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ILLUMINATION

LUXEON 5050

Assembly and Handling Information

Introduction

This application brief addresses the recommended assembly and handling guidelines for LUXEON 5050 emitters. LUXEON 5050 is a multi-die, high power package that provides high luminance from a super robust package to enable cost effective, single optic and directional fixture designs. LUXEON 5050 uses an industry standard 5050 surface mount package and is available in 6V, 24V, and 30V configurations. Proper assembly, handling and thermal management, as outlined in this application brief, ensures high optical output and reliability of these emitters.

Scope

The assembly and handling guidelines in this application brief apply to LUXEON 5050 with the following part number designations:

L 1 5 0 – **A A B B** 5 0 **C C** 0 0 0 **D** 0

Where:

- **A A** – designates nominal ANSI CCT (22=2200K, 27=2700K, 30=3000K, 35=3500K 40=4000K, 50=5000K, 57=5700K, 65=6500K)
- **B B** – designates minimum CRI (70=70CRI, 80=80CRI, 90=90CRI)
- **C C** – designates voltage (06=6V, 24=24V, 30=30V)
- **D** – designates product type (0=Round LES, S=Square LES)

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 5050 emitter (Figure 1) consists of a 5050 plastic molded lead-frame package with anode and cathode pads. Heat is dissipated through both pads. The light emitting surface (LES) is encapsulated with silicone and phosphor to protect the chips and generate white light (Figure 1). The LUXEON emitter is ESD HBM rated at ≥2kV (JEDEC JS-001-2012) and does not include a transient voltage suppressor (TVS) chip.

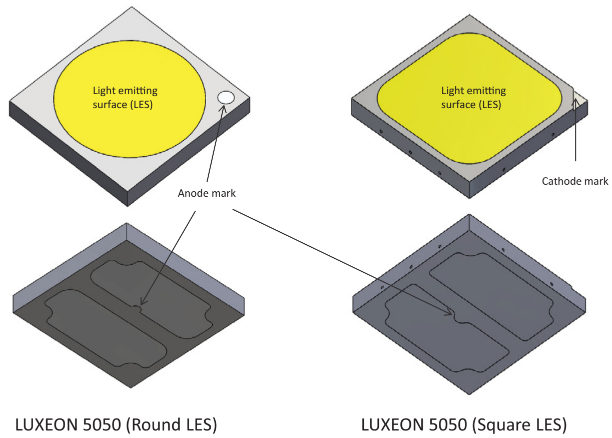

Figure 1. Package rendering of the LUXEON 5050 emitter.

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 on the Lumileds website at lumileds.com.

1.3 Handling Precautions

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

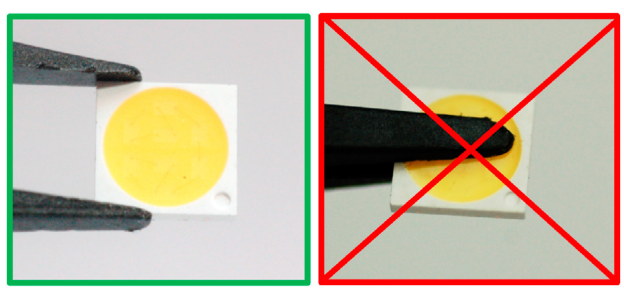

Figure 2. Correct tweezers handling of a representative LUXEON 5050 (left). Incorrect handling (right).

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 has two pads on the package bottom. On the LUXEON emitter, the exposed minimum creepage distance is between the anode and cathode pads. 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 on the Lumileds website at lumileds.com.

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 Figures 3a and 3b. In order to ensure proper heat dissipation from the emitter to Al-MCPCB for example, it is best to extend the top copper layer of the thermal pad of the PCB beyond the perimeter of the LUXEON emitter by at least 3mm.

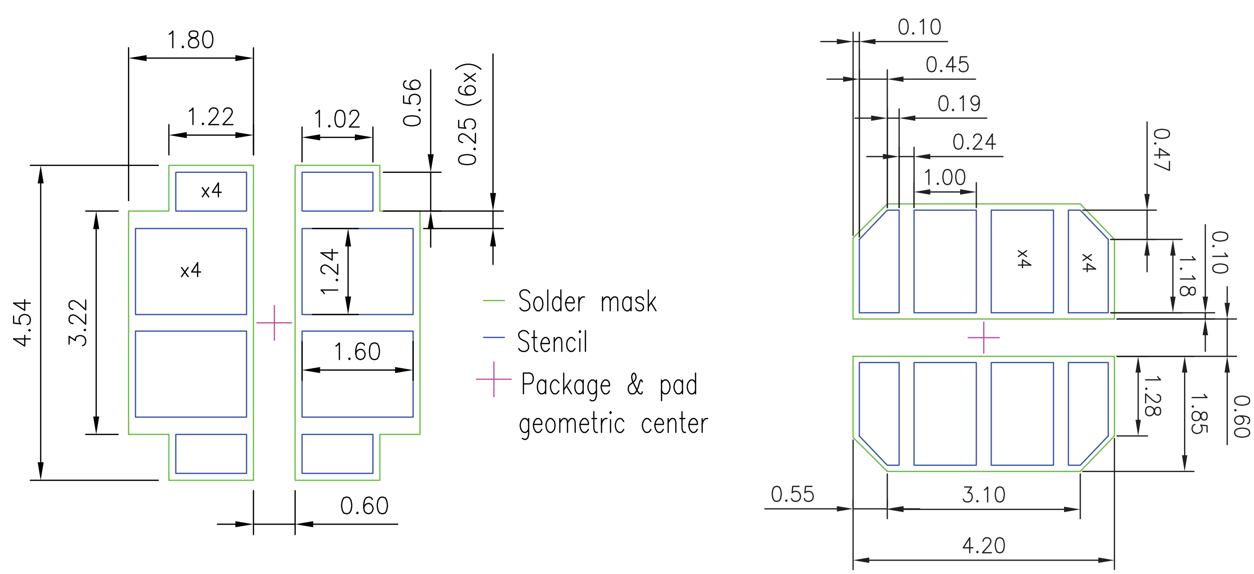

Figure 3a. Recommended PCB footprint showing solder mask and stencil opening for LUXEON 5050 (Round LES), left, and LUXEON 5050 (Square LES), right. Dimensions are in mm.

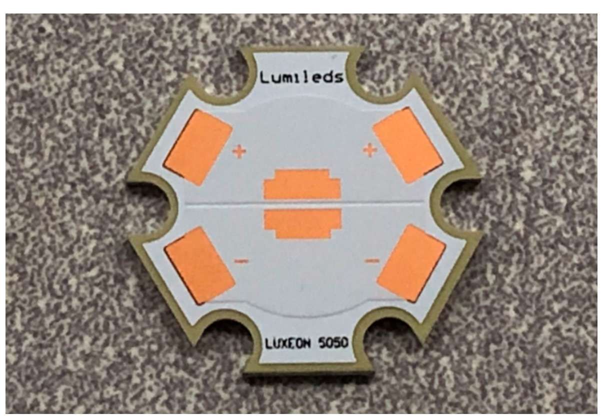

Figure 3b. An example of a LUXEON 5050 (Round LES) star board showing the LED electrode pad solder mask openings.

2.2 Solder Mask

A stable white solder mask finish (typically a polymer compound with inert reflective filler) with high reflectivity in the visible spectrum will typically meet most application needs. The white finish should not discolor over time when exposed to elevated operating temperatures. Customers are encouraged to work with their PCB suppliers to determine the most suitable solder mask options which can meet their application needs.

2.3 Surface Finishing

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

2.4 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.

2.5 PCB Quality and Supplier

Select PCB suppliers that are capable of delivering the required level of quality. At a minimum the PCBs must comply with IPC standard (IPC-A-600H, 2010 "Acceptability of Printed Boards").

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. Al-MCPCBs have been historically used in the LED industry for their low thermal resistance and rigidity.

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 pad of LUXEON 5050 emitter, as shown in Figure 4. To ensure accurate readings, the thermocouple (TC) tip must close contact to the copper of the PCB onto which the LUXEON emitter thermal pad is soldered, i.e. any solder mask or other masking layer must be first removed before mounting the thermocouple onto the PCB. The tip of the TC wire should be placed as close as possible to the LUXEON emitter package on the exposed copper layer of the thermal pad. The thermal resistance $R\theta_{j\text{-}s}$ between the sensor pad and the LUXEON emitter junction was experimentally determined based on the MCPCB with the following construction: 2oz copper, 0.1mm dielectric with thermal conductivity of 3 W/(m.K). The junction temperature can then be calculated as follows:

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

where the typical $R\theta_{j\text{-}s}$ is 6.1 K/W for LUXEON 5050 (Round LES) and 2.6K/W for LUXEON 5050 (Square LES).

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. Make sure to dispense sufficient epoxy onto the TC to secure it on the PCB. However, do not flood the TC with epoxy. Putting more epoxy than needed may change the thermal behavior of the surrounding area.

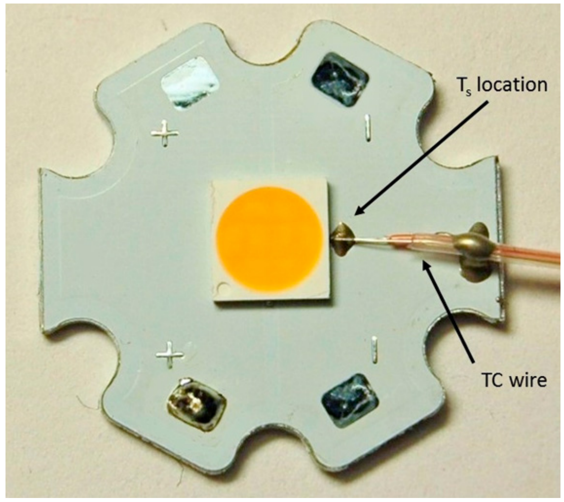

Figure 4. Actual placement of TC wire secured with thermal conductive epoxy. The thermal epoxy volume should be kept to minimum as shown.

5. Assembly Process Guidelines

5.1 Stencil Design

The recommended solder stencil thickness is 0.127mm or 5mils.

5.2 Solder Paste

Lumileds recommends lead-free solder for the LUXEON emitter. Good results have been obtained with lead-free solders such as SAC 305 solder paste from Alpha Metals (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 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.

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 it 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 after reflow under a microscope to ensure that the emitters are not accidentally damaged by the pick and place nozzle.

Examples of nozzles evaluated are shown in Figure 5.

Possible Off-the-shelf Nozzle options:

- **Juki KE2080L machine: "506"**
- **Panasonic CM 402 machine: "4407"**
- **Samsung SM421 machine: CN400 might be suitable.** Requires individual validation. ***The nozzle's outer diameter is 6.2mm, bigger than pocket cavity by 1mm. Thus the nozzle cannot go into the pocket to pick up the LED. It needs to vacuum up the LED through an air gap of 0.25mm. There could be vacuum loss which could lead to poor pickup performance. Use of this off-the-shelf nozzle requires validation as results may vary.***

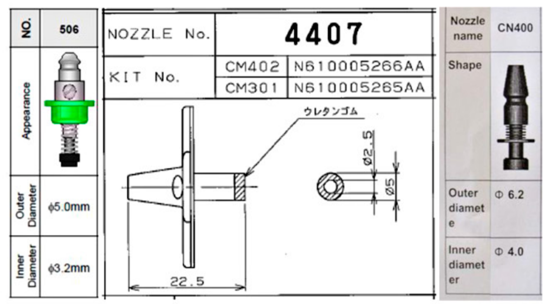

Figure 5. Examples of possible off-the-shelf nozzles.

5.5 Electrostatic Discharge Protection

The LUXEON emitter does not include any type of 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

The JEDEC moisture sensitivity level (MSL) for this LUXEON emitter is rated as level 3. Proper storage, handling and/or baking guidelines must be observed to prevent damage to the LUXEON emitter during reflow (see Table 2).

Table 2. Storage and baking conditions. Note that if any of the temperature, relative humidity, humidity indicator card or the period is not met, baking is required. For more information, see IPC/JEDEC J-STD-033C.

OPERATION	PACKING BAG STATUS	TEMPERATURE	RELATIVE HUMIDITY (RH)	HUMIDITY INDICATOR CARD	PERIOD
Storage	As received	≤30°C (non-condensing atmospheric environment)	≤90%	n/a	Within 12 months of shipment date code
Storage	After opening bag	≤30°C	≤60%	If 60% color spot is no longer blue	168 hours
Baking (drying)	n/a	60 ±5°C	≤5%	n/a	16 hours

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 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 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 3. 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
Acetic acid	acid
Hydrochloric acid	acid
Nitric acid	acid
Sulfuric acid	acid
Ammonia	alkali
Potassium hydroxide	alkali
Sodium hydroxide	alkali
Acetone	solvent
Benzene	solvent
Dichloromethane	solvent
Gasoline	solvent
MEK (Methyl Ethyl Ketone)	solvent
MIBK (Methyl Isobutyl Ketone)	solvent
Mineral spirits	solvent
Tetracholorometane	solvent
Toluene	solvent
Xylene	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 [1]
Acrylic tape	adhesive
Cyanoacrylate	adhesive

Note for Table 3:

1. Other than the use of no-clean solder paste qualified by customer. Avoid secondary solder flux, for example when manually soldering wires close to LUXEON emitter, the solder flux should not spit onto the LUXEON emitter surface or leaving excessive secondary solder flux residue onto the PCB when operating LEDs in an air tight enclosure or poorly ventilated enclosure.

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