

# Comparison of OSRAM OSTAR Headlamp Pro and OSRON Black Flat

## Application Note

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### Abstract

In this application note a new SMD LED type is presented as an alternative to existing LEDs to create multi-chip light sources for diverse application fields.

Using the example of the 2-chip OSRON Black Flat - a first variant of the new type – both the specific features and the challenges involved are described. For a first overview the LED is compared to the OSRAM OSTAR Headlamp Pro which is well-established in the automotive sector especially for headlight functions.

### Introduction

White light from LED sources is accepted as the state-of-the-art in all classes in automotive front lighting applications, for example as daytime running light (DRL).

Application in main headlight functions (low and high beam) is increasing as well, but due to the associated higher requirements greater attention is appropriate. Suitable light sources have to provide an adequate amount of light in all driving and visibility conditions, as well as cope with challenging ambient conditions, including the high temperatures in the headlight itself.

Until now, the best available technology has been prefabricated and generally predetermined multi-chip LED on board, for example the OSRAM OSTAR Headlamp Pro.

However the trend towards upgrading different light functions in front lights, as, for example, the enhancement to an adaptive high beam function, leads to the requirement for more and more flexibility of light sources as well as optimized system solutions.

Supporting this tendency and to close the “SMD” gap within high power multichip LEDs, OSRAM Opto Semiconductors is developing multi-chip LED arrays with SMT processability and standard reflow solderability.

Based on lead frame technology, this LED type is compatible with standard PCB types, especially with insulated metal substrate (IMS). This feature additionally eliminates the essential issue pertaining to the cycle stability of solder joints in automotive applications known for ceramic packages on IMS PCB.

A new version of this new LED type is the 2-chip OSRON Black Flat.

Specific features of the light source and the challenges involved are described below in comparison to the OSRAM OSTAR Headlamp Pro.

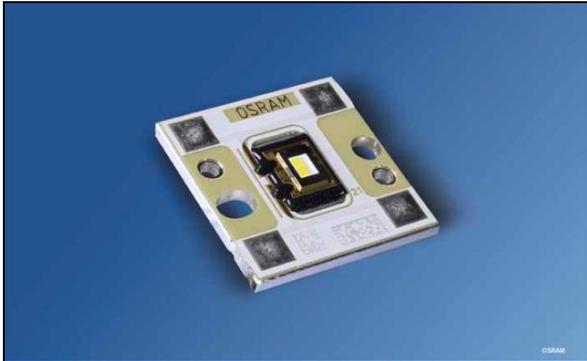
### OSRAM OSTAR Headlamp Pro

The OSRAM OSTAR Headlamp Pro falls into the category of high-power LED light sources. The LED comprises of up to five closely packed thin-film chips on a ceramic carrier. The carrier is mounted on a high-precision 20 x 20mm IMS substrate for good heat distribution, using special methods and materials to ensure highest thermal cycle stability.

Thanks to the different versions the high-flux LED is able to meet a wide range of requirements in terms of luminous intensity maintaining the same footprint.

The brightness roadmap of the OSRAM OSTAR Headlamp Pro, however, is frozen and continued only in its successor product. Typical luminous flux values are around 280lm for the single chip (1A operating

current) – and therefore 1400lm for the 5-chip version. A four-chip configuration alone can be sufficient for low beam applications.



**Fig. 1: OSRAM OSTAR Headlamp Pro (LE UW U1A2 01)**

Owing to UX:3 chip technology and a new converter, the high-power LEDs achieve steady high light output even at high currents while distributing the light uniformly and with good contrast.

The typical real thermal resistance ( $R_{th, JB real}$ ) of the LED incl. IMS board is only 4K/W for the 2-chip version.

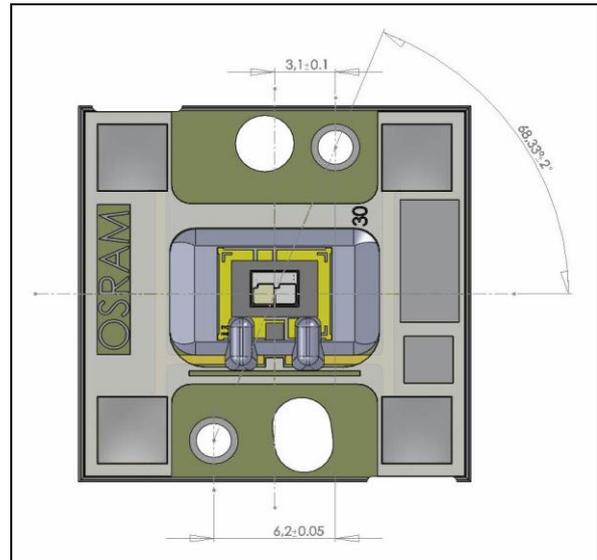
The prefabricated multi-chip LED is qualified according to Automotive Standard AEC-Q101 and beyond.

For use in headlight applications the OSRAM OSTAR Headlamp Pro module has merely to be positioned mechanically on a suitable heat sink for heat dissipation and electrically connected with the driver circuit. For secondary optics the IMS substrate provides two high-precision drill holes. Corresponding to these the optical alignment of the ceramic carrier was performed during manufacture (Fig 2).

To sum up, due to the fixed product design the LED is used “as it is”:

- High precision LED on IMS board with defined interface
- Small orientation and location tolerance referring to predefined drill holes
- Customer needs no experience in high precision SMT soldering
- Customer needs to determine the type of contacting and the corre-

sponding processing (no reflow soldering)



**Fig. 2: Orientation and location tolerance of the OSRAM OSTAR Headlamp Pro (LE UW U1A2 01)**

### OSLON Black Flat

In direct comparison the 2-chip OSLON Black Flat (KW H2L531.TE) itself represents a SMD LED, and therefore is only comparable to the basic light source element of the OSRAM OSTAR Headlamp Pro.

As a separate new type the 2-chip OSLON Black Flat can be specified as an ultra flat multi-chip LED array. The purpose-made design with lead frame technology is geared to general SMT processability and standard reflow solderability.



**Fig. 3: OSLON Black Flat (KW H2L531.TE)**

Similar to the OSRAM OSTAR Headlamp Pro there will be arrays with two to five high-  
Application Note Number: AN058

power chips connected in series. The brightness of the related arrays is at an equal or successively increasing level.

Based on its design combined with a  $R_{th}$ -optimized UX:3 technology the 2-chip version of the OSLO Black Flat features a low thermal resistance with a typical value of  $R_{th, JS \text{ real}} = 1.6K/W$ , but without board.

Therefore the challenge associated with the OSLO Black Flat is the selection of an appropriate PCB type to fulfill the requirements regarding the thermal management in the application.

Cycle stability of solder joints, however, as known from ceramic packages on IMS PCB is an insignificant issue for the black epoxy package with lead frame.

It should be noted that consistent with all SMT devices responsibility for processing and the related tolerances lies with the system integrator. Thus appropriate expertise in SMT processing and reflow soldering (e.g. soldering profiles, testing for voids, etc.) is recommended. For the soldering of the OSLO Black Flat product family nitrogen ( $N_2$ ) atmosphere is advised. For optimal self alignment the solder paste volume is very important, so for control purposes solder paste inspection (SPI) equipment is helpful.

Based on the in-house experience regarding chip mounting, the device tolerances itself are in the range of  $\pm 30\mu m$  for the height of the emission surface and  $\pm 75\mu m$  for the chip position to solder pad.

The positioning tolerance in the system is influenced by the assembly process and equipment, but also by the precision of the additional materials (PCB design, reference marker, etc.).

As an example using the recommended solder pad design and the above-mentioned preset LED values the following positioning tolerances on board can be estimated:

Assuming process tolerances of  $\pm 50\mu m^1$  for the device pads to PCB pads by reflow soldering and  $\pm 75\mu m^1$  tolerances for the

dimension referencing the pad to a reference hole on the PCB, a positioning tolerance of  $\pm 117\mu m$  ( $5\sigma$ ) may be achieved.

The height tolerance from emission surface to PCB landing surface results in  $\pm 32\mu m$  assuming a SAC solder joint<sup>1</sup> with a thickness of  $60\mu m \pm 10\mu m^1$ .

All in all the feasibility of individual SMT processing and the solderability of the OSLO Black Flat offer advantages of particular interest, because they provide freedom in designing user-specific boards.

In any case the responsibility for processing and the related tolerances is shifted to customers' side respectively lies with the system integrator.

## Distinctive Features of the 2-chip OSLO Black Flat

In a side-by-side comparison the 2-chip OSLO Black Flat represents as ultra flat multi-chip LED array a basic element of the OSRAM OSTAR Headlamp Pro.

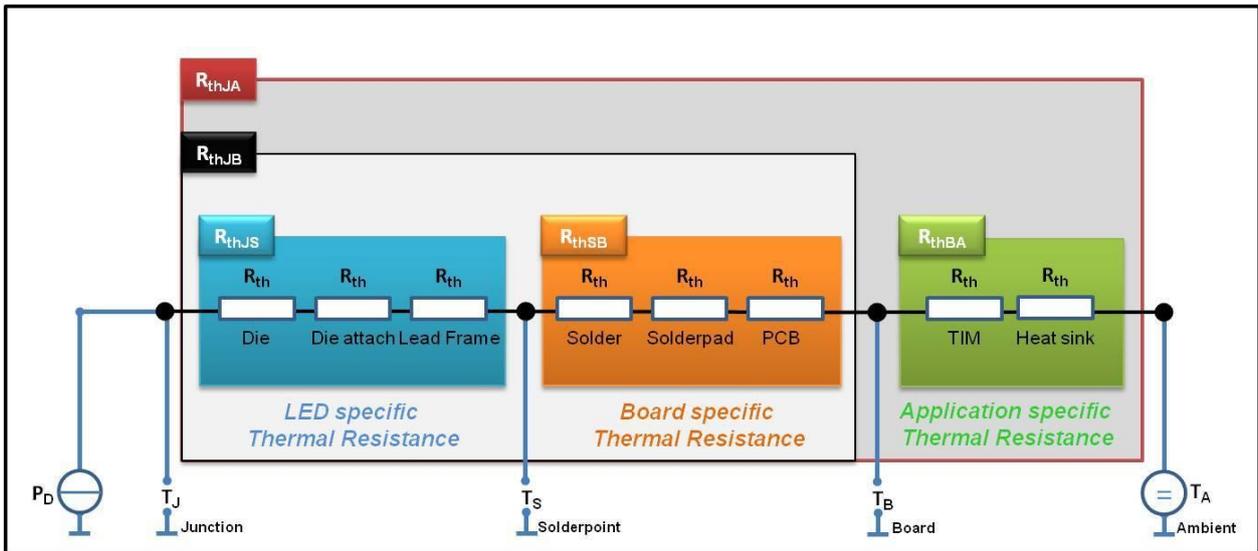
To provide general SMT processability and standard reflow solderability the new LED is designed with lead frame technology and epoxy housing. This setup fulfills also the requirements regarding cycle stability for systems with IMS board, the preferred PCB type in automotive applications.

The package design combined with an  $R_{th}$  optimized chip technology results in a low thermal resistance of  $1.6K/W$  for the LED itself. To be comparable with the OSRAM OSTAR Headlamp Pro the module value – LED soldered on IMS PCB – has to be considered (Fig. 4). The  $R_{th, JB}$  of such a module is crucially dependant on the characteristics of the IMSs' dielectric layer.

For a module configuration made up of a  $20 \times 20 \text{ mm}$  insulated aluminum substrate with a  $38\mu m$  thick dielectric (thermal conductivity of dielectric  $\lambda = 3W/mK$ ), the thermal resistance of the module with a 2-chip OSLO Black Flat will typically be about  $R_{th}$

$JB \text{ real typ}} = 3.1K/W$ .

<sup>1</sup> These values are of course influenced by the specific suppliers and processes.



**Fig 4: Diagram of a simplified, general thermal resistor network**

For a dielectric with 75µm thickness and lower thermal conductivity ( $\lambda \sim 1.6\text{W/mK}$ ) the thermal resistance of the module will be accordingly higher ( $R_{th\text{JB real typ}} \sim 5.9\text{K/W}$ )<sup>1</sup>.

Using the same chip technology the fundamental electro-optical characteristics of the corresponding LED types are quite similar. However the color grouping acc. to IEC/PAS 62707-1 is done in smaller color bins. For the multi-chip versions of the OSRON Black Flat the bin size is 46

compared to 68 for the OSRAM OSTAR Headlamp Pro.

Due to the pure device approach of the OSRON Black Flat the responsibility for processing and the related tolerances shifted to customers' side.

Figure 5 shows the list of the side-by-side comparison of the OSRAM OSTAR Headlamp Pro and its alternative – the OSRON Black Flat.

OSRAM OSTAR Headlamp Pro (2-chip)	OSRON Black Flat (2-chip)
<ul style="list-style-type: none"> <li>• Ceramic package mounted on high precision IMS PCB</li> <li>• <math>R_{th\text{JB real typ}}</math> 4.0K/W</li> <li>• Chip: UX:3</li> <li>• Tolerances of emission surface               <ul style="list-style-type: none"> <li>• Z (height): 5sigma = ± 150µm (incl. PCB)</li> <li>• Z (height) to PCB surface (@760µm): = ± 125µm</li> <li>• Position layer symmetry line to reference hole: ±100µm (X,Y), ±2°</li> </ul> </li> <li>• System height (emission surface to backside PCB): 2.41mm</li> <li>• Optical characteristics: Color bins size 68</li> </ul>	<ul style="list-style-type: none"> <li>• Solderable epoxy SMT device based on leadframe</li> <li>• <math>R_{th\text{JS real typ}}</math> 1.6K/W → System 3,1K/W (IMS w 38µm dielectric) 5,9K/W (IMS w 75µm dielectric)</li> <li>• Chip: UX:3 - <math>R_{th}</math> optimized</li> <li>• Tolerances of emission surface               <ul style="list-style-type: none"> <li>• Z (height): 5sigma = ± 30µm (w/o PCB)</li> <li>• <math>Z_{\text{system}}</math> to PCB surface*: ±32µm</li> <li>• Position layer area to solderpad: ±75µm</li> <li>• Position layer area to reference hole*: ±117µm (X,Y)</li> </ul> </li> <li>• System height on IMS PCB (emission surface to backside PCB): 2.03mm *</li> <li>• Optical characteristics: Color bins smaller: size 46</li> </ul> <p>*depending on system suppliers</p>

**Fig. 5: Summary of the most relevant differences of OSRAM OSTAR Headlamp Pro and OSRON Black Flat**

## Conclusion

As far as the electro optical properties are concerned, the performance of the OSRON Black Flat is comparable to the OSRAM OSTAR Headlamp Pro, as both use similar chip technology.

For the multi-chip OSRON Black Flat smaller color bins are offered and the brightness is expected to rise.

The thermal resistance of the OSRON Black Flat is somewhat better, but has to be compared in a more complex system with comparable value added.

It offers freedom of design for customer specific boards, whereas the OSRAM OSTAR Headlamp Pro has to be taken „as it is“.

The advantage of the individual board design, however, implicates that the responsibility for the thermal management starting at LED level and further process and system tolerances are shifted to the customers' side.

To sum up, both products have their benefits, and which is best depends on the respective 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](http://www.ledlightforyou.com)

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OSRAM, Munich, Germany is one of the two leading light manufacturers in the world. Its subsidiary, OSRAM Opto Semiconductors GmbH in Regensburg (Germany), offers its customers solutions based on semiconductor technology for lighting, sensor and visualization applications. Osram Opto Semiconductors has production sites in Regensburg (Germany), Penang (Malaysia) and Wuxi (China). Its headquarters for North America is in Sunnyvale (USA), and for Asia in Hong Kong. Osram Opto Semiconductors also has sales offices throughout the world.

For more information go to [www.osram-os.com](http://www.osram-os.com).

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