Application Note

Light Emitting Diode

LED Mounting Process Techniques for Full-color RGB SMD LEDs with a Lens

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The Nichia part numbers NSSM137A and NSSM237B 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

Nichia's full-color RGB SMD LEDs with a lens are designed to be mounted using a pick-and-place machine. However, depending on the operation conditions set for the machine or how the LEDs are handled during the mounting process, failures of the LEDs (i.e. damage to the LED, reliability issues, etc.) or mounting errors may occur.
This application note provides considerations/precautions for the mounting process of the Nichia's full-color RGB SMD LEDs with a lens.

2. Applicable Part Numbers

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

Table 1. Applicable LED Part Numbers

Part Number	NSSM137A	NSSM237B
Example of Package Appearance		
Package Size (Unit: mm)	5.3×4.24×1.95	5.3×4.24×2.25

3. Mounting Process Preparation

3.1 Reel and Embossed Carrier Tape Specifications

The LEDs are delivered in an embossed carrier tape and a reel as shown in Figure 1. The detailed specifications of the embossed carrier tape are available in the applicable specification for each LED part number.

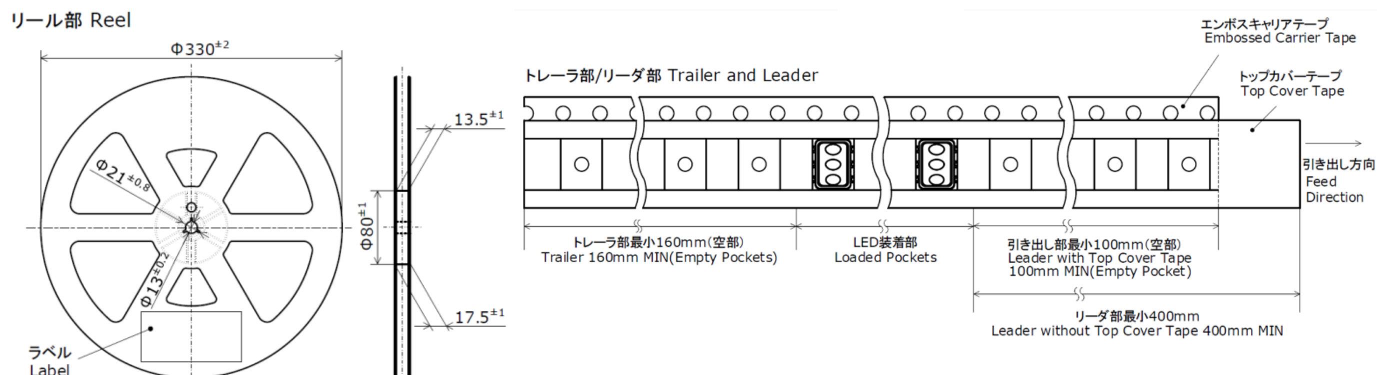

Figure 1. Reel and Embossed Carrier Tape

3.2 Prevention of Moisture Absorption

The reel of the LEDs is sealed in a moisture-proof aluminum bag as shown in Figure 2. If the 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 (see Figure 3). This may cause the optical characteristics to degrade. 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.

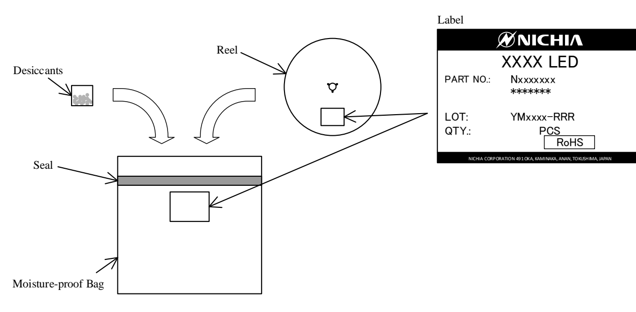

Figure 2. Moisture-Proof Aluminum Bag

The LED package absorbs moisture.

Heat during soldering causes the moisture to vaporize resulting in the package expanding.

Internal delamination occurs causing adverse effect on the optical characteristics of the LED.

Figure 3. Schematic Diagram of LED's Moisture Absorption and Vapor Expansion of the Moisture

3.3 Storage of the LEDs

Table 2 provides the required storage conditions before and after opening the moisture-proof aluminum bag.

Table 2. Storage Conditions

Conditions	Temperature	Humidity	Storage 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	MSL4	Within 72 Hours

The "After Opening" storage time is different depending on the Moisture Sensitivity Level (MSL)[1] 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.
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.

If the storage time has been exceeded for the LEDs whose "After Opening" storage time is 72 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 (see Figure 4), ensure that the LEDs are baked in the same manner. Baking should only be done once.

Note:

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

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A. When packed for shipment

The blue silica gel beads absorbed moisture and turned pink.

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

Figure 4. Appearance of Silica Gel Desiccants

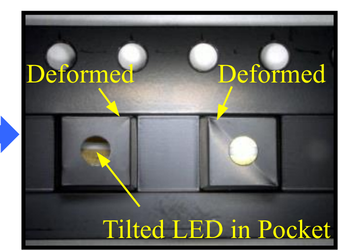
When baking the LEDs, remove the reel of the LEDs from the storage container (e.g. a moisture-proof aluminum bag). See Figure 5.

Figure 5. Example for Baking the LEDs

If the LEDs are stored in a high temperature environment (≥70°C) for a long period of time, the resin portion of the LED may stick to the top cover tape, causing pick-up errors; storing the LEDs in this manner may also cause 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 6. 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



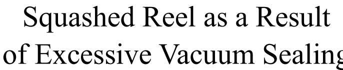

Squashed Reel as a Result of Excessive Vacuum Sealing

Figure 6. Correct/Incorrect Examples for Embossed Carrier Tape after Vacuum Sealing

4. Solder Printing

If the LED is not mounted onto a PCB with an appropriate amount and shape of solder paste, the expected characteristics of the LED may not be obtained. In order to maintain the amount/shape of solder paste in the printing process, the soldering pad pattern and metal solder stencil aperture pattern should be optimized as well as the printing conditions, and the solder paste must be prepared properly prior to use.

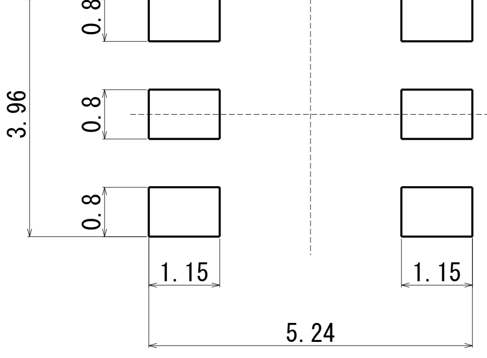
4.1 Preparations for Solder Paste

The solder paste needs to be stirred before use. The purpose of the stir is to restore the even distribution of solder particles and flux that became uneven due to storage. If the solder paste is not mixed evenly, it interferes with the rolling performance, leading to an inappropriate amount/shape of the solder when printed on the PCB.
The stirring duration is determined based on the solder paste manufacturer's recommendation.

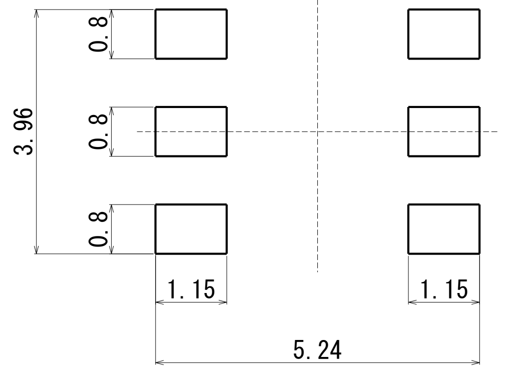
4.2 Soldering Pad Pattern and Metal Solder Stencil Aperture Pattern

The figures below show the recommended soldering pad pattern and metal solder stencil aperture pattern.

● Recommended Soldering Pad Pattern



● Recommended Metal Solder Stencil Aperture



(Unit: mm)

Figure 7. Soldering Pad Pattern and Metal Solder Stencil Aperture Pattern

4.3 Printing Condition Adjustment

Adjust the squeegee conditions and the metal solder stencil separation conditions to print with the correct amount and shape. The speed, pressing pressure, and angle of the squeegee affect the amount and condition of the solder paste filling the metal solder stencil aperture. Additionally, the speed of the separation and the distance affects how the shape of the solder on the PCB stays consistent with each use. These are also affected by the thickness of the metal solder stencil, the aperture pattern, and the surface roughness of the aperture wall.

In order to prevent the occurrence of solder bridges, etc. and maintain optimal printing conditions, adjust the cleaning method, conditions, and frequency of the metal solder stencil.
Adjust the printing conditions to obtain an appropriate solder shape (see Figures 8 and 9 for examples). In order to ensure that the appropriate amount of solder paste is applied to the soldering pads consistently, verify the amount of the solder paste by conducting an appearance inspection after the solder printing and/or an X-ray examination after the LED is mounted.
If the solder printing process is carried out continuously for a long period of time, the viscosity of the solder paste may increase, leading to printing failures due to clogging of the metal solder stencil aperture and poor release of the solder paste. To maintain an appropriate solder shape during continuous operation, it is important to check the solder stencil apertures for clogging and check the viscosity of the solder paste whenever appropriate.

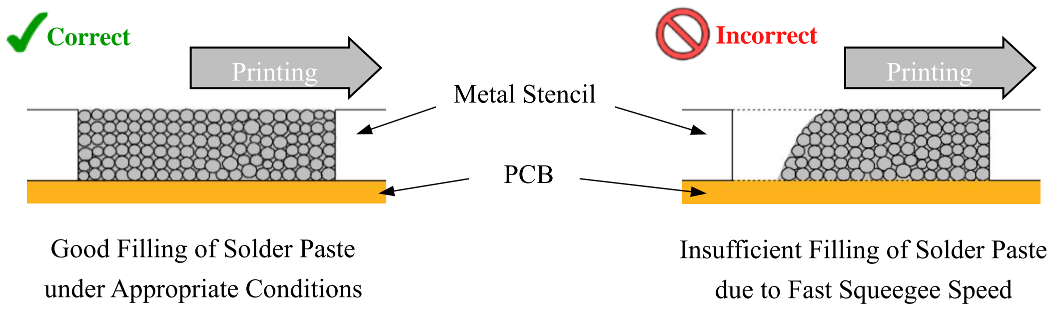


Figure 8. Squeegee Speed and Solder Paste Filling in the Metal Solder Stencil Aperture

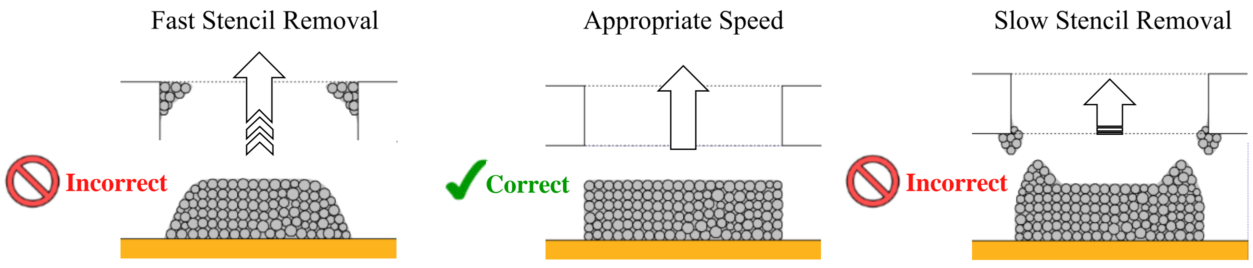


Figure 9. Speed of Solder Stencil Removal and Shape of the Solder Paste

5. LED Mounting

If the parameter settings for the pick-and-place machine and the mounting conditions are inappropriate, it may cause issues such as the LEDs falling out of the embossed carrier tape pocket or sticking to the top cover tape, pick-up errors, poor precision of the placement position, and/or damage to the LEDs. This section provides the precautions for the LED mounting process that uses a pick-and-place machine and what measures to be taken when an LED pick-up/placement error occurs.

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5.1 Recommended Nozzle

If excessive force is applied to the emitting surface of the LED, it may be damaged, which may affect the performance/reliability of the LED. Nichia recommends using a nozzle specifically designed for the LEDs. Nichia recommends the inner diameter of the nozzle tip should be round (see Figure 10). Additionally, if the tip of the nozzle has burrs, chipping, or foreign substances, the emitting surface may be damaged or contaminated. Ensure that the tip of the nozzle is cleaned before starting the pick-and-place operations.

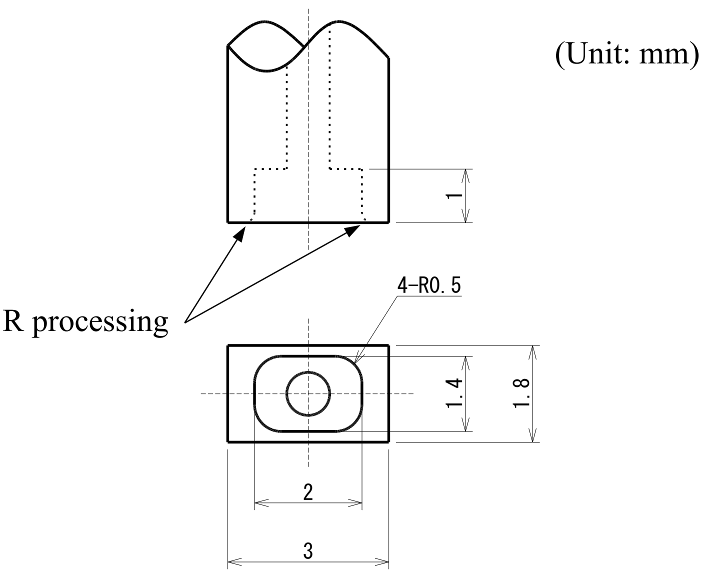

Figure 10. Recommended Nozzle

5.2 Pick-up Position

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 (see Figure 11). If the nozzle picks up the LED at an edge of the emitting area, this may damage the emitting surface (i.e. chip, crack, etc.).

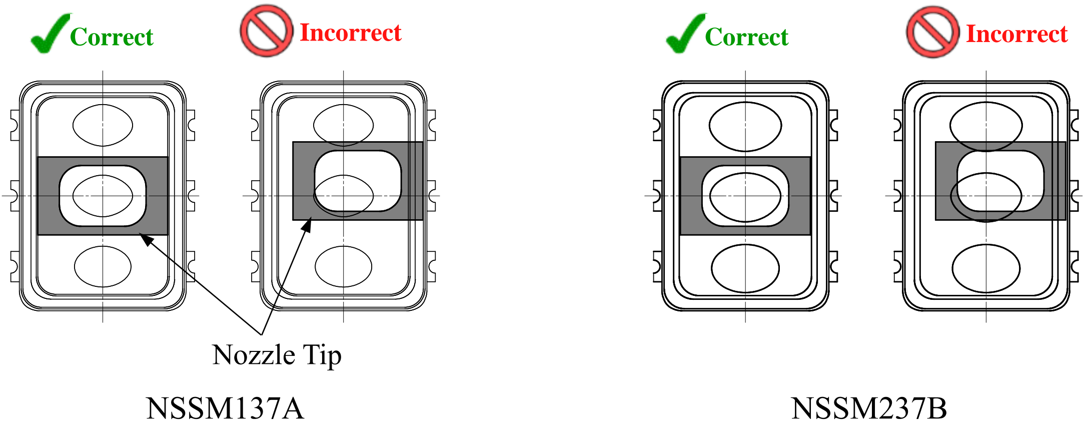

Figure 11. Nozzle Position for LED Pick-up

5.3 LED Pick-up

The recommended LED pick-up operation is to lower the nozzle slowly with suction. The nozzle should not come into contact with the LEDs. Refer to the outline dimensions of the embossed carrier tape and the LED detailed in the applicable specification for each LED part number to determine the nozzle height.
If the pick-up operation is unstable, adjust the nozzle height appropriate for the pick-and-place machine being used.

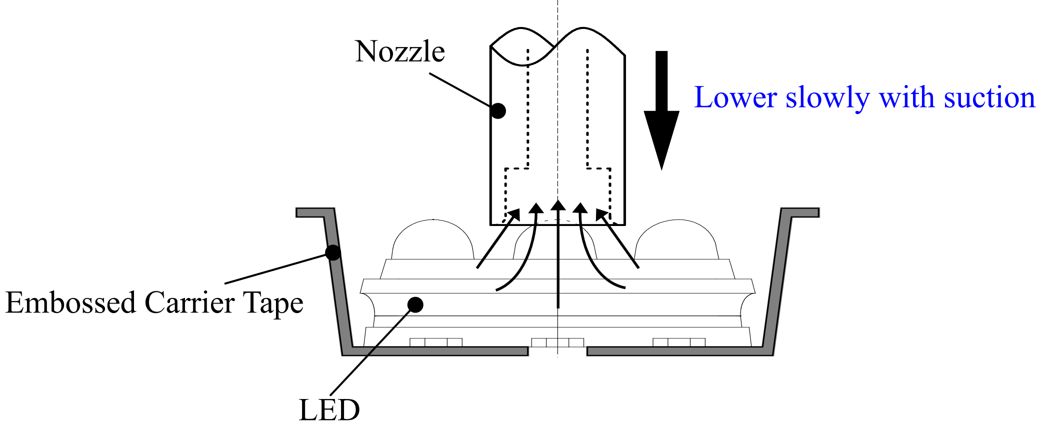

Figure 12. Recommended LED Pick-up Operation

5.4 LED Placement

When placing the LED on the PCB, the nozzle should further press the LED 0.2mm onto the PCB from the height where the LED first touches the solder paste (see Figure 13). If the placement depth of the nozzle is insufficient, the LED may float or shift after reflow. If the placement depth is too large, an excessive pressure may be applied to the LED resulting in the emitting surface being damaged and/or solder balls may occur.
The placement pressure changes if there is a warpage in the PCB; verify that the operation conditions do not cause damage to the LED in the actual mounting process before starting the operation.

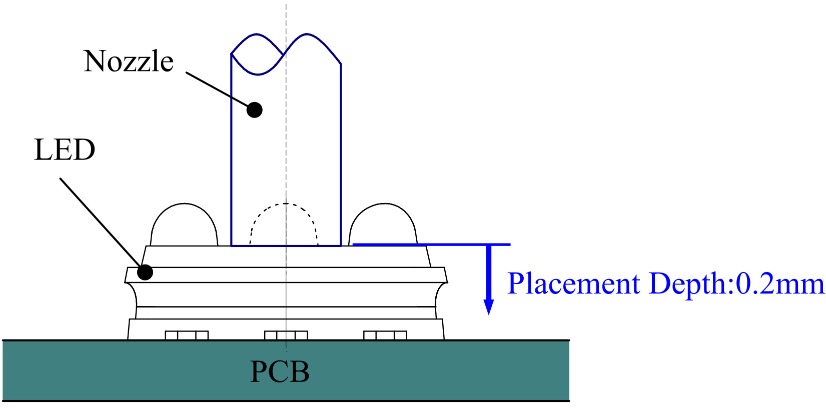

Figure 13. Recommended Nozzle Height for Placement Operation

5.5 Rewinding of a Tape on a Reel

To rewind the embossed carrier tape when the operation is interrupted, the force applied must be ≤10N to the embossed carrier tape. Otherwise, the LED may stick to the top cover tape and/or the embossed carrier tape pocket may be deformed resulting in the LED being damaged.

6. Reflow

6.1 Reflow Conditions

Figure 14 shows the Nichia recommended reflow soldering conditions provided in the applicable specification for each LED part number; use the recommended reflow conditions specified by the manufacturer of the solder paste being used if it works better for the chosen application.
Additionally, Nichia recommends using a nitrogen reflow atmosphere (O^2 concentration: <500ppm).
If the reflow is performed with an air atmosphere, the heat and atmosphere in the reflow oven may cause the optical characteristics of the LED to degrade.
Note that reflow soldering must not be performed more than twice.

When cooling the LEDs from the peak temperature, a gradual cooling slope is recommended; do not cool the LEDs rapidly. Use the cooling rate of 1.5 to 2°C/sec. for reference. If the components mounted on the PCB are damaged and/or the solder joint strength is insufficient, the conditions should be adjusted.

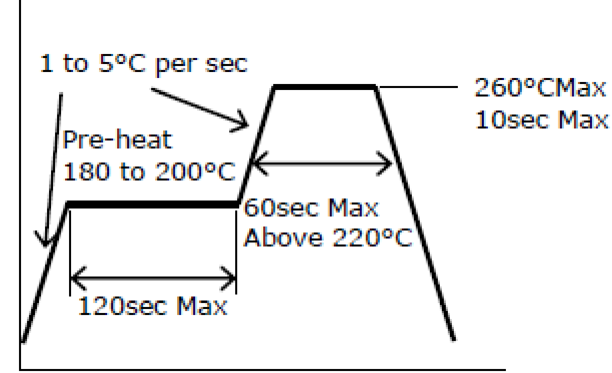

Figure 14. Reflow Soldering Condition (Lead-free Solder)

7. Inspection

7.1 Lighting Inspection

The lighting inspection is performed either visually or using an automatic imaging inspection system to check if all the LEDs emit light without issues.

7.1.1 Lighting Inspection Considerations

In order to prevent the LEDs from being damaged during the lighting inspection, operate the LEDs at a constant current and ensure that the voltage being applied is appropriate for the chosen circuit of the PCB and that the current being applied is small enough (e.g. 1mA per LED).
Additionally, ensure that a hot-wire connection[2] of the probes, etc. is not done during the lighting inspection; if the chosen voltage and current are not appropriate, a large current exceeding the absolute maximum rating current[3] may temporarily flow through the LEDs due to the inrush current causing damage to the LEDs.

7.2 Appearance Inspection

An appearance inspection should be performed visually or using an automatic imaging inspection system to check if there are any abnormalities in appearance (e.g. misalignment/floating of the LED, solder balls, damage to the LED, etc.).

7.3 X-Ray Examination

An X-ray examination should be performed to check if the solder wettability is sufficient and/or if there are any solder voids, solder balls, etc.

8. Precautions for Assembled PCBs

When handling the assembled PCBs, ensure that the following precautions are followed.

- 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.
- 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. 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.

9. Summary

The occurrence of mounting failures for the LED mounting process may vary depending on various factors including the work environments, equipment, conditions of the materials being used, etc. Ensure that there are no issues with the mounting operations by performing a mounting test, etc. before starting the operations.

Note:

[2] A hot-wire connection means a test voltage is applied to the PCB with probes, etc. while the power is on.

[3] Absolute maximum ratings of the LEDs are the maximum values that must not be exceeded even for a short period of time. For the absolute maximum rating values for each LED, refer to the applicable specification.

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NICHIA CORPORATION
491 Oka, Kaminaka-Cho, Anan-Shi, TOKUSHIMA 774-8601, JAPAN
http://www.nichia.co.jp
Phone: +81-884-22-2311 Fax: +81-884-21-0148