Comparison of OSRAM OSTAR Headlamp Pro and OSLON Black Flat

Application Note

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 OSLON 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 OSLON 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.

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 corresponding processing (no reflow soldering)

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.

Similar to the OSRAM OSTAR Headlamp Pro there will be arrays with two to five high-
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 OSLON Black Flat features a low thermal resistance with a typical value of
$R_{th,JS\ real} = 1.6K/W$, but without board.
Therefore the challenge associated with the
OSLON Black Flat is the selection of an
appropriate PCB type to fulfill the require-
ments 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 OSLON Black Flat product
family nitrogen (N₂) 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 ±30µm for the height of
the emission surface and ±75µm 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 ±50µm¹ for
the device pads to PCB pads by reflow
soldering and ±75µm¹ tolerances for the
dimension referencing the pad to a
reference hole on the PCB, a positioning
tolerance of ±117µm (5σ) may be achieved.
The height tolerance from emission surface
to PCB landing surface results in ±32µm
assuming a SAC solder joint¹ with a
thickness of 60µm ±10µm¹.
All in all the feasibility of individual SMT
processing and the solderability of the
OSLON 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
OSLON Black Flat

In a side-by-side comparison the 2-chip
OSLON 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
20x20mm insulated aluminum substrate with
a 38µm thick dielectric (thermal conductivity
of dielectric $\lambda= 3W/mK$), the thermal
resistance of the module with a 2-chip
OSLON Black Flat will typically be about
$R_{th}\ JB\ real\ typ = 3.1K/W$.

¹ 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 (λ ~1.6W/mK) the thermal resistance of the module will be accordingly higher ($R_{th,JB\ real\ typ}$ ~5.9K/W$^{1}$).

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 OSLON Black Flat the bin size is 46 compared to 68 for the OSRAM OSTAR Headlamp Pro.

Due to the pure device approach of the OSLON 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 OSLON Black Flat.

<table>
<thead>
<tr>
<th>OSRAM OSTAR Headlamp Pro (2-chip)</th>
<th>OSLON Black Flat (2-chip)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic package mounted on high precision IMS PCB</td>
<td>Solderable epoxy SMT device based on leadframe</td>
</tr>
<tr>
<td>$R_{th,JB\ real\ typ}$ 4.0KW</td>
<td>$R_{th,JB\ real\ typ}$ 1.6KW → System 3.1KW (IMS w 38μm dielectric) 5.9KW (IMS w 75μm dielectric)</td>
</tr>
<tr>
<td>Chip: UX.3</td>
<td>Chip: UX.3 - $R_t$ optimized</td>
</tr>
<tr>
<td>Tolerances of emission surface</td>
<td>Tolerances of emission surface</td>
</tr>
<tr>
<td>• Z (height): 5σ = ±160μm (incl. PCB)</td>
<td>• Z (height): 5σ = ±30μm (w/o PCB)</td>
</tr>
<tr>
<td>• Z (height) to PCB surface (@760μm): ±125μm</td>
<td>• Z$_{system}$ to PCB surface*: ±32μm</td>
</tr>
<tr>
<td>• Position layer symmetry line to reference hole: ±100μm (X,Y), ±2μm</td>
<td>• Position layer area to solderpad: ±75μm</td>
</tr>
<tr>
<td>• Position layer area to reference hole*: ±117μm (X,Y)</td>
<td>• Position layer area to reference hole*: ±94μm</td>
</tr>
<tr>
<td>System height (emission surface to backside PCB): 2.41mm</td>
<td>System height on IMS PCB (emission surface to backside PCB): 2.03mm *</td>
</tr>
<tr>
<td>Optical characteristics: Color bins size 68</td>
<td>Optical characteristics: Color bins smaller: size 46</td>
</tr>
</tbody>
</table>

*depending on system suppliers

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

As far as the electro optical properties are concerned, the performance of the OSLON Black Flat is comparable to the OSRAM OSTAR Headlamp Pro, as both use similar chip technology. For the multi-chip OSLON Black Flat smaller color bins are offered and the brightness is expected to rise. The thermal resistance of the OSLON 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

Authors: Andreas Stich; Dr. Jessica Schneider

ABOUT OSRAM OPTO SEMICONDUCTORS

OSRAM, with its headquarters in Munich, is one of the two leading lighting 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) and Penang (Malaysia). Its headquarters for North America is in Sunnyvale (USA). Its headquarters for the Asia region is in Hong Kong. OSRAM Opto Semiconductors also has sales offices throughout the world. For more information go to www.osram-os.com.
DISCLAIMER

PLEASE CAREFULLY READ THE BELOW TERMS AND CONDITIONS BEFORE USING THE INFORMATION. IF YOU DO NOT AGREE WITH ANY OF THESE TERMS AND CONDITIONS, DO NOT USE THE INFORMATION.

The Information shown in this document was produced with due care, but is provided by OSRAM Opto Semiconductors GmbH "as is" and without OSRAM Opto Semiconductors GmbH assuming, express or implied, any warranty or liability whatsoever, including, but not limited to the warranties of correctness, completeness, merchantability, fitness for a particular purpose, title or non-infringement. In no event shall OSRAM Opto Semiconductors GmbH be liable - regardless of the legal theory - for any direct, indirect, special, incidental, exemplary, consequential, or punitive damages related to the use of the Information. This limitation shall apply even if OSRAM Opto Semiconductors GmbH has been advised of possible damages. As some jurisdictions do not allow exclusion of certain warranties or limitations of liability, the above limitations or exclusions may not apply. The liability of OSRAM Opto Semiconductors GmbH would in such case be limited to the greatest extent permitted by law.

OSRAM Opto Semiconductors GmbH may change the Information at anytime without notice to user and is not obligated to provide any maintenance or support related to the Information. The Information is based on specific Conditions and, therefore, alterations to the Information cannot be excluded.

Any rights not expressly granted herein are reserved. Except for the right to use the Information included in this document, no other rights are granted nor shall any obligation be implied requiring the grant of further rights. Any and all rights or licenses to patents or patent applications are expressly excluded.

Reproduction, transfer, distribution or storage of part or all of the contents of this document in any form without the prior written permission of OSRAM Opto Semiconductors GmbH is prohibited except in accordance with applicable mandatory law.