Light Emitting Diode

Assembly and Handling Precautions for LEDs

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NJSx170x, NCSx170x, NC2x170x, NCSx131x, NC2x131x, NC2W121x, NC3W121x, NC4W121x, NC5W121x, NJ2W270x, NJ3W270x, NJSx172x, NFSx172x, NFSx123x, NC2W093x, NC3W093x, NC4W093x, NC5W093x, NSSx146x, NESx146x, NHSx146x, NHSx046x, NSSx064x, NESx064x, NHSx064x, and NSSx063x 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.

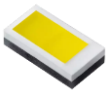
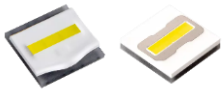
1. Overview

When handling LEDs, care should be taken to ensure that they are handled in a proper manner; if LEDs are improperly handled, it may cause damage to the LEDs and/or an adverse effect on their performance.
This application note provides assembly and handling precautions for Nichia LEDs.

2. Applicable Part Numbers

This application note applies to the LEDs shown in Table 1.

Table 1. Applicable LED Part/Series Numbers

Category	Nichia 170/131 Series[1]			Nichia 121 Series			
Part Number[2]	NJSx170x	NCSx170x NCSx131x	NC2x170x NC2x131x	NC2W121x	NC3W121x	NC4W121x	NC5W121x
Examples of Package Appearance							
Package Size (Unit: mm)	1.6×1.2×0.75	1.8×1.45×0.75	3.0×1.6×0.75	3.1×2.6×0.75	3.1×3.75×0.75	3.1×4.9×0.75	3.1×6.05×0.75
Category	Nichia 270 Series		Nichia 172 Series		Nichia 123 Series		
Part Number[2]	NJ2W270x	NJ3W270x	NJSx172x	NFSx172x	NFSx123x		
Examples of Package Appearance							
Package Size (Unit: mm)	3.5×3.5×0.75	3.5×3.5×0.75	3.0×3.0×0.8		3.0×2.0×0.7		
Category	Nichia 093 Series				Nichia 146 Series		
Part Number[2]	NC2W093x	NC3W093x	NC4W093x	NC5W093x	NSSx146x	NESx146x	NHSx146x
Examples of Package Appearance							
Package Size (Unit: mm)	8.5×8×1.5	8.5×8×1.5	8.5×8×1.5	8.5×8×1.5	2.2×1.4×0.7		
Category	Nichia 046 Series		Nichia 064 Series			Nichia 063 Series	
Part Number[2]	NHSx046x		NSSx064x	NESx064x	NHSx064x	NSSx063x	
Examples of Package Appearance							
Package Size (Unit: mm)	2.2×1.4×1.3		3.5×2.8×2.0			3.5×2.8×2.0	

Note:
[1] The electrode pattern on the back of the package for the Nichia 170 Series and Nichia 131 Series is different.
[2] The x represents a letter that follows the alphanumeric code of the same LED type.
(e.g.: NCSx170x → NCSW170C, NCSW170D, NCSW170D-PCA, NCSA170D, NCSW170F, NCSA170F, etc.)

3. Storage

3.1 Storage Conditions

If the LED package absorbs moisture and is exposed to heat during soldering, it may cause the moisture to vaporize and the package to expand and the resulting pressure may cause internal delamination. To minimize moisture absorption in storage/transit, moisture-proof aluminum bags are used for the LEDs with a silica gel packet to absorb any air moisture in the bag.
Table 2 provides the required storage conditions before and after opening the moisture-proof aluminum bag.

Table 2. Storage Conditions

Conditions	Temperature	Humidity	Time		
Before Opening the Moisture-proof Aluminum Bag	≤30°C	≤90%RH	Within 1 Year from Delivery Date		
After Opening the Moisture-proof Aluminum Bag	≤30°C	≤70%RH	MSL2	MSL2a	MSL3
			Within 1 Year	Within 4 Weeks	Within 168 Hours

The “After Opening” storage time is different depending on the Moisture Sensitivity Level (MSL)[3] of the LED. Refer to the specification for each LED part number for the MSL to ensure that soldering is completed within the specified storage time.

Once the moisture-proof aluminum bag is open, ensure that the LEDs are not exposed to a corrosive environment since the LEDs have metal-plated parts both inside and outside of the package; if the plated surfaces tarnish due to a corrosive environment, it may cause issues (i.e. solderability, optical characteristics).

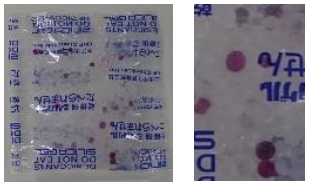
To store any remaining unused LEDs, use a hermetically sealed container with silica gel desiccants. Nichia recommends placing them back to the original moisture-proof aluminum bag and reseal it.

3.2 If the Storage Time has been Exceeded

If the storage time has been exceeded for the LEDs whose “After Opening” storage time is four weeks or 168 hours, ensure that the LEDs are baked for ≥24 hours at a temperature of 65±5ºC before use.
If any pink silica gel beads are found within the storage times, ensure that the LEDs are baked in the same manner.
Baking should only be done once.

Note:
[3] Refer to IPC/JEDEC STD-020 for detailed information regarding the MSL.

A. When packed for shipment



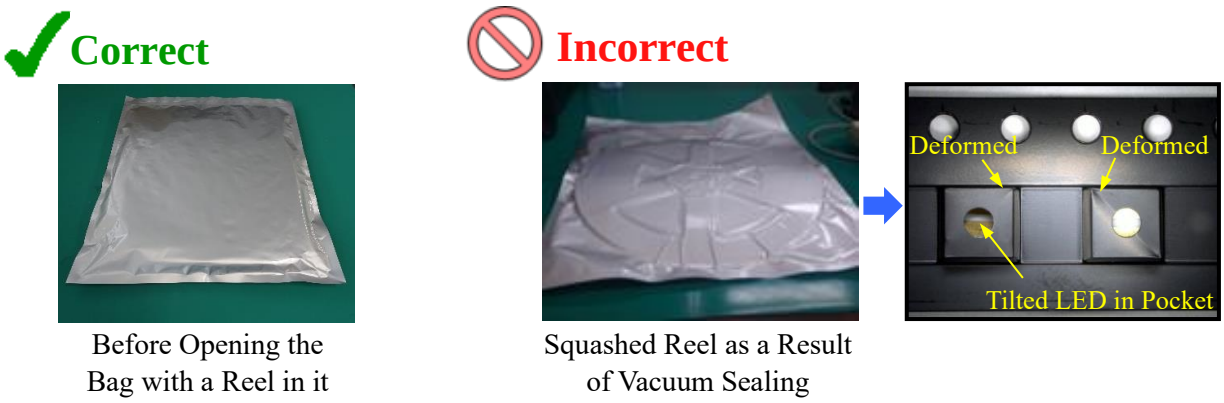
B. After being left for 168 hours at 30°C and 70%RH

The blue silica gel beads absorbed moisture and turned pink.

Figure 1. Appearance of Silica Gel Desiccants

3.3 Deformation of the Embossed Carrier Tape

Do not store the LEDs in a manner where excessive external force may be applied to the reel (e.g. the reel is stored using a vacuum seal, heavy objects are stacked onto the reel, etc.) since it may cause the embossed carrier tape to deform; see Figure 2. If the embossed carrier tape deforms, the LEDs inside the pockets of the embossed carrier tape may tilt, causing damage to the LEDs and/or pick-up errors.



Before Opening the Bag with a Reel in it

Squashed Reel as a Result of Vacuum Sealing

Figure 2. Vacuum Storage and Deformation of the Embossed Carrier Tape

3.4 Storage Environment

To avoid condensation, the LEDs must not be stored in areas where temperature and humidity fluctuate greatly. Also, ensure that the LEDs are not exposed to direct sunlight and/or an environment over a long period of time where the temperature is higher than normal room temperature, and are not stored in a dusty environment.

4. Directions for use

4.1 Absolute Maximum Ratings

Absolute maximum ratings of the LEDs are the maximum values that must not be exceeded even for a short period of time. It must be ensured that the absolute maximum ratings are taken into consideration when designing a system/application using the LED and will not be exceeded in the conditions/environments in which the LED will actually be used even for a short period of time. For the absolute maximum rating values for the LED, refer to the applicable specification.

4.2 Circuit Design Considerations

The circuit must be designed to ensure that the absolute maximum ratings are not exceeded for each LED. The LEDs should be operated at a constant current per LED. In the case of operating at a constant voltage, Circuit B is recommended. If Circuit A is used, it may cause the currents flowing through the LEDs to vary due to the variation in the forward voltage characteristics of the LEDs on the circuit.

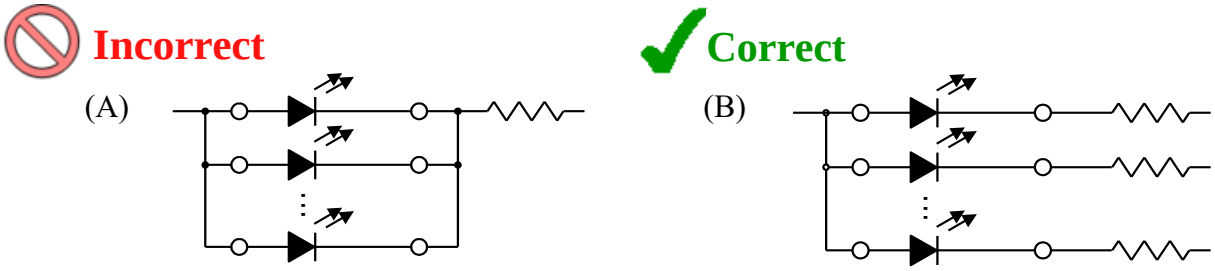


Figure 3. Examples of a Parallel Circuit

4.3 Operating Current

These LEDs are designed to be operated at a forward current. To stabilize the LED characteristics while in use, Nichia recommends that the LEDs are operated at currents ≥10% of the sorting current. For the sorting current for the LED, refer to the applicable specification.

4.4 Precautions for when the LED is Off

Ensure that no voltage is applied to the LED in the forward/reverse direction while the LED is off. If the LEDs are used in an environment where reverse voltages are applied to the LED continuously, it may cause electrochemical migration to occur causing the LED to be damaged. When not in use for a long period of time, the system's power should be turned off to ensure that there are no issues/damage.

4.5 Precautions for Environmental Conditions

Ensure that transient excessive voltages (e.g. lightning surge) are not applied to the LEDs. If the LEDs are used for outdoor applications, ensure that necessary measures are taken (e.g. protecting the LEDs from water/salt damage and high humidity).

5. Handling Precautions

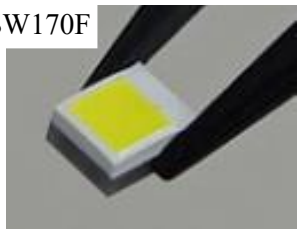
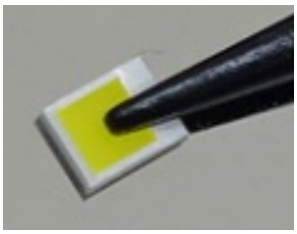
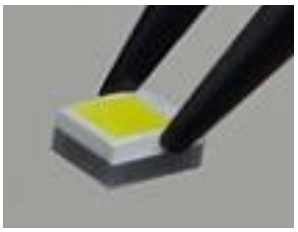
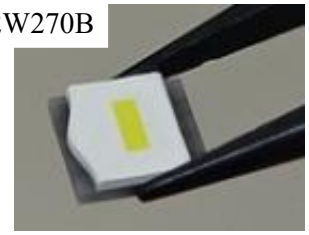
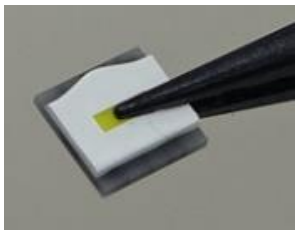
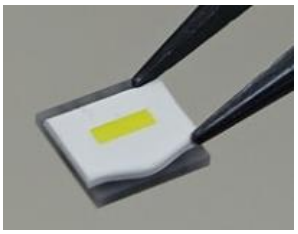
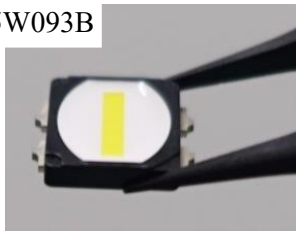
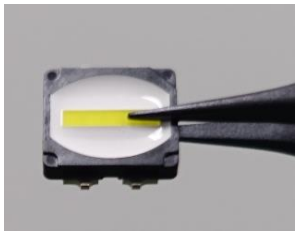
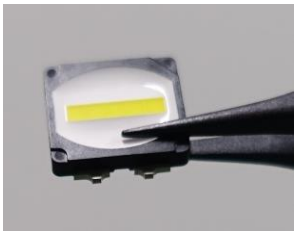
5.1 Handling with bare hands

Do not handle the LEDs with bare hands. This may contaminate the LED surface and have an effect on the optical characteristics. Also, the electrodes, package, etc. may cause injuries when the LED is handled with bare hands.

5.2 Handling with tweezers

Ensure that when handling the LEDs with tweezers, excessive force is not applied to the LED. Otherwise, it may cause damage to the light emitting area and/or the silicone resin (e.g. cut, scratch, chip, crack, etc.) and have an effect on the optical characteristics and/or the reliability.

Table 3. Correct/Incorrect Examples of Handling the LEDs with Tweezers

Correct Examples	Incorrect Examples	
✓ Correct	Incorrect	Incorrect
NCSW170F 		
NJ2W270B 		
NC5W093B 		

For the LEDs with ceramic substrates (e.g. the 170/270 series LEDs), grab/hold the LEDs by the sides of the substrate. For the resin packaged LEDs (e.g. the 093 series LEDs), grab/hold the LEDs by the sides of the package. See the Correct Examples in Table 3. Do not apply excessive force to the emitting area and/or the silicone resin as shown by the Incorrect Examples in Table 3.

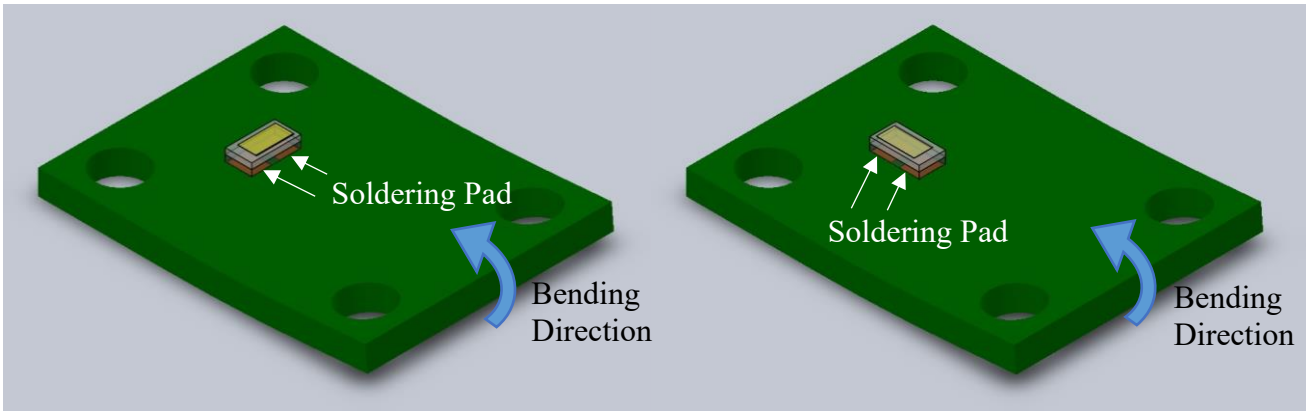
5.3 Other Precautions

Do not drop the LEDs; this may cause issues (e.g. crack, chip, and/or deformation of the LED, and/or cut, scratch, etc. on the emitting area) causing the optical characteristics and/or the reliability to be adversely affected.

6. Design Precautions

6.1 LED Position/Orientation on the PCB Assembly

If the LEDs are soldered to a PCB and the PCB assembly is bent (e.g. PCB depaneling process), it may cause the LED package to break. The PCB layout should be designed to minimize the mechanical stress on the LEDs when the PCB assembly is bent/warped; see Figure 4.



A. Recommended Direction

B. Not Recommended Direction
(Excessive force may be applied to the LED)

Figure 4. Examples of the LED Orientation for the PCB Bending Direction for a NC2x170x LED

The amount of mechanical stress exerted on the LED from depaneling may vary depending on the LED position/orientation on the PCB assembly (e.g. especially in areas near the slits and/or perforations). The PCB layout should be designed to minimize the mechanical stress on the LEDs when the PCB is separated into individual PCB assemblies. For example, in Figure 5 the amount of stress on the LED from depaneling would be smallest for LED E.
To separate a PCB populated with the LEDs, use a specially designed tool. Do not break the PCB by hand; this may cause excessive stress to be applied to the LEDs.

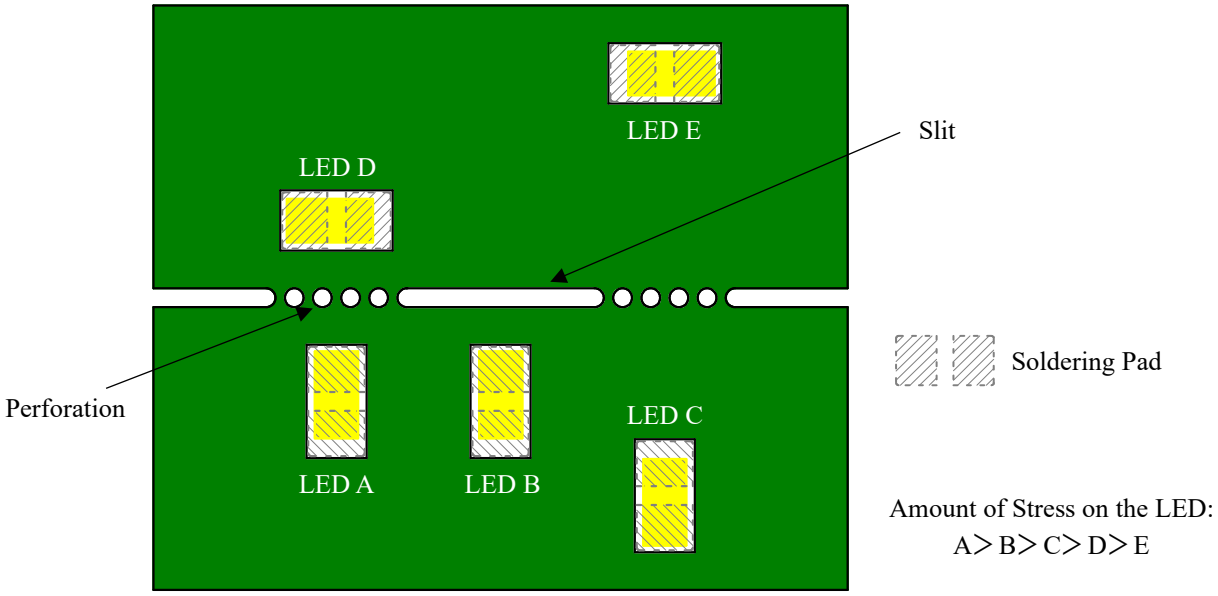
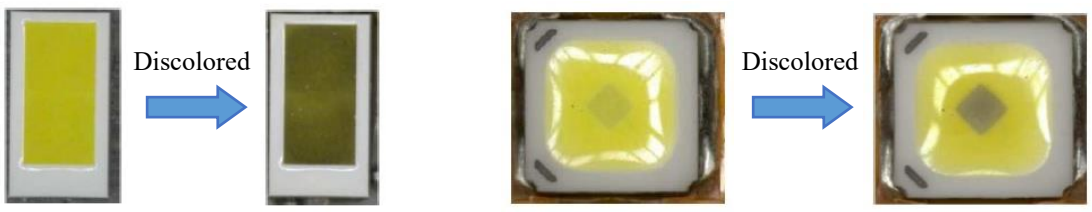


Figure 5. Examples of the LED Position/Orientation near the slits and perforations on a PCB for a NC2x170x LED

6.2 Volatile Organic Compounds (VOCs)

Materials present around the LEDs (e.g. housing, gasket/seal, adhesive, secondary lens, lens cover, grease, etc.) may contain volatile organic compounds (VOCs); the VOCs that have been released from them may penetrate the encapsulating resin of the LED. If the LEDs are being used in a hermetically/near-hermetically sealed environment, VOCs can discolor after being exposed to heat and/or photon energy and it may greatly reduce the LED light output and/or cause color shift (see Figure 6). Perform a light-up test of the chosen application for optical evaluation to ensure that there are no issues before use.
Ventilating the environment may improve the reduction in light output and/or color shift that may occur due to VOCs.



NC2W170B LED NFSW172 LED

Figure 6. Examples of Discoloration due to VOCs

6.3 Corrosive Gases

To prevent substances/gases from affecting the plated surfaces of the LEDs, ensure that the parts/materials used with the LEDs (e.g. gasket/seal, adhesive, etc.) in the same assembly/system do not release corrosive gases (i.e. the parts/materials do not contain sulfur, halogens, etc.). If the plating becomes contaminated, it may cause issues (e.g. electrical connection failures, an adverse effect on the optical characteristics, etc.). If a gasket/seal is used, silicone rubber gaskets/seals are recommended; ensure that this use of silicone does not result in issues (e.g. electrical connection failures) caused by low molecular weight volatile siloxane.

6.4 How to Select an Appropriate PCB

Note that solder cracks are more likely to occur when a ceramic material is used for the substrates or packages of the LED (see Table 4) and a metal-core PCB (especially an aluminum PCB) is selected to mount the LED on.

Table 4. LEDs with Ceramic Substrates/Packages

LEDs with Ceramic Substrates		LEDs with Ceramic Packages
Nichia 170 Series	Nichia 131 Series	Nichia 172 Series
Nichia 121 Series	Nichia 270 Series	Nichia 123 Series

Solder cracks are more likely to occur when the difference in the coefficient of thermal expansion (CTE)[4] between the LED and the PCB is large due to the thermal stress generated during operation. For example, the magnitude of the CTE values for aluminum, copper, and ceramic can be described as aluminum > copper > ceramic; using a copper-core PCB for the LED with a ceramic substrate/package is a better option than using an aluminum substrate to prevent solder cracks.
Nichia recommends that a metal-core PCB with an insulting layer with a low elastic modulus (i.e. low modulus elasticity insulating layer) is used to reduce the possibility of solder cracks. Using Non-solder Mask Defined (NSMD)[5] to create the soldering pad pattern on the PCB is also effective.
The solder crack resistance varies depending on the types of solder paste (i.e. composition) as well as the specifications of the PCBs. Ensure that sufficient verification is performed to determine the appropriate PCB and solder paste for the chosen application.

Note:
[4] CTE describes how the size of an object changes with an increase in temperature per degree of Celsius (i.e. /°C).
[5] For NSMD, the soldering pad pattern is defined by the dimensions of the copper layer with gaps between the solder resist and copper layer. For Solder Mask Defined (SMD), the soldering pad pattern is defined by the aperture of the solder resist with a large copper layer under it.

7. Precautions for the Mounting Process

7.1 Pick-and-place Nozzle

Ensure that the size and shape of the nozzle tip are appropriate for the LEDs. Otherwise, this may damage the LED (i.e. scratch, chip, crack, etc.), affecting the optical characteristics and/or the reliability. This may also lead to an incorrect pick up (i.e. the LED is picked up in a tilted position). Refer to the applicable specification for the recommended nozzle dimensions for the LED. For products that do not have the recommended nozzle dimensions described in the specification, contact a local Nichia sales representative.

When setting the LED pick-up position, ensure that the center of the nozzle and the center of the emitting area of the LED are aligned. Do not apply excessive force to the emitting area when picking up the LED. If the nozzle does not pick up the LED at the center of the emitting area, and/or if excessive force is applied to the LED, this may damage the LEDs (i.e. scratch, chip, crack, etc.), affecting the optical characteristics and/or the reliability. This may also lead to an incorrect pick up (i.e. the LED is picked up in a tilted position).

7.2 Precautions When Soldering

When soldering, do not apply stress to the LED while the LED is hot.
When flux is used, it should be a halogen-free flux. Ensure that the manufacturing process is not designed in a manner where the flux will come in contact with the LEDs.

7.3 Reflow Conditions

The LEDs are designed to be reflow soldered to a PCB. Reflow soldering must not be performed more than twice.
Nichia recommends using the reflow soldering conditions detailed in Figure 7; use the recommended reflow conditions specified by the manufacturer of the solder paste being used if it works better for the chosen application. To ensure that these reflow conditions have no negative effect on the LEDs, perform sufficient verification prior to use. When cooling the LEDs from the peak temperature, a gradual cooling slope is recommended; do not cool the LEDs rapidly.
During reflow soldering, the heat and atmosphere in the reflow oven may cause the optical characteristics to degrade. In particular, reflow soldering performed with an air atmosphere may have a greater negative effect on the optical characteristics than if a nitrogen atmosphere is used; Nichia recommends using a nitrogen reflow atmosphere.

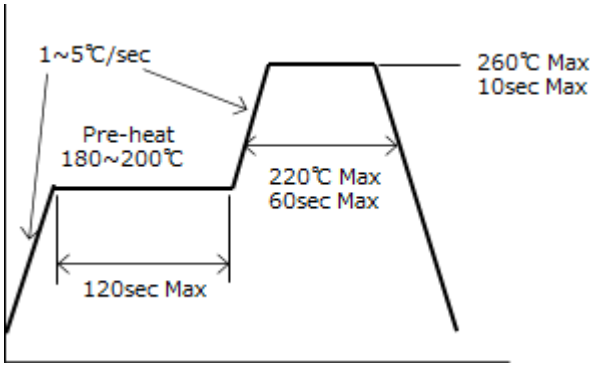


Figure 7. Recommended Reflow Soldering Condition

7.4 Precautions for Assembled PCBs

Do not stack assembled PCBs together. Otherwise, it may cause damage to the emitting area and/or the resin (e.g. cut, scratch, chip, crack, etc.) and have an effect on the optical characteristics and/or the reliability.

Refer to the applicable application notes for the detailed information for the assembly precautions.

8. Electrostatic Discharge (ESD)

8.1 ESD Precautions for Handling the LEDs

The LEDs are sensitive to transient excessive voltages (e.g. ESD, lightning surge). If this excessive voltage occurs in the circuit, it may cause the LED to be damaged causing issues (e.g. the LED to become dimmer or not to illuminate [i.e. catastrophic failure]). Ensure that when handling the LEDs, necessary measures are taken to protect them from an ESD discharge. The following examples are recommended measures to eliminate the charge:
- Grounded wrist strap, ESD footwear, clothes, and floors
- Grounded workstation equipment and tools
- ESD table/shelf mat made of conductive materials

Ensure that all necessary measures are taken to prevent the LEDs from being exposed to transient excessive voltages (e.g. ESD, lightning surge):
- tools, jigs, and machines that are used are properly grounded
- appropriate ESD materials/equipment are used in the work area
- the system/assembly is designed to provide ESD protection for the LEDs

8.2 ESD Precautions for Tools/Equipment

If the tool/equipment used is an insulator (e.g. glass cover, plastic, etc.), ensure that necessary measures have been taken to protect the LED from transient excessive voltages (e.g. ESD). The following examples are recommended measures to eliminate the charge:
- Dissipating static charge with conductive materials
- Preventing charge generation with moisture
- Neutralizing the charge with ionizers

8.3 Identifying ESD Damaged LEDs

To identify if an LED was damaged by transient excess voltages (i.e. an ESD event during the system's assembly process), perform a characteristics inspection (e.g. forward voltage measurement, light-up test) at low current (≤1mA). If the LED was damaged by transient excess voltages (e.g. ESD), it would cause the forward voltage (V_F) to decrease, the LED not to illuminate at a low current, etc.
For the failure criteria for the LED, refer to the applicable specification; the failure criteria for the V_F at the forward current of 0.5mA is specified.

9. Thermal Management

The absolute maximum junction temperature (T_J) must not be exceeded under any circumstances. The increase in the temperature of an LED while in operation may vary depending on the PCB thermal resistance and the density of LEDs on the PCB assembly. Ensure that when using the LEDs for the chosen application, heat is not concentrated in an area and properly managed in the system/assembly.
The operating current should be determined by considering the temperature conditions surrounding the LED (i.e. T_A). Ensure that when operating the LED, proper measures are taken to dissipate the heat.

10. Cleaning

Do not clean and/or wipe the emitting surface of the LED. If an area of the LED other than the emitting surface is contaminated (e.g. dust/dirt), use a cloth, swab, etc. soaked with a small amount of isopropyl alcohol (IPA) and wipe the LED with it in a manner that does not touch the emitting surface. If another solvent is used, it may cause the LED package/resin to be damaged causing the optical characteristics and/or the reliability to be affected; ensure that sufficient verification is performed prior to use.
Do not clean the LED with an ultrasonic cleaner. This may cause the optical characteristics and/or the reliability to be affected.

11. Eye Safety

There may be two important international specifications that should be noted for safe use of the LEDs: IEC 62471:2006 Photobiological safety of lamps and lamp systems and IEC 60825-1:2001 (i.e. Edition 1.2) Safety of Laser Products - Part 1: Equipment Classification and Requirements. Ensure that when using the LEDs, there are no issues with the following points:
- LEDs have been removed from the scope of IEC 60825-1 since IEC 60825-1:2007 (i.e. Edition 2.0) was published. However, depending on the country/region, there are cases where the requirements of the IEC 60825-1:2001 specifications or equivalent must be adhered to.
- LEDs have been included in the scope of IEC 62471:2006 since the release of the specification in 2006.
- Most Nichia LEDs will be classified as the Exempt Group or Risk Group 1 according to IEC 62471:2006. However, in the case of high-power LEDs containing blue wavelengths in the emission spectrum, there are LEDs that will be classified as Risk Group 2 depending on the characteristics (e.g. radiation flux, emission spectrum, directivity, etc.)
- If the LED is used in a manner that produces an increased output or with an optic to collimate the light from the LED, it may cause damage to the human eye.

If an LED is operated in a manner that emits a flashing light, it may cause health issues (e.g. visual stimuli causing eye discomfort). The system should be designed to ensure that there are no harmful effects on the human body.

12. Summary

The LEDs need to be handled and assembled in a proper manner to obtain the required characteristics and the reliability. Follow the cautions/suggestions detailed in this application note and the applicable specification for the LED to ensure that the LED is used properly.
In addition, perform sufficient verification with the conditions/environments in which the chosen application containing the LED will actually be used to ensure that the characteristics and/or the reliability for the LED are not adversely affected before selecting other components to be used with the LED.

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