Application Brief AB32

LUXEON never before possible

LUXEON® Rebel
Assembly and Handling Information

Introduction

This application brief covers recommended board designs and assembly procedures for LUXEON® Rebel LEDs.

LUXEON Rebel is a revolutionary, ultra-compact, surface mount, high-power LED. LUXEON Rebel offers a compact package with high lumen output and superior thermal performance. LUXEON Rebel's compact design allows close packing for maximum light output per unit area of board space while retaining high efficacy and maximum lumen maintenance.

Proper handling, board design, and thermal management are required for high optical output and long LED lumen maintenance times.

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1. Component

1.1 Description

LUXEON Rebel has the benefit of an electrically isolated pad. The cross section of LUXEON Rebel is shown in Figure 1, where the LED cathode and heat pad are shown isolated by a ceramic substrate. The term “pad” refers to the thermal or electrical contacts on the LUXEON Rebel.

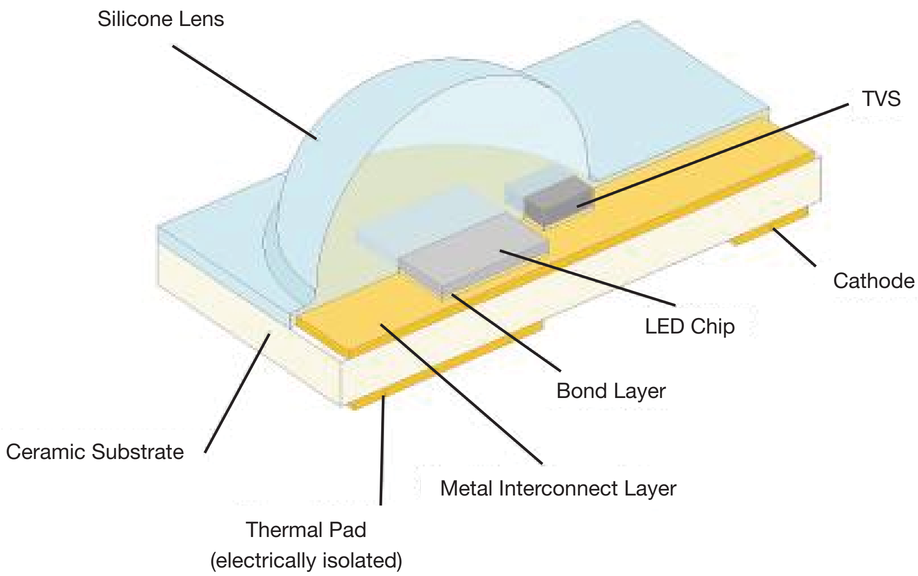


Figure 1. Cross section of LUXEON Rebel.

1.2 Optical Center

The LED has three feature sets that locate the theoretical optical center. These features are the topside fiducials, backside metallization, and LED outline.

The fiducials on the LUXEON Rebel package provide the most accurate methodology to locate the theoretical optical center as shown in Figure 2. To find the optical center of a LUXEON Rebel use the fiducials on the LED package as follows:

1. Draw an imaginary line between the centers of fiducials F1 and F2
2. Using fiducial F2 as the pivot point, rotate the line 19.66º counter clockwise
3. The theoretical optical center lies on this line and is 2.248mm above the center of F2

Once the theoretical optical center has been located, the theoretical optical center is within a circular diameter of 0.290mm with respect to that optical center.

Note that although the nominal position of fiducials is identical for the complete LUXEON Rebel family, there is a difference in metallization pattern between InGaN and AlInGaP LEDs, as indicated in Figure 3.

While the fiducials provide the most accurate technique to find the optical center of the lens, one may also utilize the edges of the LED or the backside metallization. The optical center is located 1.525mm from the top and side of the LUXEON Rebel edges. Figure 2 also illustrates the optical center with respect to the edges of the substrate.

The optical center may also be located using the edges of the thermal pad as shown in Figure 4. Using this process, the center of the lens will be within a circular diameter of 0.350mm with respect to the theoretical optical center.

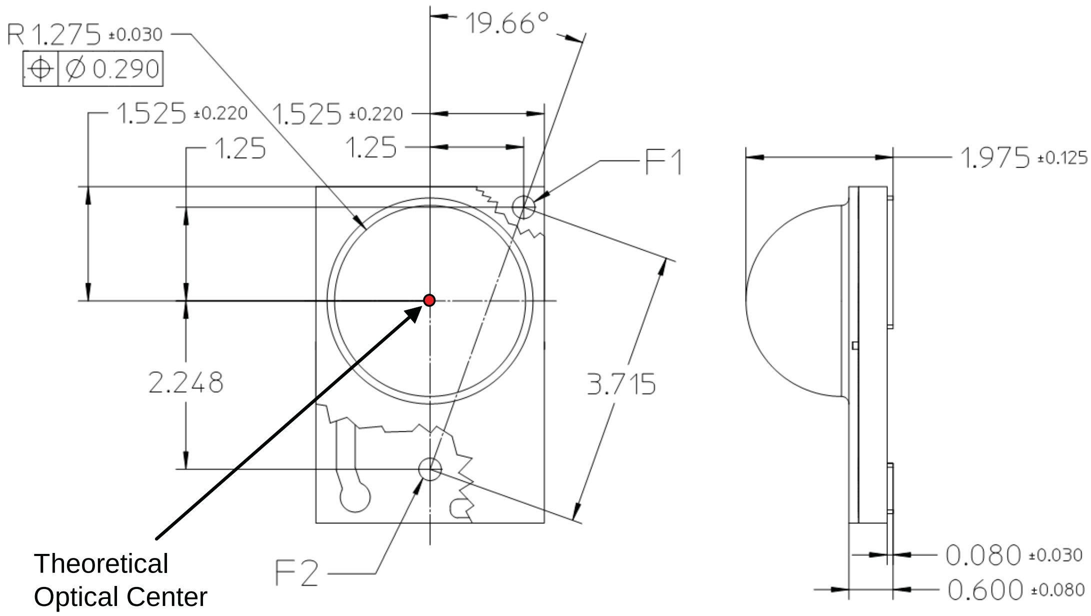


Figure 2. The most accurate method to find the theoretical optical center and the center of the dome is by using the fiducials located on the front side of the LUXEON Rebel LED. Dimensions in mm.

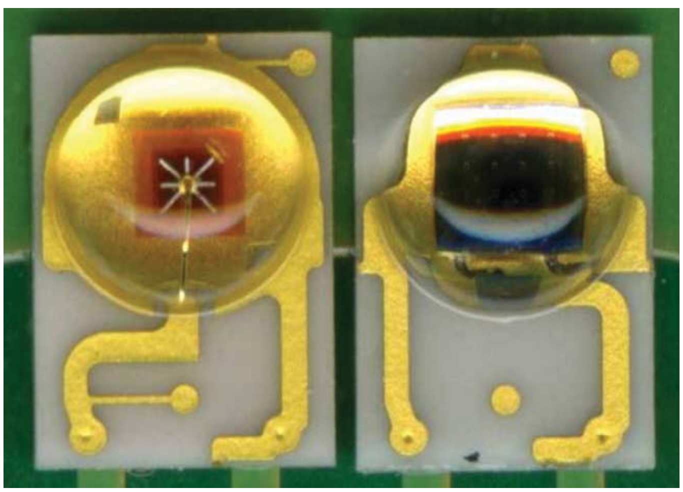


Figure 3. Picture of AlInGaP and InGaN LUXEON Rebel packages. The LUXEON Rebel AlInGaP (left) fiducials are connected to the metallization, while the LUXEON Rebel InGaN (right) has isolated fiducials.

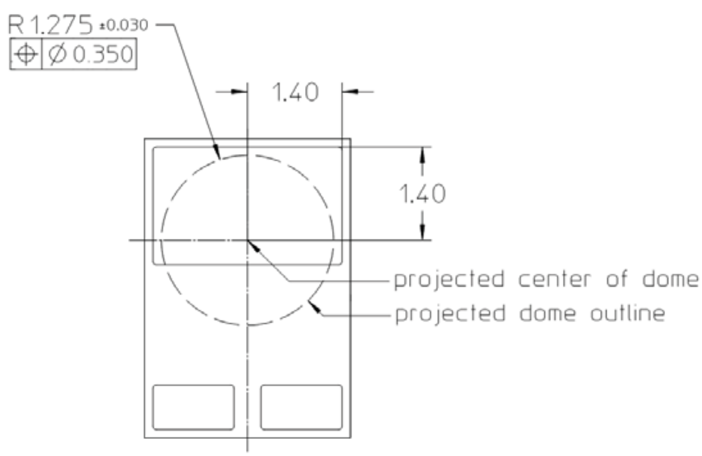


Figure 4. The optical center may be located using the edges of backside thermal pad. The center of the dome will be within a 0.35mm radius with respect to that optical center. Dimensions in mm.

1.3 Lens Handling

When utilizing a pick and place machine, ensure the pick and place nozzle does not place pressure onto the lens of the LED. The inner machining of the nozzle must clear the lens. For more information see the "Pick and Place Nozzle" section of this document.

Similar restrictions exist for manual handling. Only pick up the LEDs with the sides of the substrate and not on the lens.

The small size of the LUXEON Rebel places limits on the amount of force which may be applied onto the lens. Do not apply more than 3N of shear force (300g) directly onto the lens. Excessive force on the lens could cause mechanical damage to the part.

Figure 5. Correct handling of LUXEON emitters.

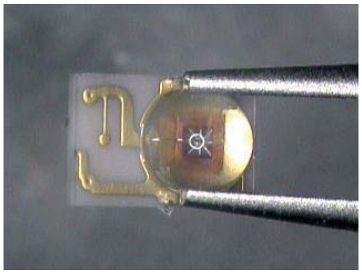


Figure 6. Incorrect handling—do not grip the lens.

1.4 Lens Cleaning

The lens of LUXEON Rebel should not be exposed to dust and debris. Excessive dust and debris may cause a drastic decrease in optical output.

In the event that an emitter requires cleaning, first try a gentle swabbing using a lint-free swab. If needed, the use of lint-free swab and isopropyl alcohol used gently removes dirt from the lens. Do not use other solvents as they may adversely react with the LED assembly.

1.5 Electrical Isolation

LUXEON Rebel has an electrically isolated thermal pad. A cross section of LUXEON Rebel is shown in Figure 1, in which the LED cathode (or anode) and thermal pad are shown isolated by a section of the ceramic substrate.

For applications in which multiple LUXEON Rebel LEDs connect electrically in series, a high voltage difference between electrical and thermal metallization can occur. Each design needs to comply with the appropriate standards of safety and isolation distances, known as clearance and creepage distance respectively. Examples of appropriate standards are IEC 60065 for audio/video equipment and IEC 60598 for general lighting applications.

Compliance with appropriate standards is application and design specific. With proper use of electrical isolation or appropriate electrical circuitry, such as short-circuit protection, the length of a series of LUXEON Rebel emitters can be many tens of units long. As there are multiple methods to use LUXEON Rebel, each design must be evaluated to the applicable standard. As a reference, the minimum distance between the top electrical metallization and the bottom thermal metallization of the LUXEON Rebel, considering x, y and z dimensions, is >0.35 mm.

2. Board Design Rules

2.1 PCB Requirements

The LUXEON Rebel can be mounted on two-layer FR4, multi-layer FR4 or MCPCB (Metal Core PCB). To ensure optimal operation of the LUXEON Rebel, the thermal resistance path should be as low as feasible.

A two layer FR4 board (with open vias or filled and capped vias) is the lowest cost solution for a thermally efficient package. One of the advantages of the MCPCB board is more rigidity than FR4. By following the guidelines outlined below, one can achieve a thermal resistance for FR4 that is equivalent or lower than a MCPCB equivalent design. Because these approaches use standard materials and SMT processing techniques, they are lower cost than MCPCB.

For reference, here are the applicable IPC standards when designing PCB boards.

- General PCB design:
  - IPC A-610D: Acceptability of Electronic Assemblies
- Filled and capped via boards:
  - IPC 4761: Design Guide for Protection of Printed Board Via Structures
  - IPC 2315: Design Guide for High Density Interconnects and Micro Vias
  - IPC 2226: Design Standard for High Density Interconnect Printed Boards

2.2 LUXEON Rebel Footprint or Land Pattern

Philips Lumileds has conducted an investigation to find the optimal board design of the LUXEON Rebel land pattern on the PCB. The goal of the study is to create a board with low thermal resistance, high placement accuracy, low solder voids, and solderability indicators.

Figure 7a shows the individual layers of the suggested layout with solderability indicators for an open via Plated Through Hole (PTH) board design. The green solder mask is a photolithographic mask, which offers a highly accurate alignment to the copper layer. The white mask labeled “White Text” is a printed layer consisting of a double printed layer of, for instance, Tamura USI - 210WP ink (UL E38152). This white layer enhances reflectivity, but is optional.

The solderability indicators, shown as the diagonally extended copper areas on the thermal and electrical land patterns, provide visual proof of effective solder reflow on all pads. In addition to acting as solderability indicators, the extended area can also be electrically probed for LED analysis. Reflow placement accuracy and thermal resistance will not be affected with the removal of the solderability indicator in the layout. In this discussion, the term Land Pattern refers to the pattern on the PCB for the LED pads.

The land pattern designs are available as .dxf files upon request at Philips Lumileds.

Board Design Rules, Continued

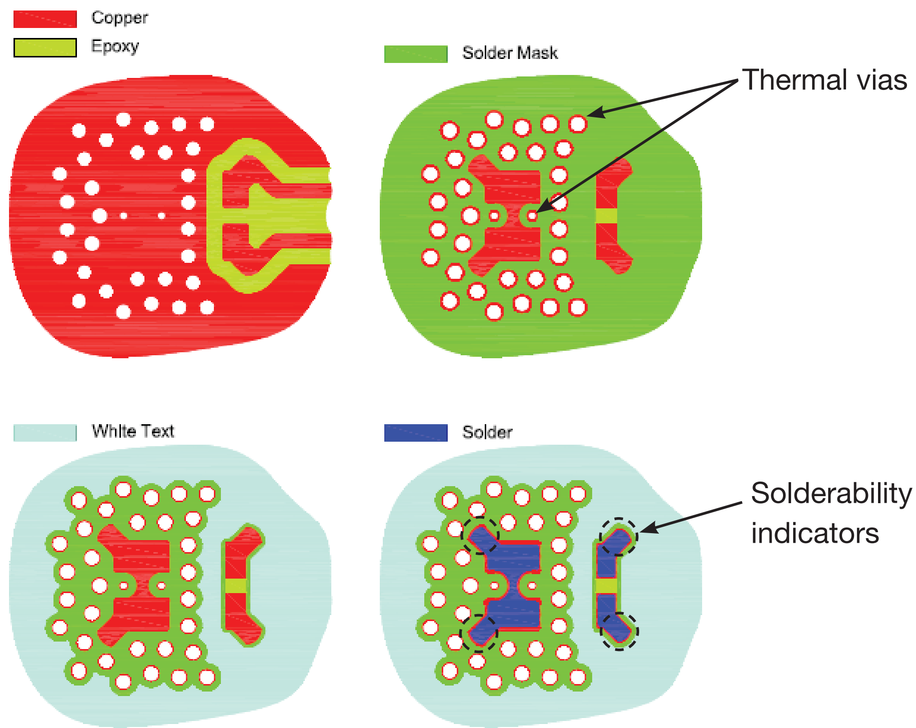


Figure 7a. Layout recommendation for LUXEON Rebel with open via PTH board.

Figure 7b shows the individual layers of the layout for a filled and capped via board design. This design is suitable for high component density assemblies. Each layer description is the same as previously noted in Figure 7a.

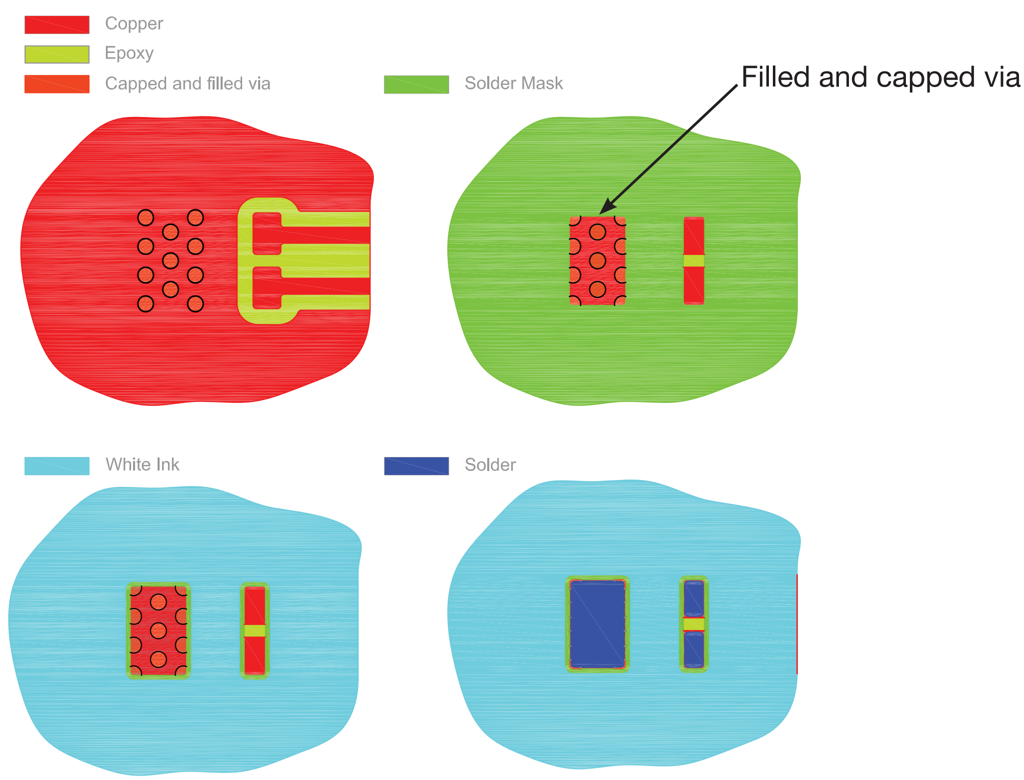


Figure 7b. Recommendation layout for LUXEON Rebel with filled and capped vias.

Board Design Rules, Continued

2.3 Surface Finishing

We recommend using a high temperature organic solderability preservative (OSP) on the copper layer.

2.4 LUXEON Rebel Close Density Placing

Philips Lumileds recommends a minimal edge-to-edge spacing of 0.3mm between components. If the edge-to-edge spacing is less, the components may drift together. For open via PTH design, close spacing of LUXEON Rebels may require the removal of the solderability indicators shown in Figure 7a. Removal of the solderability indicators does not affect the placement accuracy.

3. FR4-Based Boards

3.1 Material Properties

FR4 is an industry standard PCB technology. Depending on the LED application, drive condition and the number of LEDs on the board, the choice for Tg (Glass Transition Temperature) and CTI (Comparative Tracking Index) value of the base material needs to be set. Most common FR4 material has Tg=130°C and CTI=175V. For high voltage applications, the trace clearances and CTI values may be increased accordingly.

3.2 Optimal Thermal Design

Thermal vias are the primary method of heat transportation to the heat sink at the PCB bottom. A thermal via is a plated through hole that can be open, plugged, filled or filled and capped.

Philips Lumileds conducted a study on two thermal via designs aimed at reducing the thermal resistance. They are (a) open via PTH and (b) filled and capped via.

Open via PTH design: A cross section of this design is shown in Figure 8. The final thermal resistance is determined by the number and density of vias, the copper plating thickness and PTH thickness. Figure 9 shows a design with a standard two layer board. Here the total copper plating is 70µm with the PTH plating thickness of 35µm. In total, 33 vias are placed outside the thermal land. The placement of the two smaller thermal vias is to minimize voiding in the solder joint. For the recommended design, the measured thermal resistance for a 0.8mm thick FR4 PCB with these design features approaches 7K/W.

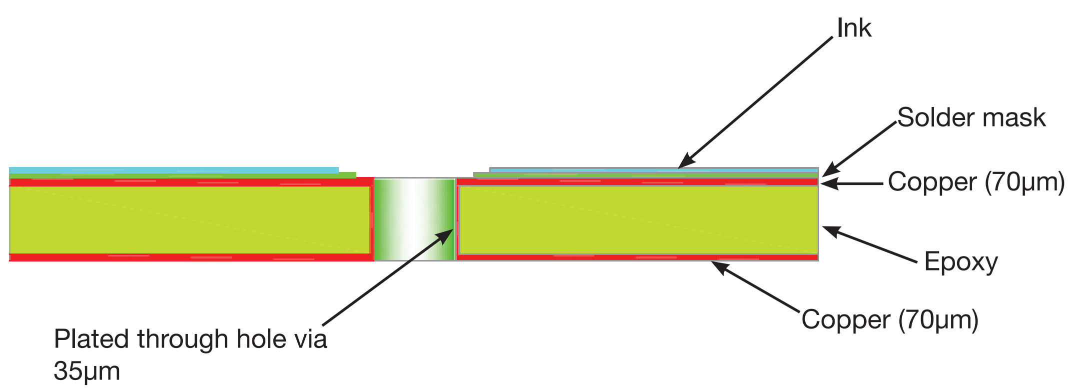


Figure 8. Cross section of FR4-based PCB with thermal vias to decrease the thermal resistance.

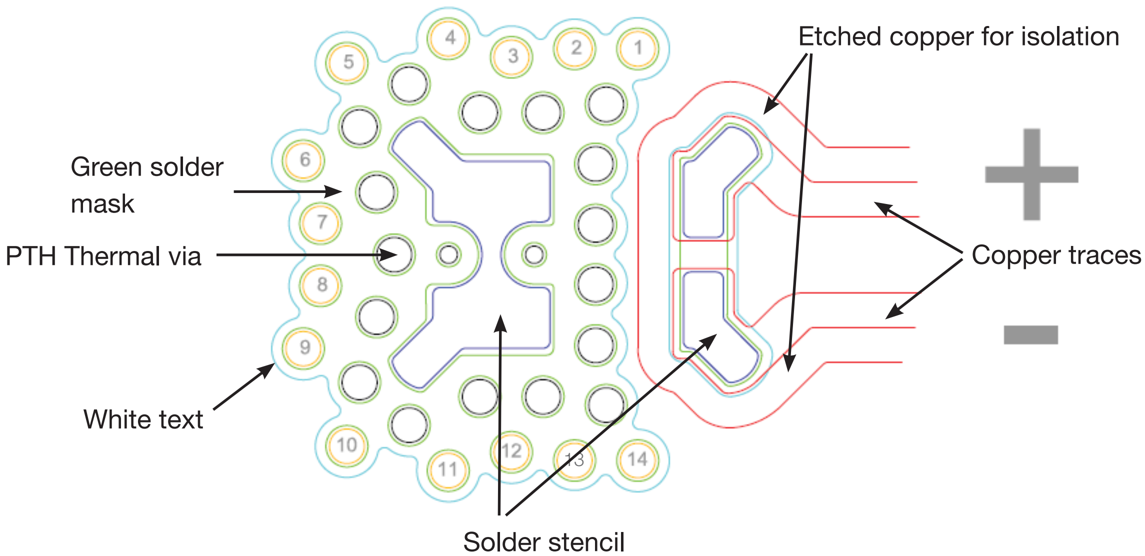


Figure 9. Outline of recommended pad layout for LUXEON Rebel (top view).
See Figure 7a for more illustrations. There is 0.5mm spacing between the thermal and electrical pads.

Filled and capped via design: A cross section of this design for a standard two layers board is shown in Figure 10. The final thermal resistance is determined by the number and density of vias, the copper plating thickness, PTH thickness and the plugging material used to fill the vias. Figure 11a shows the recommended layout for two layer board. The thermal resistance for a 0.8mm thick FR4 PCB with these design features approaches 3K/W.

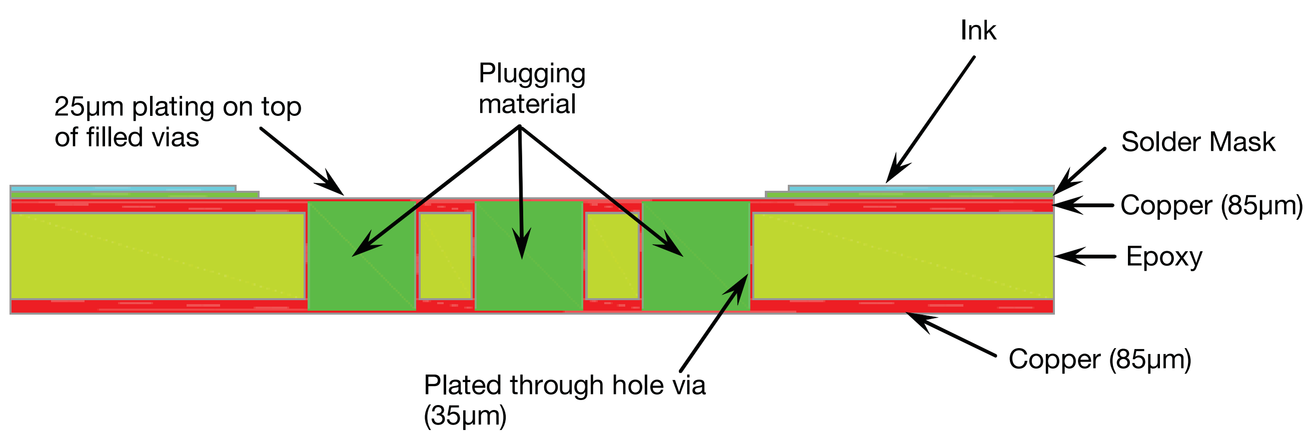


Figure 10. Cross section of FR4 based PCB with filled and capped thermal via for two layer board.

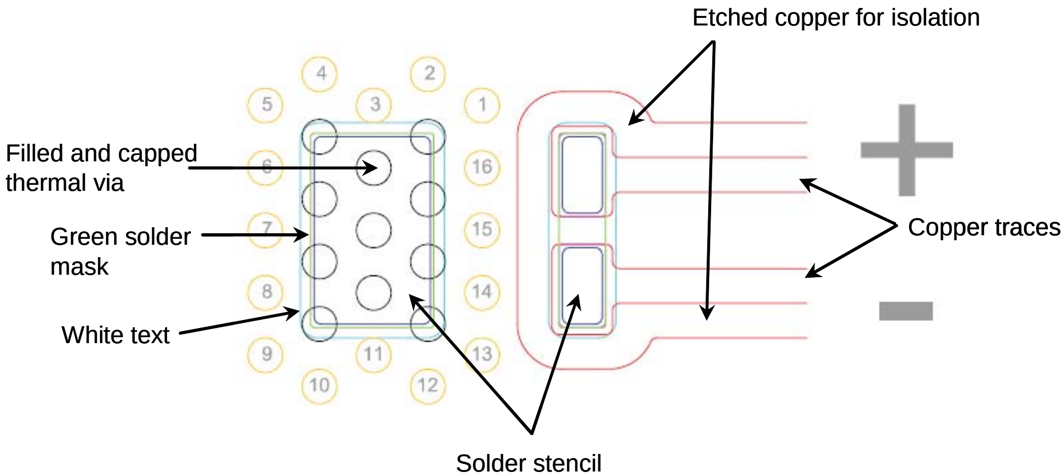


Figure 11a. Outline of recommended layout pad for LUXEON Rebel for filled and capped thermal via. See Figure 7b for alternate views.

A multilayer FR4 board with filled and capped via may be considered. See Figure 11b for a cross section of the multilayer board design.

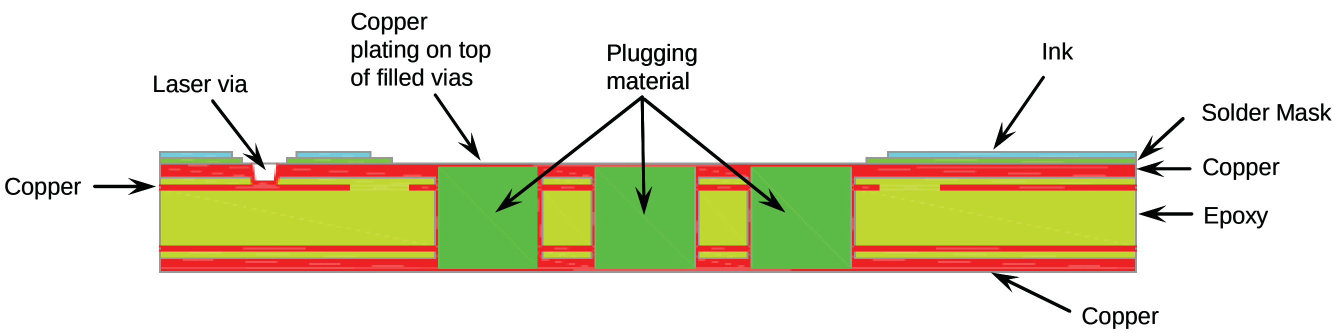


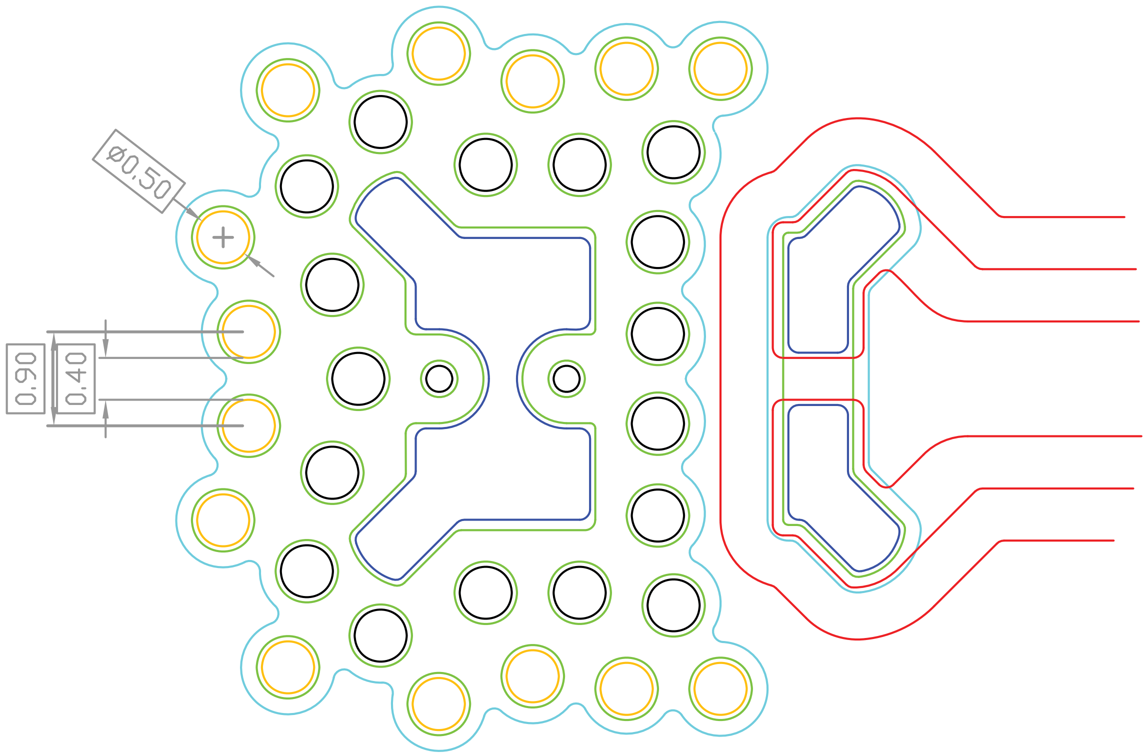
Figure 11b. Cross section of filled and capped via multilayer board.

3.3 Thermal Via Design

For both the open via PTH and filled and capped via design, the finished hole diameter is 0.5mm. A smaller diameter will lead to an increase of thermal resistance. The recommended distance between two holes is 0.4 mm. This results in a minimal pitch of 0.9 mm between the vias. Figure 12 indicates the typical dimensions. The position of the vias may differ from the preferred layout of Figure 9 and 11a, without significantly changing thermal properties.

For open via PTH design, the drill hole for the two smaller vias with a 35μm plating thickness is 0.32mm. The solder mask area around the vias is needed to avoid solder to flow through the vias to the backside. This would lead to a reduced heat sink contact of the PCB bottom surface. An opening in the solder mask of 0.05mm surrounds each via. The total minimal width of the solder mask around the via is 0.25 mm. Figure 13 shows the resulting solder mask design of the thermal pad.

For filled and cap via design, each via is filled or plugged with an epoxy material. Standard industry practices recommend using a plugging material with a CTE (Coefficient of Thermal Expansion) and Tg to match the thermal characteristics of the PCB. Recommendations on qualification criteria for the plugging process are documented in IPC-4761 “Design Guide for Protection of Printed Board Via Structures”. Use of thermally improved plugging material can further reduce the board thermal resistance, although the absolute improvement will be small.



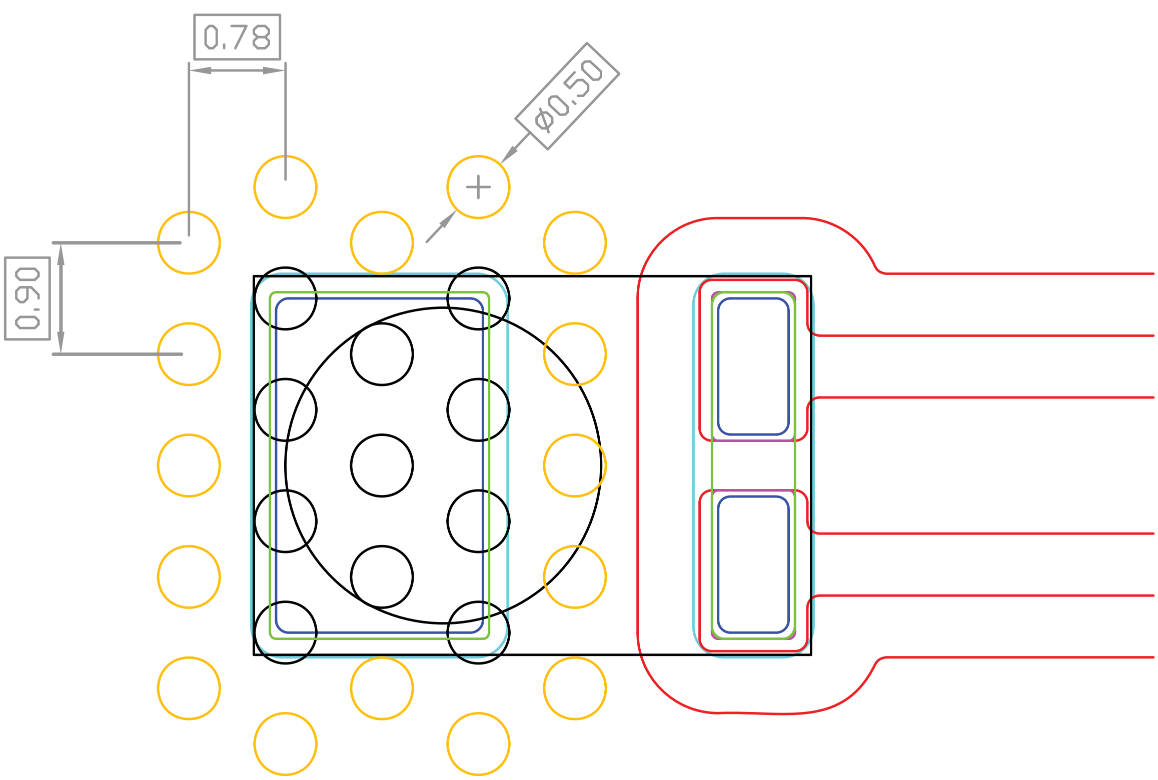


Figure 12. Recommended finished diameter and spacing dimensions for both open via PTH and filled and capped via design.

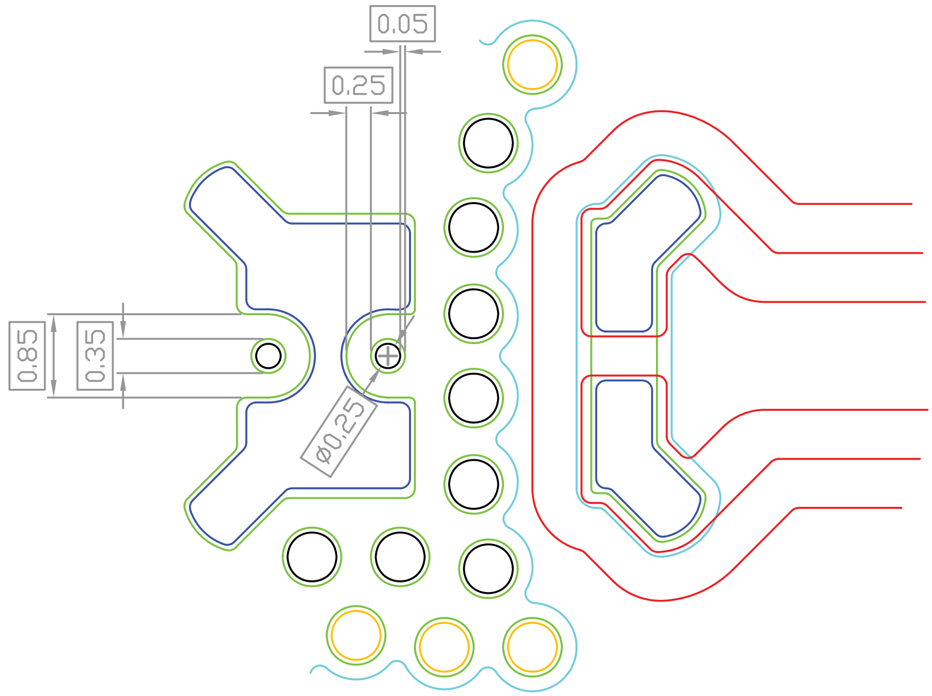


Figure 13. Solder mask design of thermal pad for open via PTH.

3.4 Component Spacing

For the open via PTH design, the minimal edge-to-edge spacing is 4mm to maintain the thermal properties, see Figure 14. Spacing below 4 mm will results in fewer vias between the components, thus increasing thermal resistance.

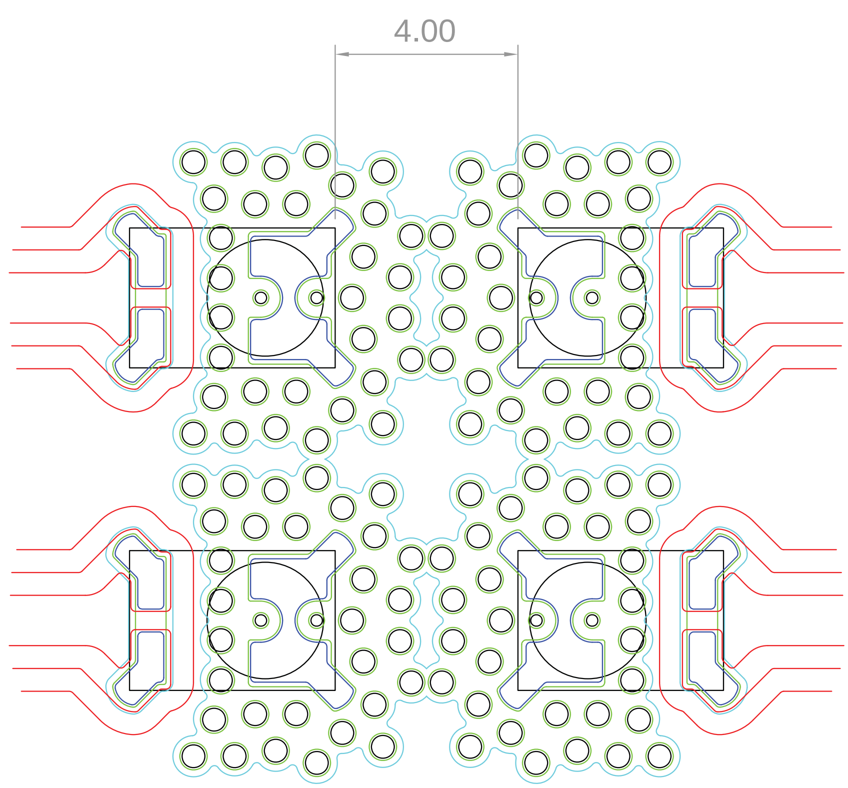


Figure 14. Illustration of edge-to-edge spacing. The thermal resistance will increase dramatically if the spacing is less than 4mm edge-to-edge.

For filled and capped via with the above recommended design, the minimal edge-to-edge spacing is 0.3mm. See Figure 15. This board design yields higher component density while still achieving a low thermal resistance.

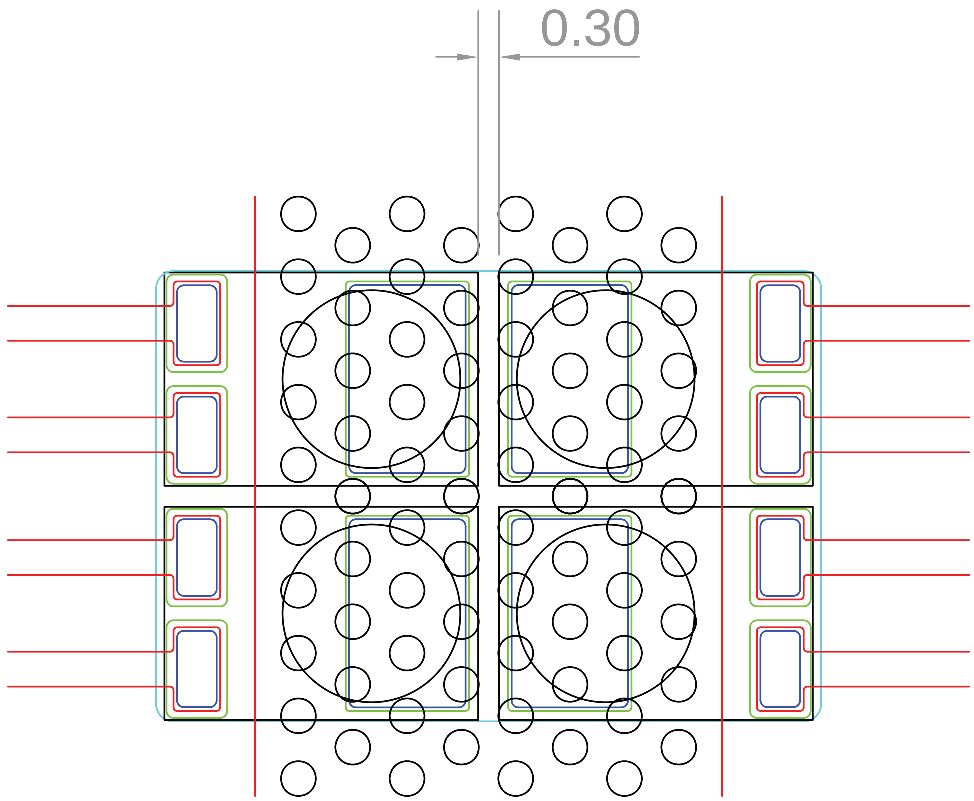


Figure 15. Illustration of edge-to-edge spacing for a filled and capped via design.

3.5 Thermal Resistance

The thermal resistance between the component case (body) and the back of the board/heatsink of the PCB (defined as $R\theta_{c-hs}$) depends on the size of Cu area around the thermal pad, the number of vias, the placement of vias, the Cu plating thicknesses, and the PCB thickness.

Effect of PCB thickness and plating thickness:

Figure 16 shows the simulated $R\theta_{c-hs}$ values for open PTH and filled and capped via as a function of PCB thickness. A double layer FR4 board with various through hole plating thickness (20µm and 35µm) and total surface plating (50µm and 70µm for open PTH, 70µm and 85µm for filled and capped via) are studied. The open PTH via board uses 33 vias design and the filled and capped via uses a 27 vias. Data is for a single LUXEON Rebel emitter.

The thicker the PCB board, the higher is the thermal resistance. Thicker plating thickness for the thermal via will reduce the thermal resistance and vice versa.

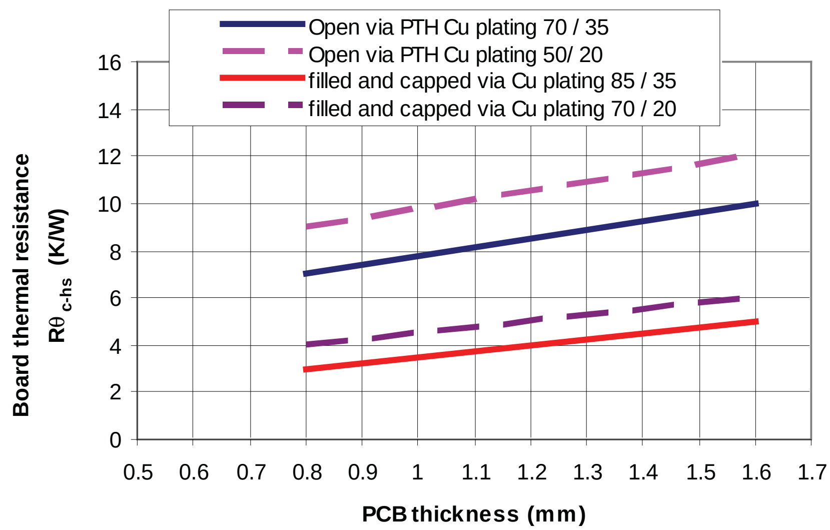


Figure 16. Simulated $R\theta_{c-hs}$ values as function of PCB thickness for two layers FR4 board with different plating thicknesses.

Impact when varying the number of thermal vias:

For open via PTH board, removal of the 14 outer vias increases the thermal resistance by approximately 1K/W. The 14 outer vias are labeled in Figure 9. Eliminating the two smaller vias in the thermal land will also increase the $R\theta_{c-hs}$ value by approximately 1K/W. The copper area around the thermal land has a large contribution to the thermal spreading. The optimal copper area extends 3mm beyond the thermal pad. Any extension beyond 3mm will not significantly lower the thermal resistance. Elimination of both the outer vias and the copper area outside the thermal pad increases the thermal resistance to above 30K/W.

With filled and capped via, the thermal resistance decreases from approximately 4K/W to approximately 3K/W when adding the additional vias around the 11 vias in the thermal land as shown in Figure 17.

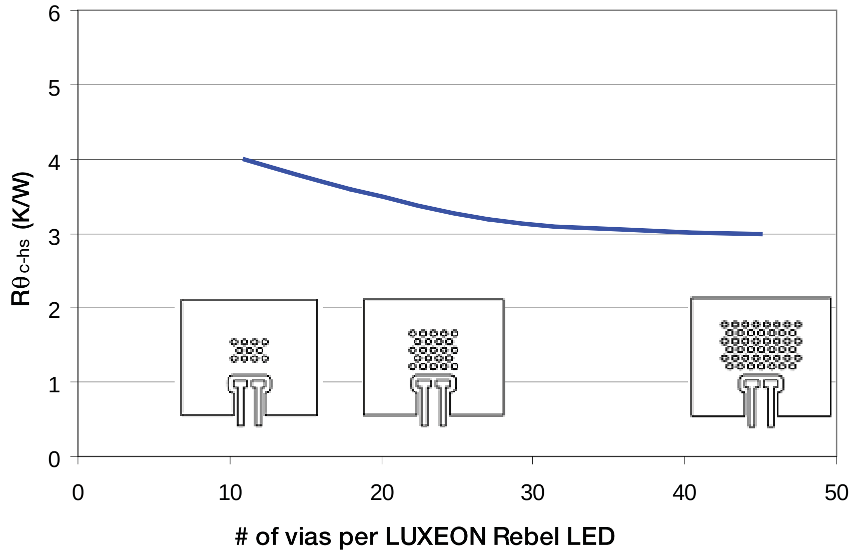


Figure 17. Simulation of the thermal resistance as a function of number of vias (filled and capped via).

Effect of component density:
For open via PTH, bringing the components closer together than 4mm will lead to elimination of vias and decreases the copper area around the thermal pad. If the spacing is less than 2mm, the thermal resistance will increase dramatically. Figure 18 shows the simulated thermal resistance as a function of spacing. Figure 19 shows the reduction of vias when the spacing decreases from 4mm to 2mm. The thermal resistance discussed in Figures 18 and 19 are for a 0.8mm FR4 board thickness with 70µm of total copper plating and 35µm copper plating via.

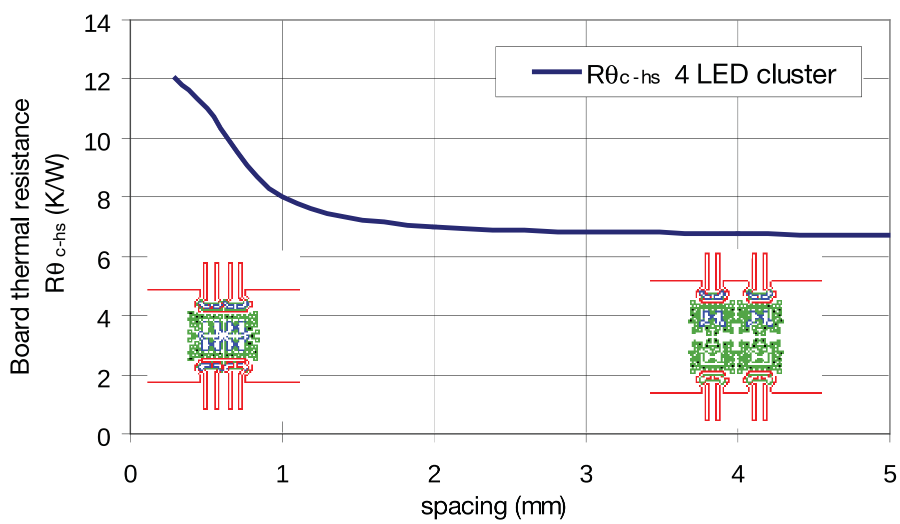
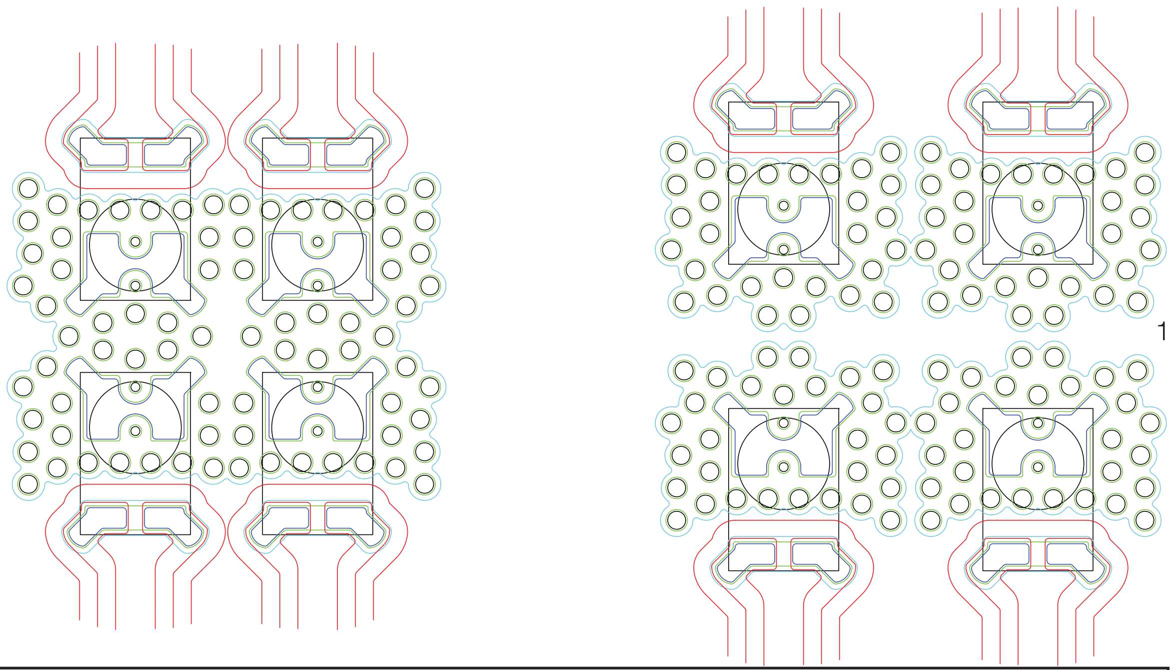


Figure 18. Simulated $R\theta_{c\text{-}hs}$ values for close spacing of LEDs for a two layer FR4 PCB.

90 Vias



124 Vias

LUXEON Rebel Spacing	2 mm	4 mm
R$\theta_{c\text{-}hs}$ per LED (simulation estimate)	7 K/W	6.8 K/W

Figure 19. When the edge-to-edge spacing is reduced from 4 to 2mm, the number of vias decreases from 124 to 90. Thermal resistance values are simulated.

FR4-Based Boards, Continued

For filled and capped via, a low thermal resistance can be achieved with a minimum component spacing of 0.3mm for a 35µm/70µm (through-hole/total surface) copper plating thickness as shown in Figure 20 (blue line).

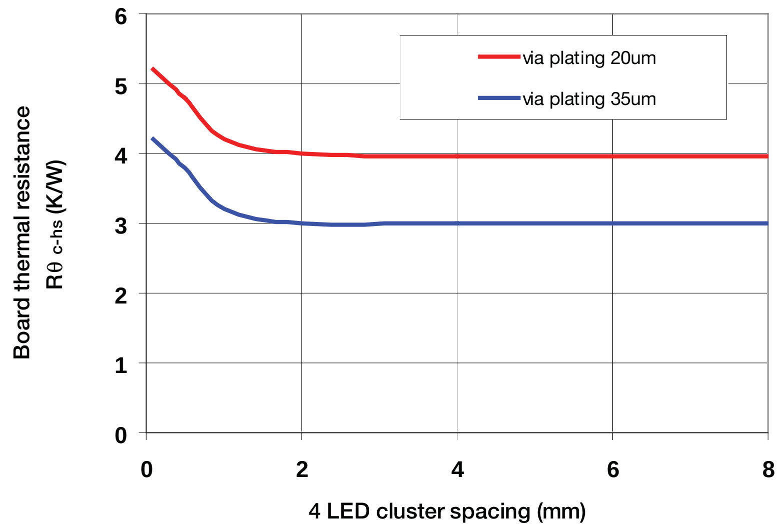


Figure 20. Simulated $R\theta_{c\text{-}hs}$ values of the PCB for different LED spacing and different via plating thicknesses.

Figure 21 shows a comparison of thermal resistance of various board technologies. MCPCB uses 35µm plating; open PTH via board uses 70/35µm copper; and filled and capped via board uses 85/35µm copper. Note that the default number of vias is 33 for open PTH and 27 for filled and capped via for 8mm LED spacing. Fewer vias are employed when the LED spacing is reduced which increases the thermal resistance.

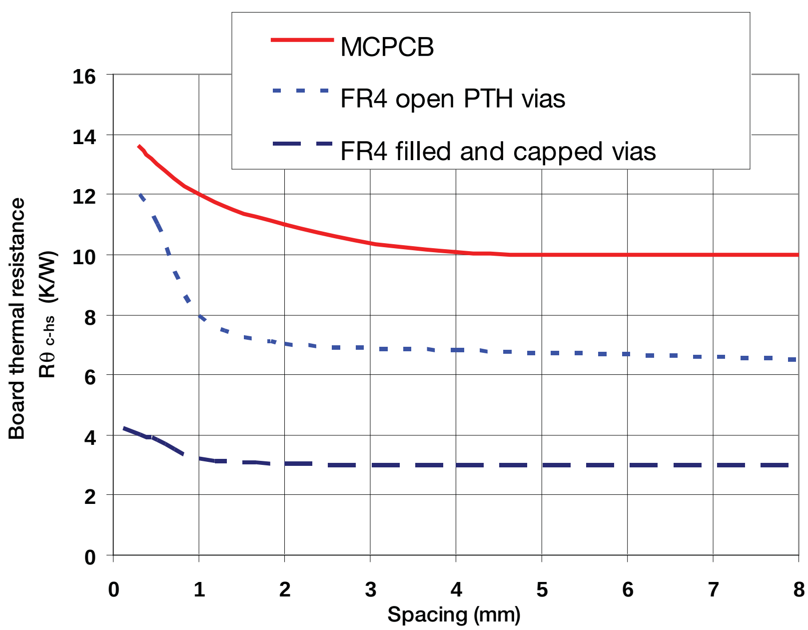


Figure 21. $R\theta_{c\text{-}hs}$ simulation of various board technologies as a function of LED spacing.

4. MCPCB Board Design

The layout for the MCPCB design is similar to the FR4 design, but without the vias. A cross section of the MCPCB is shown below.

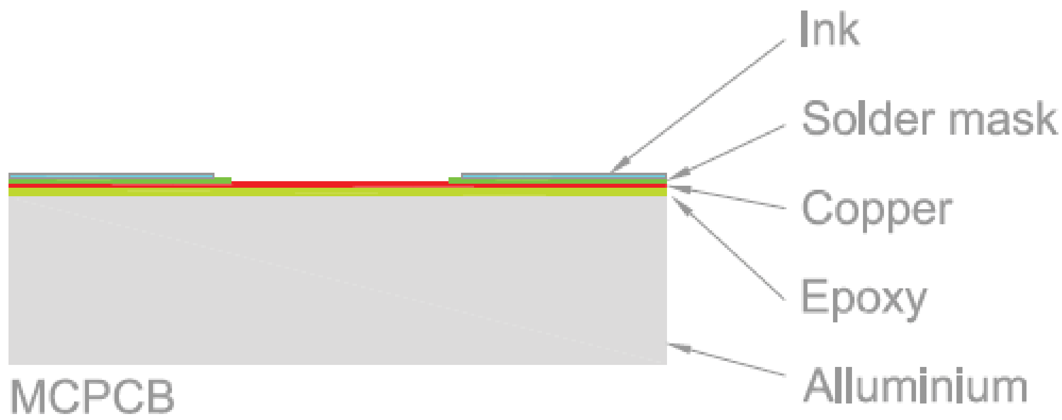


Figure 22. Cross section of MCPCB.

Table 1 summarizes typical and high thermal conductivity epoxy thermal resistances. Using standard MCPCB design rules yields a board with approximately 10K/W thermal resistance. Increasing the copper thickness and using a thinner dielectric with higher thermal conductivity lowers the thermal resistance dramatically.

In both cases the copper area extending outside the thermal pad is minimal 3mm.

Table 1. MCPCB Design Parameters.

Dielectric	Typical epoxy	High conductivity epoxy
Dielectric thermal conductivity [W/mK]	0.8	4
Al thickness [mm]	1.5	1.5
Copper thickness [µm]	30	70
Dielectric thickness [µm]	100	85
Total MCPCB thermal resistance for low density design [K/W]	10	5

The difference between the coefficients of thermal expansion (CTE) for LUXEON Rebel mounted on MCPCB is greater than the difference for LUXEON Rebel mounted on FR4 PCB. Therefore, there is greater stress on the solder joint for LUXEON Rebel on MCPCB. Despite the greater joint stress, Philips Lumileds has successfully completed 1000 temperature cycling tests from -40ºC to 125ºC with no functional failures.

5. Assembly Process Recommendations and Parameters

5.1 Stencil Design

The recommended solder stencil thickness is 125µm. The area coverage of the solder paste is greater than 90%. This yields a solder joint thickness of approximately 50µm, using the lead-free solder. Figure 23 shows the recommended stencil design for the footprint with two small thermal vias and solderability indicators for open via PTH board. Figure 24 shows the recommended stencil design for filled and capped via board.

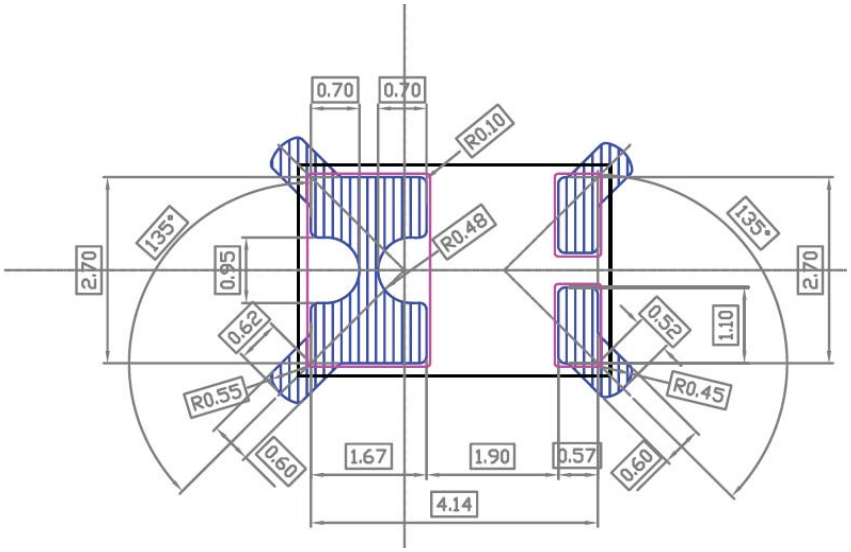


Figure 23. Solder stencil for footprint with two thermal vias and four solder ability indicators.

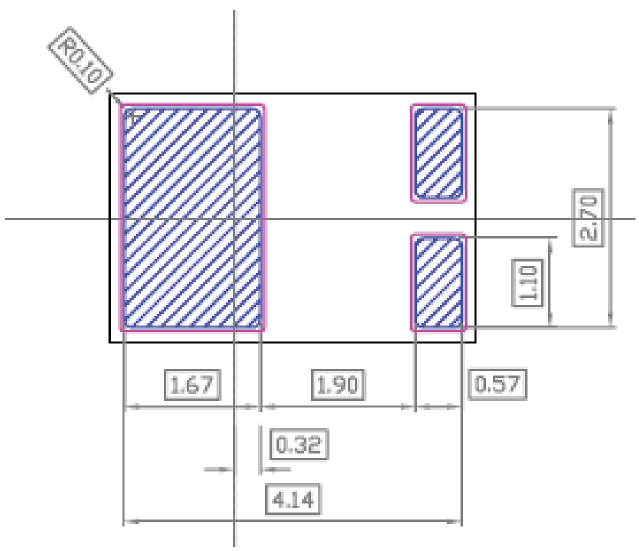


Figure 24. Solder stencil for filled and capped via.

5.2 Solder Paste

Philips Lumileds recommends lead-free solder for the LUXEON Rebel. Philips Lumileds successfully tested these SAC 305 solder pastes: Alpha Metals OM338 grade 3 and OM 325 grade 4 with satisfactory results.

Assembly Process Recommendations and Parameters, Continued

5.3 Pick and Place Nozzle

Automated pick and place equipment provides the best placement of LUXEON Rebel emitters. Philips Lumileds evaluated two pick and place nozzles: a generic nozzle for 0603 components with a pick-up area of 0.95mm x 1.75mm, and a Philips Lumileds specific nozzle for LUXEON Rebel. Neither nozzle places any contact onto the LUXEON Rebel lens.

Figure 25 shows the pick-up area on LUXEON Rebel for a 0603 pick-up nozzle. Make sure that the exterior of the nozzle does not touch the dome. Using the pattern recognition system of pick and place equipment, the position of the nozzle during pick up is manually programmed. For guidance, the bottom fiducial within the pick-up area defined above can be used as shown in Figure 25.

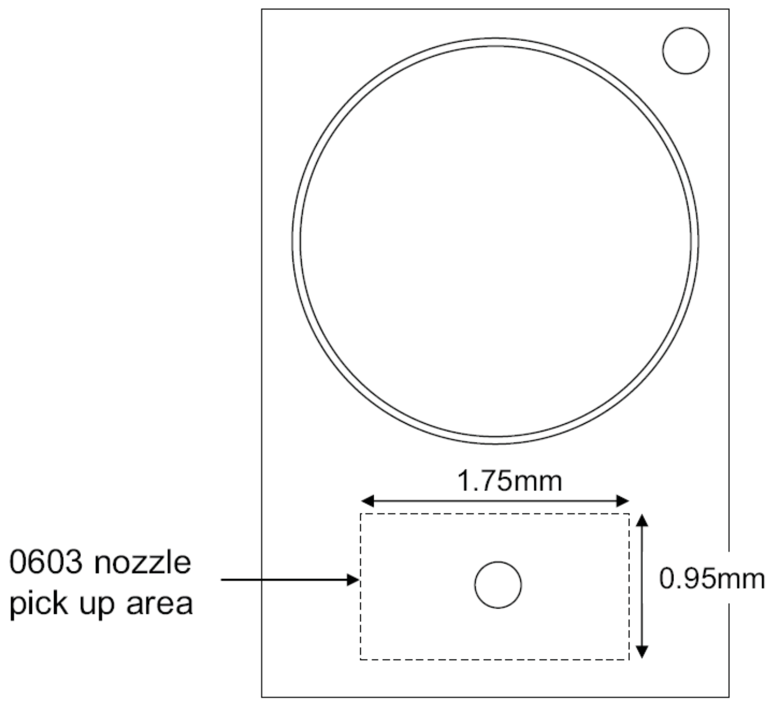


Figure 25. Pick-up area on the LUXEON Rebel for a 0603 nozzle.

Pick and place nozzles are customer specific and machined to fit specific equipment. Figure 26 illustrates the mechanical dimensions of this nozzle design (units in mm).
Philips Lumileds also uses a mold release spray to prevent the LED from sticking to the nozzle after placement. Philips Lumileds uses the mold release spray SR3-500B from Solent Maintenance.

Philips Lumileds has used the following company to make dedicated pick-up nozzles for LUXEON Rebel:

- Micro-Mechanics, Malaysia
- Email: mmmalaysia@micro-mechanics.com
- Telephone number: +604-6434648.

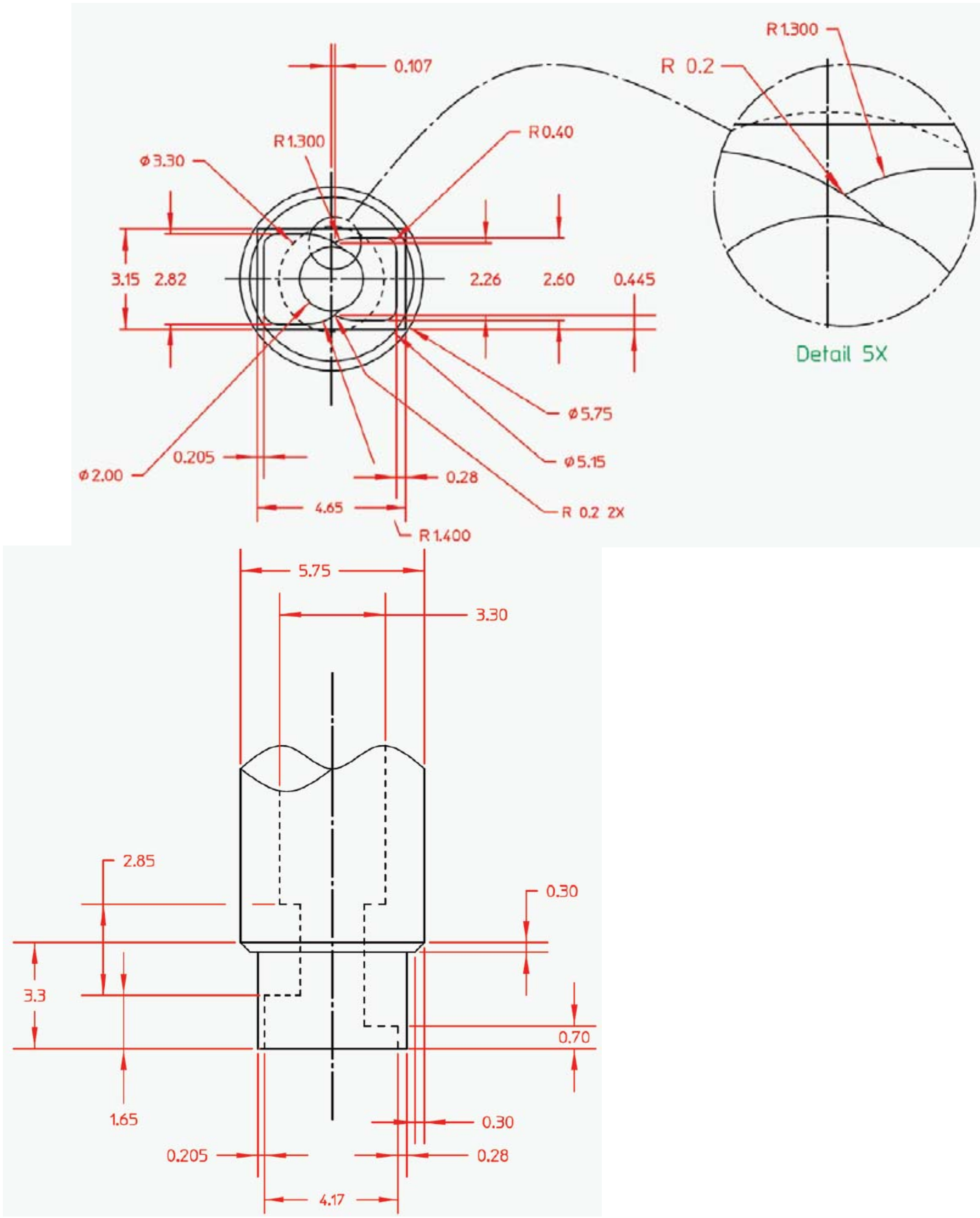


Figure 26. Dedicated LUXEON Rebel pick-up nozzle design (units mm). The nozzle tolerances must account for the LED dimensions.

5.4 Pick and Place Parameters

The pick and place parameters for Philips Lumileds nozzle is summarized in Table 2 below.

Table 2. Pick and Place Parameters.

Pick up location referenced to top of the reel, see Figure 27	-0.2
Vacuum	-20kPa
Stencil thickness [micrometer]	125
Placement into solder [micrometer]	25
Over travel spring force during placement [N]	2
Material	Black anodized aluminum

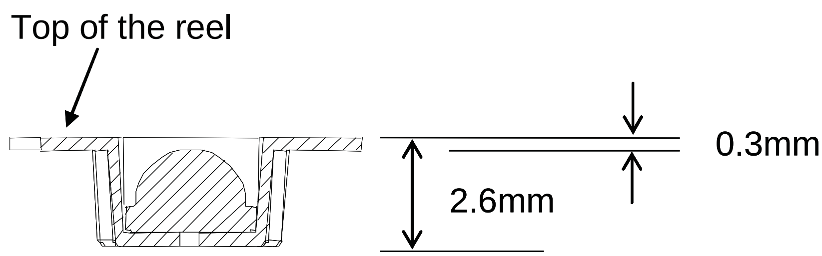


Figure 27. With the top of the reel being 0mm, the pick-up nozzle will over travel by 0.2mm into the reel.

5.5 Placement Accuracy

Achieve the highest placement accuracy by using an automatic pick and place equipment with a vision system to recognize the bottom metallization (3 pads). If available, use the SOT32 profile from the component library, and modify the lead dimensions and pitch. See Figure 28 for dimensions. Recognition tolerance can be set at 30%. A lower percentage improves placement accuracy but may reduce recognition yield.

For high density placement, such as spacing between components below 0.5mm, Philips Lumileds recommends recognition of the outline dimensions of the LED (see Figure 28). Reduce the tolerance on the outline dimensions to 5% to eliminate the risk of staggering of components.

Philips Lumileds recommends a minimal spacing of 0.3 mm between LUXEON Rebel packages. This avoids the risk of neighboring components touching each other after reflow.

For manual placement, the fiducials on the top side assist in locating the optical center. Figure 2 serves as a guideline to find the optical center on the top side.

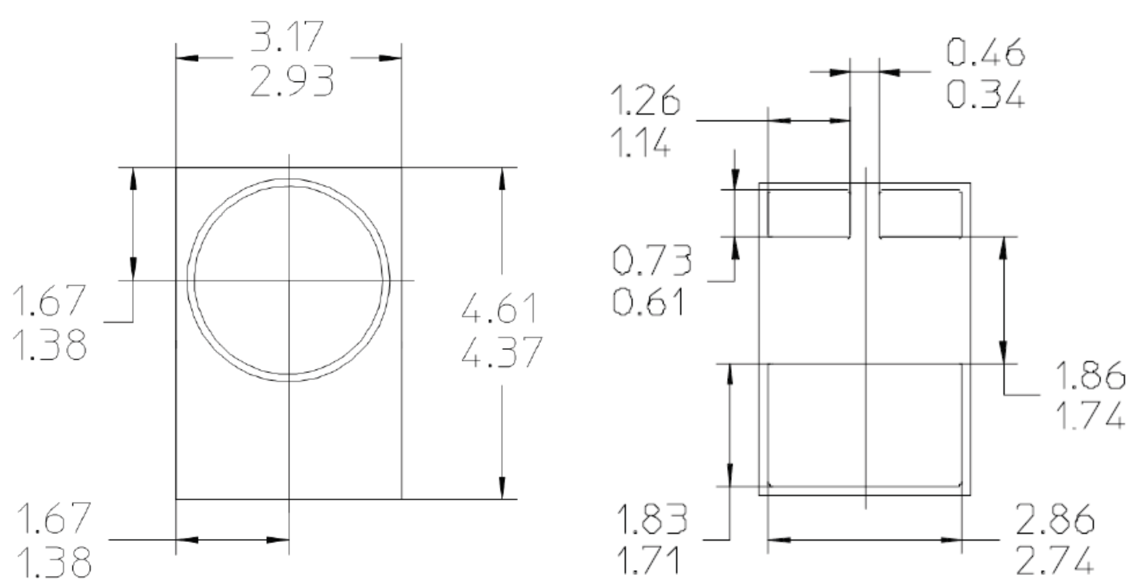


Figure 28. Mechanical dimensions of LUXEON Rebel package.

5.6 Reflow Profile

LUXEON Rebel emitters are compatible with surface mount technology and lead-free reflow. This greatly simplifies the manufacturing process by eliminating the need for adhesives and epoxies. It has been said that the most important step in reflow soldering is the reflow itself. This occurs when the boards move through the oven and the solder paste melts forming the solder joints. To form a good solder joints, the time and temperature profile must be well maintained.

A temperature profile consists of three primary phases:

1. Preheat: When the board is warmed up to a temperature lower than the melting point of the solder alloy.

2. Reflow: When 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. Cooling down: This is when the solder freezes and the board cools before exiting the oven.

As a point of reference, the melting temperature for SAC 305 is 217ºC, and the minimum peak reflow temperature is 235ºC.

Philips Lumileds successfully utilized the following reflow profile for LUXEON Rebel on PCB.

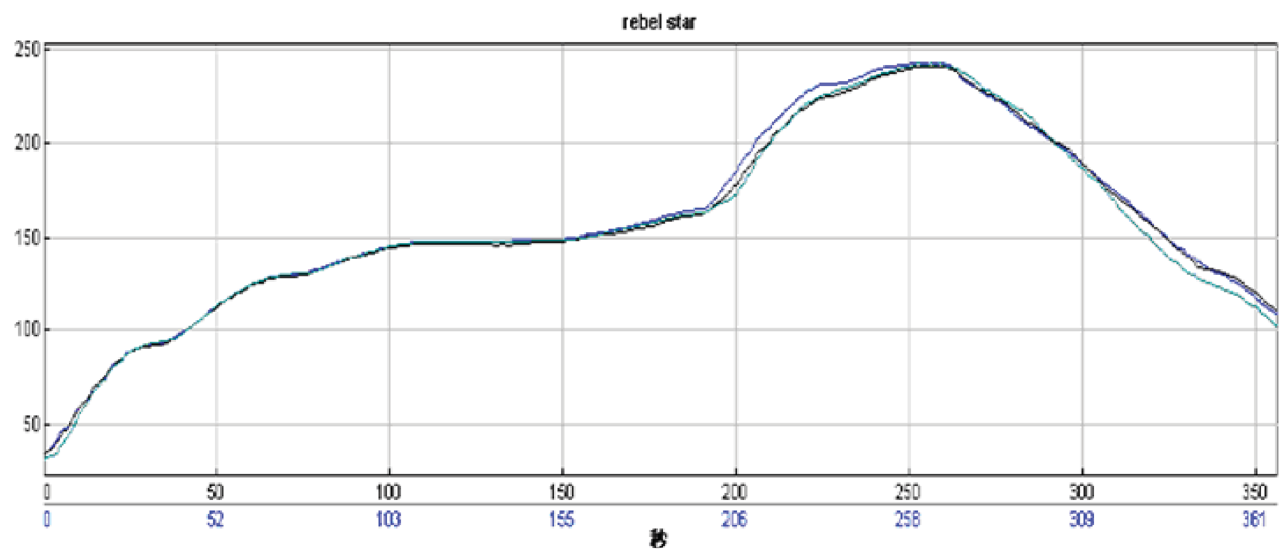


FIgure 29. Reflow profile of LUXEON Rebel using SAC-305 solder paste.

5.7 Reflow Accuracy

Calculate the reflow accuracy between the centers of the component to the nominal board position by using global fiducials on the PCB board, as shown in Figure 30. The section titled “Optical Center” defines how to calculate the theoretical center of the LUXEON Rebel. Philips Lumileds has determined the placement accuracy after reflow to be well within 90µm in the x and y directions for the footprint in Figure 9. The placement accuracy is determined as follows: The PCB onto which the LUXEON Rebel is assembled must have fiducials to determine the origin. The position of the LUXEON Rebel is determined using the component fiducials. The difference between this measured value and the nominal placement position is the placement accuracy.

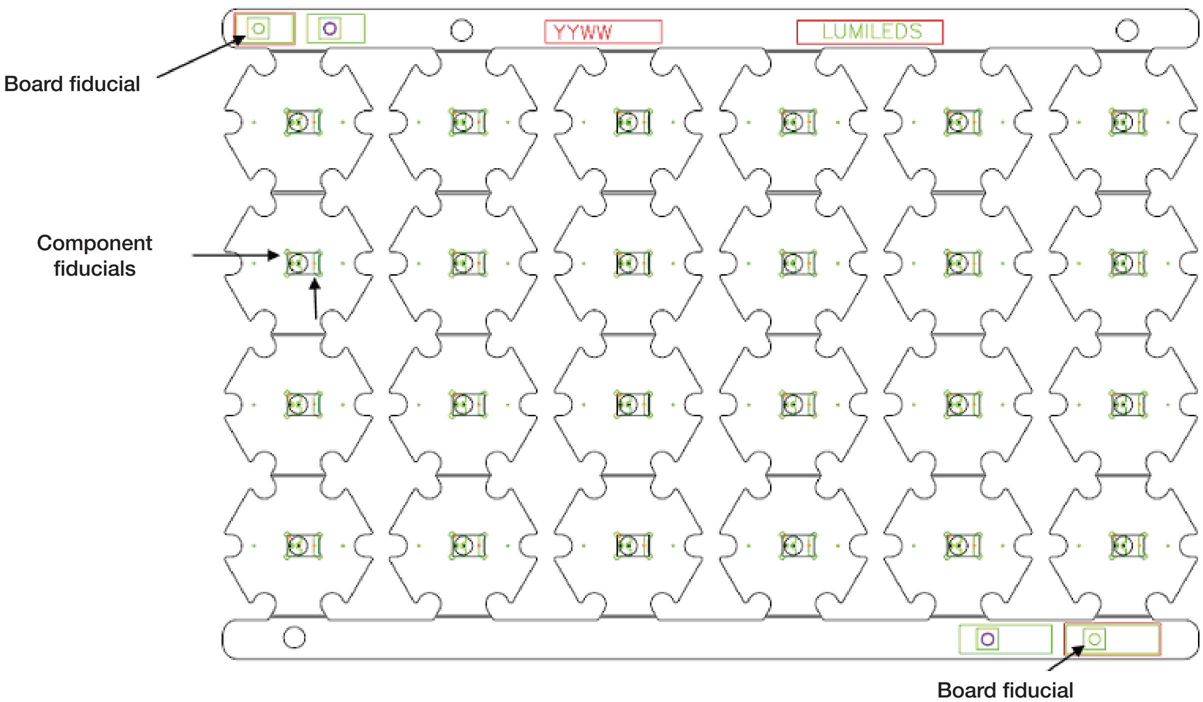


Figure 30. The board fiducials provide the origin of the board. The fiducials on LUXEON Rebel determine the optical center of the LED. The difference between the measured coordinates of the optical center and the nominal position is the placement accuracy.

5.8 Void Inspection and Solderability Indicators

An in-line X-Ray machine can inspect for voids after reflow. Philips Lumileds has determined that the two small thermal vias in the thermal pad footprint minimizes voiding by serving as an air vent during reflow.

A large percentage of voids in the thermal pad will increase of the thermal resistance. Figures 31 and 32 show impact of solder voiding on board thermal resistance ($R\theta_{c\text{-}hs}$) based on modeled data.

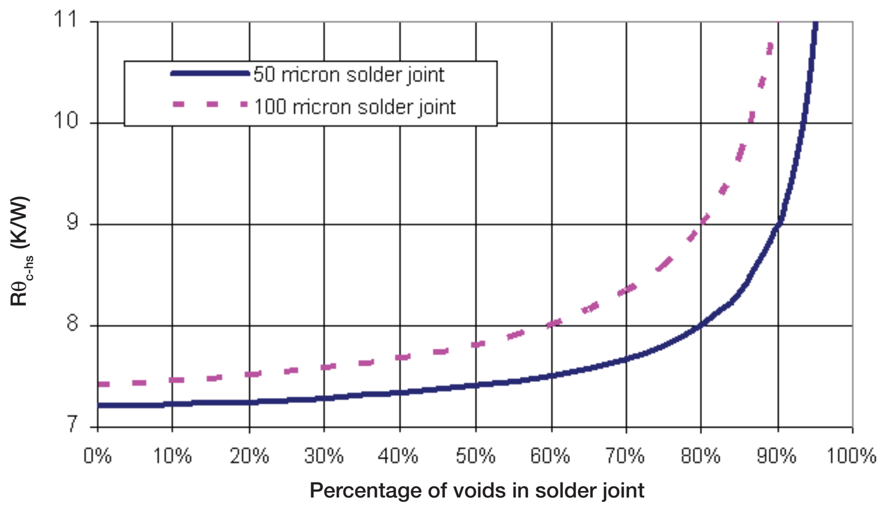


Figure 31. Impact of voiding in thermal land on thermal resistance for open via design.

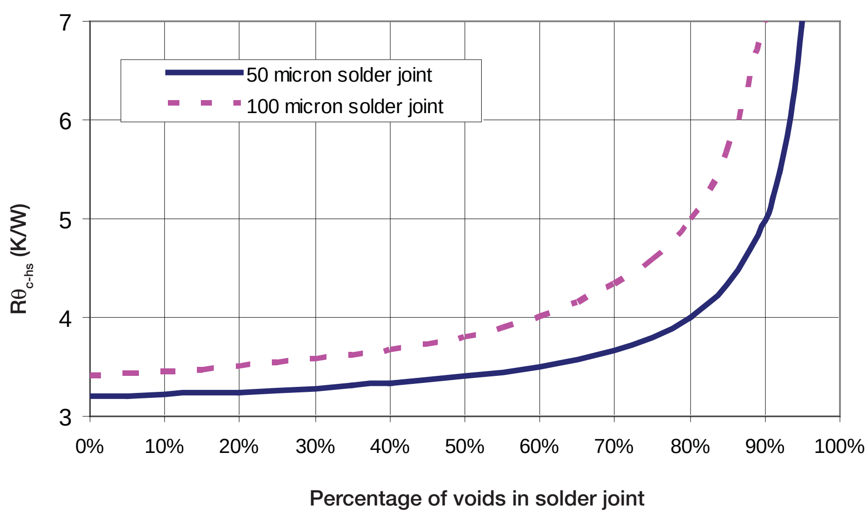


Figure 32. Impact of voiding in thermal land on thermal resistance for filled and capped via design.

For visual inspection of solder wetting, solderability indicators have been designed in the footprint, see Figure 33.

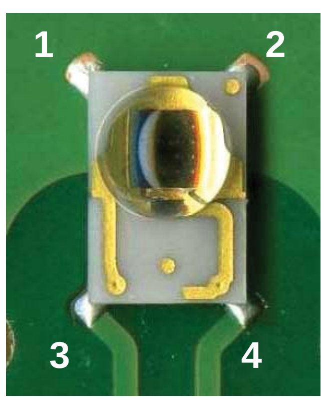


Figure 33. LUXEON Rebel reflowed into PCB with four solderability indicators.

6. JEDEC Moisture Sensitivity Level

LUXEON Rebel LEDs have a JEDEC moisture sensitivity level of 1. This is the highest level offered in the industry and highest level within the JEDEC standard.

This provides the customer with ease of assembly. The customer no longer needs to be concerned about bake out times and floor life. No bake out time is required for a moisture sensitivity level of 1.

Moisture sensitivity level 1 allows the device be reflowed three times under the specifications as described in the LUXEON Rebel datasheet (DS56).

JEDEC has defined eight levels for moisture sensitivity, as shown in Table 3.

Table 3. JEDEC Moisture Sensitivity Levels.

Level	Floor Life		SOAK REQUIREMENTS			
			Standard		Accelerated Equivalent [1]	
	Time	Conditions	Time (hours)	Conditions	Time (hours)	Conditions
1	Unlimited	≤ 30°C / 85% RH	168 +5/-0	85°C 85% RH		
2	1 year	≤ 30°C / 60% RH	168 +5/-0	85°C 60% RH		
2a	4 weeks	≤ 30°C / 60% RH	6962 +5/-0	30°C / 60% RH	120 +1/-0	60°C / 60% RH
3	168 hours	≤ 30°C / 60% RH	1922 +5/-0	30°C / 60% RH	40 +1/-0	60°C / 60% RH
4	72 hours	≤ 30°C / 60% RH	962 +2/-0	30°C / 60% RH	20 +0.5/-0	60°C / 60% RH
5	48 hours	≤ 30°C / 60% RH	722 +2/-0	30°C / 60% RH	15 +0.5/-0	60°C / 60% RH
5a	24 hours	≤ 30°C / 60% RH	482 +2/-0	30°C / 60% RH	10 +0.5/-0	60°C / 60% RH
6	Time on Label (TOL)	≤ 30°C / 60% RH	TOL	30°C / 60% RH		

Company Information

LUXEON® is developed, manufactured and marketed by Philips Lumileds Lighting Company. Philips Lumileds is a world-class supplier of Light Emitting Diodes (LEDs) producing billions of LEDs annually. 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 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 LED technology and the lighting world. Philips Lumileds technology, LEDs and systems are enabling new applications and markets in the lighting world.

Philips Lumileds may make process or materials changes affecting the performance or other characteristics of our products. These products supplied after such changes will continue to meet published specifications, but may not be identical to products supplied as samples or under prior orders.

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