Recommended Pick and Place Tools for Luminus LEDs

Overview

This Application Note provides guidance for surface mount technology (SMT) assembly of LED devices using automatic placement machines. The key goal is to achieve damage-free processing of LEDs during the pick and place process. To do this, it is important to use appropriate and individually tailored pick and place tools known as nozzles. Information is provided on important parameters that need to be considered for LED assembly processes. These include technical specifications about the LED packages and process parameters for the placement equipment.

Additionally, recommendations are provided for specific nozzle design for each type of SMT LED offered in the Luminus portfolio. Having a nozzle tailored to the unique characteristics of each LED package is crucial for ensuring reliable and gentle handling without any risk of damage. By outlining the critical assembly parameters and recommending optimized nozzle designs, this Application Note will help users properly set up their LED placement processes to allow for damage-free SMT assembly on automated pick and place machines. This will enable customers to successfully integrate LED products into their manufacturing lines while meeting quality and reliability requirements. An important goal is minimizing failures and rework by implementing best practices for automated placement of SMT LEDs.

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1. Introduction: Frequent Challenges in Pick and Place LED Production

Automated pick and place manufacturing systems for surface mount devices (SMDs) have been widely used since the 1980s. These systems are designed to place electronic components onto printed circuit boards (PCBs) accurately and efficiently. Initially, the focus of this process was on components with solid or hard-epoxy molded flat-top- packages such as capacitors, resistors, and integrated circuits. However, when LEDs with a glass or soft silicone molded dome were introduced, certain challenges arose in the pick and place process. This Application Note addresses these challenges and provides troubleshooting methods to resolve them.

Additionally, it provides recommendations for specific nozzles suitable for use with common Luminus LEDs. One of the primary concerns when working with LEDs is to ensure proper placement without the risk of pre-damage or tilting. To avoid these issues, nozzle selection plays a crucial role. The right nozzle must be chosen based on the LED's package type, dimensions, and characteristics. Proper setup is also essential to ensure successful pick and place operations for LEDs. By following the recommended troubleshooting methods, selecting the appropriate nozzle, and performing correct setup, manufacturers can overcome the challenges associated with pick and place processes for LEDs. This enables efficient and reliable manufacturing processes and quality output.

This Application Note represents a collaborative effort between Luminus and its pick and place equipment partner Count on Tools, demonstrating our commitment to continuous improvement and customer satisfaction. It showcases the shared goal of delivering high-quality LED placement solutions and addressing the challenges faced by our customers operating automated production environments.

To aid readers new to this topic, a glossary of terms and definitions is provided at the end of this document. Terms included in the glossary are shown in the document text in *italics*.

2. Proper Automated LED Feeder Setup

The placement accuracy of LEDs on a PCB is crucial for ensuring proper functionality and performance. Automated placement systems are often used because they can provide the best accuracy in this process. Process parameters need to be carefully controlled to ensure that they conform to the characteristics of the LED package. Setup includes correctly configuring the pick and place machine's parameters such as vacuum pressure, nozzle height, and placement force. Adjusting these settings appropriately helps prevent component damage and ensures accurate placement. Important parameters also include factors such as placement speed, force, and alignment. An initial production test run is recommended to verify that all the settings are correct and to make any necessary adjustments.

Figure 1 (next page) shows the LEDs on an automated tape and reel system. As the first step in the process, the placement head of the automated system picks up the LEDs from a feeder, which typically uses tape and reel packaging. The LEDs are then placed precisely on the designated locations on the PCB. To prevent any damage to the LEDs during the placement process, it is important to use an appropriate pick and place tool. This tool should be designed to handle the LEDs gently and securely without causing any harm.

There are three primary factors that define a good assembly process for LED placement: *feeding*, system parameters, and the nozzle used:

1. Feeding. Proper component feeding is essential for smooth and accurate placement. The feeder should reliably deliver the LEDs to the placement head without any jams or misfeeds. The feeding mechanism should be designed to handle the *carrier tape* and reel packaging effectively.

2. System Parameters. The system parameters, such as placement speed, force, and alignment settings, need to be optimized for the specific characteristics of the LEDs being placed. These parameters can vary depending on factors such as LED size, shape, and fragility. Finding the right balance of these parameters is crucial for achieving accurate and reliable placement.

3. Nozzle. The choice of nozzle used in the placement head is also important. The nozzle should be selected based on the size and shape of the LED package. It should securely hold the LED during the placement process and ensure precise positioning on the PCB.

Achieving a successful LED placement process requires the careful coordination of these interacting factors. Each factor must be properly adjusted and optimized to ensure accurate and reliable placement. This coordination is essential for achieving a high-quality assembly process for LEDs.

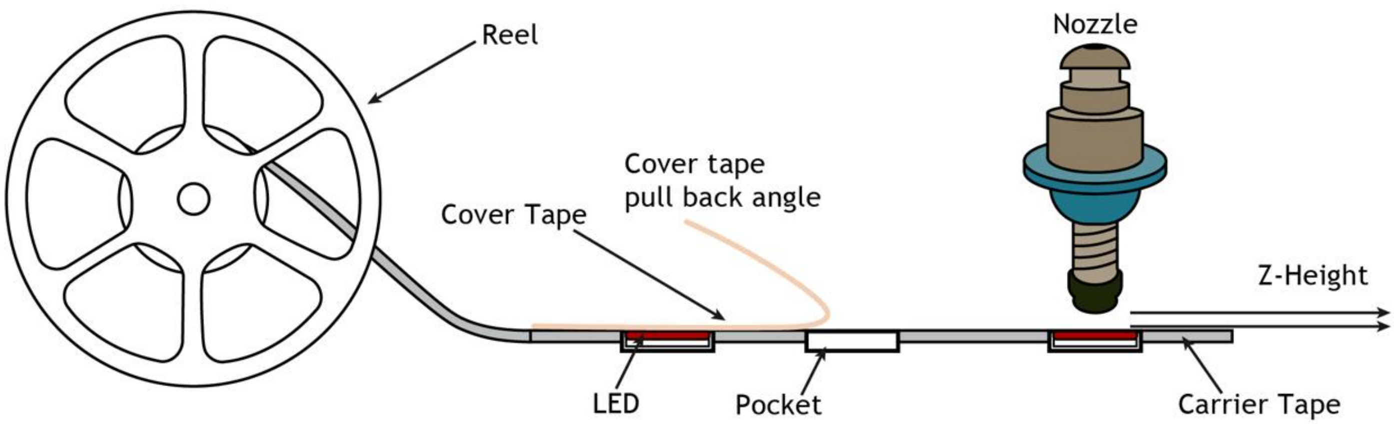


Figure 1. LEDs on tape and reel feeding to nozzle pick-up.

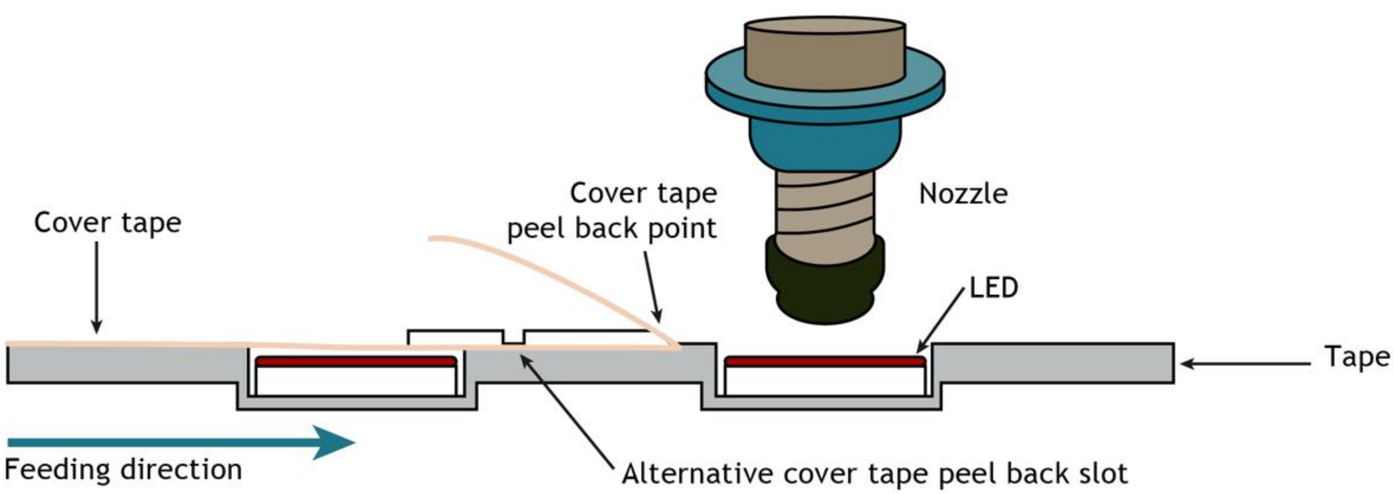


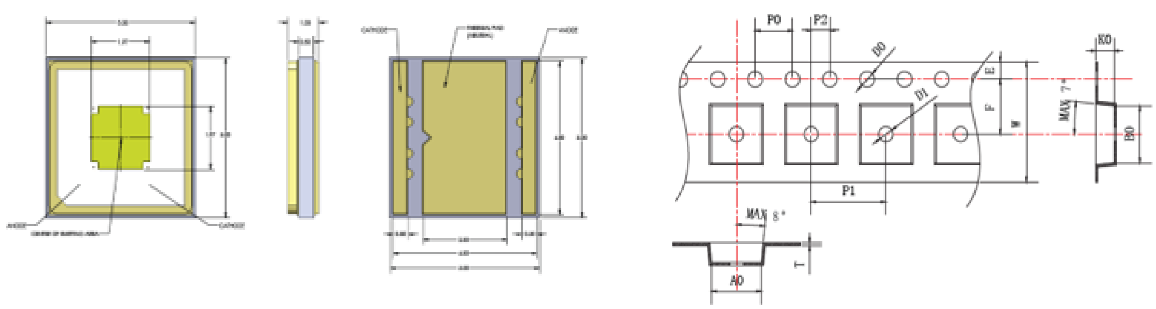
Figure 2. Alternate *cover tape* peel back.

3. System Parameter Setup

Well-defined and proper process parameters can help reduce the risk of damage to the LED during the placement process. Using the default settings of the machine as a starting point is generally good practice. One of the important process parameters that should be defined is the pickup position. This refers to the exact location from which the placement head picks up the LED from the feeder. The pickup position needs to be accurately determined based on the component and pocket dimensions.

To obtain the necessary information for defining the pickup position, you can refer to the datasheet for the specific Luminus LED component you are working with. All Luminus datasheets provide details about the dimensions and specifications of the LED (Figure 3), including the specifications of the tape and reel. Figure 3 illustrates a typical datasheet entry, which provides the necessary information for setting pickup position correctly.

Once the initial settings are defined, it is highly recommended to double-check the final settings before each production run. This is important because factors such as machine calibration, component variations, or environmental changes may require slight adjustments to the process parameters. By verifying the settings before each production run, you can ensure that they are still accurate and appropriate for the specific LED components being used. This helps maintain consistency and reliability in the placement process and reduces the risk of errors or damage to the LEDs.



Parameter	Dimension (mm)
A0	5.3±0.1
B0	5.3±0.1
D0	1.5±0.1
D1	1.5±0.25
E	1.75±0.1
F	5.5±0.1
K0	1.7±0.1
P0	4.0±0.1
P1	8.0±0.1
P2	2.0±0.1
T	0.25±0.02
W	12+0.3 12-0.1

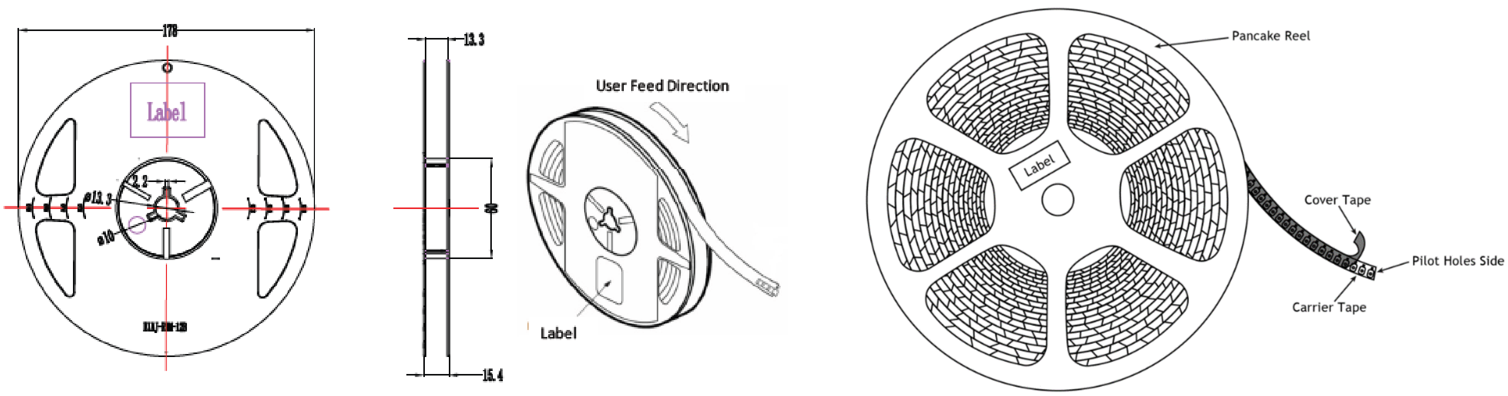


Figure 3. Top: example of information provided on a Luminus data sheet. Bottom: diagram of typical Luminus LED on carrier tape showing dimensions and specifications. Note: Cathode of the LED is towards the hole side of the carrier tape.

4. Mis-Picks and Double Stacking

A common cause of failure is components sticking to the nozzle causing mis-picks or component double stacking (Figure 4). Double stacking can occur when a component sticks to the nozzle and then another component is picked up and sticks to the bottom of the first component. A mis-pick occurs during the process of picking up LED components from the feeder and placing then onto the circuit board. Mis-picks can occur due to various reasons such as component misalignment, feeder issues, and machine calibration errors.

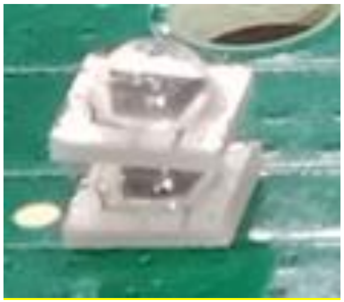


Figure 4. Example of double stacking of two domed LEDs.

Figure 5 shows a typical SMT LED with a dome; the *flashing* area around the base of the dome can cause a nozzle to stick to the component by sealing to the nozzle. Using the proper nozzle design will ensure it stays clear of this area and using a nozzle tip like Teflon will prevent the LED from sticking to the nozzle. LEDs without domes (Figure 6) can also be subject to double stacking, although not as often as domed LEDs. Proper nozzle design will prevent the component from sticking to the nozzle.

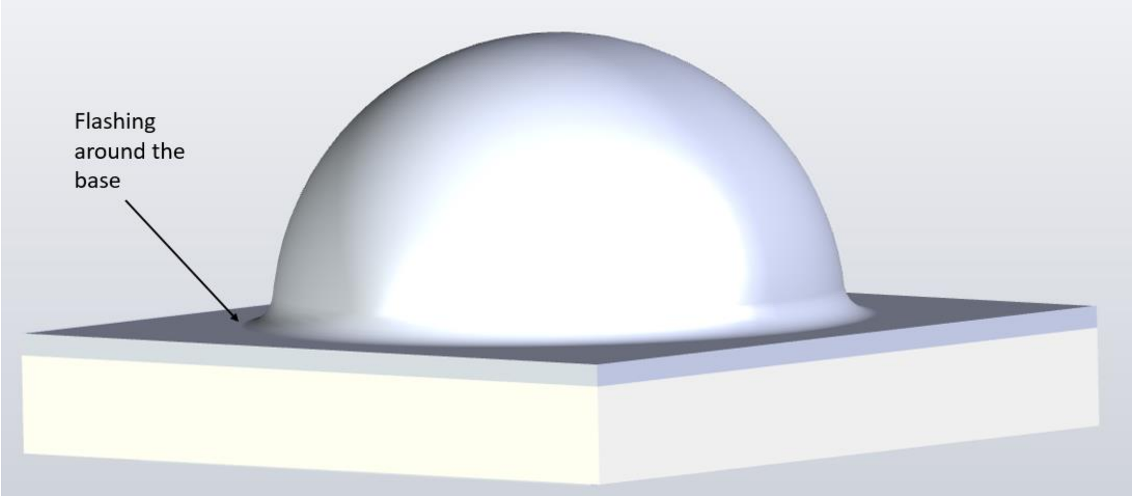


Figure 5. Typical Luminus LED with a dome and flashing.

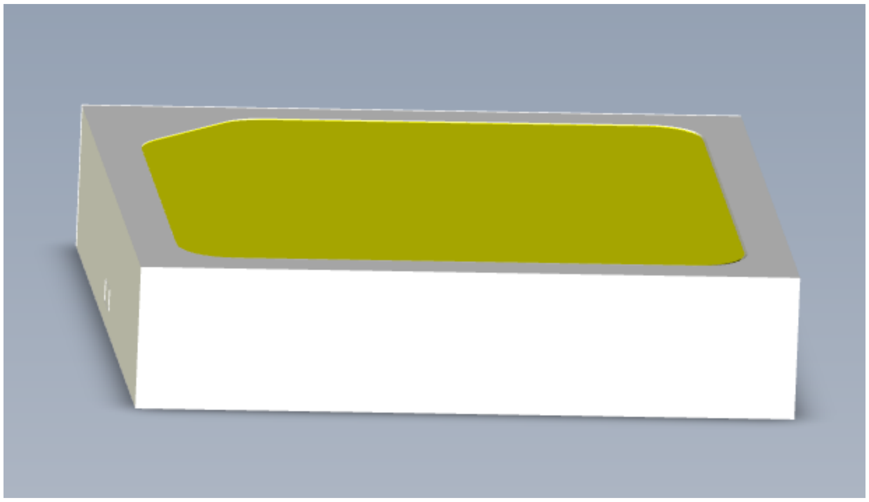


Figure 6. Typical Luminus LED without dome.

5. Sticking On Tape

When using silicone-based potting material for LEDs, it is important to be aware of the potential stickiness of the material, which can vary depending on the ambient temperature and humidity conditions. This stickiness can create challenges during the removal of the *cover tape* from the tape and reel packaging. Figure 7 (next page) illustrates possible scenarios. Static can also cause the LEDs to stick to the cover tape.

The stickiness of the potting material can lead to a couple of problems:

- **LED touching the nozzle:** As the cover tape is removed, there is a risk that the LEDs may come in contact with the placement head nozzle because the components are tilted as shown in the figures below. This can also happen if the potting material adheres to the nozzle or if the LEDs are not properly released from the tape (Figure 7, top). When the LED touches the nozzle, it can cause damage or misalignment, affecting the accuracy of the placement process.
- **LED falling back into the tape:** due to the stickiness of the potting material the LED can stick to the cover tape, then the LED falls back into the *carrier tape* after the cover tape is removed. This can result in the LED being tilted or mis-positioned within the tape pocket (Figure 7, bottom). As a result, the placement head may have difficulty picking up the LED accurately, leading to placement errors.

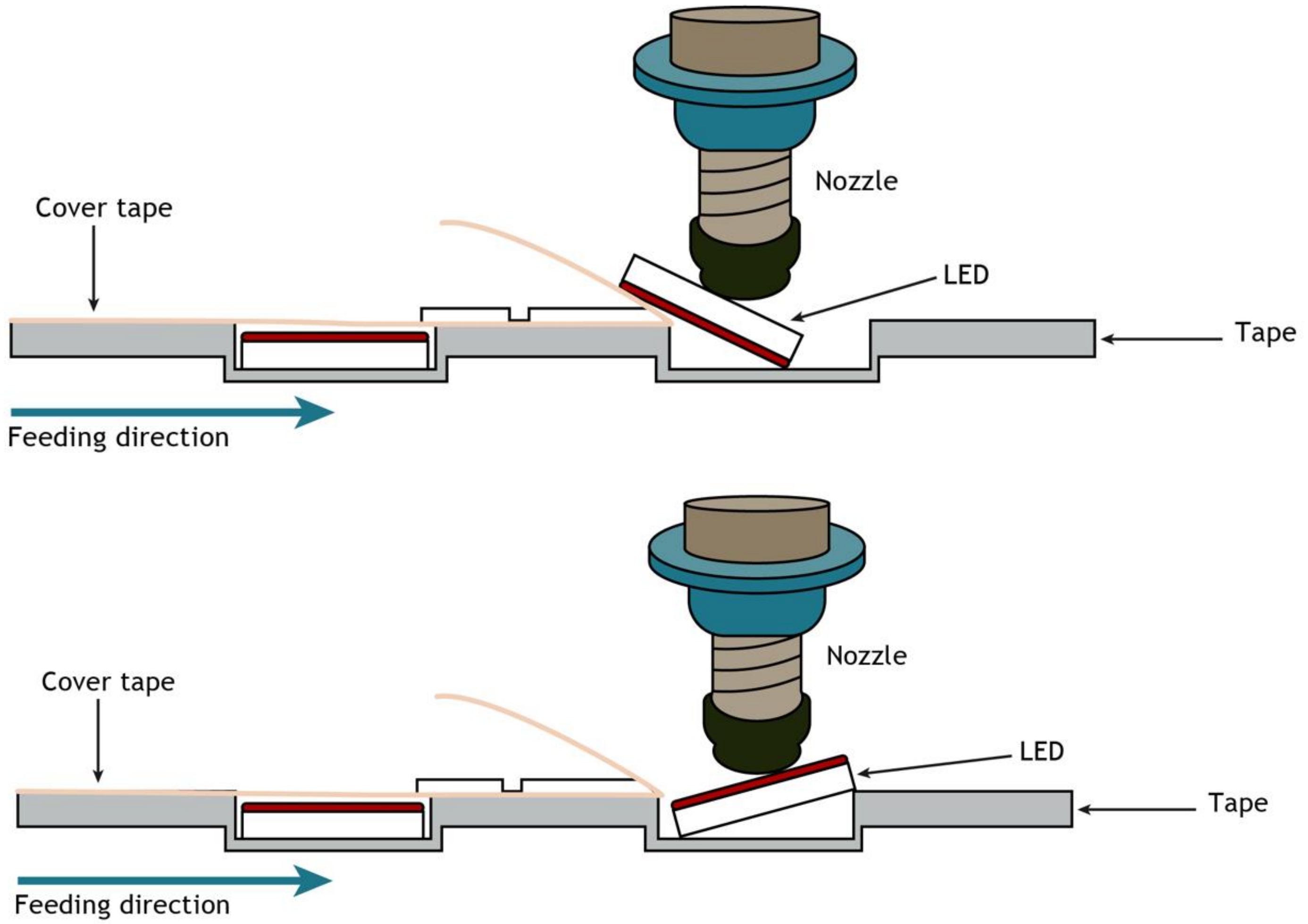


Figure 7. Illustration of typical examples of tape sticking Issues. Upper image: As the carrier tape is fed to the right, the LED is sticking to the cover tape and the bottom edge of the LED has come in contact with the nozzle. Lower image: The LED has fallen back into the carrier tape instead of adhering to the nozzle.

To mitigate these problems, several measures can be taken:

1. Adjusting process parameters: Fine-tuning the process parameters, such as the speed and force of the *cover tape* removal, can help minimize the chances of the LEDs sticking to the nozzle or falling back onto the tape. Optimizing these settings can provide better control over the removal process.

2. Controlling ambient conditions: Maintaining suitable temperature and humidity levels in the assembly area can help manage the stickiness of the potting material. Keeping the environment within specified ranges, as recommended by the material manufacturer, can minimize the potential for adhesion issues.

3. Adjusting cover tape angle: Adjusting *cover tape* angle can prevent stickiness to the tape during pull back.

These measures can mitigate the risks associated with the stickiness of silicone-based potting material during the *cover tape* removal process. This ensures proper handling and accurate placement of the LEDs onto the PCB.

6. Component Placement

Once picked up by the placement head nozzle, LED components may not release from the nozzle properly, leading to placement issues. In such situations, there are adjustments that can be made to assist in releasing the component. One of the techniques used to aid in component release is called a purge or "air kiss." This involves using forced air to apply pressure and help push the component off the nozzle. The specific air pressure and duration required will depend on the system and the type of nozzle being used.

However, it's important to note that for most components, including LEDs, a purge or air kiss is typically unnecessary when proper nozzle design and *over-travel* setup are in place in the x or y position (over-travel refers to the additional distance that the placement head travels beyond the target location after it has placed a component onto the PCB). With the right nozzle and setup, the components should release smoothly without the need for additional assistance.

If you encounter difficulties with component release during LED placement, consult with the pick and place machine manufacturer. They can provide guidance on using the purge option if available and suitable for your specific situation. They can also offer recommendations on optimizing the nozzle design and *over-travel* setup for improved performance.

A purge or air kiss may not always be available or allowed in certain situations, however. This is because the use of forced air can potentially affect other components that are already mounted on the PCB. Therefore, it's important to consider the potential impact on the overall assembly and consult with the pick and place machine manufacturer or supplier to determine the best approach. Materials provided by pick and place suppliers can offer helpful suggestions and guidelines specific to their equipment. These resources can provide valuable insights and recommendations for optimizing LED placement processes with particular machines. Also note that a placement force exceeding *2N* (2 Newtons) should be avoided, and efforts should be made to minimize force wherever possible (one Newton is defined as the force required to accelerate a one-kilogram mass at a rate of one meter per second squared).

7. Solder Pad Design

The solder pad establishes direct contact between the LED and the circuit board; thus, its design plays a pivotal role in determining the performance of the solder connection. The solder pad design significantly influences the reliability of the solder joint and aids in heat dissipation. Use the recommended solder pad because it is tailor-made to suit the specific properties and conditions of the LED (refer to Figure 8).

Each Luminus LED's datasheet includes details about the corresponding recommended solder pad. Luminus has collaborated closely with SnapMagic to ensure that information about the recommended solder pads can be conveniently downloaded in various formats (visit this SnapMagic link to download). Using the recommended solder pads ensures alignment with optimal design parameters for enhanced solder joint performance and heat management.

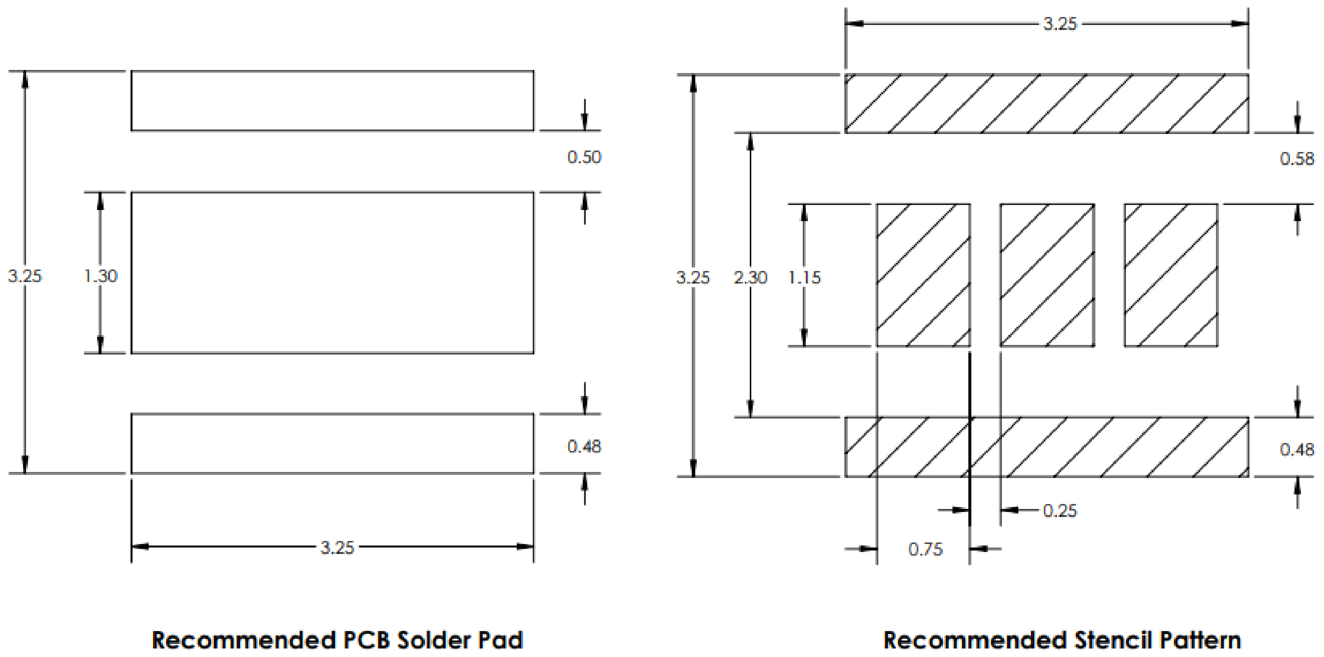


Figure 8. Example of recommended Solder Pad and Stencil Pattern (Images are enlarged to show detail; all dimension numbers are in millimeters).

8. Solder Stencil

In the SMT process, the application of solder paste is typically done by stencil printing. Effective application relies on both stencil design and precise operational procedures, which directly impact the quantity and quality of the deposited solder paste (Figure 9). Achieving accurate solder paste printing is integral to enhancing solder quality. Factors like solder bridges, solder spray, and other soldering defects are primarily determined by the design of the stencil apertures and the overall quality of stencil printing, including factors like positioning and stencil cleanliness.

Figure 9. Proper (left) vs. incorrect (right) solder paste application on solder pad.

For LED applications, a recommended stencil thickness falls within the range of 0.15 mm (0.006”) to 0.25 mm (0.010”). Further optimization efforts should be made to increase the solder paste volume. Apply solder paste to the PCB with a screen or stencil using a thickness range of 0.15mm (0.006”) to 0.25 mm (0.010”). Maintaining a consistent solder joint thickness is essential for generating reliable solder joints and achieving proper optical alignment. Employing automatic stencil printing with appropriate *fiducials*, along with electro-polished or fine-grain material stencils, results in accurate printing deposits

Luminus suggests the use of standard lead-free SAC 305 (Sn 96.5% / Ag 3% / Cu 0.5%) no-clean solder paste for the paste printing process. It is important to minimize voids in the soldering process to less than 20% of the solder area. To ensure proper setup and minimal voids, Luminus recommends a pilot run, coupled with x-ray inspections to verify the adequacy of soldering (Figure 10). To minimize voids, follow the reflow profile and recommendations in Luminus application note APN-001473.

Figure 10. Comparison of good and bad void levels.

9. Nozzle Setup and Selection

Custom nozzles are crafted specifically for diverse placement machines, tailored to accommodate unique component shapes or geometries. The meticulous selection of the right nozzle, coupled with a precise setup, is crucial for effectively extracting components from the tape and ensuring their proper placement without the risk of pre-damage or tilting. In Section 10, "Recommended Nozzle Designs," Luminus offers a comprehensive overview of its product portfolio along with corresponding nozzle recommendations.

Most in-house tests at Luminus are conducted using systems from the Hanwha SM series and Juki. For any questions on nozzle selection, individuals are encouraged to contact Luminus at techsupport@luminus.com).

Custom pick and place nozzles are designed to meet the specific requirements of each customer and LED and are typically precision-machined to seamlessly integrate with designated pick and place tools. Various pick and place machines are employed in diverse applications, necessitating the adaptation of tools to conform to specified dimensions and body structures and for compatibility with the chosen machine type.

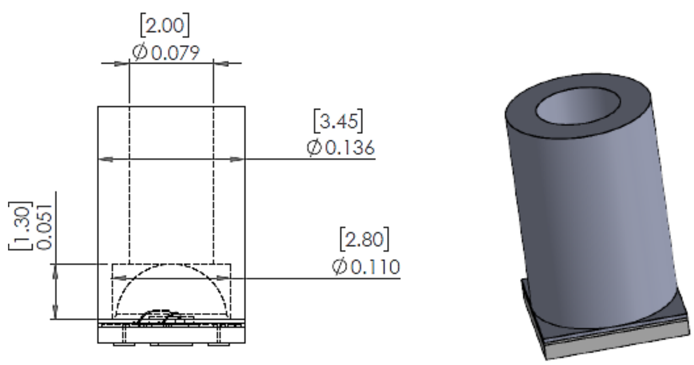
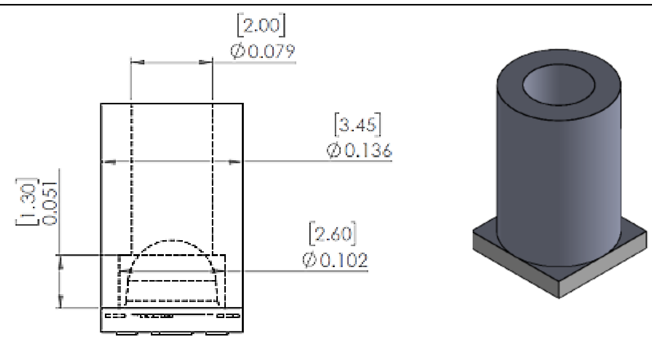
Prior to the assembly process, meticulous attention should be given to the cleanliness of the nozzle tip, ensuring that it is free from any particles that might interfere with the top surface of the silicone encapsulation. A thorough check before assembly is crucial to eliminate dust and residues, preventing potential interactions with the LED surface during pickup and placement. Additionally, regular maintenance of the equipment is imperative to mitigate the risk of malfunctions.

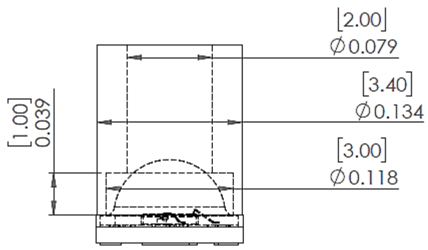
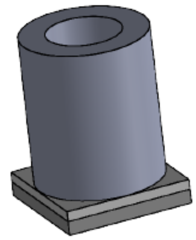
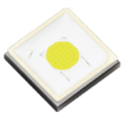
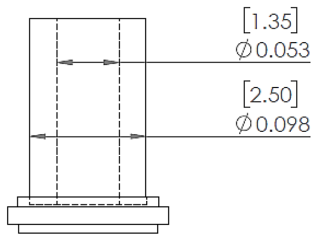
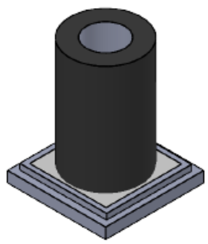
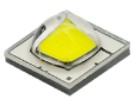
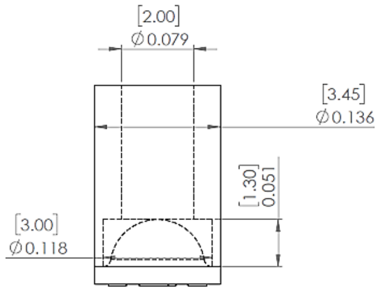
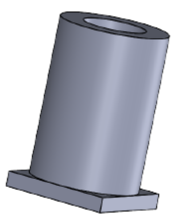
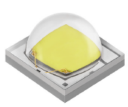
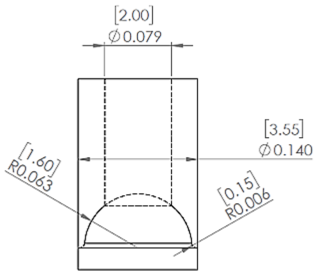
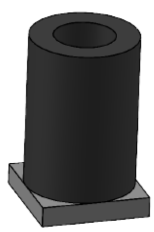
10. Recommended Nozzles

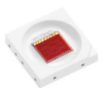
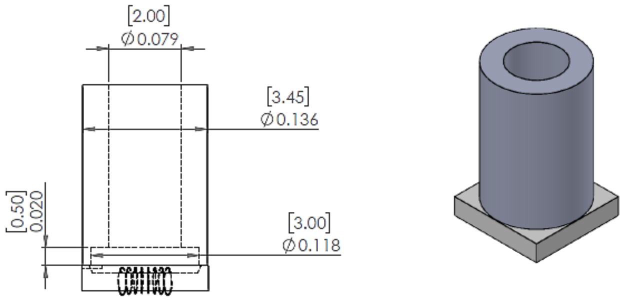
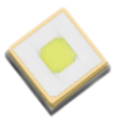
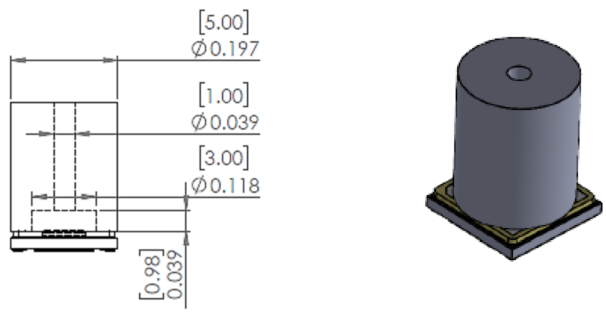
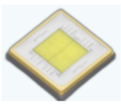
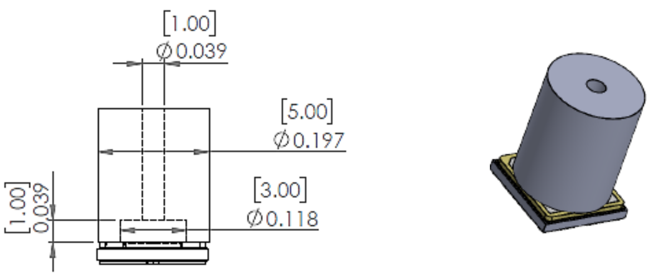
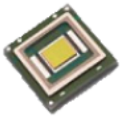
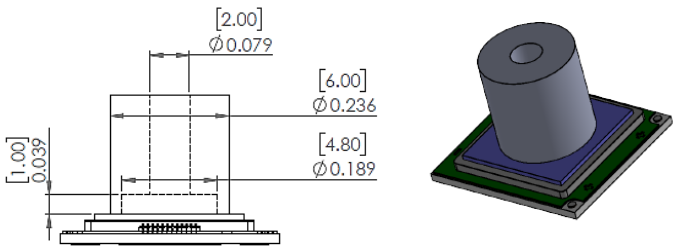
Recommended nozzles for use with each type of Luminus LED are listed in Table 1. Nozzles are designed by [Count on Tools](https://www.cotinc.com/) (see company information below) and can be purchased directly from them to fit a variety of pick and place manufacturers.

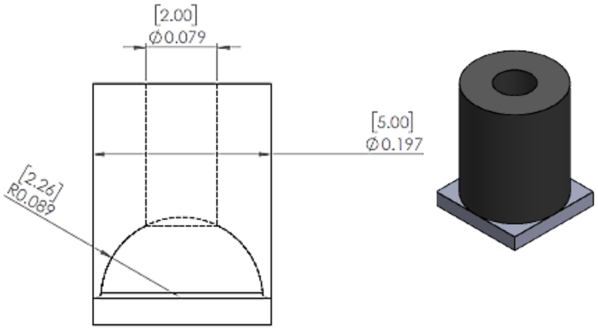
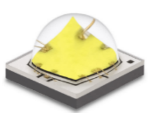
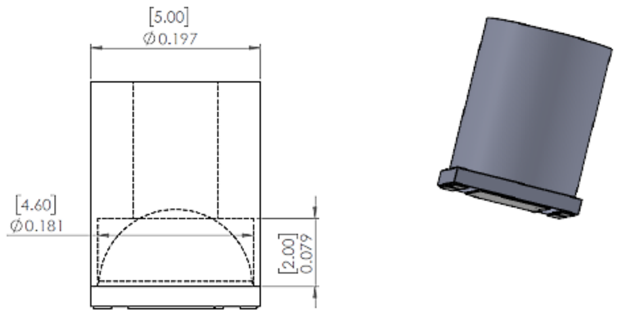
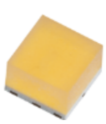
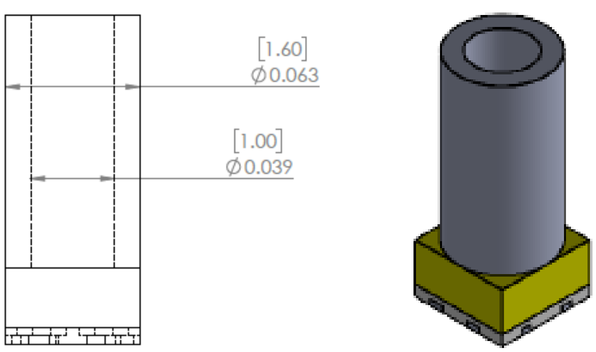
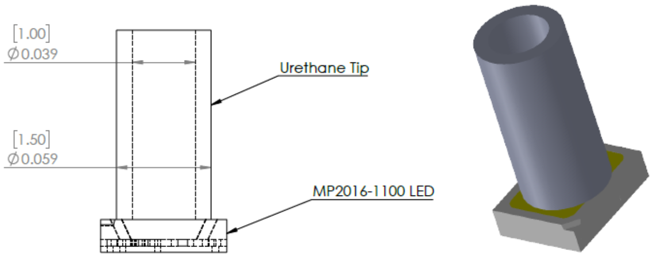
Count On Tools, Inc.
2481 Hilton Drive, Suite 3
Gainesville, GA. 30501 USA
Phone: 770-538-0411
Website: https://www.cotinc.com/

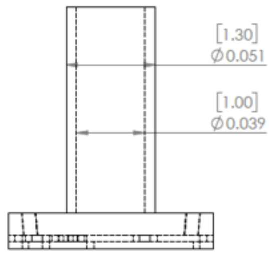
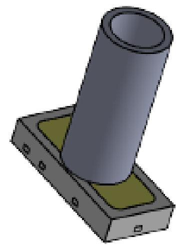
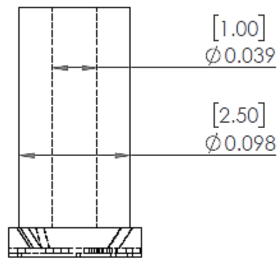
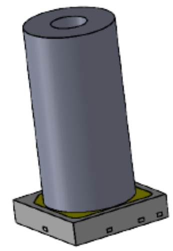
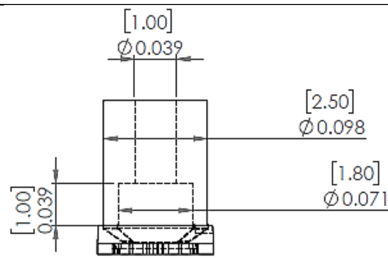
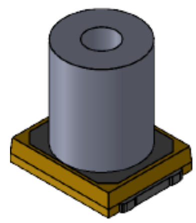
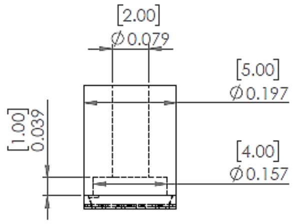
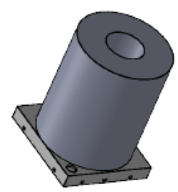
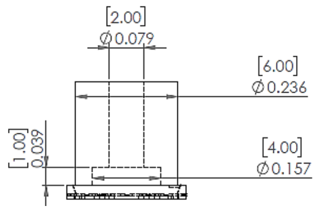
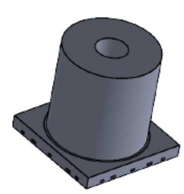
Table 1. Recommended Nozzles

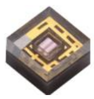
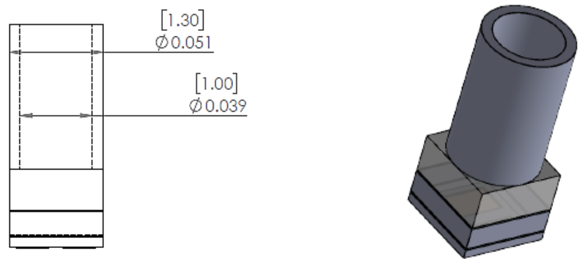
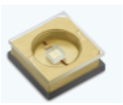
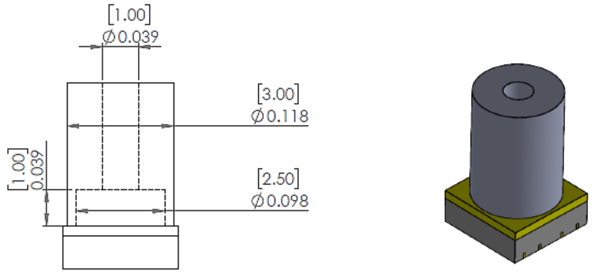
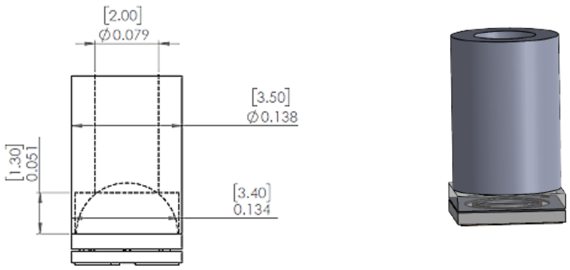
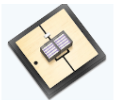
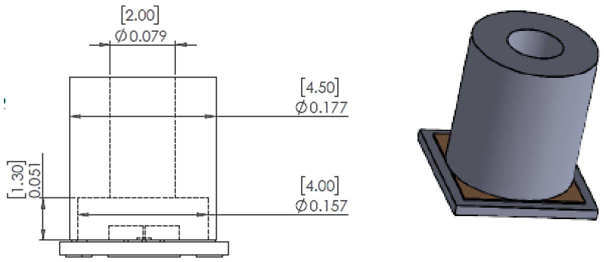
LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 SST-10 130 degree SBT-10-UV	Black *Urethane*		SST-10-B130
 SST-10 90 degree	Black Urethane		SST-10-B90

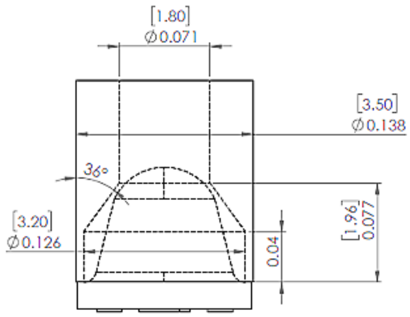
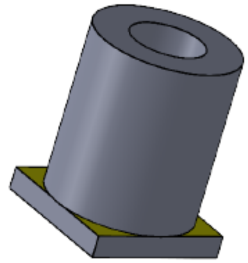
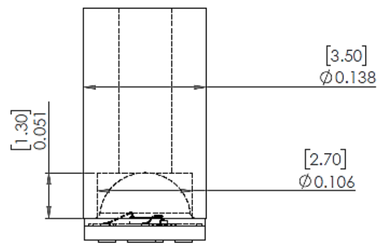
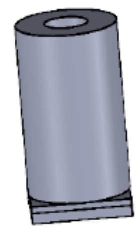
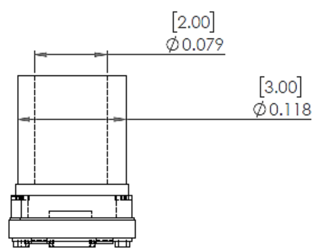
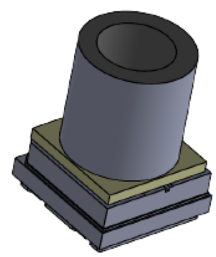
LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 SST-12	Black Urethane	 	SST-12-WxS
 SFT-12R	Black Urethane	 	SFT-12R
 SST-20	Black Urethane	 	SST-20-WxS
 SST-25	Black Urethane	 	SST-25-W

LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 SFT-20	Black Urethane		SFT-20-RA
 SFT-40	Black Urethane		SFT-40-WxS
 SFT-70X	Black Urethane		SFT-70X-WxS
 SBT-90	Black Urethane		SBT-90-Wxs

LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 SST-40	Black Urethane		SST-40-WxS
 SST-70X	Black Urethane		SST-70X-WXS
 MP-1616	Black Urethane		MP1616-1103
 MP-2016	Black Urethane		MP2016-1100

LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 MP-3014	Black Urethane	 	MP3014-1100
 MP-3030	Black Urethane	 	MP3030-120K
 MP-2835	Black Urethane	 	MP2835-12D2
 MP-5050	Black Urethane	 	MP5050-6100
 MP-7070	Black Urethane	 	MP7070-T200

LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 XBT-1313	Black Urethane		XBT-1313-UVC
 XBT-3535	Black Urethane		XBT-3535-UV
 XST-3535	Black Urethane		XST-3535-UV
 XFM-5050 2/3/4 chip	Black Urethane		XFM-5050

LED Type	Nozzle Type	Drawing of Recommended Nozzle	Count On Tools Part Number
 SST-08-B40	Black Urethane	 	SST-08-UV-B40
 SST-08-B130	Black Urethane	 	SST-08-UV-B130
 SBT-10X	Black Urethane	 	SBT-10X-UV

11. Hand Placement of LEDs

When manual processing is necessary, such as in prototype production, special care should be taken to handle LEDs properly. It is not recommended to pick up LEDs with standard metal tweezers, as they can potentially cause electrostatic discharge (ESD) damage to the LED and affect its functionality. If manual handling is unavoidable, there are specific precautions that should be followed:

- **Use anti-static materials**. It is important to use tweezers made with anti-static material to prevent ESD that could damage the LED. Anti-static tweezers are designed to dissipate static charges and minimize the risk of ESD-related damage.
- **Choose plastic/rubberized tweezers**. Use tweezers made of anti-static plastic or rubberized materials (Figure 11. . These materials have a softer grip for the LED and are less likely to cause damage to the LED during handling. It is crucial to ensure that the tweezers only grip the exterior of the lens frame to avoid any direct contact with the LED surface (Figure 11, right).

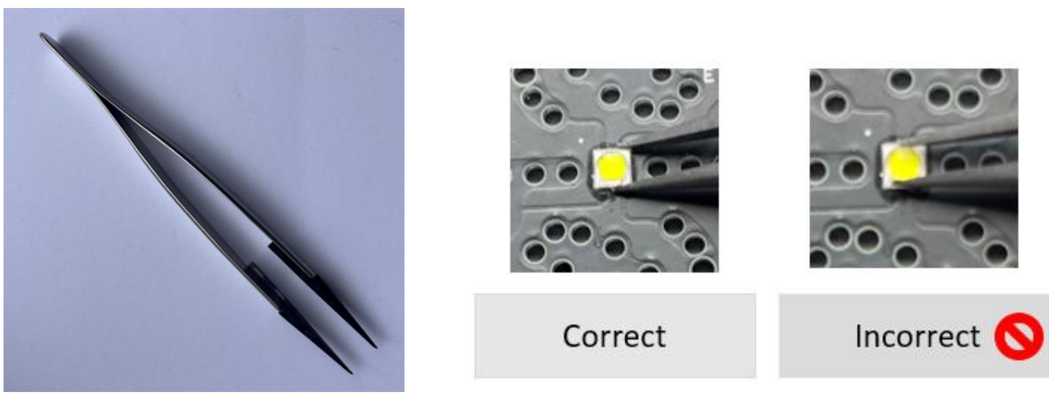


Figure 11. Rubber Tweezers. Never pick up by dome or touch the Light Emitting Surface (LES) with tweezers.

12. Summary

Luminus has collaborated with leading pick and place suppliers to develop this Application Note aimed at reducing damage and mis-pick rates for LEDs. This collaboration initiative demonstrates our commitment to assisting our customers by helping them address common challenges in picking and placing LEDs on automated high-speed production lines. By implementing the suggestions outlined here, significant reductions in mis-picks and other component handling issues can be achieved with automated systems.

Luminus Devices' dedication to supporting ongoing process improvements and making Luminus LEDs compatible with common industry pick and place processes, along with customer feedback and collaboration with pick and place equipment partners, ensures that the specific needs and challenges related to LED placement are addressed effectively. Refer to the relevant sections of this Application Note for guidance on various aspects of the pick and place process, including the selection of the proper nozzle, adjustments to the feeding mechanism, and optimal settings. These factors have proven to be instrumental in improving the performance of pick and place equipment when handling LEDs. By following the recommendations provided, users can gain insights into addressing issues and optimizing the LED placement processes, resulting in more efficient and reliable production line operations.

13. Resources

Special thanks to Count on Tools for providing images and information on the recommended pick and place nozzles. For more information about Count on Tools please visit https://www.cotinc.com/.

Count On Tools, Inc.
2481 Hilton Drive, Suite 3
Gainesville, GA. 30501 USA
Phone: 770-538-0411
Website: https://www.cotinc.com/

For custom nozzles visit https://form.jotform.us/cotinc/customnozzle

Please contact Luminus Devices Inc. at techsupport@luminus.com for additional information.

14. Glossary

2N (2 Newtons) - unit of force in the International System of Units (SI). One Newton is defined as the force required to accelerate a one-kilogram mass at a rate of one meter per second squared ($1\ m/sec^2$).

Carrier tape - The continuous strip of material that holds individual surface mount components (such as integrated circuits, resistors, capacitors, LEDs, etc.) in pockets or cavities at regular intervals.

Cover tape - The protective layer that covers the components housed in the pockets or cavities of the tape and reel packaging.

Double stacking - the machine attempts to pick up two components due to one component sticking in the nozzle but encounters a problem during the process. This error can lead to issues such as misalignment, component damage, or failure to pick up one or both components.

Feeding - components are fed into the pick and place machine from a continuous strip of carrier tape wound onto a reel. The tape is typically oriented parallel to the direction of movement of the placement head. As the tape advances, the placement head picks up components from specific pockets on the tape and places them onto the PCB.

Fiducials - circular pad or other shapes of exposed copper surrounded by a clearance area are commonly known as fiducial marks or fiducials in the context of printed circuit boards (PCBs) and electronics assembly. Fiducials serve as reference points for automated machines, such as pick-and-place machines and vision systems, during the assembly process.

Flashing – is around the base of an LED dome and refers to a thin excess of material—often silicone or epoxy—that extends beyond the base of the LED package where the dome (or lens) is attached to the package. This flashing is a byproduct of the manufacturing process

Over travel - The additional distance that the placement head travels beyond the target location after it has placed a component onto the PCB in either the x or y position.

Pick-up location - The specific position from which the machine's placement head picks up components for assembly onto a printed circuit board (PCB). This location is critical for ensuring accurate and efficient component placement during Surface Mount Technology (SMT) assembly.

Urethane – a type of polymer known for its flexibility, durability, and resistance to abrasion. These characteristics make it an ideal material for pick and place applications, including the recommended nozzles shown in Section 10.

Vacuum Nozzle - the part of the placement head that makes physical contact with the component to pick it up. It uses vacuum pressure to securely hold the component in place during the pick-and-place process.

X-Y Axis Movement - The placement head typically moves on the x and y axes to position itself over the correct location on the PCB where the component needs to be placed. This movement is controlled by motors or other mechanisms to achieve high accuracy.

Z-Axis Actuator - controls the vertical movement of the placement head, allowing it to descend to pick up a component and then ascend to place it onto the PCB with precision.