Application Note No. AN087

OSRAM
Opto Semiconductors

CERAMOS Gen C4 - an LED in Chip-Scale-Package (CSP) format

Application Note

Valid for:
CERAMOS Gen C4 - CW VHLPD2.EN

Abstract

CERAMOS Gen C4 has been developed for flash applications following the Chip-Scale-Package approach.



Compared to conventional LEDs the design of LEDs with Chip-Scale-Package (CSP) is much different. The design is downsized to the dimension of the chip used. While still being compatible with SMD assembly processes, CSP LEDs impose slightly higher requirements on handling and soldering processes.

This application note introduces the CERAMOS Gen C4 (CW VHLPD2.EN) for flash applications. It provides information about the recommended handling and processing. In addition, it gives a suggestion for a system setup.

See also:
Datasheet CERAMOS Gen C4 - CW VHLPD2.EN
Application Note:
- AN017_Cleaning of LEDs
- AN020_ESD Protection while handling LEDs
- AN036_Processing of SMD LED

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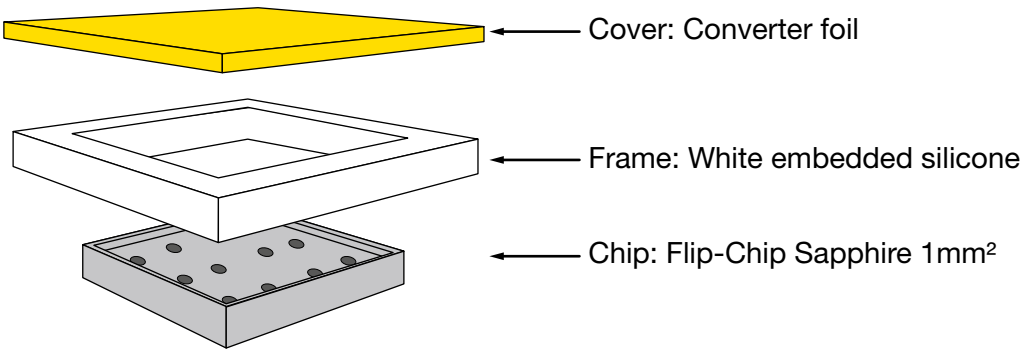
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A. CERAMOS Gen C4

The LED CERAMOS Gen C4 (CW VHLPD2.EN) was primarily developed for use as a slim light source for flash-lights in camera applications. The package does not possess a carrier like a lead frame or a substrate, and no wire bond.

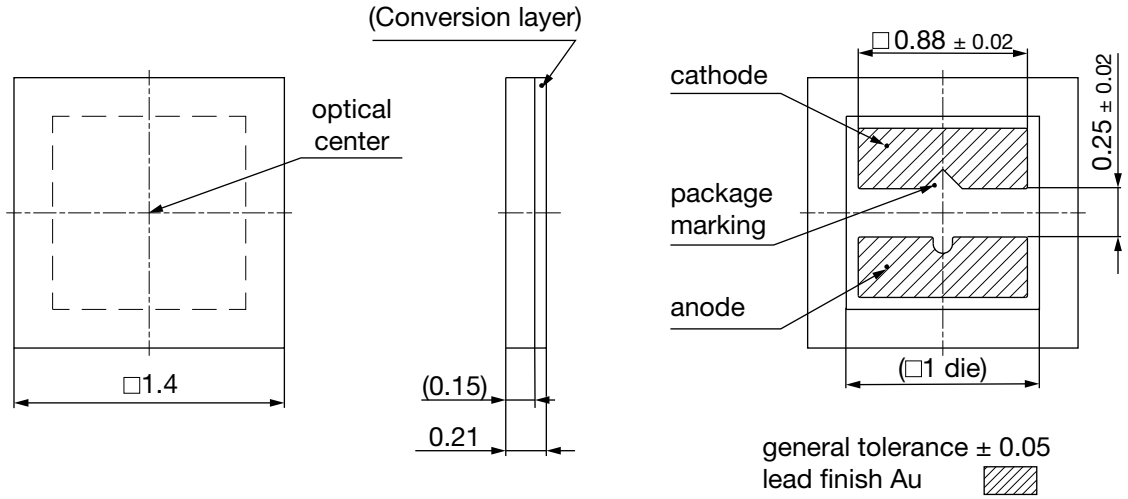
Following the Chip-Scale-Package (CSP) approach the LED consists of a highly efficient sapphire flip chip without a carrier. The chip is embedded in a white mold silicone and covered by a yellow converter foil (Figure 1).

Figure 1: Design of the CW VHLPD1



Representing a CSP top emitter, the electrical contacts are on the bottom side of the LED (chip), the pads are finished with a gold (Au) layer. Figure 2 shows the dimensions, pad design and marking of the CERAMOS GEN C4.

Figure 2: Dimensions of CERAMOS Gen C4 (CW VHLPD2.EN)



Although there is no additional ESD protection included, the LED provides ESD stability of up to 2kV. It is assigned to the "Class 2 HBM" category in accordance with ANSI / ESDA / JEDEC JS-001. With this class the CERAMOS GEN C4 can be considered as uncritical for processing and assembly by state-of-the-art SMT equipment in line with ESD precautions. For higher ESD protection on a system level an additional ESD protection needs to be applied.

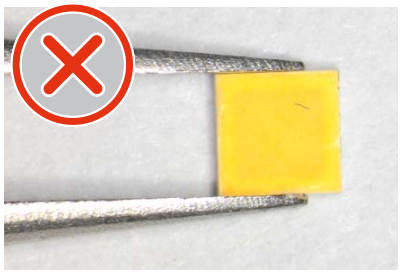
As with all LEDs from OSRAM Opto Semiconductors, the CW VHLPD2.EN also fulfills the current RoHS guidelines (European Union and China) and therefore contains no lead or other defined hazardous substances.

B. Handling

In accordance with the general guidelines for the handling of LEDs, additional care should be taken to minimize mechanical stress on the silicone.

In general, all sharp objects of any kind should be avoided to prevent damage to the encapsulation which may affect the functionality of the LED. Figure 3 shows incorrect handling with a standard tweezer.

Figure 3: Incorrect handling - any kind of tweezers (steel, plastic, etc.) are forbidden



For manual assembly and placement only, the use of vacuum tweezers is recommended (Figure 4). In general, manual assembly is not recommended and should only be performed in cases where automated placement tools cannot be used. (For example in prototypes production.)

Figure 4: Examples of vacuum tweezers



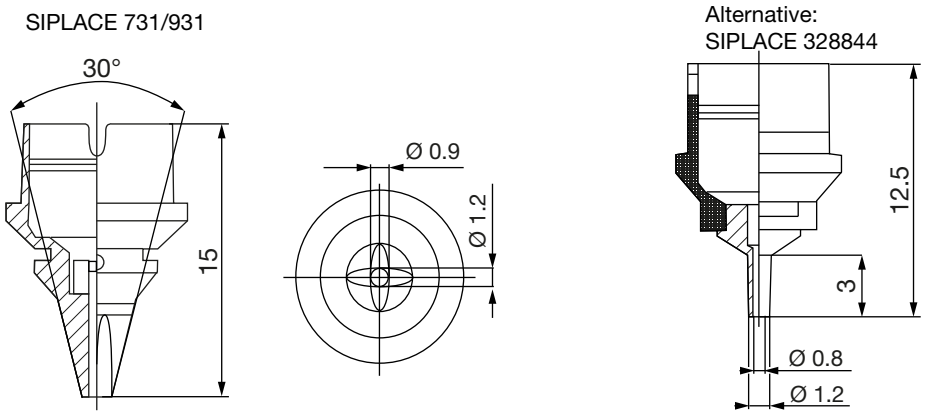
Individually exchangeable soft rubber suction tips are used in order to minimize the effective mechanical stress on the LED.

Although the CERAMOS Gen C4 provides ESD Class 2 (HBM) stability, the usual and appropriate precautions while handling should still be maintained. (See also application note "AN020_ESD Protection while handling LEDs".)

For processing by means of automated placement machines, care should be taken that an appropriate pick and place tool is used and that the process parameters conform to the package characteristics.

Figure 5 shows an overview of the recommended designs of placement tools for a damage-free processing of the CSP CERAMOS Gen C4.

Figure 5: Overview of the recommended design for the pick & place nozzle

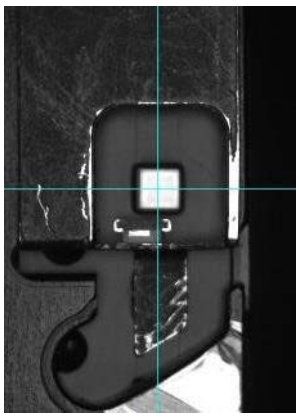


To minimize stress during the pick and place, the process parameters needs to be controlled. Important parameters are:

- z-height
- placement force
- contact area

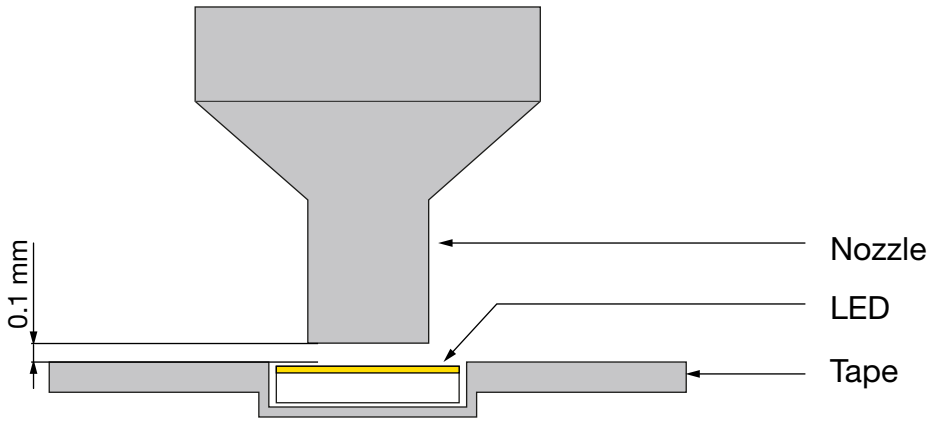
High stress can cause damage to the product. Defined and correctly aligned process parameters can reduce this risk. It is therefore important that the pick-up tool is aligned precisely (Figure 6). Centered contact minimizes the risk of mechanical damage.

Figure 6: Adjusting the nozzle pick-up position



The z-height may become a major cause of stress. Since the CSP LED features a lightweight design, the nozzle picks up the component through its vacuum suction before reaching the surface area of the tape. If the z-height is not adjusted, mechanical damage to the silicone package may occur. To avoid this, a z-height value of 0.1 mm is recommended as shown in Figure 7.

Figure 7: Nozzle pick-up, z-height definition



C. Storage

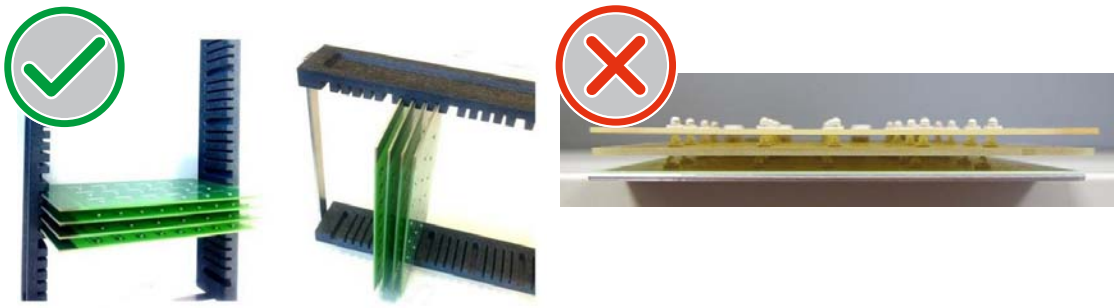
Since the CERAMOS Gen C4 is generally supplied in tape with a dry pack, it should be factory-sealed when stored.

The hermetic bag should only be opened immediately before mounting and processing, after which the remaining LEDs should be repacked according to the moisture level in the datasheet (see JEDEC J-STD-033B.1 - Moisture Sensitivity Levels).

Assembled LEDs should not be stacked on top of each other and a correct storage system should be used (Figure 8). If any force places pressure on the

assembled LEDs, these can be damaged. Therefore assemblies should not be touched directly on the LED.

Figure 8: Storage of LEDs



Generally, all LED assemblies should be allowed to return to room temperature after soldering before subsequent handling or the next process step.

D. Cleaning

From today's perspective any direct mechanical or chemical cleaning of the CERAMOS Gen C4 is forbidden.

Isopropyl alcohol (IPA) can be used if cleaning is mandatory. Other substances and especially the ultrasonic cleaning of CERAMOS Gen C4 should be avoided, as they can damage the LED. For more information on correct cleaning see the application note "AN017_Cleaning of LEDs".

Dusty LEDs can be cleaned by using pure compressed air (e.g. central supply or spray can). In any case, all materials and methods should be tested beforehand.

E. Assembly process

Generally, the CERAMOS Gen C4 is compatible with existing industrial SMT processing methods, so that current standard techniques can be used for mounting.

A standard reflow soldering process with convection N2 (O2 < 500ppm) and a solder with typical lead-free SnAgCu metal alloy is recommended. (SAC305 solder paste type 4 with a particle size 20-38µm.)

Further information and more details regarding the general processing of SMD LEDs can be found in application note "AN036_Processing of SMD LED".

Please note that CSP-LEDs feature no manual solderability or repair capability.

Since direct contact of the solder terminals of the CSP LED with a soldering iron is not possible, please note that CSP LEDs feature no manual solderability or solder connection repair.

If a component needs to be replaced, typically only manual processes can be applied to heat up the defective LED and PCB section, clean the PCB solder pads, apply the sufficient amount of solder paste, place the new component and

reflow the replaced LED. For all heating processes the maximum reflow temperature profile given in the data sheet needs to be adhered to.

Since all manual processes involve a high risk of pre-damage or long-term reliability issues, OSRAM Opto Semiconductors due not recommend any manual rework.

For ideal mounting of the CERAMOS Gen C4 to the circuit board the following aspects of the soldering process should be taken into consideration:

- Selection of PCB type
- Design of the solder pad
- Design of the solder stencil

PCB type

PCBs do not only act as a mechanical substrate and electrical contacting element for the components. In addition, modern circuit boards should also ensure stable characteristics within the circuitry. Especially for CSP LEDs, an efficiently heat dissipation is required.

The selection of the appropriate materials and design for the circuit board is therefore of high importance, since the CSP LED itself does not feature a traditional package and features therefore only a very low thermal capacity.

Materials or composites with insufficient thermal capacity and conductivity lead to a decrease of reliability or restrict operation parameters, since the generated heat cannot be dissipated in sufficient quantities.

Please note that the package can break due to PCB warpage after mounting the products. To avoid damage, the CERAMOS Gen C4 should be placed such that mechanical stress is reduced as much as possible. If flexboards are used, the area where the CSP is mounted has to be stiff. Recommended is a metal stiffener, which also increases the thermal capacity.

The design, construction and material of the PCB are essential for an optimized thermal design. As a consequence it is recommended to appropriately verify the entire system in order to improve the operational characteristics of the CSP LED.

Solder pad

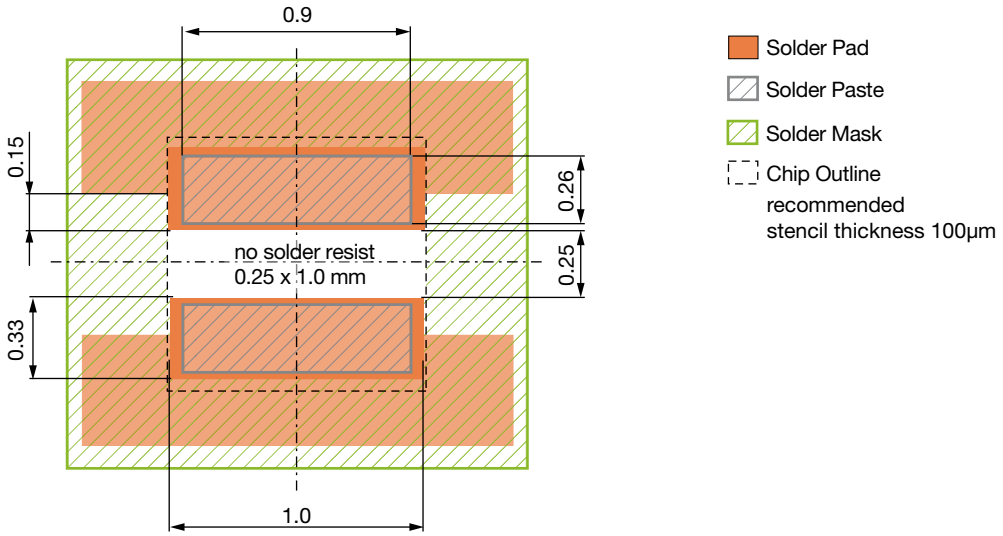
Since the solder pad effectively creates the direct contact between the LED and the circuit board, the design of the solder pad contributes decisively to the performance of the solder connection.

The design has an influence on solder joint reliability and heat dissipation, for example.

In most cases, it is therefore advantageous to use the recommended solder pad, since it is individually adapted to the properties and conditions of the LED

(Figure 9). The corresponding solder pad can also be found in the data sheet of each LED.

Figure 9: Recommended solder pad design of the CERAMOS Gen C4

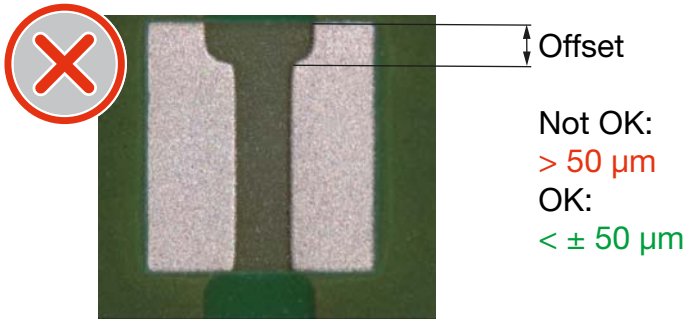


Based on the given solder pad design, an optimized balance between good processability, the smallest possible positioning tolerance and a reliable solder connection can be achieved.

However, it should be noted that the self-centering effect of the CSP LED is very limited. Since the placement and rotational alignment of the component depend on the material, process and equipment, an optimization must take all three factors into account.

The requirements for good thermal management should be taken into consideration in the application when designing the solder pads for the CERAMOS Gen C4. In general the copper area should be kept as large as possible. This serves to dissipate and spread the generated heat over the PCB. Typically it is covered with a solder resist layer. Attention need to be paid to an accurate alignment and adjustment of the solder resist towards the solder pads. The offset between the solder mask and the copper pattern has to be less than 50 µm (Figure 10). Furthermore the solder pad should be free of particles, bumps, dimples or other defects.

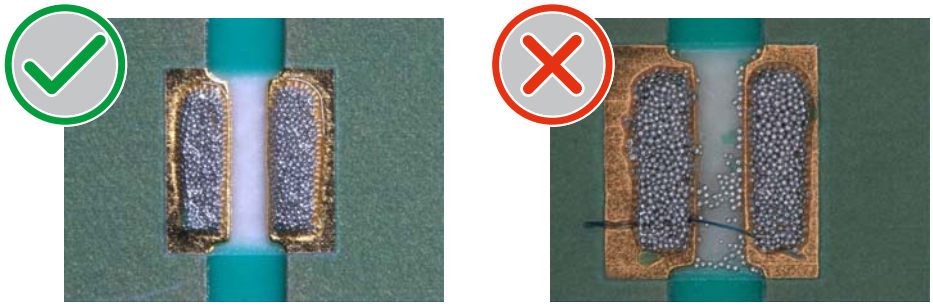
Figure 10: Solder mask offset



Solder stencil

In the SMT process, solder paste is normally applied by stencil printing. The design of the printing stencil and an accurate working process influence the applied amount and quality of the paste deposit. (Figure 11)

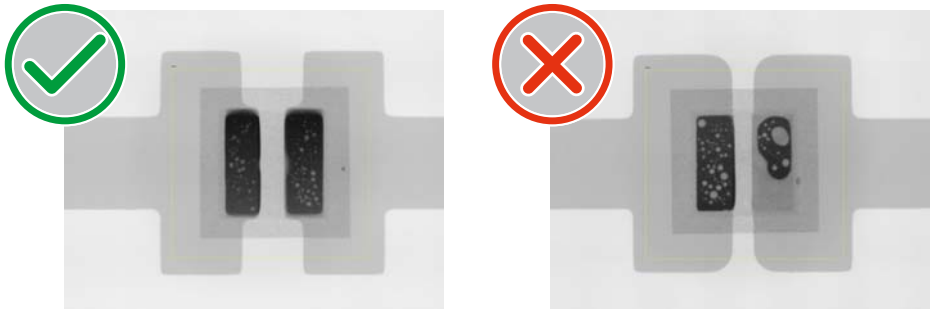
Figure 11: Example of solder paste printing



Proper solder paste printing increases the solder quality. 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.). Due to the flip chip a stencil thickness of 100 µm is recommended for the CERAMOS Gen C4.

In industry it is a good practice to perform an x-ray as shown in Figure 12 or through a cross sectional analysis to check the solder joint integrity.

Figure 12: X-Ray images of solder joints (CERAMOS Gen C4)



A uniform solder joint thickness is recommended to produce reliable solder joints and obtain an appropriate optical alignment of the CERAMOS Gen C4.

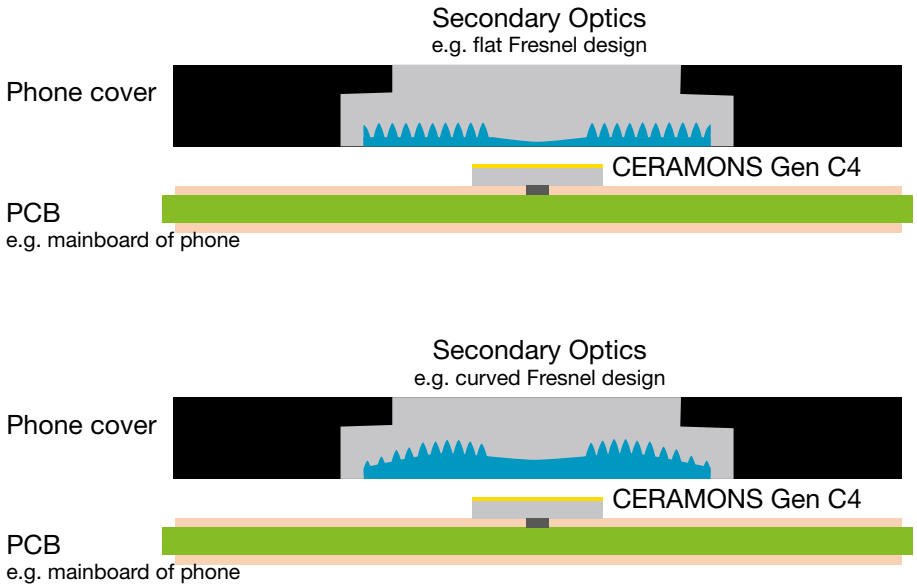
F. Suggestion for system setup

Due to the Lambertian radiation pattern of the CERAMOS Gen C4 it is recommended to operate the LED, especially for use as flash-light, in combination with secondary optics to adjust and focus the radiation to the customer-specific needs.

Figure 13 shows two examples of the CERAMOS Gen C4 assembled with external optics in a mobile phone. Generally, the LED enables great design flexibility regarding the appearance of the mobile phone by changing the lens

(opening and optical structure). The very small dimension also allows compact custom-made flat flash systems. Generally, the alignment of the LED toward the external optics has to be considered.

Figure 13: Examples of flash application concepts with CERAMOS Gen C4



G. Summary

The Chip-Scale-Package approach represents still a new frontier within LED technology, also with respect to LED processing and the manufacturing of LED applications. CSP LEDs are compatible with the standard SMT assembly and solder process. Nevertheless, the CERAMOS Gen C4 implies slightly higher requirements and attentiveness with regard to handling and processing.

Due to the LED design it is recommended to handle the LED manually only using vacuum tweezers with a soft rubber tip. The use of any other kind of tweezers is forbidden due to the risk of damage or impairment. Manual soldering is not suitable and any solder rework is not offered.

Processability tests show that a solder paste thickness of 100 µm is advisable. These tests have also shown that the self-centering effect of the CSP LED during the solder process is limited in its extent. For this reason, the pick and place process needs to be more accurate than for standard LEDs. A vision alignment placement tool is advantageous. With regards to the monitoring methods, z–height control is recommended.

With respect to LED applications the focus is moreover on thermal management. CSP LEDs feature good thermal resistance but only a very small thermal capacity. For this reason the heat generated during operation needs to be spread and dissipated away from the junction at the bottom of the LED. Therefore appropriate materials and the design of the circuit board are very important.

Insufficient or unbalanced components can lead to an impairment of reliability or restrict the operation parameters of the LED.

Further information regarding thermal management, processing and specific LED types can be found on the OSRAM Opto Semiconductor website in the “Application Notes” section.

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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