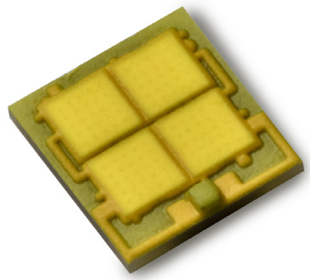
LUMILEDS

GENERAL ILLUMINATION

# LUXEON MZ

Assembly and Handling Information



## Introduction

This application brief addresses the recommended assembly and handling procedures for LUXEON MZ emitters. LUXEON MZ emitters are designed to deliver high luminous flux and efficacy from a compact optical source, enabling tighter beam control and higher punch due to a smaller apparent source size. Proper assembly, handling, and thermal management, as outlined in this application brief, ensure high optical output and long lumen maintenance for LUXEON MZ emitters.

## Scope

The assembly and handling guidelines in this application brief apply to the following products with this part number designation as described below.

| LMZA-BCDE-FGHJ | |
|---|---|
| Where: | |
| a – | designates minimum CRI (7 = 70, 8 = 80, 9 = 90) |
| b – | Four LED chips electrical configuration<br>(S = all four chips are electrically connected in series, resulting in 12V forward voltage) |
| c – | designates color designation (W = White, R = Royal Blue) |
| de – | designates nominal CCT (27 = 2700K, 30 = 3000K, etc) |
| fghi – | minimum flux lumen (optional) |

In the remainder of this document the term LUXEON MZ refers to any product in the LUXEON MZ product family.

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# 1. Component

## 1.1 Description

The LUXEON MZ emitter (see Figure 1) consists of four InGaN LED die packed in 2x2 array mounted onto a ceramic substrate. This substrate provides mechanical support and thermally connects the LED die to a thermal pad on the bottom of the substrate. An electrical interconnect via connects the LED die to a cathode and anode on the bottom of the ceramic substrate.

Each LUXEON MZ emitter includes a transient voltage suppressor (TVS) chip to protect the emitter against electrostatic discharges (ESD). The TVS chip creates some minor topographical variations across the top surface of the LUXEON MZ emitters.

The entire top surface of the LUXEON MZ is covered with a thin layer of silicone, with phosphor embedded, to shield the chip from the environment and to convert the blue light from the die into white light.

The bottom of the LUXEON MZ emitter contains four metallization pads, a large electrically isolated thermal pad in the center, an anode, a cathode, and a small pad with a laser engraved LED serial number in standard 2D data matrix code (electrically isolated). The pad with the serial number is not designed to be soldered onto a PCB.

## 1.2 Optical Center

The LUXEON MZ theoretical optical center is located 1.88mm away from the short edge of LUXEON MZ, opposite to the TVS and 2.00mm from the long edge of LUXEON MZ (see Figure 2). Note that this optical center is not the same position as the mechanical package center.

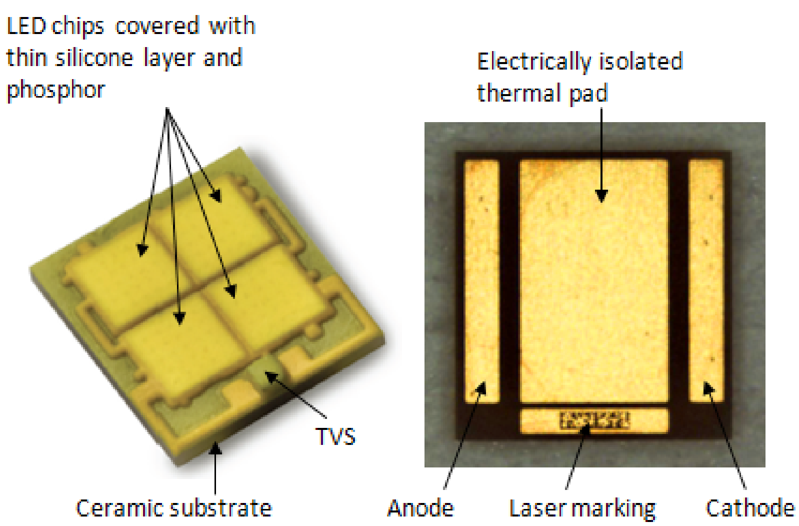



**Figure 1. Top view (left) and bottom view (right) of LUXEON MZ emitter. The pad with laser marking should not be soldered onto a PCB.**

Optical rayset files for LUXEON MZ are available from our website: www.lumileds.com.

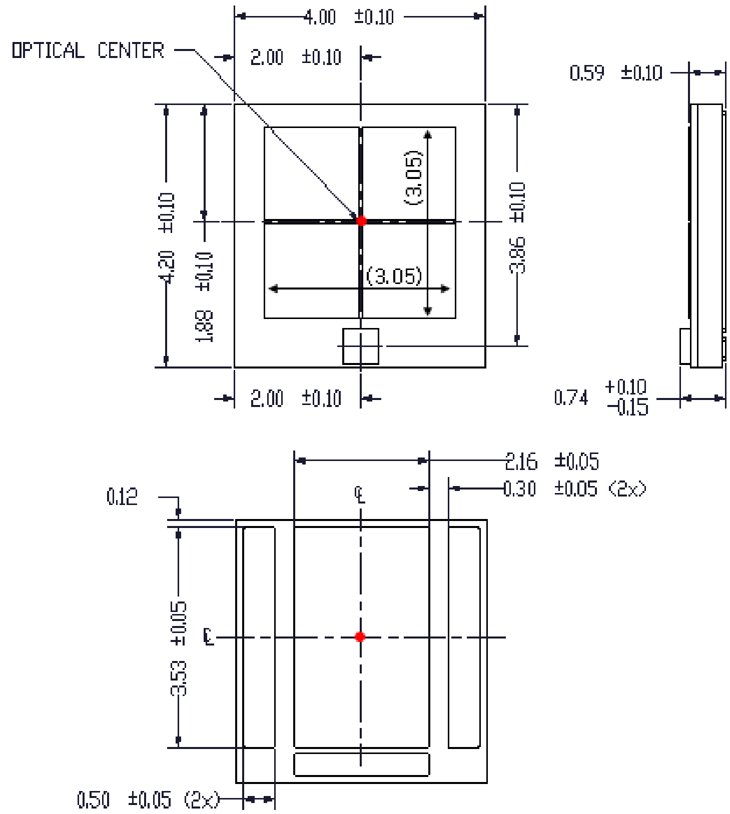



**Figure 2. The theoretical optical center of LUXEON MZ is shown as red dot on both the top and bottom drawing of the emitter.**

## 1.3 Handling Precautions

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

When handling finished boards containing LUXEON MZ emitters, do not touch the top surface with fingers or apply any pressure to it. Also, do no turn over the board for probing, if the electrodes are at the back of the board, or stack multiple boards on top of each other (see Figure 4). A rough or contaminated surface, being placed against the top of a LUXEON MZ emitter, may damage the silicone overcoat of the emitter. Furthermore, any pressure applied onto the LUXEON MZ emitter during probing may damage the silicone layer or the die underneath.

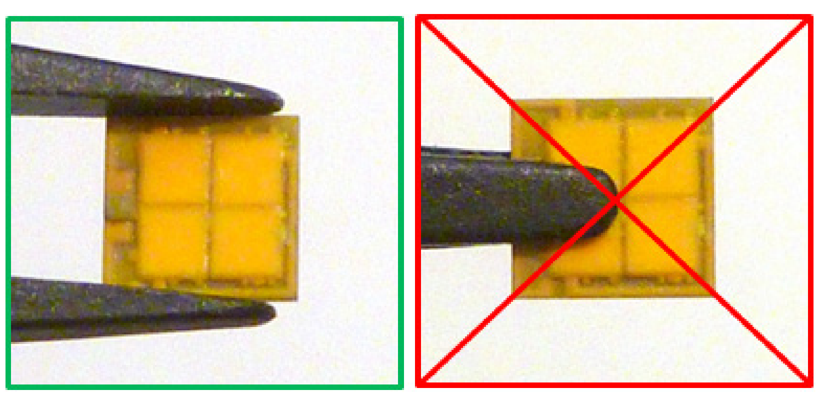


**Figure 3. Correct handling (left) and incorrect handling (right) of LUXEON MZ emitters.**

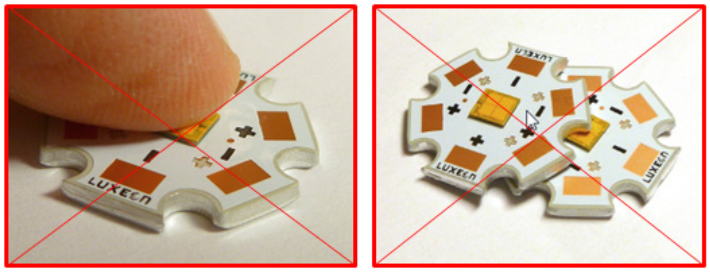


**Figure 4. Do not touch the top surface of a LUXEON MZ emitter when handling a finished board (left). Do not stack boards with one or more LUXEON MZ emitters on top of each other (right).**

## 1.4 Cleaning

LUXEON MZ should not be exposed to dust and debris. Excessive dust and debris may cause a drastic decrease in optical output. In the event that the surface of a LUXEON Z ES emitter requires cleaning, a compressed gas duster at a distance of 6" away will be sufficient to remove the dust and debris or an air gun with 20 psi (at nozzle) from a distance of 6". Make sure the parts are secured first.

## 1.5 Electrical Isolation

The thermal pad of the LUXEON MZ is electrically isolated from its cathode and anode. Consequently, a high voltage difference between electrical and thermal metallization may occur in applications where multiple LUXEON MZ emitters are connected in series. As a reference, the nominal distance between the electrical metallization and the thermal metallization of the LUXEON MZ emitter is 0.3mm.

In order to avoid any electrical shocks and/or damage to the LUXEON MZ 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 3-D STEP file drawing for LUXEON MZ is available from the Lumileds website: www.lumileds.com.

## 1.7 Soldering

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

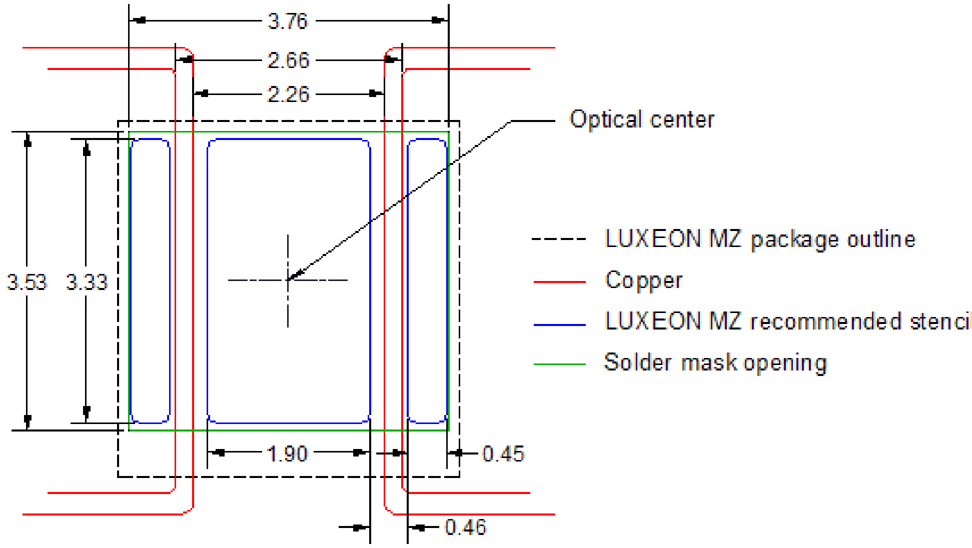



**Figure 5. Recommended LUXEON MZ footprint design. All dimensions in mm.**

# 2. LUXEON MZ Printed Circuit Board Design Rules

The LUXEON MZ emitter is designed to be soldered onto a Metal Core PCB (MCPCB) or a ceramic PCB. FR4 is not recommended due to its poor thermal resistance performance and a higher cost of making FR4 board with filled and capped thermal vias which can best served by MCPCB. To ensure optimal operation of the LUXEON MZ emitter, the PCB should be designed to minimize the overall thermal resistance between the LED package and the heat sink.

## 2.1 LUXEON MZ Footprint and Land Pattern

The LUXEON MZ emitter has three pads that need to be soldered onto corresponding pads on the PCB to ensure proper thermal and electrical operation. The pad with the laser engraved serial number is not designed to be soldered onto the PCB. Figure 5 shows the recommended footprint design for the solder mask and the copper layout on a Metal Core PCB. Lumileds recommends extending the thermal pad and electrodes at least 10mm from the center of the LUXEON MZ LED to maximize heat spreading into the PCB.

The recommended LUXEON MZ PCB footprint layout is similar to LUXEON M.

## 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

A minimum edge to edge spacing between LUXEON MZ emitters of 0.2mm can be achieved when using a pick and place machine with placement accuracy of less than ±0.05mm. However, placing multiple LUXEON MZ emitters too close to each other may adversely impact the ability of the PCB to dissipate the heat from the emitters. Thermal design must be considered when designing a tightly packed LUXEON MZ array, see section 3.

# 3. Thermal Management

The overall thermal resistance between the LUXEON MZ emitter and the heat sink is strongly affected by the design and material of the PCB on which the LUXEON MZ emitter is soldered.

Table 1 summarizes the general characteristics of various PCB material systems available for LEDs.

## 3.1 PCB designs for LUXEON MZ

**Table 1: General PCB material characteristics**

| | FR4* | MCPCB | CERAMIC PCB |
|---|---|---|---|
| Cost | Low to medium | Medium | High |
| PCB thermal resistance performance | Low to medium. Due to higher cost for a filled and capped via board and poor thermal performance, FR4 is not recommended for LUXEON MZ | Medium to excellent | High to excellent |
| Coefficient of thermal expansion (CTE) | Good CTE matching to LUXEON MZ substrate | Moderate CTE matching to LUXEON MZ substrate | Good CTE matching to LUXEON MZ substrate |
| LED assembly packing density (thermal resistance consideration) | Suitable for low density applications with large spacing between LEDs and operating at low drive current | Suitable for medium density applications with moderate spacing between LEDs | Suitable for high density applications with minimal spacing between LEDs |
| Mechanical assembly and handling | Easy as board does not easily break | Easy as board does not easily break | Extra precaution to prevent ceramic breakage (hard and brittle) |
| Supplier availability | High | High | Limited |

Notes:
1. *Provided here for comparison purpose only. Lumileds does not recommend the use of FR4 for LUXEON MZ.

Figure 6 shows various PCB board constructions. Each of these constructions has its own merits as discussed below.

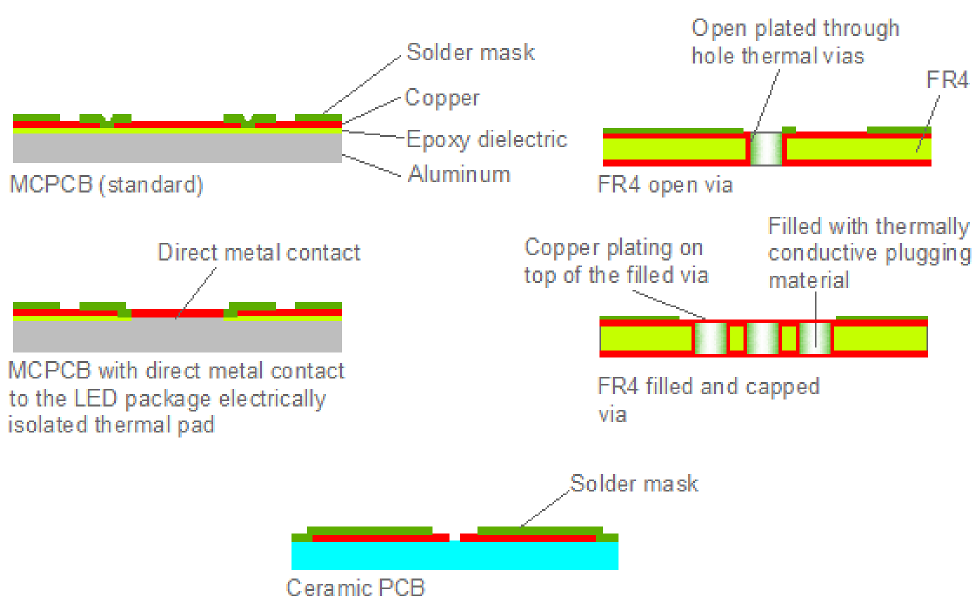



**Figure 6. Schematic cross-section of MCPCB (left), FR4 (right) and ceramic (bottom) board constructions. Drawing not to scale but to illustrate the important aspect of each board design.**

### Metal Core PCB

The most common MCPCB construction consists of the following layers:

- Metal substrate. Typically aluminum substrate. In some application, copper substrate is also used which has better thermal conductivity than aluminum (401 Wm-1K-1 versus 237 Wm-1K-1) but is more expensive.
- Epoxy dielectric layer. This layer is typically engineered to improve the thermal conductivity from the top metal foil to the metal substrate. The typical thermal conductivity for this layer is between 1 and 3 Wm-1K-1. This layer also functions as an electrical barrier during hipot test. The thickness of this layer is critical (75mm to 100mm are common) and impacts both the thermal resistance and the ability of the board to withstand a hipot test. Note that these two parameters are inversely related, i.e. a higher hipot test value, which can be achieved by increasing the dielectric thickness layer will have a negative impact on the PCB thermal resistance.
- Top copper layer. A thickness of 1oz (35μm) or 2oz (70μm) is most common.
- Solder mask. White reflective solder mask is desirable to maximize light output extraction.

Another factor which may impact the PCB thermal resistance is the size of the top copper layer around the LUXEOM MZ thermal pad. A direct metal contact of the metal substrate to the LUXEON MZ thermal pad directly without any epoxy dielectric layer in between can further reduce the MCPCB thermal resistance significantly as shown in the left-middle drawing in Figure 6. Such board provides the best thermal resistance. However, the hipot test between the metal substrate and the LUXEON MZ electrode pads need to be considered.

### FR4 PCB

FR4 board construction (not recommended for use with LUXEON MZ) consists of the following layers:

- FR4 (fiber glass reinforced epoxy laminate) sheet. This material has excellent electrical insulation properties but has a very poor thermal conductivity.
- Top and bottom copper layers. A thickness of 1oz (35μm) or 2oz (70μm) is most common.
- Solder mask. White reflective solder mask is desirable to maximize light output extraction.

In order to increase the thermal performance of FR4 boards, employing thermal vias will reduce the thermal resistance significantly. Two common approaches include:

- (i) open vias with plated through holes
- (ii) filled and capped thermal vias as shown in Figure 6. This gives better thermal performance than open via design.

It is important to determine the minimum number of thermal vias and via diameter for optimum thermal performance. Adding more thermal vias beyond this minimum quantity will not reduce the PCB thermal resistance significantly but may increase PCB manufacturing cost and may mechanically weaken the PCB board. Due to added complexity and the cost of making such FR4 board, it is better to design MCPCB board for LUXEON MZ assembly.

### Ceramic PCB

Ceramic PCB construction consists of the following layers:

- Ceramic substrate. Alumina ($Al_2O_3$) or aluminum nitride (AlN) are typically used. The thermal conductivity of Alumina ranges from 20 to 30 $Wm^{-1}K^{-1}$, depending on the content of the alumina material in the substrate. The thermal conductivity of aluminum nitride ranges from 170 to 230 $Wm^{-1}K^{-1}$ depending on the additives added during the ceramic manufacturing process.
- Top copper layer
- Solder mask. White reflective solder mask is desirable to maximize light output extraction.

Since ceramic has an excellent thermal conductivity but very poor electrical conductitivity, the LED thermal pad can be directly attached to the ceramic via copper and solder layer,  allowing LEDs to be closely packed. This makes ceramic very attractive in high density packaging.

However ceramic is brittle and require extra handling precaution during assembly and handling.

## 3.2 Other Thermal Assembly and Design Considerations

Thermal Interface Materials (TIM) Selection

Once the suitable PCB board material and design has been made, the choice of TIM material selection should be made with the following considerations:

- Pump out. Some TIMs will move out of the thermal path during extreme temperature excursions and create voids in the thermal path. These materials should not be used.
- TIM thickness. Excessive thickness of some TIMs will present an unacceptable thermal resistance even though the thermal conductivity of the material may be high.
- Surface roughness. In order to fill the air gaps between adjacent surfaces, choose the appropriate TIM that minimizes the interfacial contact resistance.
- Operating temperature. Some TIMs perform poorly at elevated temperatures. Care should be exercised to select a TIM that will perform well under the anticipated operating conditions.
- Out-gassing. Out-gassing of some TIMs at design temperatures may produce undesirable optical or appearance qualities (e.g. fogging) in a sealed system. Special consideration must be given to limit this effect.
- Clamping force. TIMs such as thermal tape or pads perform better when the right pressure is applied.

**LED Component Spacing (Density)**

Depending on the drive current and intended LED spacing, the right PCB material must be chosen. FR4 based board requires large LED to LED spacing, follows by MCPCB and ceramic PCB for optimum thermal performance. As more LEDs are packed closely together, thermal crowding effect becomes more important and will affect the ability of the PCB to dissipate heat.

**Electrical Power Distribution**

PCB electrical (copper) trace width and length (routing) can affect thermal performance. If the copper trace is too narrow and long, there is more voltage drop across the copper trace (power dissipation = current x voltage) and more heat is generated. In LED array configuration, the PCB area where the trace is generating more heat will lead to increase operating junction temperature of the neighboring LEDs. This will cause poor light output uniformity.

After selecting the PCB material to use, as a general rule of thumb, layout the copper trace first such that the most optimum thermal performance can be achieved and then figure out  how to route the electrical traces. In some network topology, it may be necessary to make the LUXEON MZ thermal pad electrically active. Figure 7 and Figure 8 illustrate the impact of copper trace length and width on overall system thermal performance.

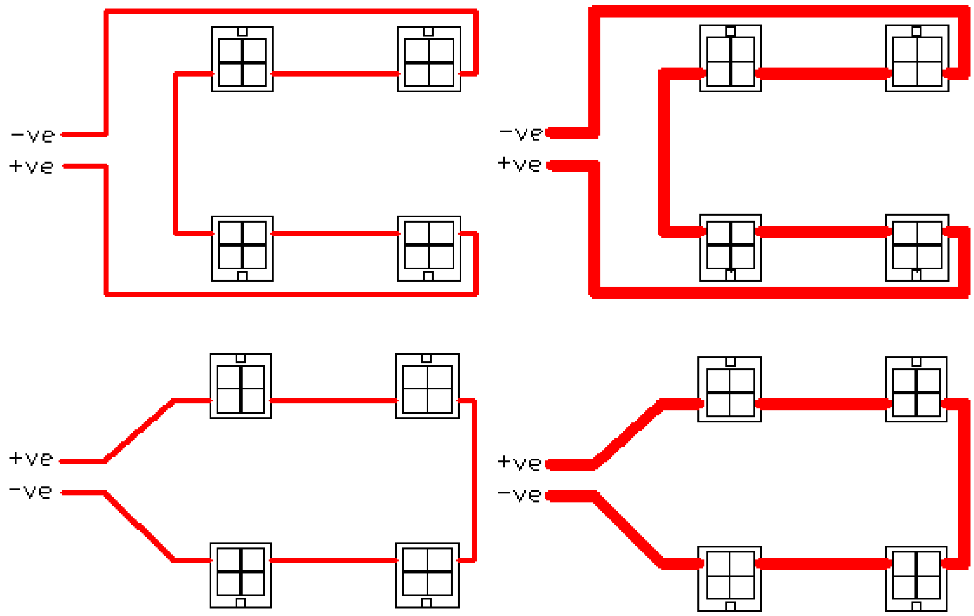



Figure 7. Top left shows long copper trace length (red lines) with narrower trace width. Top right shows the same layout as the left drawing but with wider trace width. The latter minimizes heat generated in the copper trace. Bottom left and right shows optimize trace route (shortest). Depending on the operating drive current of the LED system and the electrical layout of the LEDs (parallel-series), the copper trace width may need to be adjusted depending on the amount of current flowing through each section of the trace. See Figure 8 for this example.

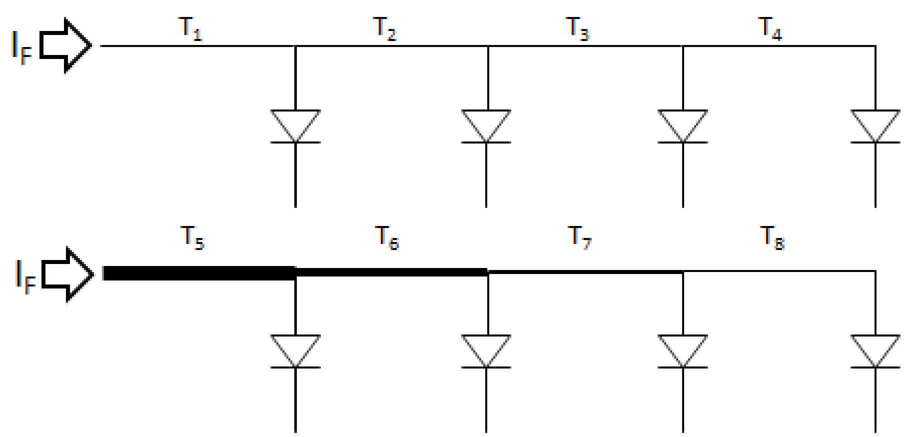



Figure 8. Top and bottom drawing each show four LEDs connected in parallel. Each LED is assumed to have the same forward voltage and same current flowing. $T_1$ to $T_8$ sections represent copper trace width. Thicker line means wider copper trace width. Top drawing has poor electrical layout since more heat is generated in $T_1$ than $T_2$, etc due to higher current flowing in $T_1$ than $T_2$, etc. Temperature in $T_1 > T_2 > T_3 > T_4$. Bottom drawing represents good electrical layout. Since more current flows in $T_5$ than $T_6$, the trace width in $T_5$ is made correspondingly larger than $T_6$ and so on. Much easier will be to make the trace width the same (larger) for all of $T_5$ to $T_8$. Note that as the copper trace area is increased, this may lead to increase PCB board capacitance and may interact with other transient tests such as electrical surge immunity test.

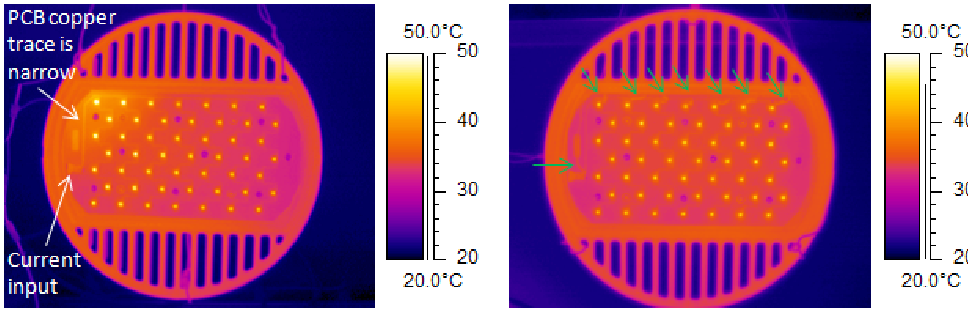



**Figure 9. A real life example of an application design concept as described in Figure 8. Left and right pictures are thermal images of the same board. The narrow PCB copper trace as indicated in the left picture carries very high current to feed several LEDs connected in parallel. Right picture with green arrows shows a modified electrical trace routing (in this case, soldering the right wire size to each node of the LEDs). Notice that the right picture shows more uniform temperature distribution than the left picture after adjusting the electrical power distribution to each LED.**

## 3.3 Thermal Resistance Results

Lumileds evaluated the thermal resistance of an Al-MCPCB star board as shown in Figure 10 with the following configuration: 1.6mm thick aluminum substrate, 1 oz top copper, dielectric thickness of 0.08mm and dielectric thermal conductivity of 2.7$Wm^{-1}K^{-1}$. This design yields a typical thermal resistance of 3.2 K/W when measured from LUXEON MZ thermal pad to bottom of MCPCB star board (heat sink).

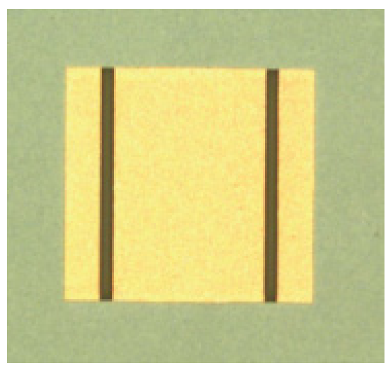


**Figure 10. LUXEON MZ Al-MCPCB pads layout showing the cathode, thermal and anode pads (left to right).**

# 4. Thermal Measurement Guidelines

## 4.1 Thermal Basics

This section provides general guidelines on how to determine the junction temperature of a LUXEON MZ emitter in a 1-up configuration in order 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 the thermal pad for LUXEON MZ is specified in the LUXEON MZ datasheet. In LUXEON MZ, most of the heat is conducted via the large thermal pad at the base of the package. 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 $P_{electrical}$ is the electrical power going into the LUXEON MZ emitter and $T_{thermal\ pad}$ is the temperature at the bottom of the LUXEON MZ thermal pad.

## 4.2 Temperature Sensor Pad ($T_s$) and Thermocouple (TC) Attachment

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 LUXEON MZ junction temperature is by measuring the temperature $T_s$ of a predetermined sensor pad on the PCB right next to the LUXEON MZ emitter with a thermocouple (TC). The junction temperature can then be calculated as follows:

$$T_j = T_s + R\theta_{j\text{-}s} \cdot P_{electrical}$$

In the above equation $P_{electrical}$ is the combined electrical power going into the LUXEON MZ emitter. The thermal resistance from junction to the $T_s$ point, $R\theta_{j\text{-}s}$ ,depends on several factors such as the PCB type and construction (e.g. MCPCB dielectric layer thickness), the location of the $T_s$ point, type and volume of the adhesive used to attach the TC wire, and the LED emitter packing density.

To ensure accurate readings, the TC must make direct contact with the copper of the PCB onto which the LUXEON MZ thermal pad is soldered, i.e. any solder mask or other masking layer must first be removed before mounting the TC onto the PCB. The TC must be attached as close as possible to the primary heat flow path of the LED emitter pad. In LUXEON MZ, this will be the position closest to the short edge and opposite the TVS location of LUXEON MZ as shown in Figure 11

Lumileds recommends has successfully used a two-part Artic Silver™ thermal adhesive in combination with a TC wire gauge of AWG 40 or 36. Excessive dispense of thermal adhesive may impact the accuracy of the $T_s$ temperature reading. In particular, if the thermal adhesive spills over onto the top of the package or blocks some side light, the $T_s$ reading may increase due to absorption of the optical energy (Figure 12). The use of non-conductive thermal epoxy is not recommended since there may be a possibility of getting some epoxy residue underneath the TC wire tip and the exposed PCB copper trace which will affect the $R\theta_{j\text{-}s}$ measurement.

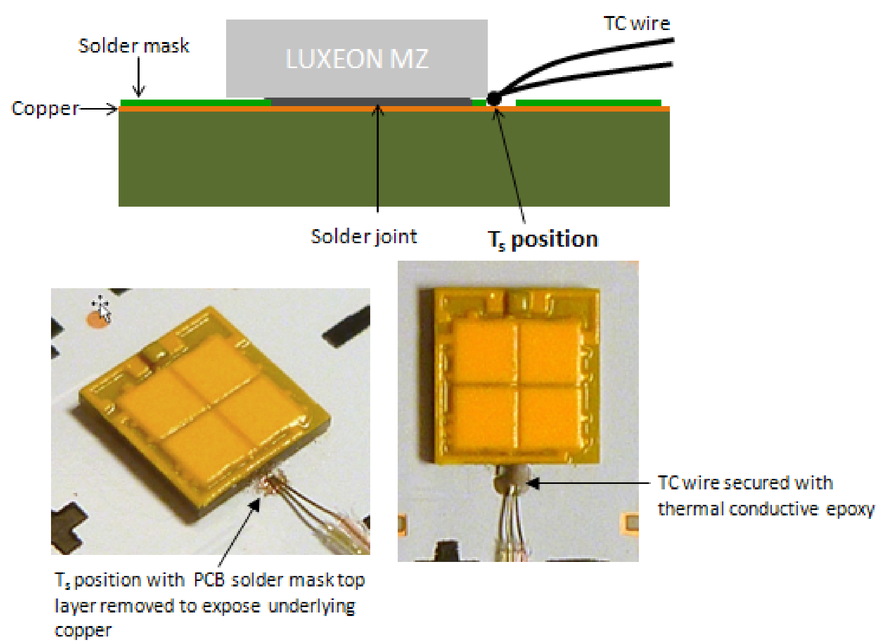



**Figure 11. Diagram showing the recommended location of $T_s$ point (top). Bottom left shows the TC wire in contact with the copper layer of the thermal pad on LUXEON MZ and bottom right shows the proper dispensed amount of thermal conductive epoxy.**

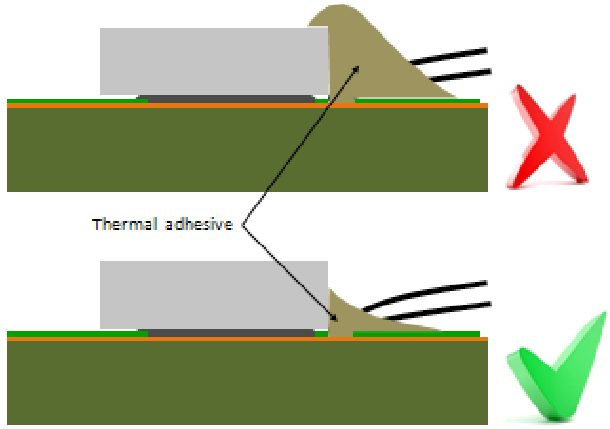



**Figure 12. Top diagram shows spillover of thermal adhesive to the top of the package. Bottom diagram shows good amount of thermal adhesive coverage to secure the TC wire.**

## 4.3 Effect of Placing $T_s$ point Further Away from LED Package

As described in 4.2, one of the factors that can affect the $T_s$ measurement is its location. Ideally the most accurate method to determine $T_j$ is by placing the TC wire directly underneath the center of the thermal pad and then using the typical LED package thermal resistance, which is widely quoted published in any an LED datasheet, to calculate the $T_j$.

Such measurements are difficult to make in real life situation, so the next best step is to place the TC wire as close as possible to the thermal pad.

Figure 13 shows a representative thermal simulation of a LED emitter package. This simulation highlights the impact of the calculated $R\theta_{j\text{-}s}$ if the $T_s$ points are located at two different locations ($T_{s1}$ and $T_{s2}$). To characterize $R\theta_{j\text{-}s}$, Lumileds selected $T_{s1}$ location since this is the closest to the LED package thermal pad when it comes to actual placement of TC wire. Once the $R\theta_{j\text{-}s}$ value is known at location $T_{s1}$, if the actual TC wire is then misplaced at location $T_{s2}$, the calculated junction temperature, $T_j$ will be under-estimated.

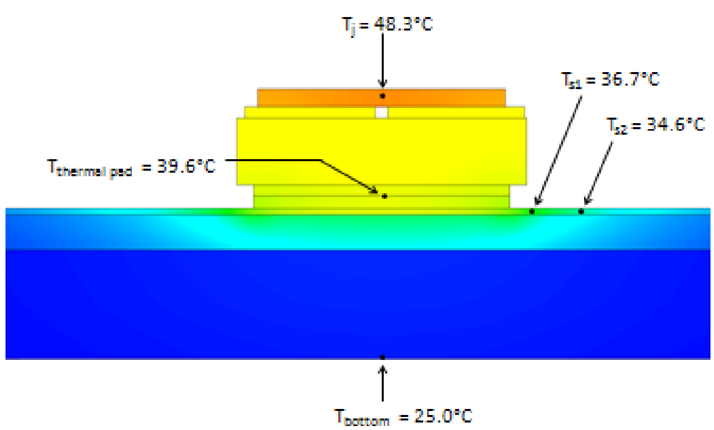



**Figure 13. Representative of thermal simulation of a typical LED package mounted on MCPCB, showing the contour temperature on one cross section through the LED package.**

## 4.4 Thermal Measurement Result

A 1.6mm thick Al-MCPCB star board with 1 oz top copper, dielectric thickness of 0.08mm and dielectric thermal conductivity of 2.7$Wm^{-1}K^{-1}$ as described in section 3.3 was used in the characterization of the $T_s$ point thermal resistance ($R\theta_{j\text{-}s}$). This value was experimentally determined to be 2.3K/W for this Al-MCPCB star board design.

For other PCB designs, an experiment or thermal simulation may need to be conducted to determine ($R\theta_{j\text{-}s}$).

$$T_j = T_s + (2.3K/W) \cdot P_{electrical}$$

# 5. Assembly Process Guidelines

## 5.1 Stencil Design

Figure 14 shows the recommended stencil design for LUXEON MZ. The recommended stencil thickness is 125µm.

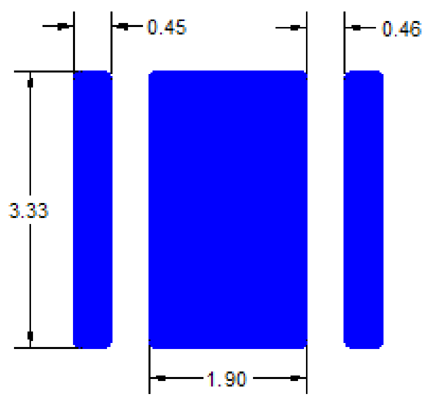



**Figure 14. Recommended stencil design for LUXEON MZ. All dimensions in mm.**

## 5.2 Solder Paste

Lumileds recommends a lead-free no clean solder paste to mount LUXEON MZ emitters onto a PCB. Lumileds successfully tested a solder paste from Alpha® SAC305-CVP390-M20 type 3. 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.

## 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. Note, though, that any enlargement in the solder mask opening for anode and cathode pads may reduce the solder reflow placement accuracy.

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, 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

## 5.4 Pick-and-Place

Automated pick and place equipment provides the best placement accuracy for LUXEON MZ emitters. Figure 16 and Figure 17 show various pick and place nozzle designs and corresponding machine settings for Juki and Samsung machines which were successfully tested for LUXEON MZ. Each nozzle is designed to pick the LUXEON MZ emitter up from the flat area outside the TVS as shown in Figure 15. The TVS is higher than the surrounding area as depicted in the mechanical dimension drawing of Figure 2 and must be avoided during nozzle tip placement.

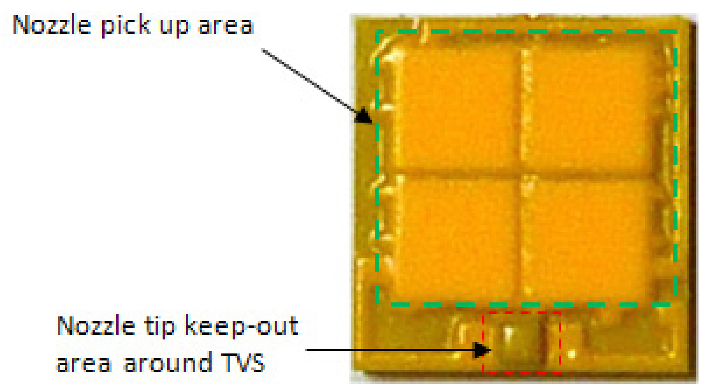
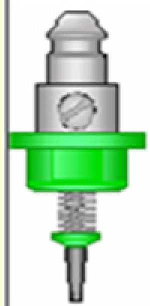



**Figure 15. Nozzle pick-up location area for LUXEON MZ emitters. Avoid the TVS area.**

Note that pick and place nozzles are customer specific and are typically machined to fit specific pick and place tools. Based on these pick and place experiments. Lumileds advises customer to take the following general pick and place guidelines into account:

- The nozzle tip should be clean and free of any particles since this may interact with the silicone coating of the LUXEON MZ during pick and place.
- During setup and the first initial production runs, it is a good practice to inspect the top surface of LUXEON MZ emitters under a microscope to ensure that emitters are not accidentally damaged by the pick and place nozzle.

Since LUXEON MZ has no primary optics or lens which can act as a mechanical enclosure protection for the LED die, the pick-up and placement force applied to the top of the package should be kept to minimum. The placement force (consisting of impact force and dwell force, also known as static force), to name a few depends on the nozzle tip material, nozzle spring stiffness, nozzle diameter, vacuum pressure, over travel distance, PCB height differences and PCB warping.

| No. | 504 |
|---|---|
| Appearance |  |
| Outer | ϕ1.5mm |
| Inner Diameter | ϕ1.0mm |

| PICK AND MOUNT INFORMATION | |
|---|---|
| Placing stroke | 0 mm |
| Picking stroke | 0 mm |
| XY speed | Fast2 |
| Picking z down | Fast2 |
| Picking z up | Fast2 |
| Placing z down | Fast2 |
| Placing z up | Fast2 |
| Laser position | -0.11 mm |

| VISION INFORMATION | |
|---|---|
| Centering method | Laser |
| Comp shape | Corner Square |
| | |
| | |
| | |
| | |
| | |
| | |

**Figure 16. Pick and place nozzle design ("504") and machine settings for Juki KE-2080L. All dimensions in mm.**


| PICK AND MOUNT INFORMATION | |
|---|---|
| Pick Height | 0 mm |
| Mount Height | 0 mm |
| Delay – Pick Up | 30 msec |
| Delay - Place | 40 msec |
| Delay - Vac Off | 0 msec |
| Delay – Blow On | 0 msec |
| Speed – XY | 1 |
| 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 | Pick & Mount |
| Mount Method | Normal |

| VISION INFORMATION | |
|---|---|
| Camera No | Fly Cam6 |
| Side | 4 |
| Outer | 5 |

**Figure 17. Pick and place nozzle design (CN140) and machine settings for Samsung SM421.**

## 5.5 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 18). Electric feeders often also contain a control panel which allows an operator to adjust 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. Figure 19 shows the feeder design of Samsung and Juki pick and place machines used in this study.

For information, 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. 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.

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.

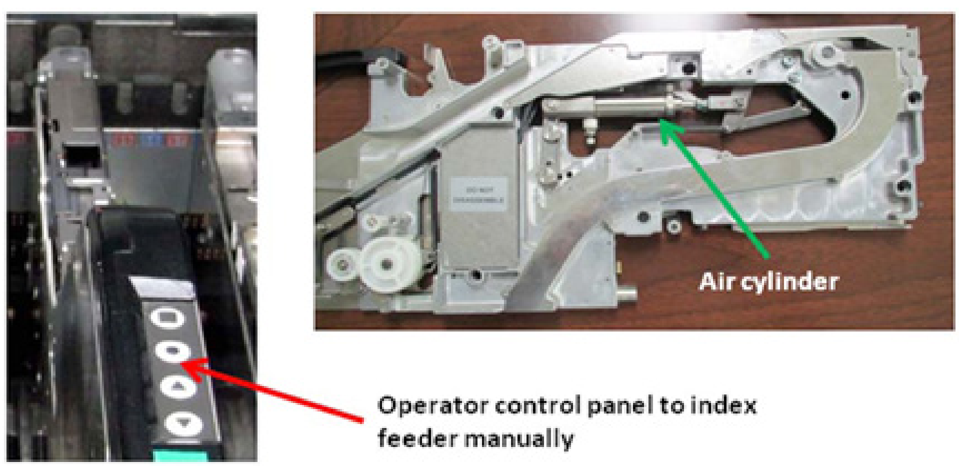



**Figure 18. Examples of an electric feeder (left) and a pneumatic feeder (right) which are typically used in pick and place machines to advance the tape with LEDs.**

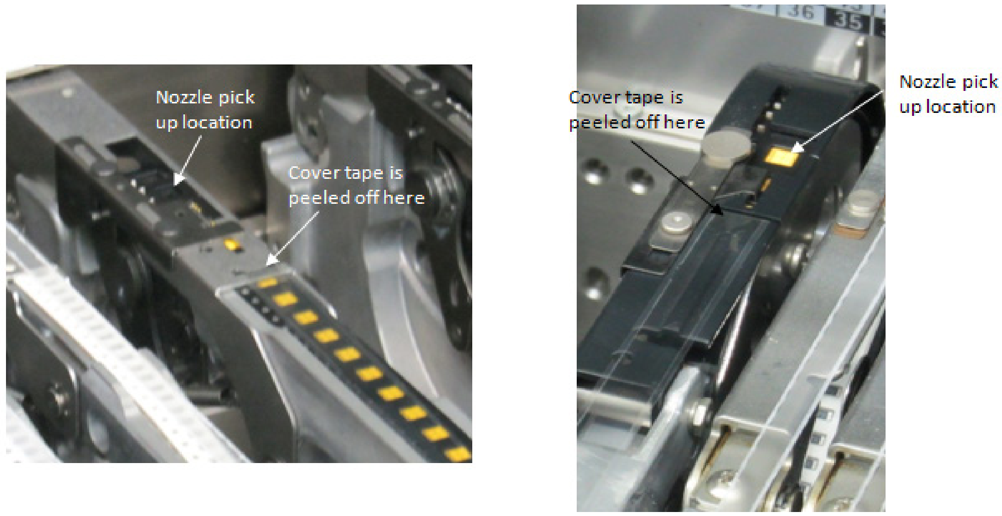



**Figure 19. Examples of feeder designs used in LUXEON MZ pick and place study here.
Left is Samsung SM421 and right is Juki KE-2080L pick and place feeders.**


**Figure 20. Pneumatic feeder with integrated air pressure control valve (left)
and modification made to the pneumatic feeder by installing air pressure control valve (right).**

## 5.6 Solder Reflow Profile

The LUXEON MZ 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.

As a point of reference, the melting temperature for SAC 305 is 217°C, and the minimum peak reflow temperature is 235°C. For detailed information on the recommended reflow profile, refer to the IPC/JEDEC J-STD-020C reflow profile in the LUXEON MZ datasheet.

### 5.7 Placement and Reflow Accuracy

In order to achieve the highest placement accuracy Lumileds recommends using an automated pick and place tool with a vision system that can recognize the bottom metallization pads of the LUXEON MZ emitter. The pads size and location are shown in Figure 2.

Using a pick and place machine with placement accuracy of ±0.05mm, a minimum component spacing of 0.2mm can be achieved.

### 5.8 JEDEC Moisture Sensitivity Levels

LUXEON MZ emitters 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 ensures ease of use since the user no longer needs to be concerned about bake out times and floor life.

## 6. Packaging Considerations – Chemical Compatibility

The LUXEON MZ package contains a silicone overcoat and dome to protect the LED chips and extract the maximum amount of light. 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 LUXEON MZ 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 MZ 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. Under heat and “blue” light, the VOCs inside the silicone coating may partially oxidize and create an appearance of 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 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 3 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 affect LED performance.

The chemicals in Table 3 are typically not directly used in the final products that are built around LUXEON MZ LEDs. 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 3. List of commonly used chemicals that will damage the silicone dome of LUXEON MZ. 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 |

RoHS COMPLIANT

# About Lumileds

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

For 100 years, Lumileds commitment to innovation has helped customers pioneer breakthrough products in the automotive, consumer and illumination markets.

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.

To learn more about our portfolio of light engines visit www.lumileds.com.

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