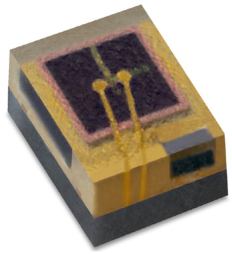
LUMILEDS

INFRARED

LUXEON IR Compact

Assembly and Handling Information



Introduction

This application brief addresses the recommended assembly and handling procedures for LUXEON IR Compact Line and LUXEON IR Compact for Automotive Line emitters. Proper assembly, handling, and thermal management, as outlined in this application brief, ensure high optical output and long light output maintenance for LUXEON IR Compact Line and LUXEON IR Compact for Automotive Line.

Scope

The assembly and handling guidelines in this application brief apply to the following products:

L1IZ–ABBBCCCCCCCCC	
Where:	
A	– designates the product line (0 for general product line, and A for Automotive line)
BBB	– designates nominal peak wavelength
CCCCCCCCC	– reserved for further customization

In the remainder of this document the term LUXEON emitter or LUXEON IR Compact refers to any product in the LUXEON IR Compact Line and LUXEON IR Compact for Automotive Line.

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1. Component

1.1 Description

The LUXEON IR Compact is an ultra-compact, surface mount, high-power infrared emitter. Each LUXEON IR Compact consists of a high brightness LED chip on a ceramic substrate. The ceramic substrate provides mechanical support and provides a thermal path from the LED chip to the bottom of the emitter. An interconnect layer electrically connects the LED chip to cathode and anode pads of equal size on the bottom of the ceramic substrate. The cathode of the LUXEON IR Compact is marked with a small notch (see Figure 1) and the pads are gold plated.

The top of the LUXEON IR Compact is covered with silicone to shield the chip from the environment. Inside the silicone, there is a transient voltage suppressor (TVS) chip which protects the LED chip against electrostatic discharge (ESD) events.

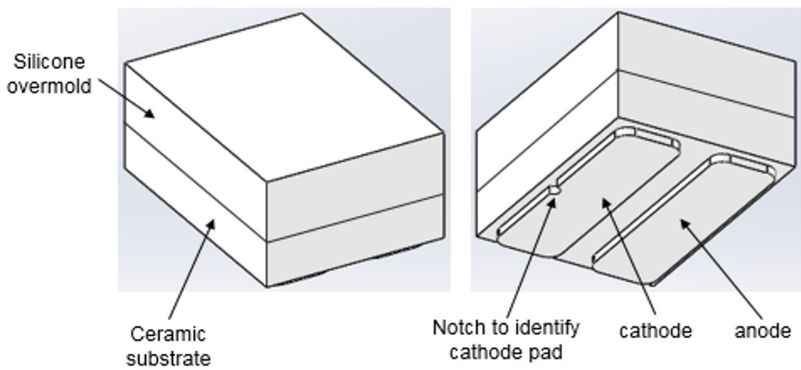


Figure 1. 3D rendition of LUXEON IR Compact emitter.

To identify the polarity orientation of LUXEON IR Compact from the top view, see Figure 2.

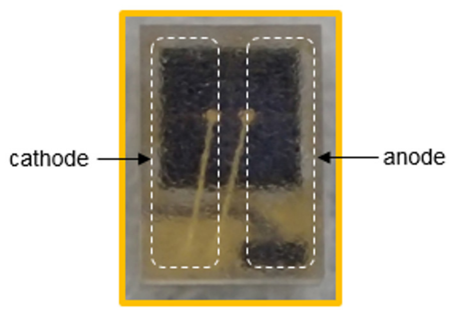


Figure 2. Polarity orientation when viewed from package top. White dashed line are the pad outlines as seen from the top.

1.2 Optical Center

The theoretical optical center of the LUXEON IR Compact is 0.685mm from the top and 0.685mm from the side edges of the package outline (see Figure 3). This corresponds to the center of the LED chip.

1.3 Handling Precautions

The LUXEON IR Compact is designed to maximize light output and reliability. However, improper handling of the emitter may damage the LED chip and affect the overall performance and reliability. In order to minimize the risk of damage to the LED chip during handling, LUXEON IR Compact should only be picked up manually from the side of the ceramic substrate as shown in Figure 4.

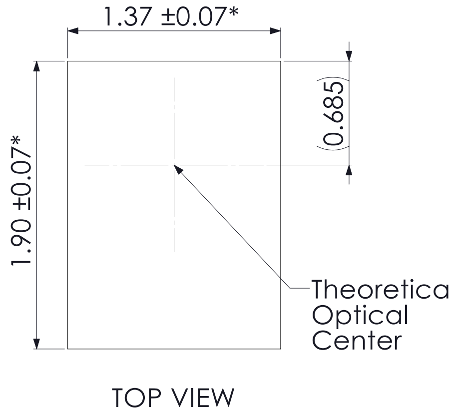


Figure 3. The optical center of LUXEON IR Compact is 0.685mm from the top and 0.685mm from the side edges.

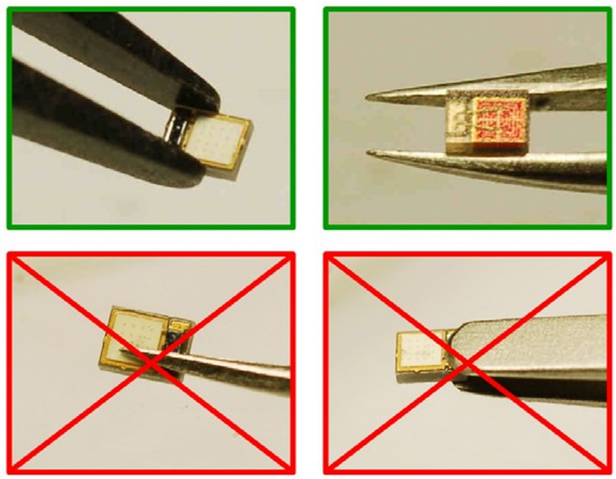


Figure 4. Illustration examples of correct handling (top) and incorrect handling (bottom) of LUXEON emitters.

When handling finished boards containing LUXEON emitters, do not touch the top surface with any fingers (see Figure 5) or apply any pressure to it. Also, do no turn over the assembled board for probing, storing or stack multiple boards on top of each other (see Figure 5). Use proper PCB carriers or racks for storage.

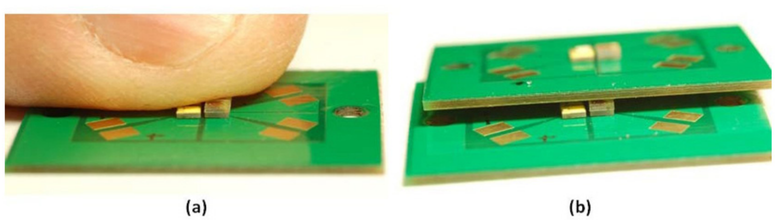


Figure 5. Do not touch the top of surface of the LUXEON emitters when handling a finished board (a) or stack boards with one or more LUXEON emitters on top of each other (b).

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 the surface of a LUXEON emitter requires cleaning, a compressed gas duster at a distance of 6 inches away will be sufficient to remove the dust and debris or an air gun with 20 psi (at nozzle) from a distance of 6 inches. Make sure the parts are secured first.

1.5 Electrical Isolation

The LUXEON IR Compact contains only two electrical pads on the bottom of the ceramic substrate with a spacing of 0.25mm between them. In order to avoid any electrical shocks 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 (3D STEP file) for LUXEON IR Compact are available at lumileds.com.

1.7 Soldering

LUXEON IR Compact is designed to be soldered onto a Printed Circuit Board (PCB). For detailed assembly instructions, see Section 2.

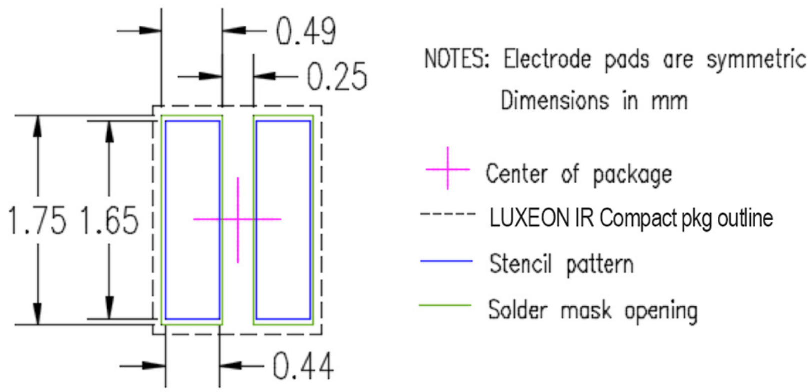


Figure 6. Recommended PCB Footprint for LUXEON IR Compact.

2. Printed Circuit Board Design

The LUXEON IR Compact is designed to be soldered onto a Metal Core PCB (MCPCB) or a multi-layer FR4 PCB. To ensure optimal operation of the LUXEON IR Compact, the PCB should be designed to minimize the overall thermal resistance between the LED package and the heat sink.

2.1 Footprint and Land Pattern

The LUXEON IR Compact has two pads that need to be soldered onto corresponding pads on a PCB to ensure proper electrical and thermal operation. Figure 6 shows the footprint design for a LUXEON IR Compact emitter.

The electrical pads of the LUXEON IR Compact also serve as thermal pads between the LED and the PCB. To enhance heat dissipation from the LUXEON emitter into the PCB, it is best to extend the copper area around each electrode approximately 4mm from the center of the LUXEON IR Compact emitter, where possible. Furthermore, it is desirable to keep the thermal resistance values of the two copper pads on the PCB underneath each LUXEON IR Compact emitter approximately equal to ensure a balanced heat transfer from the LUXEON emitter through both electrodes.

2.2 Surface Finishing

For small pad dimensions and pitch, Lumileds has good experience using electroless nickel immersion gold (ENIG) or high temperature organic solderability preservative (OSP) on the exposed copper PCB pads. Hot air solder leveling (HASL) should not be used, because it yields poor co-planarity (leveling) and is, therefore not suitable for fine pitch assembly. In addition, HASL may yield poor solder joints, potentially resulting in open failures.

2.3 Minimum Spacing

A minimum edge to edge spacing between LUXEON IR Compact of 0.2mm can generally be achieved with modern pick and place equipment. Placing multiple LUXEON emitters too close to each other may adversely impact the ability of the PCB to dissipate the heat from the emitters. Also, the light output for each LED may drop due to optical absorption by adjacent LED packages.

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 also 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 and MCPCB 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 and PCB material on the overall thermal resistance between junction and heat sink, four designs with varying copper trace layout around the anode and cathode were evaluated as shown in Table 1. The four designs are:

a. FR4 PCB material. Minimum top copper corresponds to copper trace which extends beyond the outline of the LUXEON IR Compact emitter package by 0.25mm which corresponds to half of the minimum recommended package to package spacing of 0.5mm. This configuration is representative of worst case condition for application where multiple LEDs are placed in close proximity to each other.

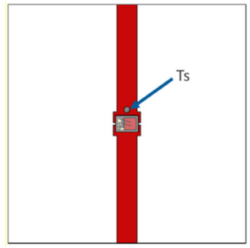
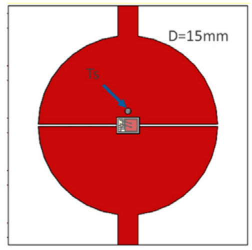
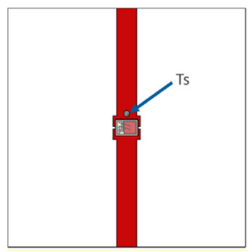
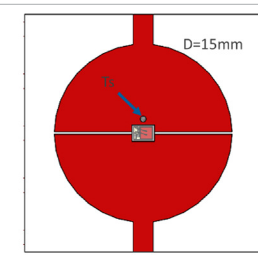
b. FR4 PCB material. Maximize top copper around the cathode and anode as much as possible, with D=15mm. This is the ideal layout for FR4 PCB since the primary heat flow of the LUXEON IR Compact emitter is through the anode pad as described in section 1.1.

c. MCPCB material. Minimum top copper corresponds to copper trace which extends beyond the outline of the LUXEON IR Compact emitter package by 0.25mm which corresponds to half of the minimum recommended package to package spacing of 0.5mm. This configuration is representative of worst case condition for application where multiple LEDs are placed in close proximity to each other.

d. MCPCB material. Maximize top copper around the cathode and anode as much as possible, with D=15mm. This is the ideal layout for MCPCB since the primary heat flow of the LUXEON IR Compact emitter is through the anode pad as described in section 1.1.

As general guidelines, increasing the top copper thickness and increasing the copper area around the anode will reduce the FR4 and MCPCB board thermal resistance. Adding a bottom copper layer to the FR4 (double sided copper clad PCB) does not reduce the FR4 board thermal resistance since the FR4 material itself is a poor thermal conductor.

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

DESIGN	MATERIAL	LAYOUT	TYPIAL $R\theta_{J\text{-BOTTOM PCB}}$ [K/W]	TYPICAL $R\theta_{J\text{-S}}$ [K/W]
A	FR4 PCB, minimum copper pattern, 0.25mm around package outline		72.2	10.3
B	FR4 PCB, maximize copper, D=15mm		25.5	7.3
C	MCPCB, minimum copper pattern, 0.25mm around package outline		9.3	6.5
D	MCPCB, maximize copper, D=15mm		8.0	6.0

4. Thermal Measurement Guidelines

The typical thermal resistance $R\theta_{j\text{-}c}$ between the junction and the solder pads of the LUXEON IR Compact emitter is 3.5K/W. With this information, the junction temperature T_j can be easily determined according to the following equation:

$$T_j = T_c + R\theta_{j\text{-}c} \cdot P_{electrical}$$

In this equation T_c is the temperature at the bottom of the LUXEON IR Compact solder pads and $P_{electrical}$ is the electrical power going into the LUXEON IR Compact emitter. In typical applications it may be difficult, though, to measure the temperature T_c directly. Therefore, a practical way to determine the junction temperature of the LUXEON IR Compact is by measuring the temperature T_s of a predetermined sensor pad on the PCB right next to the LUXEON IR Compact emitter with a thermocouple. The recommended location of the sensor pad is 0.5mm from the anode of the LUXEON IR Compact emitter, on the center line between anode and cathode, as shown in Figure 7. To ensure accurate reading, the thermocouple (TC) tip must make direct contact to the copper of the PCB onto which the LUXEON IR Compact emitter anode 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 where two dissimilar metals are welded should be placed as close as possible to the LUXEON IR Compact package on the exposed anode copper layer as shown in Figure 7.

The thermal resistance $R\theta_{j\text{-}s}$ between the thermocouple and the LUXEON IR Compact junction was experimentally determined to be about 6.2K/W on a MCPCB, which is nearly the same as the simulation result as shown in design D of Table 1. The junction temperature can then be calculated as follows:

$$T_j = T_s + R\theta_{j\text{-}s} \cdot P_{electrical} = T_s + 6.2 \cdot P_{electrical}$$

It is recommended to secure the tip of thermocouple 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 thermocouple wire with too much epoxy but sufficient enough to secure the thermocouple wire for measurement. Putting more epoxy than needed may change the thermal behavior of the surrounding area.

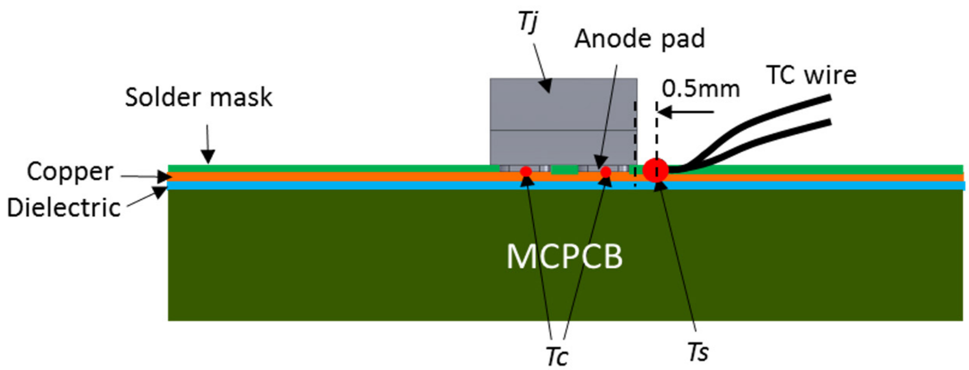


Figure 7. The recommended temperature measurement point Ts is located on the anode copper layer of the PCB, 0.5mm away from the package. The picture above shows an example where to place the welding tip of the thermocouple wire prior to dispensing any thermal conductive epoxy to secure the thermocouple wire.

5. Assembly Process Guidelines

5.1 Stencil Design

The appropriate stencil design for the LUXEON IR Compact emitter is included in the PCB footprint design (see Figure 6). Lumileds has successfully evaluated a stencil thickness of 4 mils (102µm).

5.2 Solder Paste

Lumileds successfully tested a lead-free, no clean SAC 305 solder paste from Alpha® OM-340, type 4. 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 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.

Figure 8 shows the outcome of a well-controlled stencil printing process according to method 3 above. In this example, the recommended stencil pattern of Figure 5 was used in combination with a stencil thickness of 4 mils and a solder paste from Alpha® OM-340. Also, the stencil aperture wall used should be smooth to aid smooth release of solder paste.

Figure 8. An example of a good stencil printing on PCB.

5.4 Pick-and-Place

Automated pick and place equipment provides the best handling and placement accuracy for LUXEON IR Compact. Samsung SM421, Juki KE2080L and Panasonic CM402 pick and place machines and their corresponding off-the-shelf nozzles and machine settings were successfully used to pick and place LUXEON IR Compact (Figure 9, Figure 10 and Figure 11).

General guidelines:

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

Samsung off-the-shelf nozzle model: CN065
Nozzle tip material: Ceramic (Zirconia)
Nozzle inner diameter: 0.65mm
Nozzle outer diameter: 1.20mm

Figure 9. Standard off-the-shelf nozzle CN065 for Samsung SM421.

Table 2a. Samsung SM421 pick and mount settings.

PICK AND MOUNT INFORMATION	
Pick Height	-0.2 mm
Mount Height	0.0 mm
Delay – Pick Up	30 ms
Delay – Place	30 ms
Delay – Vac Off	0
Delay – Blow On	0
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	Not use

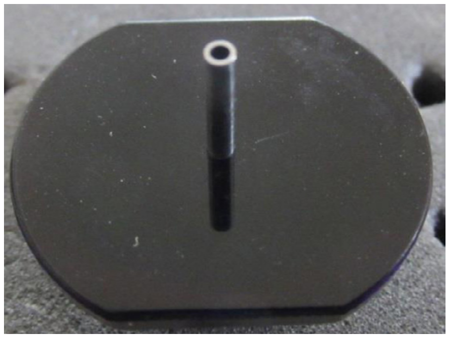
VISION INFORMATION	
Camera No	Fly Cam4
Side	0
Outer	4

Figure 10. Standard off-the-shelf nozzle "503" for Juki KE2080L.

Table 2b. Juki KE2080L pick and mount settings.

PICK AND MOUNT INFORMATION	
XY speed	Fast 2
Picking stroke	0.2 mm
Picking Z down	Fast 2
Picking Z up	Fast 2
Placing stroke	0 mm
Placing Z down	Fast 2
Placing Z up	Fast 2
Laser Position	-0.73

VISION INFORMATION	
Centering method	Laser
Comp shape	Corner Square



Panasonic off-the-shelf nozzle model: “120”
Nozzle tip material: Steel
Nozzle inner diameter: 0.9mm
Nozzle outer diameter: 1.3mm

Figure 11. Standard off-the-shelf nozzle “120” for Panasonic CM402.

Table 2c. Panasonic CM402 pick and mount settings.

PICK AND MOUNT INFORMATION	
Gap – Mount	0 mm
Gap – Pick	0.2 mm
Pickup position – Z	0 mm
Fdr drive time	Std
Pickup keep time	Std
Mount keep time	Std
Pickup speed	100
Mount speed	100

VISION INFORMATION	
Ref	81
Recog peed	Auto (Fast)
Recog hgt	0.0 mm
Lamp 1	0
Lamp 2	0
Lamp 3	0
Lamp 4	92
Lamp 5	0
Lamp 6	0
Lamp 7	0
Lamp 8	0

NOZZLE LIBRARY DATA	
VU, Vacuum rise time	5
VD, Vacuum bread time	-2
TT, Pickup holding time	5
MT, Mounting holding time	0
PM, Failure judgement pressure	-20
PF, Nozzle clogging detection pressure	-85

5.5 Reflow Accuracy

Using the solder pad footprint and stencil pattern layout as shown in Figure 6 with solder paste print as shown in Figure 8 and without any obstruction from nearby silkscreen (ink) print feature, LUXEON IR Compact parts can self-align to the nominal position during reflow process.

6. Packaging Considerations—Chemical Compatibility

The LUXEON IR Compact package contains a silicone overcoat to protect the LED chip. 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 IR Compact 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 IR Compact 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 overcoat. Under high temperature operation, the VOCs inside the silicone overcoat may partially oxidize and create a silicone discoloration. 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 overcoat 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.

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 IR Compact 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. When using adhesives, potting compounds and coatings, carefully analyze its material composition and do thorough testing of the entire fixture under High Temperature Operating Life (HTOL) test conditions.

Table 3. List of commonly used chemicals that will damage the silicone overcoat of LUXEON IR Compact. 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

Companies developing automotive, mobile, IoT and illumination lighting applications need a partner who can collaborate with them to push the boundaries of light. With over 100 years of inventions and industry firsts, Lumileds is a global lighting solutions company that helps customers around the world deliver differentiated solutions to gain and maintain a competitive edge. As the inventor of Xenon technology, a pioneer in halogen lighting and the leader in high performance LEDs, Lumileds builds innovation, quality and reliability into its technology, products and every customer engagement. Together with its customers, Lumileds is making the world better, safer, more beautiful—with light.

To learn more about our lighting solutions, visit lumileds.com.

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