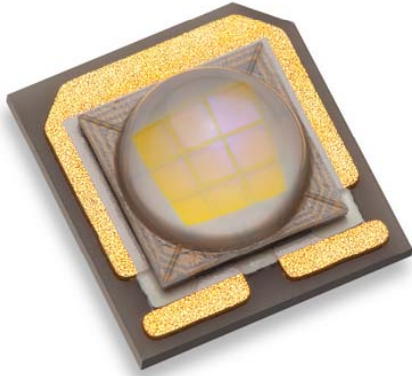




LUXEON S
Assembly and Handling
Information

Application Brief AB80

LUXEON
NEVER BEFORE POSSIBLE

LUXEON S

Assembly and Handling Information

Introduction

This application brief covers recommended assembly and handling procedures for LUXEON S emitters (part number LX58-PW30). LUXEON S emitters are designed to generate high flux densities from a uniform source, enabling high-end luminaires and spot lights. LUXEON S emitters can be directly mounted onto a heat sink with a mechanical clamp, simplifying the design of down-light applications. Proper assembly, handling, and thermal management will ensure high optical output and long LED lumen maintenance.

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I. Component

I.1 Description

The LUXEON S emitter consists of a 3x3 LED chip array on a ceramic substrate (referred to as Die-on-Ceramic or DoC). In order to facilitate assembly and handling, the DoC is mounted onto a larger Direct Bonded Copper (DBC) substrate. The DBC substrate provides a thermal path between the DoC and a heat sink on which the LUXEON S emitter is mounted. The LED electrodes are patterned on top of the DBC substrate. The bottom of the DBC contains the thermal pad. The DBC also contains a chamfer for alignment of the emitter inside a mechanical clamp. A silicone lens over the LED chip array extracts the light and shields the chip array from the environment. Every LUXEON S emitter contains a transient voltage suppressor (TVS) chip under the lens to protect the emitter against electrostatic discharge (ESD). Figure 1 highlights the main components of the LUXEON S emitter.

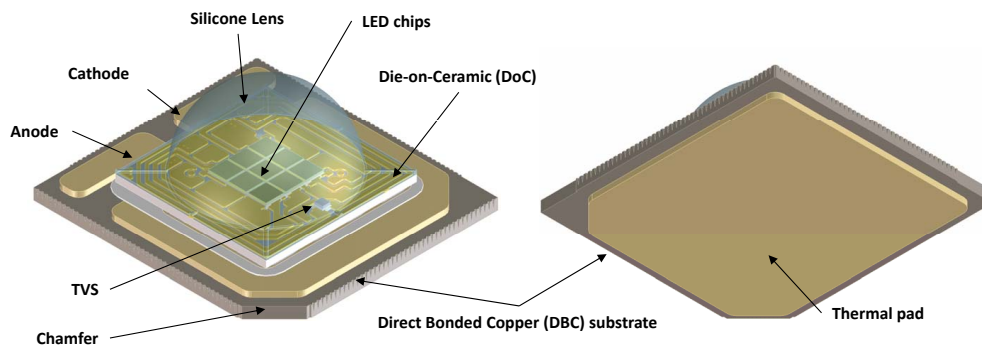


Figure 1. 3D rendering of LUXEON S emitter; top (left) and bottom (right).

I.2 Reference Document

The LUXEON S datasheet is available on the Philips Lumileds website at www.philipslumileds.com and www.philipslumileds.cn.com.

I.3 Optical Center

The optical center for LUXEON S is at the center of the DoC as shown in Figure 2. A Solderless LED Socket for LUXEON S is available through Future Lighting Solutions (see Section 2 for more details). This socket includes an LED locator ring that facilitates aligning the optical center of the LUXEON S on the heat sink.

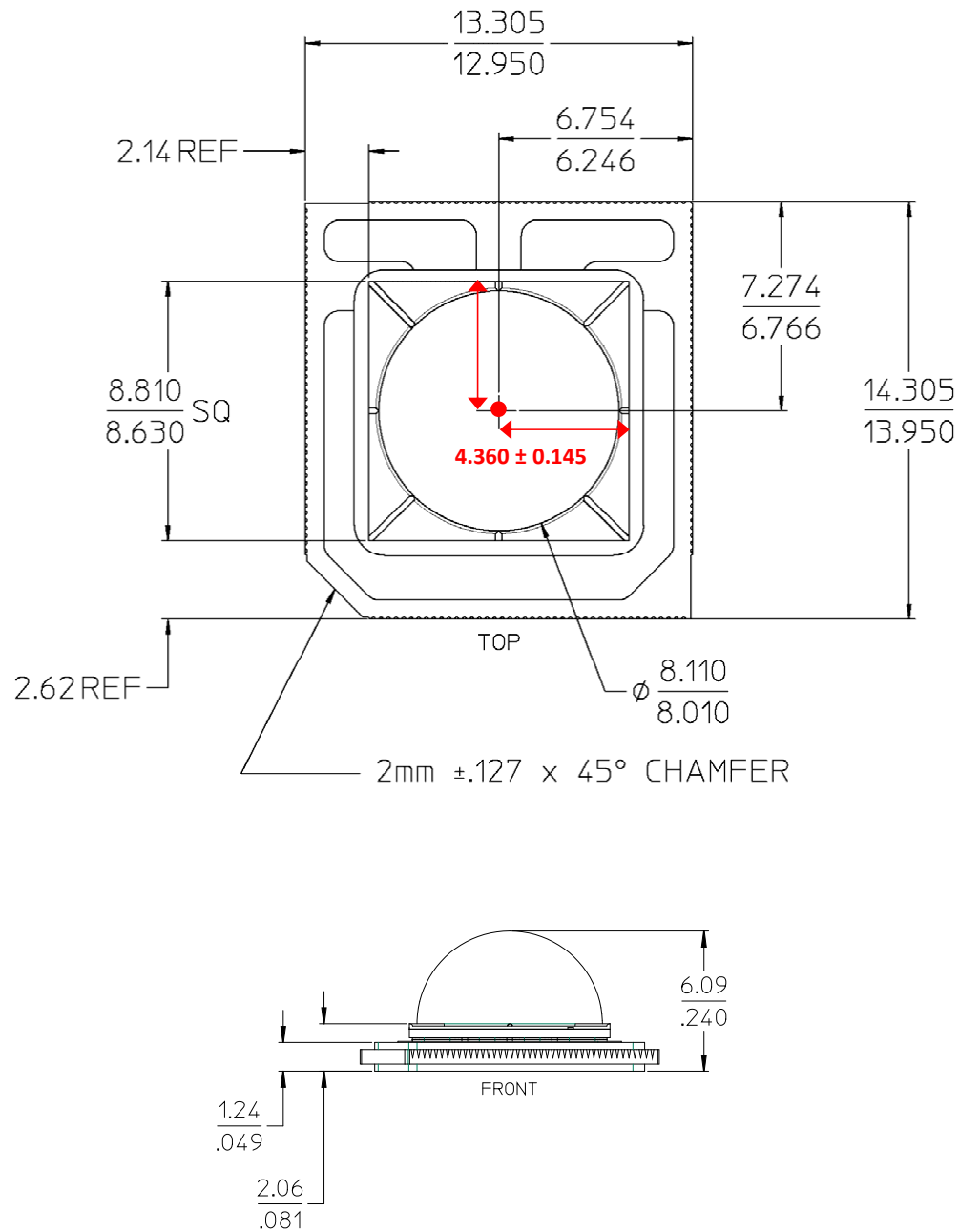


Figure 2. The optical center of LUXEON S emitters is at the center of the DoC. All dimensions are in mm.

1.4 Handling Precautions

The LUXEON S package is designed to maximize light output and reliability. However, improper handling of the device may damage the silicone dome and affect the overall light performance and reliability. In order to minimize the risk of damage to the dome during manual handling, LUXEON S emitters should only be picked up with a pair of tweezers from the DBC (Direct Bonded Copper) substrate and not from the lens (see Figure 3 and Figure 4).

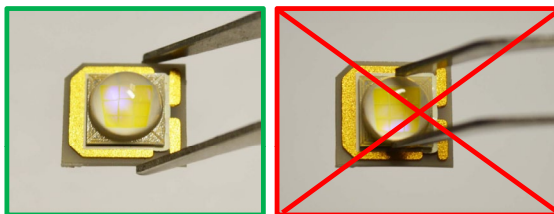


Figure 3. Correct handling (left) and incorrect handling (right) of LUXEON S emitters.

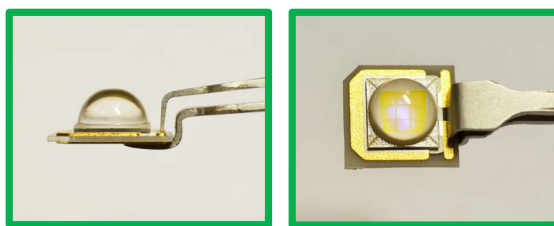


Figure 4. Alternative handling method using Excelta 390-SA-PI Tweezers.

The lens of the LUXEON S package can only withstand a limited amount of force. In order to avoid any mechanical damage to the LUXEON S package, do not apply more than 3N of shear force (300g) directly onto the lens. When utilizing a pick and place machine, ensure that the pick and place nozzle does not place excessive pressure onto the lens of the LED. Similar restrictions exist for manual handling.

1.5 Cleaning

The lens of LUXEON S should not be exposed to dust and debris. Excessive dust and debris may cause a drastic decrease in optical output. In the event that an 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 lens. Do not use other solvents as they may adversely react with the LED assembly. For more information regarding chemical compatibility, see Section 5.

1.6 Electrical Isolation

The DBC substrate of the LUXEON S package electrically isolates the thermal pad from the LED cathode and anode (see Figure 1).

1.7 Mechanical 3-D

The 3-D mechanical drawings in STP file format for LUXEON S are available on the Philips Lumileds website at www.philipslumileds.com and www.philipslumileds.cn.com.

1.8 Soldering

LUXEON S emitters are not designed to be soldered to a heat sink. For detailed assembly instruction, see Section 2. Soldering of wires and/or thermocouples directly onto the LUXEON S emitter will adversely affect the overall performance of the LUXEON S emitter.

2. Assembly Process

2.1 LUXEON S Solderless LED Socket

LUXEON S emitters are designed to be directly mounted onto a heat sink, facilitating the design and assembly of fixtures with the LUXEON S emitter. Future Lighting Solutions (www.futurelightingsolutions.com/) offers a special LUXEON S solderless LED socket developed by TE Connectivity¹ that is used to electrically, mechanically and thermally secure the LUXEON S to the heat sink, see Figure 5. The TE Connectivity Solderless LED Socket, Type LS consists of two parts: an LED locator and a socket assembly. The LED locator ensures the proper orientation of the LUXEON S emitter on the heat sink prior to socket assembly attachment. Using three screws, the TE socket secures the LUXEON S emitter to the heat sink thereby providing a thermal, mechanical and electrical connection to the LUXEON S. Further, the socket provides an easy, quick, integral insulation displacement connector termination to two user-supplied 24AWG wires. Figure 6 provides some relevant reference dimensions of the TE Connectivity Solderless LED Socket, Type LS. Figure 7 provides a reference layout and dimensions of the holes that need to be drilled into the heat sink to align and secure the LUXEON S emitter with the Solderless LED Socket, Type LS.

The Type LS socket is designed and manufactured by TE Connectivity and may be subject to change without notice. The assembly information for the Type LS socket discussed in this document is for reference only. For the latest up-to-date information on the Type LS socket, please visit <http://www.tycoelectronics.com/catalog/pn/en/2154235-2>. We suggest you check the TE Connectivity website (www.tycoelectronics.com) for the most up-to-date information on the LS socket. Philips Lumileds provides no warranty of any kind with respect to the Type LS socket.

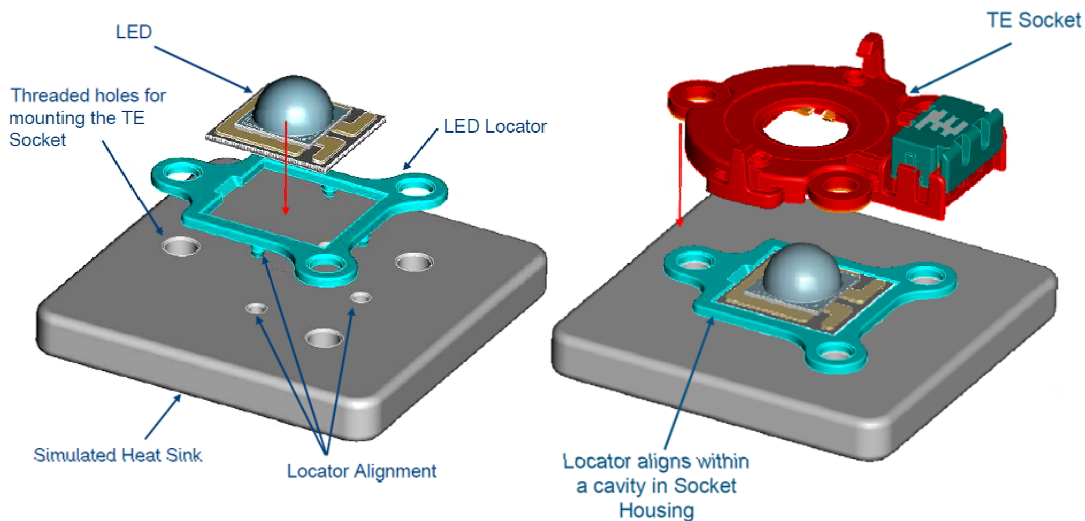


Figure 5. The TE Connectivity Solderless LED Socket, Type LS consists of two parts: an LED locator and a socket assembly.

¹ TE Connectivity, TE Connectivity (logo) and TE (logo) are trademarks of the TE Connectivity Ltd family of companies.

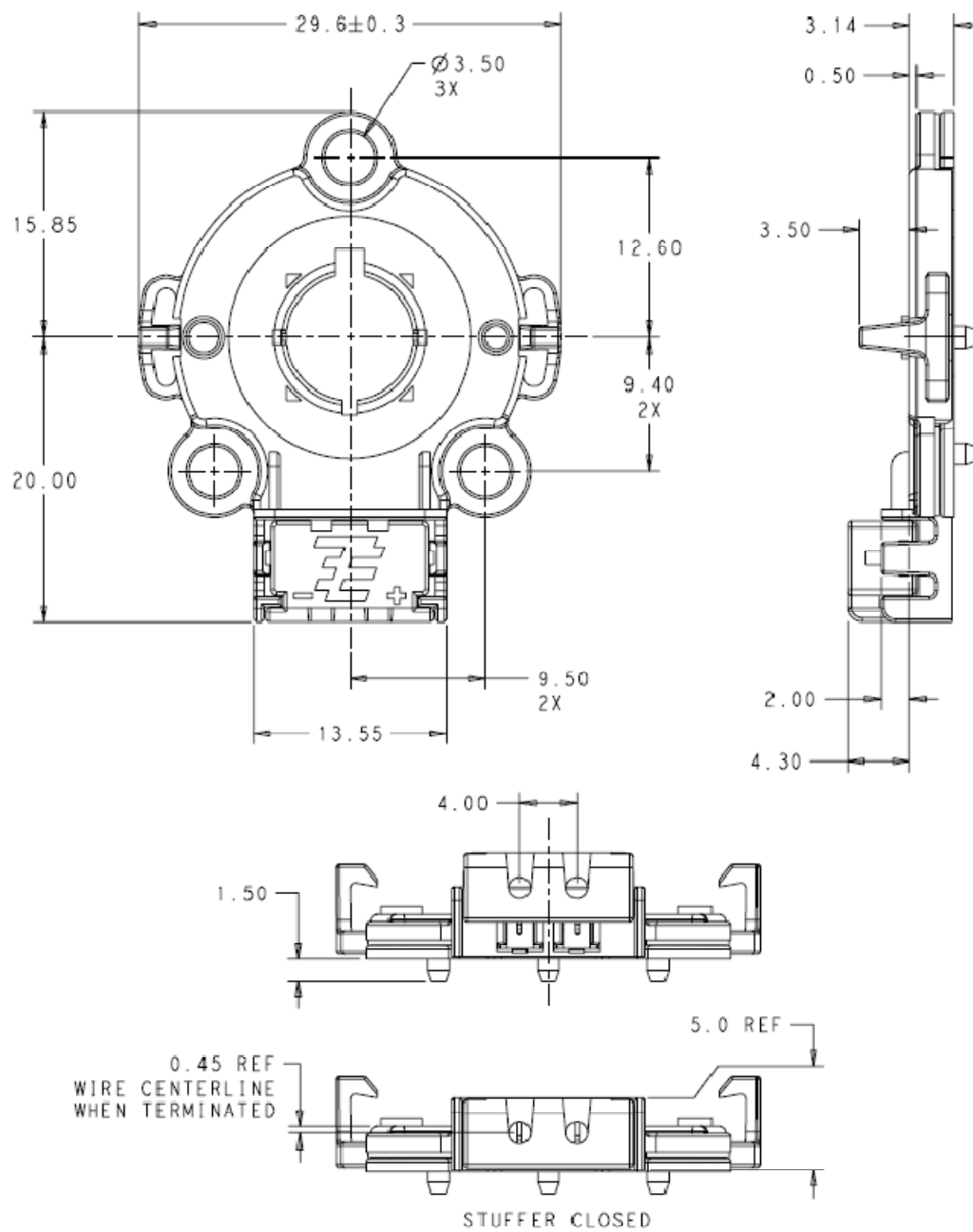
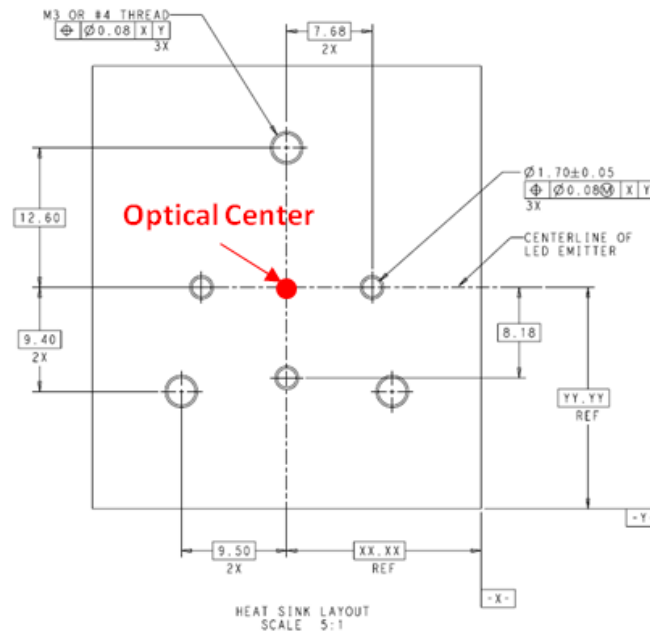


Figure 6. Reference dimensions for the TE Connectivity Solderless LED Socket, Type LS. All dimensions are in mm.

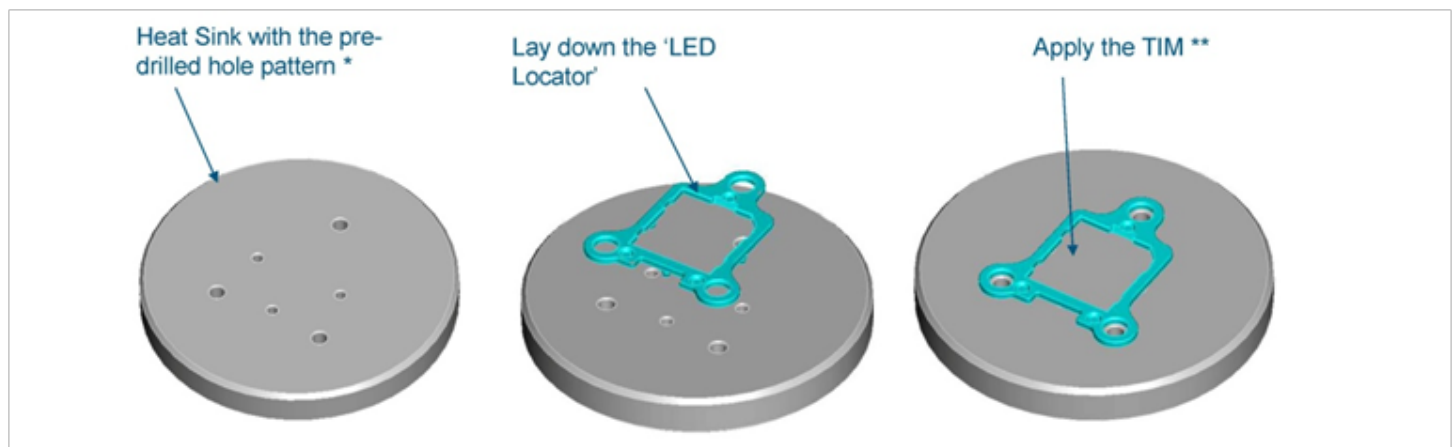


2.2 Assembly Process

Follow these steps to mount the LUXEON S emitter on a heat sink with the Solderless LED Socket, Type LS from TE Connectivity.

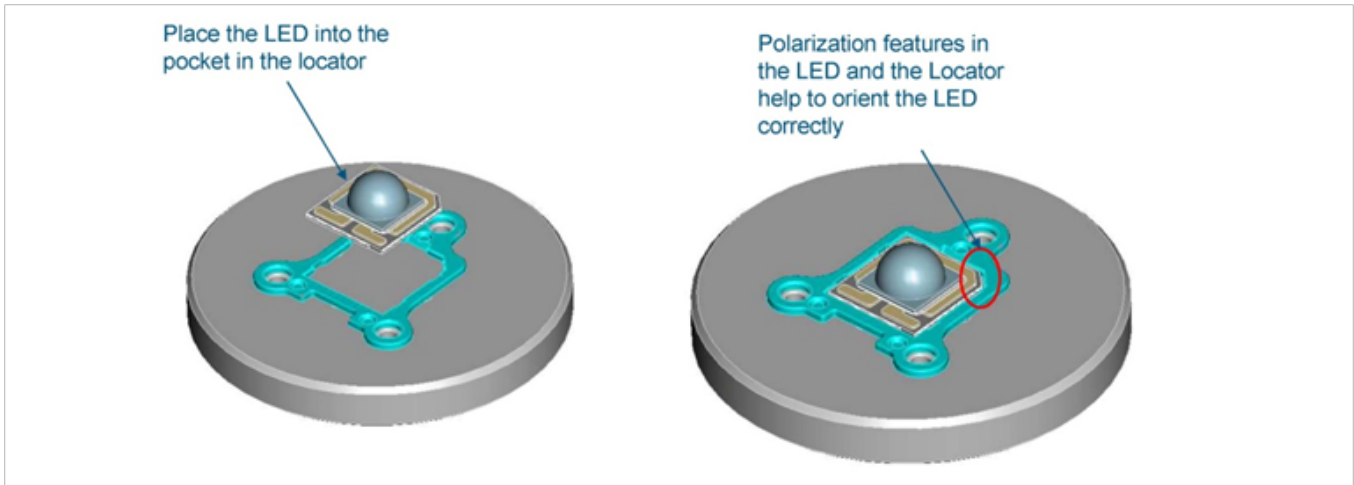
I. Preparing the heat sink

- Ensure that the heat sink surface is clean and flat ($\leq 25\mu\text{m}$, with no crowns or peaks in the mounting area). Crowns or peaks in the heat sink surface will adversely impact the thermal conductance between the DBC and the heat sink.
- Drill and tap the holes as per Figure 8 and wipe the heat sink surface clean with isopropyl alcohol (IPA).
- Place the locator ring on the heat sink such that the alignment pins of the locator mate with the alignment holes in the heat sink.
- Apply a thermal interface material (TIM) on the area inside the locator ring. If the TIM consists of a graphite sheet with adhesive, precut the sheet to size (13mm x 14mm) and apply the adhesive side of the graphite sheet to the bottom of the DBC. For more details regarding suitable TIMs, see Section 3.1.



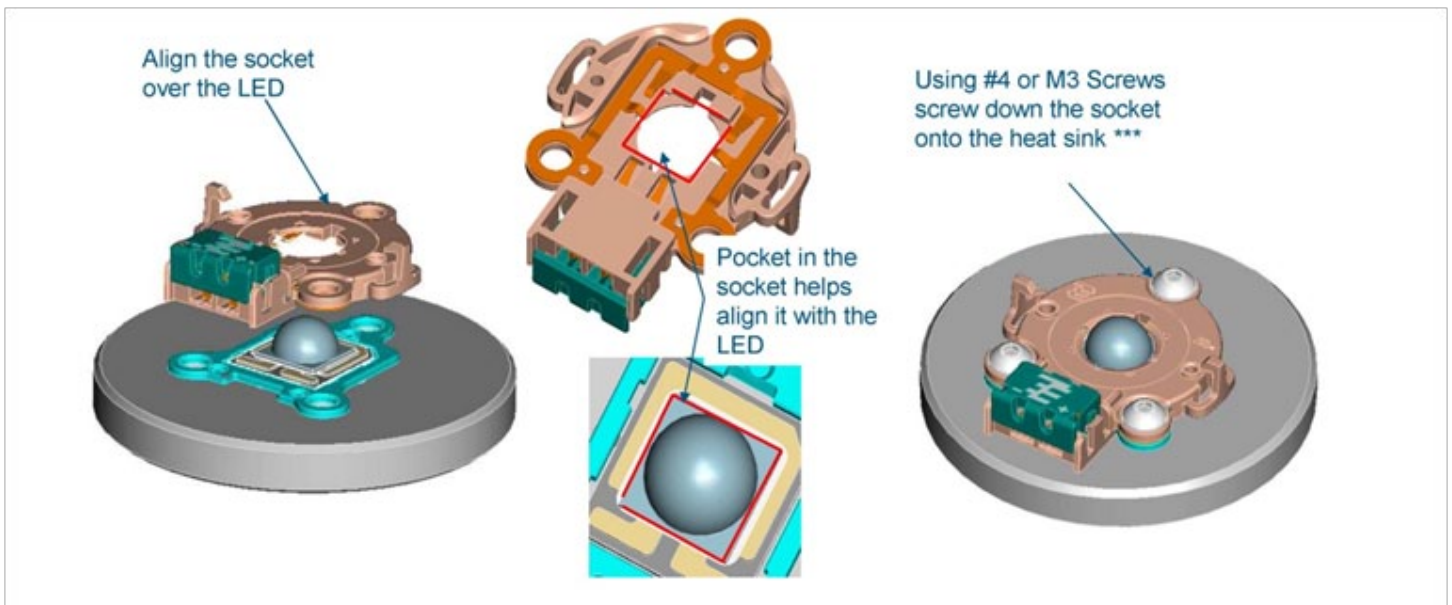
2. Aligning the LUXEON S emitter on the heat sink

- a. Use tweezers (see Section 1.4) to place the LUXEON S emitter inside the locator ring.
- b. Align the chamfer on the DBC of the LUXEON S emitter with the chamfer of the locator ring.



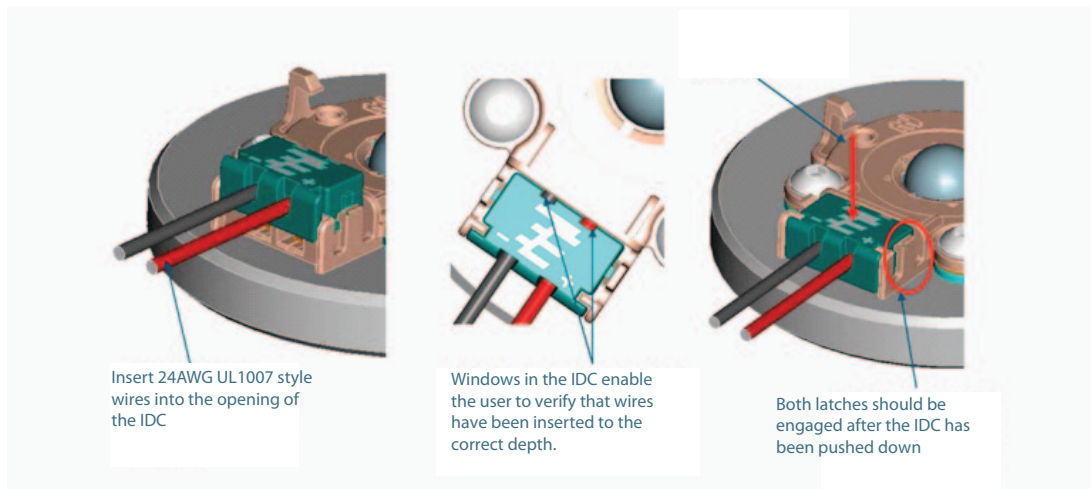
3. Mounting the TE socket

- a. Place the TE socket over the LUXEON S emitter.
- b. The TE socket contains a pocket that helps align the LUXEON S emitter with respect to the TE socket. Gently rock the TE socket while applying light pressure till the DoC of the LUXEON S emitter mates with the pocket inside the TE socket.
- c. Secure the TE socket on the heat sink with 3 #4 or M3 screws. The screw down torque should not exceed 4.0 inch lbs.



4. Terminating the wires

- Insert two 24AWG UL1007 style wires into the openings of the insulation displacement connector (IDC). The wires connect to the cathode (left) and anode (right) of the LUXEON S emitter.
- Verify that the wires are inserted to the correct depth.
- Push down on the IDC to terminate the wires. The two latches on the side of the IDC should be engaged after the IDC has been pushed down.
- Lead the wires to an appropriate LED Driver. The LUXEON S emitter is now ready for operation.



3. Thermal Management

3.1 Thermal Interface Materials (TIM) Selection

Due to the low thermal resistance of the LUXEON S assembly and its large thermal footprint (Figure 1), a variety of thermal interface materials can be used to thermally connect the emitter to the heat sink (e.g. phase change materials, thermal tapes, graphite sheets). However, TIM selection should be made with the following considerations:

- Pump out**—Some TIMs will move out of the thermal path during extreme temperature excursions and create voids in the thermal path. These materials should not be used.
- TIM thickness**—Excessive thickness of some TIMs will present an unacceptable thermal resistance even though the thermal conductivity may be high. Also, a thick TIM that doesn't completely cover the thermal pad may cause a fulcrum, making the ceramic substrate subject to fracture stress. Therefore, the maximum thickness of the TIM should not exceed 5 mils.
- Surface roughness**—To fill the air gaps between adjacent surfaces, choose the appropriate TIM that minimizes the interfacial contact resistance.
- Operating temperature**—Some TIMs perform poorly at elevated temperatures. Care should be exercised to select a TIM that will perform well under your operating conditions.
- Out-gassing**—Out-gassing of some TIMs at design temperatures may produce undesirable optical or appearance qualities (e.g. fogging) in a sealed system. Special consideration must be given to limit this effect.
- Clamping force**—TIMs such as thermal tape or pads perform better when the right pressure is applied.

Any TIM that is considered for use with LUXEON S should meet all of the above considerations. Table 1 lists several TIMs that have been tested with LUXEON S. This data is provided for informational purposes only. Philips Lumileds cannot guarantee the performance of the listed TIMs since LED operating conditions will vary with the application design.

Table 1. List of TIM materials that meet the TIM considerations outlined in this section.
Note, though, that the actual performance of these TIM materials will depend on the final application.

Manufacturer	TIM
Arctic Silver	Arctic Silver® #5
GrafTech	Graphite Sheet 1205A

3.2 Heat Sink

LUXEON S emitters must be mounted onto a heat sink with a maximum $R\theta_{\text{Heat sink-Ambient}}$ rating of 2.5°C/W at an ambient temperature of 25°C in order to dissipate the heat that's generated during operation.

3.3 Temperature Probing and Characterization

The LED junction temperature T_j can be calculated as follows: $T_j = T_c + R_{\theta_{\text{junction-case}}} P_{\text{LED}}$. In this equation T_c is the case temperature at the bottom of the DBC substrate (see Figure 8), $R_{\theta_{\text{junction-case}}}$ is the thermal resistance between the junction and the case (see datasheet DS80), and P_{LED} is the total electrical power into the LED. Since the case temperature T_c cannot be measured directly, Philips Lumileds recommends measuring the temperature at the top of the DBC substrate T_s instead, as shown in Figure 8. The relationship between temperatures T_c and T_s has been experimentally determined as $T_c = T_s - 0.5^{\circ}\text{C}$.

To ensure the long-term reliability and performance of LUXEON S emitters, the junction temperature must not exceed 110°C during operation. Figure 9 shows the maximum allowable temperature T_s at the top of the DBC as function of the drive current I_f such that the junction temperature T_j remains below 110°C .

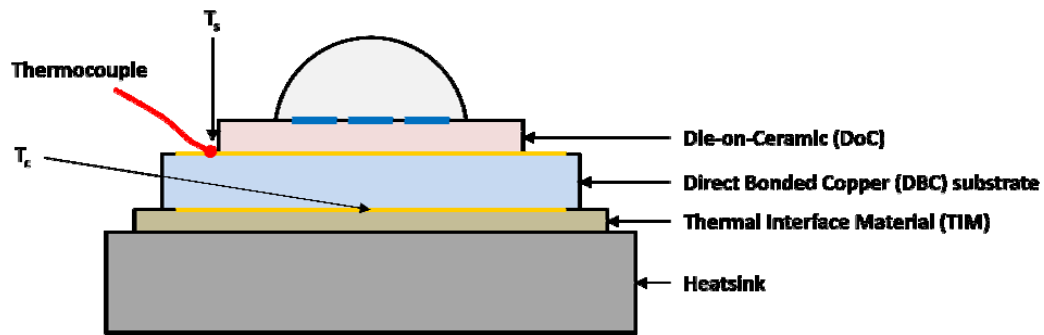


Figure 8. Cross-section of LUXEON S emitter on heat sink.

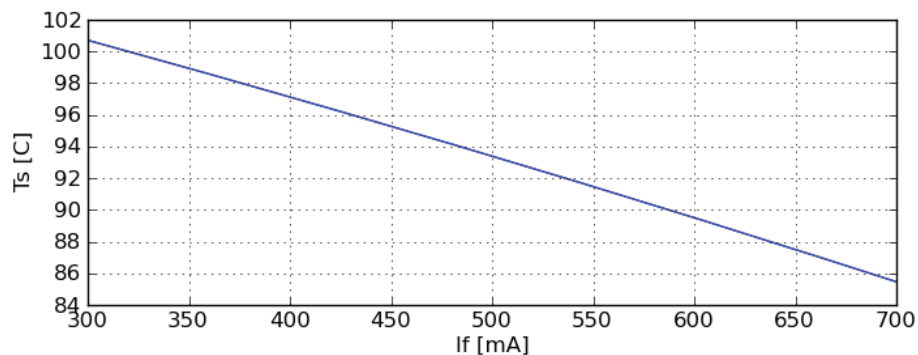


Figure 9. This graph shows the maximum allowable temperature T_s as function of drive current I_f such that the junction temperature T_j remains below 110°C .

3.4 Thermal Measurements

This section describes in detail how to mount a thermocouple on the top of the DBC in order to determine the case temperature T_c .

Supplies and Equipment

Below is the list of supplies and equipment that's needed to T_c measurements:

- Type T precision fine wire (0.003" gauge diameter) thermal couples from Omega Engineering Inc. (part number: 5SRTC-TT-T-40-36)
- Eccobond one component, low temperature curing, thermal conductive epoxy adhesive from Emerson and Cuming (part number: E 3503-1) or Arctic Alumina Thermal Adhesive compound from Arctic Silver Inc. (part number: AATA-5G)
- Disposable 3CC barrel syringe from EFD Inc. (part number 5109LL-B)
- Disposable 0.016" inner diameter fine needle tip from EFC Inc. (part number: 5122-B)
- Kapton tape
- Convection oven (for curing of Eccobond epoxy)
- Thermometer
- Magnifying glass or low power microscope (e.g. 5x to 30x)

Thermocouple mounting procedure

1. Familiarize yourself with the manufacturer's Material Safety Data Sheet (MSDS) and preparation procedures for the epoxy or adhesive compound.
2. Place the thermocouple tip within the area defined in Figure 10. The thermocouple must touch the gold pad within this area in order to avoid any interference with the contact points of the LUXEON S Mechanical Clamp and to ensure accurate measurements.
3. Use the Kapton tape to secure the thermocouple wire on the LUXEON S emitter.
4. Follow step a or b depending on the compound or adhesive that's used to thermally connect the thermocouple to the thermal pad on the top of the DBC
 - a. **Eccobond Thermal Adhesive Epoxy**
 - i. Thaw the thermal conductive epoxy per manufacturer's recommendations.
 - ii. Dispense sufficient epoxy into the 3CC barrel syringe with the fine needle tip. Store the balance per manufacturer's recommendations.
 - iii. Drop a small amount of thermal conductive epoxy just enough to cover the thermocouple tip as shown in Figure 10.
 - iv. Cure the epoxy per the manufacturer's recommendations. Make sure that the oven temperature does not exceed the maximum rated temperature of the LUXEON S emitter.
 - v. Let the board cool down to room temperature before starting any measurements.

b. Arctic Alumina Thermal Adhesive compound

- i. Since this is a two part epoxy system with an approximate pot-life at room temperature after mixing of 3-4 minutes, make sure that proper setup is done to ensure that the epoxy can be dispensed within the pot-life span.
 - ii. After mixing, put the epoxy immediately into the 3CC barrel syringe with the fine needle tip and dispense onto the thermocouple tip. Close to the end of the pot-life, it becomes difficult to dispense.
 - iii. Alternately, you can dip the fine needle tip into the epoxy mix and then “touch” the thermocouple tip to dispense the epoxy via surface tension.
 - iv. Cure the epoxy at room temperature (25°C) for at least two hours.
5. Once the epoxy/compound has hardened, the LUXEON S emitter with thermocouple should be mounted onto the heat sink with the Solderless LED Socket. If necessary, make a small groove in the Solderless LED Socket to prevent the thermocouple from getting pinched between the heat sink and the clamp (Figure 11).
 6. Plug in the thermocouple connector to the thermometer. The thermocouple now measures the temperature at the top of the DBC (T_s).
 7. Connect the power supply and light up the LUXEON S emitter with a drive current that corresponds to normal operating conditions.
If possible, attach all fixtures (e.g. clamp on heat sink, lens and any cover) to closely simulate the actual application environment.
 8. Record the temperature T_s at the top of the DBC until it stabilizes. This may take a minute or more depending on the overall thermal design.
 9. The case temperature can then be estimated as follows: $T_c = T_s - 0.5^\circ\text{C}$.

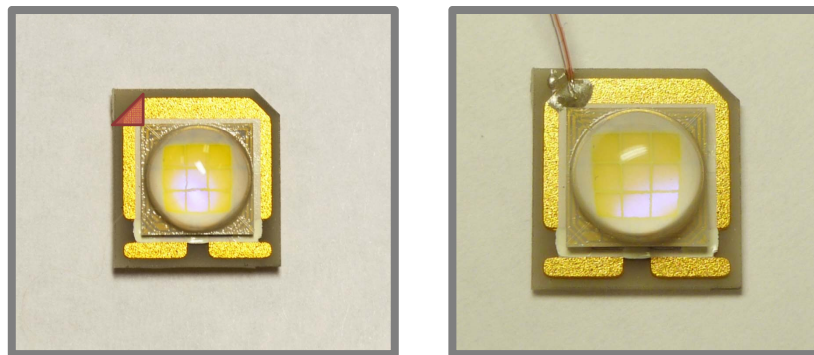


Figure 10. Thermal contact area highlighted in red (left) and example of TC probe attachment (right).

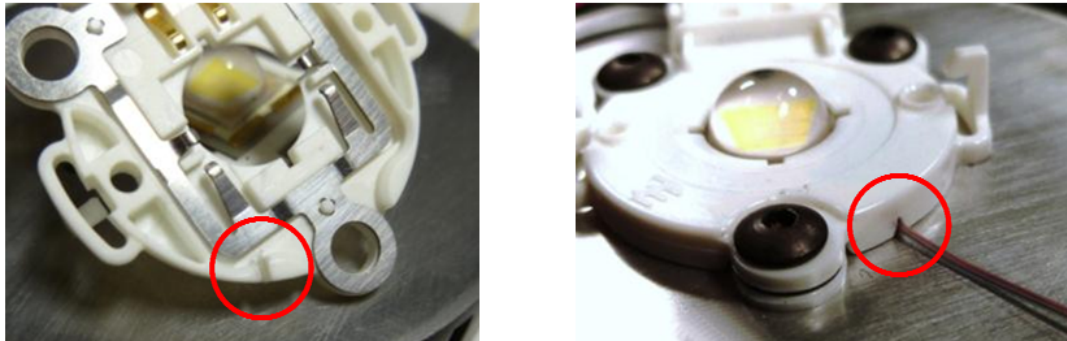


Figure 11. A small groove in the Solderless LED Socket, Type LS prevents the thermocouple from being pinched between the clamp and the heat sink.

4. Product Packaging Considerations – Chemical Compatibility

The LUXEON S package contains a silicone overcoat and dome to protect the LED chips and extract the maximum amount of light. As with most silicones used in LED optics, care must be taken to prevent any incompatible chemicals from directly or indirectly reacting with the silicone.

The silicone overcoat in LUXEON S 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 S 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 dome. Under heat and “blue” light, the VOCs inside the dome 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 dome 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 Philips 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 S 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. Philips Lumileds, therefore, recommends the following precautions when designing your application:

- When designing secondary lenses to be used over a single 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 dome of LUXEON S.
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
tetrachloromethane	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

Company Information

Philips Lumileds is a leading provider of power LEDs for everyday lighting applications. The company's records for light output, efficacy and thermal management are direct results of the ongoing commitment to advancing solid-state lighting technology and enabling lighting solutions that are more environmentally friendly, help reduce CO₂ emissions and reduce the need for power plant expansion. Philips Lumileds LUXEON® LEDs are enabling never before possible applications in outdoor lighting, shop lighting, home lighting, automotive lighting, display and digital imaging.

Philips Lumileds is a fully integrated supplier, producing core LED material in all three base colors, (Red, Green, Blue) and white. Philips Lumileds has R&D centers in San Jose, California and in the Netherlands, and production capabilities in San Jose, Singapore and Penang, Malaysia. Founded in 1999, Philips Lumileds is the high flux LED technology leader and is dedicated to bridging the gap between solid-state technology and the lighting world. More information about the company's LUXEON LED products and solid-state lighting technologies can be found at www.philipslumileds.com.

Disclaimer

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