Application Note No. AN137

OSRAM
Opto Semiconductors

TOPLED® E1608 LEDs for automotive interior design

Application Note

Valid for:
TOPLED® E1608

Abstract

The TOPLED® E1608 LED family from OSRAM Opto Semiconductors provides one of the smallest standard footprints in LED Industry in a highly reliable and well proven package. Its outstanding performance is suitable for a variety of applications especially automotive interior where a small package design with excellent reliability is needed. The TOPLED® E1608 is available in different colors and brightness levels.

This application note focuses on the advantages of the TOPLED® E1608 for automotive interior applications, as well as the handling and processing of the LEDs. In addition, the application note on the TOPLED® E1608 delivers design ideas and compares them to conventional multi-colored LED packages.

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A. LEDs for automotive interior design

The automotive interior is evolving from a function oriented design into a second living room away from home. This is mainly driven by the trend towards autonomous vehicles, where comfort, safety, and awareness are important.

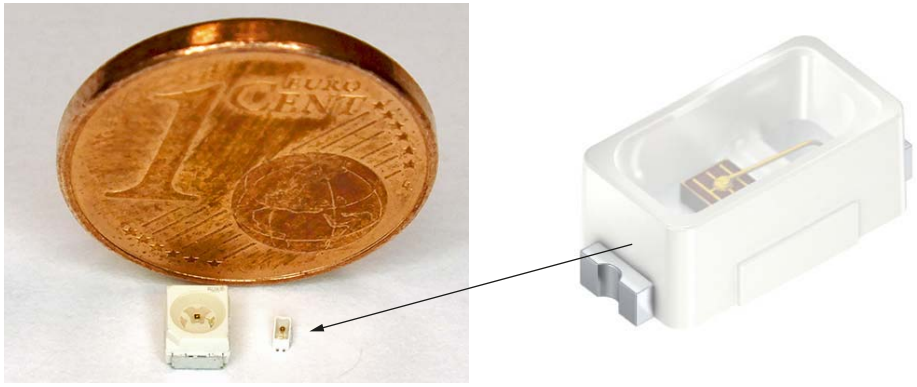
Lighting is one key element in optimizing visual communication with the driver and enhancing the comfort for all passengers during their journey.

However, not all current lighting solutions are suitable to meet these upcoming requirements. As lighting becomes more complex, individual light sources must become smaller to allow for more strategic light placement and more color flexibility. Thus, the market has pushed optoelectronic manufacturers to deliver brighter and smaller LEDs for the automotive interior industry.

B. TOPLED® E1608 LED family

OSRAM Opto Semiconductors has released its new product, the TOPLED® E1608, to meet these demands in the evolving environment of advanced interior lighting. This LED is the smallest automotive-qualified (AEC-Q102, IEC 60810) package in OSRAM Opto Semiconductors' visible LED portfolio with dimensions of 1.6 mm (L) x 0.8 mm (W) x 0.6 mm (H). Figure 1 shows the TOPLED® E1608 in comparison to a one cent coin to highlight the small package dimensions.

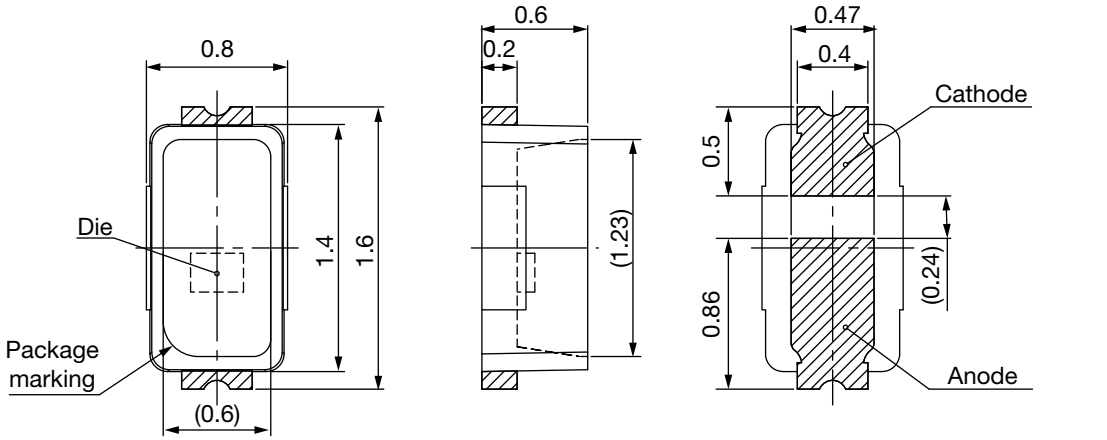
Figure 1: Size of the TOPLED® E1608



Mechanical dimensions

Figure 2 shows the mechanical dimensions of the TOPLED® E1608. For further information please refer to the respective data sheets.

Figure 2: Dimensions of the TOPLED® E1608



LED product portfolio

The TOPLED® E1608 has been released for almost all the colors available in the standard TOPLED® portfolio (Table 1). The rest of the colors, will be available in the near future. Additionally, all colors will be released with up to three different brightness levels in order to meet the requirements for both low illumination levels (search illumination) as well as high brightness applications (telltales).

Table 1: TOPLED® E1608 product portfolio

LED type	Technology	Color	Brightness
KW DELxSx.RA	InGaN	White	Low / Mid / High
KB DELxS2.12	InGaN	Blue	Mid
KP DELxS1.FP	InGaN	Converted pure green	Mid
KT DELxS1.12	InGaN	True green	Low / Mid
KP DELxS1.22	InGaAlP	Pure green	Low / Mid
KY DELxS1.22	InGaAlP	Yellow	Low / Mid / High
KO DELxS1.22	InGaAlP	Orange	Low / Mid / High
KR DELxS1.22	InGaAlP	Red	Mid / High
KS DELxS1.22	InGaAlP	Super red	Low / Mid / High

Please also visit the OSRAM Opto Semiconductors web site for the latest TOPLED® E1608 product portfolio.

Comparison to other packages

With this extensive portfolio, the TOPLED® E1608 is an excellent alternative to its predecessors, the TOPLED® and the Mini TOPLED®. Besides a slightly lower light output due to its compact size, the TOPLED® E1608 package has similar electrical and optical characteristics compared to its predecessors utilizing the same semiconductor die technology. This is a small price to pay considering that the package volume is 20x smaller than the TOPLED® and 4x smaller than the Mini TOPLED®. Therefore, the TOPLED® E1608 package enables light source upgrades by simple adaption of the LED footprint on the PCB layout.

C. Handling

The TOPLED® E1608 has been designed to be a very robust package not only for reflow soldering profile durability but also for robustness against mechanical stress. The TOPLED® E1608 has been designed to meet automotive grade quality (AEC-Q102) standards and meets automotive interior qualifications according to IEC 60810.

ESD stability

The LED provides ESD stability of up to 2 kV. It is assigned to the “Class 2 HBM” category in accordance with ANSI / ESDA / JEDEC JS-001. With this class the TOPLED® E1608 can be considered as uncritical for processing and assembly by state of the art SMT equipment aligned with ESD precautions. To achieve higher ESD protection on the system level, additional ESD protection should be applied.

As is the case for all LEDs from OSRAM Opto Semiconductors, the TOPLED® E1608 also fulfills the current RoHS guidelines (European Union and China) and therefore contains no lead or other defined hazardous substances.

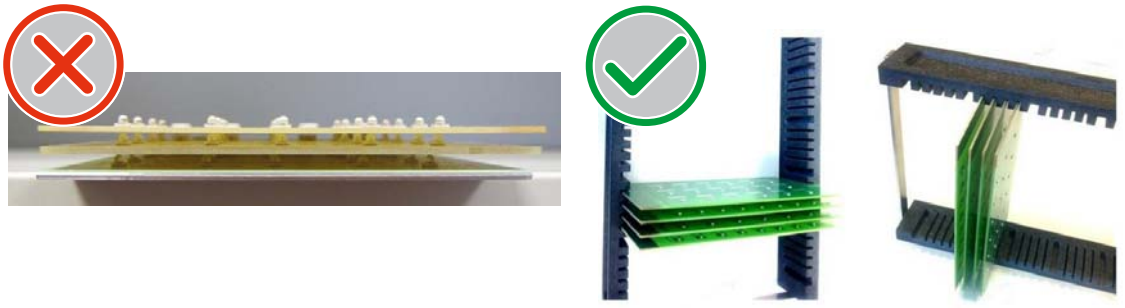
Precaution and storage

Generally, the LEDs are packaged in tape and on reels. For storage and dispatch, the reels are packed in vacuum-sealed dry bags together with desiccants. It is generally recommended to leave reels in their original package until they are required, and to store components during processing under ambient conditions of ≤ 10 % RH. Drying cabinets with dry nitrogen (N_2) or dry air are suitable for this type of storage. The TOPLED® E1608 is declared to moisture-sensitive Level 2 (MSL 2) according to JEDEC J-STD- 020E.

As with all LEDs from OSRAM Opto Semiconductors, the TOPLED® E1608 also fulfills the current RoHS guidelines (European Union and China) and therefore contains no lead or other defined hazardous substances.

A correct storage system should be used to ensure that assembled LED boards are not stacked on top of each other (Figure 3). To avoid the risk of damage to the assembled LEDs, make sure that they are not exposed to compression forces of any kind. Furthermore, LEDs must not be in direct contact with other adjacent boards in the storage system.

Figure 3: Correct storage practices



Cleaning

From today's perspective any direct mechanical or chemical cleaning of the TOPLED® E1608 is forbidden. Isopropyl alcohol (IPA) can be used if cleaning is mandatory. Other substances, especially ultrasonic cleaning, should be avoided since they can damage the LEDs. For more information on correct cleaning solutions, please refer to the application note "Cleaning of LEDs".

For dusty LEDs, simple cleaning by means of purified compressed air (e.g. central supply or spray can) with a air pressure of maximum 4 bar with a distance of 20 cm to the component is recommended. Please consider that the compressed air used is oil-free. Therefore the use of a spray can is recommended.

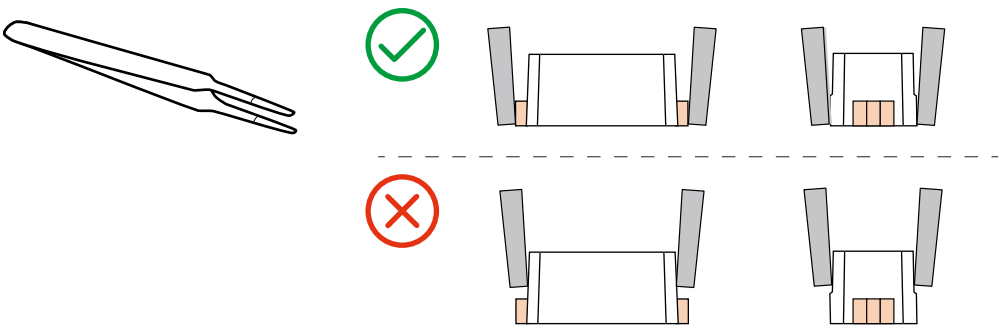
In any case, all materials and methods should be tested beforehand, as to whether or not the component shows signs of damage.

Manual handling

Although manual handling and assembly is possible, automatic LED placement is recommended.

Special care must be taken if the TOPLED® E1608 is handled manually. The LED must not be lifted from the top, because high forces can cause damage to the surface. In addition, it is recommended to hold the LED package as shown in Figure 4 by using a tweezer and applying the force equally to the entire LED package.

Figure 4: Recommended manual handling

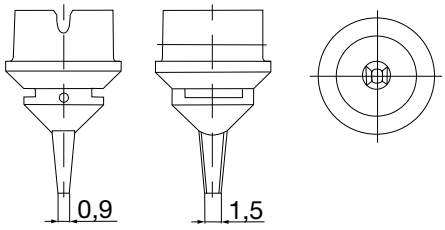


D. Processing

Pick-and-place nozzle design

For integration into SMT production lines, an appropriate pick-and-place nozzle must be selected to accurately handle the LEDs for PCB mounting. The recommended nozzle for automated placement is shown in Figure 5.

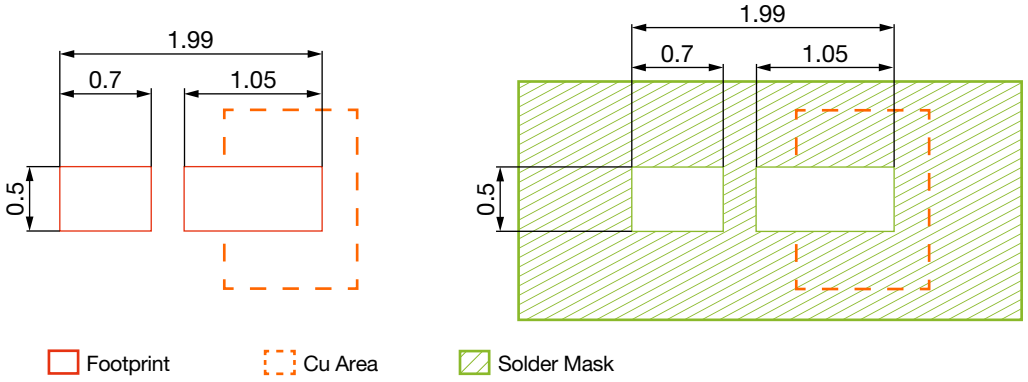
Figure 5: Recommended nozzle from ASM SIPLACE #911



Solder pad design

With the significant reduction in LED dimensions, the processing of the LEDs becomes more challenging. Therefore, a solder pad and stencil design (aperture) for the TOPLED® E1608 package are recommended to minimize solder float and additional reflow issues. Additionally, with the E1608 package being significantly smaller compared to most other automotive LEDs, care must be taken in the surface mounting parameters, including solder quantity and wetting angle, to optimize solder joint reliability and minimize package tombstoning. Figure 6 shows the solder pad design for the TOPLED® E1608. The corresponding solder pad can also be found in the data sheet of the respective LEDs.

Figure 6: Solder pad design

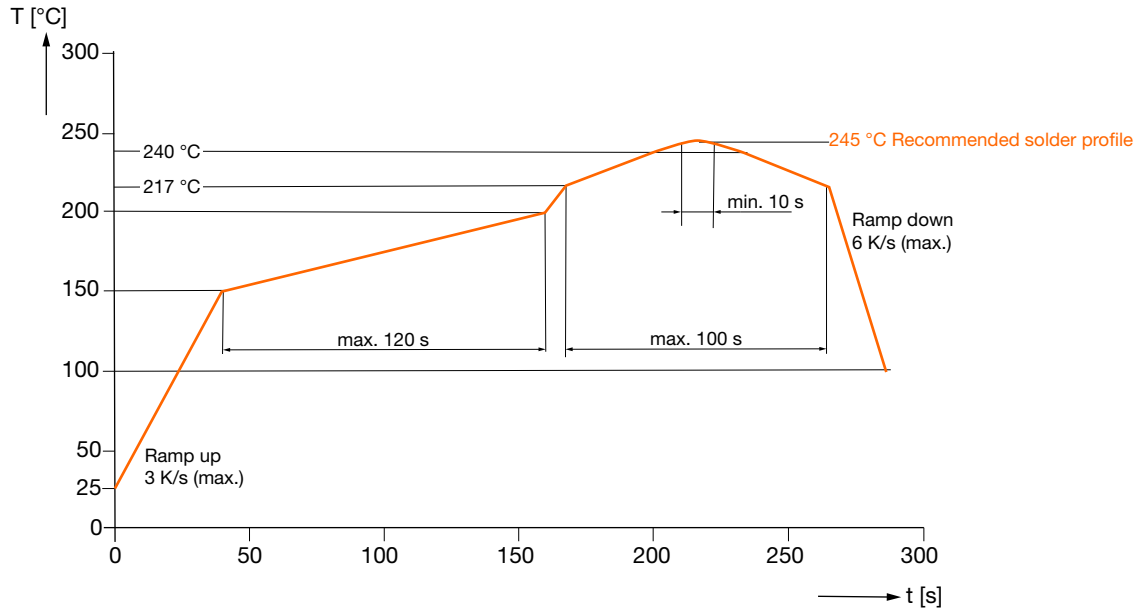


Assembly process

Since the TOPLED® E1608 is compatible with existing industrial SMT processing methods, state-of-the-art standard techniques can be used for mounting. The component is qualified for a standard Pb-free (lead-free) reflow soldering process with a maximum peak temperature of 260 °C (see Figure 7). For an optimized alignment it is recommended to check the profile on all new PCB materials and designs. The recommended temperature profile of the solder

paste manufacturer can serve as a good starting point. The assemblies should be allowed to return to room temperature after soldering before subsequent handling or the next process step.

Figure 7: Temperature profile for lead-free reflow soldering according to JEDEC JSTD-020E

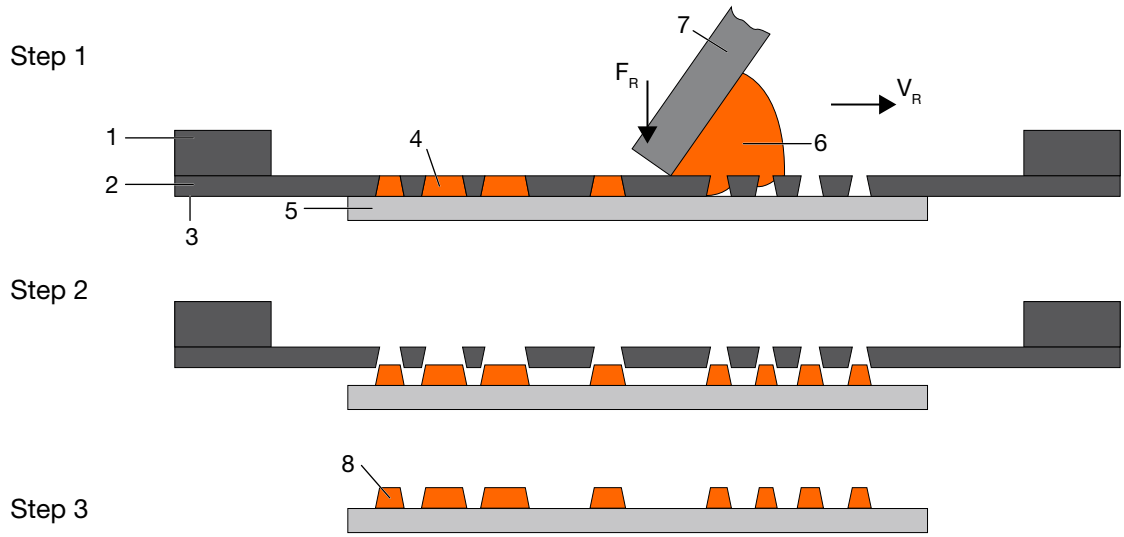


Solder quality

Uniform thickness of the solder joint is essential in order to produce reliable solder joints and achieve an appropriate optical alignment of the TOPLED® E1608. To achieve optimum solder joint connectivity results, soldering with a standard nitrogen atmosphere is recommended.

The printing stencil design and an accurate working process both have a significant influence on the solder quality of the component. The solder paste printing process is the most critical process in the entire process chain, as most failures occur during the SMT assembly process. In industry, commonly laser cut stencils usually made from stainless steel (CrNi) or electroformed stencils (Ni), are used. Aperture sidewalls are typically trapezoidal (5°) to ensure a uniform release of the paste and to reduce solder smearing or so called edge tears. Figure 8 shows a schematic diagram of the solder paste printing process.

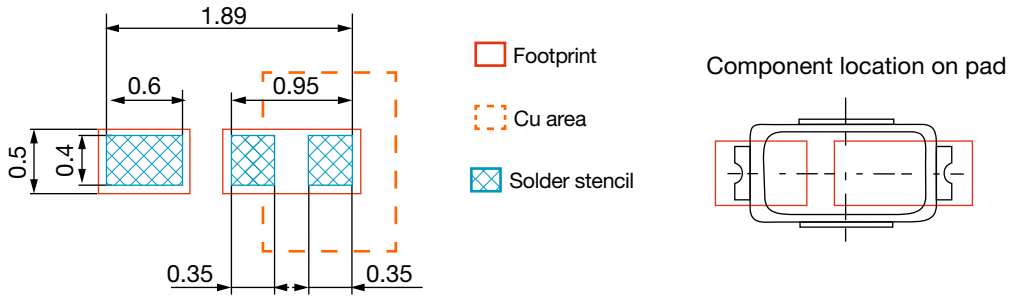
Figure 8: Solder paste printing process



1 Printing Plate	5 Substrate
2 Stencil	6 Solder Paste
3 Stencil Mounting	7 Spreader
4 Printing Pattern	8 Printed Pattern
V_R Spreader Speed	F_R Spreader Force

In order to achieve a high quality in the solder process, the solder paste must be applied in the optimal position, geometry, and precise volume as required. The volume of the printed solder paste is determined by the stencil aperture (opening of the stencil) and the stencil thickness. Figure 9 shows the geometry recommended for the solder stencil.

Figure 9: Recommended stencil geometry

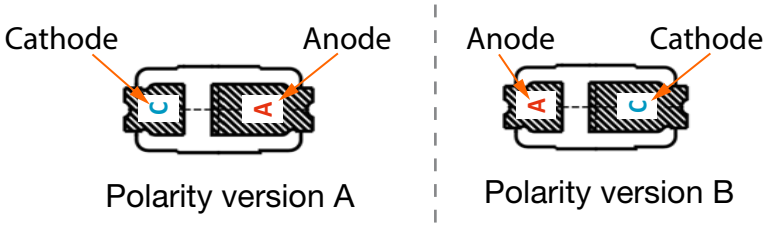


The solder joint thickness (standoff height) of the TOPLED® E1608 electrical leads should typically be between 50 µm to 75 µm, which is directly influenced by the amount of solder paste that is printed on the solder pad. The stencil thickness used in industrial SMT assembly processes varies in a range from 100 µm to 150 µm (0.004 in to 0.006 in). For the TOPLED® E1608 a stencil thickness of 120 µm is recommended. However, the actual stencil thickness also depends on other SMD components on the PCB.

E. Asymmetric footprint and recommended solutions

System designers prefer their solution being upwards compatible and flexible to be used for various projects. With regard to LEDs this means that LEDs with higher or lower luminous intensity or different colors should be used on the same design depends on the application needs and requirements. Using the same package with asymmetric pads, like TOPLED® E1608, with various brightness level of the same color or various colors can mean different polarity since chip technologies of different intensity or color can have different polarity, shown in Figure 10.

Figure 10: Different polarity versions

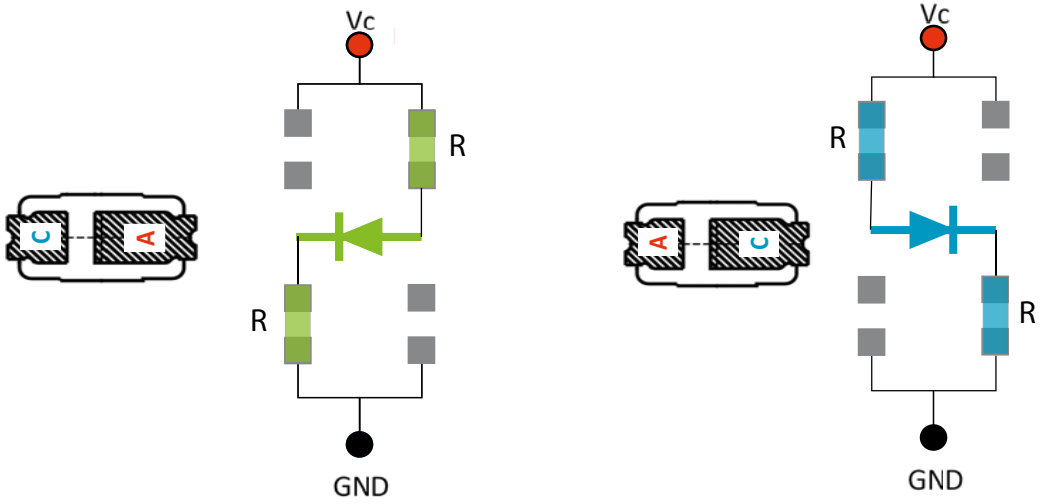


That makes the use of different colors or intensities on the same asymmetric footprint difficult. In the following two variants are introduced to solve the problem. One possibility is to solve the problem via the electrical design, the other possibility is to choose a symmetrical solder pad design.

Electrical design

The first solution is based on an electrical design. The simplest form of current source consists of a resistor. Considering a split of this resistor in two, place holders for these two resistors can be assigned in the layout to switch the direction of the current from one to the other as shown in Figure 11.

Figure 11: Design with a place holder for four current limiting resistors on PCB (R1-R4)



Depending on the polarity of the LED only two of the resistors are used.

The advantages of this solution are:

- No need to change the Layout for the LED
- No need to change the optic and its position
- Different placement for polarity options

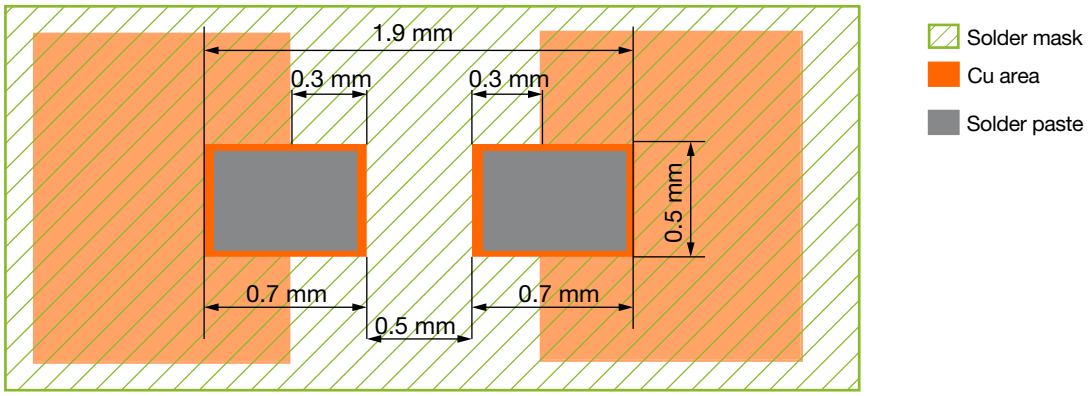
In case of an IC as constant current driver a set of zero-ohm resistors can be used to change the direction of the current through the LED. In this case the constant current driver can be place between the power source Vc and the resistor node in Figure 11.

Symmetric solder pad design

The second solution is to define a symmetric footprint. In this case the LED can be placed on the same footprint however rotated without any change of the layout or additional place holder in the design.

The recommended solder pad design in Figure 12 is symmetrical (same solder land dimensions for the anode and the cathode pad), with the target to have a reproducible alignment of the LED during the reflow soldering process.

Figure 12: Recommended symmetric solder pad design

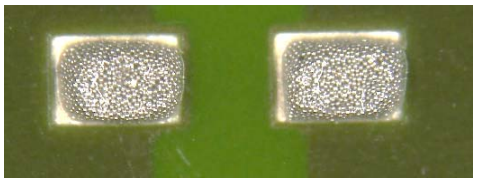


The general recommendations for a proper alignment with a symmetric solder pad design are:

- Use a half **S**older **M**ask **D**efined solder pad design
- Enable symmetrical wetting force for the anode and cathode lead
- As there is the same Cu area for the anode and cathode pad there is the same thermal mass during reflow
- The pad to pad distance should be similar to the component foot print (0,24 mm). This results in an overlap, the alignment must be done to the inner pad contour.
- An optimized solder mask/resist is needed (check the solder resist off-set with the PCB maker).
- There should be a balanced and adjusted stencil opening to achieve an

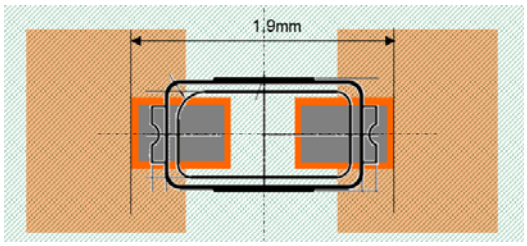
uniform solder paste volume for each polarity version. Figure 13 shows a proper solder paste printing.

Figure 13: Proper solder paste printing for a symmetrical solder pad design



The placement position in the pick-and-place machine must always be centered to the solder pads as shown in Figure 14.

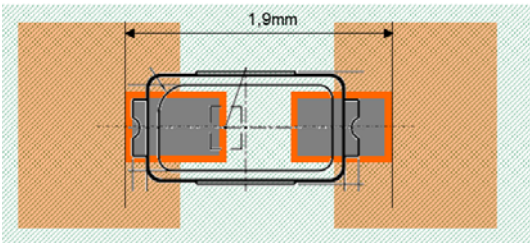
Figure 14: A proper placement position centered to the solder pads



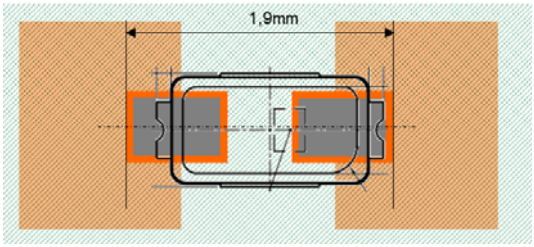
Please note that in this case the LED is slightly displaced during the soldering process (Figure 15). For a proper optical design please be also aware that the optical center is not the LED center. This will have a certain influence on the optical path.

Figure 15: Slightly displace during the soldering process

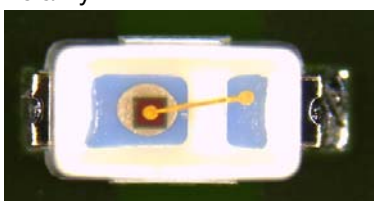
LED alignment after reflow:
Polarity A



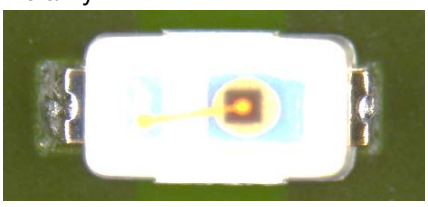
LED alignment after reflow:
Polarity B



Placed LED after the soldering process:
Polarity A



Placed LED after the soldering process:
Polarity B



For optics positioned over the LEDs which are big enough or in case of relatively big backlighting area this footprint can be considered.

Nevertheless, due to a very small offset this may not have any significant impact on proper functionality of the optical system provided the optics positioned over

this LED covers the entire light emitting area of the LED. But it is recommended that applications which can use only the brighter chip technology should use the original asymmetrical solder pad design (see chapter "D. Processing").

F. Automotive applications

Thin profile designs, thin lightguides

The compact size of the TOPLED® E1608 package allows for the flexible solutions in multiple target applications including bar graphs, thin-waveguide backlighting, and minimal footprint illuminators. In addition, the compact rectangular shape allows for multiple arrangements (Figure 16) in scenarios where more light output is desired in a designated area.

Figure 16: Design considerations

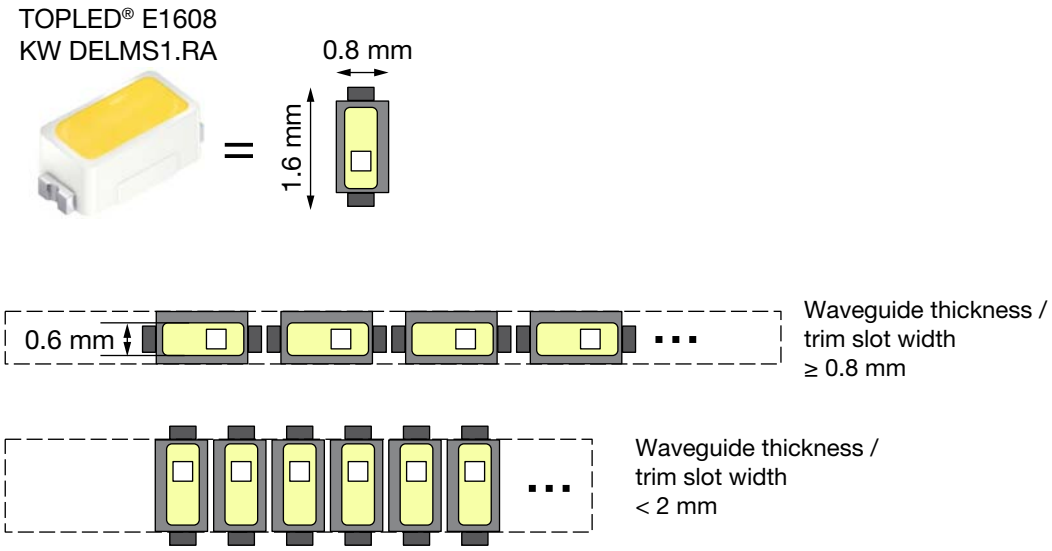
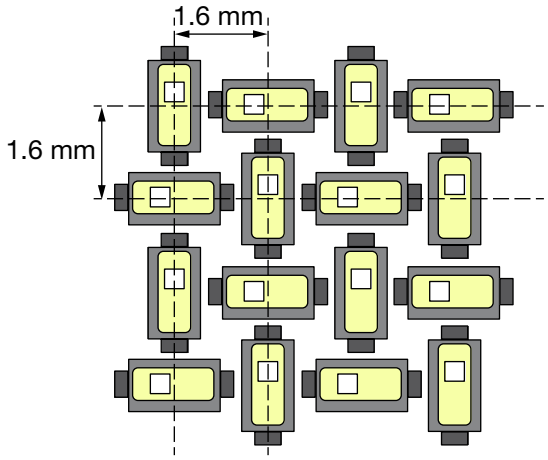


Figure 17 shows a minimal pixel pitch geometry that can be achieved by the TOPLED® E1608. However, in this case the solder pad has to be modified. Inquiries regarding this design should be addressed to the local OSRAM Opto Semiconductors office.

Figure 17: TOPLED® E1608 minimal pixel pitch

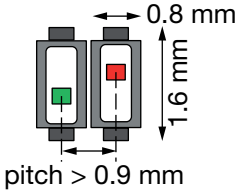


pitch: 1.6 mm
(package center to package center)

Dual color applications

These configurations are not solely limited to single color solutions. For multi-color indicators, multiple TOPLED® E1608 LEDs in close proximity allow for uniform illumination regardless of which color is active. The spatial requirement of two TOPLED® E1608 is significantly smaller than the size of a Multi TOPLED®. With single TOPLED® E1608 packages it is possible to cover a wide color portfolio. Mixed color combinations ensure that this solution addresses almost all possible multi-color backlighting scenarios (see Figure 18). It also allows individual color combinations, like white and red.

Figure 18: Small individual dual color application



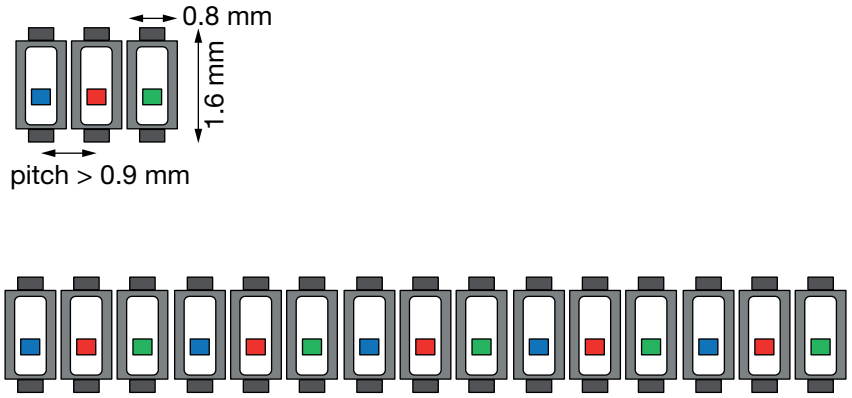
Flexible multi-color applications

The most common configuration for a multi-color solution is the combination of the colors red, green and blue, because it allows to cover a very large color gamut. Depending on customer requirements suitable combinations of the available colors and brightness levels can be chosen. Therefore, the TOPLED® E1608 approach is a very flexible solution for tunable ambient lighting.

A significant advantage is that different colors can be added to hit specific color points with higher accuracy. Additional colors of interest include saturated colors and OEM brand colors.

In addition, long strings of TOPLED® E1608 LEDs can be easily manufactured without incurring large lighting gaps (see Figure 19). It improves the color uniformity at reduced mixing distances.

Figure 19: Flexible multi-color application



G. Summary

The TOPLED® E1608 is primary designed for automotive interior applications and offers the smallest automotive-qualified package in the visible LED portfolio of OSRAM Opto Semiconductors. It is available in various colors and brightness levels in order to meet the requirements for almost all interior applications.

The compatibility to standard industrial SMT processing methods is given, so that excising population techniques can be used for the mounting process. Due to the small package size of the LED, special care must be taken at the surface mounting parameters.

The compact size of the TOPLED® E1608 package allows a flexible solution for various automotive interior applications such as for thin profile designs, narrow waveguides or multiple LED arrangements. In addition, dual and multi color applications can also be realized by the TOPLED® E1608, requiring small space.

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

ABOUT OSRAM OPTO SEMICONDUCTORS

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.

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