LUXEON® H 50-2 and LUXEON T Emitters

Assembly and Handling Information

Introduction

This application brief addresses the recommended assembly and handling procedures for LUXEON H 50-2 and LUXEON T emitters. Proper assembly, handling, and thermal management, as outlined in this application brief, ensure high optical output and long lumen maintenance for both LUXEON emitters.

Scope

The assembly and handling guidelines in this application brief apply to the following LUXEON products:

LUXEON H 50-2	LUXEON T
• LXAC-1827	• LXH8-FW27-Y
• LXAC-1830	• LXH8-FW30-Y
	• LXH8-FW35-Y
	• LXH8-FW40-Y
	• LXH8-FW50-Y

In the remainder of this document the term LUXEON emitter refers to any product in the two LUXEON product series listed above. Any handling requirements that are specific to a subset of LUXEON emitters will be clearly marked.

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1. Component

1.1 Description

The LUXEON emitter consists of an LED chip mounted onto a ceramic substrate; a high-voltage LED chip is used in the LUXEON H 50-2 emitter. The ceramic substrate provides mechanical support and thermally connects the LED chip to a thermal pad on the bottom of the substrate. An electrical interconnect layer connects the LED chip to a cathode and anode on the bottom of the ceramic substrate. The ceramic substrate is surrounded by a larger ceramic frame and is overmolded with a silicone dome to enhance light extraction and to shield the chip array from the environment.

The bottom of the LUXEON emitter (Figure 1) contains three metallization pads, a large thermal pad in the center, an anode, and a cathode. The frame itself contains a laser engraved LED serial number at the bottom.

Each LUXEON emitter contains three staircase-style fiducials on the ceramic frame outside the dome (see the top view in Figure 1). In order to identify the anode and cathode, rotate the LUXEON emitter so that the three fiducials are on the top left, bottom left, and top right corner of the ceramic substrate when viewed from above. The left side, marked by the two fiducials in the top and bottom corner, then corresponds to the cathode side of the LUXEON emitter. The anode side only contains one fiducial in the top corner, when viewed from above.

1.2 Optical Center

The LUXEON emitter contains three feature sets to locate the theoretical optical center (see Figure 2):

1. **Topside fiducials**

   The fiducial marks on the ceramic frame of the LUXEON emitter provide the most accurate methodology to locate the theoretical optical center. The theoretical optical center is located 1.75mm from the vertical and horizontal edges of each fiducial mark.

2. **Backside metallization**

   The optical center can be located using the edges of the thermal pad on the bottom of the ceramic substrate. The theoretical optical center is 0.725mm from the side and 0.73mm from the top side of the thermal pad.

3. **LED outline**

   The theoretical optical center is located 1.85mm from the edge of the LUXEON emitter.

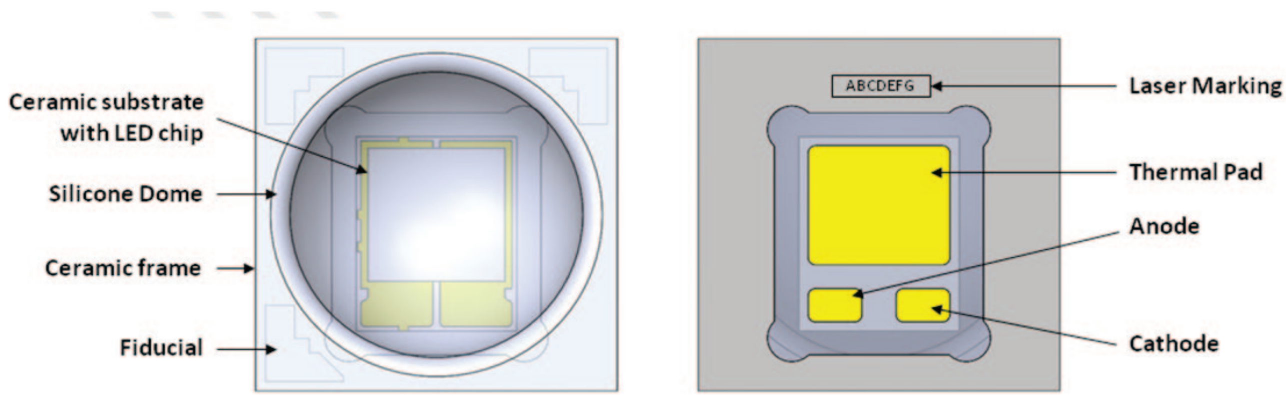


Figure 1. Top view (left) and bottom view (right) of the LUXEON emitter.

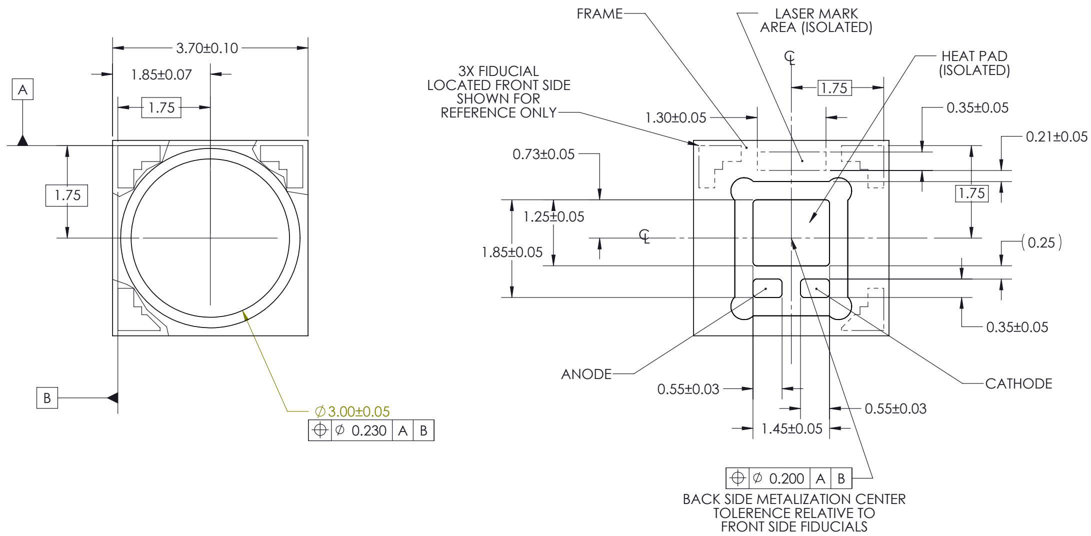


Figure 2. Fiducial marks on the top of the LUXEON emitter provide the most accurate method to locate the theoretical optical center.

Optical rayset data for the LUXEON emitter is available on the Philips Lumileds website at www.philipslumileds.com.

1.3 Handling Precautions

The LUXEON emitter is designed to maximize light output and reliability. However, improper handling of the emitter may damage the silicone dome and affect the overall performance and reliability. In order to minimize the risk of damage to the silicone dome during handling, LUXEON emitters should only be picked up from the side of the ceramic frame as shown in Figure 3.

1.4 Cleaning

A LUXEON emitter should not be exposed to dust or debris. Excessive dust or debris may cause a drastic decrease in optical output. In the event that a LUXEON emitter requires cleaning, first try a gentle swabbing using a lint-free swab. If needed, a lint-free swab and isopropyl alcohol (IPA) can be used to gently remove dirt from the silicone. Do not use other solvents as they may adversely react with the LED assembly.

1.5 Electrical Isolation

The thermal pad of the LUXEON emitter is electrically isolated from its cathode and anode. Consequently, a high voltage difference between electrical and thermal metallization may occur in applications where multiple emitters are connected in series. As a reference, the nominal distance between the electrical metallization and the thermal metallization of the LUXEON emitter is 0.25mm.

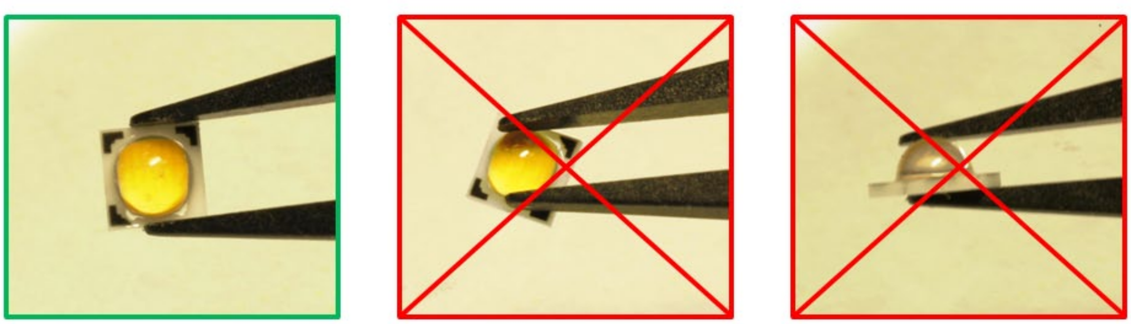


Figure 3: Correct handling (left) and incorrect handling (middle and right) of LUXEON H emitters.

In order to avoid any electrical shocks and/or damage to the LUXEON emitter, each design needs to comply with the appropriate standards of safety and isolation distances, known as clearance and creepage distances, respectively (e.g. IEC60950, clause 2.10.4).

1.6 Mechanical Files

Mechanical drawings for the LUXEON emitter are available on the Philips Lumileds website at www.philipslumileds.com.

1.7 Soldering

LUXEON emitters are designed to be soldered onto a Printed Circuit Board (PCB). For detailed assembly instructions, see Section 2.

2. LUXEON Printed Circuit Board Design Rules

The LUXEON emitter is designed to be soldered onto a PCB. To ensure optimal operation of the LUXEON emitter, the PCB should be designed to minimize the overall thermal resistance between the LED package and the heat sink.

2.1 LUXEON Footprint and Land Pattern

The LUXEON emitter has three pads that need to be soldered onto corresponding pads on the PCB to ensure proper thermal and electrical operation. Figure 4 shows the recommended PCB footprint design for the LUXEON emitter. Heat spreading into the PCB is improved by extending the thermal pad and electrodes on the PCB beyond the package outline of the LUXEON emitter. Thermal simulations indicate that heat spreading is maximized if the thermal pad and electrodes are extended 3mm from the center of the LUXEON emitter.

2.2 Surface Finishing

Philips Lumileds recommends using a high temperature organic solderability preservative (OSP) on the copper layer.

2.3 Minimum Spacing

Philips Lumileds recommends a minimum edge to edge spacing between LUXEON emitters of 0.3mm to minimize the chance of mechanical interference between neighboring units during pick and place. Note that placing multiple LUXEON emitters in close proximity to each other on a PCB may adversely impact the ability of the PCB to dissipate the heat from the emitters. Also, the light output for each LED may drop due to optical absorption by adjacent LED packages.

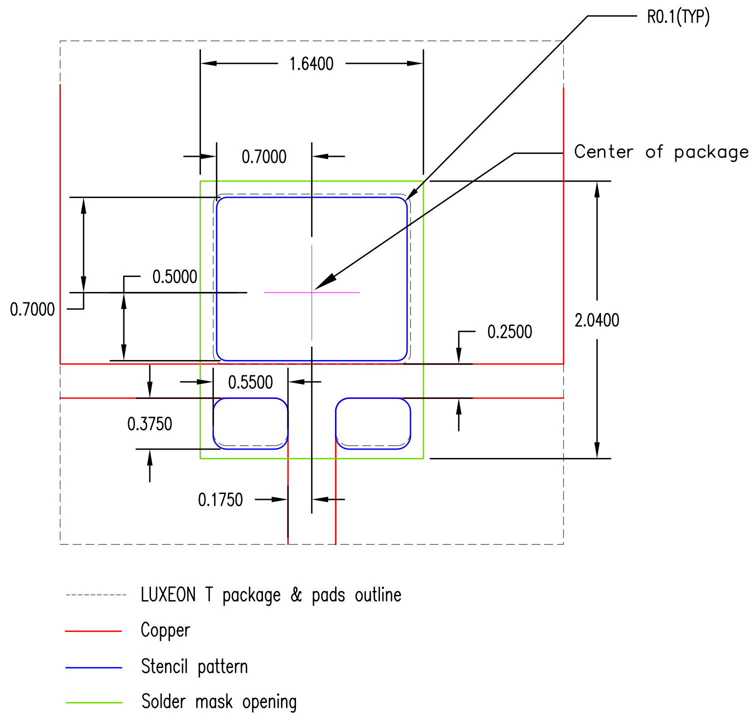


Figure 4. Recommended LUXEON PCB footprint design. All dimensions in mm.

3. Thermal Management

The overall thermal resistance between a LUXEON emitter and the heat sink is strongly affected by the design and material of the PCB on which the LUXEON emitter is soldered. Metal Core PCBs have been historically used in the LED industry for their low thermal resistance and rigidity. However, MCPCBs may not always offer the most economical solution.

Multi-layer epoxy FR4 PCBs are commonly used in the electronics industry and can, in certain LED applications, yield a lower cost solution. However, given the poor thermal conductivity of the epoxy in FR4 PCBs, it is important to include special thermal vias in the PCB design to aid the transport of heat from the LED to the heat sink on which the PCB is mounted. A thermal via is a plated through hole that can be open, plugged, filled or filled and capped. Open vias are typically placed outside the pads on which the LEDs are soldered to prevent any solder from reaching the other side of the PCB during reflow. A filled-and-capped via, in contrast, can be placed directly underneath the thermal pad of the LED, improving the thermal performance of the PCB.

The thermal resistance of an FR4 PCB depends on several variables including the board thickness, the thickness of the copper plating, the copper trace pattern, and the number and density of thermal vias. For general guidelines on FR4 PCB based designs, please refer to section 3 of Philips Lumileds document AB32 ***"LUXEON LED Assembly and Handling Information"***.

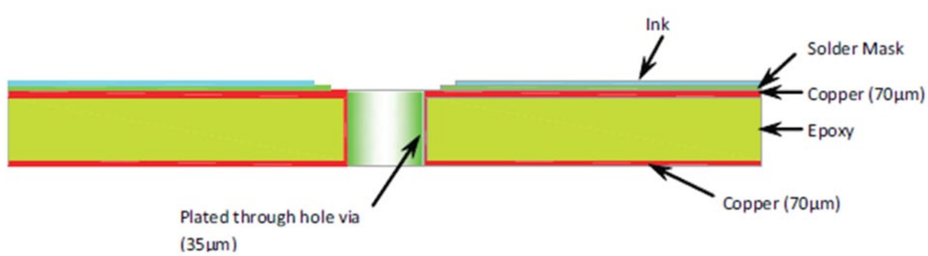
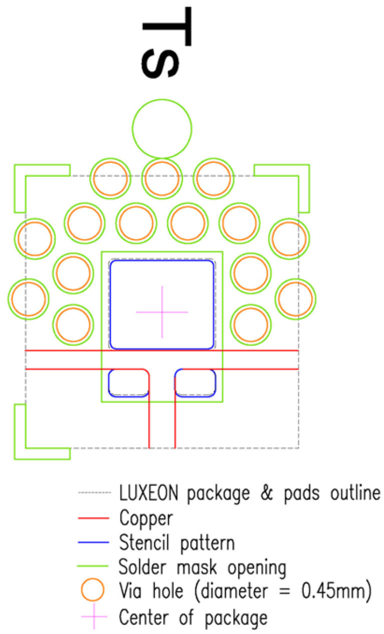


Figure 5. Typical cross section of an FR4 PCB based on an open via PTH design.



(x, y) relative to package center (mm)

HOLE No.	x	y
1	1.205	-0.175
2	1.205	0.525
3	1.050	1.205
4	0.350	1.205
5	-0.350	1.205
6	-1.050	1.205
7	-1.205	0.525
8	-1.205	-0.175
9	1.811	0.175
10	1.725	0.993
11	0.700	1.811
12	0.000	1.811
13	-0.700	1.811
14	-1.725	0.993
15	-1.811	0.175

Figure 6. FR4 PCB design with 15 open PTH vias.

Philips Lumileds has investigated the thermal performance of LUXEON emitters on 1.0mm thick FR4 PCBs with open Plated Through Hole (PTH) vias, as shown in Figure 5. The thickness of the copper plating on the top and bottom of the PCB is 70μm and the plating inside the thermal vias is 35μm. The diameter of the thermal vias is 0.45mm (as drilled). The thermal conductivity between the top and bottom layers of the PCB was measured for the PCB design in Figure 6. The design contains 15 thermal vias and yields a thermal resistance of approximately 9K/W between the thermal pad of the LUXEON emitter and the bottom of the PCB. Placing additional thermal vias around the LUXEON emitter does not provide a substantial reduction in the overall thermal resistance.

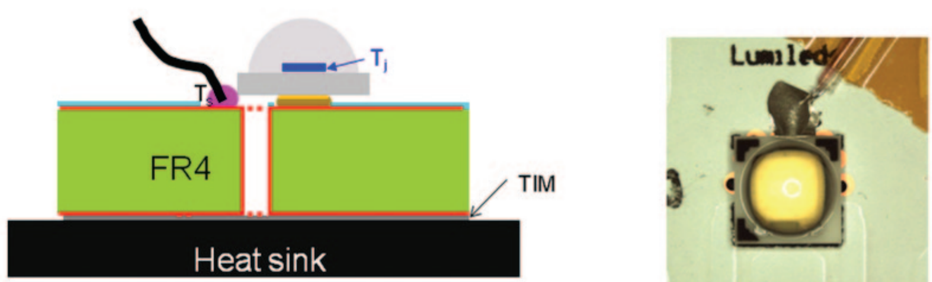


Figure 7. Schematic cross section (left) and top view (right) of a LUXEON emitter on an FR4 PCB with open PTH vias.

4. Thermal Measurement Guidelines

This section provides general guidelines on how to determine the junction temperature of a single standalone LUXEON emitter. These guidelines can be used to verify that the junction temperature in the actual application during regular operation does not exceed the maximum allowable temperature specified in the datasheet.

The typical thermal resistance $R\theta_{j\text{-thermal pad}}$ between the junction and thermal pad for a LUXEON emitter is specified in the datasheet. With this information, the junction temperature T_j can be determined according to the following equation:

$$T_j = T_{thermal\ pad} + R\theta_{j\text{-thermal pad}} \cdot P_{electrical}$$

In this equation $T_{thermal\ pad}$ is the temperature at the bottom of the LUXEON thermal pad and $P_{electrical}$ is the electrical power going into the LUXEON emitter.

In typical applications it may be difficult, though, to measure the thermal pad temperature $T_{thermal\ pad}$ directly. Therefore, a practical way to determine the junction temperature for the LUXEON emitter is by measuring the temperature T_s of a predetermined sensor pad on the PCB right next to the LUXEON emitter with a thermocouple. The recommended location of the sensor pad is right next to the LUXEON emitter, on the center line between anode and cathode, as shown in Figure 6 and Figure 7. To ensure accurate readings, the thermocouple must make direct contact with the copper of the PCB onto which the thermal pad of the LUXEON emitter is soldered, i.e. any solder mask must first be removed before mounting the thermocouple onto the PCB.

The thermal resistance $R\theta_{j\text{-}s}$ between the sensor pad and the junction of the LUXEON emitter was experimentally determined to be approximately 9K/W for the FR4 PCB design shown in Figure 6. The junction temperature can then be calculated as follows:

$$T_j = T_s + 9 \cdot P_{electrical}$$

In this equation $P_{electrical}$ is the electrical power going into the LUXEON emitter.

For guidelines on how to mount a thermocouple onto a PCB, see section 2 of Philips Lumileds document AB33 ***"LUXEON Rebel Thermal Measurement Guidelines"***.

5. Assembly Process Guidelines

5.1 Stencil Design

The recommended stencil design for the LUXEON emitter is included in the PCB footprint design of Figure 4.
The recommended stencil thickness is ≤ 125µm.

5.2 Solder Paste

Philips Lumileds recommends using a lead-free solder paste for LUXEON emitters. Philips Lumileds successfully tested a grade 3 solder paste with satisfactory results. However, since application environments vary widely, Philips Lumileds recommends that customers perform their own solder paste evaluation in order to ensure it is suitable for the targeted application.

5.3 Pick-and-Place

Automated pick and place equipment typically provides the best placement accuracy for LEDs. Figure 8 – Figure 11 show various pick and place nozzle designs and corresponding machine settings which have been successfully used to pick and place LUXEON emitters with pick and place equipment from Samsung, Yamaha, Panasonic, Juki. Each nozzle is designed to pick the LUXEON emitter up from the flat area around the dome without making any contact with the silicone dome itself.

Note that pick and place nozzles are customer specific and are typically machined to fit specific pick and place tools.

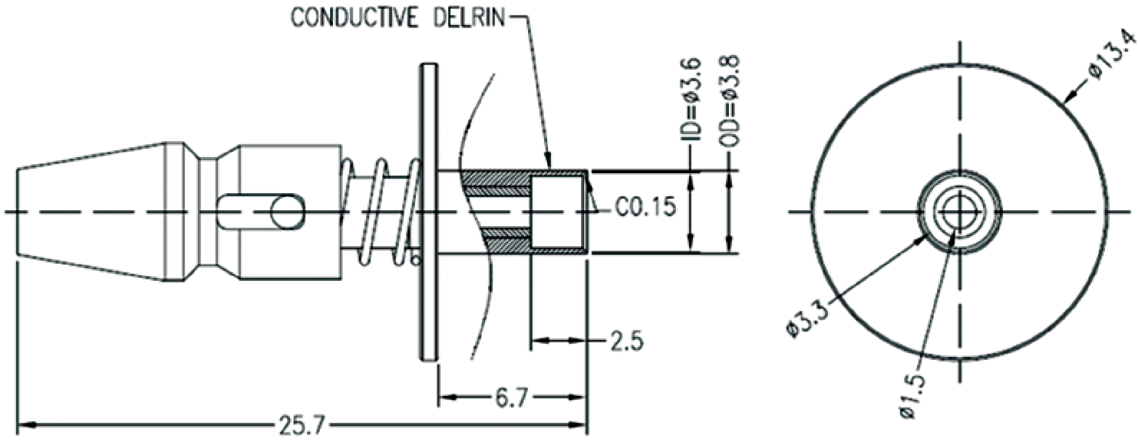
5.4 Solder Reflow Profile

The LUXEON emitter is compatible with standard surface-mount and lead-free reflow technologies. This greatly simplifies the manufacturing process by eliminating the need for adhesives and epoxies. The reflow step itself is the most critical step in the reflow soldering process and occurs when the boards move through the oven and the solder paste melts, forming the solder joints. To form good solder joints, the time and temperature profile throughout the reflow process must be well maintained.

A temperature profile consists of three primary phases:

1. **Preheat:** the board enters the reflow oven and is warmed up to a temperature lower than the melting point of the solder alloy.
2. **Reflow:** the board is heated to a peak temperature above the melting point of the solder, but below the temperature that would damage the components or the board.
3. **Cool down:** the board is cooled down, allowing the solder to freeze, before the board exits the oven.

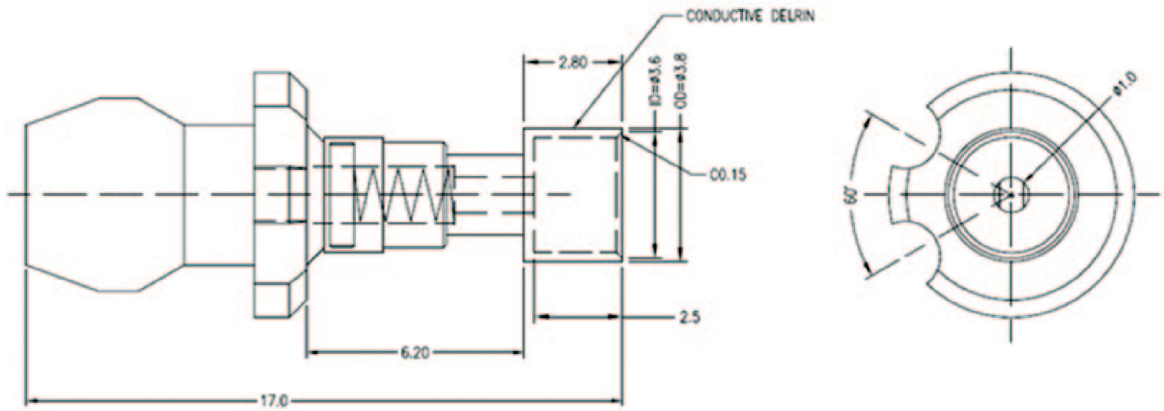
For detailed information on the recommended reflow profile, refer to the IPC/JEDEC J-STD-020C reflow profile in the LUXEON datasheet.



Pick and Mount Information	
Pick Height	-0.767 mm
Mount Height	0 mm
Delay – Pick Up	90 msec
Delay - Place	50 msec
Delay - Vac Off	0
Delay – Blow On	0
Speed – XY	2
Speed – Z Pick Down	1
Speed – Z Pick Up	1
Speed – R	1
Speed – Z Place Down	1
Speed – Z Place Up	1
Z Align Speed 2	1
Soft Touch	Not Used
Mount Method	Normal

Vision Information	
Camera No	Fly Cam4
Side	15
Outer	0

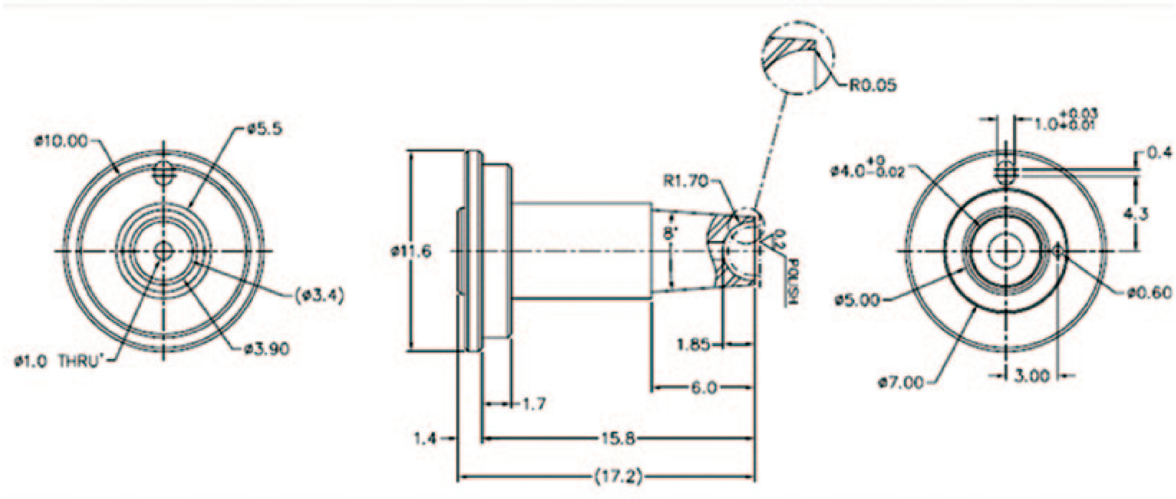
Figure 8. Pick and place nozzle design and machine settings for Samsung SM421. All dimensions in mm. Nozzle drawing courtesy of Ching Yi Technology Pte Ltd (part #: SAM-0386/12).



Pick and Mount Information	
Pick timer	0 s
Mount timer	0 s
Pick height	0.7 mm
Mount height	0 mm
Mount action	Normal
Mount speed	100%
Pickup speed	100%
Vacuum Check	Normal Chk
Pick Vacuum	20%
Mount vacuum	60%

Vision Information	
Alignment group	Special
Alignment type	Odd. Chip
Alignment module	Fore & Back & Las
Light selection	Main + Coax
Lighting level	6/8
Comp. threshold	100
Comp. tolerance	30
Search area	2.5mm
Comp. intensity	N.A.
Auto threshold	Not Used

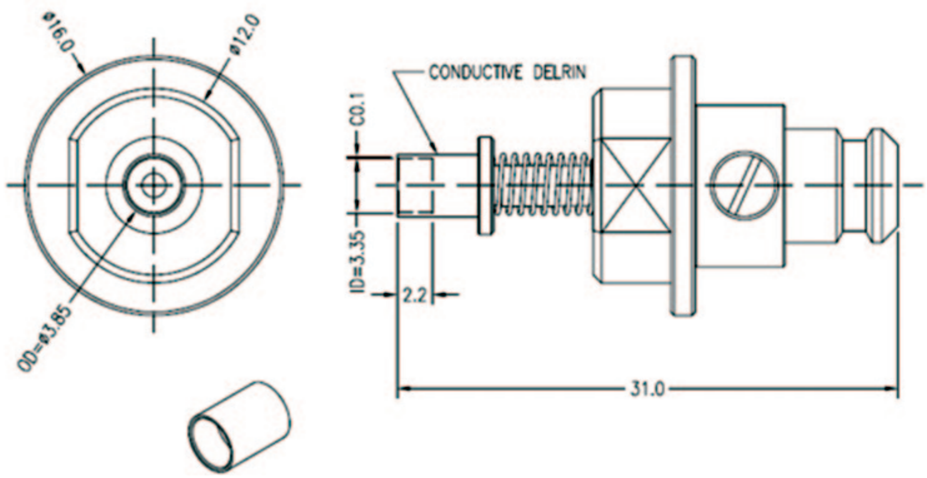
Figure 9. Pick and place nozzle design and machine settings for Yamaha YV100X. All dimensions in mm. Nozzle drawing courtesy of Ching Yi Technology Pte Ltd (part #:YMH-0389/12).



Pick and Mount Information	
XY speed	1
Theta speed	1
Nozzle movement - pickup	1:
	Descend 1 stroke
	Ascend 1 stroke
Nozzle movement - mount	1:
	Descend 1 stroke
	Ascend 1 stroke
Pickup - height	0.56 mm
Pickup - thickness	0.56 mm
Pickup - depth	0 mm
Pickup – height allowance	0 mm
Pickup – height offset	- 0.77 mm
Mount height	0.0 mm

Vision Information	
Camera	2D Small FOV
Upper L	5
Middle L	1
Lower L	0

Figure 10. Pick and place nozzle design and machine settings for Panasonic BM221. All dimensions in mm. Nozzle drawing courtesy of Micro-Mechanics Pte Ltd (part #: 19-MT-10053-02).



Pick and Mount Information	
XY	Fast2
Pick depth	0 mm
Picking stroke	0
Pick Z down	Fast2
Pick Z up	Fast2
Placing stroke	0
Place Z down	Fast2
Place Z up	Fast2
Theta (Measure)	Fast
Theta (Other)	Fast

Vision Information	
Centering method	Laser
LNC 60/61 Laser	-0.42
Comp shape	Corner Square

Figure 11. Pick and place nozzle design and machine settings for Juki KE2080L. All dimensions in mm. Nozzle drawing courtesy of Ching Yi Technology Pte Ltd (part #: JUK-0547/12).

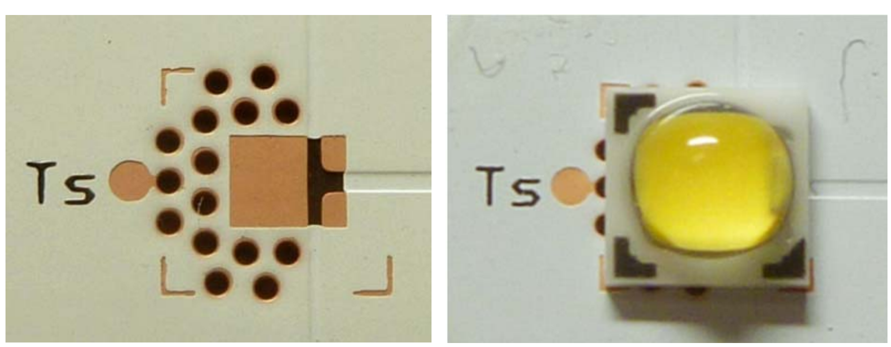


Figure 12. Small L-shaped markers in the solder mask (left) define the theoretical location of the LUXEON package after reflow. Assuming the width of these markers is known, the approximate placement accuracy of the LUXEON emitter after reflow in the x- and y-direction can be assessed with a magnifying glass or microscope (right). Note that the location of the L-shaped markers on the PCB match the location of the L-shaped fiducials on the ceramic frame. This enables visual verirfication of the proper package orientation on the PCB board.

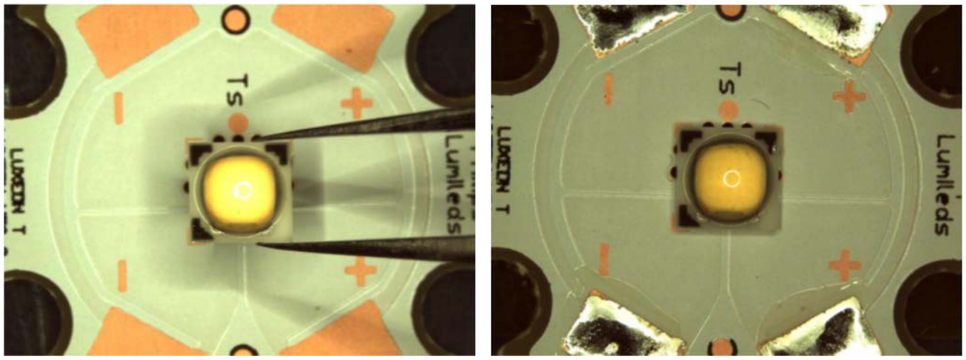


Figure 13. Manual placement of a LUXEON emitter onto a PCB (left). Self-alignment during reflow yields, in most cases, adequate placement accuracy (right) for manually placed LUXEON emitters.

5.5 Placement Accuracy

In order to achieve the highest placement accuracy Philips Lumileds recommends using an automated pick and place tool with a vision system that can recognize the bottom metallization or package outline of the LUXEON emitter.

Alignment marks on the PCB panel can be used to calculate the reflow accuracy of the LUXEON emitter with respect to its theoretical board position. Philips Lumileds has determined that the typical placement accuracy of a LUXEON emitter after reflow is within 150µm in the x- and y-direction for the footprint in Figure 4.

5.6 Manual Assembly Guidelines

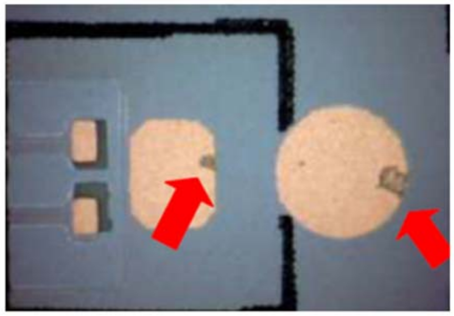
Follow these guidelines to manually mount LUXEON emitters onto a PCB:

1. Ensure that small L-shaped alignment markers, which define the desired location of the LUXEON package outline, are included in the PCB design, as shown in Figure 6 and Figure 12. It is preferable to define those markers with openings in the solder mask rather than silk screening them on top of the solder mask. If the ink height is too thick and too close to the solder mask opening, it may interfere with the stencil paste printing quality.
2. Manually dispense small amounts of solder paste on the exposed thermal and electrical pads on the PCB.
3. Place the PCB board under a microscope or use a magnifying lamp to view the PCB board.
4. Use tweezers to pick up the LUXEON emitter from the outer white ceramic frame (see Figure 3).
5. Position the LUXEON emitter with the proper package orientation just above the solder paste such that the package is aligned with the alignment markers on the board, as shown in Figure 13.
6. Gently release the LUXEON emitter such that it rests on the solder paste. Do not readjust the LUXEON emitter after it has been placed to avoid smearing the solder paste.
7. Reflow the LUXEON emitter onto the PCB board. During reflow the surface tension of the solder will, in most cases, align the LUXEON emitter to the solder pads on the board (see Figure 13).

5.7 PCB Inspection and Handling Guidelines

Given the small footprint of the LUXEON emitter, it is important that all PCBs are handled according to industry standards to ensure solderability of the LUXEON emitters onto the PCBs. In particular, to avoid contamination of PCBs and to prevent PCBs from absorbing moisture during delivery, receiving, stocking, assembly and soldering, PCBs should be stored and handled per the guidelines spelled out in industry standard IPC-1601 *"Printed Board Handling and Storage Guidelines"*.

PCBs are typically shipped in moisture proof packaging with desiccant and a humidity indicator card, which changes color (typically from blue to pink) with increasing humidity. The desiccant absorbs any moisture that may enter the bag and the humidity indicator card will provide an easy visual indication of the moisture level should there be an exposure. If the 10% dot on the humidity indicator card changes color the moisture proof packaging of the PCBs is most likely compromised. In those situations, the PCBs should be baked before use.



Particles on exposed copper pads

Figure 14. Example of unacceptable contamination on an incoming PCB.

If PCBs are exposed to a factory ambient environment (i.e. less than 30°C/60% RH) for less than 30 minutes, the PCBs can be re-packed with the original moisture barrier bag using a vacuum sealing machine. If the exposure to a factory ambient environment does not exceed 60 minutes, the PCBs can be returned to a dry storage cabinet with a relative humidity of at most 10%. If PCBs are exposed to a condition not fulfilling the above requirements, then the PCBs should be baked before use. The appropriate bake time and temperature depends on the surface finish of the PCB as outlined in IPC-1601 *"Printed Board Handling and Storage Guidelines"*.

With regards to cleanliness of incoming PCBs, ionic contamination should be kept below the maximum limit of 1.56μg NaClEq./cm^2. This is in line with the guidelines spelled out in IPC-6012 "Qualification and Performance Specification for Rigid Printed Boards".

To inspect the quality of incoming PCBs, it is best to adopt the inspection criteria in IPC-A-600F "Acceptability of Printed Boards". Figure 14 shows an example of unacceptable contamination on an incoming PCB

6. Packaging Considerations – Chemical Compatibility

The LUXEON emitter contains a silicone overcoat to protect the LED chip. As with most silicones used in LED optics, care must be taken to prevent any incompatible chemicals from directly or indirectly reacting with the silicone.

The silicone overcoat in the LUXEON emitter is gas permeable. Consequently, oxygen and volatile organic compound (VOC) gas molecules can diffuse into the silicone overcoat. VOCs may originate from adhesives, solder fluxes, conformal coating materials, potting materials and even some of the inks that are used to print the PCBs.

Some VOCs and chemicals react with silicone and produce discoloration and surface damage. Other VOCs do not chemically react with the silicone material directly but diffuse into the silicone and oxidize during the presence of heat or light. Regardless of the physical mechanism, both cases may affect the total LED light output. Since silicone permeability increases with temperature, more VOCs may diffuse into and/or evaporate out from the silicone.

Careful consideration must be given to whether LUXEON emitters are enclosed in an "air tight" environment or not. In an "air tight" environment, some VOCs that were introduced during assembly may permeate and remain in the silicone overcoat. Under heat and "blue" light, the VOCs inside the silicone overcoat may partially oxidize and create a silicone discoloration, particularly on the surface of the LED where the flux energy is the highest. In an air rich or "open" air environment, VOCs have a chance to leave the area (driven by the normal air flow). Transferring the devices which were discolored in the enclosed environment back to "open" air may allow the oxidized VOCs to diffuse out of the silicone overcoat and may restore the original optical properties of the LED.

Determining suitable threshold limits for the presence of VOCs is very difficult since these limits depend on the type of enclosure used to house the LEDs and the operating temperatures. Also, some VOCs can photo-degrade over time.

Table 1 provides a list of commonly used chemicals that should be avoided as they may react with the silicone material. Note that Philips Lumileds does not warrant that this list is exhaustive since it is impossible to determine all chemicals that may adversely affect LED performance.

The chemicals in Table 1 are typically not directly used in the final products that are built around LUXEON emitters. However, some of these chemicals may be used in intermediate manufacturing steps (e.g. cleaning agents). Consequently, trace amounts of these chemicals may remain on (sub)components, such as heat sinks. Philips Lumileds, therefore, recommends the following precautions when designing your application:

- When designing secondary lenses to be used over an LED, provide a sufficiently large air-pocket and allow for "ventilation" of this air away from the immediate vicinity of the LED.
- Use mechanical means of attaching lenses and circuit boards as much as possible. When using adhesives, potting compounds and coatings, carefully analyze its material composition and do thorough testing of the entire fixture under High Temperature over Life (HTOL) conditions.

Table 1: List of commonly used chemicals that will damage the silicone overcoat of the LUXEON emitter. Avoid using any of these chemicals in the housing that contains the LED package.

Chemical Name	Normally used as
hydrochloric acid	acid
sulfuric acid	acid
nitric acid	acid
acetic acid	acid
sodium hydroxide	alkali
potassium hydroxide	alkali
ammonia	alkali
MEK (Methyl Ethyl Ketone)	solvent
MIBK (Methyl Isobutyl Ketone)	solvent
Toluene	solvent
Xylene	solvent
Benzene	solvent
Gasoline	solvent
Mineral spirits	solvent
dichloromethane	solvent
tetracholorometane	solvent
Castor oil	oil
lard	oil
linseed oil	oil
petroleum	oil
silicone oil	oil
halogenated hydrocarbons (containing F, Cl, Br elements)	misc
rosin flux	solder flux
acrylic tape	adhesive

Company Information

Philips Lumileds is a leading provider of LEDs for everyday lighting applications. The company's records for light output, efficacy and thermal management are direct results of the ongoing commitment to advancing solid-state lighting technology and enabling lighting solutions that are more environmentally friendly, help reduce CO2 emissions and reduce the need for power plant expansion. Philips Lumileds LUXEON® LEDs are enabling never before possible applications in outdoor lighting, shop lighting, home lighting, digital imaging, display and automotive lighting.

Philips Lumileds is a fully integrated supplier, producing core LED material in all three base colors, (Red, Green, Blue) and white. Philips Lumileds has R&D centers in San Jose, California and in the Netherlands, and production capabilities in San Jose, Singapore and Penang, Malaysia. Founded in 1999, Philips Lumileds is the high flux LED technology leader and is dedicated to bridging the gap between solid-state technology and the lighting world. More information about the company's LUXEON LED products and solid-state lighting technologies can be found at www.philipslumileds.com.

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