OSIRE® E3731i – Details on design, handling and assembly

Application Note

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OSIRE® E3731i – Details on design, handling and assembly

Application Note No. AN164

Valid for:
OSIRE® E3731i

Abstract

The OSIRE® E3731i is an “intelligent” multi-color LED including an IC embedded in the package together with 3 LED-Chips. It is based on Open System Protocol that simplifies integration at customer side through an open control concept, daisy chaining of units, integrated temperature monitoring and access to calibration data for each unit.

This Application Note provides recommendations for proper handling and assembly. Please read carefully and follow the instructions in order to avoid damages to the LED and secure long lifetime under application conditions.

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1 Basic information

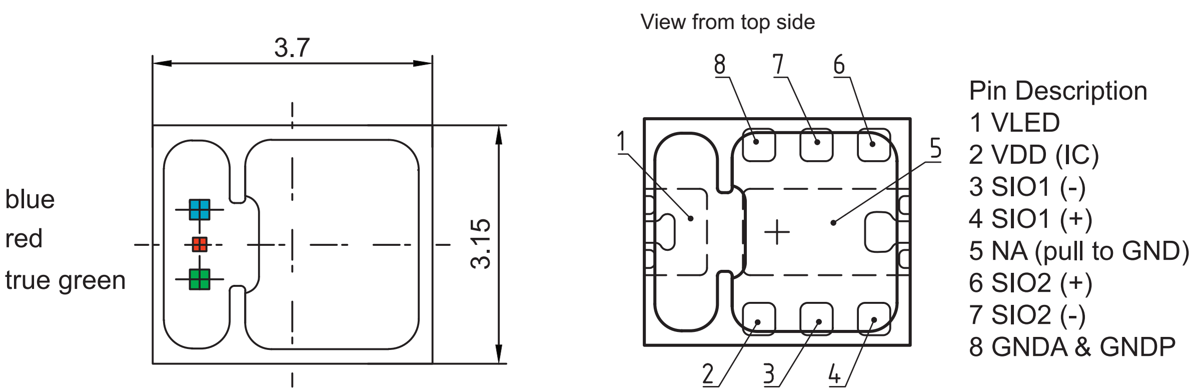
The OSIRE® E3731i is primarily designed for automotive interior applications requesting high dynamic RGB lighting scenarios. An embedded IC from ams OSRAM integrates the drivers for the three R/G/B LEDs and provides the optical measurement data as well. An external micro controller can address and control each device in a daisy chain architecture via an Open System Protocol (OSP). The open protocol allows the micro controller to read back these data and to run any color mixing algorithm. It also allows to read back a temperature value to optimize this color setting algorithm. For more details, please refer to the application note “OSIRE E3731i - Open System Protocol 1.0”.

1.1 Design and technical advantages

The OSIRE® E3731i is a small 3.7 mm x 3.15 mm x 0.65 mm LED in a top-looker pre-mold SMT package. The integration of LED and IC to one component reduces the space demand in applications in comparison to standard light sources with additional external drivers. Furthermore single layer PCB designs are possible. This dynamic light source offers variable color and brightness control. A controllable chain of multi-color LEDs is possible and additional functions, such as situational information for the driver can be enabled.

For more details on the technical advantages, please refer to the Application Note "OSIRE® E3731i - Startup Guide". Figure 1 shows the design and the PIN description of the OSIRE® E3731i.

Figure 1: Figure 1: OSIRE® E3731i package design and PIN description



For detailed information on the mechanical dimensions please refer to the drawings available in the data sheet. To obtain CAD data and optical rayfile, please visit the "Optical Simulation / Ray Files + Package CAD Data" webpage on ams-OSRAM AG website.

For more information on importing rayfiles and ray-measurement files, please refer to the application note "Importing rayfiles and ray-measurement files of LEDs".

1.2 Corrosion robustness

LEDs are categorized in several corrosion robustness classes, depending on material properties. Each robustness class reflects different test conditions.

The LED fulfills the requirements of corrosion robustness class 2B. For further information on how to prevent failures caused by corrosive materials and corrosion robustness classes, see the "Preventing LED failures caused by corrosive materials" application note.

2 PCB design recommendations

A well-designed PCB layout is essential. In general a EMC-friendly PCB design should be created. To avoid signal reflection on high-speed serial communication interfaces (SCI), all the lines should be as short as possible and should also be of the same length. There should be no line crossing and no vias between the lines.

Depending on the number of devices in the chain and the driving conditions, the voltage drop on supply and ground wire resistance should be considered.

The following design guidelines should be considered for **single-ended signal lines**:

- Keep the lines as short as possible
- Design the line-ground loop with min. area
- Design no line crossing and no vias between single-ended lines
- An off-board design is not recommended

The following design guidelines should be considered for **LVDS signal lines** between the RGBis:

- Keep the wires parallel and close to each other to minimize interference with radiated electromagnetic fields and noise injection
- The wire lengths for the SIOx_P and SIOx_N pair should be balanced
- Off-board twisted pair
- Avoid or minimize stubs and junction taps to avoid reflections
- Avoid right-angle traces to minimize radiated emission

2.1 Recommendations for external components

It is recommended to consider the following guidelines for external components:

Connect to each common anode VLED (PIN1) min.1 µF low ESR ceramic capacitor.

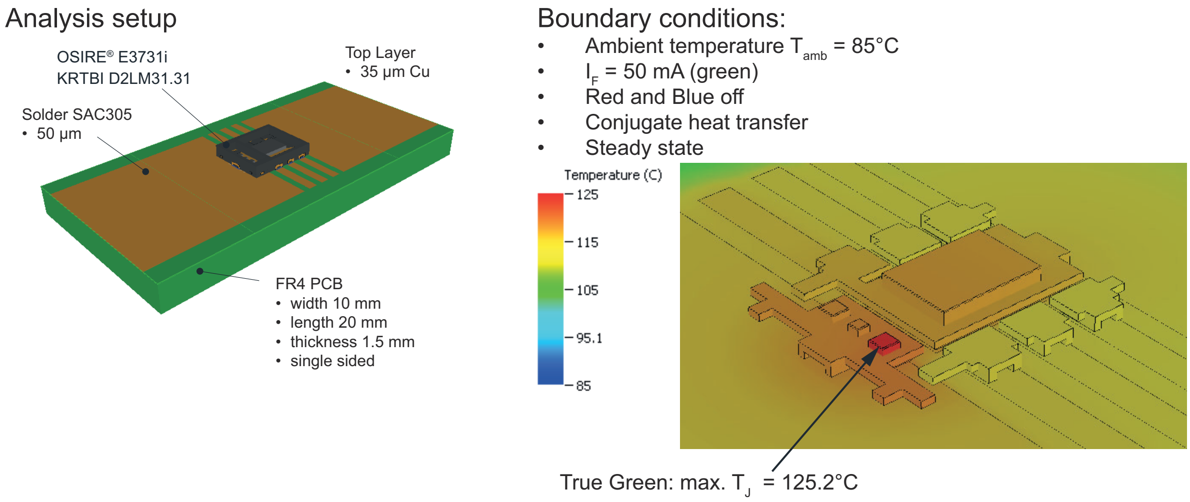
- A 100 nF capacitor should be set as close as possible to the 5 V IC supply VDD (IC) (PIN2).
- Pull-up resistors are required to choose the MCU and transceiver communication mode or for the End of line detection. Please see "OSIRE® E3731i - Startup Guide". Please place a 10 k resistor on SION and/or SIOP in parallel to the 5 V supply according to the recommendation. Additional pull down resistors are not needed due to included 100 k pull downs on SION & SIOP.
- It must be ensured that the max. rating supply voltage 5.5 V (e.g. Z-diode 5.5 V) is observed.

2.2 Thermal PCB guidelines

In addition to their primary function as a mechanical substrate and electrical contacting element, circuit boards have the task to efficiently dissipate the heat which is generated. Thermal management is important to stabilize the LED's output. The LED's p-n junction temperature (T_J) represents one of the major factors which influence the lifetime and the reliability of LEDs. The selection of appropriate materials and designs for the circuit board is therefore of importance. The maximum junction temperature T_{J_max} can be found in the data sheet. Detailed information on this topic is provided in the application notes "Package related thermal resistance of LEDs".

For the temperature distribution the thermal path of the LEDs via VLED PIN1 and the IC via PIN5 must be considered. The thermal spread should be as big as possible. An additional layer on the bottom side can help. For double layer PCBs a better thermal performance can be achieve by using plugged and filled thermal vias in the thermal pads. The thermal simulation in Figure 2 shows the heat spreading at T_{J_max} exemplary for the green LED. In this simulation a single layer PCB with an ambient temperature of 85°C and a steady state mode was assumed. The operating conditions were I_F = 50 mA on the green chip, the red and blue LEDs were not operated. It shows that the junction temperature T_J of 125 °C at the green chip is spread over the thermal pads.

Figure 2: Thermal simulation of the green LED



3 Handling recommendations

LEDs are exposed to various mechanical stresses during processing and in the application. However, each mechanical stress has direct effects on the functionality and lifetime of the LED. Excessive stress may lead to a LED failure. For detailed information please refer to the application note "Fundamentals of LED handling".

The use of any kind of sharp objects should generally be avoided since this can damage the component. The LED light emitting area must generally not be touched or punctured as this can damage the component.

As is the case for all LEDs from ams-OSRAM AG, the LED also fulfills the current RoHS guidelines (European Union and China) and therefore contains no lead or other substances defined as hazardous.

3.1 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 LED 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 must be applied.

Nevertheless, please be aware of ESD safety while handling LEDs. As a matter of principle, common ESD safety precautions must be observed during the handling, assembly and production of electronic devices (LEDs). For further information on ESD protection please refer to the application note “ESD protection while handling LEDs”.

3.2 Cleaning

Any direct mechanical or chemical cleaning of the LED should be avoided. Isopropyl alcohol (IPA) can be used if cleaning is mandatory. Other substances, and especially ultrasonic cleaning, are generally not recommended.

For dusty LEDs, simple cleaning by means of purified compressed air (e.g. central supply or spray can) is recommended. To ensure that the compressed air does not contain any oil residues, the use of a spray can is recommended. A maximum pressure of 4 bar at a distance of 20 cm to the component should be observed.

In any case, all materials and methods should be tested beforehand, particularly as to whether or not damage can be associated with the component.

3.3 Precautions and storage

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

LEDs are generally supplied in tape with a dry pack and should stay factory-sealed when stored. This package 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-033 - Moisture Sensitivity Levels). For further information on dry pack please refer to the application note "Fundamentals of LED handling", especially if long-term storage is desired.

A suitable storage system should be implemented in order 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, the LED of the assemblies must also not be touched directly. Generally, all LED assemblies should return to room temperature after soldering, before subsequent handling, or next process step.

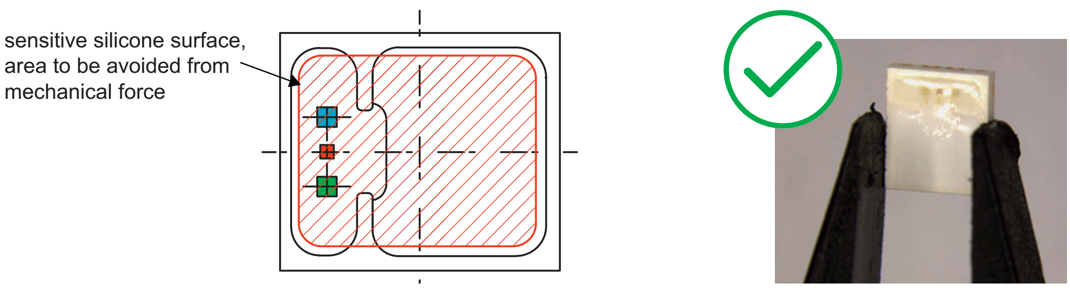
Figure 3: Correct storage

3.4 Manual handling

When handling LEDs, the general guidelines must be observed. Mechanical stress (e.g. shear forces) on the elastic silicone encapsulation should be excluded or reduces as far as possible (see also application note "Fundamentals of LED handling"). In general, all types of sharp objects (e.g. forceps, fingernails, etc.) should be avoided in order to prevent stress to or penetration of the encapsulation, as this can lead to impairment of the component.

Automated placement of the LEDs is strongly recommended. Even if manual handling and mounting is possible, it should be avoided. Due to the integrated IC, there are also sensitive structures under the white encapsulation layer, so this area should not be touched during handling. If manual handling is necessary, the LED should only be held by the package frame with ESD-tweezers, applying force evenly to the entire LED package, as shown in Figure 4.

Figure 4: Recommended manual handling



4 Processing

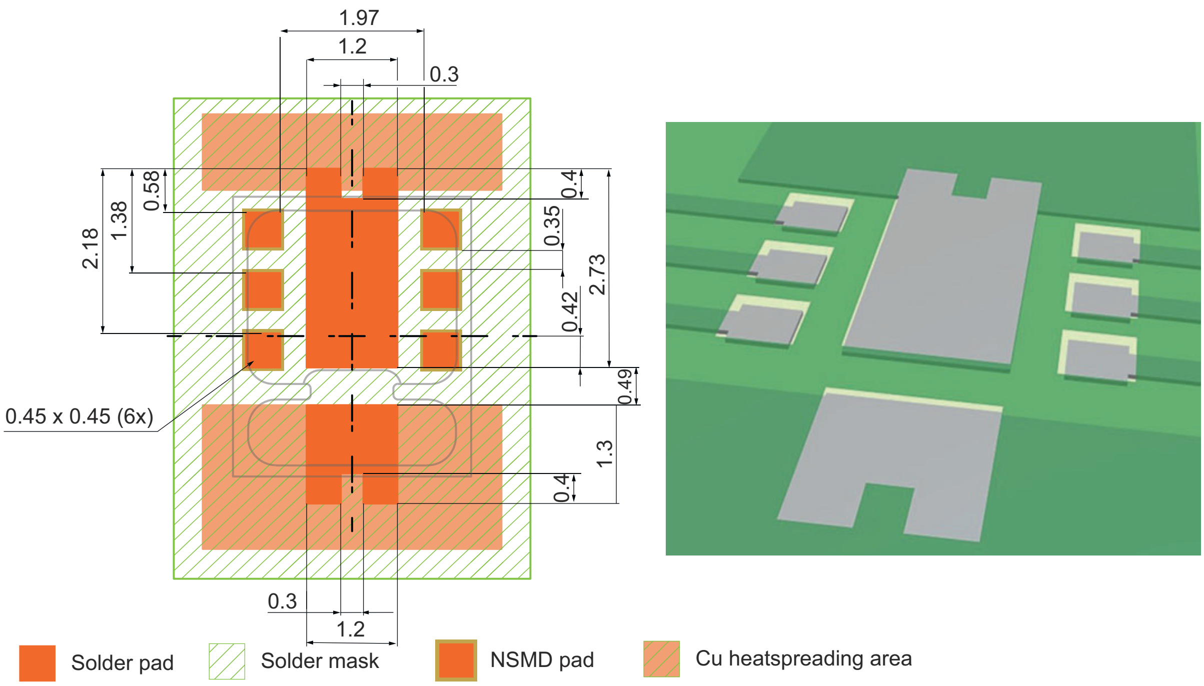
4.1 Solder pad design

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.

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

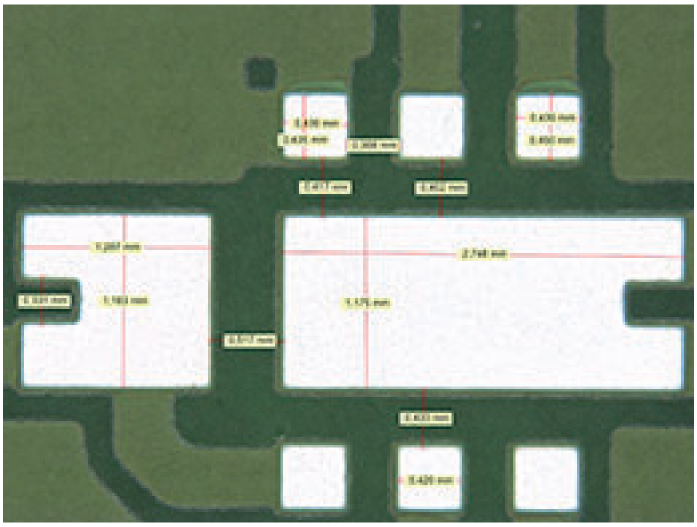
Figure 5: Recommended solder pad design



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.

During PCB manufacturing a typical registration tolerance of ±50µm between the copper trace pattern and solder mask needs to be respected. To achieve an optimal solder joint contact area and to limit the impact of mis-registration or the expansion effect of the solder mask, it is recommended to use a NSMD pad (Non Solder Mask Defined) for all electrical signal pads (see Figure 5). Nevertheless, it is recommended to check and re-measure the solder pad dimensions (Figure 6) on the actual PCB before the first assembly process.

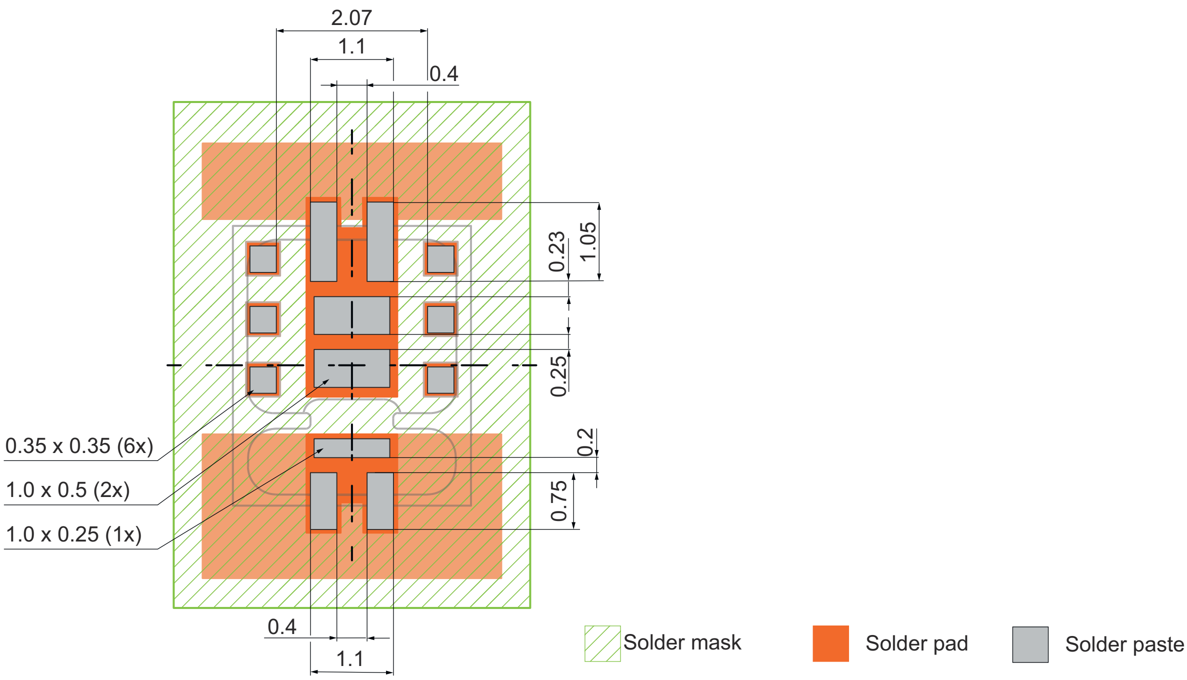
Figure 6: Verifying the solder pad design before processing



4.2 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 7).

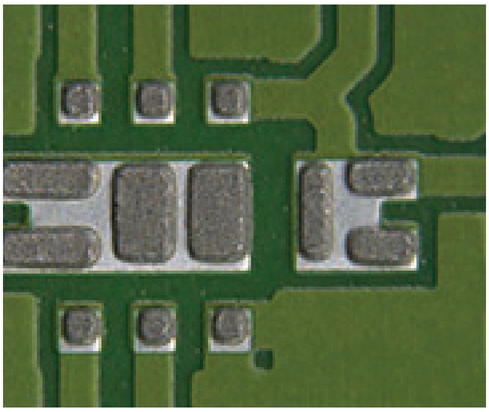
Figure 7: Recommended solder stencil



A 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.). For the LED a stencil thickness of 120 µm is recommended. Further optimization to improve the amount of solder paste volume should take place. A uniform solder joint thickness is recommended in order to produce reliable solder joints and obtain an appropriate optical alignment. An automatic stencil printing with proper fiducial and electro polished or fine grain material stencil is resulting in proper printing deposits.

Use standard lead free SAC 305 (Sn 96,5% / Ag 3% / Cu 0,5%) no clean solder paste for the paste printing process. ams-OSRAM AG has successfully used the standard SAC 305 Type 4 solder paste (HERAEUS F640 SAC 305 M4). For process evaluation, process control and failure prevention it is recommended to check the solder paste volume with 3D SPI (Solder Paste Inspection) regularly. Figure 8 shows a proper solder paste print.

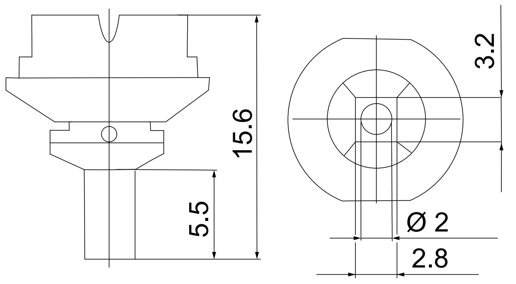
Figure 8: Proper solder paste print



4.3 Pick-and-place nozzle design

When processing by means of automated placement machines, care should be taken to use an appropriate pick and place tool and to ensure that the process parameters conform to the package's characteristics. An example of a suitable pick-and-place nozzle design for damage-free processing is shown in Figure 9. Care should generally be taken that an appropriate pick and place tool is used and that process parameters conform to package characteristics. The placement force applied to the top of the package should be kept to minimum. For example, it can be tested with the standard default setting (2.0 N in most cases) at the beginning and should be then further reduced, if possible.

Figure 9: Recommended pick-and-place tools



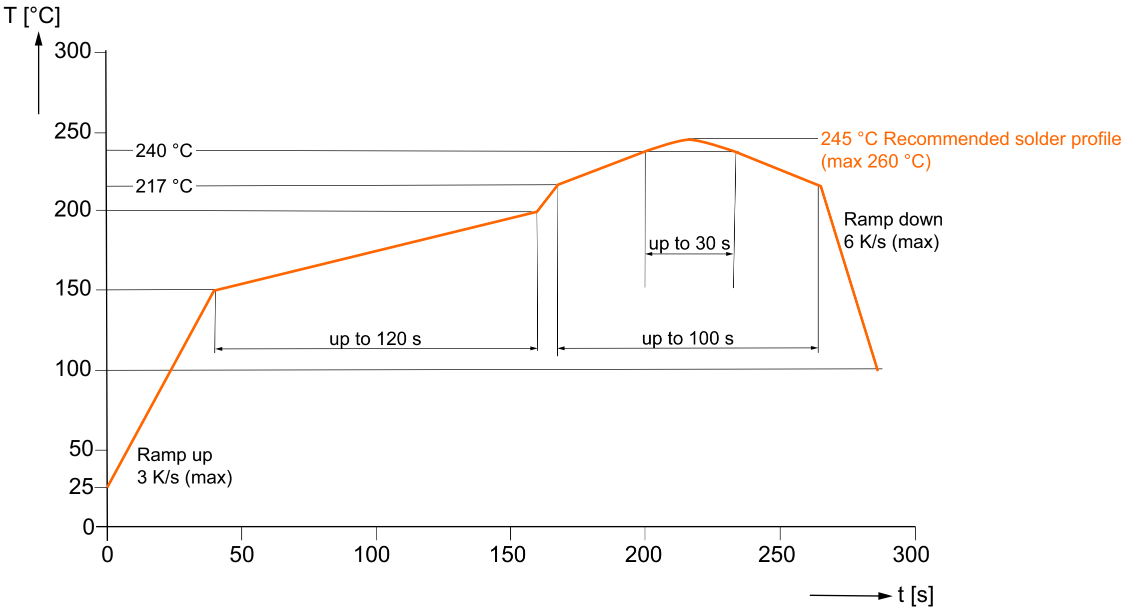
Since the LED was tested with ASM SIPLACE pick and place machines, SIPLACE nozzles are recommended. If other types of pick and place machines are used in the field, please use modified tools according to the given dimensions and body structure for the mounting.

4.4 Reflow soldering

Since the LED is compatible with existing industrial SMT processing methods, state-of-the-art populating techniques can be used for the mounting process. The individual soldering conditions for each LED type according to JEDEC can be found in the respective data sheet. A standard reflow soldering process with forced convection under standard N_2 atmosphere is recommended for mounting the component, in which a typical lead-free SnAgCu metal alloy is used as solder. For superior solder joint connectivity results it is recommended to use a nitrogen atmosphere <500ppm O_2.

Figure 10 shows the temperature profile for lead-free soldering with the recommended peak temperature of 245 °C. In this context, it is recommended to check the profile on all new PCB materials and designs. As a good starting point, the recommended temperature profile provided by the solder paste manufacturer can be used. The maximum temperature and also ramp-up and cool down gradient for the profile as specified in the data sheet should, however, not be exceeded. Please check and verify the reflow profile for every new design (see also application note "Measuring of the temperature profile during the reflow solder process"). Please ensure not to apply any stress during soldering or while the LED is cooling down to ambient temperature.

Figure 10: Recommended temperature profile for lead-free reflow soldering in accordance with to JEDEC J-STD-020E



Profile Feature	Symbol	Pb-Free (SnAgCu) Assembly			Unit
		Min	Recommended	Max	
Ramp-up rate to preheat[1] 25 °C to 150 °C			2	3	K/s
Time t_S $T_S$min to $T_S$max	t_S	60	100	120	s
Ramp-up rate to peak[1] T_{Smax} to T_P			2	3	K/s
Liquidus temperature	T_L		217		°C
Time above liquidus temperature	t_L		80	100	s
Peak temperature	T_P		245	260	°C
Time within 5 °C of the specified peak temperature T_P - 5 K	t_P	10	20	30	s
Ramp-down rate[1] T_P to 100 °C			3	6	K/s
Time 25 °C to T_P				480	s

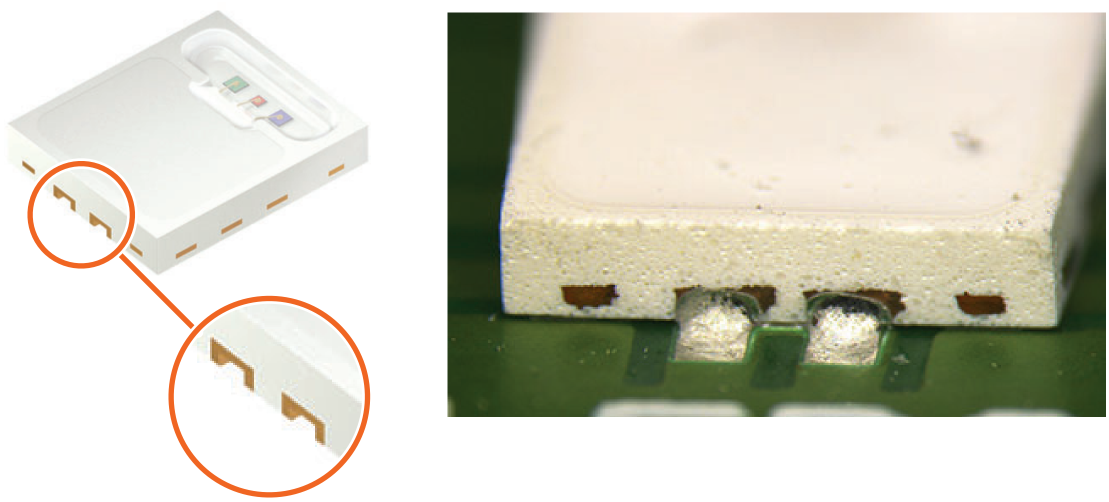
All the temperatures refer to the center of the package, measured on the top of the component
[1]slope calculation DT/Dt: Dt max. 5 s; fulfillment for the whole T-range

4.5 Solder joint inspection

A visual inspection in combination with X-ray inspection ensures proper solder joint quality and helps to identify common solder joint issues or defects such as solder balls, solder bridges, high void level or placement position. In addition, a proper inspection ensures to determine correct design (PCB solder pad and stencil) or assembly process settings (printing parameter, pick-and-place position and settings). As a common industry standard, it is recommended to inspect the solder joint quality for every new product or design and therefor indicate design or manufacturing issues in an early stage.

The package design is featured with integrated wettable side flanks or so-called solder control structures which enable an excellent self-alignment during reflow soldering. The solder wetting structure shown in Figure 11 enhances the solder wetting to form a solder fillet and minimize the risk of rotation and tilting of the component. Uniform solder fillets are therefore beneficial to enable visual inspection and usage of automatic optical inspection systems (AOI).

Figure 11: Solder side wetting structure for solder joint inspection

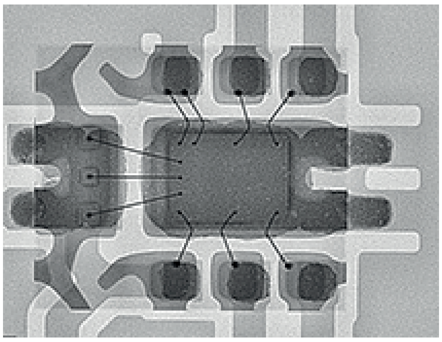


As an established practice during inhouse tests, X-ray inspection should be performed twice, before the reflow process and after. Before soldering, x-ray image gives an optimal indication of proper component placement. For example, if solder paste squeeze out can be seen, it is an indication for high placement force. Since the distances between the solder pads are relatively small, it is possible to see in early stages whether solder balls or solder bridges are formed.

X-ray inspection after reflow soldering is typically used to check void level but also confirm that there are no solder balls or solder bridges under the components. Figure 12 show examples of an x-ray solder joint inspection before and after the reflow process.

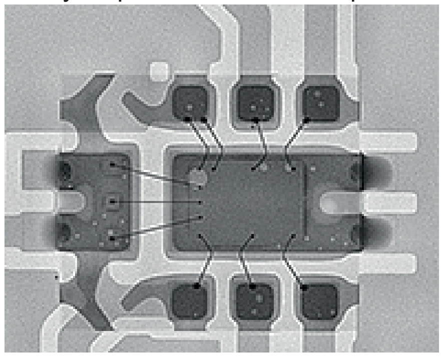
Figure 12: x-ray solder joint inspection

X-Ray inspection before reflow process



Proper component placement
No indication of possible soldering failures

X-Ray inspection after reflow process



Proper self centering
Acceptable voiding level

5 Summary

The OSIRE® E3731i is an intelligent RGB-LED which is based on a license free Open System Protocol (OSP). The LED integrates an IC into an RGB LED.

Due to this integration, PCB design requirements are higher and specific guidelines for single-ended signal lines and signal lines should be followed. Adequate ESD protection must be ensured during handling. In general, mechanical stress on the LED during handling and processing should be kept to the minimum necessary. The process recommendations described in this application note should be followed. Processing should be carried out with automatic placement machines using the recommended solder pads, solder stencils and pick-and-place nozzles. Due to the small solder structures, proper solder paste printing and inspection of the solder joints is essential for the final solder quality.

ABOUT ams OSRAM Group (SIX: AMS)

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