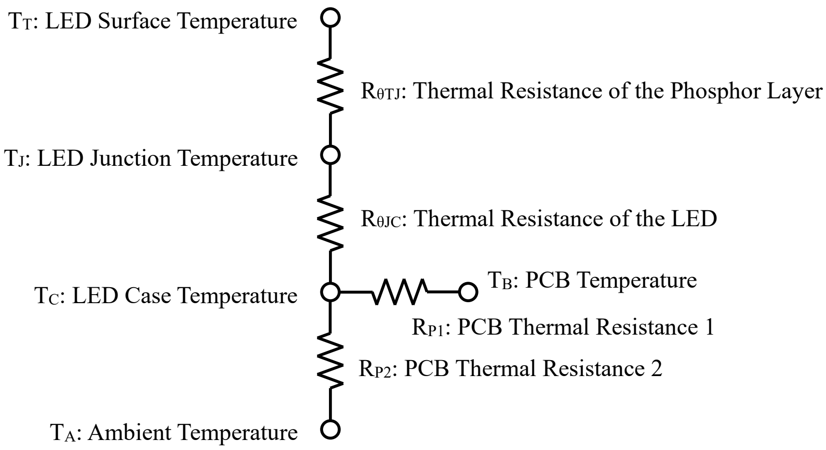


Figure 7. Simplified Thermal Resistance Model for the Nichia E11A Series LEDs

Table 2. Terms and Descriptions Related to Thermal Design

Term	Symbol	Descriptions
Ambient Temperature	T_A	The ambient temperature of the LED. If the heat dissipation of the chosen application is not good around the LED module due to the design of the chosen application, note that the T_A and the T_J will be higher.
LED Surface Temperature	T_T	The temperature of the emitting surface of the LED.
LED Junction Temperature	T_J	The temperature of the LED chip. The T_J must not exceed the absolute maximum junction temperature; the absolute maximum junction temperature for the Nichia E11A Series LEDs is 135°C. Note that the lower the T_J is, the longer the lifetime of the LEDs will be.
LED Case Temperature	T_C	The temperature of the electrode of the LED. As noted in the specification, the T_C is used in a thermal simulation; it cannot be measured once these LEDs are soldered to the PCB.
PCB Temperature	T_B	For the Nichia E11A Series LEDs, the T_C cannot be measured; instead, the temperature of the soldering pad pattern on the PCB is measured with a thermocouple.
Thermal Resistance of the Phosphor Layer	$R_{\theta TJ}$	The thermal resistance from the LED chip to the emitting surface of the LED.
Thermal Resistance of the LED	$R_{\theta JC}$	The thermal resistance from the LED chip to the electrode of the LED. As noted in the specification, the $R_{\theta JC}$ is obtained according to the measurement/calculation methods detailed in JESD 51-1.
Thermal Resistance from the LED to the PCB	$R_{\theta JB}$	The thermal resistance from the LED chip to the T_B measurement point on the PCB: $R_{\theta JB} = R_{\theta JC} + R_{P1}$.
PCB Thermal Resistance	R_{P1}	The thermal resistance from the T_C point of the LED to the T_B measurement point on the PCB. The value of the R_{P1} varies depending on the geometry of the soldering pad pattern, PCB materials, the thermal performance of the solder paste, the operating conditions, etc.
	R_{P2}	The thermal resistance of the PCB. The value of the R_{P2} varies depending on the thermal performance of the PCB and other components of the chosen application that affect the heat dissipation performance.

3.2 Materials for PCBs

To achieve the performance and reliability that are specified in the applicable specification for each part number, it is important to select a proper PCB for the LEDs considering its power consumption (i.e. amount of the heat generated from the LEDs). Table 3 provides typical PCB materials and their advantages/ disadvantages.

The rated power consumption for the Nichia E11A Series LEDs is 0.25W. This means the Nichia E11A Series LEDs are operated at a relatively low input power compared to other LEDs. With this low power consumption, the possibility of the LED junction temperature becoming too high is smaller even if the heat dissipation performance of the chosen application is not good; resin-based substrates (e.g. CEM-3, FR-4), which are less thermally conductive and cheaper than metal-core substrates, can be used. Flexible substrates may also be used to make smaller and lighter luminaires. However, note that a flexible substrate that is made from polyimide, etc. has a high thermal resistance; the thermal design may be more challenging.

Table 3. Typical PCB Materials

PCB Material		Advantage/Disadvantage	Heat Dissipation[2]
Rigid	Paper Phenol (FR-1)	It is cheaper than other options and the durability and fire-resistance are low; FR-1 PCBs are often used for low-cost, low-performance applications.	Lower than normal
	Glass Epoxy (FR-4)	Most commonly used PCB: complicated FR-4 multilayer PCBs are used in electronic devices, etc. FR-4 substrates are often used as the PCB for LEDs.	Good
	Glass Composite (CEM-3)	It is cheaper than other options, but the dimensional stability is lower than FR-4 PCBs.	Good
	Metal-core	Made of metal with high thermal conductivity (e.g. aluminum, copper); an application using a metal-core PCB can be used at a larger input power than an application using a resin PCB. Metal-core PCBs are used for high power LEDs whose heat cannot be dissipated properly with a resin PCB.	Excellent
Flexible (FPC)		Thin, light, and bendable which enables three-dimensional arrangements for electrical circuits. In recent years, flexible PCBs have started to be used in various types of applications due to the demand for compact and light electric devices.	Lower than normal

[2] For reference purposes only. The heat dissipation performance depends on the individual PCB.

3.3 Soldering Pad Pattern

Figure 8 shows a recommended soldering pad pattern for the Nichia E11A Series LEDs. For more information about assembly precautions, refer to the application note: Assembly Precautions for the Nichia E11 Series LEDs.

There are two types of copper layer designs to create the soldering pad pattern: Solder Mask Defined (SMD) and Non-solder Mask Defined (NSMD). For SMD, the soldering pad pattern is defined by the aperture of the solder resist with a large copper layer under it. For NSMD, the soldering pad pattern is defined by the dimensions of copper layer. See Figure 9. Generally, NSMD can create a soldering pad pattern that is more precise in size and shape than SMD since the copper layer allows for better control of the dimensional tolerances than the solder resist. However, since the area of the copper layer is smaller for NSMD the heat dissipation performance is better with SMD. Nichia recommends using SMD to create the soldering pad pattern when good thermal dissipation is required. Also, the length of the soldering pad pattern (i.e. area of the soldering pad pattern) affects the heat dissipation performance (i.e. the thermal resistance, etc.) (refer to section 5); the heat dissipation performance of the chosen application can be improved by using SMD and having the copper layer around the LEDs be as large as possible.

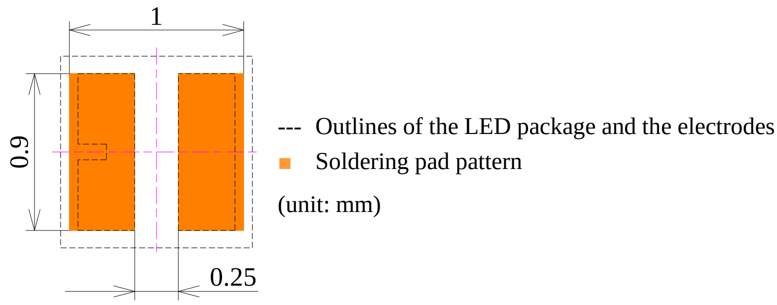


Figure 8. Recommended Soldering Pad Pattern for the Nichia E11A Series LEDs

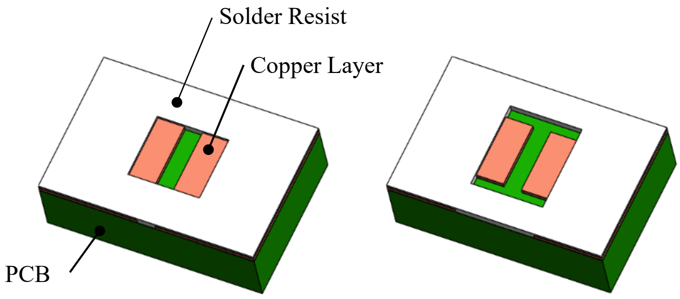


Figure 9. Reference Images of SMD and NSMD

4. How to Calculate the Junction Temperature

4.1 Calculation Methods

The junction temperature (T_J) of the Nichia E11A Series LEDs is calculated using one of the following two methods:

1. Calculated from the PCB temperature (T_B), the input power, and the thermal resistance from the LEDs to the PCB ($R_{\theta JB}$).
2. Calculated by measuring the ΔV_F of the LEDs.

For detailed information on these calculation methods, refer to the application note: Thermal Design Considerations for the Nichia NCSxE17A or NVSxE21A LEDs. Ensure that the T_J does not exceed 135°C (i.e. the absolute maximum junction temperature for the Nichia E11A Series LEDs) for both calculation methods.

4.2 How to Measure the T_B

For the Nichia E11A Series LEDs, the temperature of the electrode/solder joint cannot be measured due to its structure. Also, since the LEDs are very compact, if a thermocouple is attached directly to the LEDs the adhesive and the thermocouple itself will dissipate the heat and that may reduce the accuracy of the measurements. Nichia recommends measuring the T_B at the measurement point on the PCB.

To attach a thermocouple to measure the T_B, create an opening in the solder resist whose diameter is 1mm on the surface of the PCB at the point 2.05mm from the center of the LEDs. Use solder or adhesive with a high thermal conductivity to attach a thermocouple at the opening. Ensure that the flux/adhesive does not adhere to the LEDs when attaching a thermocouple.

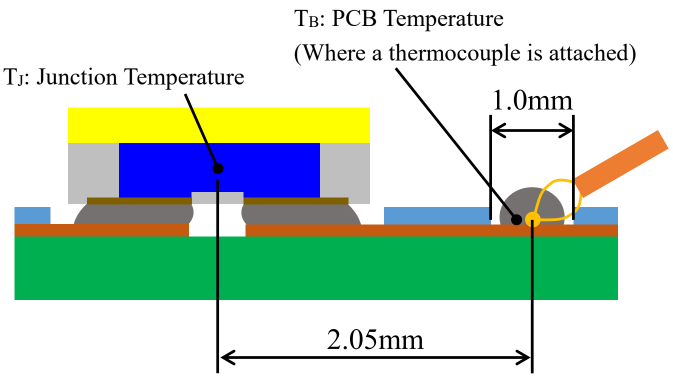


Figure 10. T_B Measurement Point

4.3 How to Calculate the T_J

The value of the $R_{\theta JB}$, the thermal resistance from the LED chip (i.e. junction) to the T_B measurement point on the PCB, may vary depending on the individual PCB.

The T_J can be calculated using Equation 2 below.

Equation 2: T_J (°C) = T_B (°C) + Power consumption (W) × $R_{\theta JB}$ (°C/W)

5. Thermal Evaluations for the Nichia E11A Series LEDs

Nichia evaluated the junction temperature (T_J) and the thermal resistance from the LEDs to the PCB ($R_{\theta JB}$) for the Nichia E11A Series LEDs using different conditions. The values of the T_J and $R_{\theta JB}$ were obtained according to the measurement/calculation methods detailed in JESD 51.

5.1 Evaluation Conditions

Nichia performed evaluations using the following conditions and parameters.

Evaluated LEDs:

LED 1: NFSWE11A LED with the color rank of sm50 (equivalent to 5000K) and CRI rank of R8000
LED 2: NFSWE11A LED with the color rank of sm27 (equivalent to 2700K) and CRI rank of R9050
LED 3: NFSGE11A-V1 LED with the color rank of G013 (Green)
LED 4: NFSRE11A-V1 LED with the color rank of Rp (Red)
LED 5: NFSBE11A-V1L1 LED with the color rank of W014 (Blue)

For the white LEDs, the amount of the heat that will be generated from the LEDs varies depending on the type of the phosphor and/or how much phosphor is used; considering that, Nichia used two different white LEDs for the evaluations.
The absolute maximum junction temperature (T_{Jmax}) for the Nichia E11A Series LEDs is 135°C.

PCBs:

PCB 1: CEM-3
PCB 2: FPC (Made from polyimide)

Table 4 provides the details of the PCBs that were used for the evaluations. The evaluations were performed without using other components that may affect the heat dissipation performance of the LEDs and PCB (e.g. heatsink).

Table 4. PCBs Used for the Evaluations

PCB	Thermal Conductivity (W/m·K)	Thickness of the Copper Layer (μm)	Thickness of the PCB (mm)
CEM-3	1.0	35	1.2
FPC	0.4	35	0.2

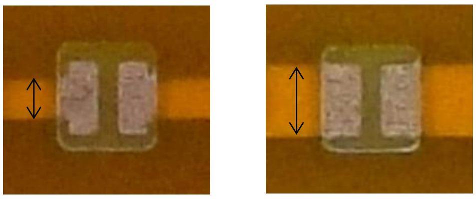
Soldering pad pattern:

Soldering Pad Pattern: Nichia recommended soldering pad pattern (see Figure 8)
Copper Layer Design: NSMD

Width of the PCB traces:

PCB Trace 1: 0.5mm in width
PCB Trace 2: 0.9mm in width

The PCB trace with the width of 0.5mm is not recommended since it is shorter than the length of the recommended soldering pad pattern (i.e. electrode), the heat is not sufficiently dissipated. See Figure 11.



0.5mm 0.9mm

Figure 11. Width of the PCB Trace

Operating current:

Operating current 1: 65mA (i.e. sorting current)
Operating current 2: 130mA
Operating current 3: 200mA
Operating current 4: 250mA (i.e. absolute maximum rating current)

T_B measurement point:

Refer to section 4.2 How to Measure the T_B.

5.2 Evaluation Results

5.2.1 Junction Temperature (T_J)

Figures 12-21 show the evaluation results for the T_J.

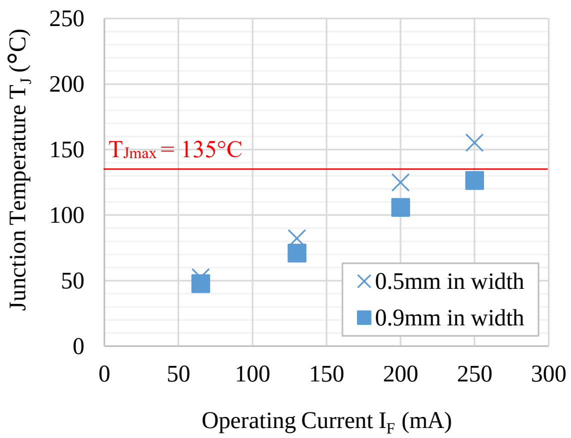


Figure 12. LED 1 (sm50 and R8000) on PCB 1 (CEM-3)

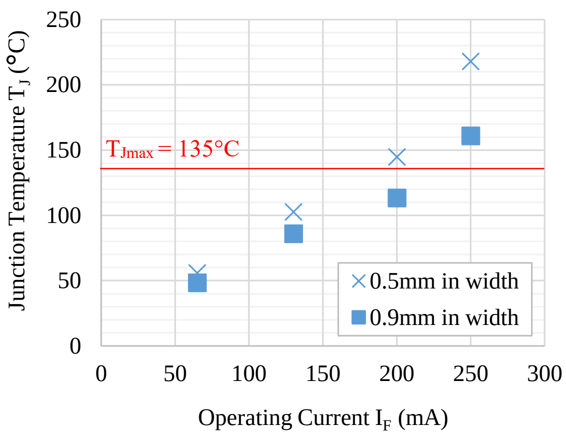


Figure 13. LED 1 (sm50 and R8000) on PCB 2 (FPC)

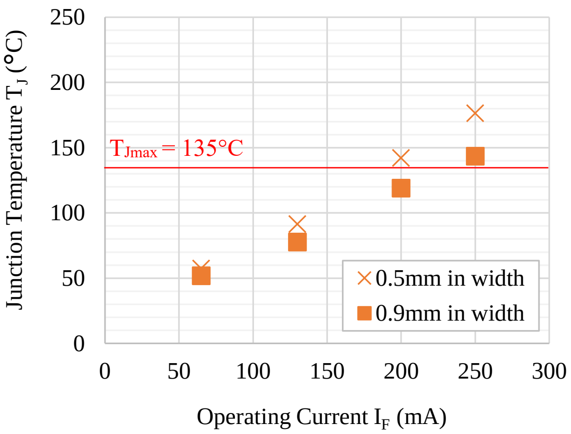


Figure 14. LED 2 (sm27 and R9050) on PCB 1 (CEM-3)

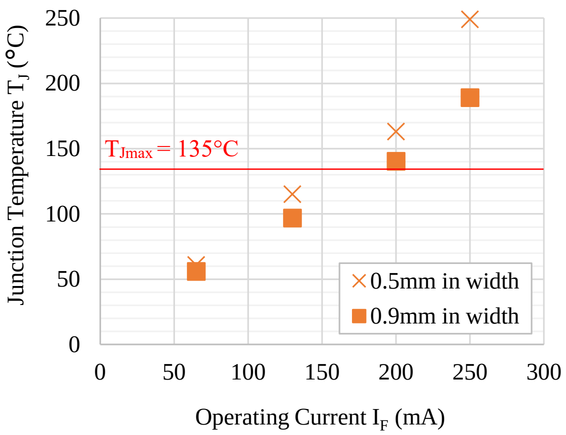


Figure 15. LED 2 (sm27 and R9050) on PCB 2 (FPC)

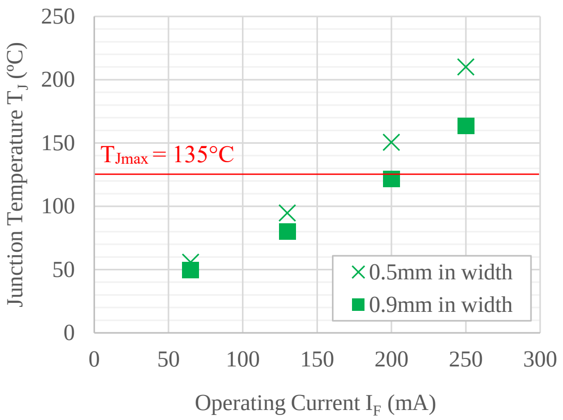


Figure 16. LED 3 (G013) on PCB 1 (CEM-3)

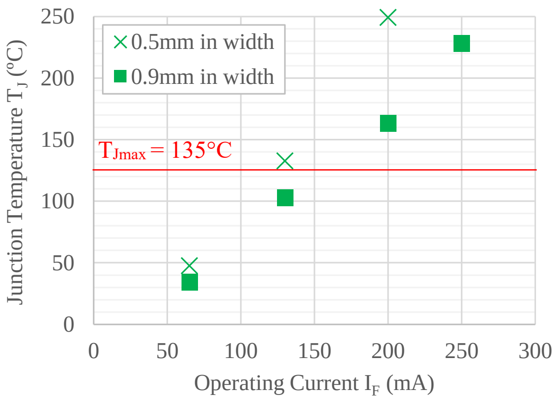


Figure 17. LED 3 (G013) on PCB 2 (FPC)[3]

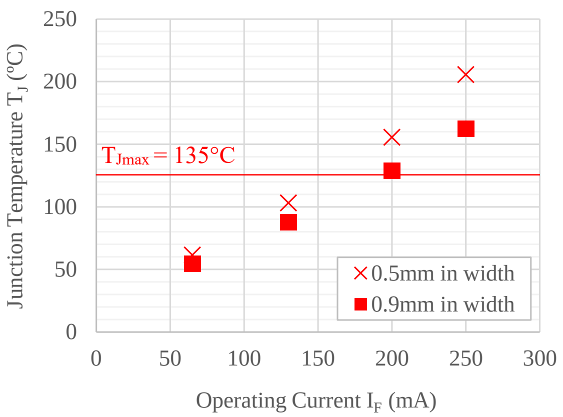


Figure 18. LED 4 (Rp) on PCB 1 (CEM-3)

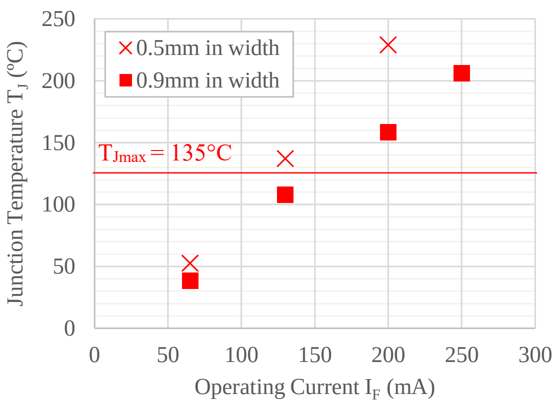


Figure 19. LED 4 (Rp) on PCB 2 (FPC)[3]

[3] Evaluations were not performed for the conditions where the TJ became significantly higher than the absolute maximum T_J.

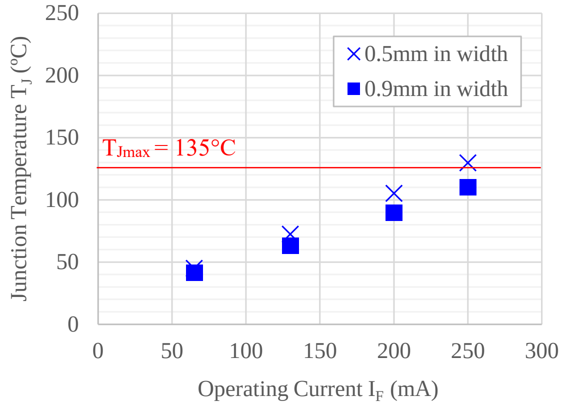


Figure 20. LED 5 (W014) on PCB 1 (CEM-3)

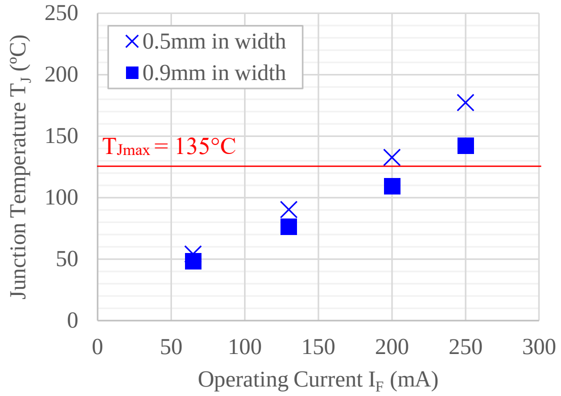


Figure 21. LED 5 (W014) on PCB 2 (FPC)

The evaluation results show that the T_J became higher for LED 2 (sm27 and R9050) than LED 1 (sm50 and R8000) since LED 2 generated more heat from the phosphor. For LED 5 (blue), the T_J did not become high since it does not contain phosphor. Also, the T_J was higher for PCB 2 (FPC) than PCB 1 (CEM-3), and higher for PCB Trace 1 (0.5mm in width) than PCB Trace 2 (0.9mm in width); PCB 2 and PCB Trace 1 had a lower heat dissipation performance. The T_J increased proportional to the operating current except for the evaluation conditions at which the T_J rapidly increased; that indicates that the heat dissipation performance was quite insufficient for the amount of the heat generated from the LEDs under those conditions.

As long as the LEDs are operated at close to or below the sorting current (i.e. 65mA), there will be no thermal issues with any LEDs/PCBs. If the LEDs are operated at a higher current, Nichia recommends using a PCB with a high heat dissipation performance and/or heat dissipation component(s) (e.g. heatsink).

5.2.2 Calculated $R_{\theta JB}$

The $R_{\theta JB}$ values were calculated using the T_J and T_B values obtained from the measurements. Figures 22-31 show the evaluation results for the $R_{\theta JB}$.

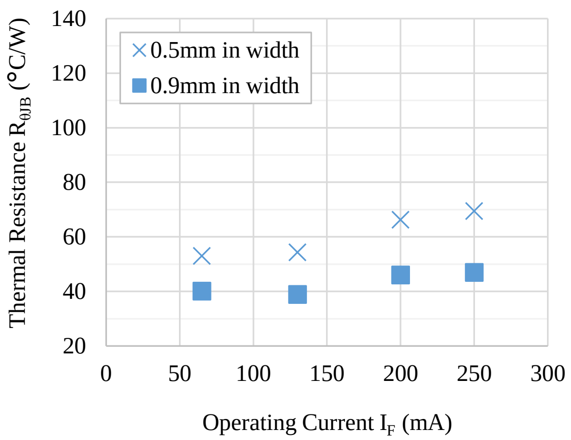


Figure 22. LED 1 (sm50 and R8000) on PCB 1 (CEM-3)

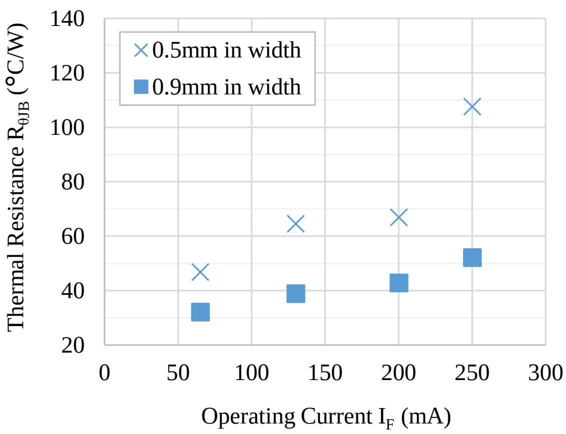


Figure 23. LED 1 (sm50 and R8000) on PCB 2 (FPC)

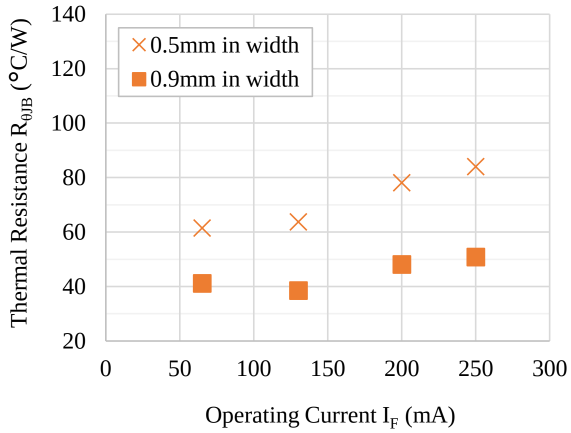


Figure 24. LED 2 (sm27 and R9050) on PCB 1 (CEM-3)

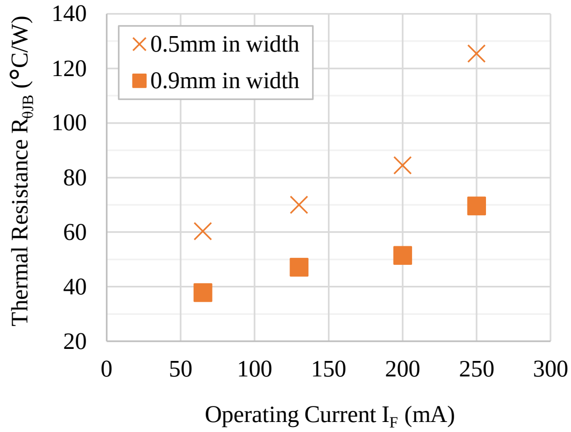


Figure 25. LED 2 (sm27 and R9050) on PCB 2 (FPC)

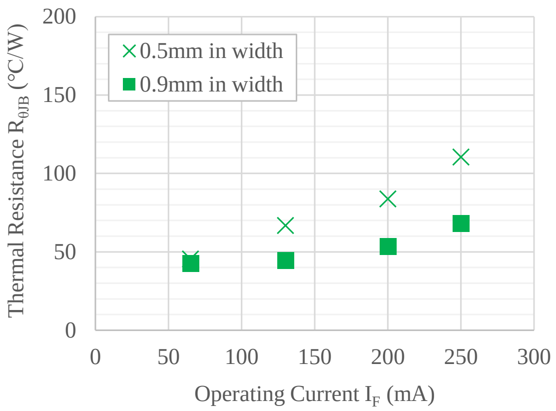


Figure 26. LED 3 (G013) on PCB 1 (CEM-3)

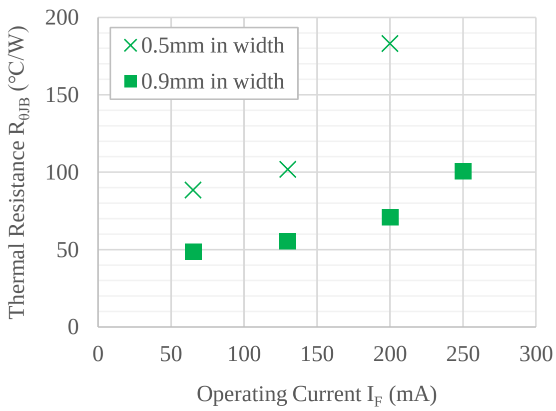


Figure 27. LED 3 (G013) on PCB 2 (FPC)[3]

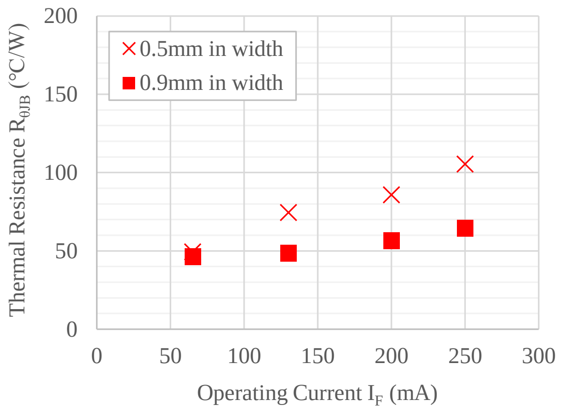


Figure 28. LED 4 (Rp) on PCB 1 (CEM-3)

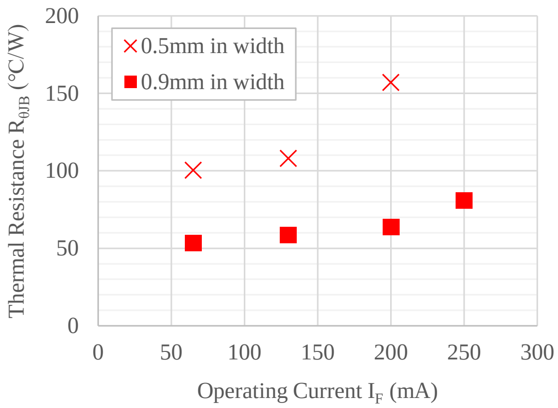


Figure 29. LED 4 (Rp) on PCB 2 (FPC)[3]

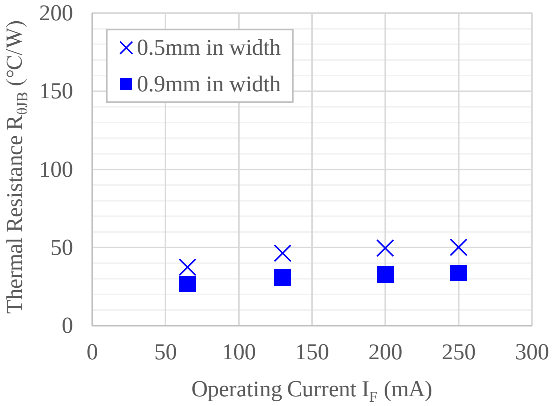


Figure 30. LED 5 (W014) on PCB 1 (CEM-3)

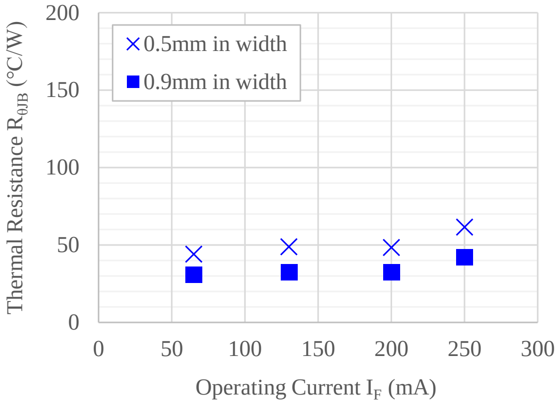


Figure 31. LED 5 (W014) on PCB 2 (FPC)

The evaluation results indicate that the $R_{\theta JB}$ was greatly affected by the width of the PCB trace since the T_B was measured at a point on the PCB trace. Assuming the LEDs would be used in a compact application, the evaluations were performed using an NSMD copper layer design. If the restrictions for the design and size of the PCB allow, the $R_{\theta JB}$ can be lowered by using SMD and having the width of the PCB trace as large as possible.
The evaluation results also show that the $R_{\theta JB}$ rapidly increased when a high current was applied to the LEDs that were mounted on PCB 2 (FPC) with PCB Trace 1 (0.5mm in width) since the combination had a lower heat dissipation performance; this behavior was similar to that of the T_J as detailed in section 5.2.1. That means the heat dissipation performance of the PCB was not sufficient for the amount of the heat generated from the LEDs under those conditions.

If the $R_{\theta JB}$ is known, the T_J can be calculated using the measured T_B. As the evaluation results indicate, the values of the $R_{\theta JB}$ may greatly vary depending on the conditions. When the $R_{\theta JB}$ is used to calculate the T_J, select the value of the $R_{\theta JB}$ that was obtained under the evaluation conditions closest to the conditions being used for the chosen application. Note that the values shown above are for reference purposes only and the $R_{\theta JB}$ may vary depending on the conditions/environments in which the LEDs will actually be used.

6. Thermal Evaluations Using an Infrared Thermal Imaging Camera

6.1 LED Surface Temperature (T_T)

Generally, a white LED creates white light by mixing blue light and yellow light; the blue LED chip emits blue light and part of it is converted to yellow light by the phosphor. In this color conversion process, there will be an energy loss (i.e. heat generation). Both the LED chip and the phosphor are heat sources within the LED (see Figure 32). Note that if the resin-based components used in the LED are exposed to high temperatures, they may rapidly degrade causing adverse effects on the performance and/or reliability of the LED.

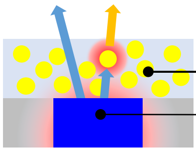


Figure 32. Reference Image of Heat Generation for a White LED

6.2 How to Measure the T_T

The T_T cannot be measured accurately with a thermocouple since the adhesive used to attach the thermocouple will generate heat when the LEDs are illuminated. Nichia recommends performing a non-contact temperature measurement using an infrared thermal imaging camera (see Figure 33). With an infrared thermal imaging camera, it is possible to identify the hottest LED on the PCB, to detect any LEDs that are generating heat abnormally, etc. since the camera can evaluate the temperature distribution.

Ensure that the T_T is measured at the center of the emitting surface (i.e. where the temperature is highest); prior to measuring the T_T, operate the LEDs for long enough to stabilize the temperature. The following are other precautions for measuring the T_T using an infrared thermal imaging camera.

- There will be measurement variations for an infrared thermal imaging camera due to the measurement conditions/environments; ensure that the thermal design for the chosen application has sufficient margins/tolerances.
- Select an infrared thermal imaging camera that has sufficient resolution. The T_T may vary depending on where it is measured on the LED surface; the T_T values may be different at the center (i.e. right above the LED chip) and at an edge of the surface. See Figure 33. With an infrared thermal imaging camera whose resolution is insufficient, the T_T may be measured to be lower than the actual temperature since the different temperatures on the LED surface cannot be captured independently with the camera and will be averaged.
- If foreign materials (e.g. flux, dust, particles, etc.) have adhered to the LED surface, the T_T may not be measured accurately.
- For a high-density application, the temperatures of the LEDs that are placed in the middle of the PCB tend to become higher than those of the other LEDs due to the heat generated from the adjacent LEDs. The temperature distribution on the PCB may be uneven depending on the conditions of the PCB; evaluate the temperature distribution within the chosen application prior to use.

・If the LEDs are used with an optical component that has a low heat resistance temperature, ensure that there are no issues caused by the heat of the LED surface prior to use.

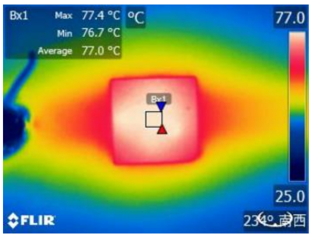


Figure 33. Example of a Temperature Measurement with an Infrared Thermal Imaging Camera

6.3 Evaluation Results

Nichia measured the T_B and T_T using the same conditions for the evaluations detailed in section 5; the T_B was measured with a thermocouple and the T_T was measured with an infrared thermal imaging camera. The difference between the T_T and T_J was also evaluated.

6.3.1 Evaluation Results for the T_T Measured with an Infrared Thermal Imaging Camera

Figures 34-43 show the values of the T_T measured with an infrared thermal imaging camera.

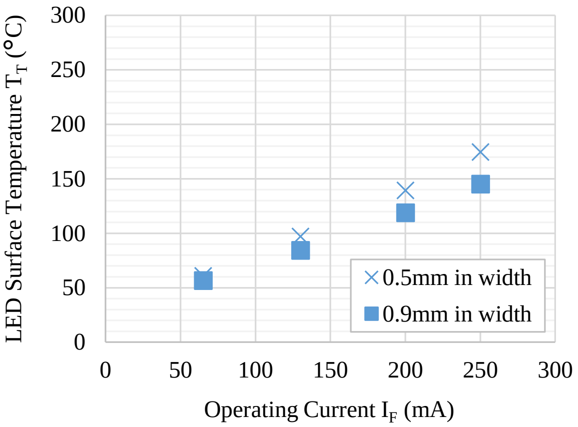


Figure 34. LED 1 (sm50 and R8000) on PCB 1 (CEM-3)

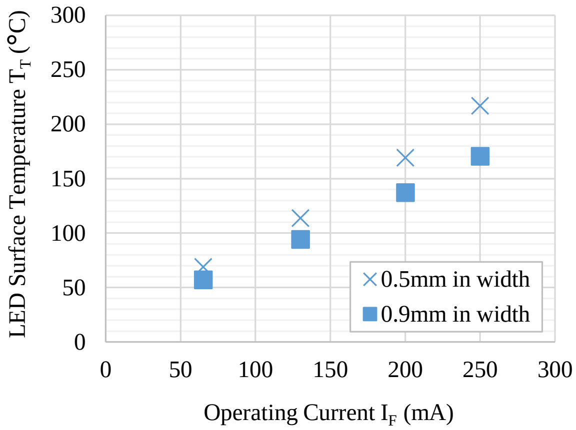


Figure 35. LED 1 (sm50 and R8000) on PCB 2 (FPC)

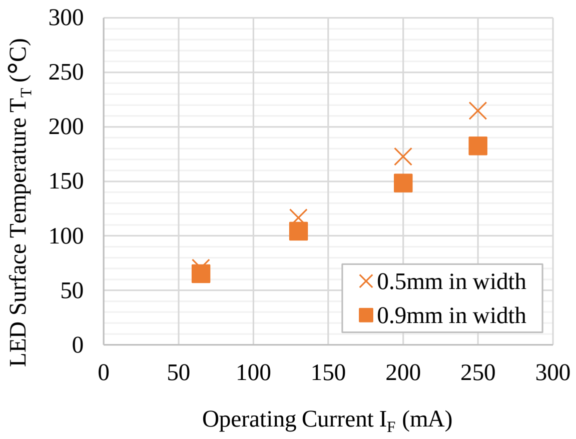


Figure 36. LED 2 (sm27 and R9050) on PCB 1 (CEM-3)

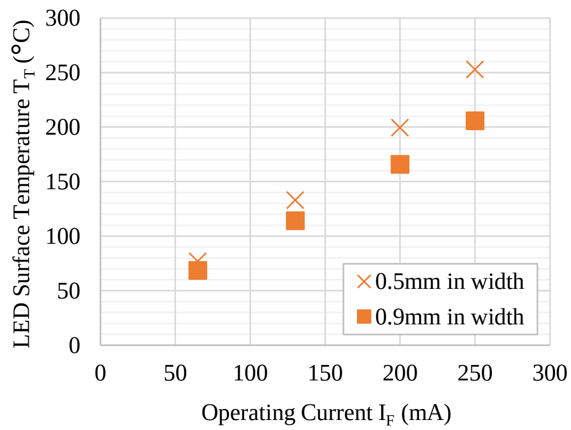


Figure 37. LED 2 (sm27 and R9050) on PCB 2 (FPC)

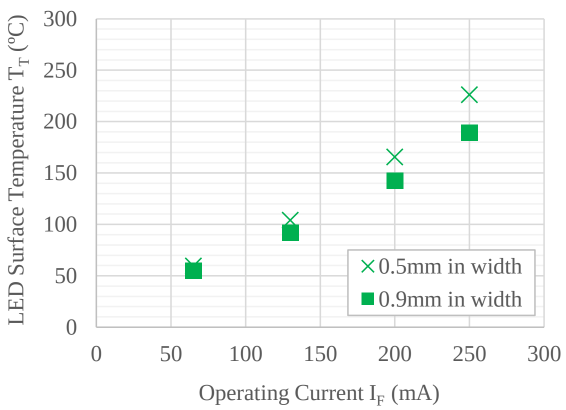


Figure 38. LED 3 (G013) on PCB 1 (CEM-3)

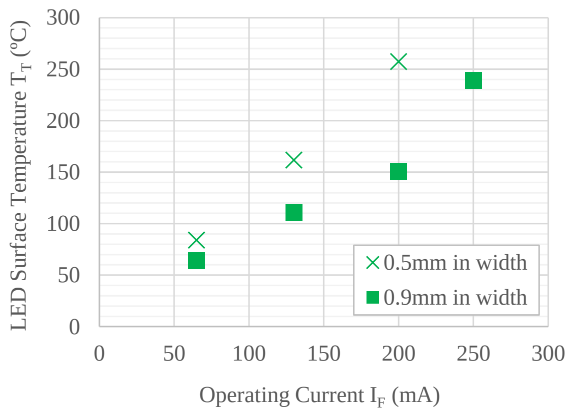


Figure 39. LED 3 (G013) on PCB 2 (FPC)[3]

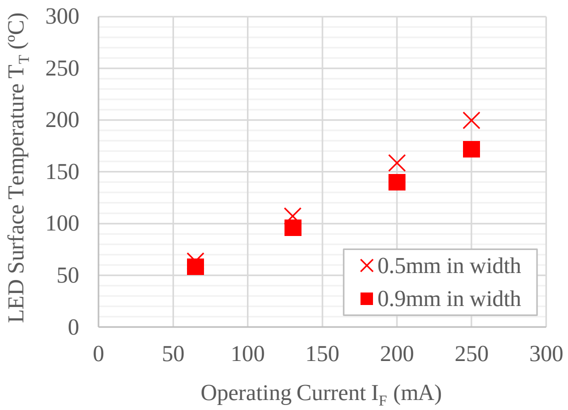


Figure 40. LED 4 (Rp) on PCB 1 (CEM-3)

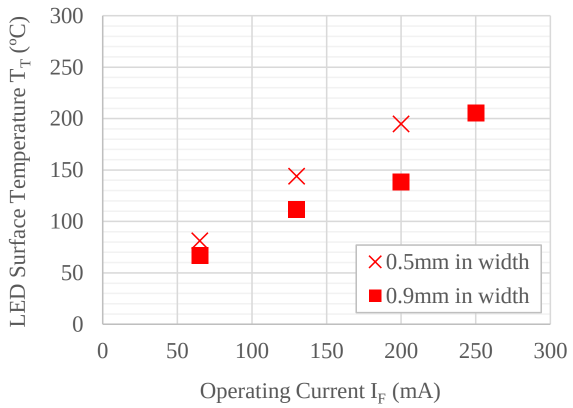


Figure 41. LED 4 (Rp) on PCB 2 (FPC)[3]

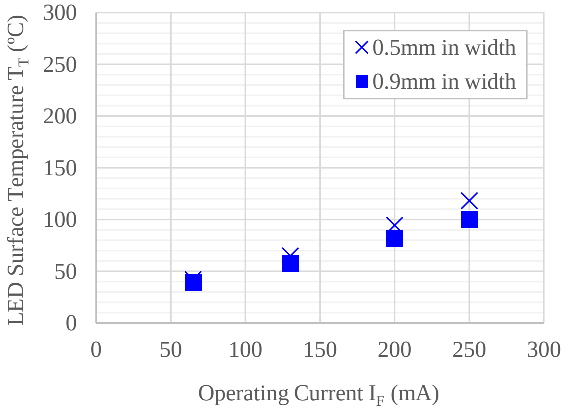


Figure 42. LED 5 (W014) on PCB 1 (CEM-3)

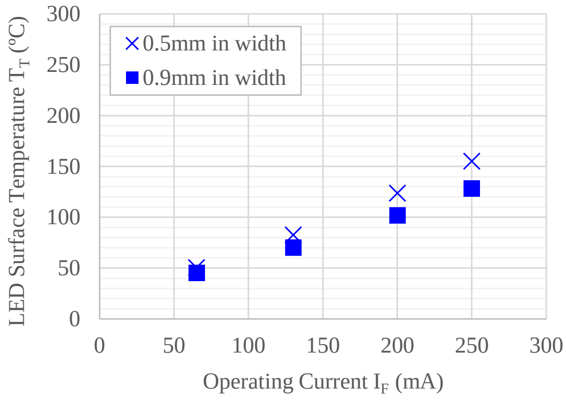


Figure 43. LED 5 (W014) on PCB 2 (FPC)

The T_T increased in proportion to the increase of the operating current. The T_T was significantly different depending on the color ranks since the T_T was greatly affected by the heat generated from the phosphor.

6.3.2 Relationship between the T_T and T_J

Nichia calculated the T_J using the measured T_T and T_B to evaluate the difference between the T_T and T_J. Figures 44-53 show the results.

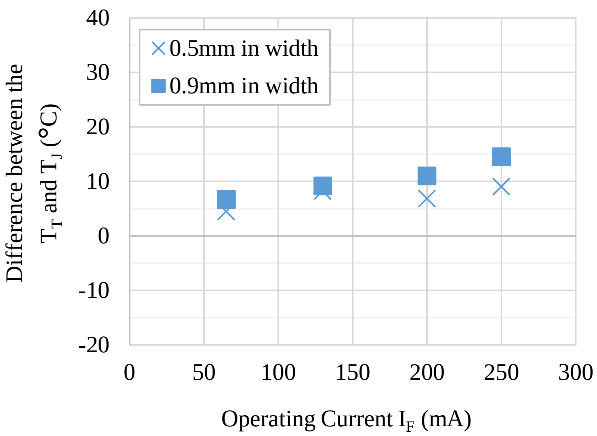


Figure 44. LED 1 (sm50 and R8000)
on PCB 1 (CEM-3)

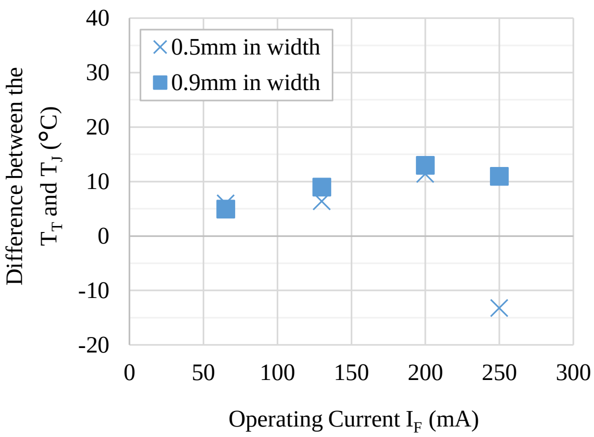


Figure 45. LED 1 (sm50 and R8000)
on PCB 2 (FPC)

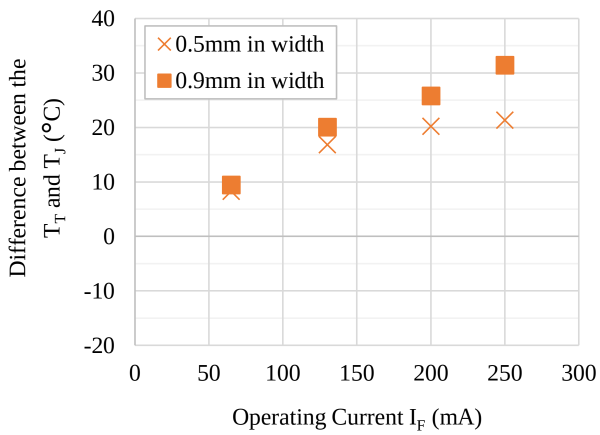


Figure 46. LED 2 (sm27 and R9050) on PCB 1 (CEM-3)

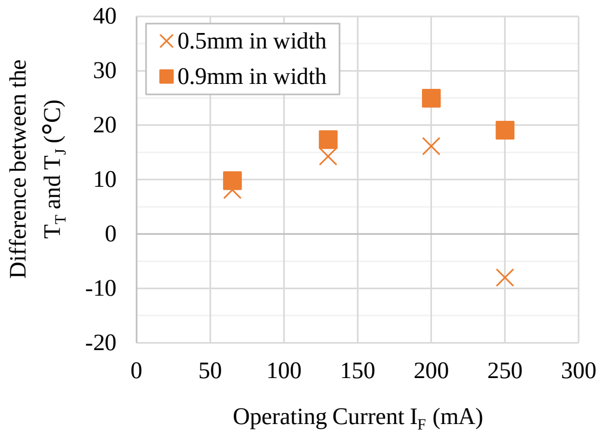


Figure 47. LED 2 (sm27 and R9050) on PCB 2 (FPC)

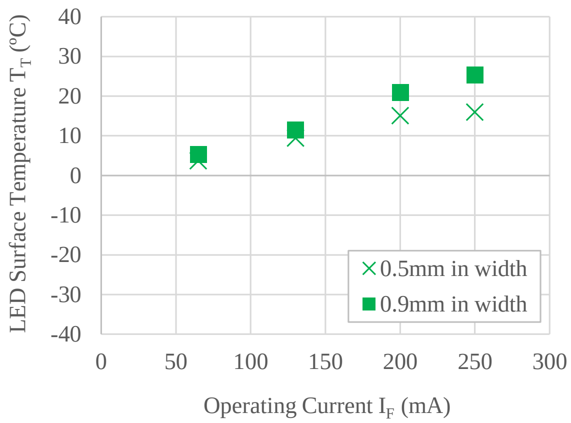


Figure 48. LED 3 (G013) on PCB 1 (CEM-3)

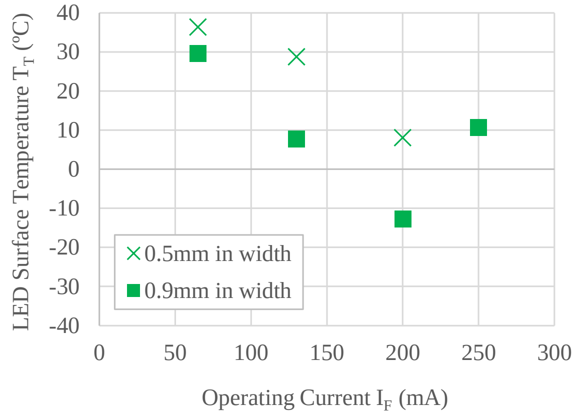


Figure 49. LED 3 (G013) on PCB 2(FPC)[3]

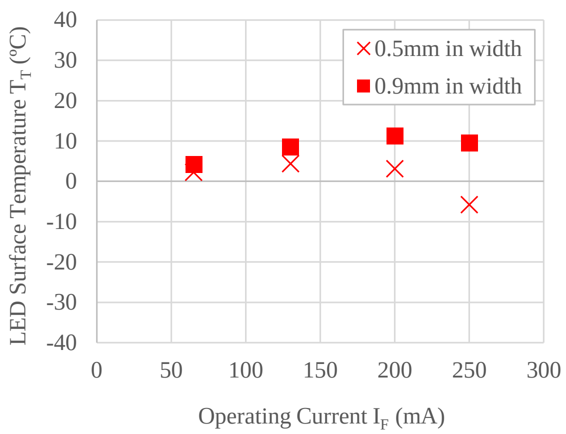


Figure 50. LED 4 (Rp) on PCB 1 (CEM-3)

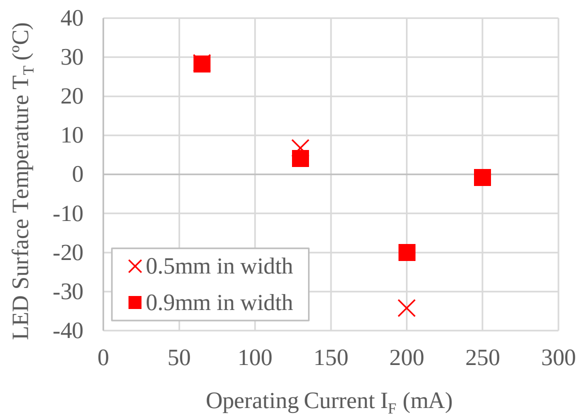


Figure 51. LED 4 (Rp) on PCB 2 (FPC)[3]

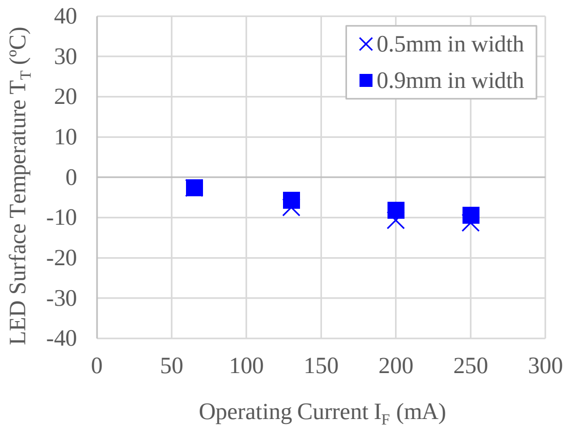


Figure 52. LED 5 (W014) on PCB 1 (CEM-3)

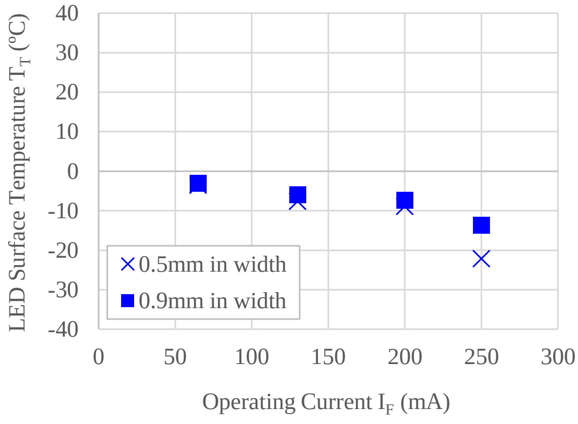


Figure 53. LED 5 (W014) on PCB 2 (FPC)

The evaluation results show the T_T became higher than the T_J. When the PCB used had a low heat dissipation performance (i.e. FPC), the T_J could be higher than the T_T. For LED 5 (i.e. blue), the T_J became higher than the T_T since it does not contain phosphor.
Using these evaluation results, the T_J can be estimated from the T_T measured with an infrared thermal imaging camera. Note that different results may be obtained depending on the heat dissipation performance of the PCB and/or other components/materials that are being used to dissipate the heat. It must be ensured that values for both the T_T and the T_J are obtained, and that the absolute maximum T_J will not be exceeded under any circumstances.

7. Summary

For the Nichia E11A Series LEDs, the thermal design and temperature measurement are challenging since the LEDs themselves are very small and the applications into which the LEDs will be assembled may also be compact. However, if the increase of the junction temperature and surface temperature of the LEDs is controlled by ensuring proper thermal design, the LEDs can expand the design flexibility of the luminaires.
Ensure that the content herein is taken into consideration for the thermal design and the temperature measurement for the chosen application. Note that the thermal resistance values provided herein are the values obtained under Nichia's evaluation conditions/measurements environments and for reference purposes only; they may vary depending on the chosen operation conditions/environments. In addition, Nichia recommends the chosen thermal design has sufficient margins/tolerances.

Disclaimer

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