Product Document

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High-power OSCONIQ® P — Details on properties, handling and processing

Application Note

Valid for:
OSCONIQ® P 3030
OSCONIQ® P 3737 (2W)
OSCONIQ® P 3737 (3W)

Abstract

The OSCONIQ® P family is a new high-power LED with a lead-frame-based package design. It offers an alternative to ceramic-based packages, by providing superior corrosion robustness and long life-time performance as well as low thermal resistance and excellent second level board reliability.

The OSCONIQ® P is specifically designed to deliver high luminous flux and efficacy from a single optical source, enabling a compact luminaire design for a wide range of outdoor and industrial lighting, as well as a nice fit for portable applications.

This application note presents a fundamental overview of the LED design and its characteristics. In addition, appropriate assembly, handling, compatible optics accessories and thermal management are recommended to enable an optimized application design.

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A. Description of OSCONIQ® P

The OSCONIQ® P LED is a lead-frame-based package alternative to the well-known ceramic-based high-power LEDs, providing superior corrosion robustness and performance. The LED stands out due to low thermal resistance, superior corrosion robustness, excellent second level board reliability and a long life-time performance, which makes it an ideal choice for general indoor and outdoor lighting applications such as Street Lighting, Tunnel Lighting, High Bay and Low Bay Lighting.

Figure 1: OSCONIQ® P family

OSCONIQ® P 3737 (2W) and OSCONIQ® P 3737 (3W)

OSCONIQ® P 3030

B. Features and construction

The OSCONIQ® P follows the Quad Flat No Lead (QFN) package design which consists of a lead frame and a white epoxy mold compound. A highly efficient semiconductor chip is mounted and electrically connected on the lead frame, covered by a clear silicone lens. In addition to the mounting and the electrical connection of the LED to the circuit board, the lead frame serves to dissipate the heat that is generated during operation.

This OSCONIQ® P design ensures low thermal resistance. As ESD protection is included, the LED withstands voltage up to 8 kV and is assigned according to ANSI / ESDA / JEDEC JS-001 — HBM, Class 3B.

Containing no lead or other hazardous substances, the OSCONIQ® P fulfills the current RoHS guidelines (European Union and China).

C. Design considerations

Mechanical and optical design resource

Optical Rayfile and package CAD models are available online.

http://www.osram-os.com/osram_os/en/applications/application-support/optical-simulation/index.jsp?fb_dir=LED%2fOSCONIQ%2fOSCONIQ+P%2f

Electrical device pad polarity

The OSCONIQ® P 3737 (2 W and 3 W) and the OSCONIQ® P 3030 feature three pads that need to be soldered onto the corresponding pads on the PCB to ensure proper thermal and electrical operation (see Figure 2 and Figure 3). Please refer to the respective data sheets for the recommended footprint design for the solder mask and copper layout on the PCB.

The center thermal pad is cathode potential and non-isolated. It must NOT be connected to the anode pad, as the thermal pad is on cathode potential. It is recommended to either leave the thermal pad isolated or clamp it to the cathode.

Figure 2: OSCONIQ® P 3737 (2 W) or OSCONIQ® P 3737 (3 W) solder pad design

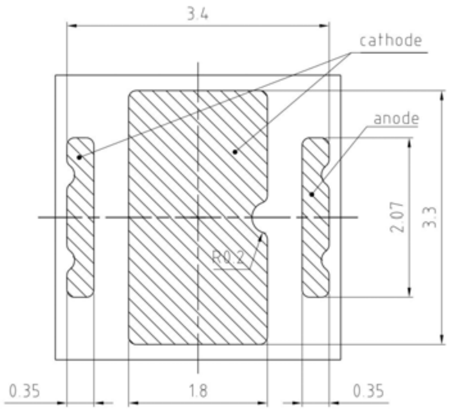
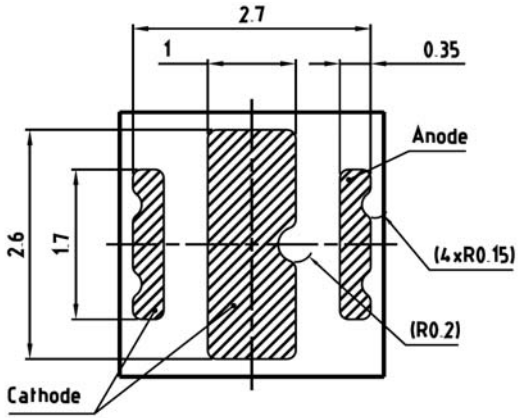


Figure 3: OSCONIQ® P 3030 solder pad design



Isolation and PCB design

The OSCONIQ® P 3737(2 W), OSCONIQ® P 3737 (3 W) and OSCONIQ® P 3030 LEDs are designed to be soldered onto an MCPCB or a multi-layer FR4 PCB. To ensure optimal operation, the PCB should be designed to minimize the overall thermal resistance between the LED package and the heat sink as shown in Figure 4 for the OSCONIQ® P 3737 and in Figure 5 for the OSCONIQ® P 3030.

From a thermal perspective it is not required to connect the thermal pads on MCPCBs. It is also recommended to use thermal interface material (TIM) in between the PCB and the heat sink for improved thermal dissipation.

Figure 4: PCB layout for OSCONIQ® P 3737 (2 W) or OSCONIQ® P 3737 (3 W)

LED on MCPCB | LED on FR4 (2 layers)

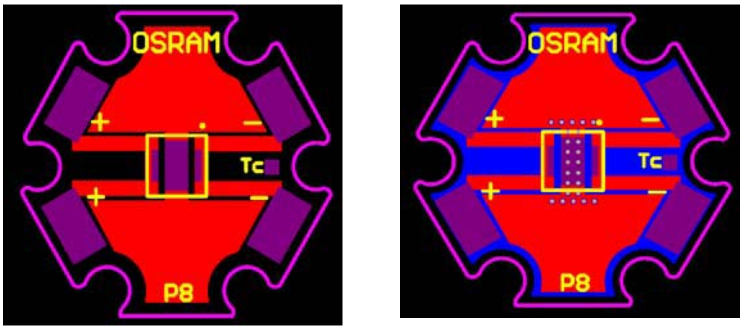
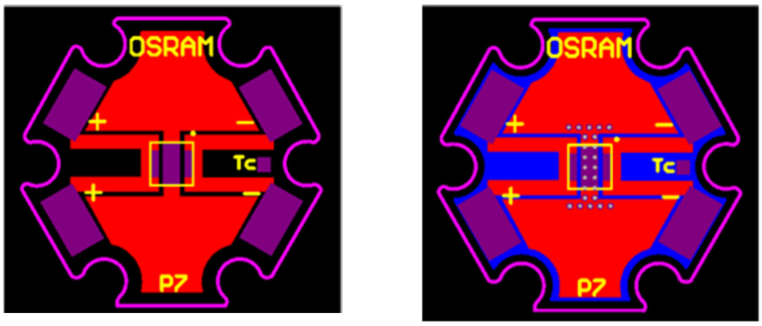


Figure 5: PCB layout for OSCONIQ® P 3030

LED on MCPCB | LED on FR4 (2 layers)

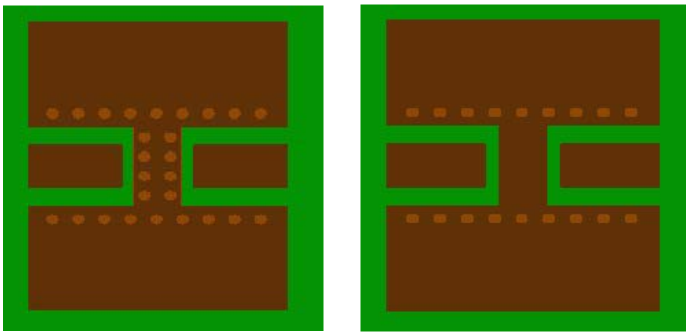


Thermal management of the OSCONIQ® P

The total thermal resistance between the OSCONIQ® P and the environment is highly affected by the overall design and the material used for the PCB. MCPCBs are commonly used in industry for their low thermal resistance and proven durability.

FR4 is an alternative option (Figure 6). It is important to include arrays of thermal vias in the PCB design to reduce thermal resistance. Vias are usually placed around the copper pad area to create a contact between the upper pads and the bottom. A capped via, in contrast, can be placed directly below the thermal pad of the LED, improving the thermal performance of the PCB.

Figure 6: FR4 with capped vias (left) and open vias (right) for OSCONIQ® P 3737 (2 W), OSCONIQ® P 3737 (3 W) or OSCONIQ® P 3030



PCB technology and selection

Thermal measurement must be performed as close to the LED as possible, which is the measuring point temperature T_{mp} as shown below (see Figure 7). For this procedure, measuring the T_{mp} of a predetermined location on the PCB right next to the OSCONIQ® P is done with a thermocouple.

Thermally conductive epoxy or solder is recommended to ensure a good heat transfer from the board to the thermocouple. The thermocouple must be in direct contact with the copper thermal pad, i.e. any solder mask must be removed first before mounting the thermocouple onto the PCB copper pad.

The Tables 1, 2, and 3 summarize the thermal resistance values R_{th} of the board and also T_j to T_{mp} between the different PCB designs and technologies.

Figure 7: Measuring point temperature T_{mp} for OSCONIQ® P 3030, OSCONIQ® P 3737 (2 W) or OSCONIQ® P 3737 (3 W)

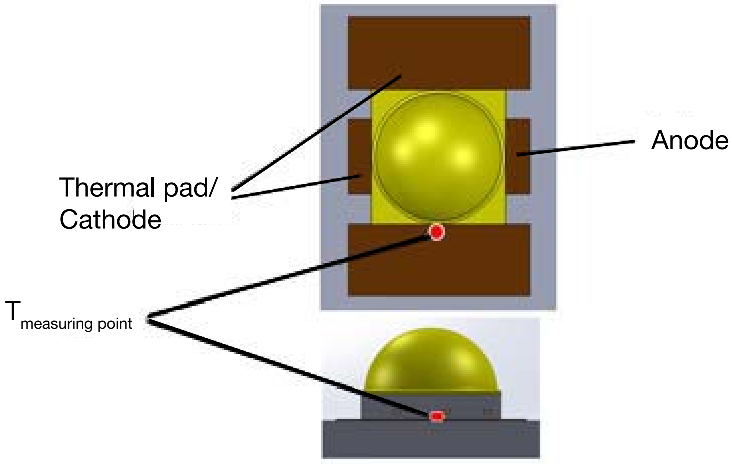


Table 1: Simulation result for OSCONIQ® P 3030 R_{th} with different dielectrics and copper foils

PCB technology	**Details substrate thickness = 1 mm**	**Cu foil**	$R_{th\ sb\ el}$	$R_{th\ jmp\ el}$
Al-core MCPCB	38 µm dielectric (3.0 W/mK)	35 µm (1 oz)	5.8 K/W	7.8 K/W
Al-core MCPCB	75 µm dielectric (2.2 W/mK)	35 µm (1 oz)	6.0 K/W	8.5 K/W
Al-core MCPCB	100 µm dielectric (1.3 W/mK)	35 µm (1 oz)	6.7 K/W	9.5 K/W
FR4[1] (capped vias)	vias on thermal pad and electrodes	70 µm (2 oz)	5.6 K/W	9.0 K/W
FR4[1] (open vias)	vias on thermal pad and electrodes	70 µm (2 oz)	5.8 K/W	9.5 K/W

[1] FR4 properties: Vias diameter: 0.5 mm, Vias pitch distance: 1 mm, the copper pad area is identical at the front and bottom

Table 2: Simulation result for OSCONIQ® P 3737 (2 W) R_{th} with different dielectrics and copper foils

PCB technology	Details substrate thickness = 1 mm	Cu foil	$R_{th\ sb\ el}$	$R_{th\ jmp\ el}$
Al-core MCPCB	38 µm dielectric (3.0 W/mK)	35 µm (1 oz)	2.1 K/W	3.0 K/W
Al-core MCPCB	75 µm dielectric (2.2 W/mK)	35 µm (1 oz)	3.6 K/W	3.6 K/W
Al-core MCPCB	100 µm dielectric (1.3 W/mK)	35 µm (1 oz)	6.0 K/W	4.2 K/W
FR4[1] (capped vias)	vias on thermal pad and electrodes	70 µm (2 oz)	7.2 K/W	4.7 K/W
FR4[1] (open vias)	vias on thermal pad and electrodes	70 µm (2 oz)	12.3 K/W	7.0 K/W

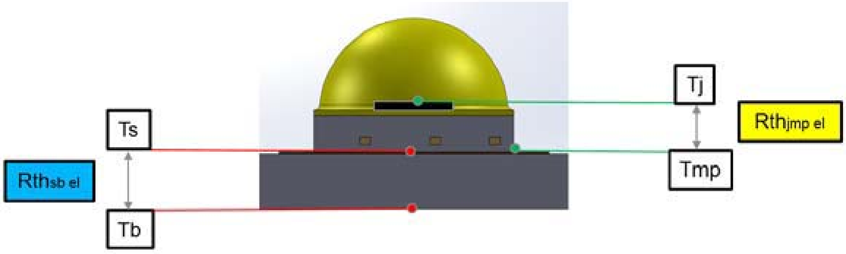
[1] FR4 properties: Vias diameter: 0.5 mm, Vias pitch distance: 1 mm, the copper pad area is identical at the front and bottom

Table 3: Simulation result for OSCONIQ® P 3737 (3 W) Rth with different dielectrics and copper foils

PCB technology	Details substrate thickness = 1 mm	Cu foil	$R_{th\ sb\ el}$	$R_{th\ jmp\ el}$
Al-core MCPCB	38 µm dielectric (3.0 W/mK)	35 µm (1 oz)	1.6 K/W	2.8 K/W
Al-core MCPCB	75 µm dielectric (2.2 W/mK)	35 µm (1 oz)	2.9 K/W	3.3 K/W
Al-core MCPCB	100 µm dielectric (1.3 W/mK)	35 µm (1 oz)	4.9 K/W	3.4 K/W
FR4[1] (capped vias)	vias on thermal pad	70 µm (2 oz)	4.0 K/W	3.3 K/W
FR4[1] (open vias)	vias on thermal pad	70 µm (2 oz)	10.1 K/W	5.3 K/W

[1] FR4 properties: Vias diameter: 0.5 mm, Vias pitch distance: 1 mm, the copper pad area is identical at the front and bottom

Figure 8: R_{th} network for OSCONIQ® P 3030, OSCONIQ® P 3737 (2 W) and OSCONIQ® P 3737 (3 W)



Junction temperature T_j calculation

The typical thermal resistance $R_{th\ jmp}$ between the junction and solder point for the OSCONIQ® P can be obtained from the Tables 1 – 3. With the information, the junction temperature T_j can be calculated according to the following equation:

$T_j = T_{mp} + I_F \bullet V_F \bullet R_{th\ j\ mp}$

, where

- T_j is the junction temperature of the LED [°C],
- T_s is the solder pad temperature on the PCB [°C],
- I_F is the forward current of the system [A],
- V_F is the forward voltage of the system [V],
- $R_{th\ j\ mp}$ is the thermal resistance of the LED from the junction to measuring point [K/W].

To determine the junction temperature T_j experimentally, switch on the LED assembly at the necessary forward current, I_F until it reaches a stable temperature.

Example. The thermal resistance $R_{th\ j\ mp}$ between the OSCONIQ® P 3737 (3W) junction and the measuring point is approximately 3.3 K/W on an MCPCB with 2.2 W/mK and 75 µm dielectric thickness. Values for different MCPCBs are stated in Table 1. The T_j can be calculated as below:

$T_j = T_{mp} + I_F \bullet V_F \bullet 3.3\ K/W$

There might be situations where a small confined area is utilized to put in a tight dimension array of LEDs. The OSCONIQ® P LEDs can be arrayed with a minimal spacing of 1 mm on an MCPCB with 1.3 W/mK thermal conductivity and 100 µm thickness with no significant effect on the T_j.

D. Assembly & processing

Handling precautions

Following general guidelines for the handling of LEDs, additional care should be taken to minimize mechanical stress on the silicone encapsulation (see also application note "Handling of silicone resin LEDs").

In general, all types of sharp objects (e.g. forceps, fingernails, etc.) should be avoided to prevent damage to the encapsulation, which can lead to the spontaneous failure of the LED. For manual handling of the component, the use of vacuum tweezers is recommended. The effective mechanical stress on the LED is minimized by means of soft rubber suction tips. (Figure 9).

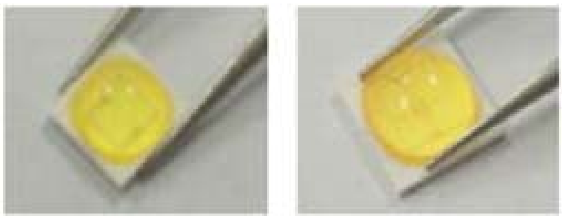
Figure 9: Examples of vacuum styluses

Pick and place

As mentioned before, the use of vacuum styluses is recommended. These tweezers create a vacuum (e.g. by pressing the button of the tweezers) with which the component (e.g. the LED) can be lifted. If there is no alternative to the exceptional use of tweezers (anti-static), the LED must be picked and handled only at the epoxy mold compound (Figure 10).

Figure 10: Manual handling of the OSCONIQ® P

Pick the LED only on the plastic base



Do not touch the silicone resin!

When processing in automatic pick-and-place machines, care should be taken that an appropriate pick-and-place tool is used and the process parameters conform to the mechanical characteristics of the package. A placement force of 2.0 N is recommended to start and this should be minimized where possible.

For camera teaching during the machine setup, make sure to teach the camera the later package image (Figure 11 and Figure 12) before continuing the pick-and-place process.

Figure 11: OSCONIQ® P 3737 (2 W) or OSCONIQ® P 3737 (3 W) package image

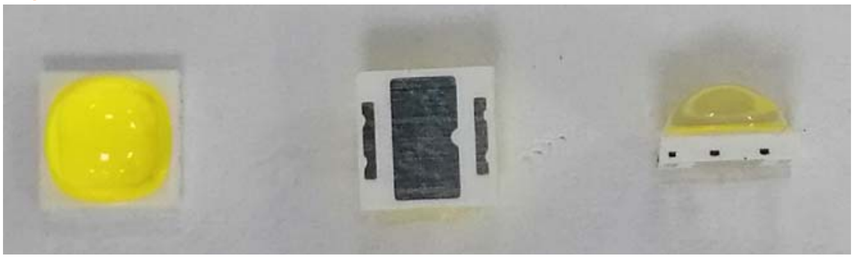


Figure 12: OSCONIQ® P 3030 package image

The recommendations for pick-and-place nozzle types for the OSCONIQ® P family are shown below. Figure 13 shows a recommendation of a pick-and-place nozzle for the OSCONIQ® P 3030.

Figure 13: Recommended pick-and-place tool for the OSCONIQ® P 3030

Ching Yi 2050 nozzle JUK-0510/18

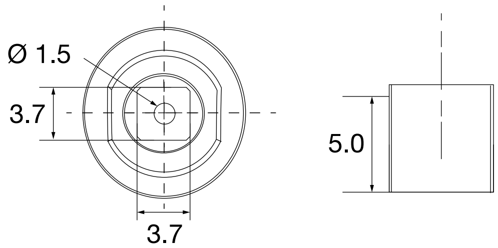


Figure 14 shows the recommendation of pick-and-place nozzle types for the OSCONIQ® P 3737 (2 W) and OSCONIQ® P 3737 (3 W). Similar to other OSCONIQ® P, nozzle recommendations fit for ASM SIPLACE machines as well as for JUKI KE-2080RL pick-and place-machines.

Figure 14: Recommended pick-and-place tool for the OSCONIQ® P 3737 (2 W) & OSCONIQ® P 3737 (3 W)

ASM SIPLACE 3127726-01

Ching Yi 2050 nozzle JUK-0461/15

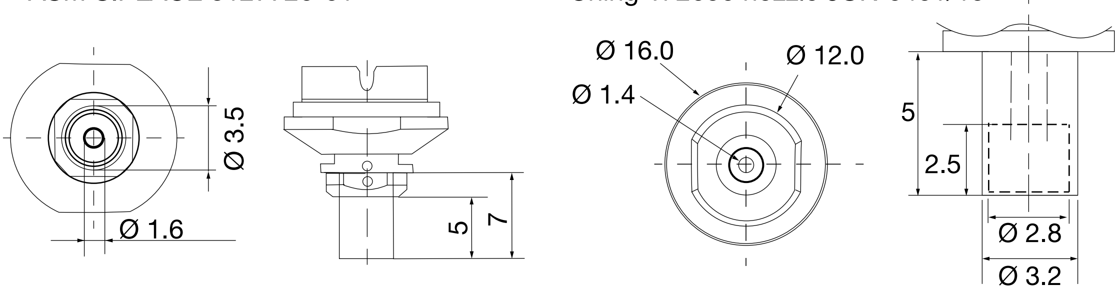
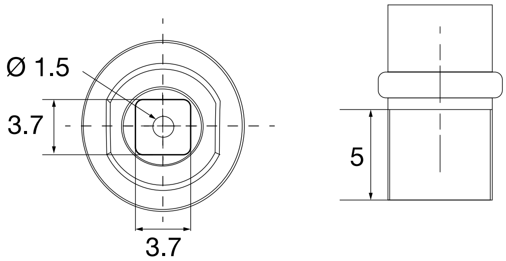


Figure 15 shows the nozzle recommended for the OSCONIQ® P 3737 (3W) Flat version.

Figure 15: Recommended pick-and-place nozzle for the OSCONIQ® P 3737 (3W) Flat version

Ching Yi 2050 nozzle JUK-0510/18



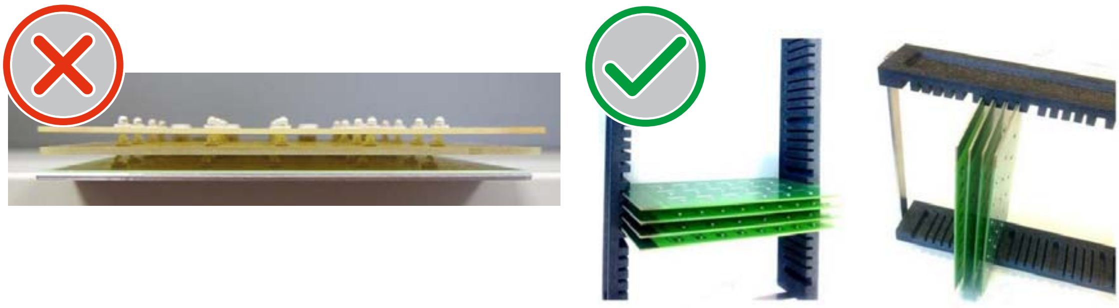
Storage

The OSCONIQ® P are generally supplied in tape with dry pack and should be factory-sealed when stored.

The hermetic pack should only be opened for immediate mounting and processing, after which the remaining LEDs should be repacked according to the moisture level inducated the data sheet (q.v. JEDEC J-STD-033B.1 — Moisture Sensitivity Levels).

PCBs or assemblies containing LEDs should not be stacked such that force is applied to the LED (Figure 16), and should not be handled directly at the LED. Generally, all LED assemblies should be allowed to return to room temperature after soldering, before subsequent handling or the next process step.

Figure 16: Storage of LEDs



Cleaning

From today's perspective any direct mechanical or chemical cleaning of the OSCONIQ® P is forbidden.

Isopropyl alcohol (IPA) can be used if cleaning is mandatory.

Ultrasonic cleaning of the OSCONIQ® P is generally not recommended.

For dusty LEDs, simple cleaning by means of purified compressed air (e.g. central supply or spray can) is recommended.

Processing

The OSCONIQ® P are generally supplied in tape and reel format and are compatible with existing industrial SMT processing methods.

For mounting the component, a standard reflow soldering process with forced convection under standard N_2 atmosphere is recommended, in which a typical lead-free SnAgCu metal alloy solder is used. In order to reduce the voids, it is recommended to use a reflow soldering oven with a vacuum chamber.

The recommended temperature profile provided by the solder paste manufacturer can be used as a good starting point. The maximum temperature for the profile as specified in the data sheet should not be exceeded.

In general, it is recommended that any twisting, warping, bending and other forms of stress to the circuit board should be avoided after soldering in order to prevent breakage of the LED housing or the solder joints.

Therefore, the circuit boards should not be separated manually and should only be carried out with a specially designed tool.

SMT process

In the SMT process, the solder paste is normally applied by stencil printing. The quality of printing has an influence on the solder quality, since effects such as solder bridges, solder spray and/or other soldering defects are largely determined by the design of the stencil apertures and the quality of the stencil printing (e.g. positioning, cleanliness of the stencil, etc.).

The stencils and their apertures are thus specially laid out for the respective application. As an example, the recommended design and dimensions of the stencil apertures for the solder pad for the OSCONIQ® P are shown in Figure 17 and Figure 18.

Since the solder pad effectively creates the direct contact between the LED and the circuit board, the design of the solder pad has an influence on the solder joint reliability, the self-centering effect and the heat dissipation.

In most cases, it is therefore advantageous to use the recommended solder pad from the data sheet, since it is individually adapted to the properties and conditions of the LED. If the placement position is greater than 150 µm from the center, the components should not be reflowed as electrical shorts resulting from solder bridges may be produced.

Figure 17: Recommended solder pad and solder stencil for OSCONIQ® P 3737 (2W) or OSCONIQ® P 3737 (3W)

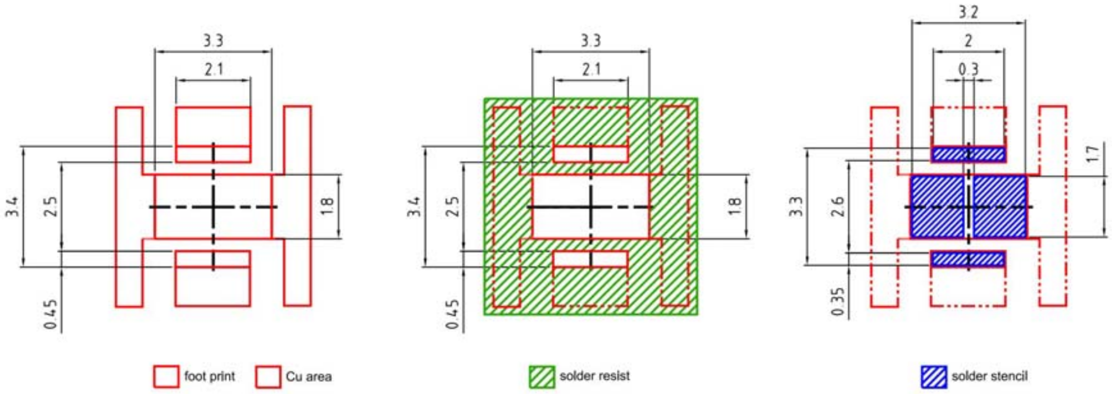
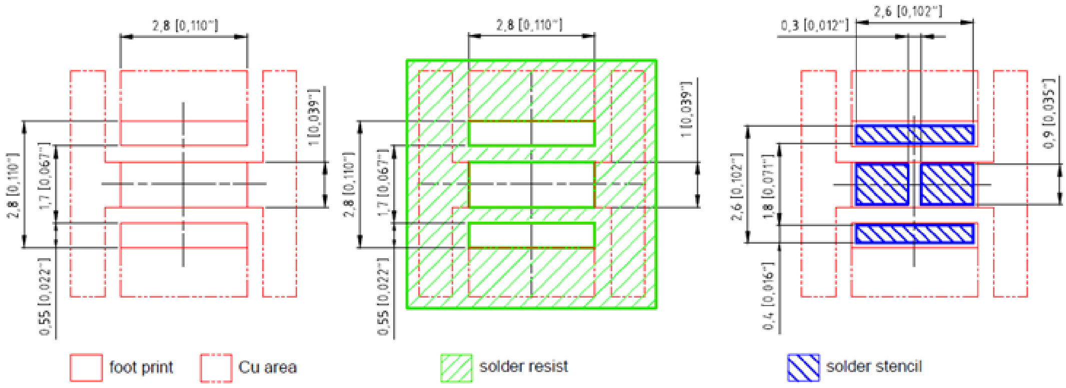
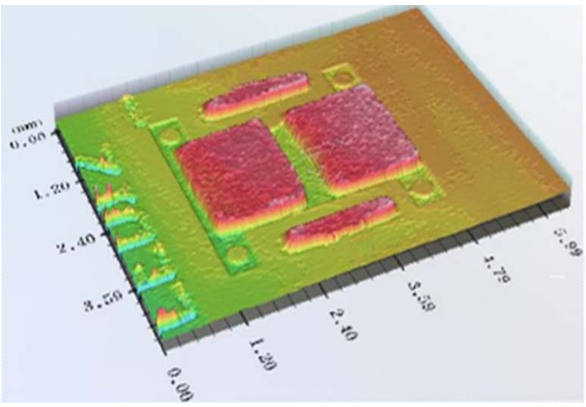


Figure 18: Recommended solder pad and solder stencil for OSCONIQ® P 3030



When printing with a stencil, the amount of solder paste is determined by the thickness of the stencil. For OSCONIQ® P, a thickness of 120 µm is suitable. Figure 19 shows the solder paste profile from the 3D offline solder paste inspection system for the OSCONIQ® P 3737 (2 W).

Figure 19: 3D image of 120 µm solder paste



Voids

For good thermal connection and a high board level reliability, it is recommended that voids and bubbles should be eliminated in all solder joints. A total elimination of voids, particularly for the larger thermal pad, is difficult. Therefore, the design of the stencil aperture is crucial for the minimization of voids.

The recommended design openings in the stencil enable the outgassing of the solder paste during the re-flow soldering process and also serve to regulate the final solder thickness.

Apart from the stencil design, the reflow oven with a build-in vacuum chamber has a significant impact on reducing the voids.

Therefore, typically solder paste coverage of 60 % — 80 % is tipically recommended. In industry standards such as IPC-A-610 D or J-STD-001D (which only refer to surface-mount area array components such as BGA, CSP, etc.) the amount of voids (verified by the x-ray pattern) should be less than 25 %.

Figure 20: X-ray image of a solder joint of OSCONIQ® P 3737 (2 W) or OSCONIQ® P 3737 (3 W)

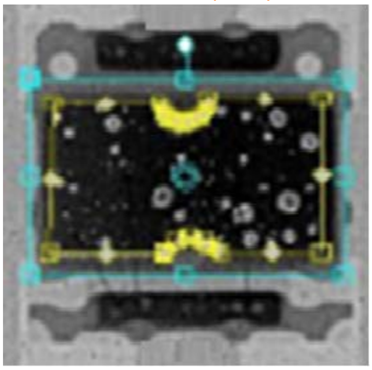
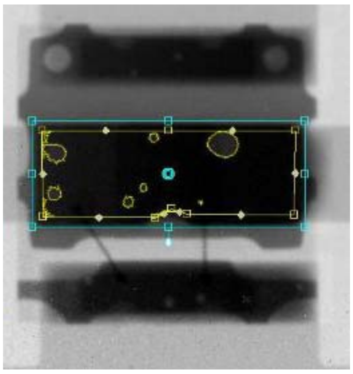


Figure 21: X-ray image of a solder joint of OSCONIQ® P 3030



Internal studies and simulations at OSRAM Opto Semiconductors have determined, however, that for areas up to 35 % of the thermal pad area, the voids only have a minor effect on the thermal resistance.

E. Accessories

Compatible optics and partners

Several optics partners have been identified and examples of compatible optics are listed in LED Light For You (LLFY) and partner websites, such as Kathod, Ledil, Carclo Optics, Gaggione, BICOM, LedLink and Darkoo.

Table 4: OSCONIQ® P 3737 (2 W) compatible optics

Supplier	Lens family
LEDil	STRADA
LEDil	STRADA-IP-2X6
LEDil	STRADA-T-6X1
LEDil	STRADA-2X2
LEDil	STRADA-SQ
LEDil	STRADA-T
Carclo Optics	Hubbles
Carclo Optics	Freeform
Carclo Optics	TIR
BICOM	BK LED

Table 5: OSCONIQ® P 3737 (2 W) compatible optics

Supplier	Lens family
LEDil	STRADA
LEDil	STRADA-IP-2X6
LEDil	STRADA-2X2
LEDil	STRADA-A2
LEDil	STRADA-T

For more information and for other accessories, please refer to “LED Light For You” or our certified optics partners’ web pages.

https://www.ledlightforyou.com/en-index.php

F. Application support and services

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So make it good, make it fast, and make it easy — with PASS.

https://www.osram.com/os/pass/index.jsp

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