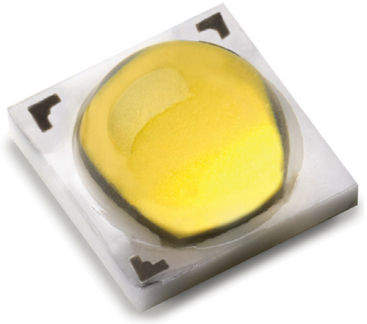
LUXEON T and LUXEON TX

Assembly and handling information



Introduction

This application brief addresses the recommended assembly and handling procedures for LUXEON T and LUXEON TX 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 T
LUXEON TX

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 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 two 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. LED outline

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

The actual optical center of a LUXEON emitter, defined as the dome centering, is within a circular diameter of 0.23mm with respect to the theoretical optical center (Figure 2).

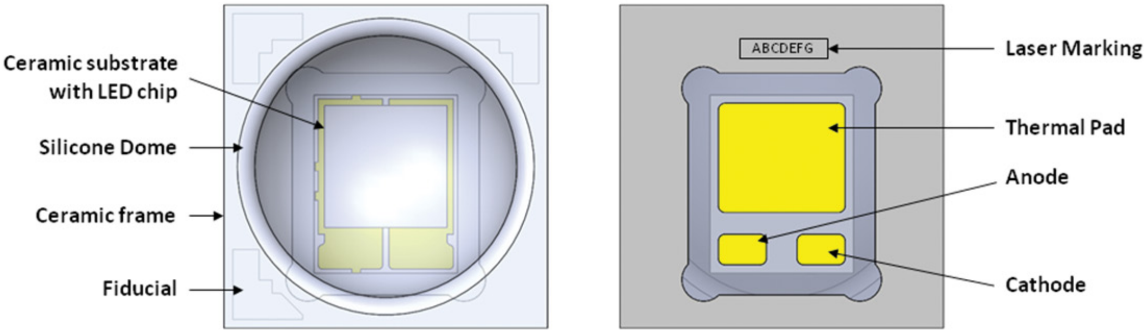


Figure 1. Top view (left) and bottom view (right) of the LUXEON emitter.

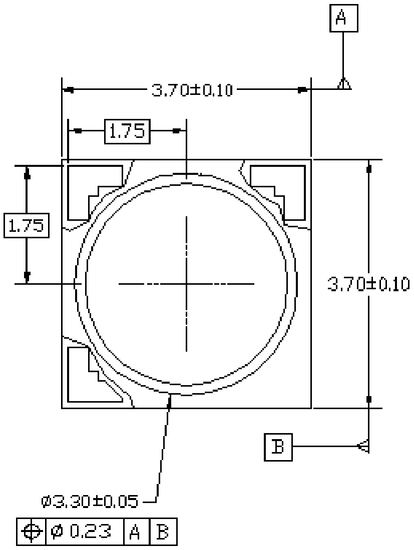


Figure 2. Fiducial marks on the top of the LUXEON emitter provide the most accurate method to locate the theoretical optical center.

Optical rayset data for the LUXEON emitter is available on the Lumileds website at lumileds.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.

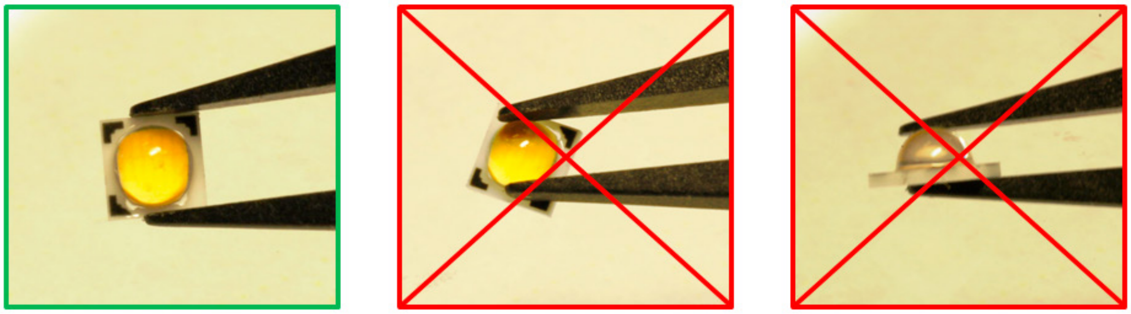


Figure 3. Correct handling (left) and incorrect handling (middle and right) of LUXEON T and LUXEON TX emitters.

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 Lumileds website at lumileds.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

Lumileds recommends using a high temperature organic solderability preservative (OSP) or electroless nickel immersion gold (ENIG) plating on the exposed copper pads.

2.3 Minimum Spacing

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.

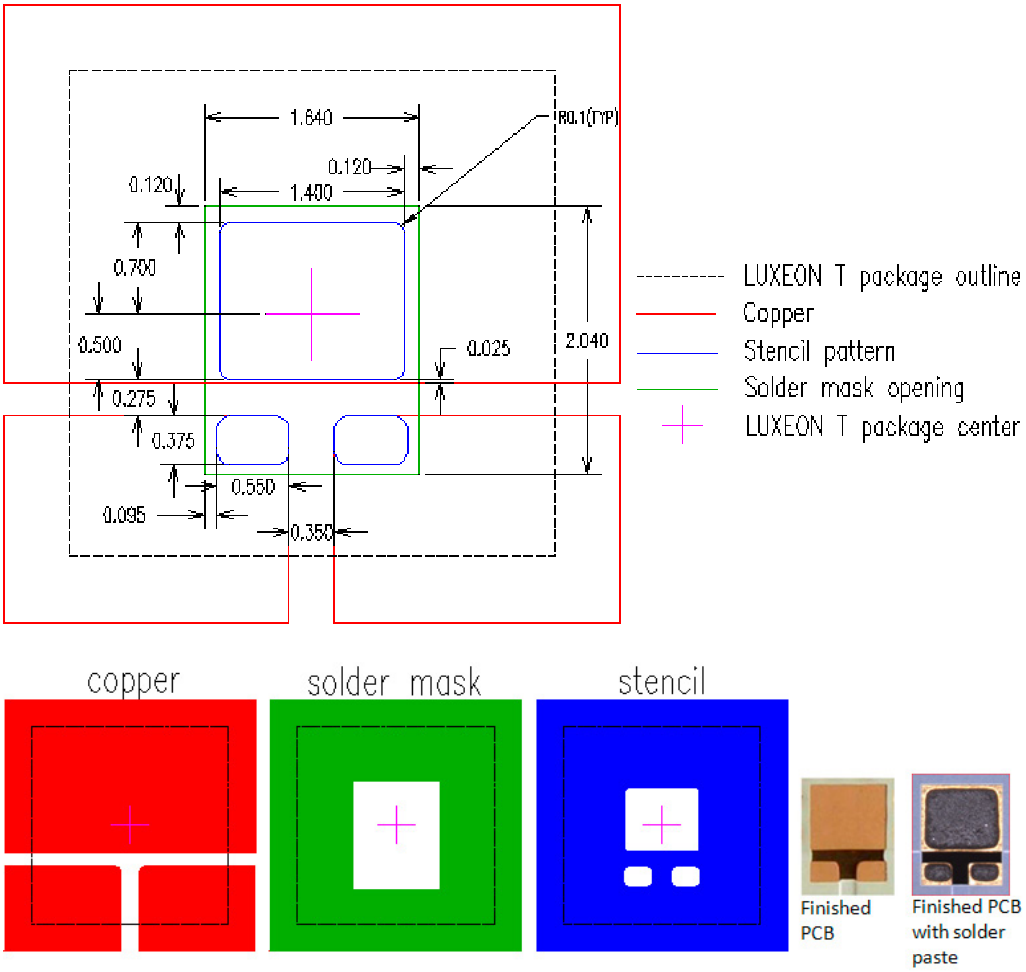


Figure 4. Recommended LUXEON PCB footprint design (top). All dimensions in mm. Bottom row figures from left to right: copper trace pattern, solder mask opening, stencil pattern opening, finished PCB without solder paste and with solder paste.

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 Lumileds document AB32 “LUXEON LED Assembly and Handling Information.”

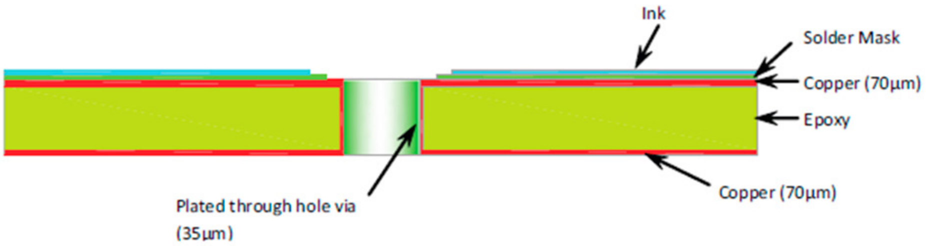
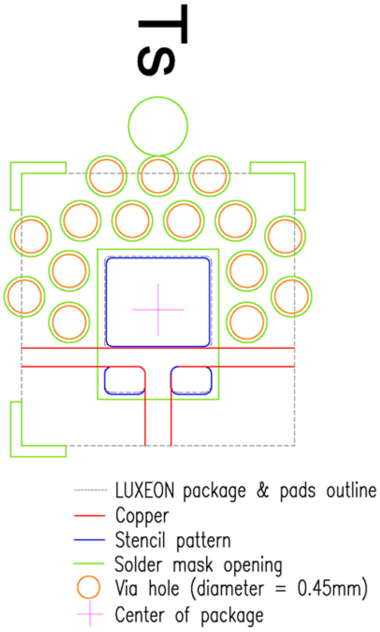


Figure 5. Typical cross section of an FR4 PCB based on an open via PTH design.

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.



(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.

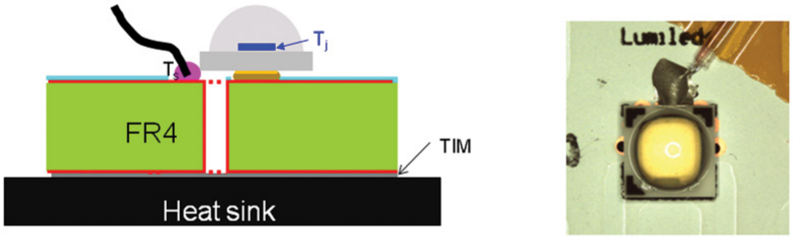


Figure 7. Schematic cross section (left) and top view (right) of a LUXEON emitter on an FR4 PCB with open PTH vias.

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 $R\theta_{\text{j-thermal pad}}$ 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:

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

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

In typical applications it may be difficult, though, to measure the thermal pad temperature $T_{\text{thermal pad}}$ 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 $R\theta_{\text{j-s}}$ 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:

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

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

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

5. Solder Reflow Guidelines

5.1 Stencil, Solder Mask Design, and Silk Screen Labels

Given the small size of the electrical and thermal pads of the LUXEON emitter, it is important that the appropriate amount of solder paste is dispensed onto the PCB prior to reflow of LUXEON emitters. The recommended solder mask and stencil design for the LUXEON emitter is included in the PCB footprint design of Figure 4. The recommended stencil thickness is 127µm or 5mils. Note that any silk screen labels (anode/cathode markers, LED #, etc.) on top of the solder mask should be placed outside the outline of the LUXEON emitter. If labels are placed too close to the solder mask openings, the height of the ink may interfere with the stencil paste printing quality.

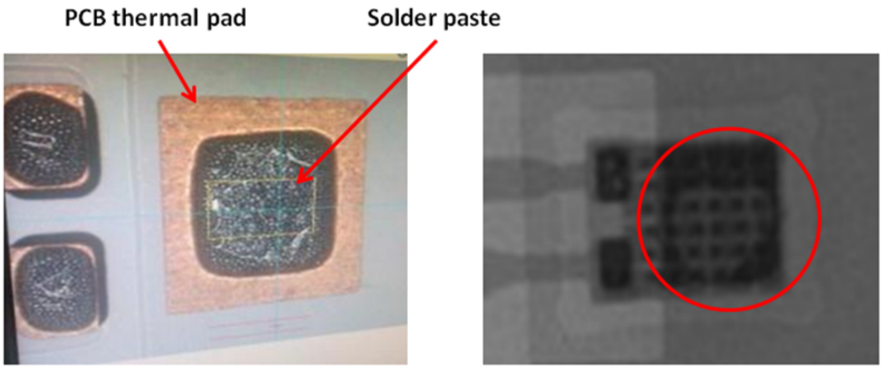


Figure 8. A stencil opening which is too small results in insufficient solder paste being dispensed onto the electrical and/or thermal pads before reflow, yielding poor solder coverage after reflow.

The actual volume and placement of solder paste onto the PCB has a direct impact on the solder joint quality and reliability after reflow. Too little solder paste may result in poor solder coverage after reflow (see Figure 8) while too much solder paste may cause the LUXEON emitter to tilt and/or rotate during reflow (see Figure 9). In addition, poor placement of the stencil prior to solder dispense may result in some of the solder paste being screen printed onto the solder mask, reducing the amount of solder paste which is available to establish a strong solder joint during reflow (see Figure 10). The behaviors in Figure 8 – Figure 10 are typically observed on PCBs where the solder paste is dispensed manually or semi-automatically.

In order to mitigate any problems due to limited machine capabilities, the size of the solder mask opening may have to be enlarged so that there is more room to deposit solder paste and to prevent solder paste from overlapping with the solder mask. The amount by which to enlarge the solder mask opening should be based on the solder paste screen printing accuracy as well as the solder mask registration tolerances of the PCB vendor. See Section 5.3 for more detail.

Note that solder paste may also be accidentally wicked away from one of the smaller electrical pads of the LUXEON emitter to the larger thermal pad if the two are incorrectly connected on the PCB, as shown in Figure 11.

5.2 Solder Paste

Lumileds recommends using a lead-free solder paste for LUXEON emitters. Lumileds successfully tested a grade 3 solder paste with satisfactory results. However, since application environments vary widely, Lumileds recommends that customers perform their own solder paste evaluation in order to ensure it is suitable for the targeted application given the limitations of the pick and place and reflow equipment which is available.

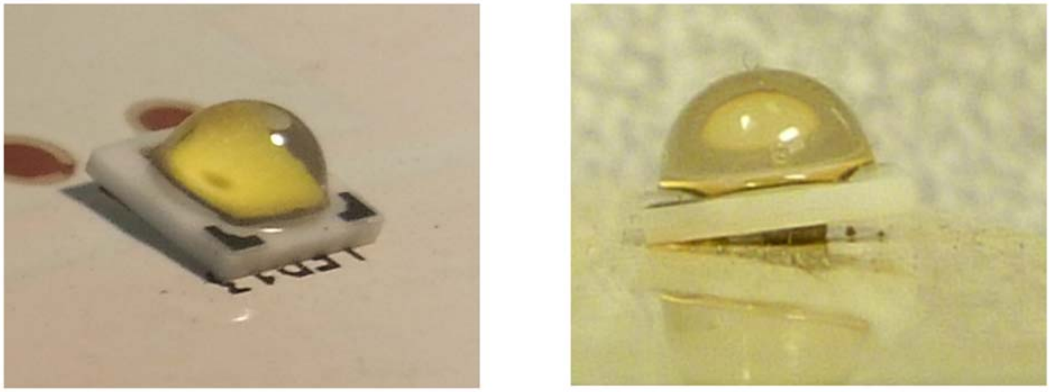


Figure 9. Excessive solder paste may cause the LUXEON emitter to tilt and/or rotate during reflow.

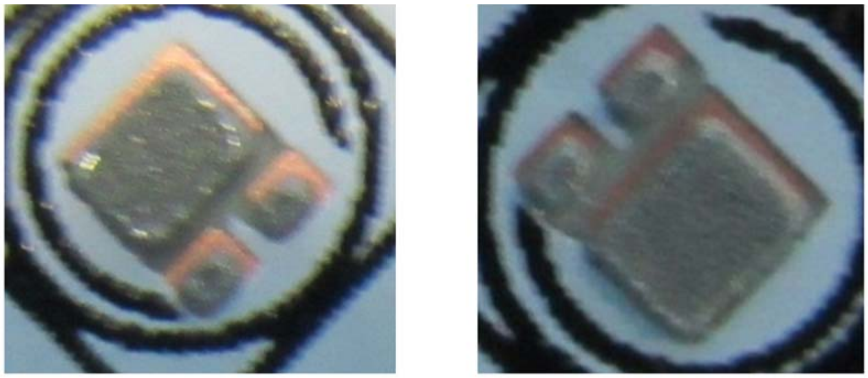


Figure 10. A poorly placed stencil may cause some of the solder paste to be deposited onto the solder mask, reducing the amount of solder paste which is available on the pads to establish a strong solder joint. In this example, the silk screened circles within the LUXEON package outline may also lift the stencil from the solder mask, compromising the quality of the solder paste deposition process.

5.3 Solder Paste Screen Printing

In general there are three methods to align the stencil to the PCB during solder paste screen printing:

1. The stencil is manually aligned to the PCB prior to printing. No adjustments are made during printing.
2. The stencil is manually aligned to the PCB prior to printing. During printing, the machine keeps track of the PCB fiducial mark(s) and makes any necessary adjustments to maintain proper alignment with the PCB.
3. A technician performs a crude alignment of the stencil to the PCB. During printing, the machine keeps track of the PCB fiducial mark(s) and the stencil fiducial mark(s) and maintains proper alignment between the fiducials throughout the process.

Method 1 has the worst accuracy and repeatability of the three methods discussed. Method 2 offers the same accuracy as method 1 but ensures better repeatability. Method 3 has the best accuracy and best repeatability of the 3 methods discussed.

Depending on what screen printing method is used, the size of the anode and cathode solder mask openings on the PCB may have to be enlarged to compensate for any misalignments between the stencil and the PCB panel.The size of the anode and cathode openings in the stencil should be enlarged accordingly. Given the large size of the thermal pad compared to the anode and cathode pads of the LUXEON emitter, the size of the thermal pad typically does not require any modifications in the solder mask or stencil. Note, though, that any changes in the solder mask opening for anode and cathode pads should not change the spacing between the three pads on the PCB, i.e. the spacing between the two electrical pads should be 0.35mm while the spacing between the electrical pads and the thermal pad should be 0.25mm.

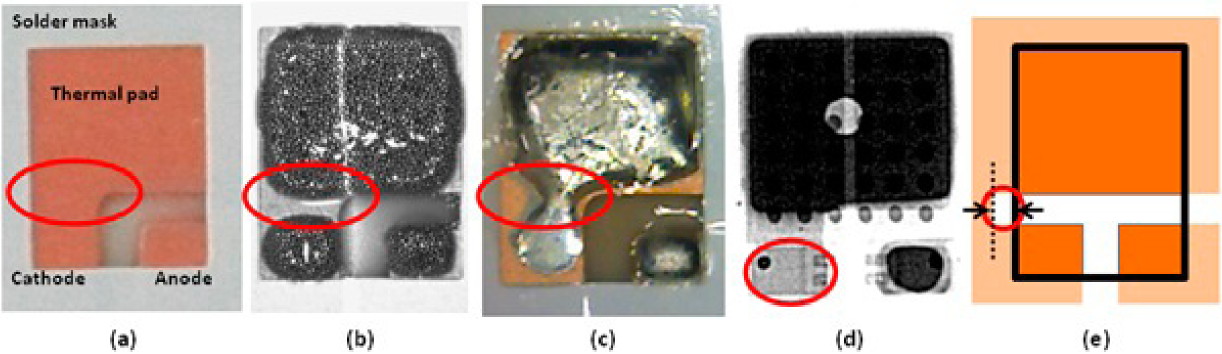


Figure 11. An incorrectly laid out PCB may result in solder being wicked away from the smaller electrical pad to the larger neighboring thermal pad. In this example, the cathode was directly connected to the thermal pad without any solder mask barrier in between (a). Even though the solder paste on the thermal pad and cathode were disjointed after dispense (b), during reflow the solder bridges between the cathode and thermal pad (c). In the worst case scenario, all the solder is wicked away from the smaller cathode to the larger thermal pad causing an electrical open (d). The PCB should, therefore, be designed such that any connection between the electrical pad and thermal pad remains covered by the solder mask even for the worst possible alignment error between the solder mask and the metallization (e).

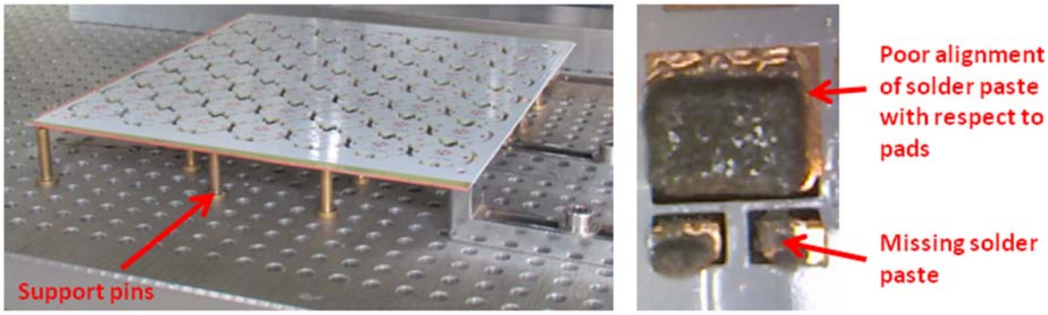


Figure 12. PCB panels should be rigidly supported during solder paste printing to ensure proper alignment between the stencil and the PCB as well as reliable transfer of solder paste onto the PCB. A rigid support panel is preferred over multiple support pins, especially for PCB panels with v-scores or perforated holes for de-panel purposes.

In order to ensure proper alignment between the stencil and the PCB as well as reliable transfer of solder paste onto the PCB, all PCB panels should be rigidly supported during solder paste printing. Instead of placing the PCB panel on multiple support pins (see Figure 12), it is best to place the PCB panel on a single solid plate. This is particularly important for PCB panels which contain v-scores or perforated holes for de-panel purposes.

Other parameters which may impact the solder dispense screen printing process include the quality of the incoming stencil, the frequency with which the stencil is cleaned, and the direction in which the screen printing is performed.

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 appropriate datasheet for each LUXEON product.

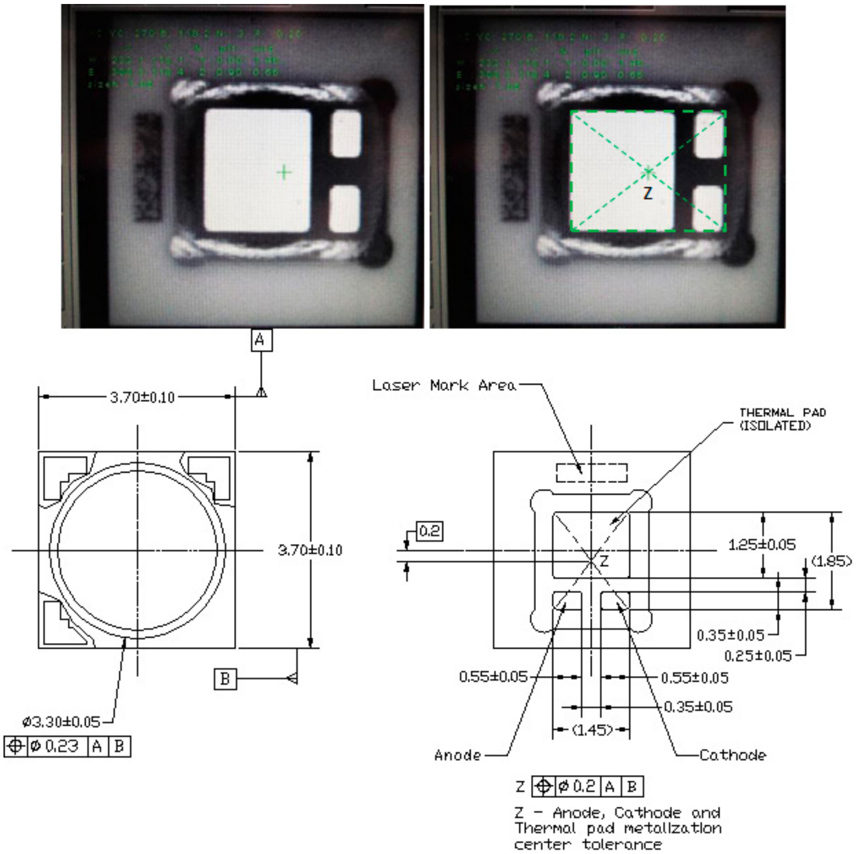


Figure 13. In order to achieve the best placement accuracy for the LUXEON T/TX emitter on a PCB, an uplook camera should be used during pick and place to accurately register the location of the bottom pads of the package. Left top photo shows the anode, cathode and thermal pads metallization center (green cross-hair) as registered by pick and place machine and right photo shows how the green cross-hair (Z) is defined.

5.5 Placement Accuracy

In order to achieve the best placement accuracy Lumileds recommends using an automated pick and place tool with a vision system that can recognize the bottom metallization (preferred) or package outline of the LUXEON emitter. Figure 13 shows the LUXEON T/TX emitter theoretical bottom metallization center, Z. The theoretical location Z is located 1.85mm and 2.05mm from the package outline. The actual Z position is within a circular diameter of 0.20mm with respect to the theoretical metallization center. For more detailed pick and place guidelines, see Section 7.

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. 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 Solder Wetting and Voids

To ensure good solder joint reliability, the solder reflow process should be tuned such that dewetting and solder voids after reflow are minimized. Lumileds recommends a maximum specification of 25% on the combined dewetting and solder void area under critical pads. However, since application environments vary widely, customers should always perform their own evaluation in order to ensure that the maximum allowable amount of dewetting and solder voids is suitable for the targeted application and operating conditions.

If excessive dewetting is observed, standards JESD22-B102E and IPC J-STD-003 provide guidelines on how to assess the solderability of the surface mount component and the corresponding PCB, respectively. According to these specifications a minimum of 95% of the critical surfaces tested shall exhibit good wetting. For LUXEON LEDs the critical area is typically defined as the area of the pads on the LED.

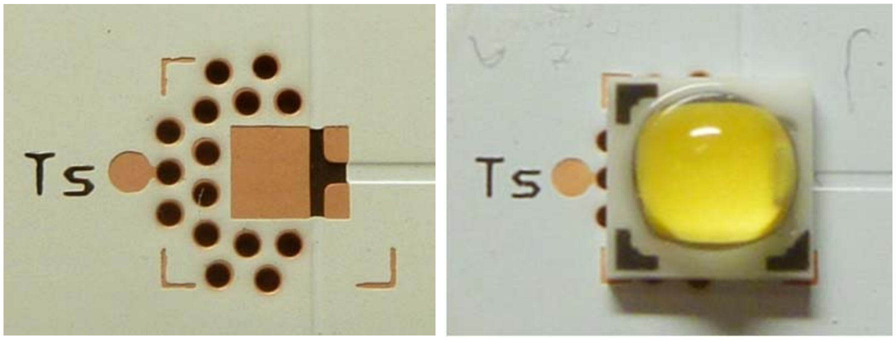


Figure 14. Small L-shaped markers in the solder mask (left) define the theoretical location of the LUXEON package after reflow. Assuming the width of these markers is known, the approximate placement accuracy of the LUXEON emitter after reflow in the x- and y-direction can be assessed with a magnifying 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 verification of the proper package orientation on the PCB board.

6. Manual Assembly and Rework 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 14. 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 15.
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 15).

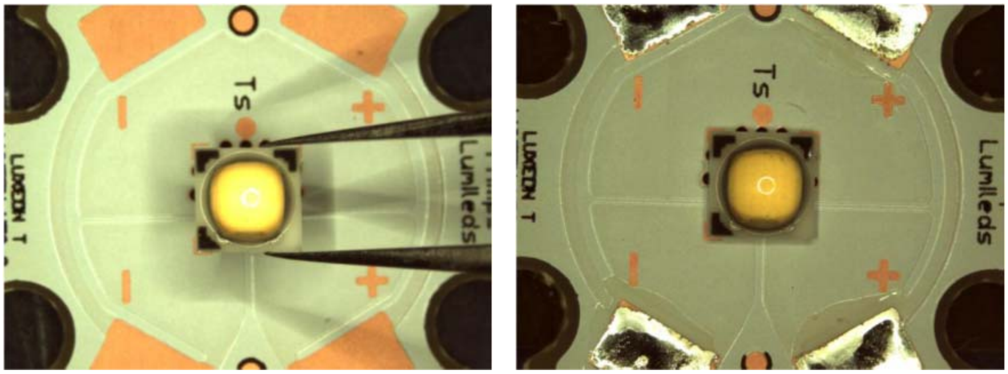


Figure 15. Manual placement of a LUXEON emitter onto a PCB (left). Self-alignment during reflow yields, in most cases, adequate placement accuracy (right) for manually placed LUXEON emitters.

In the event a LUXEON emitter needs to be removed from a PCB for rework, follow the recommendations below (see also Figure 16):

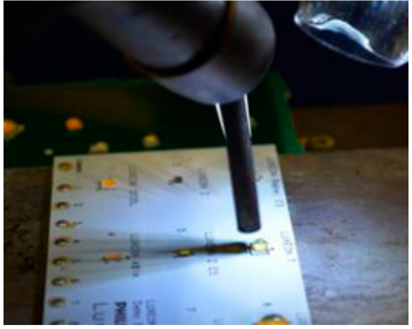
1. Pre-heat the PCB on a hot plate
    a. Heat a hot plate to approximately 130°C (265°F).
    b. Place the PCB to be reworked onto the hot plate and allow the temperature to stabilize.
    c. Verify that the PCB temperature is approximately 115°C to 120°C.
2. Apply localized heat in order to remove the desired LED
    a. Apply heat with a hot air tool in a circular pattern around the LUXEON emitter of interest. Make sure not to focus the heat in any one area too long.
    b. Using tweezers periodically test the emitter until the solder melts and the emitter can be lifted off from the PCB. Note: For reliability reasons, Lumileds does not recommend reusing any LUXEON emitters which have been removed with this method.
3. Clean and prepare the solder pad areas on the PCB
    a. Remove the board from the hot plate and allow it to cool down to room temperature.
    b. In order to ensure a proper solder joint after reflow, any residual flux and/or excessive solder should be removed from the exposed solder pads on the PCB. This can be typically accomplished with IPA and a cotton applicator.
4. Apply fresh solder paste (manually or with an air powered solder dispense system) to the exposed and cleaned pads
5. Place a new LUXEON emitter onto the solder paste according to the manual assembly guidelines above
6. Reflow the entire PCB assembly in a standard reflow oven

    Note: Lumileds does not recommend using a hot air tool to reflow LUXEON emitters onto a PCB. Since the temperature of the emitter cannot be accurately controlled with a hot air tool, long term solder joint and/or device reliability cannot be guaranteed.

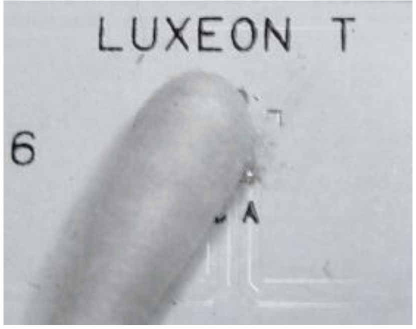
7. Conduct a light up test to verify proper operation of all emitters on the board

1. Pre-heat the PCB on a hot plate

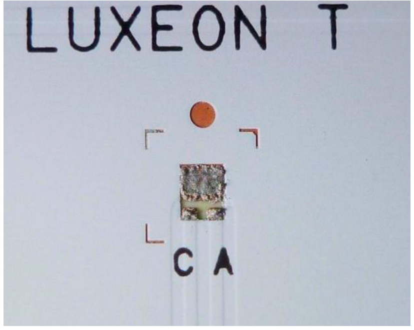
2. Apply localized heat to remove the emitter



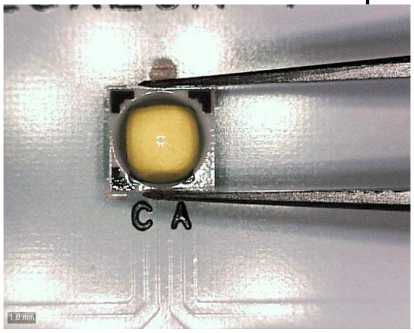
3. Clean and prepare the solder pads



4. Apply fresh solder paste



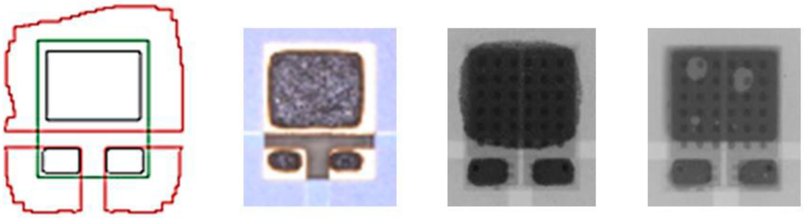
5. Place new emitter onto solder paste



6. Reflow the PCB board

7. Perform light-up test of PCB after reflow

Figure 16. Recommended rework process if a LUXEON emitter needs to be removed from a PCB.



(a) (b) (c) (d)

Figure 17. A properly designed PCB (a), in combination with adequate solder paste (b), and minimal overtravel during pick and place to prevent bridging of solder paste prior to reflow (c) results in good solderability of the LUXEON emitter (d).

7. Pick-and-Place Process Guidelines

7.1 Pick-and-Place Nozzles and Machines Settings

Automated pick and place equipment typically provides the best placement accuracy for LEDs. However, the pick and place process should be tuned such that no bridging of solder paste occurs between pads prior to reflow to ensure optimal solderability results after reflow (see Figure 17). In particular, it is important that the overtravel distance is set such that solder paste is not squeezed out from underneath the electrical pads during pick and place (see Figure 18). Note that certain solder pastes offer a wider process window in terms of nozzle overtravel than others.

A proper starting point for the mounting height of the LUXEON T emitter is 2/3 of the stencil thickness against the top of the soldermask reference datum, i.e. the nozzle should be in an undertravel position. This mounting height has been successfully used with a multitude of board pad/stencil opening design combinations, leading to a higher degree of freedom to optimize the design towards minimum voiding. Note that this may require a z-height control stage with a step resolution of ≤ 5μm.

Figure 19 – Figure 21 show various nozzle designs and corresponding machine settings which have been successfully used to pick and place LUXEON emitters with equipment from Samsung, Yamaha and Panasonic. Each nozzle is designed to pick the LUXEON emitter up from the flat area around the dome without making 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. Also, the pick and place machine settings in this application brief are typical values and should be used as a starting point to fine tune the actual pick and place process of interest. Finally, some pick and place machines may have additional, hidden, parameters, and when used with the nozzle design as described here, can affect the overall performance. Sometimes a customized nozzle such as the one shown in Figure 22 (castellated nozzle) to prevent LUXEON emitter from getting stuck to the nozzle tip during pick and place process may be needed. It may be necessary to tweak the number of cavities on the nozzle tip, depth and width to further optimize the process. Contact Count on Tools Inc (www.cotinc.com) for castellated nozzle that fits your pick-and-place machine.

For pick and place machines with a larger z-height step resolution (e.g. 100μm) or for spring loaded nozzles, it may be necessary to reduce the stencil openings to reduce the volume of solder paste which is dispensed prior to pick and place (see Figure 18).

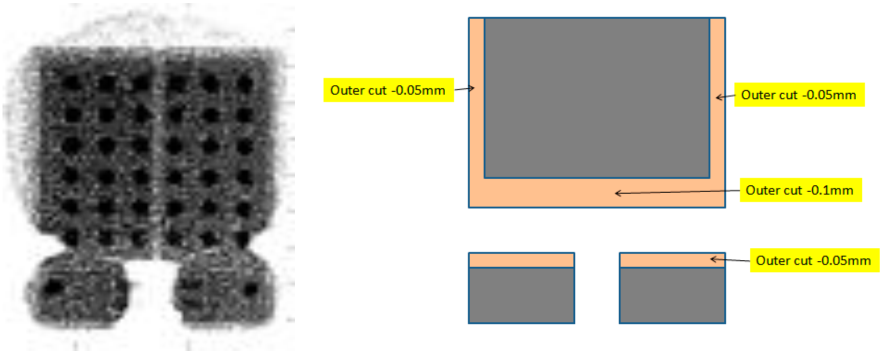
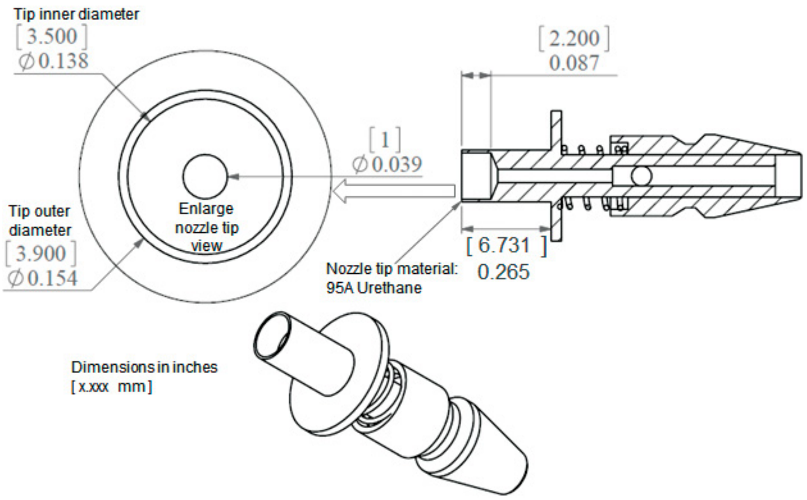


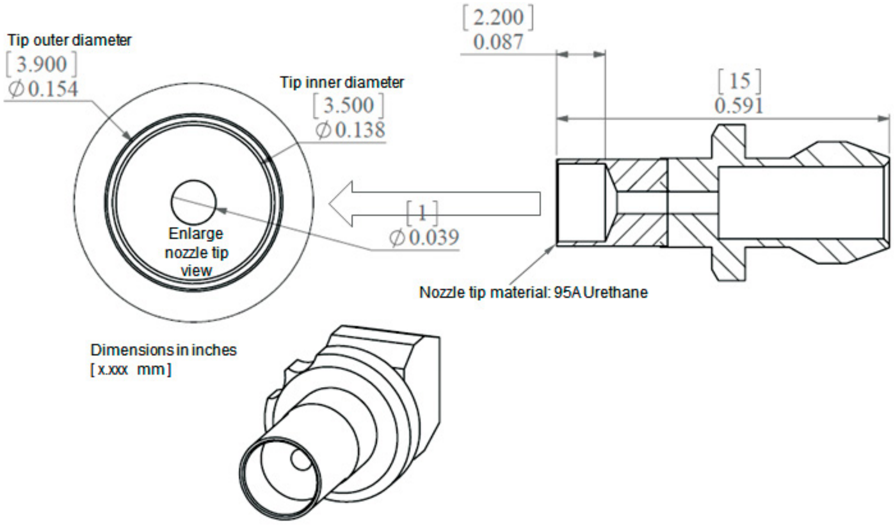
Figure 18. Solder bridging between neighboring pads prior to reflow (left) should be avoided. This is typically an indication that the pick and place overtravel distance is too large and/or too much solder paste is applied. The preferred method to address this issue is by limiting the overtravel of the pick and place nozzle. However, if overtravel control is limited on the pick and place machine which is used, an alternative method is to slightly modify the solder stencil openings (right), reducing the overall volume of solder paste which is dispensed prior to pick and place.



PICK AND MOUNT INFORMATION	
Pick Height	-0.767 mm
Mount Height	0mm
Delay – Pick Up	90msec
Delay – Place	50msec
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

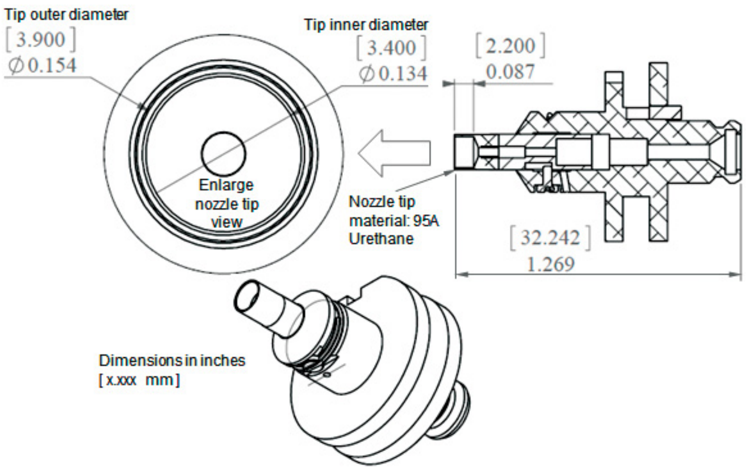
Figure 19. Pick and place nozzle design and machine settings for Samsung SM421. Nozzle drawing courtesy of Count On Tools Inc.



PICK AND MOUNT INFORMATION	
Pick timer	0s
Mount timer	0s
Pick height	0.7mm
Mount height	0mm
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 20. Pick and place nozzle design and machine settings for Yamaha YV100X.
Nozzle drawing courtesy of Count On Tools Inc.**



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	0.56mm
Pickup - thickness	0.56mm
Pickup - depth	0mm
Pickup – height allowance	0mm
Pickup – height offset	-0.77mm
Mount height	0mm
Mount Method	Normal

VISION INFORMATION	
Camera	2D Small FOV
Upper L	5
Middle L	1
Lower L	0

Figure 21. Pick and place nozzle design and machine settings for Panasonic BM221. Nozzle drawing courtesy of Count On Tools Inc.

Figure 22. Pictures of castellated nozzle to prevent LUXEON T/TX from getting stuck to the nozzle tip during pick and place process. Below is the drawing of a castellated nozzle for Yamaha YV100X. Drawing courtesy of Count on Tools Inc.

7.2 Pick-and-Place Machine Optimization

Pick and place machines are typically equipped with special pneumatic or electric feeders to advance the tape containing the LEDs. In pneumatic feeders, air pressure is used to actuate an air cylinder which then turns the sprocket wheel to index the pocket tape; electric feeders, in contrast, use electric motors to turn the sprocket wheel (see Figure 23). Electric feeders often also contain a panel which allows an operator to control the electric feeder manually.

The indexing step in the pick and place process may cause some LEDs to accidentally jump out of the pocket tape or may cause some LEDs to get misaligned inside the pocket tape, resulting in pick-up errors. Depending on the feeder design, minor modifications to the feeder can substantially improve the overall pick and place performance of the machine and reduce/eliminate the likelihood of damage to the dome of the LEDs.

There are many types of pick and place feeder designs available. Some feeders can be used as-is without any further modifications, some feeders require a shift in the position where the cover tape is peeled off the tape, and yet other feeders require the shutter to be completely removed so that the cover tape peeling position can be adjusted. Figure 24 shows representative pictures of each feeder design. Since there are many different feeder designs in use, it is important to understand the basic principle behind modifying the feeders so that effective modifications can still be carried out when different feeder designs are encountered.

The underlying principle behind each feeder modification is to protect the silicone dome with the cover tape until the LED is ready to be picked up by the nozzle. To achieve this, the cover tape should only be peeled off just before the nozzle picks up the LED (see Figure 25 and Figure 26).

In some instances, the new peeling location is not wide enough. In such cases, the peeling location needs to be widened so that the cover tape can be peeled off without any obstruction (see Figure 27).

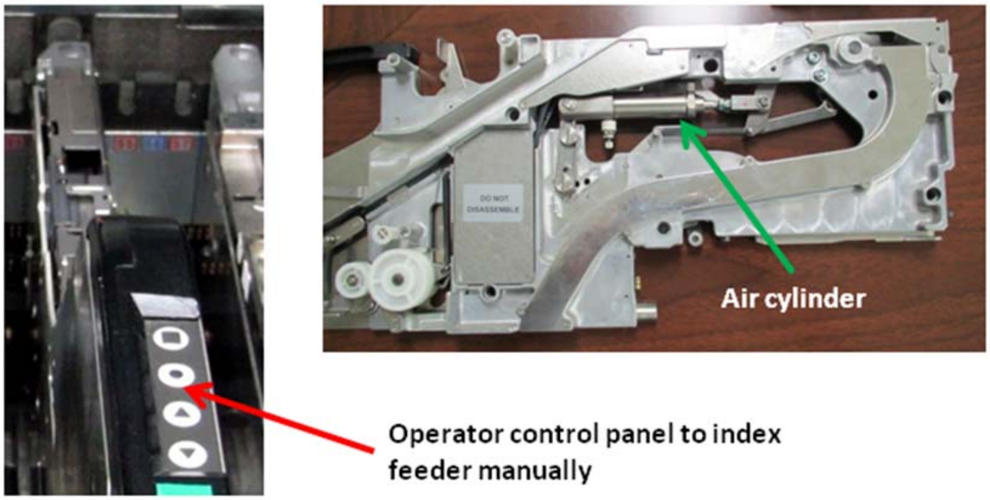


Figure 23. Examples of an electric feeder (left) and a pneumatic feeder (right) which are typically used in pick and place machines to advance the tape with LEDs.

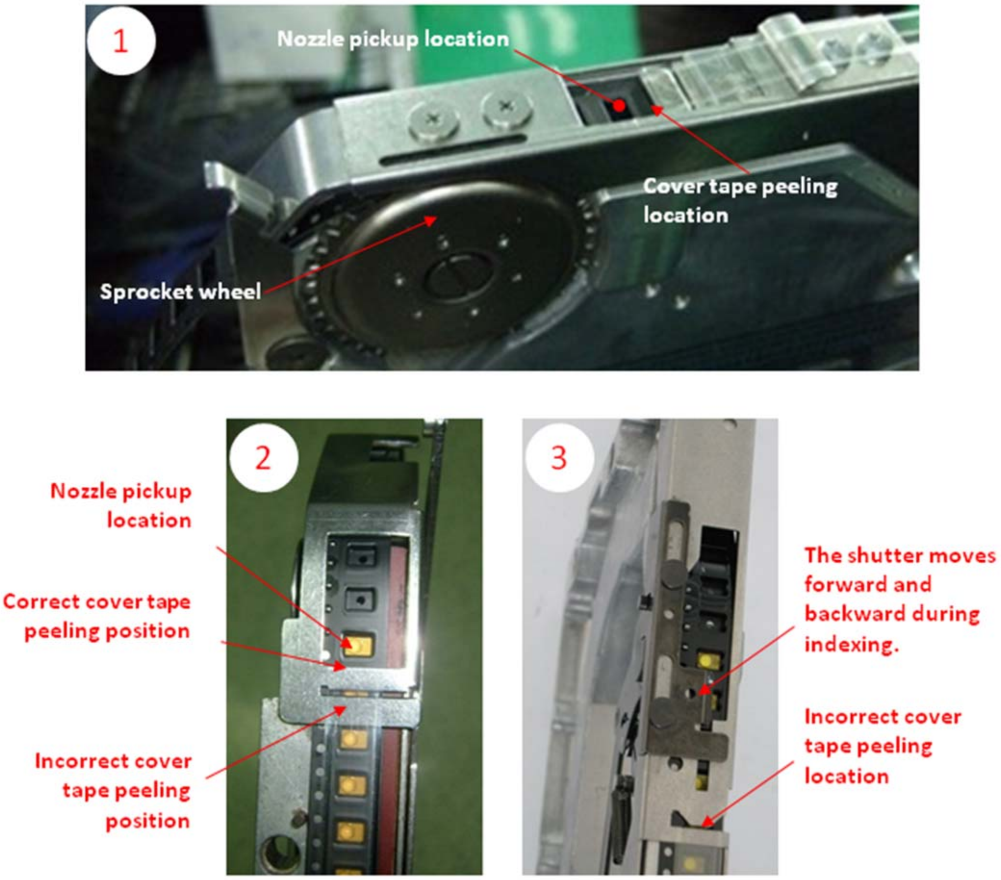


Figure 24. Three representative feeder designs.
Feeder 1 does not require any modification.
Feeder 2 requires the cover tape peeling position to be shifted.
Feeder 3 requires the shutter to be removed before the cover tape peeling position can be adjusted.

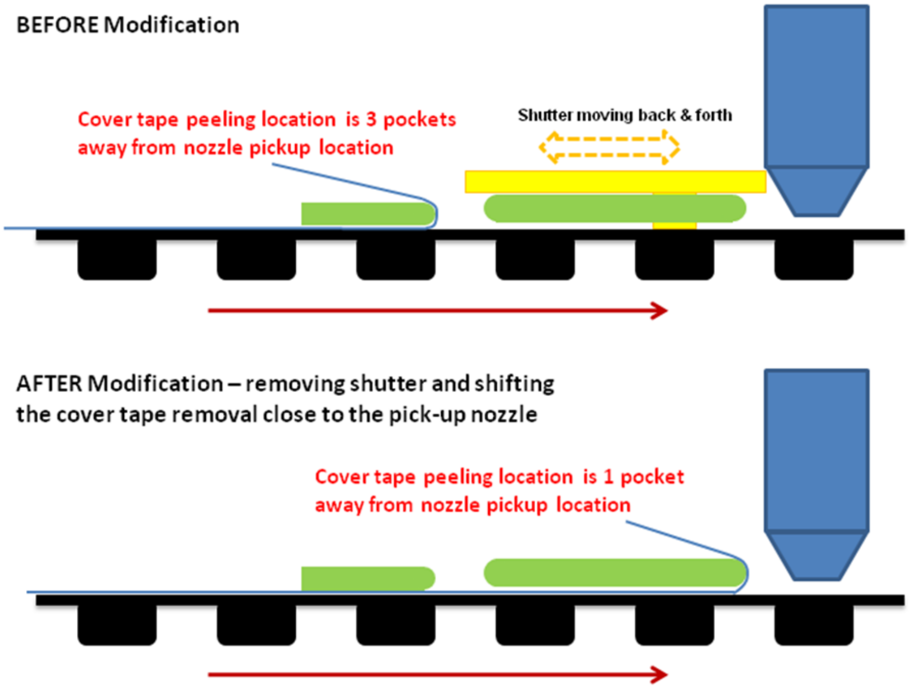


Figure 25. Illustration of the general principle behind the feeder modification.

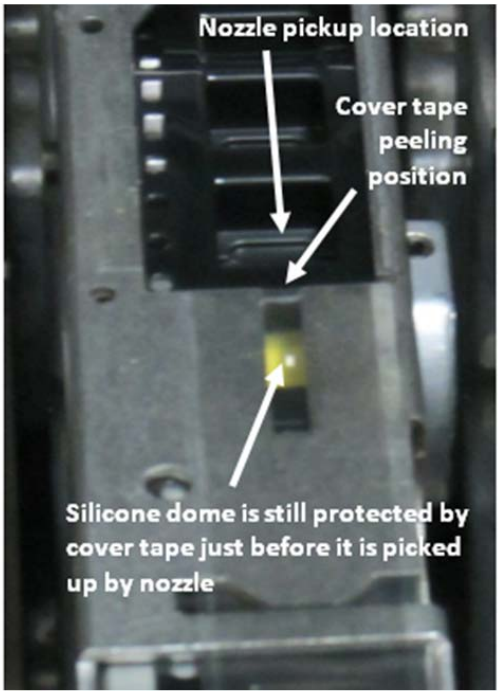


Figure 26. Example of a modified feeder which protects the silicone dome prior to pickup.

To minimize the jerking of components in pneumatic feeders during indexing, it may be necessary to install an air pressure control valve. In some pneumatic feeder designs, such a control valve is already integrated by the machine supplier; in others an external control valve may have to be installed (see Figure 28).

Figure 29 shows examples of pneumatic and electric feeders before and after modification.

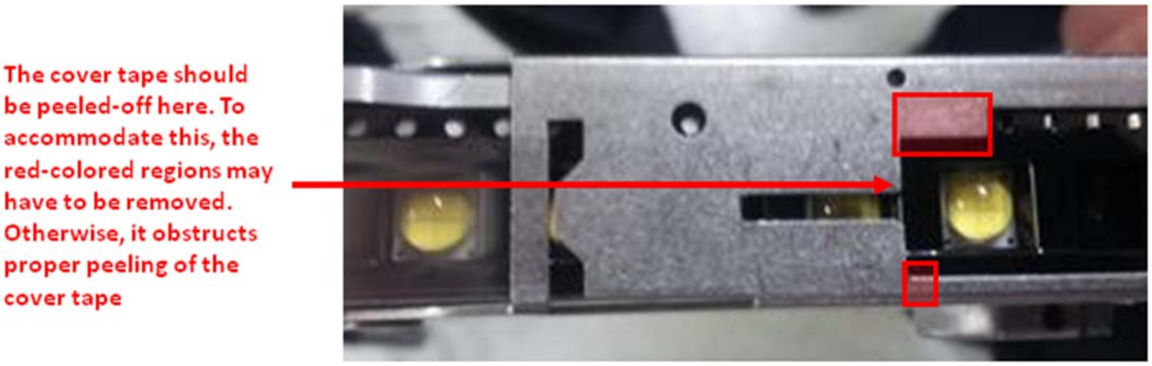


Figure 27. The cover tape peeling location in this feeder needs to be widened so that the cover tape can be peeled off without any obstruction.

Figure 28. Pneumatic feeder with integrated air pressure control valve (left) and pneumatic feeder with air pressure control valve installed afterwards (right).

8. PCB Inspection and Handling Guidelines

8.1 Introduction

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.”

8.2 Packaging

PCBs are typically shipped in moisture proof packaging with desiccant and a humidity indicator card, which changes color (typically from blue to pick) with increasing humidity (see Figure 30). 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.

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.”

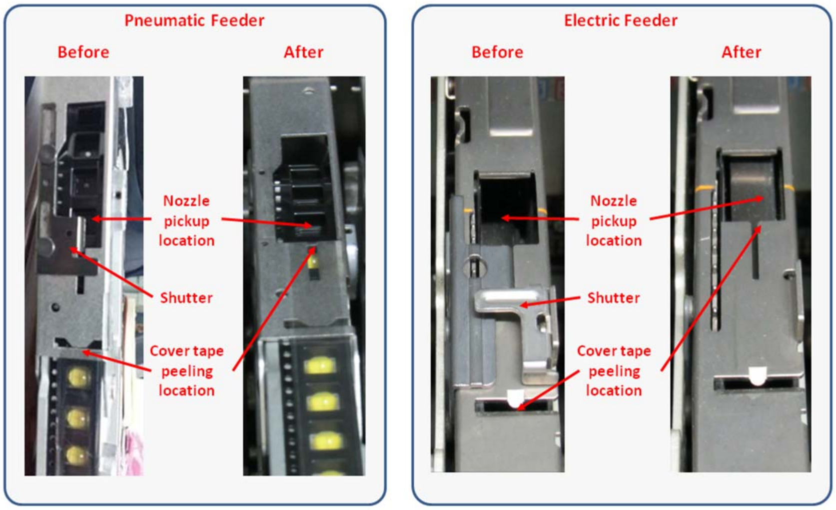


Figure 29. Example of pneumatic feeder (left) and electric feeder (right) before and after modification.

Figure 30. PCBs are typically shipped in moisture proof packaging with desiccant and a humidity indicator.

With regards to cleanliness of incoming PCBs, ionic contamination should be kept below the maximum limit of 1.56µg NaClEq./cm2. This is in line with the guidelines spelled out in IPC-6012 “Qualification and Performance Specification for Rigid Printed Boards.”

8.3 Inspection of Incoming PCBs

To inspect the quality of incoming PCBs, it is best to adopt the inspection criteria in IPC-A-600F “Acceptability of Printed Boards.” Figure 31 shows examples of unacceptable defects and contamination on incoming PCBs.

During PCB manufacturing poor positional control of the solder mask layer with respect to the top metallization can impact the pad dimensions on the PCB. Figure 32 shows four top-view pictures of the solder mask opening and underlying copper layer on the same 4-up PCB. In this particular example, the anode and cathode dimensions for three out of the four LUXEON emitters are smaller than designed. Consequently, some solder paste may be placed onto the solder mask during screen printing, causing the electrodes to have insufficient solder paste to make a reliable electrical connection.

Figure 33 shows examples of poor PCB workmanship, possibly due the solder mask strip process. These can cause problems when depositing solder paste onto the pads and making electrical connection when the LUXEON emitter is placed onto the PCB.

9. 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.

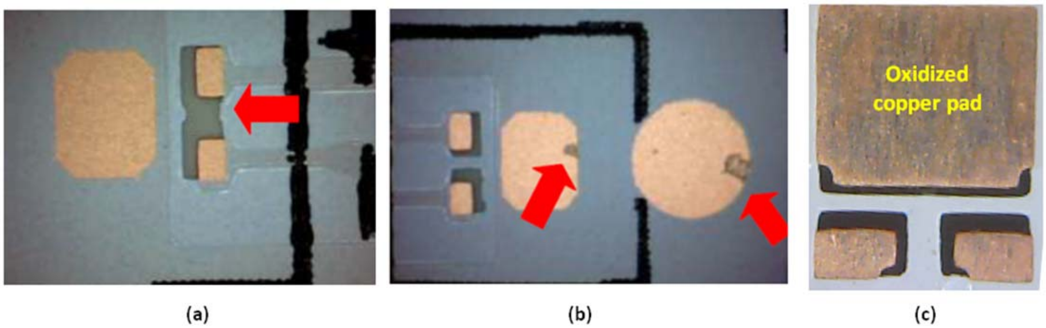


Figure 31. Examples of unacceptable defects and or contamination on incoming PCBs: missing solder resist between electrical pads (a), particles on exposed copper pads (b), and oxidized copper pads possibly due to poor OSP control, which may cause de-wetting and/or non-wetting of the pads during reflow (c).

Figure 32. During PCB manufacturing poor positional control of the solder mask layer with respect to the top metallization layer can impact the actual pad dimensions on the PCB. The four pictures in this example were all taken from the same physical 4-up PCB. The anode and cathode dimensions for positions (a) – (c) on this PCB are smaller than originally designed. Only the pad dimensions for position (d) were in specification.

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.

Figure 33. Examples of poor PCB workmanship which may adversely impact the solder joint between the PCB and the LUXEON emitter.

Table 1 provides a list of commonly used chemicals that should be avoided as they may react with the silicone material. Note that 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. 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

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Lumileds is the light engine leader, delivering innovation, quality and reliability.

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Lumileds is shaping the future of light with our LEDs and automotive lamps, and helping our customers illuminate how people see the world around them.

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