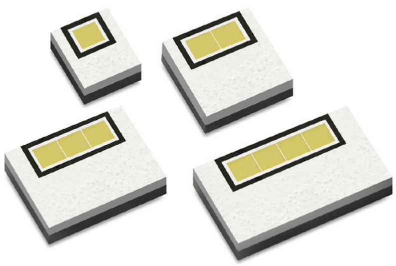
LUMILEDS

AUTOMOTIVE

LUXEON Altilon Intense

Assembly and Handling Information



Introduction

This application brief addresses the recommended assembly and handling procedures for LUXEON Altilon Intense emitters. LUXEON Altilon Intense are designed to deliver high contrast in high and low beam in automotive exterior lighting applications. Due to the small size of light emitting area and the laser marking feature, they require special assembly and handling precautions.

Proper assembly, handling and thermal management, as outlined in this application brief, ensures high optical output, long term lumen maintenance and high reliability of LUXEON Altilon Intense emitters in automotive applications.

Scope

The assembly and handling guidelines in this application brief apply to the following product(s):

PRODUCTS
LUXEON Altilon Intense 1x1
LUXEON Altilon Intense 1x2
LUXEON Altilon Intense 1x3
LUXEON Altilon Intense 1x4

Any assembly or handling requirements that are specific to a subset of LUXEON Altilon Intense products is clearly marked. In the remainder of this document, the term LUXEON Altilon Intense refers to any product in the LUXEON Altilon Intense product family.

Table of Contents

1. Component

1.1 Reference Documents

The LUXEON Altilon Intense datasheets DS229, DS230, DS239 and DS240 are available upon request. Please contact your sales representative.

1.2 Description

The LUXEON Altilon Intense consists of a single or an array of LED chips combined with a phosphor converter to emit light. They are mounted onto a ceramic substrate. Underneath the substrate are electrical pads and thermal pads. An electrical interconnect layer connects the LED chips to a cathode and anode on the bottom of the ceramic substrate. There are two additional thermal pads directly underneath the LED chips, which are electrical isolated. The outside of the package is coated with white silicone to shield the chip from the environment and to prevent light leakage to the sides (top of emitter). The LUXEON Altilon Intense includes an separate transient voltage suppressor (TVS) chip on top of the carrier substrate and covered by side coat to protect the emitter against electrostatic discharges (ESD). See Figure 1 for top and bottom view.

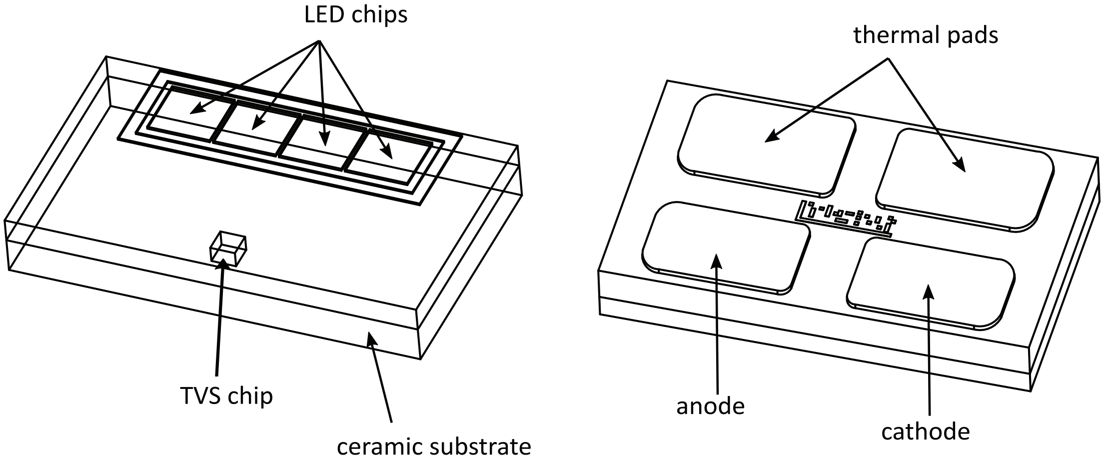
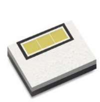
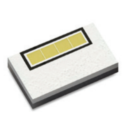


Figure 1. Top view (left) and bottom view (right) of the LUXEON Altilon Intense.

Table 1. Design features of LUXEON Altilon SMD by part number.

PRODUCT		PART NUMBER	MAX DC DRIVE CURRENT	DIE SIZE	NO. OF DIES	PACKAGE SIZE (W x L x H)
	LUXEON Altilon Intense 1x1	A1SL-58501DH0XXXX0	1125 mA	0.5 mm^2	1	1.900 mm x 2.320 mm x 0.853 mm
	LUXEON Altilon Intense 1x2	A1SL-58502DH0XXXX0	1125 mA	0.5 mm^2	2	2.700 mm x 3.000 mm x 0.853 mm
	LUXEON Altilon Intense 1x3	A1SL-58503DH0XXXX0	1125 mA	0.5 mm^2	3	3.850 mm x 3.000 mm x 0.853 mm
	LUXEON Altilon Intense 1x4	A1SL-58504DH0XXXX0	1125 mA	0.5 mm^2	4	5.000 mm x 3.000 mm x 0.853 mm

1.3 Dot Matrix Code

The LUXEON Altilon Intense has a Dot Matrix Code (DMC) on the bottom side of the 1x2, 1x3 and 1x4 device (see Figure 2 below). This is a unique traceability code and does not contain any color or flux information. Specific performance and manufacturing information is linked to this DMC and can be retrieved on special request. LUXEON Altilon Intense 1x1 holds a 12-digit code for the same purpose. Please contact your sales representative for details.

The DMC applies to:

- ISO standard ISO/IEC 16022:200
- Symbol attribute according ECC 200
- Dot size: 40-50 μm
- Dot Matrix: 8 x 32 dots

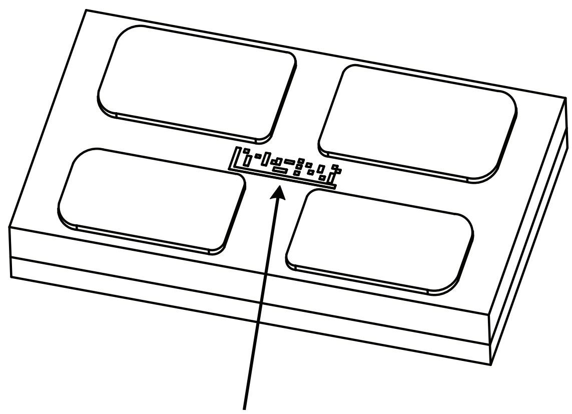


Figure 2. Example of a dot matrix code on bottom side of LUXEON Altilon Intense.

1.4 Mechanical Files

Mechanical drawings for LUXEON Altilon Intense (2D and 3D) are available upon request. For details, please contact your sales representative.

2. Handling Precautions

Like all electrical components, there are handling precautions that need to be taken into account when setting up assembly procedures. The precautions for LUXEON Altilon Intense are noted in this section.

2.1 Electrostatic Discharge (ESD) Protection

Electrostatic discharge, rapid transfer of charges between two bodies due to an electrical potential difference between those bodies, can cause damage to electronic components. In LED devices, ESD events can result in a slow degradation of light output and/or early catastrophic failures. In order to prevent ESD from causing any damage, Lumileds devices include a protection diode that is in parallel to the chip. This transient voltage suppressor (TVS) diode provides a current path for transient voltages (see Figure 3).

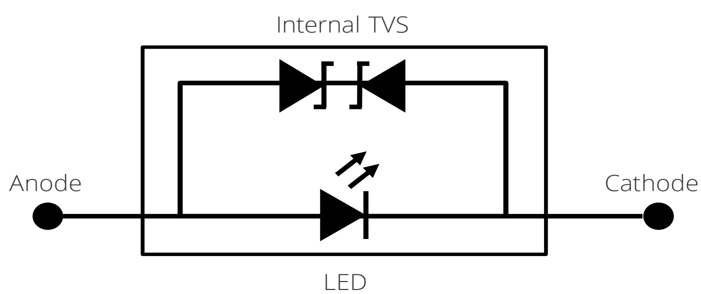


Figure 3. Electrical schematic of a Lumileds LED with bidirectional TVS for LUXEON Altilon Intense.

Common causes of ESD include the direct transfer of charges from the human body or from a charged conductive object to the LED component. In order to test the susceptibility of LEDs to these common causes of ESDs, three different models are typically used:

- Human Body Model (HBM)
- Machine Model (MM)
- Charged Device Model (CDM)

LUXEON Altilon Intense have been independently verified to successfully pass ESD tests under HBM, MM and CDM conditions. For the respective test voltages of these tests please refer to the latest LUXEON Altilon Intense datasheets. Nevertheless, Lumileds strongly recommends that customers adopt handling precautions for LEDs similar to those which are commonly used for other electronic surface mount components which are susceptible to ESD events. Additional external ESD protection for the LED may be needed if the LED is used in non-ESD-protected environments and/or exposed to higher ESD voltages and discharge energies, such as described in ISO 10605 or IEC 61000-4-2 (severity level IV). For details please contact your sales representative.

2.2 Component Handling

Minimize all mechanical forces exerted onto the LED package. The white package consists of fragile silicone material and should not be handled with tweezers, which can lead to damage of the package, especially not with metallic tweezers. Any force above 2.0 N may damage the silicone side coat and change optical performance. A vacuum pen can be used instead of tweezers (see Figure 4).

The suction tip should be made of a soft material such as rubber to minimize the mechanical force exerted onto the top surface of the LED and apply no forces to the silicone side coat layer. Avoid contaminating the top side surface of the LED with the soft material. Do not stick any tape on top of the light emitting surface, such as capton- or UV-tape. A contamination of glue or its invisible constituent parts may change the LED performance.

Electrical testing before assembly should be avoided. Probe tips may scratch or dent the pad surface, which may lead to solder issues and damage the LED. Avoid contact with the LED other than what is required for placement.

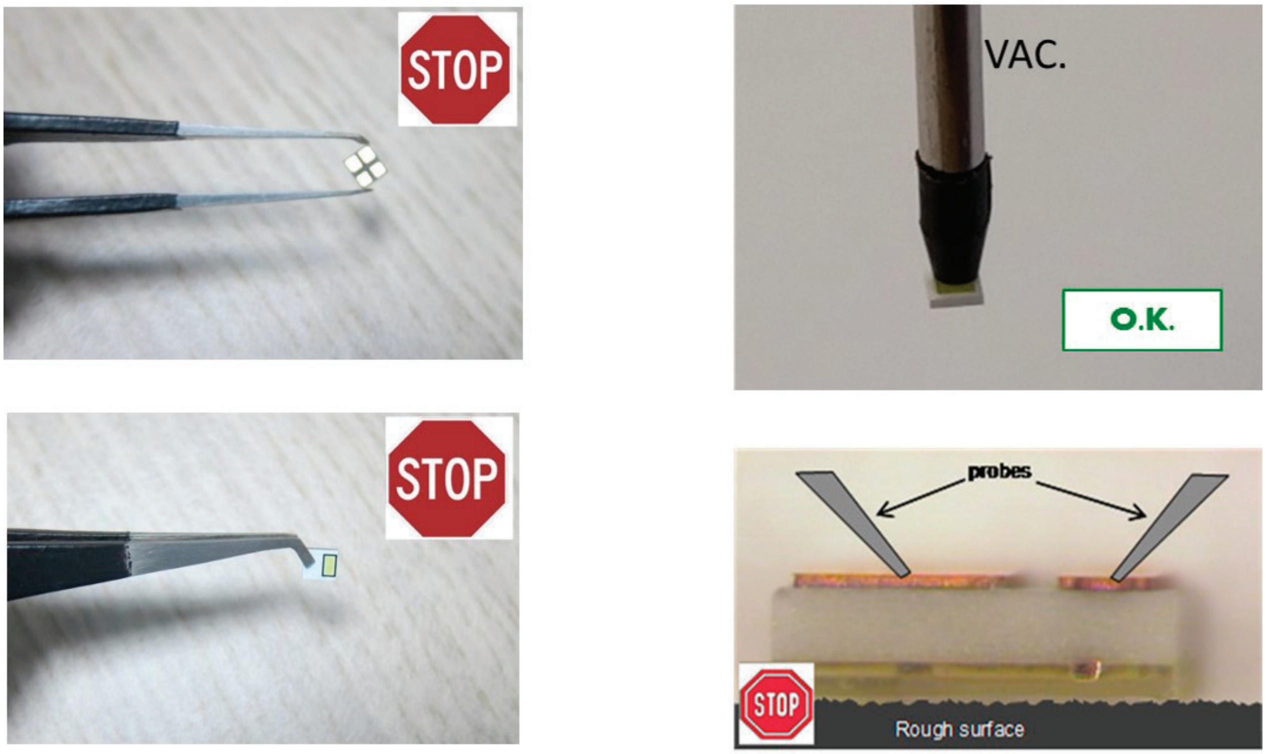


Figure 4. LED handling for LUXEON Altilon Intense.

Do not touch the top surface with fingers or apply any pressure to it when handling finished boards containing LUXEON Altilon Intense emitters. Do not stack finished boards because the LED can be damaged by the other board outlines. In addition, do not put finished boards with LUXEON Altilon Intense emitters top side down on any surface. The surface of a workstation may be rough or contaminated and may damage the LED. These warnings are shown in Figure 5.

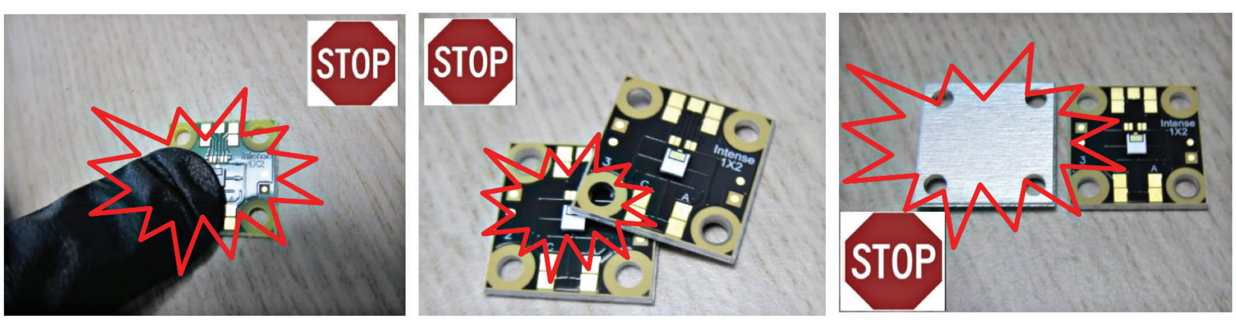


Figure 5. Board handling for LUXEON Altilon Intense.

In order to avoid any electrical shocks and/or damage to the LEDs, each design needs to comply with the appropriate standards of safety and isolation distances, known as clearance and creepage distances, respectively (e.g. IEC60950, clause 2.10.4).

2.3 Cleaning

The surface of the LED should not be exposed to dust and debris. Excessive dust and debris on the LED surface may cause a decrease in light output and optical behavior. It is best to keep LEDs in their original shipping reel until actual use.

In the event that the surface requires cleaning, a compressed gas duster or an air gun with 1.4 bar (at the nozzle tip), a distance of 15 cm will be sufficient to remove the dust and debris. Make sure the parts are secured first, taking above handling precautions into account.

One can also rinse with isopropyl alcohol (IPA). Do not use solvents that are listed in Table 16, as they may adversely react with the LED assembly. Extra care should be taken not to damage the housing around the LED chips. Lumileds does not recommend ultrasonic supported cleaning for Lumileds LEDs.

3. Printed Circuit Board

3.1 PCB Requirements

LUXEON Altilon Intense can be mounted on multi-layer FR4 Printed Circuit Boards (PCB) or Insulated Metal Substrates (IMS). To ensure optimal operation of the LED, the thermal path between the LED package and the heatsink should be optimized according to the application requirements. Please ensure that the PCB assembly complies to the applicable IPC standards listed below.

General PCB Standards:

- IPC A-600J: Acceptability of Printed Boards
- IPC A-610G: Acceptability of Electronic Assemblies
- IPC 2221B: General Standard on Printed Board Design
- IPC 7093: Design and Assembly Process Implementation for Bottom Termination Components

Filled and capped via boards:

- IPC 4761: Design Guide for Protection of Printed Board Via Structures
- IPC 2315: Design Guide for High Density Interconnects and Micro Vias
- IPC 2226A: Design Standard for High Density Interconnect Printed Boards

3.2 Land Pattern

Lumileds recommends using solder mask defined land pattern for LUXEON Altilon Intense, as shown in Figure 6. Due to this, the copper area can be extended as far as possible for better heat spreading, which results in lower thermal resistance. However, a solder mask defined pad requires good mask quality and tight registration tolerances during PCB manufacturing (see section 3.6 “PCB Quality and Supplier” for more details).

For the solder mask defined land pattern, the self-alignment of the component during reflow soldering can be controlled well by solder mask geometry in X- and Y-direction.

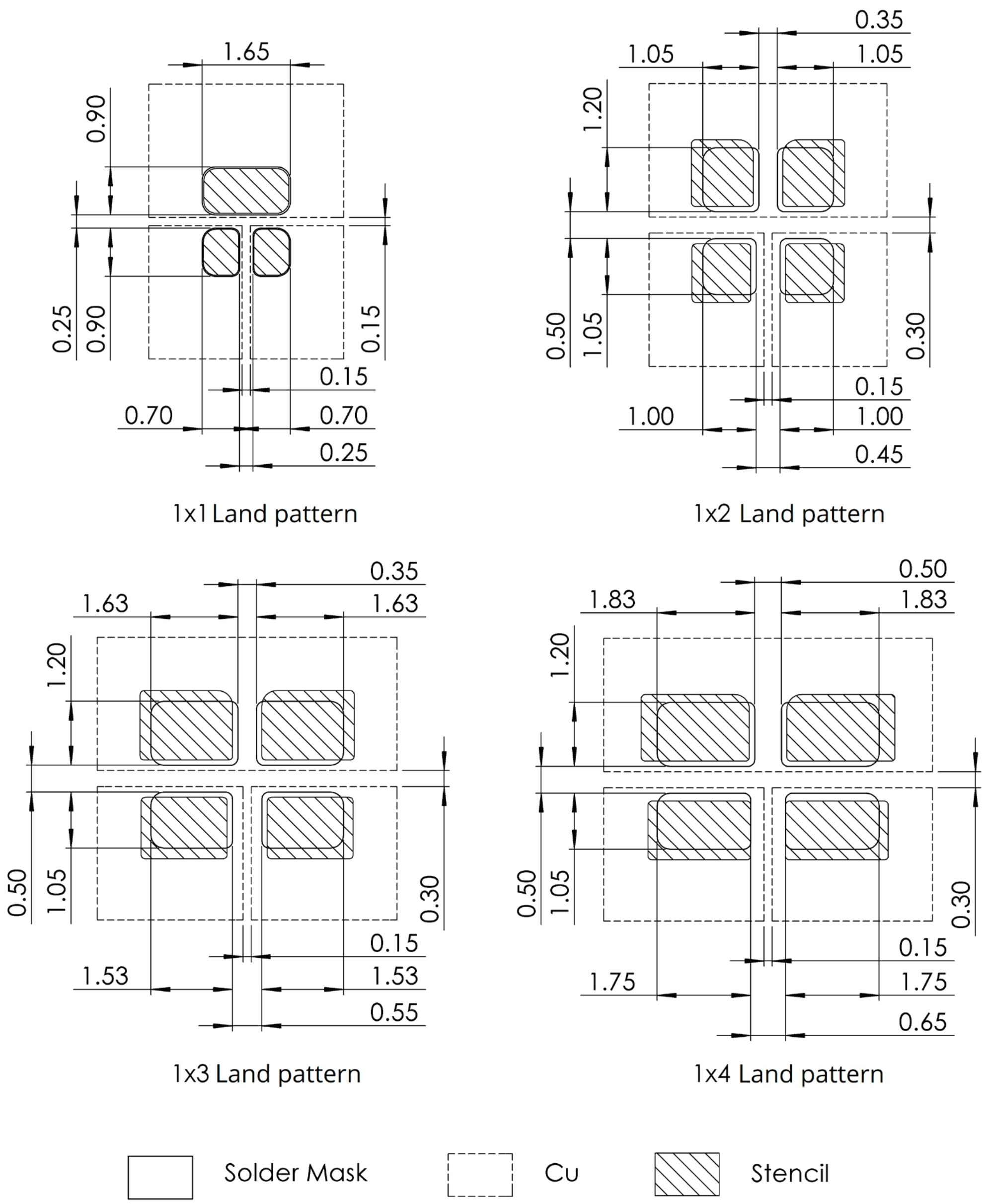


Figure 6. Solder-mask defined land pattern for LUXEON Altilon Intense.

The metal-defined land pattern leaves less area for heat spreading of the thermal power generated by the LED. Also, higher tolerances for LED tilting and position tolerances can be encountered. The positive aspect is that the requirements to the printed circuit board tolerance requirements for solder mask alignment to metal structure are lower than for solder mask defined land pattern.

3.3 Surface Finishing

Lumileds recommends using ENIG (Electroless Nickel Immersion Gold) plating according to IPC-4552. Other surface finishes are possible but have not been tested by Lumileds. Surface finish Hot-Air-Solder-Leveling (HASL) may lead to inhomogenious pad height and is not recommended. Unsymmetrical solder thickness may have an influence on LED height and soldering tolerances. The actual quality of HASL finish shall be checked in each single case.

3.4 Solder Mask

A flat solder mask thickness on top of metal layer is desired. Solder mask thickness variation and offset tolerances have impact on solder quality and post-solder position accuracy. Mask and PCB vendors have to be evaluated for proper quality. Detailed specifications and information regarding solder mask requirements are contained in IPC-6012 and IPC-SM-840 (see section 3.6 "PCB Quality and Supplier" for more details).

3.5 Silk Screen or Ink Printing

Silk screen markings within and around the LED outline should be avoided because the height of the ink may interfere with the LED and solder stencil printing process.

3.6 PCB Quality and Supplier

Select only PCB suppliers that are capable of delivering the required level of quality. Leastwise, the PCBs must comply with IPC standard IPC-A-600J, 2016 (***"Acceptability of Printed Boards"***).

A maximum mask registration tolerance of 50 μm between the copper trace pattern and solder mask is desirable to achieve optimum solder joint contact area. If the offset between the solder mask and the copper land pattern is large, one side of electrode pads will have less solder joint contact area. This may affect package centering, tilting, and thermal performance and may increase risk of solder bridging (short circuit) and solder balling if the stencil is not properly aligned to the solder mask during printing.

Figure 7 shows an example of the solder pad size for three different registration offset levels between the copper trace pattern and the solder mask on the PCB. Large misalignment between solder mask opening and copper trace will cause one of the two electrode copper land patterns to be smaller than the other. Depending on the PCB manufacturer capability, PCB cost consideration and customer position tolerance needs, it may be necessary to extend the area of the solder mask opening.

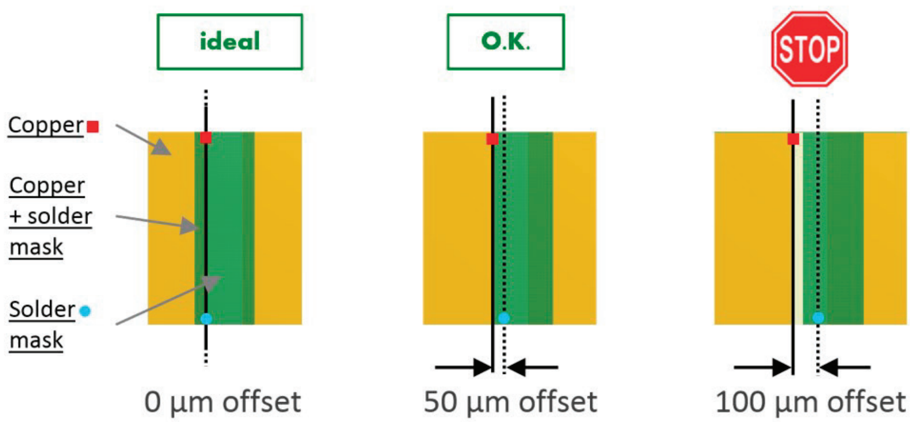


Figure 7. Solder mask registration offset to copper trace for LUXEON Altilon Intense.

4. Thermal Management

4.1 Thermal Resistance

The thermal resistance between the junction of the LED and the bottom side of the PCB depends on the following key design parameters of a PCB:

- PCB dielectic materials
- Cu plating thickness
- Connection of the thermal pad to the board
  - e.g. pedestal to brige the removed dielectric layer of IMS boards
- Solder pad pattern and solder thickness

Lumileds conducted simulations to evaluate the thermal performance of LUXEON Altilon Intense on different PCB design concepts. Details of the simulation model are given in Figure 8. The model geometry comprises the LUXEON Altilon Intense on a board (metal-core printed circuit board, FR4 board with AlN inlay, or FR4 board with filled and capped vias) that is mounted on a plate Al heatsink. A thermal interface material (TIM) is assumed to be present between board and heat sink. In the simulations, a constant temperature boundary condition ($T = T_0$ = 25°C) is imposed at the bottom of the heat sink. More details on the simulation and the parameters of the materials used are below and in Table 2. The thermal resistances junction-to-board bottom $R_{th,j\text{-}b,el}$ (thermal resistance based on electrical input power) are calculated as $R_{th,j\text{-}b,el} = R_{th,j\text{-}b,real}$*(1–WPE), where WPE denotes the wall plug efficiency. The WPE is not constant and depends on drive condition and flux binning class. The thermal resistance $R_{th,j\text{-}b,real}$ is based on thermal power and is obtained by $R_{th,j\text{-}b,real} = (T_j\text{-}T_b)/P_{th}$, where T_j is the average junction temperature, T_b the maximum temperature at the bottom side of the board obtained from the simulations, and P_{th} the thermal input power.

Table 2 Simulation Details

Simulation Model	
LUXEON Altilon Intense on board and plate heatsink with TIM Simulation of heat conduction and radiation Bottom of heat sink is assumed to be ideally heat-sunk to ambient	
Heat sink and TIM Parameters	
Heat sink size	50 mm x 50 mm x 5 mm
Al heat sink thermal conductivity	200 W/(mK)
TIM thickness	100 µm
TIM thermal conductivity	2 W/(mK)
Board Parameters	
Board area	20 mm x 20 mm
Board thickness	1.0 mm (Cu-IMS) or 1.5 mm (Al-IMS, FR4)
Cu metal core thermal conductivity	390 W/(mK)
Al metal core thermal conductivity	200 W/(mK)
Cu layer thickness	70 µm
layer thermal conductivity	390 W/(mK)
IMS dielectric thickness	75 µm or 38 µm
IMS dielectric thermal conductivity	2.2 W/(mK) or 3 W/(mK)
FR4 epoxy thermal conductivity	0.35 W/(mK)
AlN inlay thermal conductivity	170 W/(mK)
Vias plating thermal conductivity	390 W/(mK)
Vias filling thermal conductivity	0.35 W/(mK)
Solder mask thermal conductivity	0.2 W/(mK)
Solder Parameters	
Thickness (BLT)	100 µm, 150 µm or 220 µm
Thermal conductivity	56 W/(mK)

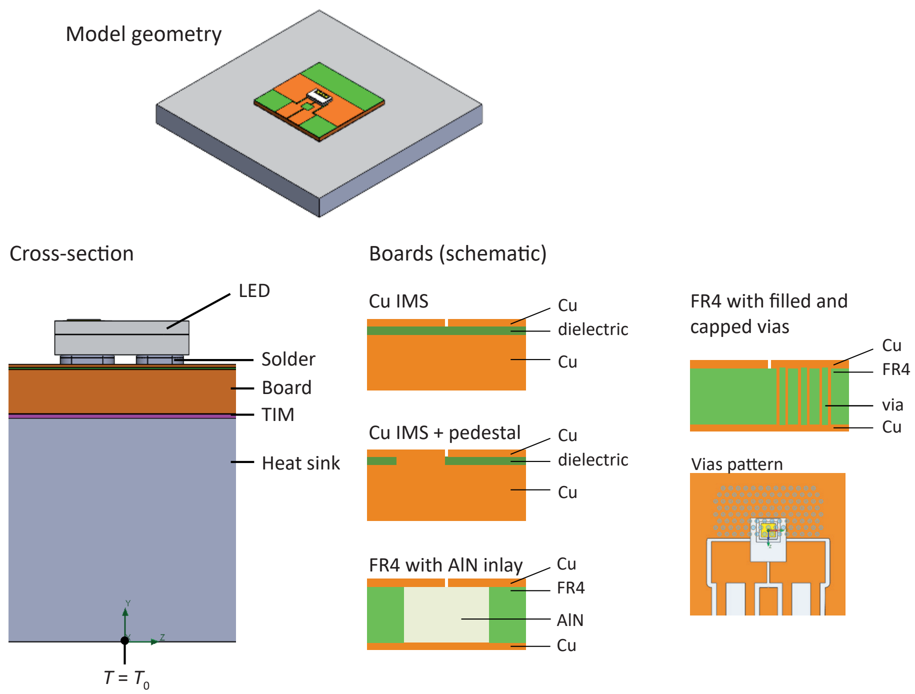


Figure 8. Model geometry and board parameters used for simulations for LUXEON Altilon Intense LEDs.

Table 3 lists the simulated thermal resistances $R_{th,j\text{-}b,real}$ and the thermal resistances $R_{th,j\text{-}b,el}$ for LUXEON Altilon Intense 1x2 to 1x4 on different board types. To calculate $R_{th,j\text{-}b,el}$, a wall-plug efficiency of 0.22 has been used. Lumileds´ recommendation to optimize the thermal performance of the system is to use metal-core boards with pedestals for the thermal pads or boards with AlN-inlays. The simulated thermal resistances $R_{th,j\text{-}b,real}$ and the thermal resistances $R_{th,j\text{-}b,el}$ for LUXEON Altilon Intense 1x1 on different board types are given in Table 4.

Table 3. Simulated LED-junction-to-board-bottom thermal resistances $R_{th,j\text{-}b,real}$ (based on thermal power) and $R_{th,j\text{-}b,el}$ (based on electrical power) for different board types. The thermal resistances $R_{th,j\text{-}b,el}$ have been calculated assuming a WPE of 0.22 for LUXEON Altilon Intense 1x2, 1x3 and 1x4.

BOARD MATERIAL/DIELECTRIC/ BOND LINE THICKNESS (BLT)	1x2		1x3		1x4	
	$R_{th,j\text{-}b,real}$ (K/W)	$R_{th,j\text{-}b,el}$ (K/W)	$R_{th,j\text{-}b,real}$ (K/W)	$R_{th,j\text{-}b,el}$ (K/W)	$R_{th,j\text{-}b,real}$ (K/W)	$R_{th,j\text{-}b,el}$ (K/W)
1.0 mm Cu-IMS pedestal, 150 µm BLT	7.6	5.9	5.0	3.9	4.0	3.1
1.0 mm Cu-IMS, 38 µm dielectric with 3 W/(mK), 150 µm BLT	8.7	6.8	5.8	4.6	4.7	3.7
1.0 mm Cu-IMS, 75 µm dielectric with 2.2 W/(mK), 150 µm BLT	9.9	7.7	6.8	5.3	5.6	4.4
1.5 mm FR4 with AlN inlay, 100 µm BLT	7.5	5.9	5.0	3.9	4.0	3.1

Table 4. Simulated LED-junction-to-board-bottom thermal resistances $R_{th,j\text{-}b,real}$ (based on thermal power) and $R_{th,j\text{-}b,el}$ (based on electrical power) for different board types. The thermal resistances $R_{th,j\text{-}b,el}$ have been calculated assuming a WPE of 0.22 for LUXEON Altilon Intense 1x1.

BOARD MATERIAL/DIELECTRIC/ BOND LINE THICKNESS (BLT)	1x1	
	$R_{th,j\text{-}b,real}$ (K/W)	$R_{th,j\text{-}b,el}$ (K/W)
1.0 mm Cu-IMS, 38 µm dielectric with 3 W/(mK), 70 µm BLT	14.3	11.1
1.0 mm Cu-IMS, 75 µm dielectric with 2.2 W/(mK), 70 µm BLT	15.7	12.2
1.5 mm FR4 with filled and capped vias, 70 µm BLT	17.9	14.0

4.2 Thermal Measurement Instructions

The use of a temperature probe may be desirable to verify the overall system design model and expected thermal performance. Different methods exist to determine the LED temperature in terms of case temperature T_c, junction temperature T_j or phosphor temperature T_{ph}.

Table 5 lists three methods, along with the expected measurement accuracy. The more accurate a measurement is, the closer T_c and T_j can be designed to their maximum allowable values as specified in the LUXEON Altilon Intense datasheets.

Table 5. Temperature measurement methods for LUXEON Altilon Intense.

METHOD	ACCURACY [°C]	EFFORT	EQUIPMENT COST
Thermo sensor (e.g. thin wire thermocouple)	±2.0 to ±5.0 [1]	Low	Low
Forward voltage measurement	±0.5	High	High
Infrared thermal imaging	±2.0 to ±10.0 [2]	Medium	High

Notes for Table 5:
1. See section "Temperature Probing by Thermo Sensor" for parameters determining the measurement accuracy.
2. See section "Temperature Measurement by IR thermal imaging" for parameters determining the measurement accuracy.

Figure 9 schematically shows the LED soldered to a PCB, including the relevant temperatures as defined for specific positions in the setup. Since the LED is directly soldered to the board, the case temperature is equal to the temperature of the solder material T_{solder}. A practical way to verify the case temperature T_c is to measure the temperature T_{sensor} on a predefined sensor pad thermally close to the case by means of a thermocouple or a thermistor as shown in Figure 9.

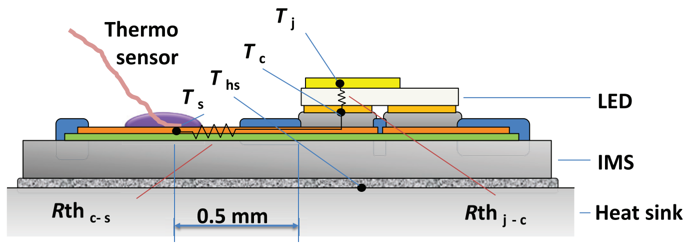


Figure 9. Temperature probing by thermo sensor for LUXEON Altilon Intense.

The case temperature can be calculated according the following equations:

$$T_c = T_{sensor} + R_{th,c\text{-}sensor,el} \cdot P_{el}$$

$$T_c = T_{sensor} + R_{th,c\text{-}sensor,real} \cdot P_{th}$$

In these equations, T_{sensor} is the sensor temperature at the predefined location, P_{el} the electrical power of LUXEON Altilon Intense, $P_{th} = P_{el} \cdot (1 - \text{WPE})$ the thermal power of LUXEON Altilon Intense, $R_{th,c\text{-}sensor,el}$ the thermal resistance between case and sensor point based on the electrical power, and $R_{th,c\text{-}sensor,real}$ the thermal resistance between case and sensor point based on the thermal power. The thermal resistances $R_{th,c\text{-}sensor,real}$ and $R_{th,c\text{-}sensor,el}$ are application specific and can be determined with help of thermal simulations and measurements. Lumileds has determined values for typical $R_{th,c\text{-}sensor,real}$ and $R_{th,c\text{-}sensor,el}$ for LUXEON Altilon Intense on different board types (see Table 6a and 6b). Please refer to section 4.1 for more detailed information regarding the board design parameters. The sensor has been mounted at a distance of 0.5 mm to the edge of the package as indicated in Figure 9. The accuracy of the measurement depends on the board type, the measurement accuracy of the thermocouple, and the mounting position. The temperature signal at the thermo sensor measurement point is higher for boards with large heat spreading in the top Cu layer (typically boards with low-conductive dielectric). LED boards with different configuration, design, or material from the ones given in Table 6a and 6b may require additional thermal modeling or measurements to determine the right case-to-sensor thermal resistances.

Table 6a. Typical $R_{th,c\text{-}sensor,real}$ and $R_{th,c\text{-}sensor,el}$ values of different board concepts. The thermal resistance $R_{th,c\text{-}sensor,el}$ has been calculated from $R_{th,c\text{-}sensor,real}$ assuming a WPE of 0.22 for LUXEON Altilon Intense 1x2, 1x3 and 1x4.

BOARD TYPE	1x2		1x3		1x4	
	$R_{th,c\text{-}sensor,real}$ (K/W)	$R_{th,c\text{-}sensor,el}$ (K/W)	$R_{th,c\text{-}sensor,real}$ (K/W)	$R_{th,c\text{-}sensor,el}$ (K/W)	$R_{th,c\text{-}sensor,real}$ (K/W)	$R_{th,c\text{-}sensor,el}$ (K/W)
1.0 mm Cu-IMS pedestal	1.8	1.4	1.3	1.1	0.8	0.6
1.0 mm Cu-IMS, 38 μm dielectric with 3 W/(mK)	2.6	2.0	2.0	1.6	1.5	1.2
1.5 mm FR4 with AlN inlay	1.5	1.2	1.1	0.9	0.7	0.6

Table 6b. Typical $R_{th,c\text{-}sensor,real}$ and $R_{th,c\text{-}sensor,el}$ values of different board concepts. The thermal resistance $R_{th,c\text{-}sensor,el}$ has been calculated from $R_{th,c\text{-}sensor,real}$ assuming a WPE of 0.22 for LUXEON Altilon Intense 1x1.

BOARD TYPE	1x1	
	$R_{th,c\text{-}sensor,real}$ (K/W)	$R_{th,c\text{-}sensor,el}$ (K/W)
1.0 mm Cu-IMS, 38 μm dielectric with 3 W/(mK)	4.3	3.4
1.5 mm FR4 with filled and capped vias	7.5	5.8

Temperature Probing by Forward Voltage Measurement

The forward voltage measurement uses the temperature dependence of the LED's forward voltage. The forward voltage, after switching off the thermally stabilized system, is measured and analyzed, yielding information on the LED junction temperature. By using a thermal model of LUXEON Altilon Intense or the LED junction-to-case thermal resistance as indicated in the datasheets, the case temperature T_c can be estimated.

To ensure high accuracy, a precise and fast voltage measurement system is needed. In addition, the relationship between forward voltage and temperature needs to be properly characterized for each individual LED. Please contact your sales representatives for further support on this topic.

Temperature Probing by Infrared Thermal Imaging

Infrared (IR) thermal imaging can be used to measure the surface temperature/phosphor temperature of the LED or the board temperature. Lumileds does not recommend using IR measurements to estimate the LED junction or case temperature.

For an accurate determination of the absolute temperature via IR thermography, the determination of the exact emissivity value is crucial. The emissivity generally depends on material, surface properties, and temperature. It can be determined by heating up the unbiased device to a defined temperature that can be, for example, measured with a thermocouple. Then, an IR measurement can be taken of this setup, and the emissivity setting of the material of interest (typcially the phosphor or the board surface) can be adjusted to match the thermocouple reading. The obtained emissivity value can be used to evaluate the IR image of the device in operation to determine the temperature of interest. The temperature at which the emissivity value is determined should be similar to the temperature in operation that is to be measured. During IR imaging, make sure that the recorded image is not disturbed by unwanted background reflections. Due to the small dimensions of the LUXEON Altilon Intense, an imaging system with high magnification should be used in order to get a sufficient resolution of the LED in the IR image.

Note that due to losses in the phosphor converter layer, the phosphor temperature of the LUXEON Altilon Intense is typically higher than the LED junction temperature and that the absolute temperature difference depends on the drive current.

5. Assembly Process Guidelines

5.1 Solder Paste

For reflow soldering, a standard lead-free solder paste (SnAgCu) with no clean flux can be used. The majority of the Lumileds internal testing has been conducted with the Indium 8.9HF SAC305 solder paste, which showed reasonable reflow and voiding performance for the given settings. An Innolot based solder paste can improve thermal cycling reliability performance under certain conditions. We recommend Heraeus F640IL Innolot in combination with Cu-IMS boards. Vacuum soldering equipment can be used to achieve a lower void level. Solder paste with powder type 3 is recommended for required stencil thickness and aperture size.

5.2 Stencil Design

For solder-mask defined land pattern, the appropriate stencil aperture is given in Figure 10 shown below. The corner radius of stencil aperture should be selected according to paste particle size to improve paste release. For type 3 paste, a radius of 100 μm or larger is recommended.

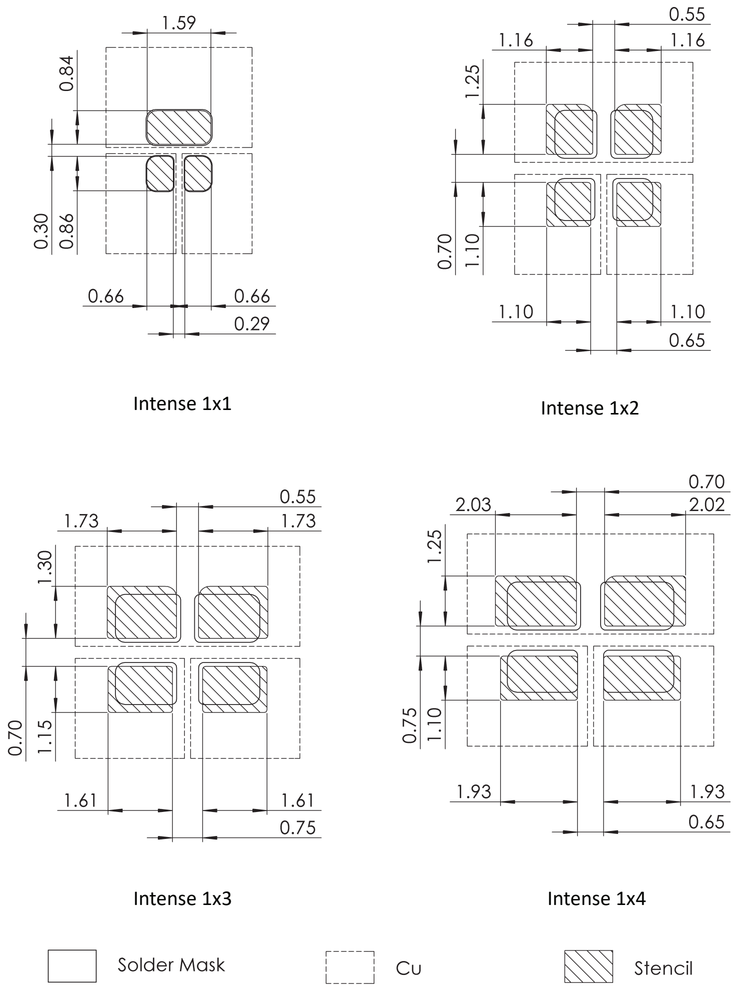


Figure 10. LUXEON Altilon Intense Stencil Design.

Table 7. Stencil design recommendation for Altilon Intense family.

LUXEON ALTILON INTENSE	THICKNESS	APERTURE	BOND LINE THICKNESS
1x1	5 mil	90%	70 µm
1x2	8 mil	115%	150 µm
1x3	8 mil	115%	150 µm
1x4	8 mil	115%	150 µm

For designs where overprint is used, the solder paste is printed on top of the solder mask. This area should be flat. A trench in the copper layer underneath or close to it should not be used. Otherwise, solder paste may be trapped during reflow, leading to solder balling.

5.3 Pick-and-Place

The LUXEON Altilon Intense is packed in a tape and reel with the light emitting surface facing upwards. Automated pick and place equipment provides the best handling and placement accuracy for LUXEON Altilon Intense emitters.

Lumileds recommends taking the following general pick and place guidelines into account:

1. The pick-up area is defined in Figure 11.
2. The nozzle tip should be clean and free of any particles since this may interact with the top surface coating of the LUXEON Altilon Intense during pick and place.

3. During setup and the first initial production run, it is good practice to inspect the top surface of LUXEON Altilon Intense emitters under a microscope to ensure that the emitters are not accidentally damaged by the pick and place nozzle.
4. To avoid any mechanical overstress, it is a good choice to use soft material for pickup. Rubber nozzles are available from various suppliers.
5. Ceramic nozzle can be used for low mass nozzles.
6. Lower Z-axis velocity at the point of board contact to avoid LED damage.

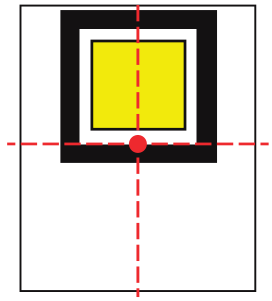


Figure 11. Pick-up position and nozzle scheme used for LUXEON Altilon Intense.

Since LUXEON Altilon Intense has no primary optics or lens which can act as a mechanical enclosure protection for the LED chip, the pick-up and placement force applied to the top of the package should be minimized and kept well controlled.

Picking the component out of the carrier tape should be performed from a defined height position and should not apply forces to the component and carrier tape, as this may damage the component. The LUXEON Altilon Intense is packed in a recess of the carrier tape, and the nozzle geometry must be selected accordingly to not get in contact with carrier tape (see Figure 12).

See datasheets for latest information on distances and tolerances.

Table 8. Distance of top clearance for pick-up from carrier tape for Altilon Intense family.

LUXEON Altilon Intense	d (mm)
1x1	0.27
1x2	0.47
1x3	0.47
1x4	0.47

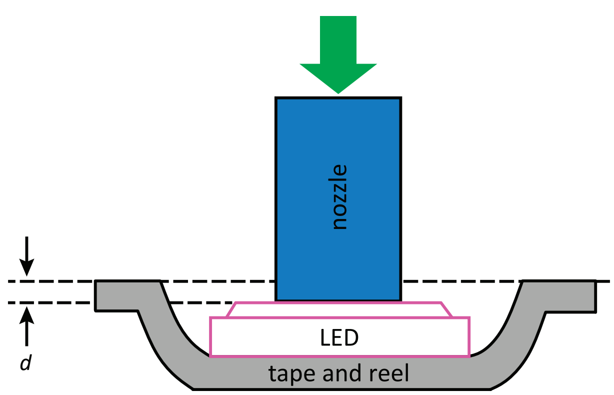


Figure 12. Dimensions of top clearance for pick-up from carrier tape for LUXEON Altilon Intense.

Standard nozzle

Table 9 shows the standard pick and place nozzle designs, which can be used to handle the LUXEON Altilon Intense Family.

Table 9. Nozzle recommendations for LUXEON Altilon Intense family.

STANDARD NOZZLE	03054923-01	3057035	3081896
Supplier	ASM Siplace	ASM Siplace	ASM Siplace
Nozzle form	Rectangular	Rectangular	Rectangular
Material: housing/tip	Vectra A230	Vectra A230	Vectra A230
Name	2033	2035	2072-001
Measurements [mm]	A=2.2x1.6 a=1.7x1.1	A=3.5x1.9, a=2.5x1.2	A=5.6x3.6, a =4.4x2.4
SUITABLE FOR			
LUXEON Altilon Intense	1x1 and 1x2	1x3	1x4

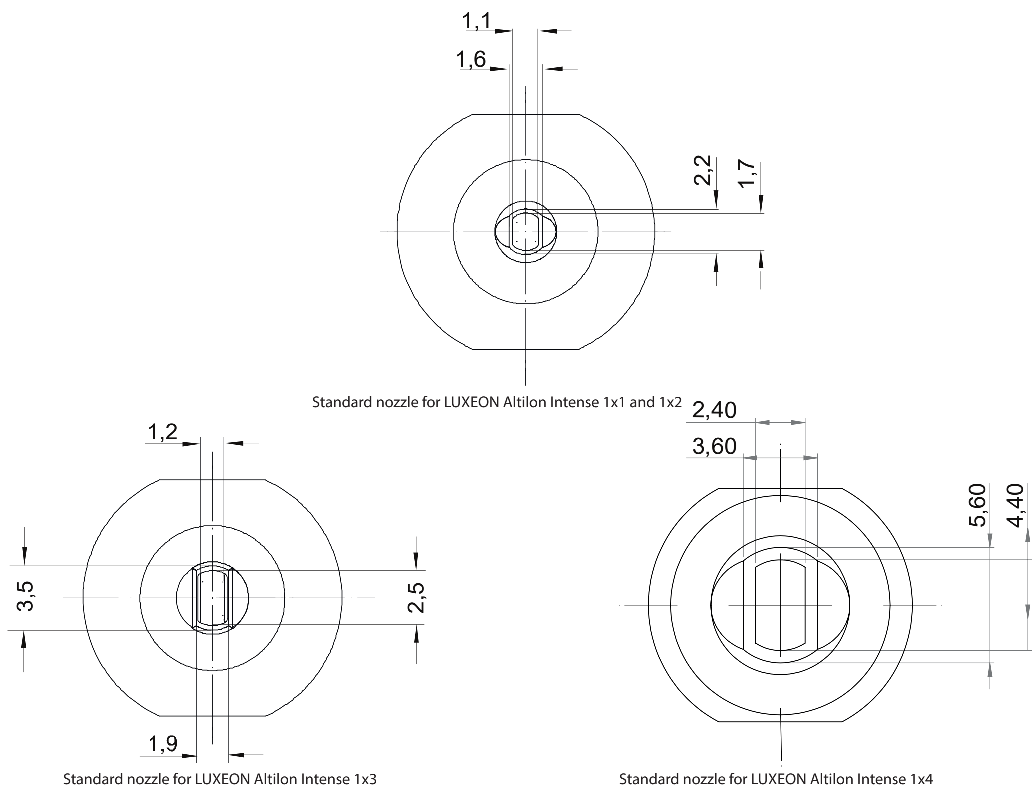


Figure 13. Standard nozzle recommenations for LUXEON Altilon Intense family.

5.4 Placement Force

In order to avoid any damage of the LED and minimize squeeze-out of solder paste, placement process needs to be tightly controlled. Lumileds recommends using low placement forces during the pick and place process. The force during pick and place should not exeed 2.0 N. An additional large dynamic peak force occurs if the LED is placed with high z-axis velocity at the point of touching the board and if the nozzle mass is high. Under worst case conditions, the phosphor LED coating can be damaged. Lower the z-axis velocity if needed.

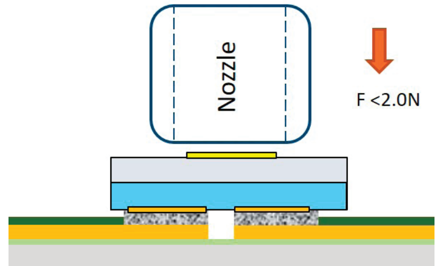


Figure 14. LED touching the board during pick and place can, in worst case, damage the LUXEON Altilon Intense LED.

5.5 Feed System

Pick and place machines are typically equipped with special pneumatic or electric feeders to advance the tape containing the LEDs. The indexing step in the pick and place process may cause some LEDs to accidentally jump out of the pocket tape or may cause some LEDs to get misaligned inside the pocket tape, resulting in pick-up errors. Depending on the feeder design, minor modifications to the feeder can substantially improve the overall pick and place performance of the machine and reduce/eliminate the likelihood of scratch or damage to the LEDs. An optimum situation will be given when the pickup position is right after cover tape peel off. Do not leave index positions uncovered between peel off and pick position. This will prevent the LEDs from tilting over or jumping out when indexing. Furthermore, the cover tape peeling angle, relative to the tape, should be small to reduce the vertical pulling force during indexing (see Figure 15).

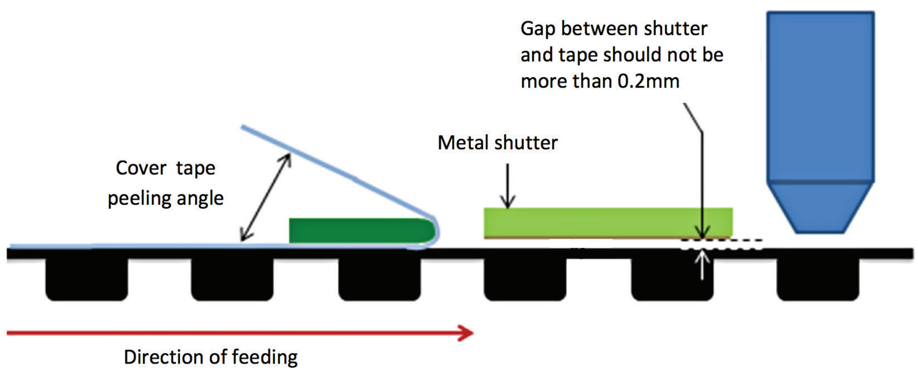


Figure 15. Pick position and cover tape peeling for LUXEON Altilon Intense.

5.6 Reflow Profile

The LUXEON Altilon Intense is compatible with standard surface-mount and lead-free reflow technologies. This greatly simplifies the manufacturing process by eliminating the need for adhesives and epoxies. The reflow step itself is the most critical step in the reflow soldering process and occurs when the boards move through the oven and the solder paste melts, forming the solder joints. To form good solder joints, the time and temperature profile throughout the reflow process must be well maintained.

A temperature profile consists of three primary phases:

1. **Preheat:** the board enters the reflow oven and is warmed up to a temperature lower than the melting point of the solder alloy.
2. **Reflow:** the board is heated to a peak temperature above the melting point of the solder, but below the temperature that would damage the components or the board.

3. **Cool down:** the board is cooled down rapidly, allowing the solder to freeze, before the board exits the oven. As a point of reference, the melting temperature for SAC 305 is 217 °C, and the minimum peak reflow temperature is 235 °C. Lumileds successfully utilized the reflow profile in Figure 16 and Table 10 for LUXEON Altilon Intense on FR4 and MCPCB.

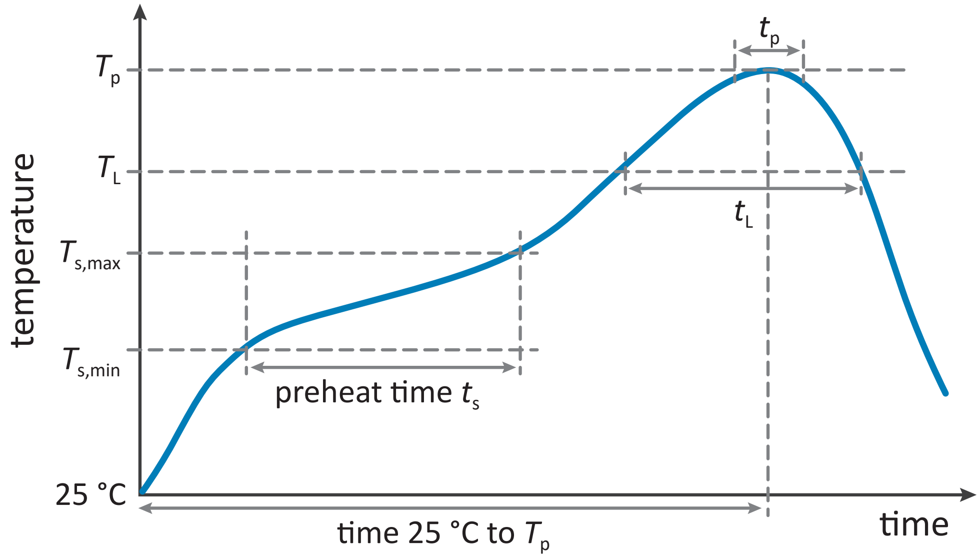


Figure 16. Reflow profile definition according to JEDEC J-STD-020E.

Table 10. Temperature measurement methods.

PROFILE FEATURE	TYPICAL VALUE	IPC/JEDEC J-STD-020D
Preheat Minimum Temperature (T_{smin})	150 °C	150 °C
Preheat Maximum Temperature (T_{smax})	200 °C	200 °C
Preheat Time (T_{smin} to T_{smax})	100 s	60 to 120 s
Ramp-Up Rate (T_{smax} to T_p)	2 °C/s average	3 °/s
Liquidus Temperature (T_L)	217 °C	217 °C
Time Maintained Above Temperature T_L (t_L)	60 s	60 to 150 s
Peak / Classification Temperature (T_p)	240 °C	260 °C
Time Within 5°C of Actual Peak Temperature (t_p)	20 s	30 s
Maximum Ramp-Down Rate (T_p to T_L)	2.5 °C/second average	6 °C/s
Time 25°C to Peak Temperature	310 s	480 s

Note: All temperatures refer to the application Printed Circuit Board (PCB), measured on the surface adjacent to the package body.

Things to watch for after reflow should include:

1. Solder voids—perform X-ray inspection
2. Solder bridge between anode and cathode
3. Solder balling
4. Any visible damage, tilt or misplacement of LED
5. Any contamination on light emitting area – this may impact the light output extraction or cause color shift
6. Functional test (open/short)

5.7 Reflow Accuracy

For solder-mask defined designs, Lumileds facilitated internal tests with shown position accuracy after reflow (see Figure 17 and Table 11). Results may vary based on printed circuit board quality and used assembly process. See datasheets for latest information on distances and tolerances.

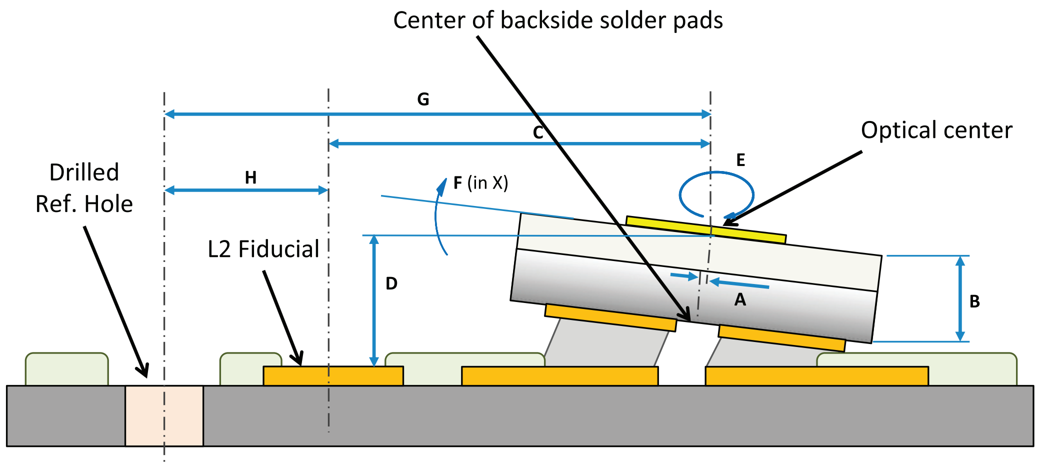


Figure 17. L1 and L2 tolerance definition for LUXEON Altilon Intense.

Table 11. Dimension and placement tolerances for LUXEON Altilon Intense.

ITEM	DESCRIPTION	MAXIMUM VALUE	NOMINAL VALUE
A	L1: Optical center to back-side metal x/y	±50 µm	—
B	L1: Total thickness z	±50 µm	—
C	L2: Optical center to L2 fiducial, x/y	±125 µm	±100 µm
D	L2: Optical center to L2 fiducial, z **	±105 µm	±75 µm
E	L2: Optical center to L2 fiducial, Theta **	±1.0°	±0.5°
F	L2: LED package tilting to board **	—	—
G	L2: Optical center to L2 reference hole **	±105 µm	±75 µm
H	L2 Fiducial to L2 reference hole **	±150 µm	±75 µm

Note: ** these values depend on EMS supplier capabilities and PCB quality level.

There are ways to improve position accuracy by applying glue locking or select only PCB suppliers that are capable of delivering the required level of quality.

5.8 Board Handling and Bending

The LED package handling precaution, as described in section 2.2, "Component Handling," must also be applied when handling completed boards. Even though this product has a small form factor and is unlikely to cause any problems, forces on the package should be kept to a minimum. Bending of a PCB is a common handling problem typically seen on large boards. A printed circuit board may warp after reflow when layers with different CTE (coefficient of thermal expansion) are applied to the top and bottom of the boards. If the PCB is subsequently secured to a flat surface, a vertical force is applied to the LED package (see Figure 18).

Any deformation by mounting the board and screwing it onto a heatsink or by de-paneling, like punching-off or breaking-off, should be kept to a minimum. As a general guideline, it should be at most 2 mm of vertical deflection for every 90 mm of FR4 PCB length. The guideline should be maintained to prevent the sapphire chip, used in the LED, from cracking and causing device failure. Reference AEC-Q200-005 for board bending test preparation.

This guideline does not apply to solder joint reliability, as the ability of the solder joint to withstand this stress (elongation) depends on the footprint layout, solder joint thickness, solder voiding and the type of solder paste used.

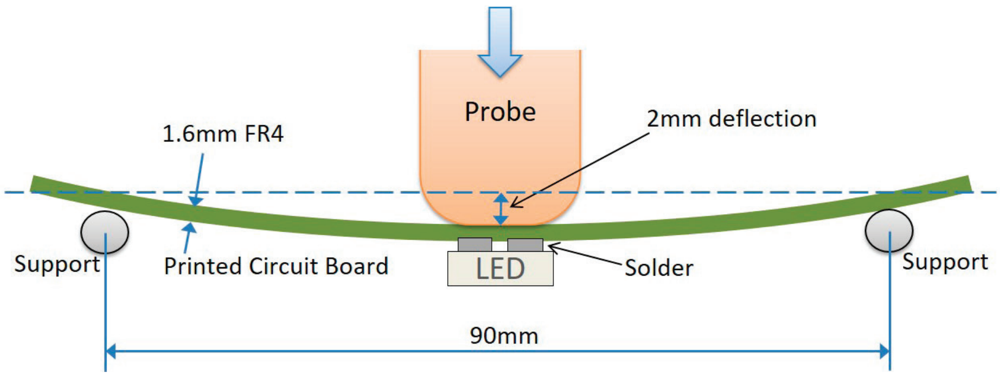


Figure 18. Maximum PCB bending guideline to prevent damage to the LUXEON Altilon Intense package.

6. Interconnect Reliability

The reliability of board interconnect under thermal cycling and thermal shock condition is mainly determined by thermal expansion of used materials. The LUXEON Altilon Intense package is made of AlN which has a low CTE (coefficient of thermal expansion) of ~4 ppm (coefficient of thermal expansion). The CTE mismatch between LED package and printed circuit board will lead to mechanical stress and cause solder fatigue or solder cracking. To achieve highest possible reliability, the CTE of the board material should be as similar to the LED package as possible. Table 12 shows commonly used materials and their CTE.

Table 12. CTE of common board substrate materials for LUXEON Altilon Intense.

MATERIAL	COEFFICIENT OF THERMAL EXPANSION (CTE)
Sapphire (LED chip)	5-6 ppm
Solder SAC305	19-22 ppm
Copper	16.5 ppm
FR4	12-17 ppm*
Aluminium	23.1 ppm
AlN	4 ppm
$Al_2 0_3$	6-8 ppm

* Depending on laminate vendor, prepreg type and fiber orientation.

Also, the mechanical properties of solder material and solder thickness have an impact on interconnect reliability. Using a ductile material and increasing the bond line thickness will increase solder joint reliability.

Table 13a and Table 13b list what Lumileds confirmed and recommends. There are many other possible options but customers should confirm suitability in their application.

Table 13a. Thermal cycling performance using different board types, solder material and process for LUXEON Altilon Intense 1x2, 1x3 and 1x4.

ITEM	BOARD MATERIAL [1]	BOND LINE THICKNESS	SOLDER MATERIAL	SOLDER PROCESS	THERMAL CYCLING PERFORMANCE [2]
1	Cu-IMS	150 µm	Innolot	Vacuum Reflow	1000 cycles
2	Cu-pedestal	150 µm	Innolot	Vacuum Reflow	1000 cycles
3	FR4+AlN Inlay	100 µm	SAC305	Vacuum Reflow	1000 cycles
4	FR4+AlN Inlay	100 µm	Innolot	Vacuum Reflow	2000 cycles

Notes for Table 13a:
1. IMS dielectric layer considered as hard dielectric material.
2. Thermal cycling performance is related to a passive test according JEDEC standard J-ESD22-A104E: Condition G -40/+125°C, 10s transition, 30min dwell.

Table 13b. Thermal cycling performance using different board types, solder material and process for LUXEON Altilon Intense 1x1.

ITEM	BOARD MATERIAL [1]	BOND LINE THICKNESS	SOLDER MATERIAL	SOLDER PROCESS	THERMAL CYCLING PERFORMANCE [2]
1	Cu-IMS	70 µm	Innolot	Vacuum Reflow	1000 cycles
2	FR4 + with filled and capped vias	70 µm	SAC305	Vacuum Reflow	1000 cycles

Notes for Table 13b:
1. IMS dielectric layer considered as hard dielectric material.
2. Thermal cycling performance is related to a passive test according JEDEC standard J-ESD22-A104E: Condition G -40/+125 °C, 10 s transition, 30 min dwell.

7. JEDEC Moisture Sensitivity Level

The LUXEON Altilon Intense has a JEDEC moisture sensitivity level of 1. This is the highest level offered in the industry and the highest level within the JEDEC J-STD-020D.1 standard. This provides the customer with ease of assembly; the customer no longer needs to be concerned about bake out times and floor life. No bake out time is required for a moisture sensitivity level of 1.

Moisture sensitivity level 1 allows the device to be reflowed three times under the specifications as described in the respective LUXEON Altilon Intense datasheets. JEDEC has defined eight levels for moisture sensitivity, as shown in Table 14.

Table 14. JEDEC moisture sensitivity levels for LUXEON Altilon Intense.

LEVEL	FLOOR LIFE		SOAK REQUIREMENTS			
			STANDARD		ACCELERATED EQUIVALENT1	
	TIME	CONDITIONS	TIME (HOURS)	CONDITIONS	TIME (HOURS)	CONDITIONS
1	Unlimited	≤30 °C/85% RH	168 Hours +5/-0	85°C/85% RH		
2	1 Year	≤30 °C/60% RH	168 Hours +5/-0	85°C/60% RH		
2a	4 Weeks	≤30 °C/60% RH	696 Hours +5/-0	30°C/60% RH	120 +1/-0	60 °C/60% RH
3	168 Hours	≤30 °C/60% RH	192 Hours +5/-0	30°C/60% RH	40 +1/-0	60 °C/60% RH
4	72 Hours	≤30 °C/60% RH	96 Hours +2/-0	30°C/60% RH	20 +5/-0	60 °C/60% RH
5	48 Hours	≤30 °C/60% RH	72 Hours +2/-0	30°C/60% RH	15 +5/-0	60 °C/60% RH
5a	24 Hours	≤30 °C/60% RH	48 Hours +2/-0	30°C/60% RH	10 +5/-0	60 °C/60% RH
6	Time on Label (TOL)	≤30 °C/60% RH	TOL	30°C/60% RH		

8. Packaging Considerations—Chemical Compatibility

The LUXEON Altilon Intense package contains a silicone overcoat to protect the LED chips and extract the maximum amount of light. As with most silicones used in LED optics, care must be taken to prevent any incompatible chemicals from directly or indirectly reacting with the silicone.

The silicone overcoat in LUXEON Altilon Intense is gas permeable. Consequently, oxygen and volatile organic compound (VOC) gas molecules can diffuse into the silicone overcoat. VOCs may originate from adhesives, solder fluxes, conformal coating materials, potting materials and even some of the inks that are used to print the PCBs. Some VOCs and chemicals react with silicone and produce discoloration and surface damage. Other VOCs do not chemically react with the silicone material directly but diffuse into the silicone and oxidize during the presence of heat or light. Regardless of the physical mechanism, both cases may affect the total LED light output. Since silicone permeability increases with temperature, more VOCs may diffuse into and/or evaporate out from the silicone.

Careful consideration must be given to whether LUXEON Altilon Intense emitters are enclosed in an "air tight" environment or not. In an "air tight" environment, some VOCs that were introduced during assembly may permeate and remain in the silicone overcoat. Under heat and "blue" light, the VOCs inside the silicone overcoat may partially oxidize and create a silicone discoloration, particularly on the surface of the LED where the flux energy is the highest. In an air rich or "open" air environment, VOCs have a chance to leave the area (driven by the normal air flow). Transferring the devices, which were discolored in the enclosed environment back to "open" air, may allow the oxidized VOCs to diffuse out of the silicone overcoat and may restore the original optical properties of the LED.

Determining suitable threshold limits for the presence of VOCs is very difficult since these limits depend on the type of enclosure used to house the LEDs and the operating temperatures. Also, some VOCs can photo-degrade over time. Table 12 provides a list of commonly used chemicals that should be avoided as they may react with the silicone material. Note that Lumileds does not warrant that this list is exhaustive since it is impossible to determine all chemicals that may affect LED performance.

The chemicals in Table 16 are typically not directly used in the final products that are built around LUXEON Altilon Intense LEDs. However, some of these chemicals may be used in intermediate manufacturing steps (e.g. cleaning agents). Consequently, trace amounts of these chemicals may remain on sub-components, such as heatsinks. Lumileds, therefore, recommends the following precautions when designing your application:

1. When designing secondary lenses to be used over an LED, provide a sufficiently large air-pocket and allow for "ventilation" of this air away from the immediate vicinity of the LED.
2. Use mechanical means of attaching lenses and circuit boards as much as possible. When using adhesives, potting compounds and coatings, carefully analyze its material composition and do thorough testing of the entire fixture under High Temperature Over Life (HTOL) conditions.

Table 16. List of commonly used chemicals that may damage the silicone encapsulant of LUXEON Altilon Intense.

CHEMICAL NAME	TYPICAL USE
Hydrochloric Acid	Acid
Sulfuric Acid	Acid
Nitric Acid	Acid
Acetic Acid	Acid
Sodium Hydroxide	Alkali
Potassium Hydroxide	Alkali
Ammonia	Alkali
MEK (Methyl Ethyl Ketone)	Solvent
MIBK (Methyl Isobutyl Ketone)	Solvent
Toluene	Solvent
Xylene	Solvent
Benzene	Solvent
Gasoline	Solvent
Mineral spirits	Solvent
Dichloromethane	Solvent
Tetrachloromethane	Solvent
Castor Oil	Oil
Lard	Oil
Linseed Oil	Oil
Petroleum	Oil
Silicone Oil	Oil
Halogenated Hydrocarbons (containing F, Cl, Br elements)	Misc.
Rosin Flux	Solder Flux
Acrylic Tape	Adhesive

About Lumileds

Companies developing automotive, mobile, IoT and illumination lighting applications need a partner who can collaborate with them to push the boundaries of light. With over 100 years of inventions and industry firsts, Lumileds is a global lighting solutions company that helps customers around the world deliver differentiated solutions to gain and maintain a competitive edge. As the inventor of Xenon technology, a pioneer in halogen lighting and the leader in high performance LEDs, Lumileds builds innovation, quality and reliability into its technology, products and every customer engagement. Together with its customers, Lumileds is making the world better, safer, more beautiful—with light.

To learn more about our lighting solutions, visit lumileds.com.

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