ILLUMINATION

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• LUXEON 3014

LUXEON 4014

Assembly and Handling Information

Introduction

This application brief addresses the recommended assembly and handling guidelines for LUXEON 4014 emitters. These emitters deliver high efficacy and quality of light for distributed light source applications in a compact 1.4mm x 4.0mm package. Proper assembly, handling, and thermal management, as outlined in this application brief, ensure high optical output and reliability of these emitters.

Scope

The assembly and handling guidelines in this application brief apply to the following LUXEON product(s):

- LUXEON 4014 (MXZx-PWxx-xxxx)

In the remainder of this document the term LUXEON emitter refers to any product in the LUXEON series listed above.

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1. Component

1.1 Description

The LUXEON 4014 emitter (Figure 1) consists of a 4014 lead-frame package with an anode and a cathode. A small notch on the corner of the package marks the cathode side of the emitter package. The anode and cathode both serve as thermal pads for the emitter, with the majority of the heat being dissipated through the larger pad, corresponding to the cathode. The LUXEON emitter does not include a transient voltage suppressor (TVS) chip to protect the emitter against electrostatic discharges (ESD). Appropriate precautions should therefore be taken when handling this device (see Section 5.5).

1.2 Optical Center

The optical center coincides with the mechanical center of the LUXEON emitter. Optical rayset data for the LUXEON emitter are available at lumileds.com.

1.3 Handling Precautions

The LUXEON emitter is designed to maximize light output and reliability. However, improper handling of the device may damage the silicone coating and affect the overall performance and reliability. In order to minimize the risk of damage to the silicone coating during handling, the LUXEON emitter should only be picked up from the side of the package (Figure 2).

1.4 Cleaning

The LUXEON emitter should not be exposed to dust and debris. Excessive dust and 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 coating. Do not use other solvents as they may adversely react with the package of the LUXEON emitter. For more information regarding chemical compatibility, see Section 6.

1.5 Electrical Isolation

The LUXEON emitter contains two electrode pads on the long side of the package. It is important to keep sufficient distance between the LUXEON emitter package and any other objects or neighboring LUXEON emitters to prevent any accidental shorts.

In order to avoid any electrical shocks, flashover 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 at lumileds.com.

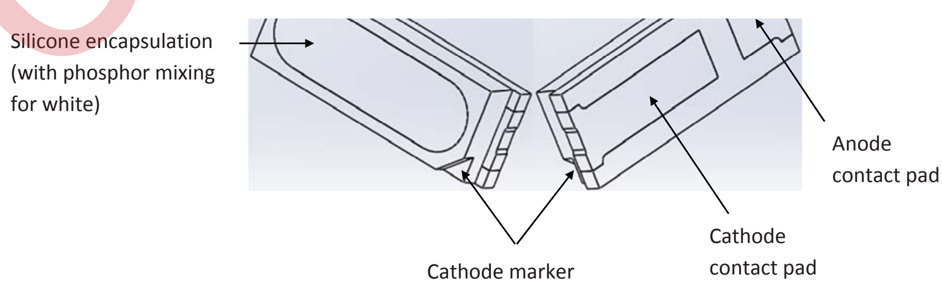


Figure 1. Package rendering of the LUXEON 4014 emitter.

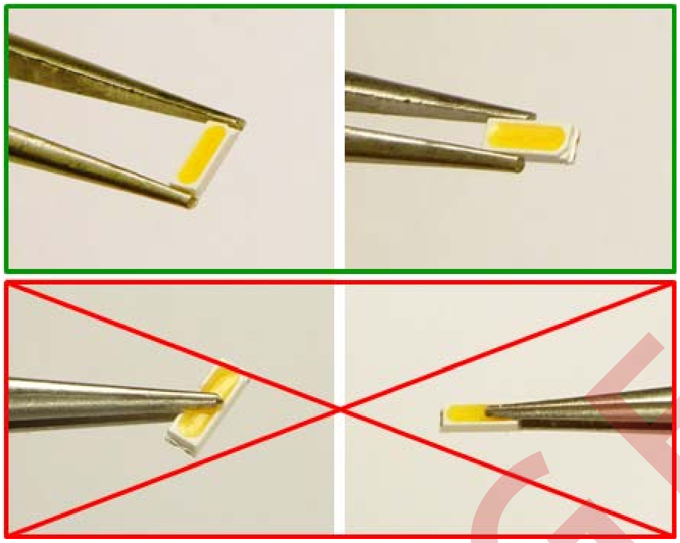


Figure 2. Correct handling (top) and incorrect handling (bottom) of LUXEON emitters.

2. PCB Design Guidelines for the LUXEON Emitter

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

2.1 PCB Footprint and Land Pattern

The recommended PCB footprint design for the LUXEON emitter is shown in Figure 3. In order to ensure proper heat dissipation from the emitter electrodes to the PCB, it is best to extend the top copper layer of the PCB beyond the perimeter of the LUXEON emitter by at least 4mm (see Section 3).

2.2 Surface Finishing

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

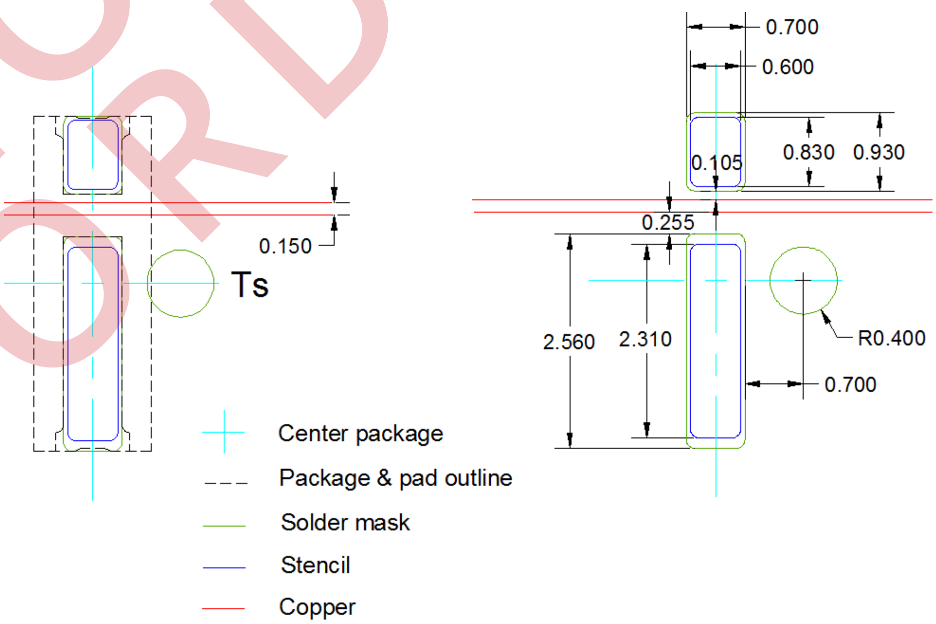


Figure 3. Recommended PCB footprint design for the LUXEON emitter. In order to ensure proper heat dissipation from the package electrodes to the PCB, it is best to extend the top copper layer of the PCB several millimeters beyond the package of the LUXEON emitter. See Section 3 for more information on the copper layout. All dimensions are in mm.

2.3 Minimum Spacing

Lumileds recommends a minimum edge to edge spacing between LUXEON emitters of 0.5mm. Placing multiple LUXEON emitters too close to each other may adversely impact the ability of the PCB to dissipate the heat from the emitters and may cause accidental shorts between the metal stubs on the side of neighboring LUXEON emitters.

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 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, if properly designed, yield an appropriate low-cost solution for various LED applications.

Lumileds investigated the thermal performance of LUXEON emitters on a 1.0mm thick FR4 PCB with a top copper plating of 35μm (single sided copper layer PCB). In order to quantify the impact of the top copper metallization design layout on the overall thermal resistance between junction and heat sink, three designs with varying copper trace layout around the anode and cathode were evaluated as shown in Table 1. The three designs are:

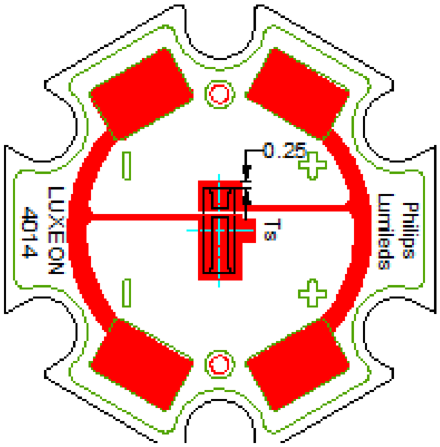
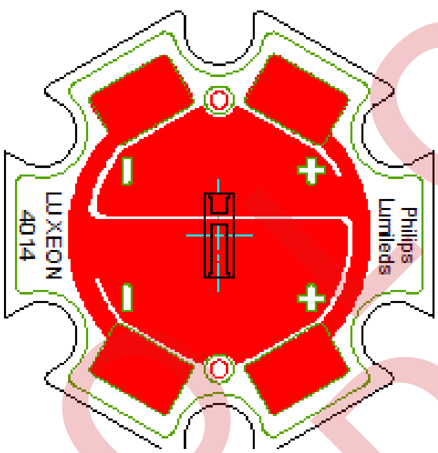
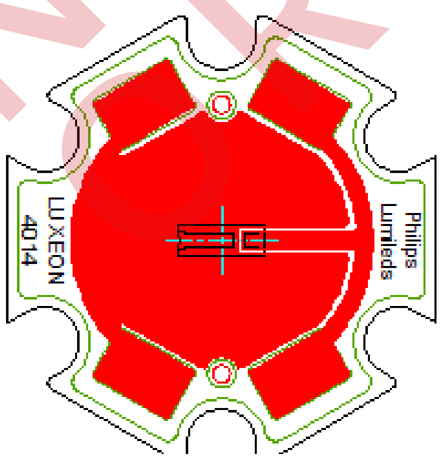
a. A – Minimum top copper corresponds to copper trace which extends beyond the outline of the LUXEON emitter package by 0.25mm which corresponds to half of the minimum recommended package to package spacing of 0.5mm. This configuration is representative for application where multiple LEDs are placed in close proximity to each other.

b. B – Maximize top copper equally around the anode and cathode pads of the LUXEON emitter package.

c. C – Maximize top copper around the cathode as much as possible. This is the ideal layout since the primary heat flow of the LUXEON emitter is through the cathode pad as described in section 1.1. This yields the lowest board thermal resistance.

As general guidelines, increasing the top copper thickness and increasing the copper area around the cathode will reduce the FR4 board thermal resistance. Adding a bottom copper layer to the FR4 does not reduce the FR4 thermal resistance since the FR4 material itself is a poor thermal conductor.

Table 1. Typical thermal resistance values for FR4 PCBs with varying top copper trace pattern (solid red area). Design C yields the lowest board thermal resistance.

DESIGN	TYPICAL $R\Theta_{J\text{-}BOTTOM\ PCB}$ [K/W]	TYPICAL $R\Theta_{J\text{-}S}$ [K/W]
A (mimimum copper pattern, 0.25mm around package outline) 	146	62
B (maximize copper equally around anode & cathode pads) 	81	50
C (maximize copper around cathode as much as possible) 	66	47

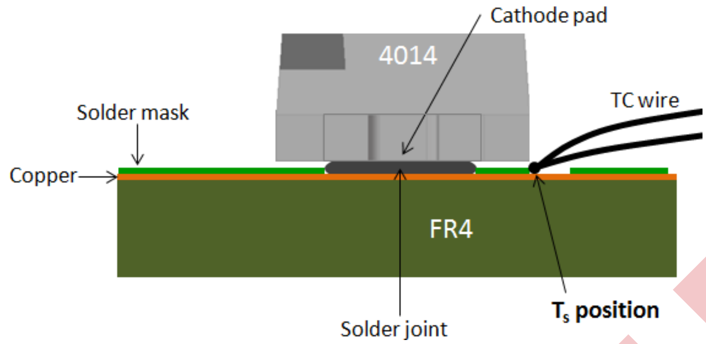


Figure 4. The recommended temperature measurement point T_s is located on the cathode copper layer of the PCB, closest to the package. The picture above shows where to place the welded tip of the 40 gauge TC wire prior to dispensing any thermal conductive epoxy to secure the TC wire.

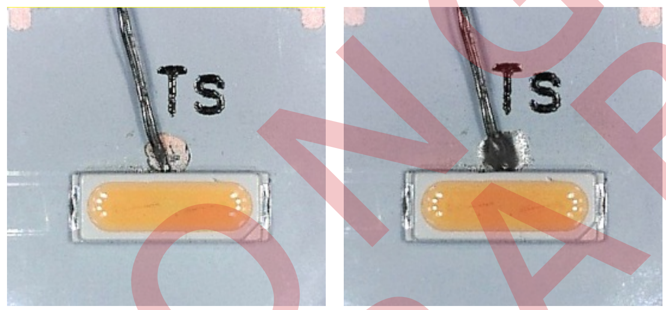


Figure 5. Left photo showing actual placement of TC wire and right photo showing the TS point secured with thermal conductive epoxy. The thermal epoxy volume should be kept as small as possible.

4. Thermal Measurement Guidelines

The typical thermal resistance $R\theta_{(j\text{-}case)}$ between the junction and the solder pads of the LUXEON emitter is provided in the datasheet. With this information, the junction temperature T_j can be determined according to the following equation:

$$T_j = T_{case} + R\theta_{(j\text{-}case)} \cdot P_{electrical}$$

In this equation T_{case} is the temperature at the bottom of the solder pads of the LUXEON emitter and $P_{electrical}$ is the electrical power going into the emitter. In typical applications it may be difficult, though, to measure the temperature T_{case} directly. Therefore, a practical way to determine the junction temperature of the LUXEON emitter is by measuring the temperature T_s of a predetermined sensor pad on the PCB with a thermocouple.

The recommended location of the sensor pad is right next to the cathode of the LUXEON emitter on the PCB, as shown in Figure 4 and Figure 5. To ensure accurate readings, the thermocouple must make direct contact with the copper of the PCB onto which the LUXEON emitter pads are soldered, i.e. any solder mask or other masking layer must be first removed before mounting the thermocouple onto the PCB. The thermal resistance $R\theta_{(j\text{-}s)}$ between the sensor pad and the LUXEON emitter junction was experimentally determined on FR4 PCBs with minimum and maximum metallization (see Table 1). The junction temperature can then be calculated as follows:

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

It is recommended to secure the tip of TC wire to the exposed copper area with a good thermal conductive epoxy such as Artic Silver™ thermal adhesive. Note that the Artic Silver™ epoxy is not formulated to conduct electricity. During dispensing of epoxy, avoid flooding the TC wire with too much epoxy but sufficient enough to secure the TC wire for measurement. Putting more epoxy than needed may change the thermal behavior of the surrounding area.

5. Assembly Process Guidelines

5.1 Stencil Design

The recommended solder stencil thickness is 125µm or 5mils.

5.2 Solder Paste

Lumileds recommends lead-free solder for the LUXEON emitter. Lumileds tested SAC 305 solder paste from Alpha Metals (SAC305-CVP390-M20 type 3) 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.

5.3 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 rapidly, 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.

5.4 Pick and Place

The LUXEON emitter is packaged and shipped in tape-and-reel which is compatible with standard automated pick-and-place equipment to ensure the best placement accuracy. Note that pick and place nozzles are customer specific and are typically machined to fit specific pick and place tools. Lumileds advises customer to take the following general pick and place guidelines into account:

a. The nozzle tip should be clean and free of any particles since they may interact with the top surface of the silicone encapsulation of the LUXEON emitter package.

b. During setup and the first initial production runs, it is a good practice to inspect the top surface of the LUXEON emitters under a microscope to ensure that the emitters are not accidentally damaged by the pick and place nozzle.

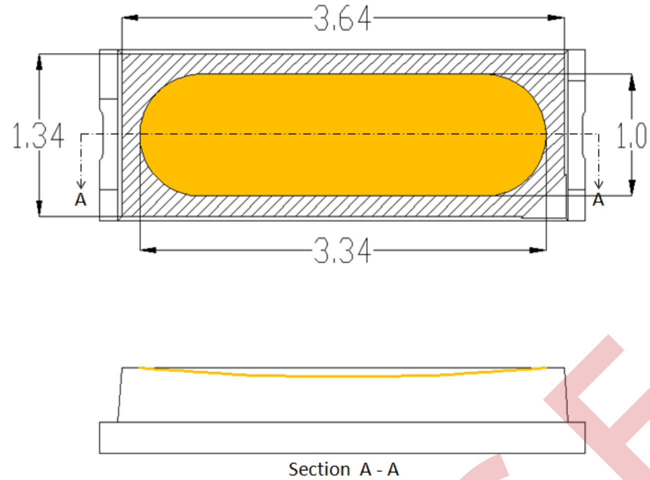


Figure 6. The recommended pick and place nozzle contact area as shown in the shaded area.

The top surface of the silicone encapsulation of the LUXEON emitter is not flat but with a depression as shown in Figure 6, section A-A. However we recommend the nozzle tip contact surface should be in contact with any of the shaded area as shown in Figure 6. Care should be taken to avoid nozzle tip with external diameter or outline that is smaller than the shaded area in Figure 6 (in both x and y) or larger than the LUXEON emitter pocket dimension (1.7 mm x 4.3 mm) as described in the emitter pocket dimension of datasheet DS205.

Figure 7 and Figure 8 list out the Samsung SM421 and Yamaha YV100X pick and place parameters used to successfully assembled LUXEON emitters on the recommended footprint.

Nozzle name	CN065
Shape	
Outer diameter	Φ 1.2
Inner diameter	Φ 0.65

PICK AND MOUNT INFORMATION	
Pick Height	0 mm
Mount Height	0 mm
Delay – Pick Up	30 msec
Delay - Place	40 msec
Delay - Vacuum 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	1
Soft Touch	Pick and Mount

VISION INFORMATION	
Camera No	Fly Cam6
Light - Side	8
Light - Outer	5

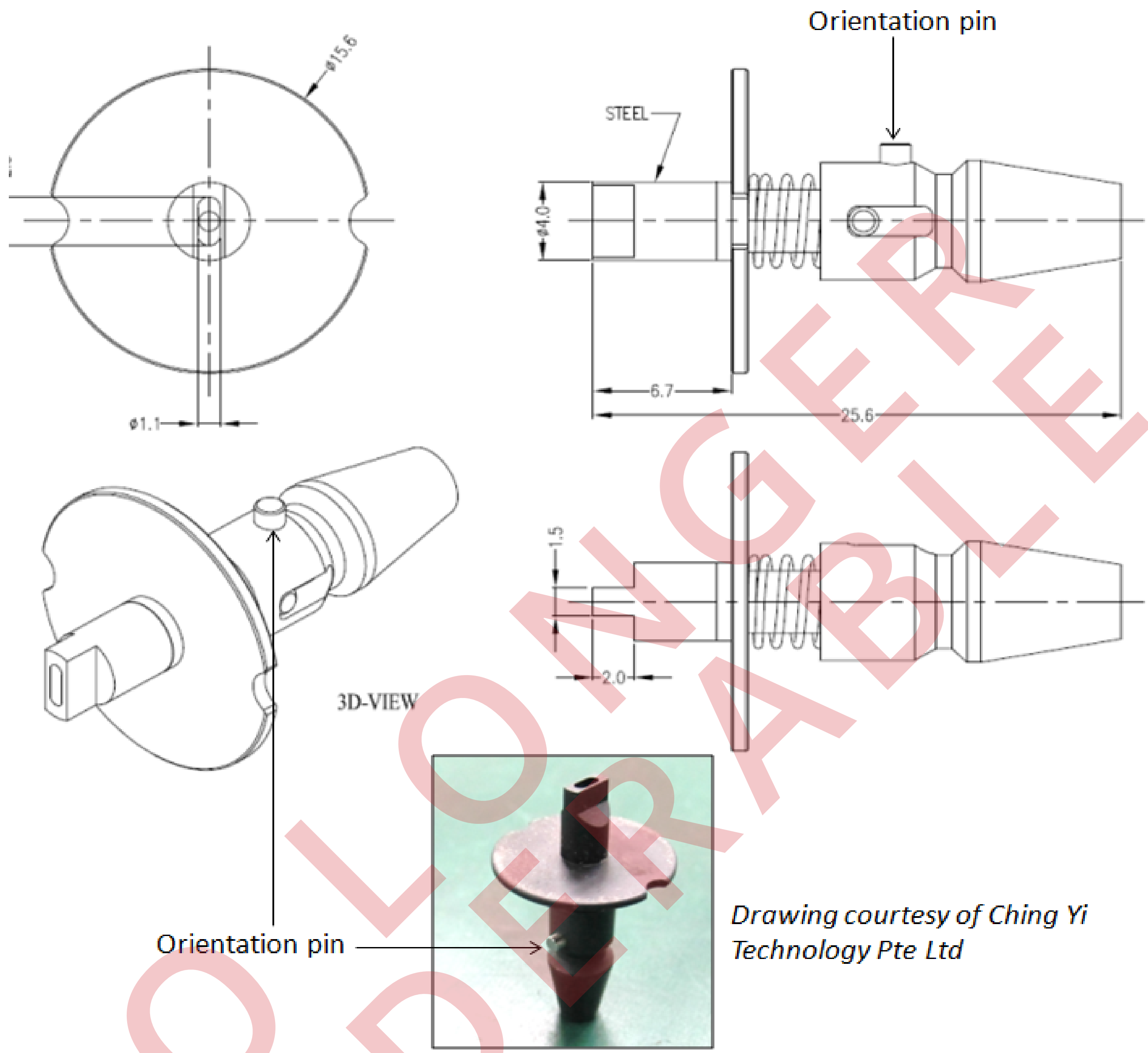
Figure 7. Pick and place nozzle design and corresponding machine settings for Samsung SM421 in combination with the standard off-the-shelf nozzle "CN065".

PICK AND MOUNT INFORMATION	
Pick timer	0 s
Mount timer	0 s
Pick height	0 mm
Pick action	QFP
Mount height	0 mm
Mount action	Normal
Mount speed	100%
Pickup speed	100%
Vacuum Check	Normal Chk
Pick Vacuum	20%
Mount vacuum	60%

VISION INFORMATION	
Alignment group	Special
Alignment type	Odd. Chip
Alignment module	Fore & Back & Las
Light selection	Main + Coax
Lighting level	6/8
Comp. threshold	75
Comp. tolerance	15
Search area	2.5mm
Comp. intensity	N.A.
Auto threshold	Not Used

Figure 8. Pick and place nozzle design and corresponding machine settings for Yamaha YV100X in combination with the off-the-shelf nozzle "7WA".

Lumileds has also evaluated a customized nozzle for Samsung SM421 pick and place machine, if any issue is encountered with the standard off-the-shelf nozzle. Figure 9 shows the customized nozzle (part# SAM-0508 / 13; Drawing no. 12021B) from Ching Yi Technology (www.chingyi.com) which has been successfully tested.



Drawing courtesy of Ching Yi Technology Pte Ltd

Figure 9. A customized nozzle for Samsung SM421 pick and place machine with pick up contact area closely matching the shaded area in Figure 6.

5.5 Electrostatic Discharge Protection

The LUXEON emitter does not include a transient voltage suppressor (TVS) chip to protect against electrostatic discharges (ESD). Therefore, Lumileds recommends observing the following precautions when handling the LUXEON emitter:

- During manual handling always use a conductive wrist band or ankle straps when positioned on a grounded conductive mat.
- All equipment, machinery, work tables, and storage racks that may get in contact with the LUXEON emitter should be properly grounded.
- Use an ion blower to neutralize the static discharge that may build up on the surface and lens of the plastic housing of the LUXEON emitter during storage and handling.

LUXEON emitters which are damaged by ESD may not light up at low currents and/or may exhibit abnormal performance characteristics such as a high reverse leakage current, and a low forward voltage (leaky diode). It is also important to take note that ESD can also cause latent failure, i.e. failure or symptoms as described above may not show up immediately but until after use. Hence continuous ESD protection is needed during assembly.

5.6 JEDEC Moisture Sensitivity

LUXEON 4014 MSL (JEDEC moisture sensitivity level) is rated as level 2. Below is the general handling and storage procedure:

a. The maximum shelf life in sealed bag (unopened) is 24 months after the manufacturing date when stored at less than 40°C with maximum relative humidity (RH) of 90%.

b. If the bag is opened, the floor life of the parts will be 1 year when kept at less than 30°C at not more than 60% RH or stored in a dry cabinet with less than 10% RH.

c. Baking is required to drive moisture out if the enclosed humidity indicator card 60% spot mark has changed colors other than blue or any of the two criterion as described in item b. is not met.

d. If baking is required, the devices may be baked for 20 hours at 60 ± 5°C.

6. Packaging Considerations—Chemical Compatibility

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

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

Careful consideration must be given to whether LUXEON emitters are enclosed in an "air tight" environment or not. In an "air tight" environment, some VOCs that were introduced during assembly may permeate and remain in the silicone. Under heat and "blue" light, VOCs captured inside the silicone 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 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 2 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 2 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 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 2: List of commonly used chemicals that will damage the silicone 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

About Lumileds

Lumileds is the global leader in light engine technology. The company develops, manufactures and distributes groundbreaking LEDs and automotive lighting products that shatter the status quo and help customers gain and maintain a competitive edge.

With a rich history of industry "firsts," Lumileds is uniquely positioned to deliver lighting advancements well into the future by maintaining an unwavering focus on quality, innovation and reliability.

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