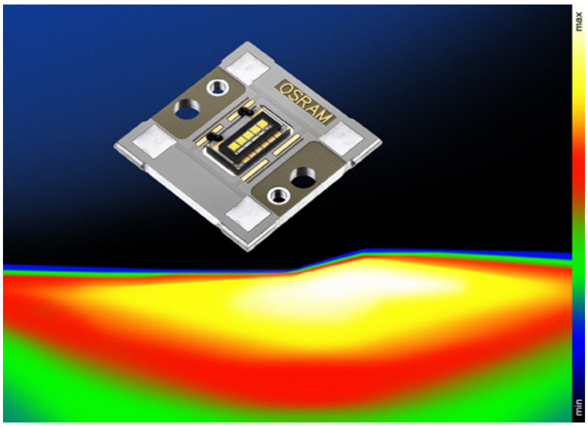
OSRAM OSTAR Headlamp – Details on Handling, Mounting and Electrical Connection

Application Note

Abstract

This application note provides information about the handling and processing of LEDs of the OSRAM OSTAR Headlamp product group. Particular focus is given to the various methods for electrical contact of these LEDs.



Construction of the OSRAM OSTAR Headlamp

As a light source for the LEDs, one or more highly efficient semiconductor chips (max. of 5) of the thin film technology ThinGaN are used, depending on the variant. These are mounted on ceramic, connected with contact leads and covered with glass.

For optimal heat dissipation, the ceramic itself is directly mounted to the aluminum of the insulated metal substrate printed circuit board (IMS-PCB). The contacts to the board (bond wires) are protected against external environmental influences by means of an elastic Globe-Top encapsulant.
The metal core substrate itself serves for dissipation of heat and provides a sufficiently large surface for a simple thermal connection to the system heat sink.

Through the design and construction, the light sources themselves possess a low thermal resistance, typically R_{thJB} = 3.0 to 8.3 K/W depending on the respective type.

With the integrated drill holes, the carrier board is ready for use with additional optics.
By means of the ESD protection diode, LEDs of the OSRAM OSTAR Headlamp group are protected against ESD up to 8 kV according to ISO10605-contact.

The color coordinates of the LED correspond to the white field of ECE/SAE, in which the red component of the LED is greater than 5 % according to ECE Regulation No 112.

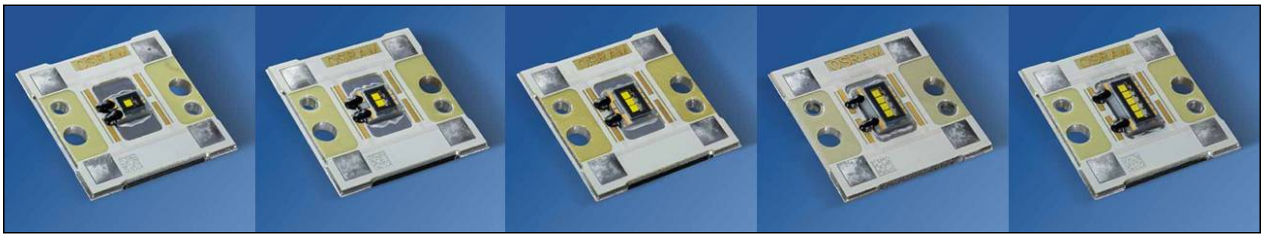


Figure 1: Overview of the High Power Light Sources of the OSRAM OSTAR Headlamp

As with all other LEDs from OSRAM Optp Semiconductors, the OSRAM OSTAR Headlamp product group fulfills the current RoHS guidelines (European Union & China), and therefore contains no lead or other hazardous substances.

Handling of the OSRAM OSTAR Headlamp

In addition to general guidelines for the handling of LEDs, additional care should be taken that mechanical tension on the carrier board and particularly, stresses (e.g. sheer-ing forces) to the glass cover or ceramic are avoided.
This means, for example, that the LED must not be picked up or handled by the glass or ceramic.

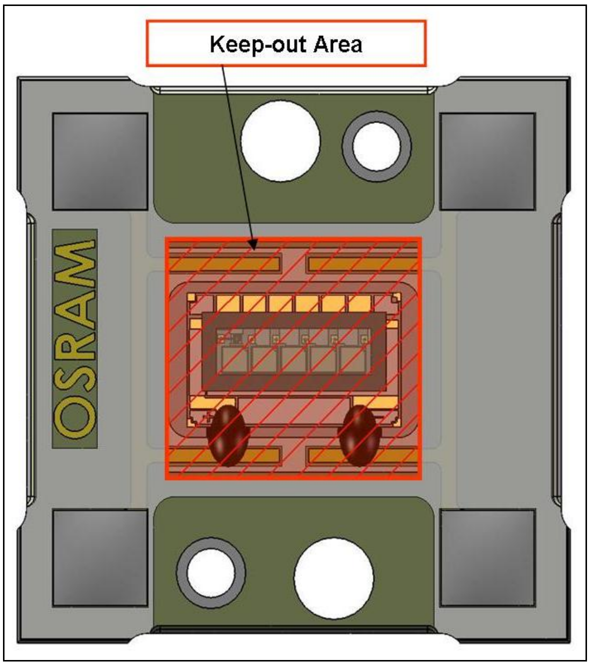


Figure 2: Forbidden zone of the OSRAM OSTAR Headlamp

In general, all types of sharp objects (e.g. forceps, fingernails, etc.) should be avoided in order to prevent stress to or penetration of the encapsulant, since this can lead to damage of the component.
Exerting pressure on the elastic Globe-Top can lead to spontaneous failure of the LED (damage to the contacts).

Care should be taken as well to ensure that no other components (e.g. additional optics) in the application are mounted flush with the sensitive components (glass cover, Globe-Top) of the OSRAM OSTAR Headlamp.

When placing the LED into operation, it should be guaranteed that the compact light source is provided with sufficient cooling.

Since the OSRAM OSTAR Headlamp features an open design which allows an exchange between the inside and the outside of the glass cover it should be minded that no particulate matter of any kind will be dumped by water or any other liquid into the inner section of the light source.
It is also recommended to prevent organics from the environment which could interact with the hot surfaces of the operating chips.

Mounting procedures

Basically, several options can be used for mounting the OSRAM OSTAR Headlamp, such as

- Screws
- Clamps
- Adhesive
- etc.

For use in automotive applications, the preferred mounting technology of the OSRAM OSTAR Headlamp is, fastening with screws (<M3), each with a washer and locking compound is generally recom-mended. When mounting the screws (M2.5), a maximum torque of 0.5 Nm should be used.

Care must be taken to ensure that washer does not damage the ceramic submount during the mounting process.

With the use of adhesives, care should be taken that in addition to good adhesive properties, the adhesives should be thermal stable and possess a good thermal conductivity (for adhesives see “LED Light for you”).

When selecting an appropriate method, it is generally recommended to take the individual requirements of the respective application area into consideration.

In addition, care should be taken that a good transfer of heat is provided between the OSRAM OSTAR Headlamp and the heatsink and that this is also guaranteed during operation.

An insufficient or incorrect installation can subsequently lead to thermal or mechanical problems in the structure.

When mounting a component to a heatsink, it should generally be kept in mind that two solid surfaces must be brought into close physical contact.

Technical surfaces are never really flat or smooth, however, but have a certain roughness due to microscopic edges and depressions. When two such surfaces are joined together, contact occurs only at the surface peaks. The depressions remain separated and form air-filled cavities (Figure 3).
Since air is a poor conductor of heat, these cavities should be filled with a thermally conductive material in order to significantly reduce the thermal resistance and increase the heat flow between the two bordering surfaces.

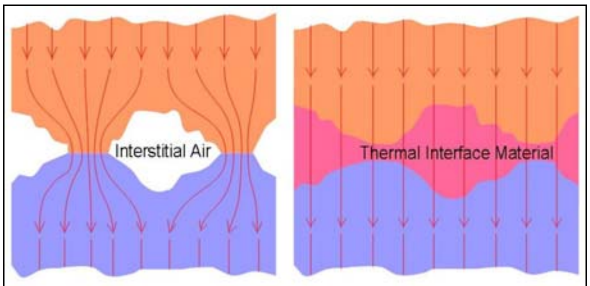


Figure 3: Heat flow with and without heat conductive material

Without an appropriate, optimally effective interface, only a limited amount of heat exchange occurs between the two components, eventually leading to overheating of the light source.

In order to improve the heat transfer capability and reduce the thermal contact resistance, several materials are suitable.
Thermally conductive pastes and compounds possess the lowest transfer resistance, but require a certain amount of care in handling.
Elastomers and foils/bands are easy to process, but usually require a particular contact pressure, even with pretreated surfaces.
The success of a particular thermal transfer material is dependent on the quality, the processing of the material and the thoroughness of the design.

Verification of the design through measurement of the board temperature

Despite the existing possibilities of thermal simulation it is recommended, to verify the design and/or the thermal management with a prototype under real conditions including all additional heat sources.

Thereby the board temperature T_B of the LED modules is taken as calculation basis for the determination of the junction temperature T_J.

The board temperature itself refers to the device back, where also the thermal resistance of the LED module is defined (see also Application Note „Package related thermal resistance of LEDs“).

Since LED modules are usually mounted on a cooling element, the board temperature however cannot be directly measured on the bottom respectively only with higher complexity.
The simplest and most practicable solution also for enclosed applications is a temperature measurement via a thermocouple on the surface of the module. To get a useable

result the thermocouple has to be fixed directly alongside the light source (ceramics) of the module (see also Application note „Temperature Measurement with Thermocouples").

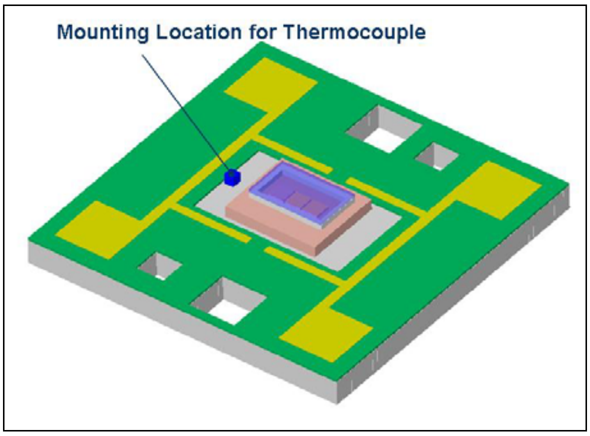


Figure 4: Possible area (grey) to fix thermocouple

To the OSRAM OSTAR Headlamp modules with 1 to 3 chips the thermocouple can be attached for that purpose on the open aluminium surface (= grey area) beside the ceramics (Figure 4).

For the remaining versions with 4 and 5 chips the available aluminium surface is potentially too small depending on the type of thermocouple used and must be increased if necessary by removing the dielectric at the surface of the IMS PCBs. However this machining must be done carefully since the LED module can be damaged.

In general the thermocouple can also be mounted in a drilled hole with adapted diameter and depth.

As it is shown by simulation, and confirmed by measuring, the detected temperature ($T_{Mounting\text{-}Location}$) on the surface matches nearly with the board temperature T_B, and can be therefore used for the calculation of the junction temperature (Figure 5).

$$T_J = R_{th,JB} \cdot P_{Heat} + T_{MountingLocation}$$

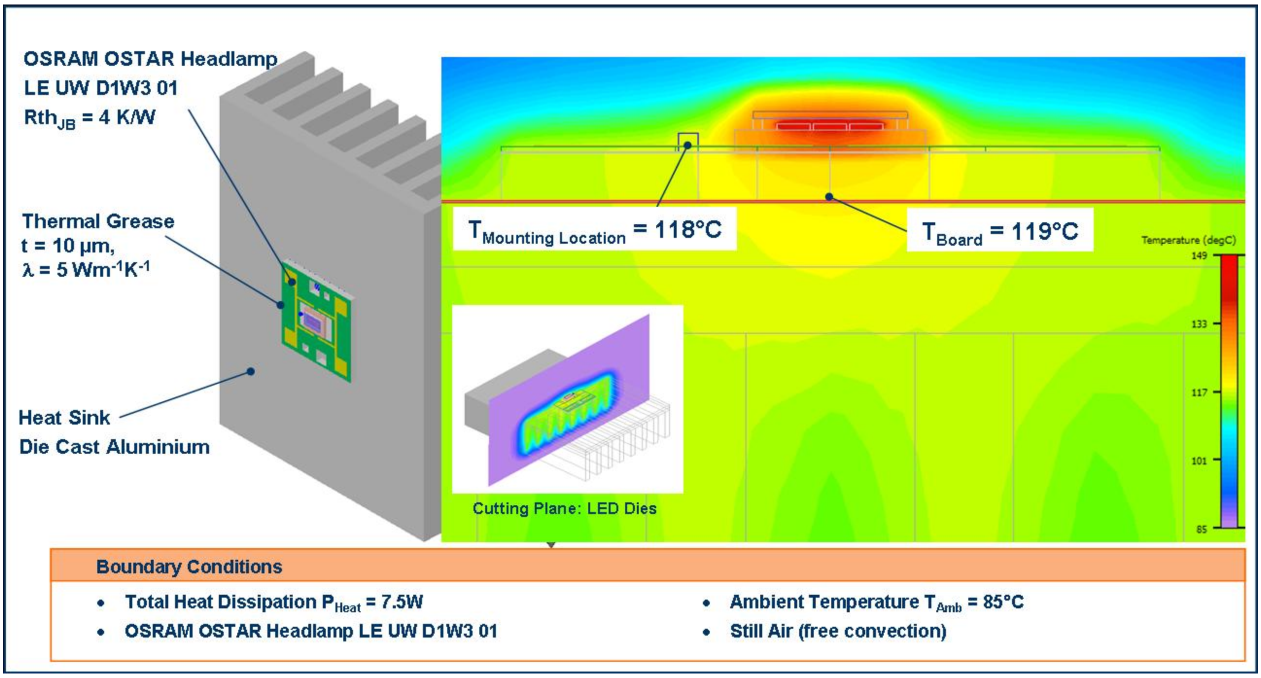


Figure 5: Simulation of T_{Board} of OSRAM OSTAR Headlamp in application

Electrical contact

For electrical contact of the OSRAM OSTAR Headlamp, four solder pads are available on the carrier board – one in each corner. Internally, two of the solder pads are wired to the anode and two to the cathode (redundancy).

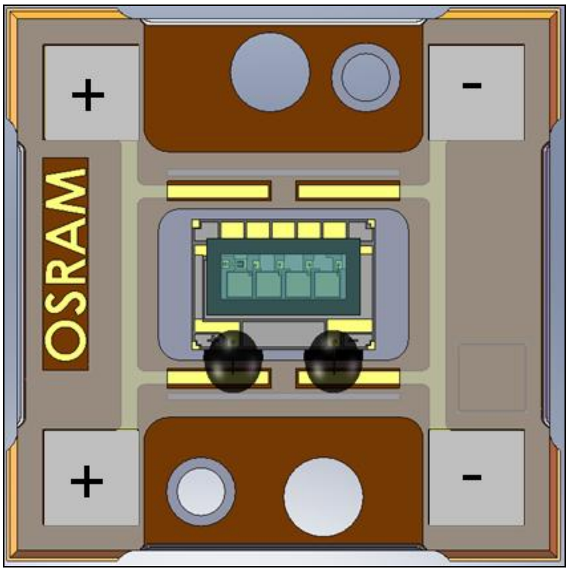


Figure 6: Pin assignment of the OSRAM OSTAR Headlamp (Pin 1: anode, Pin 2: cathode)

The solder pads have a size of 3.5 mm x 3.5 mm and are already pre-tinned for easy processability and solderability (SnAgCu solder = SAC solder).

For the electrical contact, various mounting methods can be used, such as:

- Wire
- Flexboard
- PCB connecting fames
- Connector system

- Contacting by means of wire

The simplest form of contact is a connection with two wires.
The wires are attached to the solder pads by means of a soldering iron and a small amount of solder.

This form of electrical contact is mostly used for prototypes or small production quantities.

Generally, wires with a diameter of up to 1.02 mm (e.g. AWG 18) can be used for contacting the OSRAM OSTAR Headlamp.
Typically, however, wires with smaller diameters such as AWG 20 or AWG 22 are used, depending on the chosen forward current.

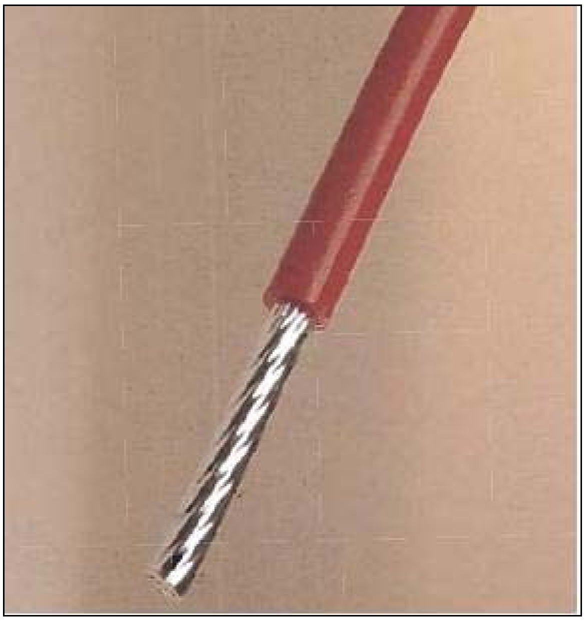


Figure 7: Wire with tinned end (AWG20)

Preparation of the wire/solder should be carried out according to IPC-A-610D, Chapter 6.3. The stripped wire (lead) should be protected with a thin layer of solder (Figure 7).

For the processing, a solder station with a power rating of at least 80 W should be used (Figure 8), in order to guarantee a quick wetting of the contact and an effective heat flow, possibly in conjunction with an additional heating plate.

Figure 8: Example of a soldering station (I-CON from ERSA)

When selecting the tip for the soldering iron, the appropriate geometry should be taken into consideration. A chisel-formed tip with a width of 2.4 mm has proven to be the best and most reliable tip for the combination of the OSRAM OSTAR Headlamp and contact wire.

In order to avoid problems when mounting the device, the solder used should consist of the same alloy as the pre-tinned solder pads (SnAgCu). As an example, the 0.5 mm thick solder wire SnAgCu from EDSYN can be used.
Since this involves a selective lead-free soldering process, the applicable regulations and guidelines should generally be taken into consideration.

Figure 9: Soldered wires on MCPCB

When evaluating the soldering process, for example, one should always start with the lowest temperature; the temperature of the soldering tip should not exceed 350 °C.

Under consideration of the general requirements for lead-free soldering and the properties of the material used, a good and rapid solder heat flow allows the corresponding solder connection to be formed within 5-6 seconds (Figure 9).

For reference and further information on manual lead-free soldering see also the application note “Manual Lead-free Soldering of LEDs”.

Flexboard connection

Another possibility for connection is contacting with a flexible PCB, a so-called flexboard (FPC).

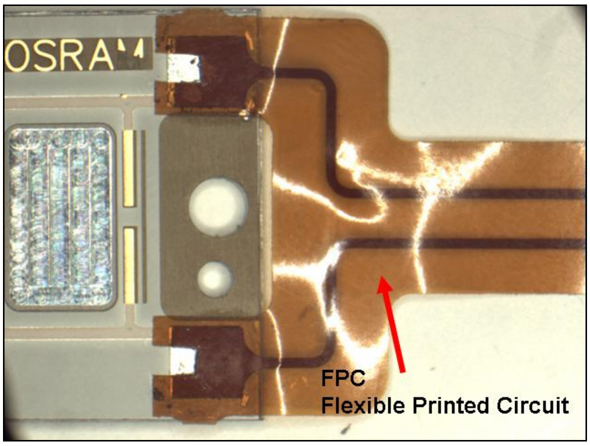


Figure 10: Example of an OSRAM OSTAR Headlamp connected to an FPC

The foil-like flexboard consists of a 25 µm or 50 µm layer of polyamide with a 35 µm thick layer of copper.
The preparation and processing of the flexboard is the same as for a normal circuit board (layout creation – light exposure and etching of the structures – tinning with SAC solder – cutting).

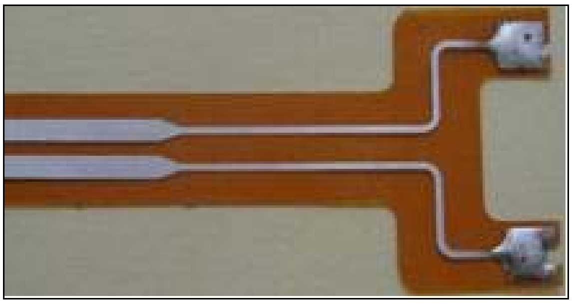


Figure 11: Example of an FPC with a test layout

The electrical connection (Figure 12) takes place between the solder pads of the OSRAM OSTAR Headlamp and the corresponding solder pads on the flexboard by means of a hot bar or iron soldering process.

Figure 12: Example of an FPC solder joint

With the soldering process, the connection is made within a few seconds (contact time approx. 3 sec.) with a 350 °C hot bar (Figure 13).

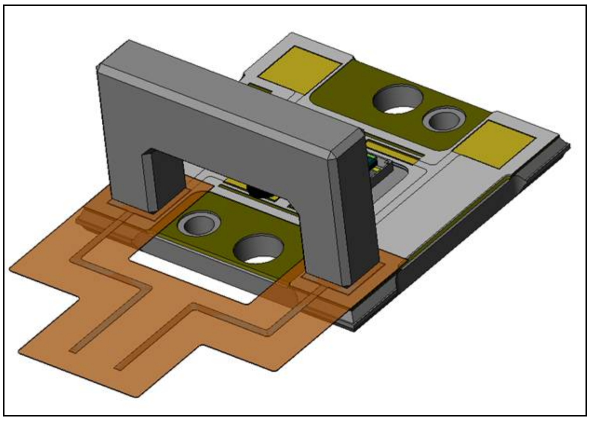


Figure 13: Principle of hot bar soldering

Contacting by means of a flexboard offers the advantage that the contacts are significantly more flexible and thinner than wires. In addition, the process can be automatically performed in a reproducible manner.

Inspection of the soldering or soldering connection can be carried out by means of a nut or hole in the flexboard (see Figure 12).

PCB connecting frame

Another contacting and mounting technique for the OSRAM OSTAR Headlamp is the use of a circuit board frame (Figure 14).

Here, the OSRAM OSTAR Headlamp is soldered and electrically connected to the back side of the frame at the four solder pads.

With the frame design, the circuit board permits additional optics to be added to the LED.

The primary advantage of this method, however, is the possibility to integrate additional components on the circuit board such as:

- Customer specific connectors
- NTC resistors for temperature sensing
- Driver ICs
- Resistors for coding of the LED properties are possible (e.g. brightness BIN)
- etc.

With the high level of design flexibility, several different options are available to the user. Different OSRAM OSTAR Headlamp LED types can be driven with only one board, for example.

Depending on the durability requirements of the application, the frame can be constructed with one or two layers (Figure 15).

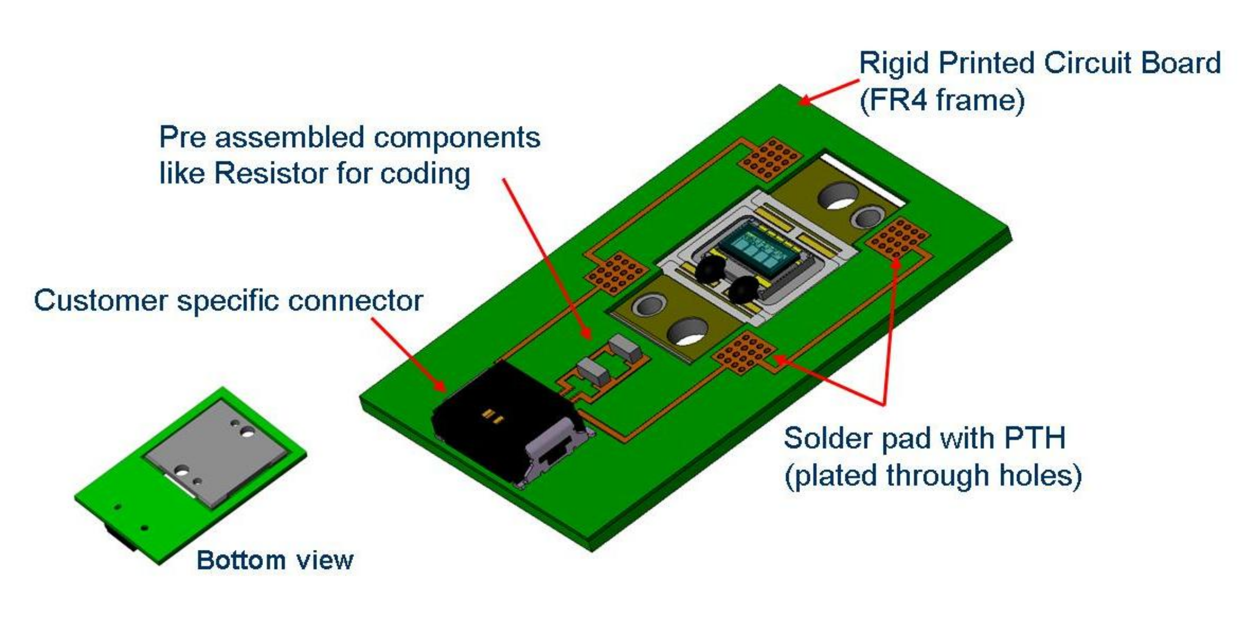


Figure 14: Electrical connection via the PCB connecting frame

The first layer consists of a double-sided PCB (e.g. thickness = 0.36 mm) with the desired layout and the solder pads including the through holes for the electrical contact.

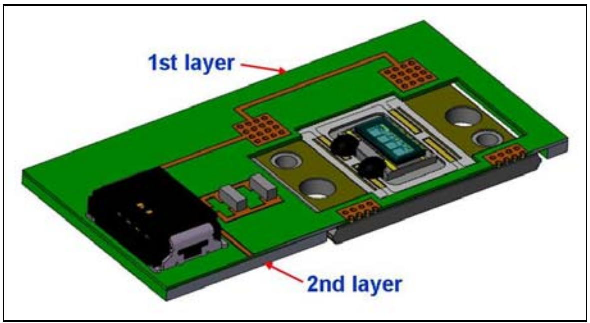


Figure 15: Design example of OSRAM Opto Semiconductors

The second layer basically serves to increase the stability and to additionally align the LED and consists of a PCB without a copper layer with a thickness of 0.5 to 1.5 mm.

Here, various methods can be used for soldering such as

- Hot bar soldering
- Iron soldering
- Laser soldering
- Hot air soldering
- etc.

In the end, however, this depends on the design and the thickness of the PCB frame.

As an example, a soldering with the demonstrated design from OSRAM Opto Semiconductors can be seen in Figure 16.

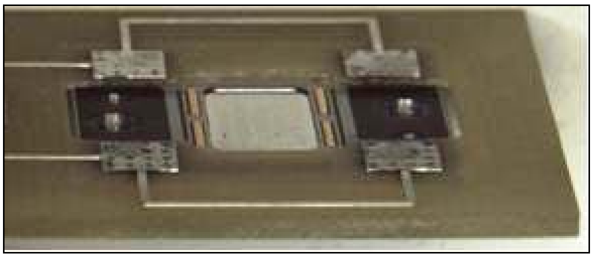


Figure 16: Soldered FR4 PCB on OSRAM OSTAR Headlamp MCPCB

This was carried out with a soldering iron (soldering station WD2M with 160 W) in which a good solder connection was able to be created with soldering tip temperature of 350 °C and a duration of 3.5 sec.

Connector System

A further method is a solderable connector system (MQS) specially developed for the OSRAM OSTAR Headlamp by Tyco.

With this system, electrical contact occurs by two contact fingers that are soldered to the solder pads. In this case, part of the system is rigidly attached to the OSRAM OSTAR Headlamp.

For selective soldering of the leads, various methods are suitable, here, such as hot bar, iron soldering or similar methods.

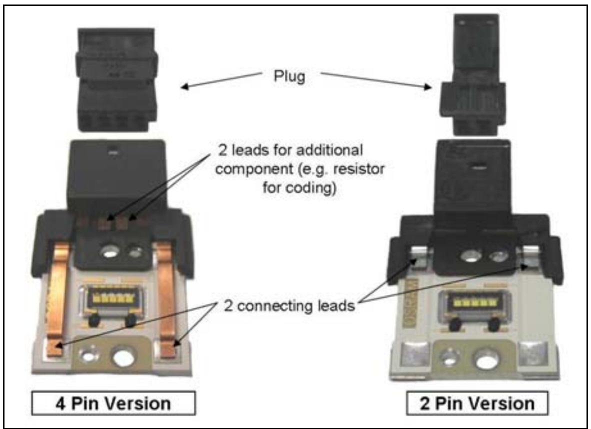


Figure 17: MQS connector system from Tyco

Summary

The intention of the methods for electrical connection described above is to provide concepts or examples which show the basic design and principal soldering process.

OSRAM Opto Semiconductors can support their customers during the soldering process development in finding the best solution for their specific application.

Appendix

Don't forget: LED Light for you is your place to be whenever you are looking for information or worldwide partners for your LED Lighting project.

www.ledlightforyou.com

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About Osram Opto Semiconductors

Osram Opto Semiconductors GmbH, Regensburg, is a wholly owned subsidiary of Osram GmbH, one of the world's three largest lamp manufacturers, and offers its customers a range of solutions based on semiconductor technology for lighting, sensor and visualisation applications. The company operates facilities in Regensburg (Germany), San José (USA) and Penang (Malaysia). Further information is available at www.osram-os.com.