Light Emitting Diode

LED Pitch and Heat Dissipation Performance (5-10mm Pitch)

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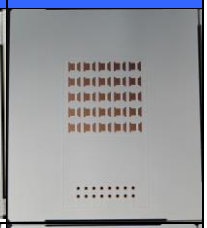
1. Objective

When LEDs are used for a lighting fixture, in general, multiple LEDs, not a single one, are installed in the unit.
Operating a single LED generates high heat; all the more heat is generated when multiple LEDs are mounted on a board due to the mutual effect. Then, the junction temperature (hereinafter referred to as T_J) of each LED gets higher, than in a single usage, leading to the decrease in their lifetimes and their luminous flux.
Minimizing T_J equates to better thermal management, allowing for a longer lifetime.
Therefore, LEDs must be mounted with the optimal pitch among them.
This document shows the optimal pitch between LEDs by demonstrating some configurations.

2. Materials and Procedures

First, we prepared and used the aluminum board (hereinafter referred to as AL) and the glass epoxy board (hereinafter referred to as FR-4) as follows (cf. Table 1). Then, we mounted 9 LEDs on each board according to the simulation pitches (cf. Table 2). Please note that the pitch is the distance between the centers of an LED and its neighboring one (cf. Figure 1).

Table1. Testing Board

	Aluminum on either surface	Glass Epoxy on both surfaces
Top Surface		
Reverse Surface		
Thickness	1.0 mm	1.6 mm
Copper Foil Thickness	35 μ m	
Insulating Layer Thickness	120 μ m	

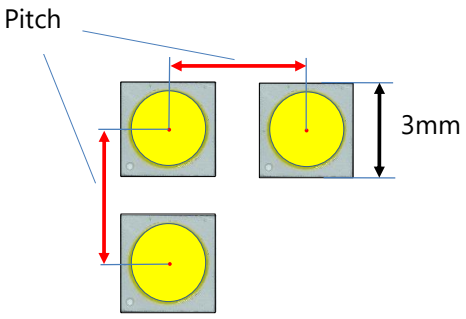
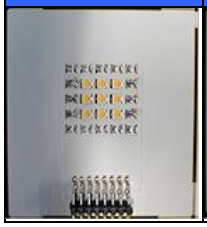
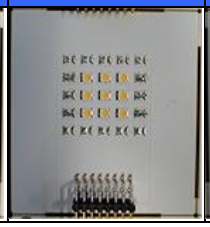


Figure 1. Pitch

Second, the LEDs were operated in a closed environment for 15 minutes. Then, when the temperature was saturated, the soldering temperature (hereinafter referred to as Ts) of the cathode side of the LED located in the center was measured. Figure 2 shows the Ts measurement point.

Table 2. Pitch Pattern

5mm Pitch	6mm Pitch	7mm Pitch	10mm Pitch
			

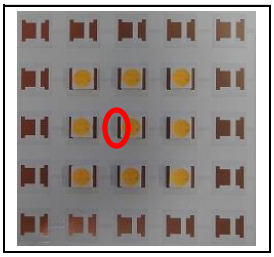


Figure 2. Ts Measuring Point

3. LED Models for Demonstration

We demonstrated the configurations by using the 2 models below:

Table 3. LEDs for Demonstration

LED Models	Part No. NS2W757A-V1	Part No. NF2W757AR-V1
Overview		
Dimensions [mm]	3.0×3.0×0.52	
Forward Current [mA]	65	150
Maximum Forward Current [mA]	180	200
Forward Voltage [V]	2.85	6.3
Maximum Junction Temperature [°C]	120	

4. T_J Measurement Results According to each Pitch

4.1 Part No. NS2W757A-V1

Figure 3 shows the T_J measurement results at 4.1W (I_F=150 mA) and 1.7W (I_F=65 mA) according to the specified pitches. On the FR-4, the LED pitches did not affect the T_J much, when the input powers were low; however, when the input powers were increased, the T_J varied depending on the LED pitches: The smaller the LED pitch was, the higher the T_J became. On the other hand, there was no difference in the T_J values on the AL, regardless of the LED pitches.

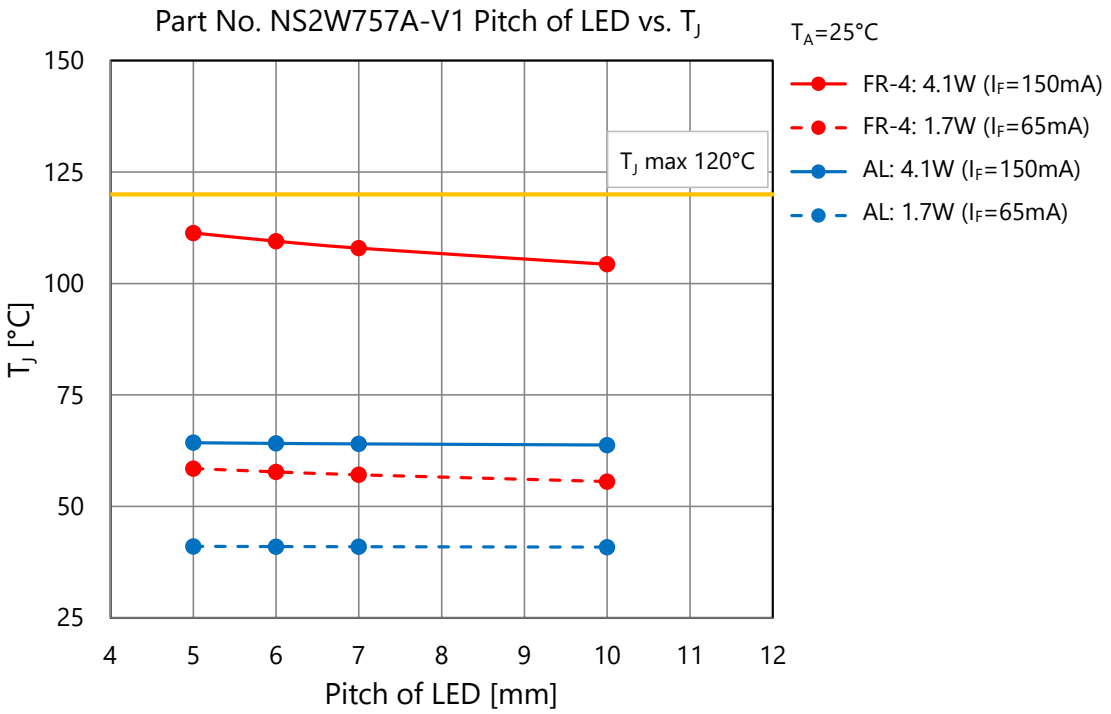


Figure 3. Junction Temperature According to LED Pitch (Part No. NS2W757A-V1)

4.2 Part No. NF2W757AR-V1

Figure 4 shows the T_J measurement results at 8.5W (I_F=150 mA) and 5.7W (I_F=100 mA) according to the specified pitches. The T_J values on FR-4 were affected by the LED pitches: The smaller the LED pitches were, the higher the T_J became. On the other hand, there was little difference in the T_J values on the AL, regardless of the LED pitches.

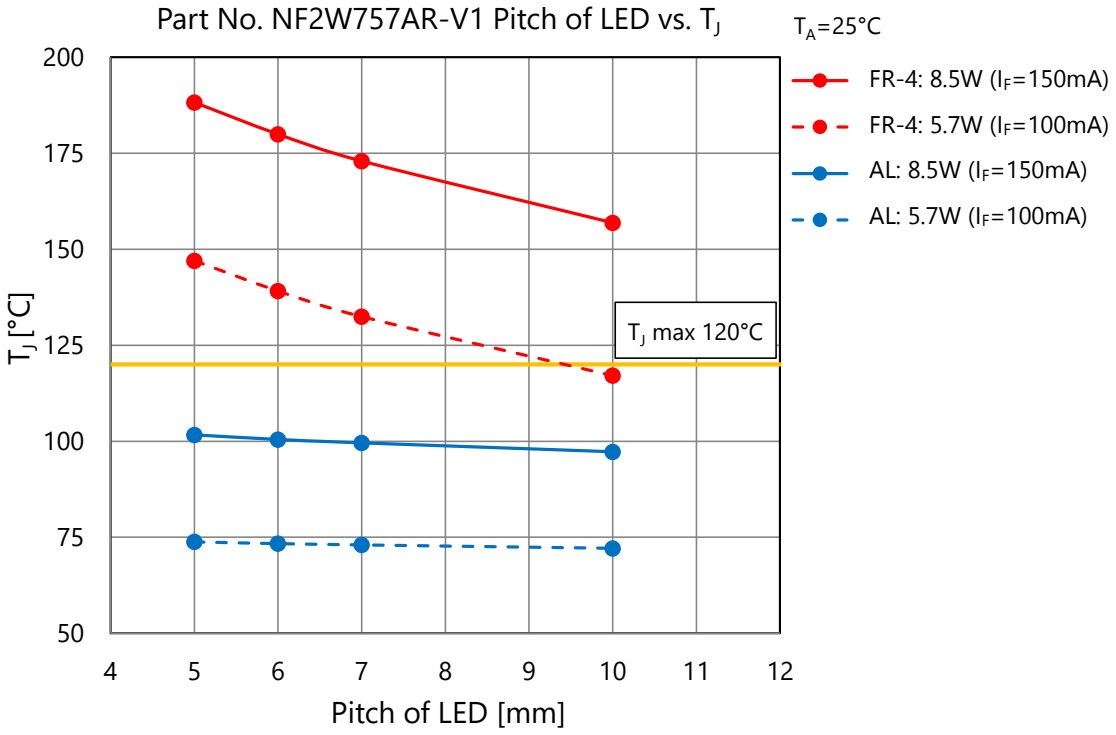


Figure 4. Junction Temperature According to LED Pitch (Part No. NF2W757AR-V1)

As shown in Figure 4, the T_J slightly increased, as the LED pitch got smaller. The aluminum board has a higher thermal conductivity than the FR-4, diffusing heat over the board more easily. Therefore, the heat can be dispersed even when the LED pitch is small.

On the AL, there was little difference in the T_J values depending on the LED pitches. Then, we evaluated the T_J by increasing the amount of the LEDs mounted on the board and the input power more.

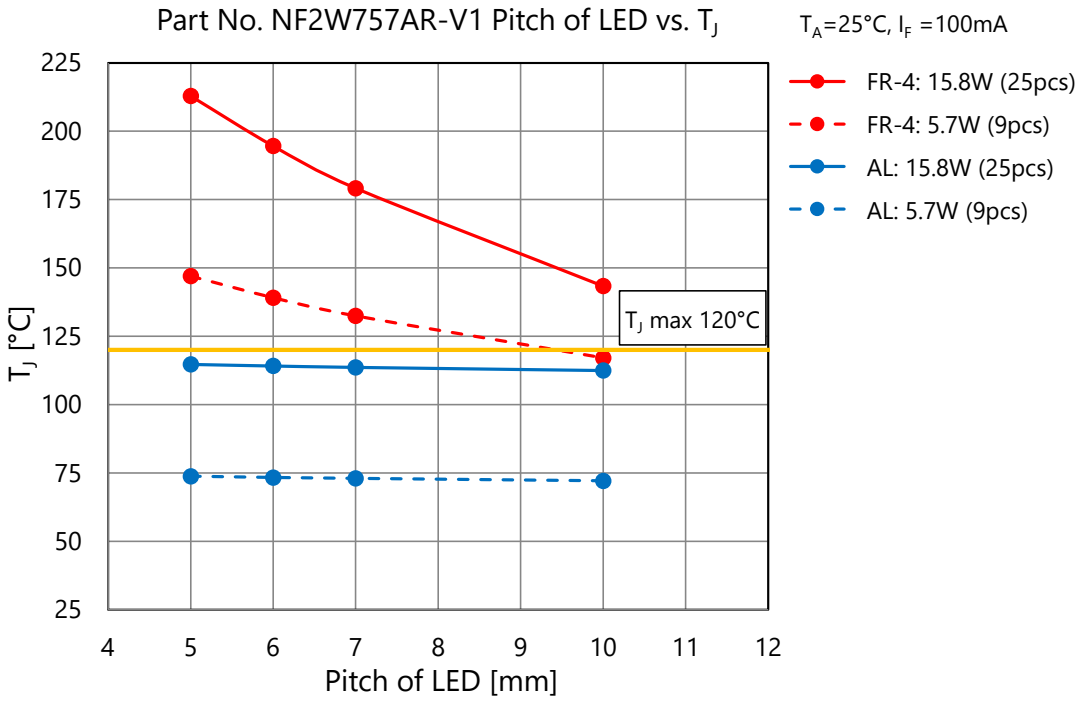


Figure 5. Junction Temperature According to LED Pitch (Part No. NF2W757AR-V1)

(Higher Input Power, 25 LEDs mounted)

On the FR-4, the T_J significantly increased, as the LED pitches became smaller. Therefore, the LED pitches thermally impact on the LED-mounted board. On the other hand, the T_J was not significantly affected by the LED pitches on the AL.

Please note that we performed the test above the T_J max. If LEDs are used above the T_J max in practical use, they can burn out as seen in Figure 6. Customers should take care so as not to operate the LEDs above the T_J max with proper heat dissipation system such as heat sinks.

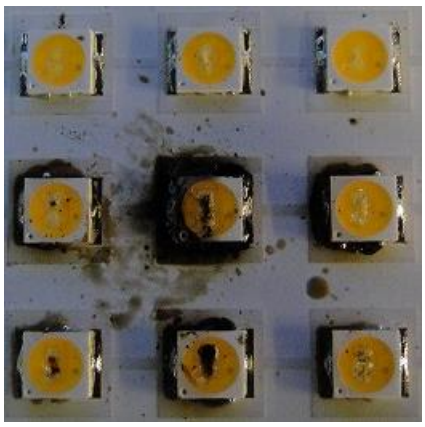


Figure 6. LED Burnout Damage

5. Conclusion

Based on the evaluation results, it has been determined that the T_J is affected by the LED pitch and the input power (W). The optimal pitch between LEDs needs to be designed according to the input power (W). Customers should take care of the board's thermal conductivity in designing the LED pitch.
When the FR-4 is used, heat cannot be easily dispersed due to its low thermal conductivity. Therefore, when the LED pitch is small on the FR-4, heat is excessively increased due to the mutual interaction of the LEDs.
On the other hand, heat can be easily dispersed on the AL due to its high thermal conductivity. Therefore, the AL can reduce the rise in temperature even with the narrow pitch due to lower mutual interaction of the LEDs.
Please design the LED configuration to reduce the influence by heat, by referring to the simulation data shown herein. Your product can thus sustain a long lifetime and maintain the best optical characteristics.

Please use this document as reference, since the measurement data varies depending on LED model and usage conditions/environment at customer sites.
We appreciate your understanding and cooperation.

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