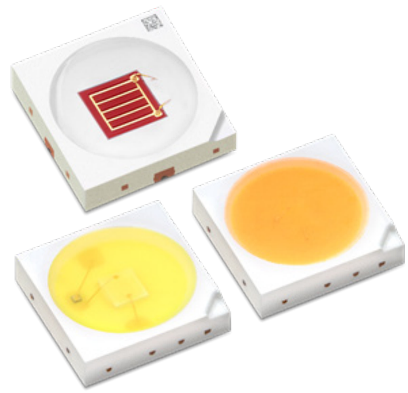
AUTOMOTIVE

LUXEON Versat 3030

Assembly and Handling Information



Introduction

This application brief addresses the recommended assembly and handling procedures for Versat 3030. The LUXEON Versat 3030 is designed to deliver high luminous flux and efficacy in automotive exterior lighting applications. As a matter of principle, LEDs 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 the LUXEON Versat 3030 in automotive applications.

Scope

The assembly and handling guidelines in this application brief apply to the products in all available colors:

- LUXEON Versat 3030 HP
- LUXEON Versat 3030 ST

Any assembly or handling requirements that are specific to a subset of LUXEON Versat 3030 products are clearly marked. In the remainder of this document, the term Versat refers to any product in the Versat 3030 product family.

The acronym "HP" and "ST" are exemplary for its whole subset.

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1. Component

1.1 Reference Documents

The LUXEON Versat datasheets are available upon request. Please contact your sales representative.

1.2 Description

The Versat LED consists of a single chip, covered by silicone material. For CW (Cool White) and PCA (Phosphor Converted Amber) products, the silicone is combined with a phosphor material to convert emitted light. The products delivering red light are directly emitting LEDs. The metal lead frame forms the electrical pads on its bottom side and the chip is placed on the top of the lead frame. The Versat 3030 HP lead frame solder indicators are embossed to the four edges of the package. These solder indicators are not part of the Versat 3030 ST lead frame design. See in Figure 1 the package of the Versat HP, that is made of silicone mold compound (SMC). For Versat ST in Figure 2, the housing is made of epoxy mold compound (EMC). The Versat LED for CW and PCA includes a separate transient voltage suppressor (TVS) chip on the carrier substrate, that is covered by the current material in the cup. The TVS shall protect the emitter against electrostatic discharges (ESD). For all red orange LEDs, this protection is given by the intrinsic semiconductor. See Figure 1 for the Versat HP and Figure 2 for the Versat ST for top and bottom view.

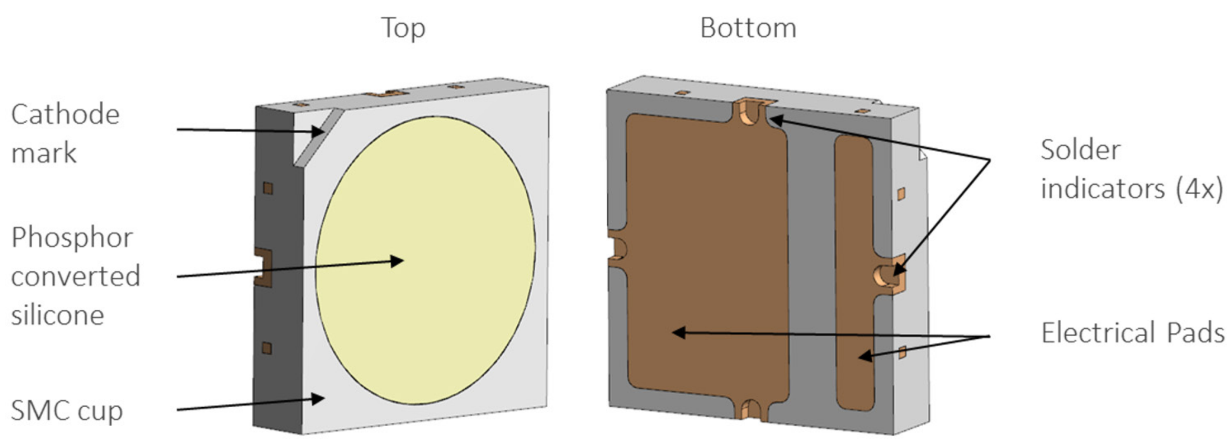


Figure 1. Top view (left) and bottom view (right) of the LUXEON Versat 3030 HP CW

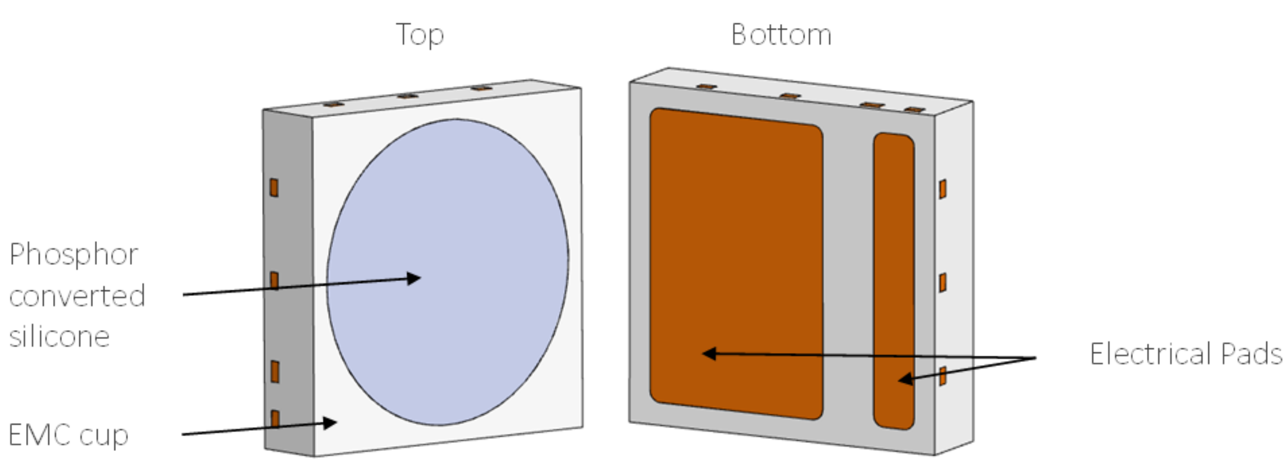


Figure 2. Top view (left) and bottom view (right) of the LUXEON Versat 3030 ST RO

Table 1. Design features by LUXEON Versat part number

PRODUCT		PART NUMBER	NOMINAL DRIVE CURRENT (mA)	PACKAGE TYPE	ESD PROTECTION
	LUXEON Versat 3030 HP 700 RO*	A1VA-O612C10	700	SMC	Intrinsic semiconductor
	LUXEON Versat 3030 HP 150 CW	A1VA-5850A010	150	SMC	Internal TVS-diode
	LUXEON Versat 3030 HP 150 PCA	A1VA-P591A010	150	SMC	Internal TVS-diode
	LUXEON Versat 3030 HP 350 CW	A1VA-5850C010	350	SMC	Internal TVS-diode
	LUXEON Versat 3030 HP 350 PCA	A1VA-P591C010	350	SMC	Internal TVS-diode
	LUXEON Versat 3030 HP 200 RO*	A1VA-O612A10	200	SMC	Intrinsic semiconductor
	LUXEON Versat 3030 ST 350 RO*	A1VC-0612D10	350	EMC	Intrinsic semiconductor

* See datasheet for other Red product colors (RO=Red Orange).

1.3 Form Factor

See Figure 3 and Figure 4 for the differences in LED package, between Versat HP and Versat ST. Refer to the latest datasheet for detailed dimensions and applicable tolerances.

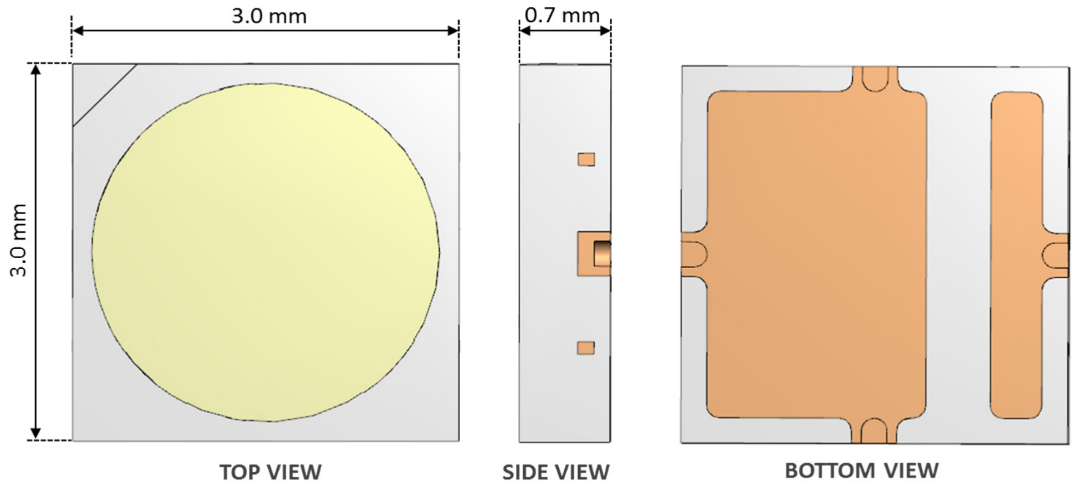


Figure 3. Outline dimensions for Versat 3030 HP

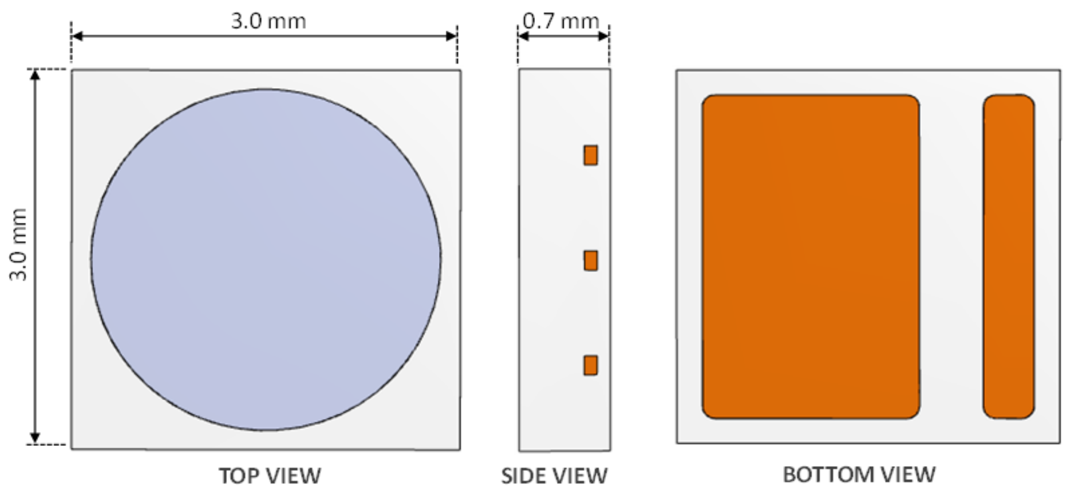


Figure 4. Outline dimensions for Versat ST

1.4 Optical Center

The Versat family has no lens (primary optics). The optical center is at the center of the circle shaped cup, as indicated by the red dot in Figure 5. See datasheet for latest information on distances and tolerances. Optical rayset data is available upon request.

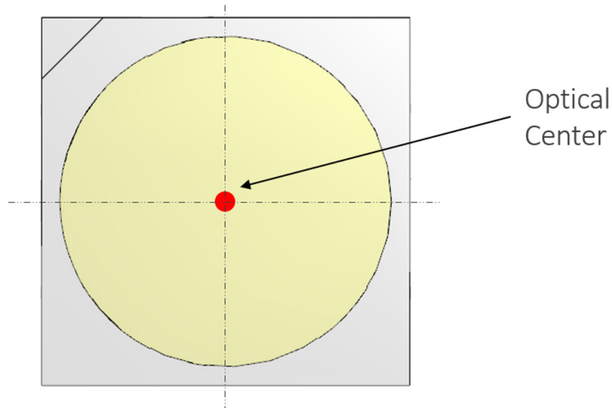


Figure 5. Optical center for LUXEON Versat 3030

1.5 Mechanical Files

Mechanical drawings for Versat 3030 are available upon request. For details, please contact your sales representative.

2. Handling Precautions

2.1 Electrostatic Discharge (ESD) Protection

As shown in Table 1, the Versat is ESD protected. LEDs with an intrinsic chip have an electrical conductivity that has a positive electrical effect to protect the LEDs against ESD. LEDs without intrinsic chips must be protected by an additional TVS device. This transient voltage suppressor (TVS) diode provides a current path for transient voltages (see Figure 6).

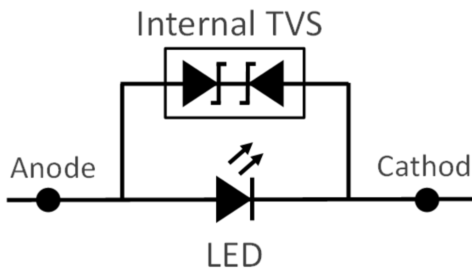


Figure 6. Electrical schematic of a LED with internal TVS

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 Modell (CDM)

The Versat has 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 LED datasheets. Additional external ESD protection for the LED may be needed if the LED is used in non ESD-protected environments or exposed to higher ESD voltages and discharge energies, e.g. 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. It should not be handled with tweezers that can lead to damage of the package, especially not with metallic tweezers. Any force above 2.0 N may damage the LED and change optical performance. A vacuum pen can be used instead of tweezers (see Figure 7).

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. Avoid contaminating the top side surface of the LED. Do not stick any tape on top of the light emitting surface, such as Kapton™- or UV-tape. A contamination with 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 any contact with the LED other than what is required for placement.

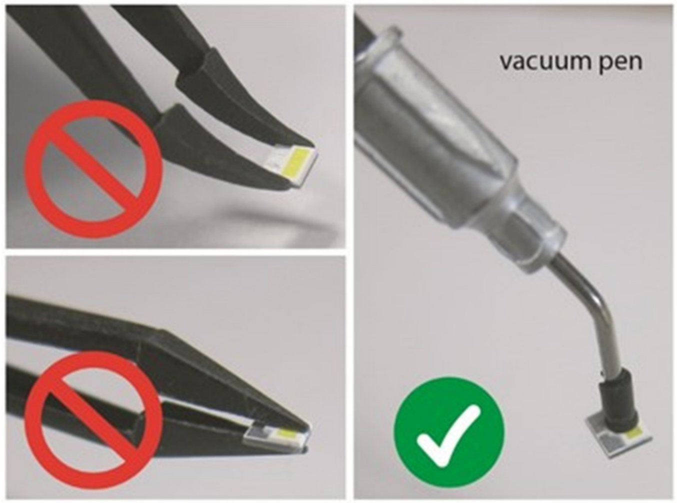


Figure 7. LED handling

Do not touch the top surface with fingers or apply any pressure to it when handling finished boards containing LEDs. Do not stack finished boards because the LEDs can be damaged by the other board outlines. In addition, do not put finished boards with LEDs top side down on any surface. The surface of a workstation may be rough or contaminated and may damage the LEDs. These warnings are shown in Figure 8.

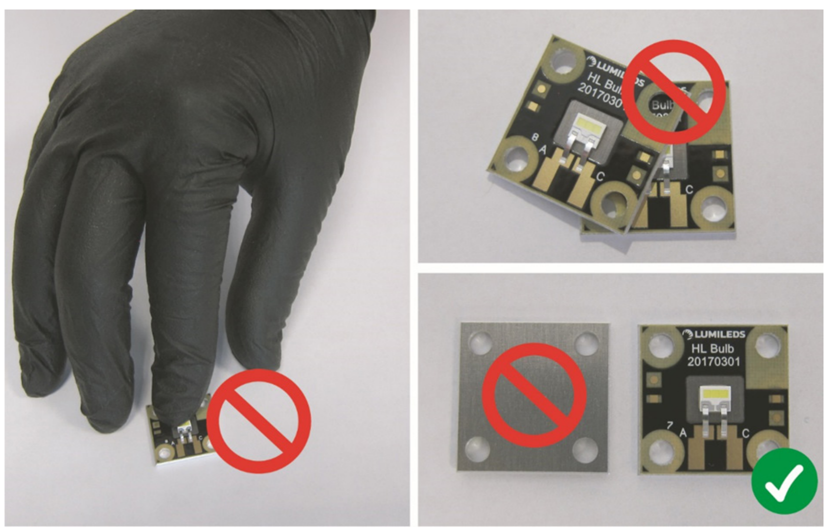


Figure 8. Board handling

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 LED 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 1.4bar (at the nozzle tip) and a distance of 15cm will be sufficient to remove the dust and debris. Make sure that the parts are secured first, taking above handling precautions into account.

One can also rinse with isopropyl alcohol (IPA). Do not use solvents listed in Table 8, 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 LEDs.

3. Printed Circuit Board

3.1 PCB Requirements

The LED 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 heat sink 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 Footprint and Land Pattern

Lumileds recommends using solder mask defined land pattern for Versat HP, as shown in Figure 9 and for Versat ST in Figure 10. 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 Chapter "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.

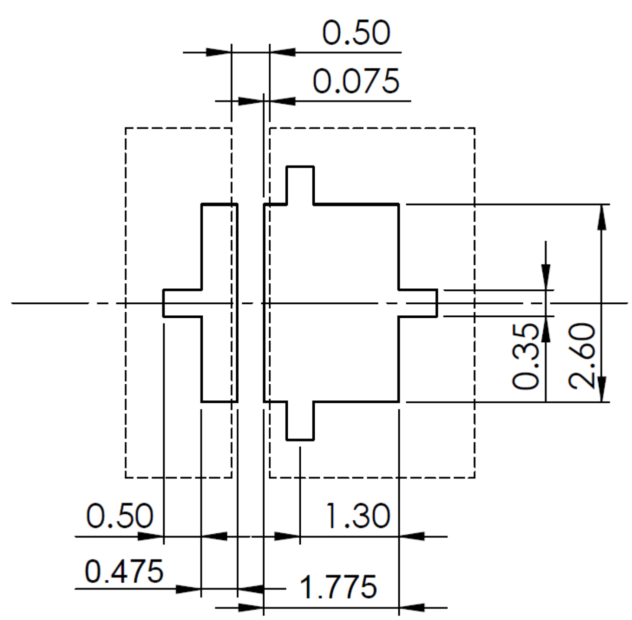


Figure 9. Solder mask defined land pattern for Versat 3030 HP

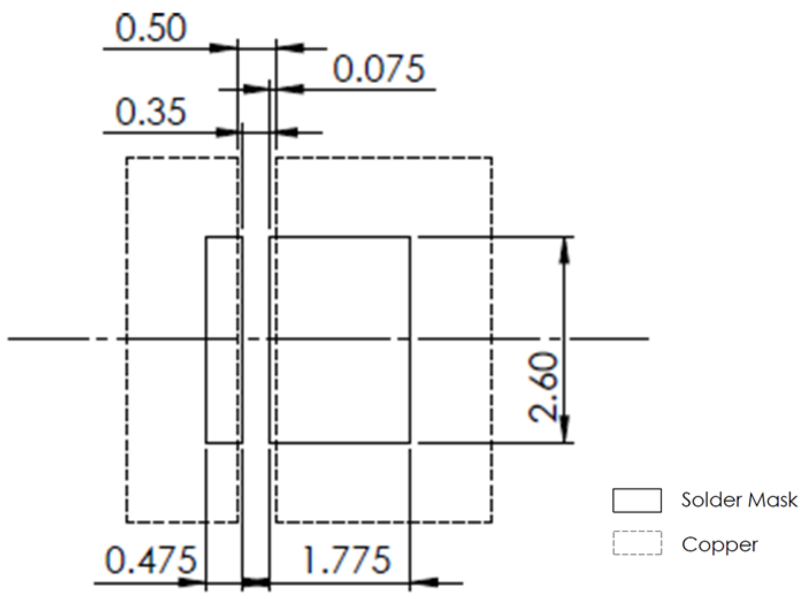


Figure 10. Solder mask defined land pattern for Versat 3030 ST

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 finishing by 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 the 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 Chapter "PCB Quality and Supplier", Figure 11 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 solder stencil printing process.

3.6 PCB Quality and Supplier

Select only PCB suppliers that are capable of delivering the required level of quality. 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 the solder mask is desirable to achieve the optimum solder joint contact area using the recommended solder mask defined footprint, as shown in Figure 9. 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 the risk of solder bridging (short circuit) and solder balling if the stencil is not properly aligned to the solder mask during printing.

Figure 11 shows an example of the solder pad size for the nominal position and maximum offset level between the copper trace pattern and the solder mask for this LED, using the recommended footprint in Figure 9. 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.

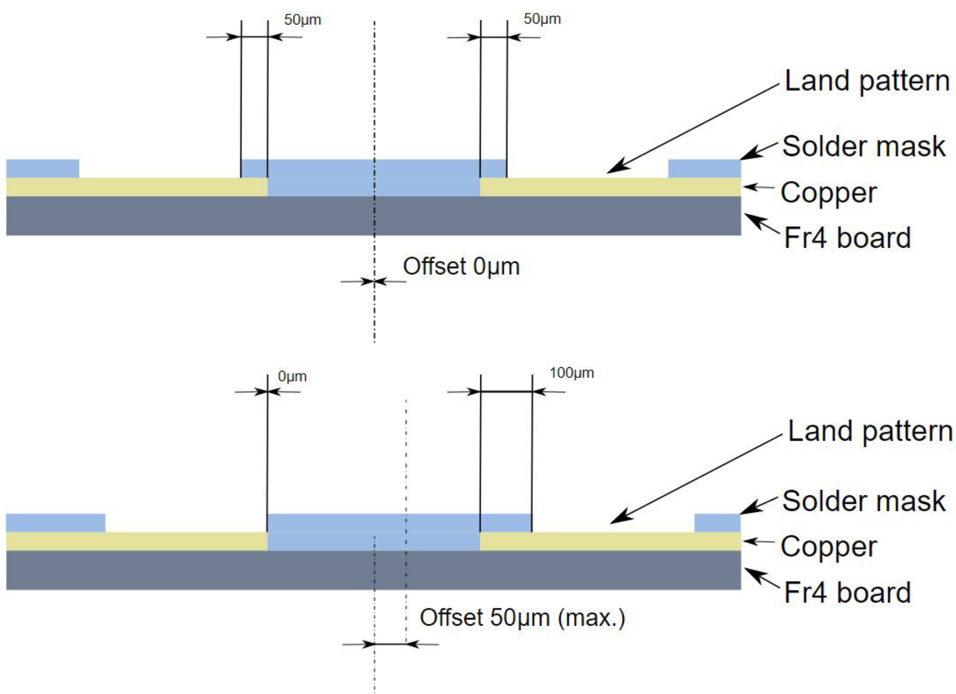


Figure 11. Solder mask registration offset to copper trace

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
- Solder pad pattern and solder thickness

Lumileds conducted simulations to evaluate the thermal performance of the Versat 3030 HP on different PCB design concepts. Details of the simulation model are given in Figure 12. The model geometry comprises the LED on a board (metal-core printed circuit board or FR4 board) that is mounted on a plate Al heatsink. A thermal interface material (TIM) is assumed to be present between board and heatsink. 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.

Simulation Details

Simulation Model

- LED on board and plate heatsink with TIM
- Simulation of heat conduction and radiation
- Bottom of heatsink is assumed to be ideally heat-sunk to ambient

Heatsink and TIM Parameters

- Heatsink size: 50 mm x 50 mm x 10 mm
- Heatsink material: Al – 200 W/(mK)
- TIM thickness: 200 µm
- TIM th. cond.: 2 W/(mK)

Board Parameters

- Board area: 20 mm x 20 mm
- Board thickness: 1.5 mm
- Al metal core th. cond.: 200 W/(mK)
- Cu layer thickness: 35 µm
- Cu layer th. cond.: 380 W/(mK)
- IMS diel. thickness: 75 µm or 38 µm
- IMS dielectric th. cond.: 2.2 W/(mK) or 3 W/(mK)
- FR4 epoxy th. cond.: 0.35 W/(mK) or 0.50 W/(mK)
- Vias plating th. cond.: 380 W/(mK)

Board Thermal Conductivities

- Cu: 380 W/(mK)
- IMS dielectric: 2.2 W/(mK) or 3 W/(mK)
- FR4 epoxy: 0.35 W/(mK)
- Vias plating (Cu): 380 W/(mK)

Solder Parameters

- Thickness (BLT): 55 µm
- Th. conductivity: 56 W/(mK)

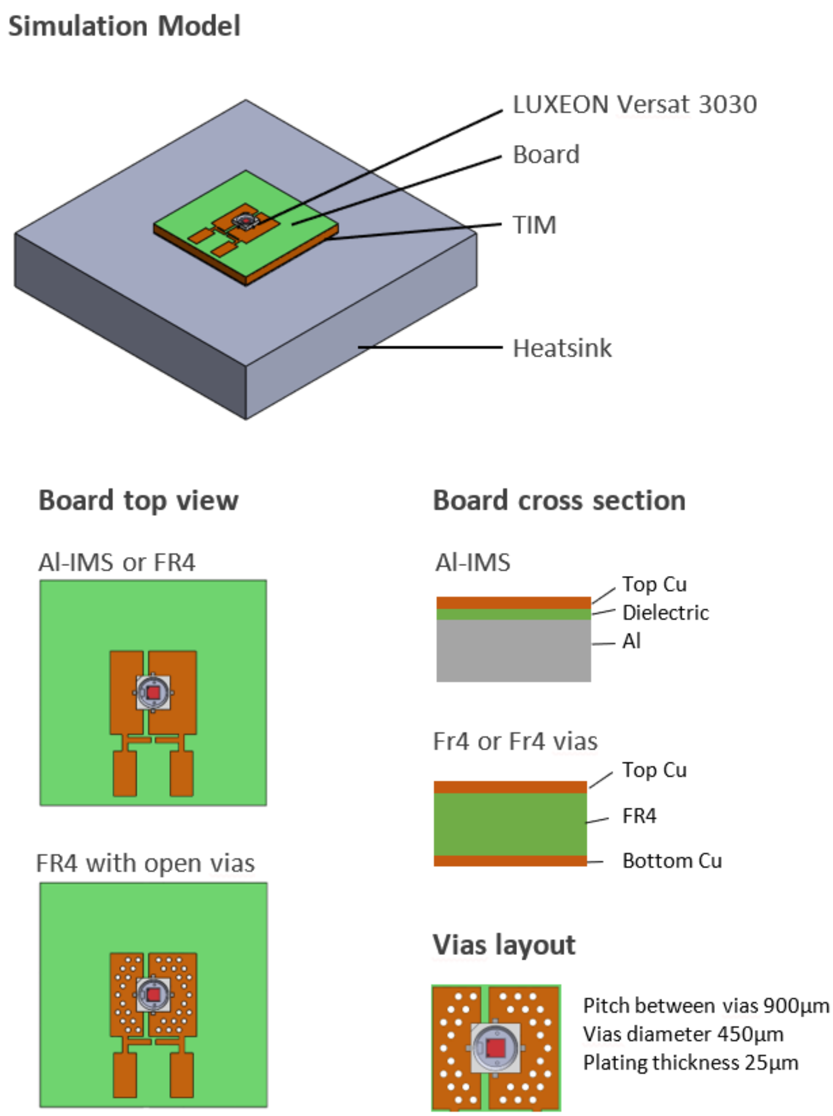


Figure 12. Model geometry and board parameters used for the simulation

Table 2 lists the simulated thermal resistances $R_{th,j\text{-}b,real}$ and the thermal resistances $R_{th,j\text{-}b,el}$ for the LUXEON Versat 3030 HP CW, LUXEON Versat 3030 HP PCA, and LUXEON Versat 3030 HP RO. To calculate $R_{th,j\text{-}b,el}$ a wall-plug efficiency of 0.41, 0.27, and 0.28 has been used for LUXEON Versat 3030 HP CW, LUXEON Versat 3030 HP PCA, and LUXEON Versat 3030 HP RO, respectively.

Table 2. 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 0.41 for the cool white products, a WPE of 0.27 for the PCA products and a WPE of 0.28 for the red product.

BOARD MATERIAL/DIELECTRIC	LUXEON Versat 3030 150 CW		LUXEON Versat 3030 150 PCA		LUXEON Versat 3030 350 CW		LUXEON Versat 3030 350 PCA		LUXEON Versat 3030 350 PCA	
	$R_{th,j\text{-}b,real}$ (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)	$R_{th,j\text{-}b,real}$ (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)
1.5mm Al-IMS, dielectric 3 W/(mK) – 38µm	28	19	28	20	19	12	19	14	9	6
1.5mm Al-IMS, dielectric 2.2 W/(mK) – 75µm	31	18	31	22	22	13	29	16	11	8
1.5mm FR4 with open vias, 0.35 W/(mK) epoxy	52	31	52	38	36	22	36	27	26	19
1.5mm FR4 with 0.50 W/(mK) epoxy material	95	56	95	69	83	49	83	60	72	52
1.5mm FR4 with 0.35 W/(mK) epoxy material	118	70	118	86	103	61	103	75	93	66

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 or junction temperature T_j.

Table 3 lists two 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 datasheet.

Table 3. Temperature measurement methods for LUXEON Versat

METHOD	ACCURACY [°C]	EFFORT	EQUIPMENT COST
Thermo sensor (e.g. thin wire thermocouple)	±5.0 [1]	Low	Low
Forward voltage measurement	±0.5	High	High

Notes for Table 3:
1. See section "Temperature Probing by Thermo Sensor" for parameters determining the measurement accuracy.

Temperature Probing by Thermo Sensor

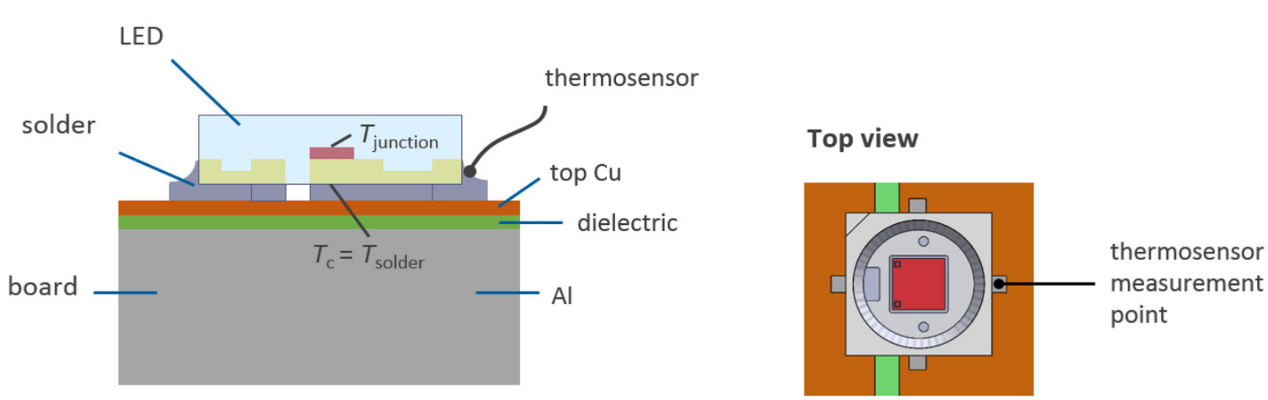


Figure 13. Temperature probing by thermo sensor.

Figure 13 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}) at a measurement point close to the case of the LED. Lumileds recommends to attach the sensor to the solder-joint inspection pad at the long edge of the anode as indicated in Figure 15. In this case, the case temperature can be directly measured, since it holds $T_c = T_{sensor}$.

Temperature Probing by Forward Voltage Measurement

The forward voltage measurement uses the temperature dependence of the LED's forward voltage (V_f). 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 Versat 3030 or the LED junction-to-case thermal resistance as indicated in the datasheet, 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 in this topic.

5. Assembly Process Recommendations and Parameters

5.1 Solder Paste

For reflow soldering, a standard lead free SAC solder paste (SnAgCu) 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. 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 patterns, the appropriate stencil aperture is given in Figure 14 for the Versat HP and in Figure 15 for the Versat ST. The corner radius of the stencil aperture should be selected according to paste particle size to improve paste release. For Versat 3030 HP, a stencil thickness of 150 µm (6 mil) with a type 3 paste is recommended. Lumileds internal testing has been conducted for Versat 3030 HP with a stencil aperture of 58% (Anode pad) and 54% (Cathode pad) of the LED footprint area. For Versat 3030 ST, a stencil thickness of 125 µm (5 mil) with a type 3 paste is recommended. Lumileds internal testing has been conducted for Versat 3030 ST with a stencil aperture of 78% (Anode pad) and 82% (Cathode pad) of the LED footprint area.

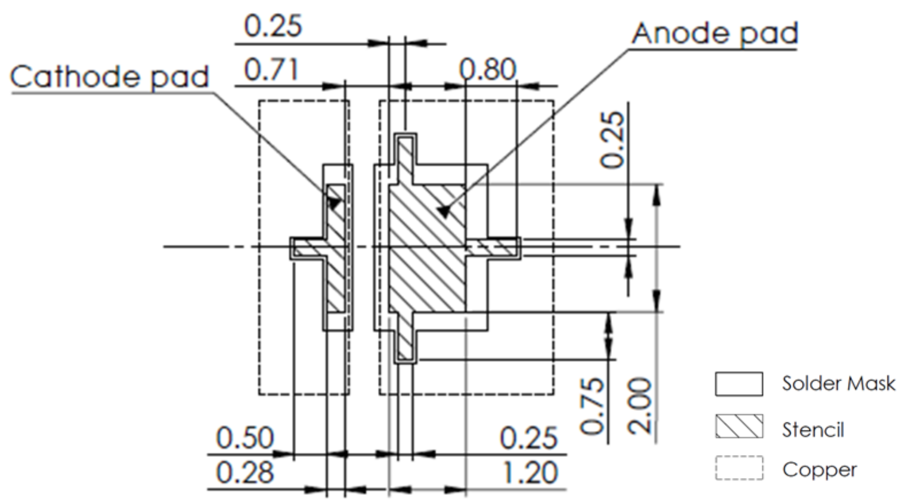


Figure 14. Versat 3030 HP stencil aperture for solder mask defined design

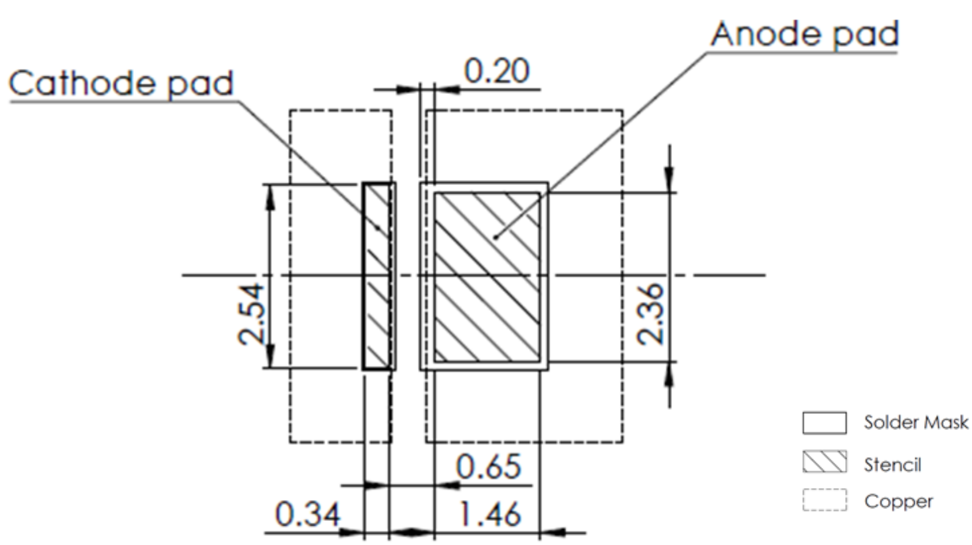


Figure 15. Versat 303 ST stencil aperture for solder mask defined design

5.3 Pick and Place Nozzle

The LED 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 the Versat LED.

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

1. The pick-up area is defined in Figure 16.
2. The nozzle tip should be clean and free of any particles since this may interact with the top surface coating of the LED during pick and place.
3. During setup and the first initial production run, it is good practice to inspect the top surface of the LED 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 as low mass nozzles.
6. Lower Z-axis velocity at the point of board contact to avoid LED damage.

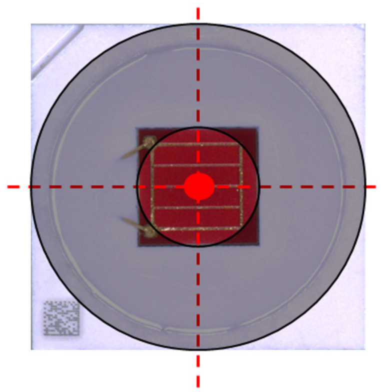


Figure 16. Pick-up position and nozzle scheme used for Versat 3030 LED

Since the LED 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 LED 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 17).

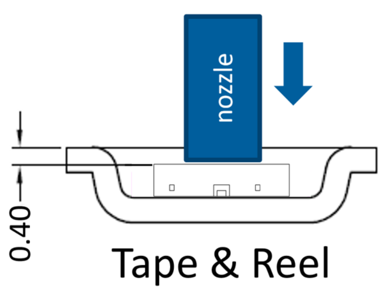
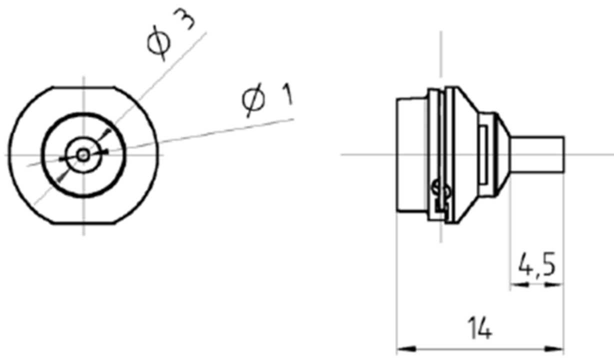


Figure 17. Pick-up from carrier tape

The Nozzle tip geometry should be round, rectangular or square with an outer diameter equal or above 3 mm and an inner diameter equal or below 2 mm.Figure 18: Nozzle recommandation for the Versat 3030. Figure 18 shows a standard pick and place nozzle design for typical SMT machine vendor, with an inner diameter of 1 mm (matching the requirement < 2 mm).



Standard nozzle (order code)	033203323-01
Supplier	ASM Siplace
Nozzle from	Round
Material: Housing / Tip	Vectra / Peek
P&P Head	2020 CPP
Name	Nozzle Special 20xx D3 di1 L14
Measurements [mm]	D=3.0mm, d=1.0, L=14

Figure 18. Nozzle recommendation for theVersat 3030

Nozzles for specific equipment platforms are under analysis. Please contact your Lumileds sales representative if you need support regarding pick and place nozzle selection.

5.4 Placement Force / Height Control

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 or a Z-height controlled placement during the pick and place process. The force during pick and place should not exceed 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, if e.g. large particles are underneath or if due to a placement offset, the side coat touches the board surface (see Figure 19). Lower the Z-axis velocity if needed.

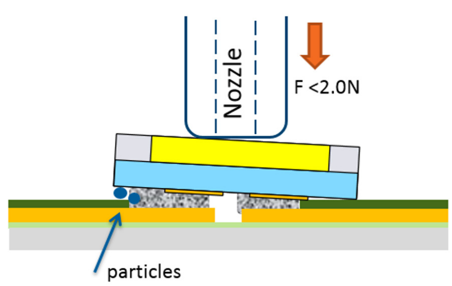


Figure 19. LED touching the board during pick and place can in worst case damage the LED

5.5 Feed System

Pick and place machines are typically equipped with special pneumatic or electric feeders to advance the tape that contains 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. The pick-up position should be right after the 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. The cover tape peeling angle, relative to the tape, should be small to reduce the vertical pulling force during indexing (see Figure 20).

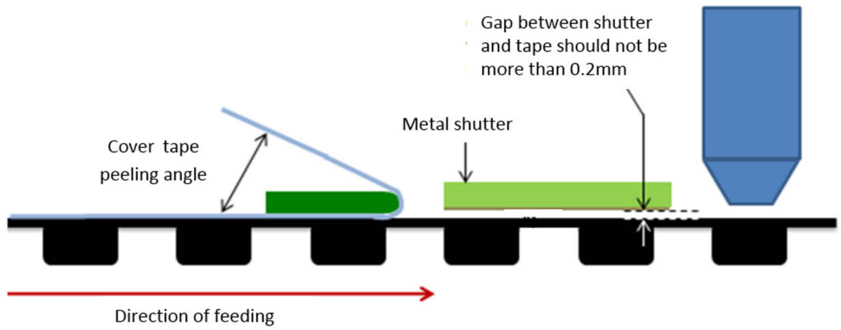


Figure 20. Pick position and cover tape peeling

5.6 Reflow Profile

The Versat LED 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 controlled.

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 this reflow profile in Figure 21 and listed in Table 4 for Versat LEDs on FR4 and MCPCB.

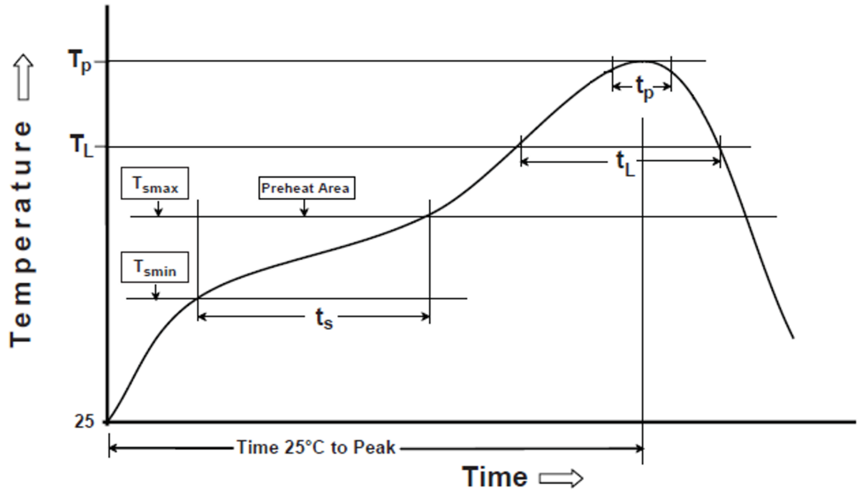


Figure 21. Reflow profile definition according to JEDEC J-STD-020E

Table 4. Temperature measurement methods

PROFILE FEATURE	TYPICAL VALUE	MAXIMUM ACC. JEDEC J-STD-020E
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 seconds	60 to 120 seconds
Ramp-Up Rate (T_{smax} to T_p)	2 °C/second average	3 °C/second
Liquidus Temperature (T_L)	217 °C	217 °C
Time Maintained Above Temperature T_L (t_L)	60 seconds	120 to 150 seconds
Peak / Classification Temperature (T_p)	240 °C	260 °C
Time Within 5°C of Actual Peak Temperature (t_p)	20 seconds	30 to 50 seconds
Maximum Ramp-Down Rate (T_p to T_L)	2.5 °C/second	6 °C/second
Time 25°C to Peak Temperature	310 seconds	480 seconds
Nitrogen Atmosphere (O2)	< 1000 ppm	

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)
7. Current test, e.g. V_f @ 1mA ≥ 2.0V

5.7 Reflow Accuracy

For solder mask defined designs, Lumileds facilitated internal tests with shown position accuracy after reflow (see Figure 22 and Table 5). Results may vary based on printed circuit board quality and used assembly process.

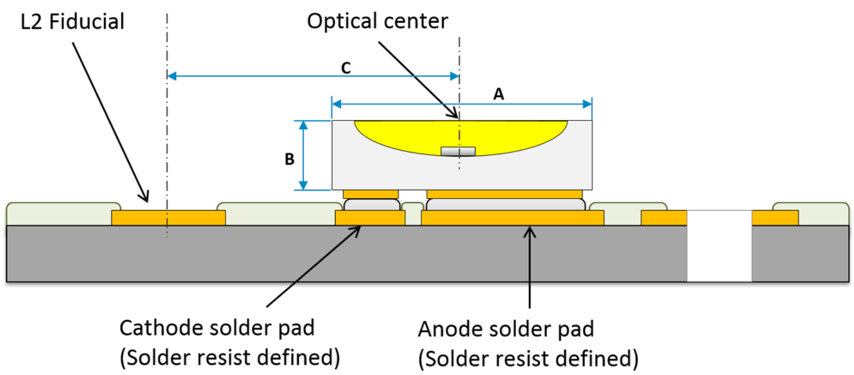


Figure 22. L1 and L2 tolerance definition

Table 5. Dimension and placement tolerances for LUXEON Versat

ITEM	DESCRIPTION	MAXIMUM VALUE (5σ)	TYPICAL VALUE
A	L1: Package outline X/Y	±100 µm	—
B	L1: Total thickness Z	±100 µm	—
C	L2: Optical center to L2 fiducial, X/Y	—	±100 µm

Note: Typical values given are derived from sample based assembly tests performed at Lumileds and calculated for 5 Sigma.

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 LED assemblies. For example, 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 23).

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 minimum. As a general guideline, it should be at most 2 mm of vertical deflection for every 90mm of FR4 PCB length. This 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 board bending test 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.

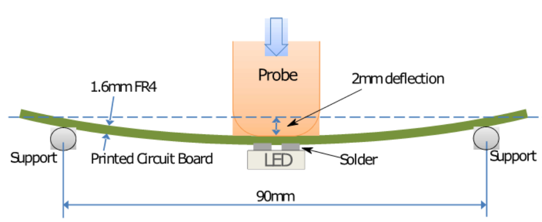


Figure 23. Setup of LED board bending test

5.9 Packing of Assembled LED Module

Finished boards must be protected against damage during transport. It is recommended to use a customized tray package which is designed to hold the PCBs during transport (see Figure 24).

Here are some general rules of best practice tray design:

1. Design the tray to avoid accidently touching the LED by manual handling. Ideally, the tray only allows one way to hold the assembly. If there are several ways to put assemblies into the tray or take them out, a strict operator discipline and clear instruction on how to safely handle the assemblies is needed.
2. It must be designed in a way that no force from the tray or packing material is applied to the LED.
3. In a stack of multiple trays, the PCB should also be secured from the top. This can be done by bottom structures of the next tray which is put on top of the stack.
4. The tray should also protect the LED against movement and shaking/vibrations during transport.

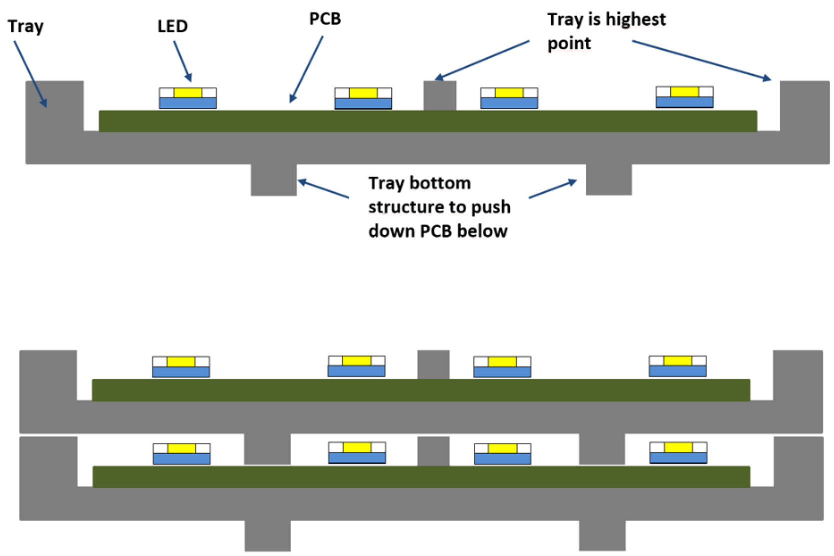


Figure 24. Schematic of a good tray design. The LEDs are protected against movement and no force is applied to the LEDs

6. Interconnect Reliability

The reliability of the board interconnect under thermal cycling and thermal shock condition is mainly determined by the thermal expansion of used materials. The Versat package is based on a copper lead-frame, which has a CTE of ~16 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 6 shows commonly used materials and their CTE.

Table 6. CTE of common board substrate materials

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_20_3	6-8 ppm

* Depending on laminate vendor, pre-preg type and fiber orientation.

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

Lumileds performed solder joint reliability testing of the Versat 3030 on FR4 and Al-IMS board materials. Cross-sections of solder joint and x-rays for voiding and solder balling behavior were taken. The test results after conditioning by Air to Air Thermo-mechanical shock (AA-TMSK) from -40 to + 125 °C for 1000 / 2000 / 3000 cycles are shown in Figure 25. The solder joint is still in a proper condition, without cracks or delamination.

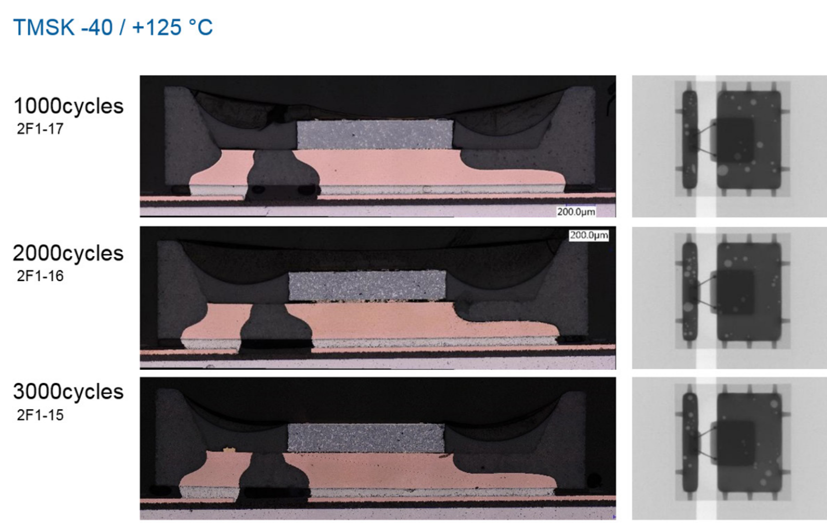


Figure 25. X-section and x-ray of Versat 3030 after AA-TMSK testing

7. JEDEC Moisture Sensitivity Level

JEDEC has defined eight levels for moisture sensitivity, as shown in Table 7

Table 7. JEDEC moisture sensitivity levels for LUXEON Versat 3030

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 Hours +1/-0	60°C/60% RH
3	168 Hours	≤30°C/60% RH	192 Hours +5/-0	30°C/60% RH	40 Hours +1/-0	60°C/60% RH
4	72 Hours	≤30°C/60% RH	96 Hours +2/-0	30°C/60% RH	20 Hours +5/-0	60°C/60% RH
5	48 Hours	≤30°C/60% RH	72 Hours +2/-0	30°C/60% RH	15 Hours +5/-0	60°C/60% RH
5a	24 Hours	≤30°C/60% RH	48 Hours +2/-0	30°C/60% RH	10 Hours +5/-0	60°C/60% RH
6	Time on Label (TOL)	≤30°C/60% RH	TOL	30°C/60% RH		

The Versat LED has a JEDEC moisture sensitivity level of 1. This is the best level in the industry and within the JEDEC J-STD-020D.1 standard. 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 Versat datasheets.

8. Packaging Considerations—Chemical Compatibility

The 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 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 the LEDs 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 output 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 8 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 8 are typically not directly used in the final products that are built around the 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:

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. 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 8. List of commonly used chemicals that may damage the silicone encapsulant of the LED

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
Tetracholorometane	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.

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