Assembly Precautions for the Nichia NFMW48xAR Series LEDs

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The part number NFMW481AR,NFMW484AR,NFMW486AR,NFMW488AR,NFMW488AR-V1 in this document are the part number of our product, and do not have any relevance or similarity to other companies' products that may have trademark rights.

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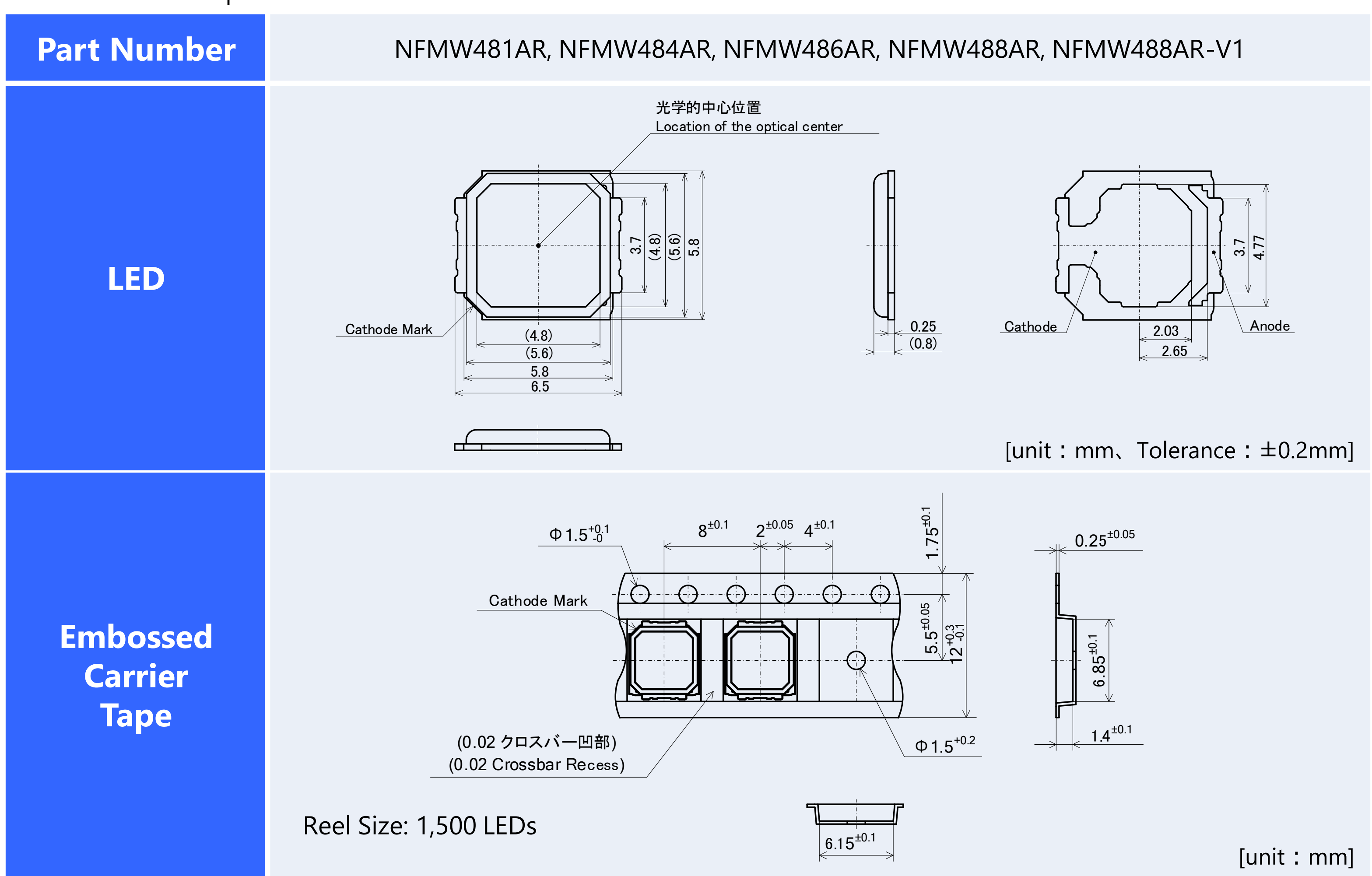
1. LED Outline Dimensions/Tape Dimensions

Table 1. Product Specifications



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2. Handling Precautions

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,
- this may cause the LED to deform and/or the wire to break causing a catastrophic failure (i.e. the LED not to illuminate),
- the lead frame may cause injuries when the LED is handled with bare hands.

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 resin (e.g. cut, scratch, chip, crack, delamination and deformation) and the internal connection to fail causing a catastrophic failure (i.e. the LED not to illuminate).

ESD Precautions

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 have a reduction in the radiant flux or not to illuminate [i.e. catastrophic failure]). When handling the LEDs, ensure that necessary measures have been taken to protect them from transient excess voltages. Refer to the applicable specification for more details.

Stacking assembled PCBs together

Do not stack assembled PCBs together. Otherwise, it may cause damage to the resin (e.g. cut, scratch, chip, crack, delamination and deformation) and the internal connection to fail causing a catastrophic failure (i.e. the LED not to illuminate).

Storage

The storage/packaging requirements for the Nichia 481/484/486/488 Series LEDs are comparable to JEDEC Moisture Sensitivity Level (MSL) 3 or equivalent. Nichia used IPC/JEDEC STD-020 as a reference to rate the MSL of this LED. If the “After Opening” storage time has been exceeded or any pink silica gel beads are found, ensure that the LED are baked before use. Baking should only be done once.

Incorrect

Caution: Do not grab/hold the LEDs with tweezers around the encapsulating resin.

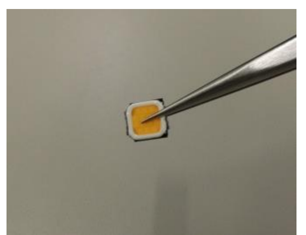

Figure 1. Example of an Improper Holding Position

Incorrect

Caution: Do not stack assembled PCBs on top of each other.

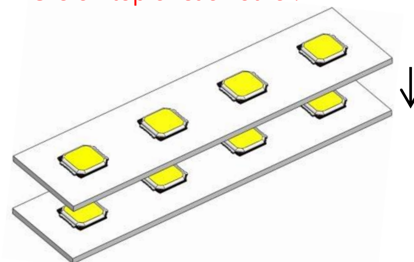

Figure 2. Example of Improper Stacking

Table 2. Storage/Baking Conditions

Conditions		Temperature	Humidity	Time
Storage	Before Opening Aluminum Bag	≤ 30°C	≤ 90% RH	Within 1 Year from Delivery Date
	After Opening Aluminum Bag	≤ 30°C	≤ 70% RH	≤ 168 hours
Baking		65±5°C	-	≥24 hours

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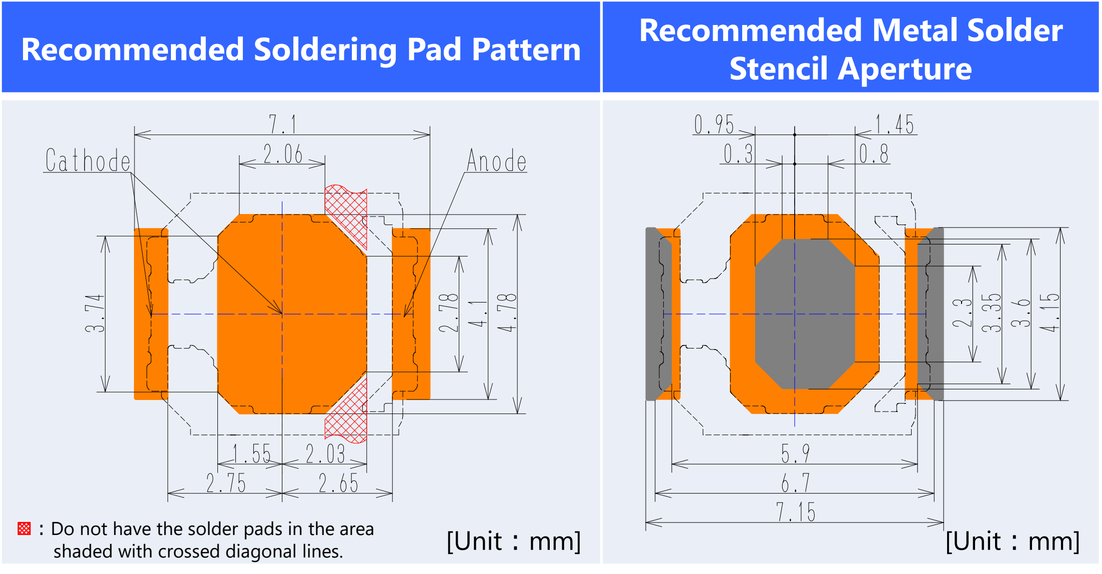
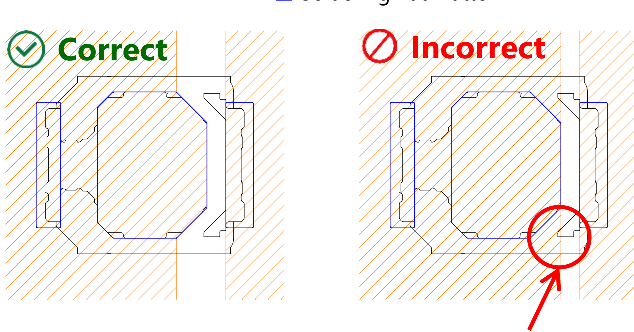
3. Design Recommendations for Optimal Amount of Solder

Soldering Pad Pattern/Metal Solder Stencil Aperture

Table 3. Recommended Soldering Pad Pattern/Metal Solder Stencil Aperture



···: LED outline and Electrodes
: Soldering Pad Pattern
: Metal Solder Stencil Aperture



If this area is covered by a copper foil layer that has been connected to the cathode, there is the potential for a short circuit due to contact with the anode of the LED.

Figure 3. Prohibited Area for the Copper Layer

Table 4. Recommended Solder/Metal Solder Stencil Conditions

Item	Recommended Conditions
Metal Solder Stencil (Thickness)	150 μm
Solder Paste (Composition)	Sn-3.0Ag-0.5Cu

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4. Precautions for Setting Up a Pick-and-Place Machine/Nozzle

Table 5. Cautions/Suggestions for setting up equipment

Item	Recommended Conditions/Specifications	Cautions/Suggestions
Pick-and-place machine[1]	Modular mounter	
Pick-and-place nozzle	Specially designed nozzle (see Figure 4)	See "Pick-and-Place Nozzle" on Page 6 for the details.
Tape-and-reel feeder	Electrical (motorized) feeder Tape width: 12mm Feed length: 8mm	See "Tape-and-Reel Feeder" on Page 6 for the details.
Nozzle height for pick-up operations	The contact surface of the nozzle head for pick operations should be adjusted to 0.6mm below the edge of the embossed carrier tape pocket.	See "Recommended Nozzle Height for Pick-up Operations" on Page 7 for the details.
Nozzle height for placement operations (i.e. placement depth)	0.2mm for placement depth	See "Recommended Nozzle Height for Placement Operations (Placement Depth)" on Page 7 for the details.
Imaging-based Automatic Inspection	Using the electrode as a reference is recommended to locate the center of the LED.	See "Imaging-based Automatic Inspection" on Page 8 for the details.

Note:
[1] The recommended conditions/specifications above have been determined under the following verification conditions:

Pick-and-place machine (modular mounter):
- YS100 High-Speed General-Purpose Modular (manufactured by Yamaha Motor Co., Ltd.)

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4-1. Pick-and-Place Nozzle

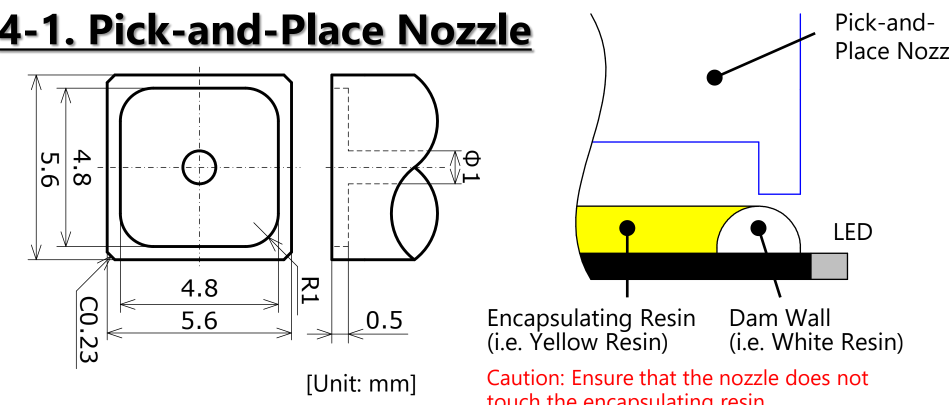

Figure 4. Recommended Nozzle Dimensions

Figure 5. Correct nozzle position to pick up the LEDs

- This LED uses a silicone resin for the encapsulating resin; the silicone resin is soft. If pressure is applied to the silicone resin, it may cause the resin to be damaged, chipped, delaminated and/or deformed. If the resin is damaged, chipped, delaminated and/or deformed, it may cause the wire to break causing a catastrophic failure (i.e. the LED not to illuminate) and/or reliability issues (e.g. the LED to corrode and/or to become dimmer, the color/directivity to change, etc.). Ensure that pressure is not applied to the encapsulating resin. Ensure that the nozzle do not touch the encapsulating resin and only touches the dam wall (i.e. white resin area around the encapsulating resin) when it picks up the LEDs.
- The placement force applied by the nozzle on the LEDs must be ≤ 8N.

4-2. Tape-and-Reel Feeder

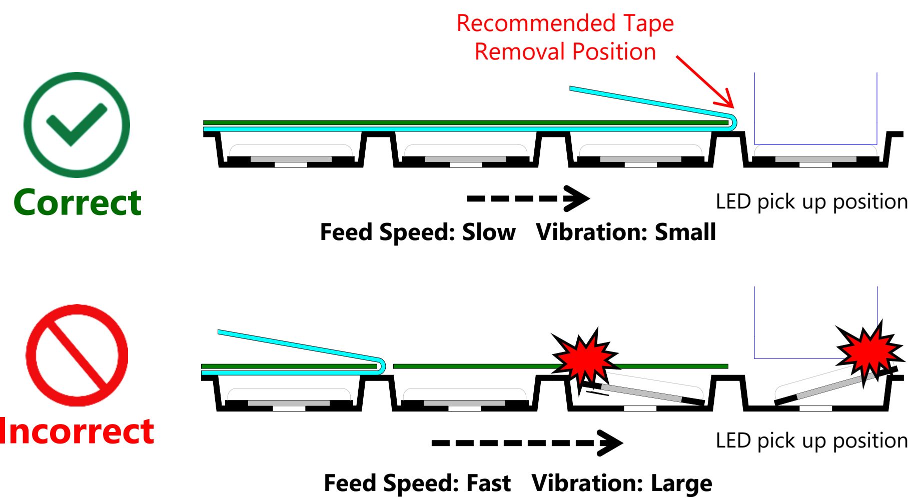

Figure 6. Examples of Correct/Incorrect Top Cover Tape Removal Positions

- Recommended setting for the tape-and-reel feeder.

  Tape width: 12mm
  Feed length: 8mm

- Use a tape-and-reel feeder that ensures it does not create excessive vibrations causing assembly issues.

  Example: Electrical (motorized) feeder

- When removing the top cover tape, it should be done adjacent to the target LED (See Figure 5). Otherwise, it may shake the embossed carrier tape and cause the LED to move within the tape pocket. This may cause
  - the nozzle to fail to pick up the LED or not to pick it up properly and shift while on the nozzle during the transport to the PCB (i.e. pick-up/placement failure)
  - the LED to hit the feeder cover and become damaged.

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4-3. Recommended Nozzle Height for Pick-up Operations

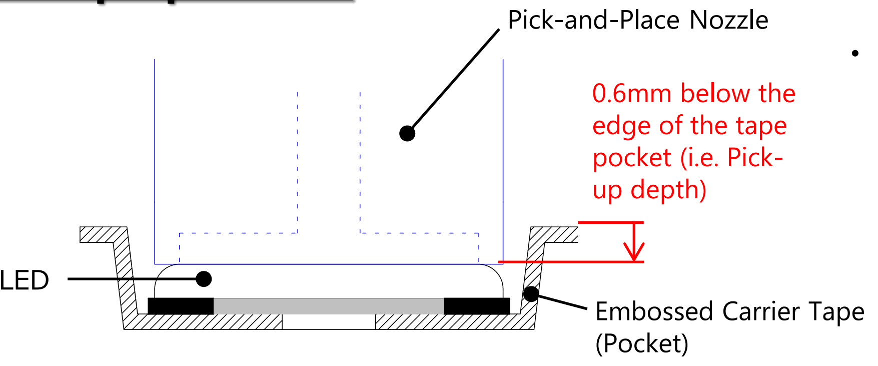

Figure 7. Recommended Nozzle Height for Pick-up Operations

- Ensure that the nozzle goes down onto the LED in the tape pocket until the tip touches the flat surface around the lens.
  Pick-up depth: 0.6mm
- The recommended nozzle height for pick-up operations has been determined by Nichia under the verification conditions (See Table 5 Note) and may not function as expected with some other pick-and-place machines. If the pick-up operations are unstable even with using the recommended nozzle height, adjust the nozzle height appropriate for the pick-and-place machine being used.

  If the pick point of the nozzle is too high,
  - it may cause insufficient suction power leading to picking errors (e.g. the nozzle's failure to pick/lift the LED into the air, incorrect picking causing the LED to tilt when in the air).

  If the pick point of the nozzle is too low,
  - it may cause issues (e.g. causing the embossed carrier tape to shake, causing the tape pocket to deform) leading to picking failures.

4-4. Recommended Nozzle Height for Placement Operations (Placement Depth)

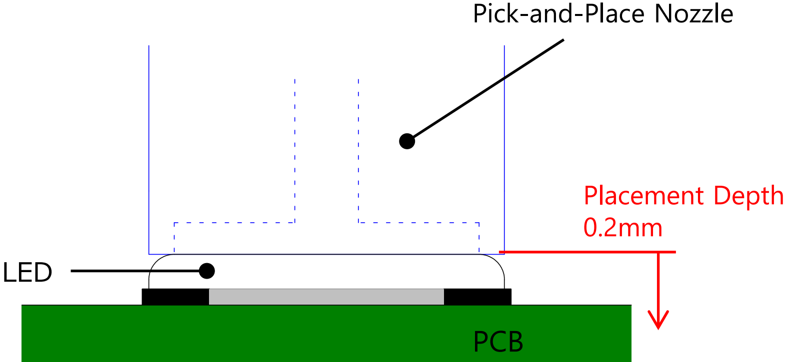

Figure 8. Recommended Nozzle Height for Placement (Placement Depth)

- Adjust the nozzle height to ensure that the nozzle applies an additional force (i.e. placement depth of 0.2mm) to the LED after the LED has come in contact with the PCB.

  If the release point of the nozzle is too high,
  - it may cause placement issues (e.g. the LED to stick to the nozzle after placement, the LED to become soldered to the PCB in a tilted position, etc.) .

  If the release point of the nozzle is too low,
  - excessive forces may be applied to the LED during placement and it may cause the LED to become damaged.

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4-5. Imaging-based Automatic Inspection

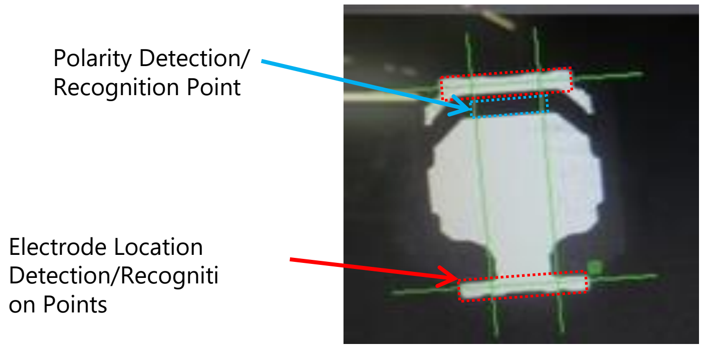

Figure 9. Recommended reference points to detect, recognize, or locate the polarity/electrodes

- Nichia recommends using the electrodes as a reference to locate the center of the LED.
- If the imaging device has trouble detecting/recognizing the electrodes due to the uniqueness of the electrode pattern, adjust it to detect/recognize the outer portions of the electrodes (i.e. the areas circled in red in Figure 9 to the left).
- If an automatic polarity detector is used for the LEDs, set up the imaging device to detect the empty space between the anode and cathode electrodes (i.e. Polarity Detection/Recognition Point in Figure 9 to the left). In the example in Figure 9, the equipment measures the brightness of the empty space against the threshold to locate the electrodes and/or determine the polarity.

5. Precautions When Reflow Soldering

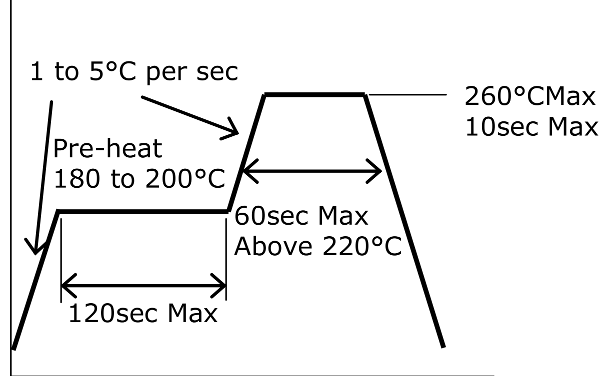

Figure 10. Recommended Reflow Soldering Condition (Lead-free Solder)

- Reflow soldering must not be performed more than twice.
- Using the recommended reflow soldering conditions (See Figure 8 to the left) as a reference, modify if necessary, the recommended reflow conditions specified by the manufacturer of the solder paste being used.

  Note:
  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.

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6. Evaluation of the Effect of Solder Volume

6-1. Evaluation Method/Conditions

The effect of solder volume on the workmanship of the reflow-soldered LEDs (i.e. LED emission failure, solder wettability/solder void percentage, number of solder balls, LED tilt) was evaluated using three different amounts of solder (i.e. three metal solder stencil thicknesses including the recommended thickness to control the amount).

Metal Solder Stencil Thicknesses:

120µm, 150µm (Nichia's recommendation), 180µm

6-2. Evaluation Results

Emission failure, and solder wettability/void percentage

- There were no issues with the evaluated amounts of solder used.
- The solder spread was sufficient; the average solder void percentage of the cathode electrode area in the middle was approx. 10%.

For more details, refer to Table 6 on Page 10.

LED tilt

0° direction: The average gap between the LED and the PCB was approx. 29µm (i.e. the LED has a tilt of 0.26°).

90° direction: The gap between the LED and the PCB was very small.

For more details, refer to Figures 11 on Page 11.

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6-2. Evaluation Results (continued)

Table 6. Evaluation Results (LED Emission, Solder Ball and Solder Void Percentage)
Sample size: 400 LEDs per condition (i.e. stencil thickness)

Stencil Thickness	120μm	**150μm (Nichia's Recommendation)**	180μm
X-Ray Image[2]	Cathode (Edge) Cathode (Middle) Anode		
Emission Inspection	LED emitted	LED emitted	LED emitted
Solder Ball	No solder balls were formed	No solder balls were formed	No solder balls were formed
Solder Void Percentage[3]	Cathode (Edge): 5.5 % Cathode (Middle): 12.6 % Anode: 6.9 %	Cathode (Edge): 6.2 % Cathode (Middle): 8.4 % Anode: 6.8 %	Cathode (Edge): 4.9 % Cathode (Middle): 9.2 % Anode: 3.8 %

Note:
[2] Example of LEDs with average void percentages under the same evaluation conditions (i.e. amount of solder).
[3] Solder void percentage [%]: Area of a space within the solder joint that lacks solder paste / area of the electrode.

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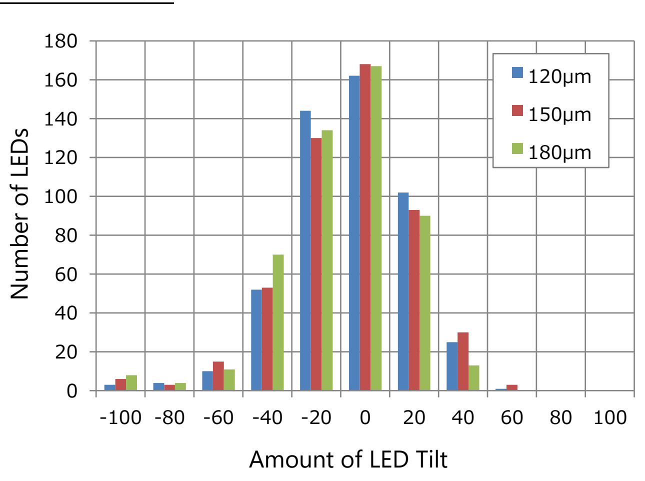
6-2. Evaluation Results (continued)



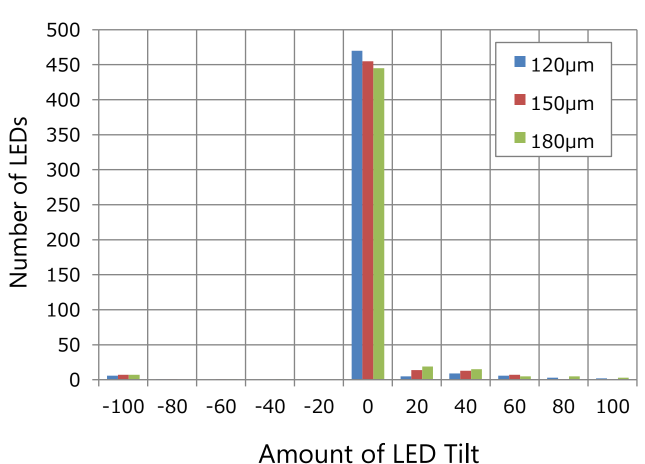
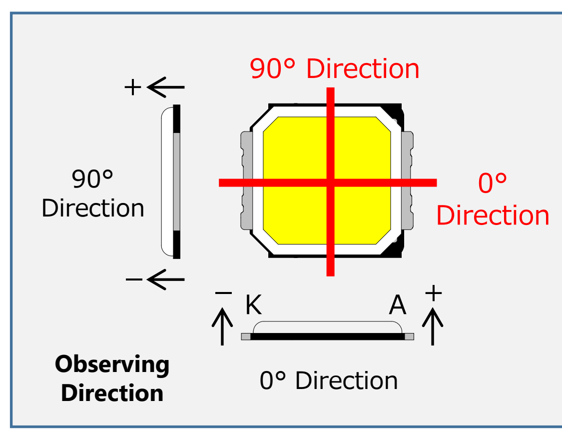


Figure 11. Evaluation Results (LED Tilt)
Sample size: 400 LEDs per condition (i.e. stencil thickness)



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7. Evaluation of Self-Alignment Performance

7-1. Evaluation Method/Conditions

The self-alignment performance of the reflow-soldered LEDs was evaluated using the following evaluation method/conditions:

- Three different amounts of solder (i.e. three metal solder stencil thicknesses including the recommended thickness to control the amount),
- Evaluation LEDs were intentionally rotated (i.e. $\Delta\theta$ = 5°, 10°, 30°, 45°) or placed on specified points (i.e. $\Delta x,y$ = 0.1mm, 0.2mm),
- The amounts of parallel/angular deviation from the center of the soldering pad pattern were measured for each stencil thickness (i.e. solder volume).

Metal Solder Stencil Thickness:

120µm, 150µm (Nichia's recommendation), 180µm

7-2. Evaluation Results

- There were no issues (e.g. causing the LED not to illuminate) with the evaluated LEDs with the parallel/angular deviations above.
- The LEDs with a parallel deviation of $\Delta x,y \leq 0.1$mm moved to positions that were sufficiently close to the correct one (i.e. the center of the soldering pad pattern) by themselves during reflow soldering (i.e. surface-driven self-alignment).
- The LEDs moved/rotated closer to the correct position as the amount of solder was increased. However, if the LEDs are soldered to a PCB with an angular deviation ≥ 10°, they are more likely to have a short circuit between the electrodes while in operation.

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7-2. Evaluation Results (continued)

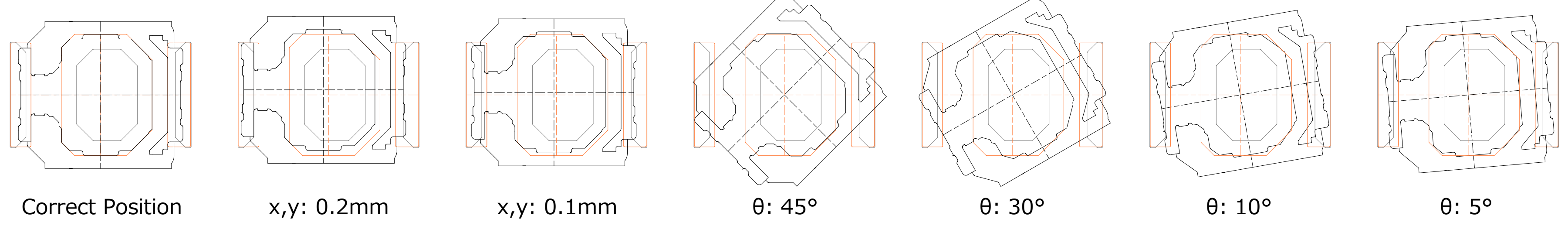

Figure 12. LED Misalignment Conditions

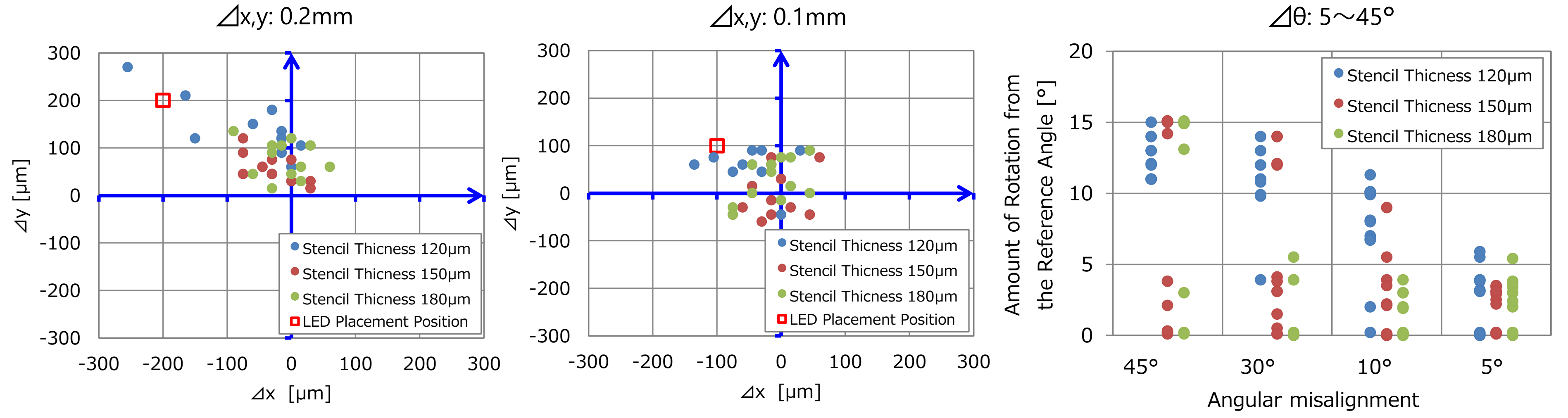

Figure 13. Evaluation Results
Sample size: 12 LEDs for each condition

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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