Light Emitting Diode

Thermal Design Considerations for the Nichia NCSWE13x, NCSxE17x, or NVSxE21x Series LEDs

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NCSWE13x, NCSxE17x, and NVSxE21x 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

Thermal design is very important for LEDs since it determines the optical and electrical characteristics (e.g. luminous flux, forward voltage, etc.) of the LEDs and it even affects the lifetime of the LEDs. When performing a thermal evaluation, check how high the junction temperature of the LED will be when the LED is operated in the conditions/environments in which the LED will actually be used.

Nichia's NCSWE13x, NCSxE17x, and NVSxE21x LEDs are much smaller in size than other LEDs that produce the same amount of light energy and they have a high luminous flux density. Note that the thermal design may be challenging since the input power per unit area of the package for the LEDs is higher than for conventional LEDs.

This application note provides the thermal design considerations for these 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. Structure and Thermal Path of the NCSWE13x, NCSxE17x, and NVSxE21x LEDs

For the NCSWE13x, NCSxE17x, and NVSxE21x LEDs, the light emitting device (hereinafter referred to as "chip") is soldered directly to an aluminum PCB to ensure that the heat that is generated at the chip is efficiently dissipated to the atmosphere. With this structure, the heat generated at the chip can be transferred and dissipated efficiently as noted below and shown in Figure 1:

LED chip → Electrode → Solder → Copper Layer → Insulation Layer → Aluminum → Heatsink

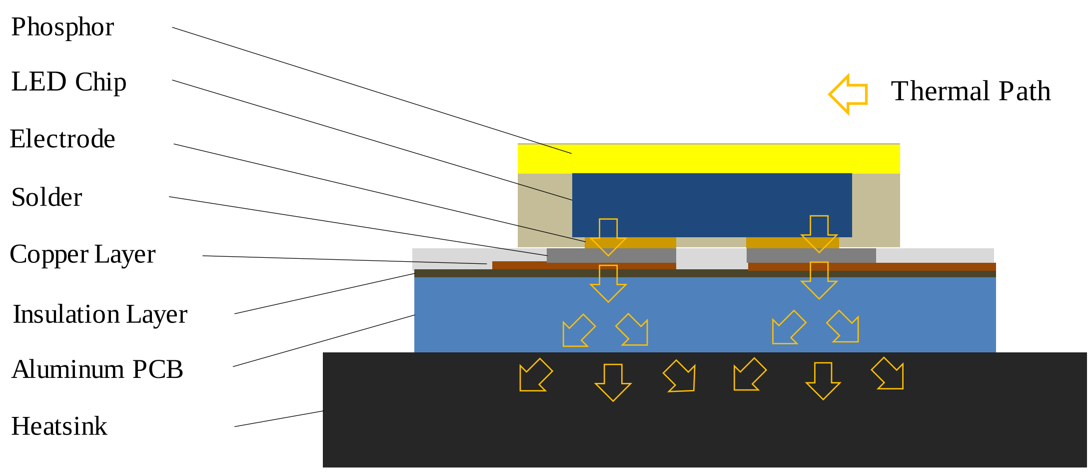
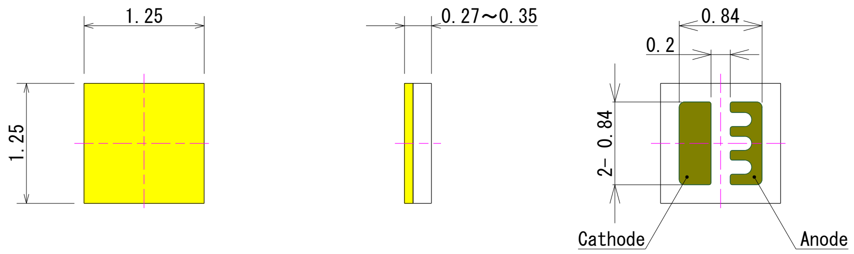


Figure 1. Reference Image of the Structure of the NCSWE13x, NCSxE17x, and NVSxE21x LED and Thermal Path

The size of the electrodes are relatively small in proportion to the outline dimensions of the package for the NCSWE13x[1], NCSxE17x, and NVSxE21x LEDs; materials to be used in the thermal path between the electrodes and heatsink for these LEDs must have sufficiently high heat dissipation. If a PCB with a low heat dissipation is used (e.g. glass epoxy resin PCB), the heat may not be appropriately dissipated causing the junction temperature of the LED to become extremely high, the luminous flux to be reduced, etc.

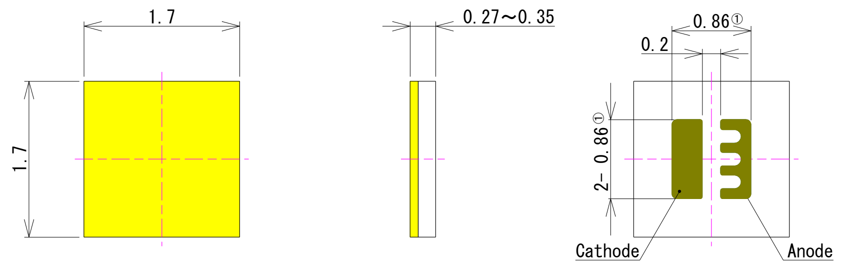
See Figures 2, 3, and 4 for the dimensions of the electrodes of the NCSWE13x, NCSxE17x, and NVSxE21x LEDs.



(Unit: mm)

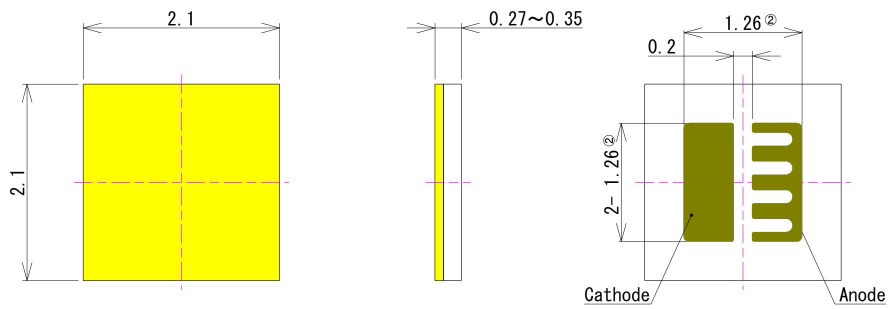
Figure 2. Outline Dimensions of the NCSWE13x LED

The outline dimensions of the NCSWE13x LEDs are geometrically similar to those of the NCSxE17x LEDs; the NCSWE13x LEDs are smaller. The NCSWE13x and NCSxE17x LEDs use the same chip.



(Unit: mm)

Figure 3. Outline Dimensions of the NCSxE17x LED



(Unit: mm)

Figure 4. Outline Dimensions of the NVSxE21x LED

[1] The size of the electrodes for the NCSWE13x are not as small in proportion to the outline dimensions of the package when compared to the packages of the NCSxE17x and NVSxE21x LEDs.

For the NCSxE17x and NVSxE21x LEDs, the dimensions of the electrodes are different depending on the product version. See the applicable specifications for details.
① NCSxE17A: 0.86mm, NCSxE17A-V1: 0.84mm
② NVSxE21A: 1.26mm, NVSxE21A-V1: 1.24mm

3. Thermal Design

3.1 Thermal Resistance Model and Parameters

Figure 5 shows a cross-sectional view of a NCSWE13x, NCSxE17x, or NVSxE21x LED mounted on an aluminum PCB with heat dissipation using a heatsink and Figure 6 shows a simplified thermal resistance model for these LEDs.

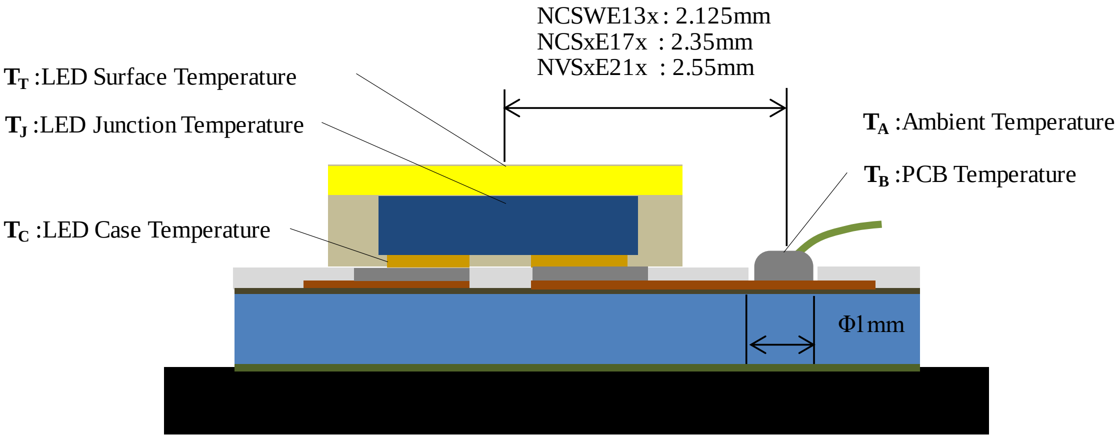


Figure 5. Cross-sectional View of the LED

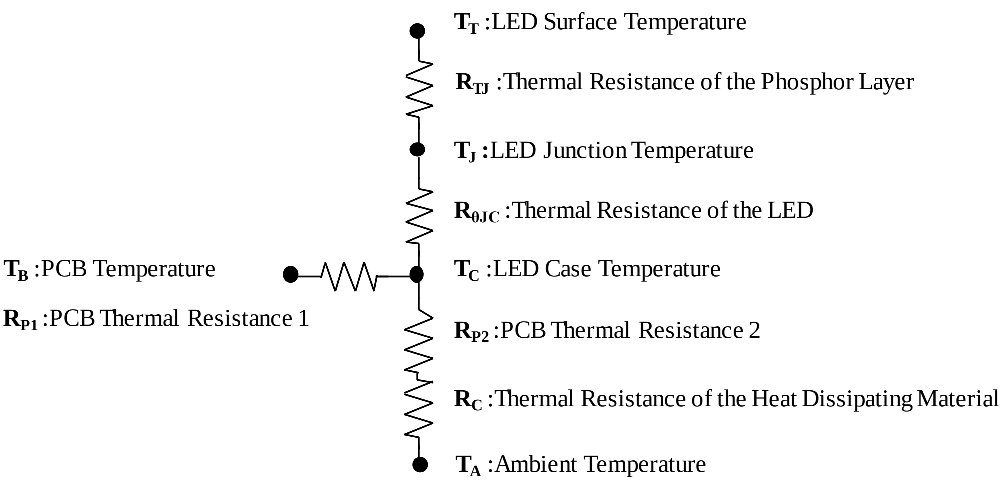


Figure 6. Simplified Thermal Resistance Model

Table 1. Terms, Descriptions, and Main Precautions

Term	Symbol	Descriptions and Cautions/Suggestions
LED Surface Temperature	T_T	Temperature of the emitting surface of the LED.
LED Junction Temperature	T_J	The temperature of the LED chip. The maximum junction temperature of the NCSWE13x, NCSxE17x, and NVSxE21x LED is 135°C. To achieve longer reliability, ensure that the LEDs are operated at a junction temperature of 100°C or less.
Thermal Resistance of the LED	$R_{\theta JC}$	Thermal resistance from the LED chip to the LED electrode of the LED. The $R_{\theta JC}$ is obtained according to the measurement/calculation methods detailed in JESD 51-1 standard. The maximum thermal resistance of the NCSWE13x and NCSxE17x LEDs is 1°C/W and for NVSxE21x LED it is 0.6°C/W, which are very low.
LED Case Temperature	T_C	Temperature of the electrode of the LED. The T_C is used in a thermal simulation; it cannot be measured once the LED is soldered to the PCB.
PCB Temperature	T_B	PCB surface temperature near the side of the LED package. For the NCSWE13x, NCSxE17x, and NVSxE21x LEDs, since there are no solder fillets at the electrodes and it is difficult to measure the temperature at the soldered area directly, the measurement should be conducted at TB point shown in Figure 5.
PCB Thermal Resistance 1	R_{P1}	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 soldering pad pattern for the LEDs, the copper area and heat dissipation performance of the aluminum PCB, heatsink, the operating temperature, etc.
Thermal Resistance of from the LED to the PCB	$R_{\theta JB}$	Thermal resistance from the LED chip to the T_B measurement point on the PCB. This thermal resistance value can be obtained by using the following equation: $R_{\theta JB} = R_{\theta JC} + R_{P1}$
PCB Thermal Resistance 2	R_{P2}	Combined thermal resistance of an aluminum PCB in the vertical direction from the soldered area towards the heatsink. The thermal resistance of an aluminum PCB varies significantly depending on the properties of the insulating layer (thermal conductivity, thickness). Take this into consideration when selecting materials. The thermal resistance of an aluminum PCB can be obtained by using the following equation: Thermal resistance (°C/W) = Thickness of the insulating layer (m)/(Thermal conductivity of the insulating layer [W/m·K] × Its area [m²])
Thermal Resistance of Thermal Dissipation Material	R_C	Combined thermal resistance of a thermal sheet, thermal grease, heatsink, etc.
Ambient Temperature	T_A	Ambient temperature of the LED assembled in the chosen application.

Section 3.2 explains the importance of what PCB is selected for the LEDs based on the results of the thermal simulations Nichia performed.

3.2 Thermal Simulations for PCBs

Since the electrodes of the NCSWE13x, NCSxE17x, and NVSxE21x LEDs are very small, the heat dissipation of the PCB used is important. When the chosen application requires a large electric power, Nichia recommends using an aluminum PCB with a high thermal conductivity instead of using a glass resin substrate (FR4), a glass composite substrate (CEM3), or an aluminum PCB with a low thermal conductivity. For reference, Figures 7 and 8 show the thermal simulations when an LED is mounted on aluminum PCBs with low and high thermal conductivity.

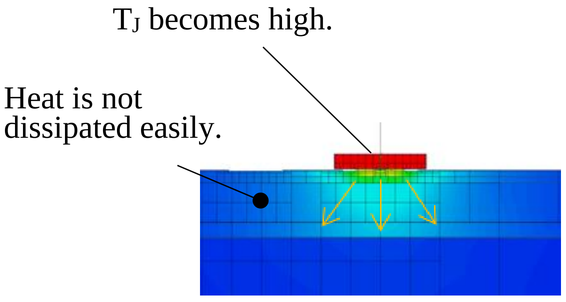


Figure 7. Aluminum PCB with a Low Thermal Conductivity

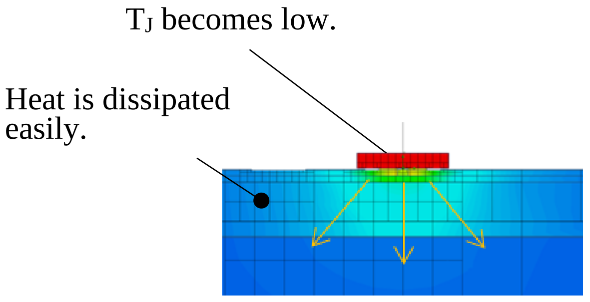


Figure 8. Aluminum PCB with a High Thermal Conductivity

When an LED is mounted on an aluminum PCB with a low thermal conductivity, the heat dissipation becomes insufficient, resulting in a high junction temperature, whereas when an LED is mounted on an aluminum PCB with a high thermal conductivity, the heat generated from the LED can dissipate efficiently, resulting in a low junction temperature.

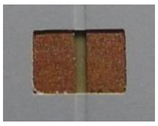
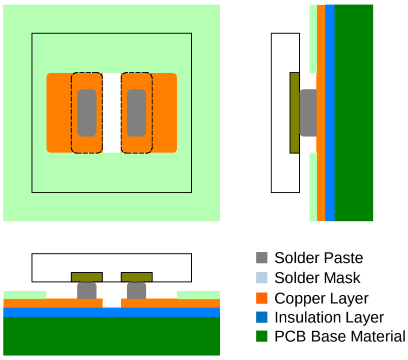
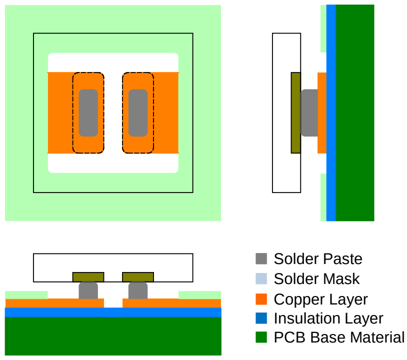
3.3 Two Types of Copper Layer Designs and Their Heat Dissipation Performance

There are two types of copper layer designs as explained below. Table 2 provides their advantages and disadvantages.

Solder Mask Defined (SMD): The shape and location of the soldering pad pattern are defined by the aperture of the solder resist that is applied to the surface of the PCB.

Non-Solder Mask Defined (NSMD): The shape and location of the soldering pad pattern are defined by the dimensions of the copper layer, not by those of the solder resist.

Table 2. Comparison between SMD and NSMD

Soldering Pad Pattern	SMD	NSMD
Appearance		
Reference Diagram		
Placement Accuracy	Not Good Disadvantage: The coating accuracy of the solder resist effects the placement accuracy.	Good Advantage: The coating accuracy of the solder resist does not have as much of an effect on the placement accuracy.
Heat Dissipation	Good Advantage: Good heat dissipation performance due to a large copper layer area.	Not Good Disadvantage: Limited heat dissipation performance due to a small copper layer area.

- Placement Accuracy

The electrodes of the NCSWE13x, NCSxE17x, and NVSxE21x LEDs are very small and the clearance between the anode and cathode terminals is only 0.2mm. Thus, PCBs need to be fabricated precisely. For SMD, since the dimensions and location of the soldering pad pattern are defined by the solder resist, the location of the soldering pad pattern will deviate from the target location if the solder resist is not applied to the PCB precisely; it will cause a difference between the dimensions of the soldering pad patterns for the anode and cathode. These defects directly cause a placement failure for the LEDs (e.g. open or short circuit, positional deviation, float, solder ball); if SMD is used, it must be ensured that the PCB is fabricated precisely and that sufficient evaluations for the LED placement are performed.

For NSMD, since the dimensions and location of the soldering pad pattern are defined by the copper layer, positional deviation of the solder resist does not have a major effect on the placement accuracy; NSMD provides better placement accuracy for the LEDs.

Note that once the NCSWE13x, NCSxE17x, and NVSxE21x LEDs are soldered to a PCB, they must not be repaired. Refer to Nichia's application notes “Assembly Precautions for the Nichia E13 Series LEDs” or “Assembly Precautions for the Nichia NCSxE17x or NVSxE21x LEDs” and perform sufficient evaluations before use.

- Heat Dissipation

To efficiently transfer the heat generated from the LEDs to the aluminum PCB, it is required to have the copper layer around the electrodes as large as possible. With NSMD, it cannot be wider than the electrode width. With SMD, it can be very large as long as the chosen PCB assembly design allows; SMD provides better heat dissipation. Regarding the thickness of the copper layer, the thicker it is, the better the heat dissipation performance will be. However, Nichia recommends using a PCB whose copper layer has a thickness of 35μm with consideration of imprecise etching that can occur when fabricating PCBs due to the narrow clearance (i.e. 0.2mm) between the electrodes.

3.4 Soldering Pad Patterns

Figure 9 shows the recommended soldering pad patterns for the NCSWE13x, NCSxE17x, and NVSxE21x LEDs for the NSMD structure.

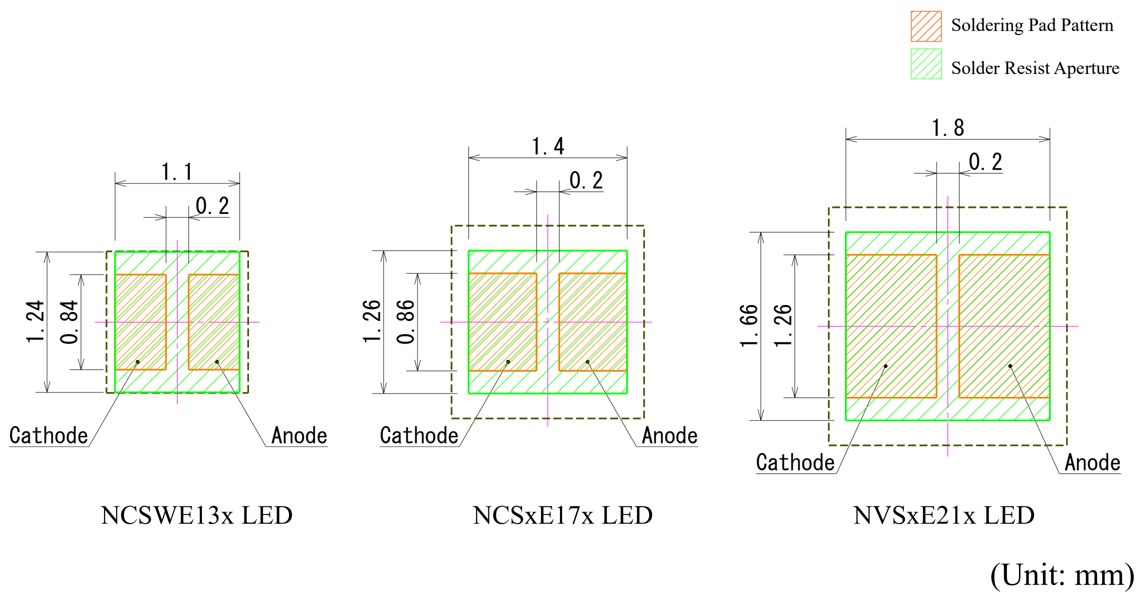


Figure 9. Recommended Soldering Pad Pattern for the NSMD Structure

For example, for the NCSxE17x LEDs, it is recommended that the solder resist is as long as 1.26mm while the soldering pad pattern is only 0.86mm long; if the positional deviation of the solder resist is less than 0.2mm, it will not affect the placement accuracy of the LEDs. Both SMD and NSMD structures have advantages and disadvantages; ensure that the better method is selected for the chosen application with careful consideration of the information provided in section 3.3.

Nichia measured the thermal resistance values ($R_{\theta JB}$) of the LEDs. The parameters and evaluation results are detailed in Section 4.

4. Thermal Resistance of the LEDs

Nichia measured the thermal resistance ($R_{\theta JB}$) of the NCSxE17x and NVSxE21x LEDs using the following parameters: the thermal conductivity rate of the insulating layer of an aluminum PCB and the copper layer design. The $R_{\theta JB}$ was obtained in accordance with the measurement method detailed in JESD 51 standard.

4.1 Specifications of the PCBs used for the Evaluation

Nichia used six different types of aluminum PCBs with insulating layers whose thermal conductivity ranged from 1.8W/m·K to 11.1W/m·K. The specifications of the PCBs are shown in Table 3.

Table 3. Specifications of the PCBs

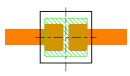
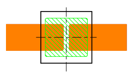
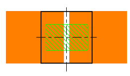
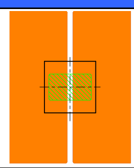
Aluminum PCB[2]	Unit	NRA-ES1	NRA-8	NRA-E(3.0)	NRA-E(6.5)	NRA-H6	NRA-H10
Thermal Conductivity Rate of the Insulating Layer[3]	W/m·K	1.8	2.1	2.7	4.5	5.7	11.1
Thickness of the Insulting Layer	µm	120	120	120	120	120	120
Thickness of the Copper Layer	µm	35	35	35	35	35	35
Thickness of the Aluminum Layer	mm	1	1	1	1	1	1

4.2 Copper Layer Designs and PCB Traces

- The NCSxE17x LEDs

For the evaluation, Nichia used two types of copper layer designs (i.e. NSMD and SMD) and PCBs with four different PCB traces: the minimum (0.5mm), the same as the electrode length (0.86mm), the same as the length of the package (1.7mm), and the maximum (5mm).

Table 4. Evaluation Conditions for the NCSxE17x LEDs

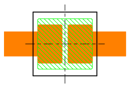
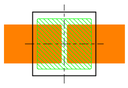
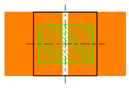
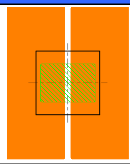
Condition	A	B	C	D
Copper layer Design	NSMD	NSMD	SMD	SMD
PCB Trace Width	0.5mm	0.86mm	1.7mm	5mm
Image of the PCB Trace				
Recommended Use	Not Recommended	High-density Applications	High-density Applications	Non-high-density Applications

[2] The aluminum PCBs are manufactured by NIPPON RIKA INDUSTRIES CORPORATION.
[3] The thermal conductivities of the insulating layers are the values stated in the aluminum PCB manufacture's data sheet, these are not guaranteed values.

- The NVSxE21x LEDs

For the evaluation, Nichia used two types of copper layer designs (i.e. NSMD and SMD) and PCBs with four different PCB traces: the minimum (0.8mm), the same as the electrode length (1.26mm), the same as the length of the LED package (2.1mm), and the maximum (5mm).

Table 5. Evaluation Conditions for the NVSxE21x LEDs

Condition	A	B	C	D
Copper layer Design	NSMD	NSMD	SMD	SMD
PCB Trace Width	0.8mm	1.26mm	2.1mm	5mm
Image of the PCB Trace				
Recommended Use	Not Recommended	High-density Applications	High-density Applications	Non-high-density Applications

4.3 Measurement Results for the Transient Thermal Resistance

- Figure 10 shows the evaluation results for the thermal resistance ($R_{\theta JB}$) for the NCSxE17x LEDs (sm27, R8000) at I_F=700mA.

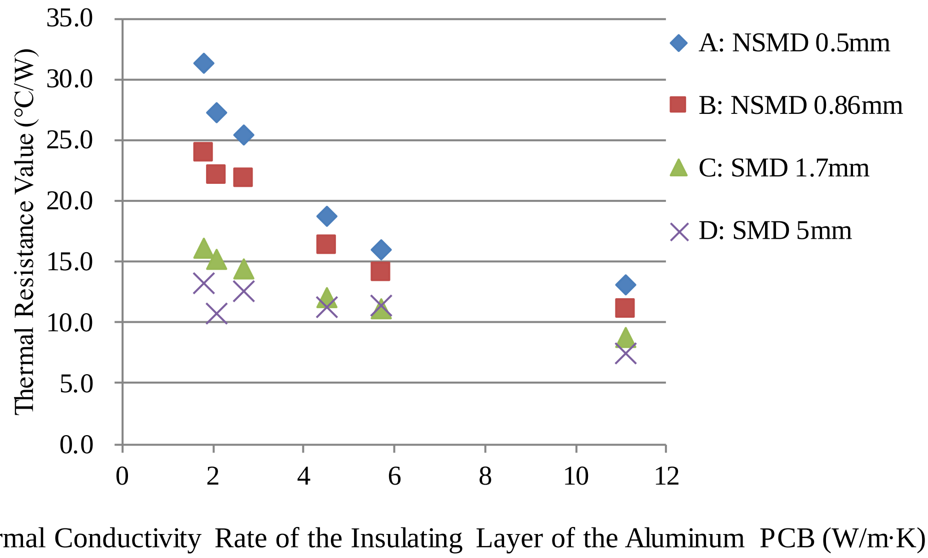


Figure 10. Thermal Resistance ($R_{\theta JB}$) for the NCSxE17x LEDs

- Figure 11 shows the evaluation results for the thermal resistance ($R_{\theta JB}$) for the NVSxE21x LEDs (sm27, R8000) at I_F=1400mA.

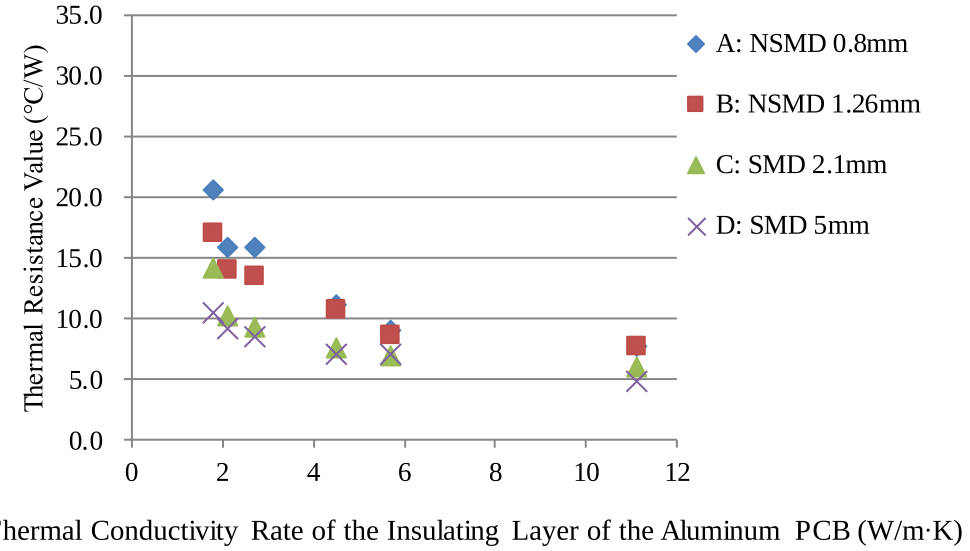


Figure 11. Thermal Resistance ($R_{\theta JB}$) for the NVSxE21x LEDs

For the NCSxE17x and NVSxE21x LEDs, the larger the thermal conductivity rate of the insulating layer of the aluminum PCB was, the smaller the thermal resistance became. The thermal resistance was smaller for the copper layer design of SMD than for NSMD. Also, the larger the width of the PCB trace was, the smaller the thermal resistance became.

4.4 Recommended Aluminum PCB

If an aluminum PCB with a high thermal conductivity rate is used, the thermal resistance of the LEDs ($R_{\theta JB}$) will be smaller and the effect that may be caused on the $R_{\theta JB}$ by the copper layer design/the width of the PCB trace will be limited. For the NCSWE13x, NCSxE17x, and NVSxE21x LEDs, Nichia recommends using an aluminum PCB whose insulating layer has a thermal conductivity rate of ≥5.7W/m·K.

5. Junction Temperature (T_J)

The junction temperature (TJ) of the LEDs is calculated using one of the following two methods:
- Calculated from the PCB temperature (T_B) and the input power (see section 5.1).
- Calculated by measuring the ΔV_F of the LED (see section 5.2).

This section provides the detailed information on these calculation methods.

5.1 Calculating the T_J Using T_B and Input Power

The equation below is used to calculate the approximate T_J.

Equation 1: $T_J = T_B + R_{\theta JB} \times W$

T_J = Junction Temperature (°C)
T_B = PCB Temperature (°C)
$R_{\theta JB}$=Thermal Resistance from LED Chip to T_B Measurement Point (°C/W)
W = Input Power ($I_F \times V_F$) (W)

Table 6. Thermal Resistance

Part Number[4]	Symbol	Unit	PCB A[5]	PCB B[6]
NCSxE17x (NCSWE13x)	$R_{\theta JB}$	°C/W	16	31
NVSxE21x	$R_{\theta JB}$	°C/W	9	21

As explained in section 4, the $R_{\theta JB}$ will significantly vary depending on the PCB used. Table 6 shows the $R_{\theta JB}$ of the LEDs for different PCBs; these values are obtained from the evaluation that is explained in section 4 with the severest condition for the PCB trace width (i.e. 0.5mm) and copper layer design (i.e. NSMD). The value may vary depending on the chosen operation conditions/environments; these values should be used for reference purposes only.

- Measurement of T_B Temperature

The appropriate sensor position for a thermocouple is where it will not damage the LED when the sensor is soldered to the PCB and where it is as close as possible to the LED. Nichia recommends placing the temperature measurement point (diameter: 1.0mm) 2.125mm from the center of the LED for the NCSWE13x LEDs, 2.35mm for the NCSxE17x LEDs, and 2.55mm for the NVSxE21x LEDs. Figure 12 shows a thermocouple Nichia uses. Figure 13 provides an example of how a thermocouple is attached to a PCB.

Figure 12. Thermocouple (Type K)

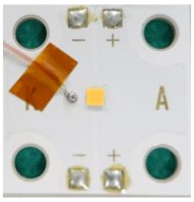


Figure 13. Example of How a Thermocouple is Attached to a PCB

[4] For the NCSWE13x LEDs, refer to the $R_{\theta JB}$ for the NCSxE17x LEDs since they use the same LED chips.
[5] Aluminum PCB whose insulating layer has a thermal conductivity rate of ≥5.7W/m·K and a thickness of 120μm.
[6] Aluminum PCB whose insulating layer has a thermal conductivity rate of ≥1.8W/m·K and a thickness of 120μm.

5.2 Calculating the T_J Using the ΔV_F Method

The forward voltage (V_F) of an LED varies as the ambient temperature (T_A) changes. The T_J calculation method discussed in this section takes advantage of this property to calculate the T_J of the LEDs incorporated into a light module.

- Temperature Coefficient for a Single LED on a PCB

The V_F is measured with the light module placed in a constant temperature chamber and the T_A changed from 25ºC to 135ºC. The temperature coefficient is calculated from the measurement result using the equation below.

Equation 2: Temperature Coefficient, $K = V_{F\ at\ 25°C} - V_{F\ at\ 135°C} / (135\text{-}25)$

The measuring current must be a very low current of I_M=1mA; with this current, the self-heating of the LED will not affect the V_F measurement and the V_F measurement will be reproducible. Figure 14 shows an example of a measurement circuit. Figure 15 shows the relationship between the T_A and V_F.

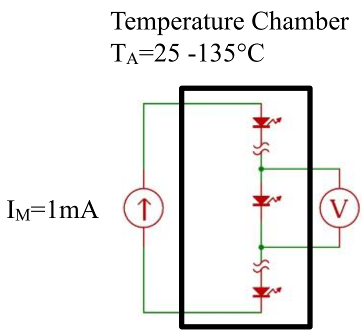


Figure 14. Example of a Measurement Circuit

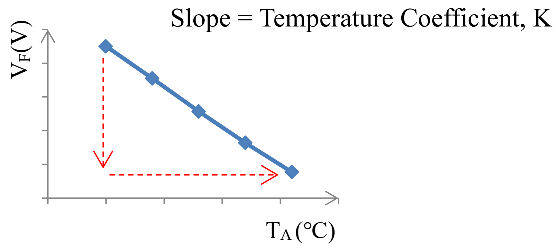


Figure 15. Relationship between the T_A and V_F

- T_J Calculation after Thermal Saturation

The forward voltage is measured immediately after the LED is energized (V_{F1}) and when the saturation temperature at the junction has been reached after aging (V_{F2}) to calculate the ΔV_F ($\Delta V_F = V_{F1}\text{-}V_{F2}$). The measuring current for the V_{F1} and V_{F2} must be a very low current of I_M=1mA; with this current, the self-heating of the LED will not affect the V_F measurement and the V_F measurement will be reproducible. The aging current (I_F, the current applied to have the saturation temperature reached) must be the current that will be actually used for the chosen application. The equation below shows the relationship between the T_J and ΔV_F; the approximate T_J is obtained with this equation.

Equation 3: $T_J = \Delta V_F / K + T_A$

Figure 16 shows an example of a measurement circuit. Figures 17 and 18 show an example of input currents and V_F measurement respectively for reference purposes.

I_M=1mA (for V_{F1}/V_{F2} Measurement)
I_F= Aging Current

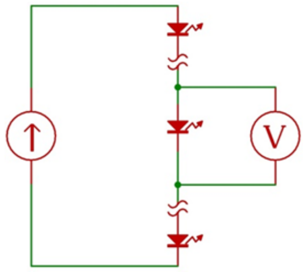


Figure 16. Example of a Measurement Circuit

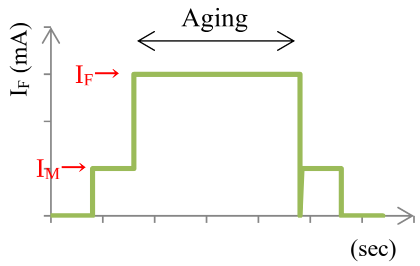


Figure 17. Example of Input Currents

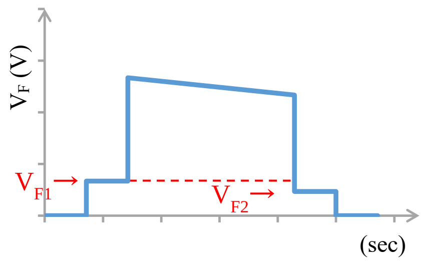


Figure 18. Example of V_F Measurement

The ΔV_F method provides a higher measurement accuracy than the method detailed in section 5.1; the T_J can be calculated more accurately. However, the ΔV_F method is not easy to use since it requires equipment (e.g. constant temperature chamber, power supply to apply a measuring current, measurement instruments, etc.) and that the measurement for the temperature coefficient K and ΔV_F must be accurate. Nichia provides a simpler temperature evaluation method in section 6.

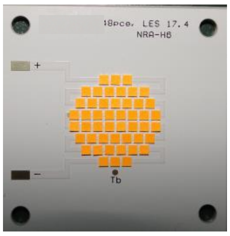
6. Thermal Evaluation

Infrared thermography is an effective method to evaluate the temperatures of an LED light module. The LED junction temperature cannot be measured by infrared thermography; however, the LED surface temperature and the temperature distribution over the entire surface of the PCB can be obtained by infrared thermography.

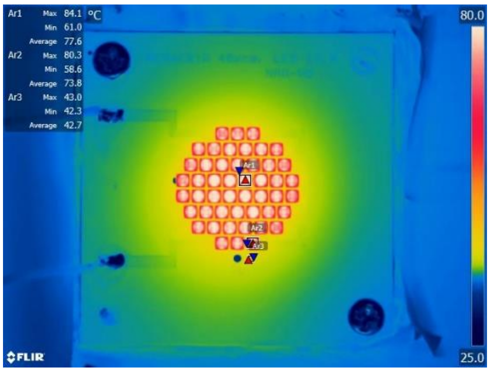
Figure 19 shows an example of Nichia's thermal evaluation.

6.1 Example of Thermal Evaluation for an LED Light Module

Evaluated Module:



PCB Outline Dimensions: 40×40mm
Light Emitting Surface (LES): φ17.4mm
P/N of the LEDs: NCSxE17x (sm27, R8000)
Number of LEDs: 48 LEDs
  I_F: 350mA
  Input Power: 48W
Insulating Layer of the Aluminum PCB:
  Thermal Conductivity: 5.7W/m·K
  Thickness: 120μm
Copper Layer Design: NSMD
Thermal Resistance of the Heatsink: 0.5°C/W



Measurements		°C
Ar1[7]	Max	84.1
	Min	61.0
	Average	77.6
Ar2[8]	Max	80.3
	Min	58.6
	Average	73.8
Ar3[9]	Max	43.0
	Min	42.3
	Average	42.7

Parameters	
Emissivity	0.95
Refl. temp	25°C

Figure 19. Thermal Evaluation Using a Thermal Imaging Camera[10]

6.2 LED Surface Temperature

Since the NCSWE13x, NCSxE17x, and NVSxE21x LEDs have a phosphor layer above the LED chip, the LED surface temperature tends to be higher than the LED junction temperature. Most of the heat is generated in the LED junction area; however, heat is also generated in the phosphor layer due to the Stokes' loss in the wavelength conversion. The phosphor layer of these LEDs is very thin and is located far from the heat dissipation path of the LED chip, leading to the poor heat dissipation. Refer to Figure 20 for a schematic diagram of how the heat generated flows within these LEDs.

7 Ar1: Surface temperature of an LED in the middle of the LED cluster.
8 Ar2: Surface temperature of an LED at the edge of the LED cluster.
9 Ar3: PCB temperature.
10 Thermal Imaging Camera Used: T620 (640×480 pixel), manufactured by Teledyne FLIR LLC

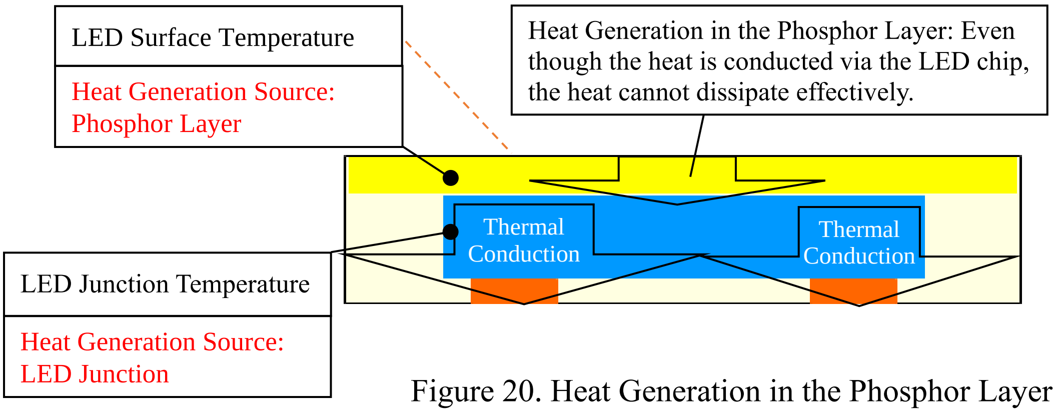


Figure 20. Heat Generation in the Phosphor Layer

The amount of the heat generated in the phosphor layer changes depending on the color temperature, color rendering index, and light output of the LEDs. Figures 21 and 22 show the temperature difference between the LED surface and the LED junction at different forward currents.

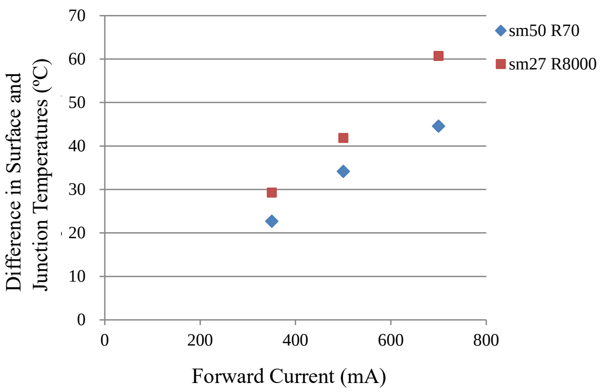


Figure 21. Relationship between the LED Surface and Junction Temperature Differences for the NCSxE17x LED

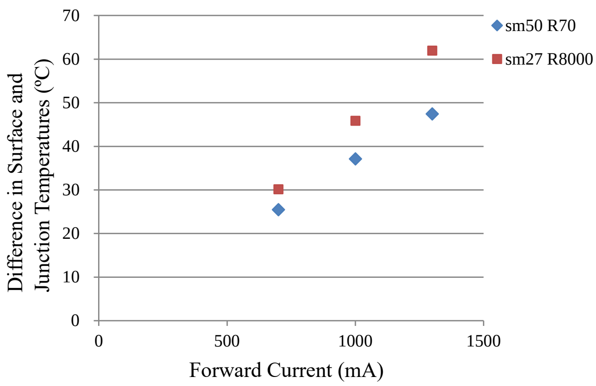


Figure 22. Relationship between the LED Surface and Junction Temperature Differences for the NVSxE21x LED

For example, it is indicated in Figure 21 that when the NCSxE17x LEDs (R8000, sm27) are operated at I_F=350mA, the LED surface temperature becomes higher than the junction temperature by approximately 30°C. Using this evaluation result, the approximate junction temperature can be calculated. See the equation below for the calculation.

Calculation for the NCSxE17x LEDs (R8000, sm27) at I_F=350mA:

Approx. T_J = LED surface temperature (measured by a thermal imaging camera) - 30°C (based on Figure 21)

6.3 Precautions for Thermography Measurement

- Infrared thermography measurements will contain errors due to the measurement equipment, measurement conditions, measurement environment, etc. When using measurement values obtained through infrared thermography for the thermal design, the chosen application must be designed with sufficient margins to ensure the heat is dissipated properly.
- The LED surface temperature becomes even higher than the LED junction temperature during operation. When using optical components (e.g. lens or reflector) with a low heat resistance temperature, ensure that the appropriate clearance is provided between the optical component and the LED and that the heat resistance temperature of the optical component used must not be exceeded.
- Nichia recommends that the LED surface temperature is 150ºC or less[11]. When the LED surface temperature is high, it indicates that the LED has been operated under significant severe conditions; ensure that the PCB used, the shape of the soldering pad pattern, the performance of the heatsink, and the value of the forward current are appropriate for the chosen application.

7. Summary

This application note explains important information and precautions for the thermal design of the NCSWE13x, NCSxE17x, and NVSxE21x LEDs. Select suitable PCB materials and thermal management materials for the LED light module when designing the chosen application.
Perform sufficient thermal evaluations prior to use with the chosen application with consideration of conditions/environments in which the LEDs will actually be used to ensure there are no issues.

[11] The LED surface temperature should be ≤150°C for the R70, R8000, R9050, or R9080 CRI Rank LEDs, and ≤135°C for the Rs060 CRI Rank LED.

Light Emitting Diode

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