LUXEON HR30

Assembly and Handling Information

Introduction

This application brief addresses the recommended assembly and handling guidelines for LUXEON HR30 emitter. This emitter is specifically designed and tested for use in the most demanding environments and conditions. This emitter delivers high efficacy and quality of light for distributed light source applications in a compact 3.0mm x 3.0mm 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 LUXEON 3030 HR30 with the following part number designation:

L130 – AABBCCHR00000	
Where:	
AA –	designates nominal ANSI CCT (27=2700K, 30=3000K, etc.)
BB –	designates minimum CRI (70=70CRI, 80=80CRI, etc.)
CC –	designated ESD protection level per JEDEC JS-001-2012 (00=2kV and 0T=8kV)

In the remainder of this document the term LUXEON emitter refers to any product in the LUXEON product series listed above. Any handling requirements that are specific to a subset of LUXEON emitters will be clearly marked.

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1. Component

1.1 Description

The LUXEON HR30 emitter (Figure 1) is a SMC (silicone resin molding compound) molded, no-lead, surface mount package consisting of a symmetrical anode and cathode pads. A small chamfer corner on the top of the package marks the cathode side of the emitter. The heat generated by the LED chips are being dissipated equally through both electrode pads. The silicone encapsulant protects the LED chips and the wire bonds against external environment. The lead frame and the pad finishes are plated with gold. This emitter is available with and without a transient voltage suppressor (TVS) chip.

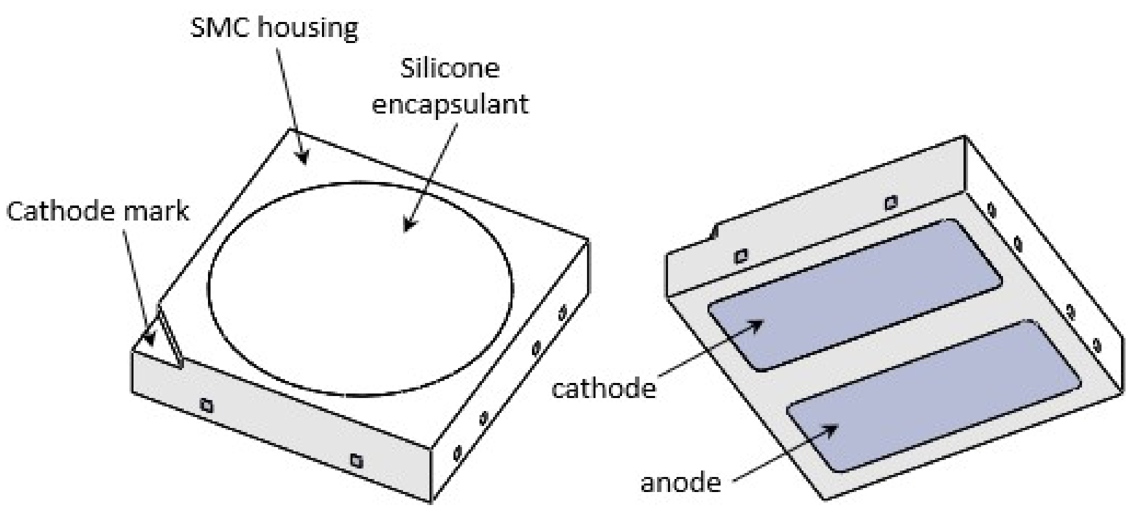


Figure 1. Package rendering of LUXEON HR30 emitter.

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 www.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).

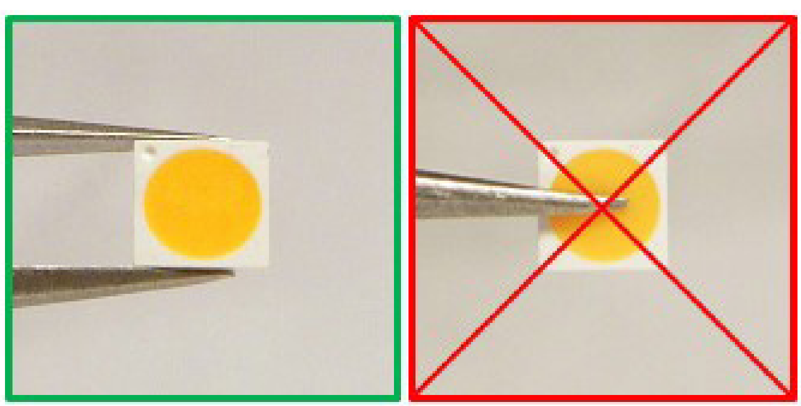


Figure 2. Correct handling (left) and incorrect handling (right) of LUXEON emitters.

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 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 files for the LUXEON emitter are available on the Lumileds website at www.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 heatsink.

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 (see 2.4).

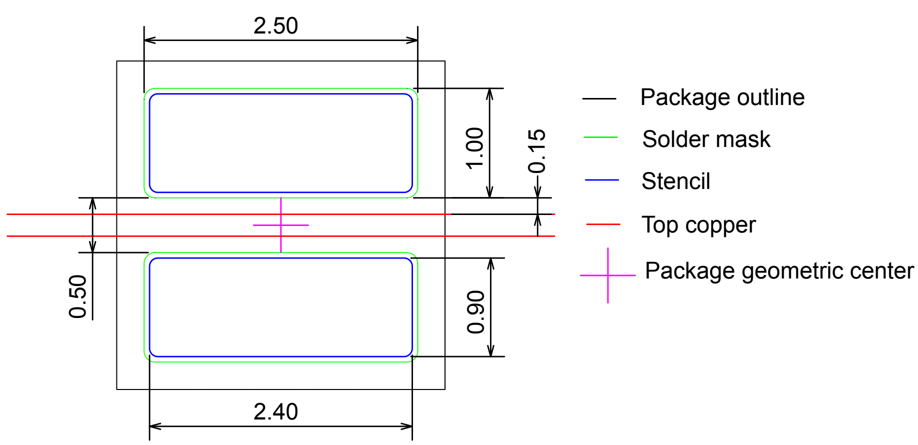


Figure 3. Recommended PCB footprint design for the LUXEON emitter. Dimensions are in mm.

2.2 Surface Finishing

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

2.3 Minimum Spacing

Lumileds recommends a minimum edge to edge spacing between LUXEON emitters of 0.5 mm. Placing multiple LUXEON emitters too close to each other may adversely impact the ability of the PCB to dissipate the heat from the emitters.

2.4 PCB Substrate Selection and Design

Table 1 provides a summary of various relevant performance characteristics of common PCB substrates to aid material selection. Specific PCB design considerations for each substrate material are summarized below.

Table 1: General PCB substrate characteristics for consideration when designing a PCB for LUXEON HR30 emitter.

	FR-4/CEM-3	MCPCB
Cost	Low to medium	Medium
PCB thermal conductivity performance	Low to high (FR4 with filled and capped vias but with increase cost)	High
LED assembly packing density (thermal resistance consideration)	Generally suitable for low density application with a large spacing between LEDs and/or low operating currents	Suitable for high density application with close spacing between emitters
Dielectric withstand voltage (top copper to bottom of substrate)	Extremely high (>20kV/mm)	Depends on dielectric material thickness and its property. Typically 4kV for 100um thick.

Metal Core PCB

The most common MCPCB construction consists of the following layers (Figure 4):

- A metal substrate, typically aluminum.
- Epoxy dielectric layer. This is the most important layer in the MCPCB construction as it affects the thermal performance and electrical breakdown strength. The typical thermal conductivity of the dielectric layer on a MCPCB is around $2Wm^{-1}K^{-1}$. A higher value is better for good thermal performance. A thinner dielectric layer is better for thermal performance but can negatively impact the ability of the MCPCB to withstand electrical insulation test to meet minimum electrical safety standards as required in certain lighting markets. The typical dielectric thickness layer is about 100µm.
- Top copper layer. A thicker copper layer improves heat spreading into the PCB but may pose challenges for PCB manufacturers when fabricating narrow traces or spaces. A thickness of 1oz (35µm) or 2oz (70µm) is common. For optimum thermal performance on both 1oz and 2oz copper design, the copper area should extend at least 4mm away from the package outline.
- Use of white solder mask.

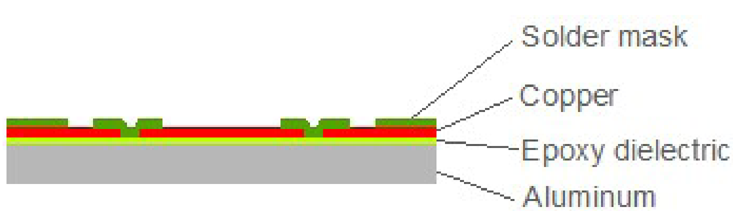


Figure 4. MCPCB typical cross section of the three-pad openings with aluminum substrate.

FR-4/CEM-3 PCB

FR-4/CEM-3 board construction consists of the following layers (Figure 5):

- FR-4 (woven fiber glass fabrics reinforced epoxy laminate, Figure 6) sheet or CEM-3 (composite epoxy material constructed from both woven and non-woven fiber glass fabrics, Figure 6). These two materials have excellent electrical insulation properties but have very poor thermal conductivity. Between these two, CEM-3 thermal conductivity is generally better than FR-4. For detail specifications of PCB, refer to a standard generated by Association Connecting Electronics Industries, (www.ipc.org), IPC-4101C "Specification for Base Materials for Rigid and Multilayer Printed Boards" standard.
- Top and bottom copper layers. To improve thermal performance, adding thermal vias will help but may require an electrically insulting thermal interface material (TIM) between an FR-4 and the heat-sink to ensure that the PCB system can meet a minimum high potential (hipot – electrical insulation barrier) test and to prevent potential device shorting over time due to breakdown of the TIM material. Two common approaches include:
  - (i) Open vias with plated through holes (Figure 5)
  - (ii) Filled and capped thermal vias (Figure 5).

  The filled and capped design gives better thermal performance than open via design but at a much higher manufacturing cost and require good surface co-planarity for small package. The diameter of the via, position and the quantity need to be studied to find optimum thermal performance at acceptable cost.
- Use of white solder mask.

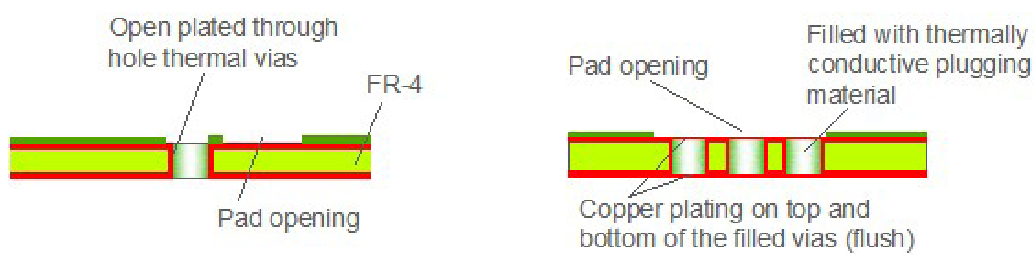


Figure 5. Left picture shows a cross section of an open via with plated through hole design with one pad opening where the LED pad is soldered onto. Right picture shows a cross section of a filled and cap via design with one pad opening. One of the LED pads is then soldered on top of the flush area where the filled and capped vias are underneath it to create direct thermal path connection between LED and bottom of PCB.

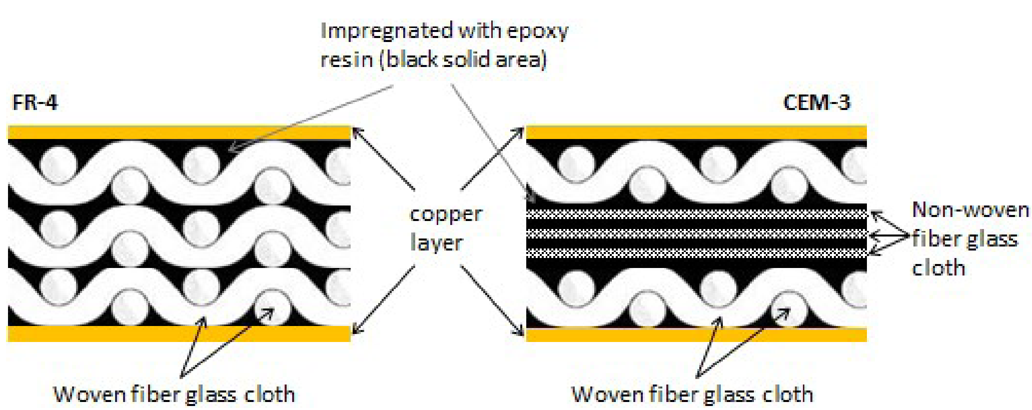


Figure 6. Cross section of a FR-4 and CEM-3 PCBs. Not drawn to scale; for illustration purposes only.

3. Thermal Management

The overall thermal performance of LUXEON emitter is affected by the following factors:

a. PCB layout, construction and material as described in section 2.4.

b. LEDs spacing (e.g. close packing).

c. Thermal interface materials (TIM) property if assembled PCB is mounted onto a heatsink.

d. Orientation of the LED strips, module or heat sink (e.g. vertical or horizontal mounting and LED facing upwards or downwards).

e. Presence of air flow or still air.

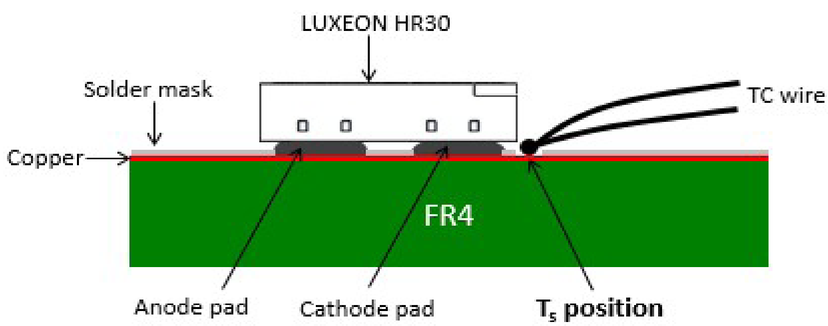
f. Presence of nearby heat source (e.g. inefficient LED driver generates heat during operation).

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 (TC).



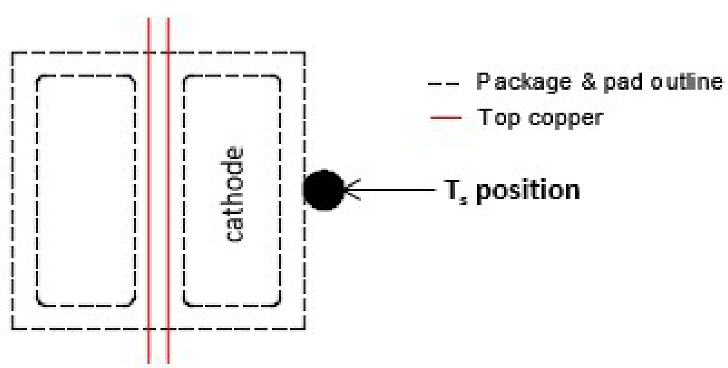


Figure 7. The recommended temperature measurement point T_s is located on the cathode copper layer of the PCB, closest to the package. The top picture shows the side view. Bottom picture shows the top view of the T_s location.

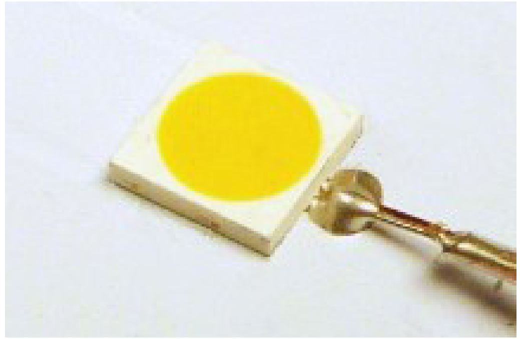


Figure 8. Photo showing representative placement of TC wire secured with thermal conductive epoxy. The thermal epoxy volume should be kept to minimum as shown.

The recommended location of the sensor pad is right next to the cathode of the LUXEON emitter on the PCB, as shown in Figure 7 and Figure 8. To ensure accurate reading, the thermocouple tip must make direct contact to the copper of the PCB onto which the LUXEON emitter cathode 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 cathode copper layer as shown in Figure 7. 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.

The thermal resistance $R\theta_{j\text{-}s}$ between the sensor pad and the LUXEON emitter junction was experimentally determined and provided here. The junction temperature can then be calculated as follows:

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

Lumileds investigated the thermal performance of LUXEON emitters on a 1.0mm thick aluminum MCPCB with 2oz (70µm) top copper plating with dielectric thermal conductivity of 2W/(mK) and 100um thick. The typical thermal resistance $R\theta_{j\text{-}s}$ obtained using this type of PCB is 17 K/W. Note that $R\theta_{j\text{-}s}$ may vary according to the PCB design.

5. Assembly Process Guidelines

5.1 Stencil Design

The recommended solder stencil thickness is 5mils (127µm). Adjustment may be required to achieve optimum assembly yield and quality.

5.2 Solder Paste

Lumileds recommends lead-free solder for the LUXEON emitter 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, 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.

In selecting a suitable nozzle size for picking up these LUXEON emitters, there are two important factors to consider:

1. The nozzle outer diameter should not be larger than the opening of the reel pocket tape otherwise it may interfere with the pocket tape cavity during the pick-up process.
2. The nozzle outer diameter should also not be smaller than the silicone encapsulant surface (Figure 1) otherwise this may allow the nozzle tip to be in full contact with the silicone-filled area and may cause damage to the surface or cause pick-up/release issues.

See Figure 9 for the best nozzle outer diameter. There is no constraint on the nozzle inner diameter as long as there is sufficient vacuum to hold the LED emitter during pick and place process.

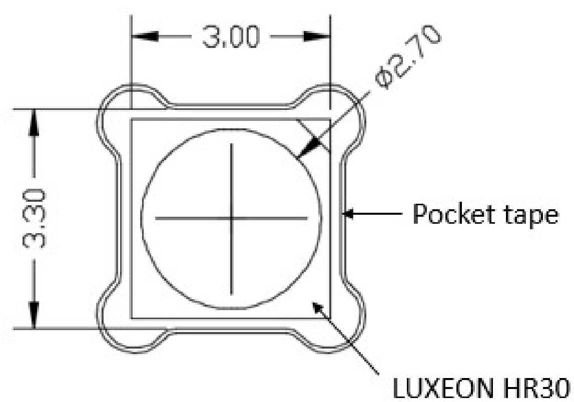


Figure 9. LUXEON emitter in a pocket tape. Dimensions in mm. Best to use nozzle with outer diameter between 2.7mm and 3.3mm to avoid interfering with the pocket tape cavity or picking solely from the silicones.

An example of a nozzle from Yamaha that is suitable for pick and place the LUXEON emitter is shown in Figure 10.

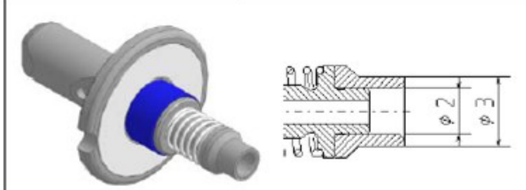
Nozzle Name	P055
Part No.	LC6-M772L-000
	

Figure 10. Example of a nozzle that fits Yamaha i-PULSE series pick and place machine.

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.

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.

5.5 Electrostatic Discharge Protection

For the part number without transient voltage suppressor (TVS) chip to protect against electrostatic discharges (ESD), 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 (J-STD-020D) MSL (moisture sensitivity level) of the LUXEON emitter has unlimited floor life (MSL Level 1) when stored under this condition: ≤30°C at 85% relative humidity.

6. Environmental Corrosion Testing

Corrosive environment can negatively affects LED performance over time. Hydrogen sulfide (H_2S) is well known to react with silver (tarnish) and leads to drop in light output and potentially weaken the wire bond adhesion strength over time.

To test the robustness of LUXEON HR30 emitter susceptibility to corrosive environment, two test setups were evaluated:

1. H_2S exposure test per IEC 60068-2-43. Environmental condition: 40°C, H_2S 15ppm, 80% RH (relative humidity) up to 21 days.

2. Flowing mixed gas corrosion test per IEC 60068-2-60, Method 4. Environmental condition: H_2S 10ppb, NO_2 200ppb, Cl_2 10ppb, SO_2 200ppb, all at 25°C 75% RH up to 21 days.

LUXEON HR30 performs exceptionally well with average light output change of less than 10% and color shift of less than 0.006 points in delta u'v' after 21 days in both test conditions. Please contact your regional sales representatives for further information.

7. 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 breakdown 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 exposing to blue light, some VOCs can breakdown inside the silicone and may cause 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 VOCs to diffuse out of the silicone and may restore the original optical properties of the LED.

Table 2 provides a list of commonly used chemicals that should be avoided as some 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. Determining suitable threshold limits for the presence of chemical/VOCs is very difficult since these limits depend on the type of enclosure used to house the LEDs and the operating temperatures.

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 overcoat of the LUXEON emitter.
Avoid using any of these chemicals in the housing that contains the LED package or in direct contact with the silicone.**

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 (turpentine)	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
Acrylic Tape	Adhesive
Cyanoacrylate	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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