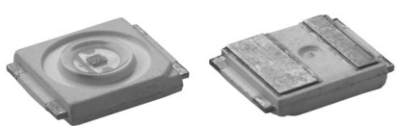
Specification, Handling, Thermal Management and Design-In



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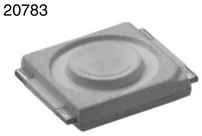

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Introduction

The Little Star package is designed for high current application up to 400 mA, with a super high flux output and presented in a compact package outline. (6.0 x 6.0 x 1.5). With its low package height of 1.5 mm it presents the best combination of compactness and highest brightness.

The following application note details product specification in corresponding data sheets for the different series of the product.

The InGaN based devices are casted with silicone. Silicone casting has big advantages in terms of optical stability and stress relief, but requires a special handling procedure in assembly.

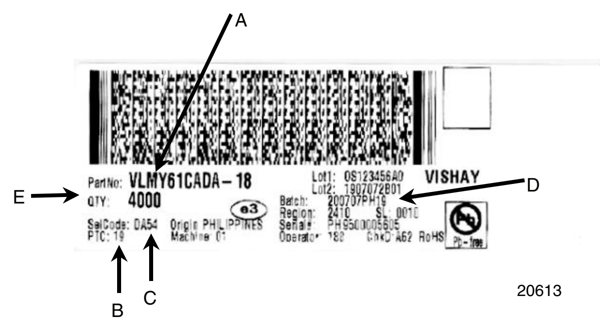
For the solder process there is no special requirement. The device is compatible to the existing SMT processes and standard IR-reflow.

Manual solder process is only accepted for engineering purposes and de-soldering for failure analysis. Special conditions are recommended to avoid thermal damage. Optical parameters especially for InGaN based devices are strongly temperature dependent.

As a summary beside the handling recommendation a proper thermal management of is the most important part for the design in of high power LED. Driving the LED a high portion of the electrical energy will be converted to heat. This heat conducts from the junction area through the LED die, then trough the package and finally to the ambient via the heatsink. The following application note describes all this phenomena in detail and gives the necessary instructions for a efficient application and a long LED life time.

Product Specification

The datasheet presents the performance for the Little Star in tables and diagrams. Brightness group and color are already defined in the device type name. More details as V_F group and color group, production date can be seen on the label.



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A) Type of component
B) Manufacturing plant
C) SEL - selection code (bin):
   e.g.: DA = code for luminous intensity group
   5 = code for color group
   4 = code for forward voltage
D) Batch:
   200707 = year 2007, week 07
   PH19 = plant code
E) Total quantity

Fig. 1 - Design of the Label

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LUMINOUS INTENSITY/FLUX CLASSIFICATION RED/AMBER/YELLOW				
GROUP	LUMINOUS INTENSITY I_V (mcd)		LUMINOUS FLUX Φ_V (MLM) CORRELATION TABLE	
STANDARD	MIN.	MAX.	MIN.	MAX.
AA	7150	9000	20 700	26 100
AB	9000	11 250	26 100	33 000
AC	11 250	14 000	33 000	39 000
AD	14 000	18 000	39 000	52 000
AE	18 000	22 400	52 000	71 000
AF	22 400	28 500	71 000	97 000

Note:
Luminous intensity is tested at a current pulse duration of 25 ms and an accuracy of ± 11 %.
The above type numbers represent the order groups which include only a few brightness groups. Only one group will be shipped on each reel (there will be no mixing of two groups on each reel).
In order to ensure availability, single brightness groups will not be orderable.
In a similar manner for colors where wavelength groups are measured and binned, single wavelength groups will be shipped in any one reel.
In order to ensure availability, single wavelength groups will not be orderable.

COLOR CLASSIFICATION				
GROUP	DOM. WAVELENGTH (nm) YELLOW		DOM. WAVELENGTH (nm) AMBER	
	MIN.	MAX.	MIN.	MAX.
A	585	588	610	616
B	588	591	616	620
C	591	594		
D	594	597		

Note:
Wavelengths are tested at a current pulse duration of 25 ms and an accuracy of ± 1 nm.

FORWARD VOLTAGE CLASSIFICATION		
GROUP	FORWARD VOLTAGE (V)	
	MIN.	MAX.
02	2.2	2.5
03	2.5	2.8

Note:
Forward voltages are tested at a current pulse duration of 25 ms and a tolerance of ± 0.05 V.
In order to ensure availability, a single forward voltage group can not be ordered.

Fig. 2 - Classification Table for brightness, Color and V_F

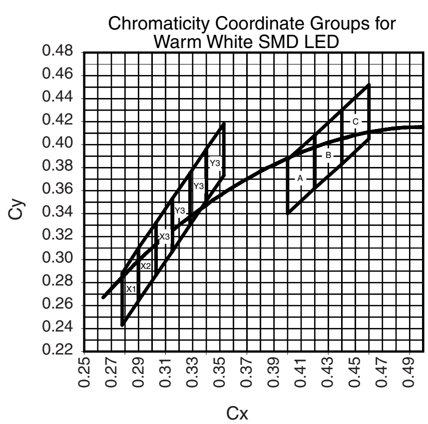

Fig. 3 - Color Grouping on White and Warm-White

Handling Procedure

The Little star package is, as all platic packages, humidity sensitive. The Jedec level 2a is specified. This means the floortime is 672 h in an environment of 10 °C to 30 °C and humidity < 60 % RH.
After more than 672 h under these conditions moisture content will be too high for reflow soldering. In case of moisture absorption, the devices will recover to the former condition by drying under the following condition:
192 h at 40 °C + 5 °C/- 0 °C and < 5 % RH (dry air/nitrogen)
or
96 h at 60 °C + 5 °C and < 5 % RH for all device containers
or
24 h at 100 °C + 5 °C not suitable for reel or tubes.

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AlInGaP based devices as red, amber and yellow are casted with clear resin. There is no special requirement for mechhanical handling. For InGan based devices, especially for the white silicone is used as encapsulant. The advantage of silicone is the thermal and photo stability in a variety of harsch environment. This features minimize the risk of yellowing or changing in physical properties during device operation. As a result of the advantages of a silicone encapsulant the lifetime of the LED can be increased up to 100 kh.
On the other side silicone is much softer compared to epoxy resin. Thus, when handling the LED, care should be taken not to apply excessive pressure on top of the silicone. Sharp objects might pierce through the silicone encapsulant and damage the LED.
When handling the LED using tweezers, care should be taken to ensure that the tweezers would not be in contact with the silicone surface to prevent scratches on the lens. The right way to pick or place the LED using tweezers from the side of the package as shown in Fig. 4.

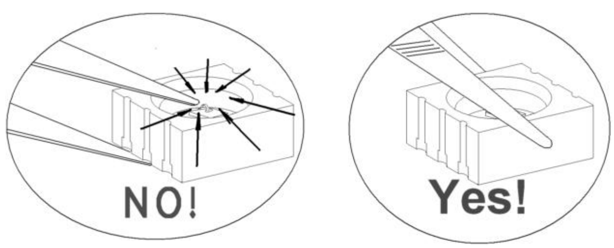

Fig. 4 - Requirement for Manual Handling

For SMT mounting, the pick and place nozzle use must be bigger than the LED emission area, to prevent the LED from sticking to the pick and place nozzle. Parameter settings for pick and place process should also be evaluated to ensure no damage to the LED's.
If cleaning is required after soldering, we suggest to use IPA as cleaning agent. Maximum recommended rinsing time is 10 s. No use of ultrasonic to avoid damages during cleaning. Due to the silicone is soft in nature; the tendency of foreign particulate to adhere on the silicone surface would be greater compared to epoxy resin. A certain amount of particles can be accepted without influencing the performance of the LED.
Typical contamination in an acceptable range is shown in fig. 5

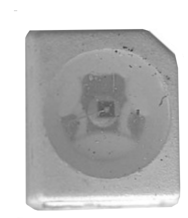

Fig. 5 - Acceptable Foreign Particle Level on a Silicone Casted LED

Optical and Electrical Charactersistics Across Operation Temperature Range

The optical and electrical characteristic of a power LED depends strongly on the junction temperature.
The forward voltage decreases while the dominant wavelengths increases with the temperature, as shown in fig. 6 to 8 for AlInGaP and InGaN based devices.

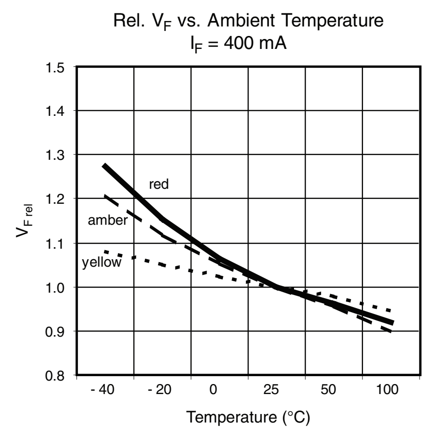

Fig. 6 - V_F over Temperature for AlInGaP Based Devices

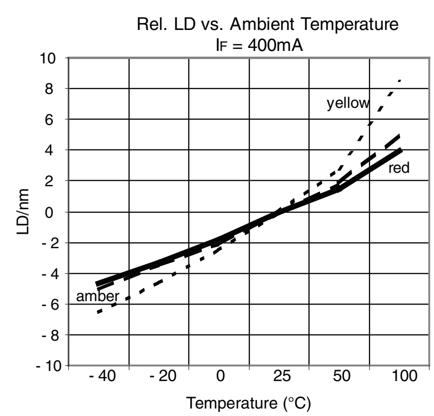

Fig. 7 - Dominant Wavelength vs. Ambient Temperature

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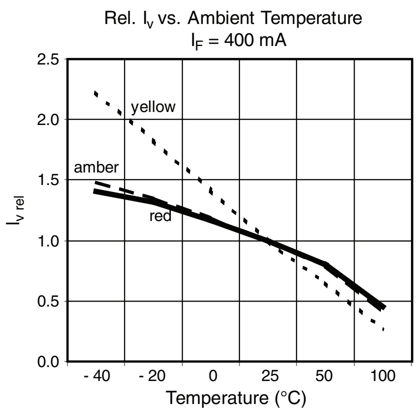

Fig. 8 - Relative Luminous Intensity vs. Ambient Temperature

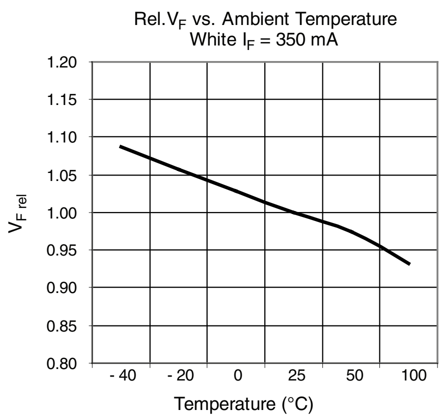

Fig. 9 - V_F vs. Ambient Temperature for White

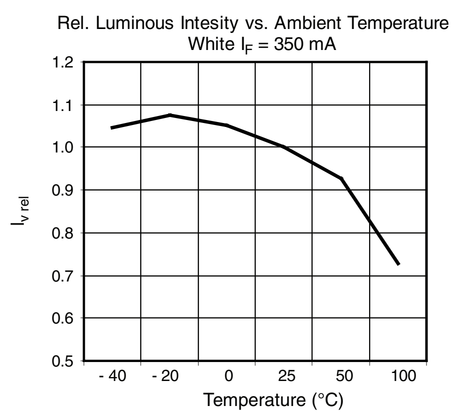

Fig. 10 - Relative Luminous Intensity vs. Ambient Temperature for White

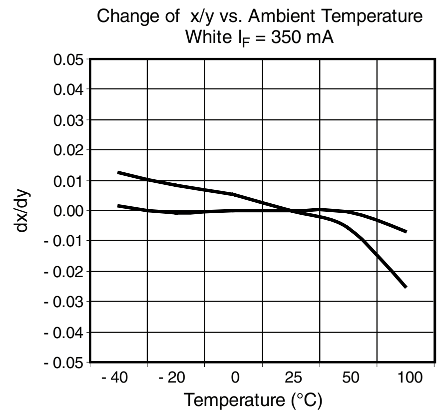

Fig. 11 - Color Coordinates x, y vs. Ambient Temperature

Dimming the Little Star

The dominant wavelength is a function of the junction temperature and therefore also a function of the forward current applied to the LED due to a part of energy converted to heat.

The typical relationship between the forward current change versus the wavelengths or CxCy shift is shown in fig. 13, 15. For unique illumination of an area the individual device is driven by different brightness and therefore with different current. This will shift the dominant wavelengths and therefore also the color. In applications where this shift can not be tolerated, pulse width modulation (PWM) should be used to dim the brightness. The frequency of PWM should be above 200 Hz, so that the human eye can not follow the on/off cycle. The colour shift can be avoided by PWM (fig. 16).

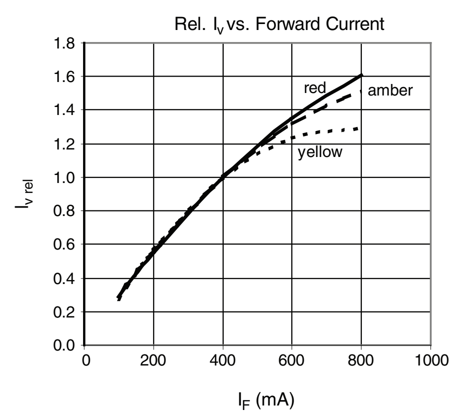

Fig. 12 - LOP vs. Forward Current

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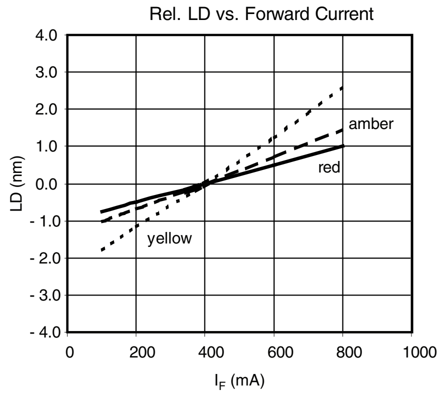

Fig. 13 - Dominant Wavelength vs. Forward Current

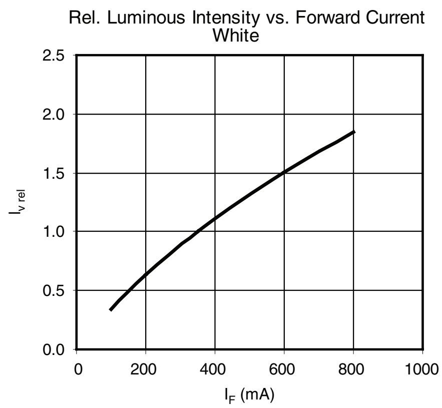

Fig. 14 - White: Luminous Intensity vs. Forward Current

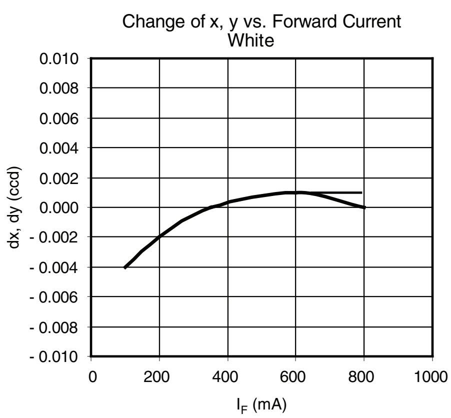

Fig. 15 - White: X, Y vs. Forward Current

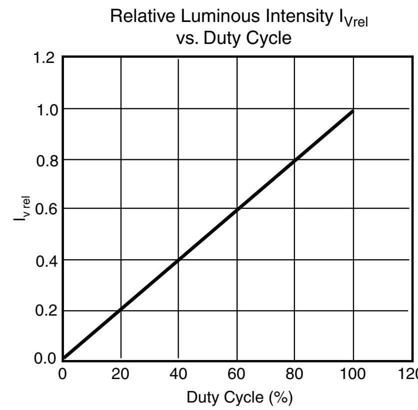

Fig. 16 - Relative Luminous Intensity vs. Duty Cycle

Thermal Management

Driving an LED part of the power is converted to light. The major part of the energy is converted to heat. This heat generated at the PN junction has to be transferred out of the LED through the package to the PCB and from there to the local ambient as shown in fig. 17 and 18.

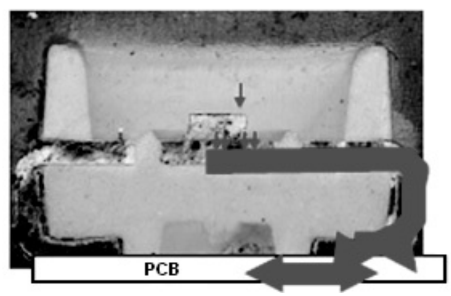

Fig. 17 - The Way the Heat Goes out of the LED via Leadframe to the PCB

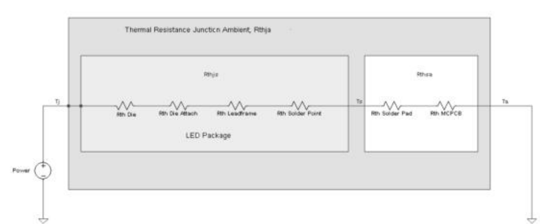

Fig. 18 - The Thermal Resistance R_{thja} as a Summary of Individual Parts

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The heat transfer out of the system described in fig 17 is following "Ohm's Thermal Law"

$T_j = T_a + R_{thja} \times (V_F \times I_F)$ (1)

T_j = LED junction temperature

T_a = Ambient temperature

R_{thja} = Thermal resistance junction to ambient

V_F = Forward voltage

I_F = Forward current

Out of the summary of individual parts to total thermal resistance

$R_{thja} = R_{thjs} + R_{thsa}$ (2)

R_{thjs} = Thermal resistance junction to solder point

R_{thsa} = Thermal resistance solder point to ambient

From "ohm's thermal law"

$T_j - T_s = R_{thjs} \times (V_F \times I_F)$ (3)

or

$T_j = R_{thjs} \times (V_F \times I_F) + T_s$ (4)

T_s = Solder temperature

Equation (4) is particular important in practical calculation to ensure under specific operating condition, the junction temperature will not exceed absolute maximum T_j rating defined in the datasheet.

The T_s can be measured by soldering a thermocouple to the solder-point.

Theoretically the thermal resistance junction to solder point is solely a function of the component package. In practical the junction to solder point resistance will vary with the different cooling environment. Measurements are shown in fig. 19 and 20.

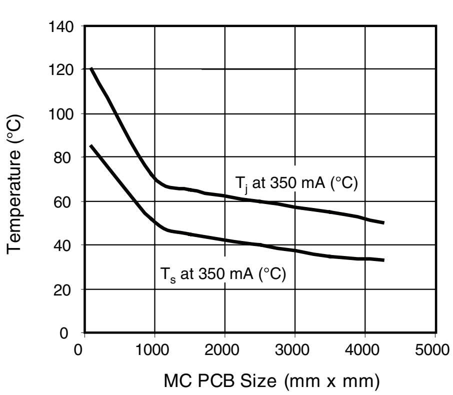

Fig. 19 - The Effect of Heat Sink Size on Junction and Solder Point Temperature

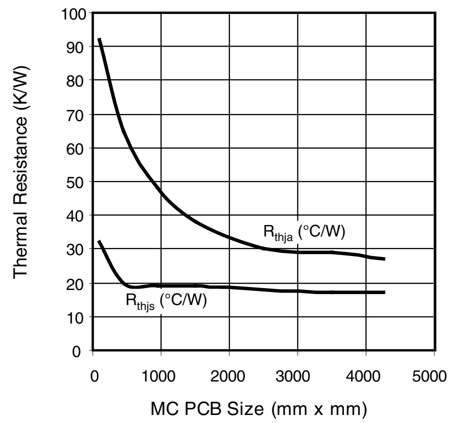

Fig. 20 - Effect of Heat sink size on R_{thjs} and R_{thja}

Solder Requirements

The soldering surfaces are plated 100 % pure Sn. The component is designed to be compatible to the existing industry SMT process and IR-reflow. There are no special processes or equipment required for the mounting of the components in different applications. Both the thermal and electrical connections are provided by the conventional process. Therefore, there is no need to provide for additional process or material to take care for the thermal connection.

However, due to the unique design, all the soldering terminals are located at the bottom surface of the component. This greatly reduces the space required and also enhances the thermal dissipation capability of the component. Heat from the LED chip is directly conducted via the soldering terminals to the external environment. Thermal path is kept to the very minimum.

As for the soldering process, the component is qualified for both Pb and lead (Pb)-free soldering profile. Both profiles as described in the datasheet are applicable.

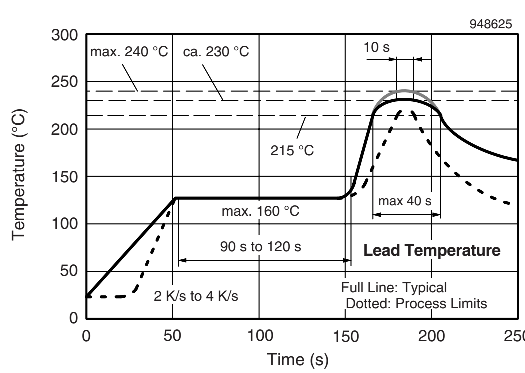

Fig. 21 - Recommended Lead (Pb)-free IR-reflow Profile for Lead (Pb)-free Soldering

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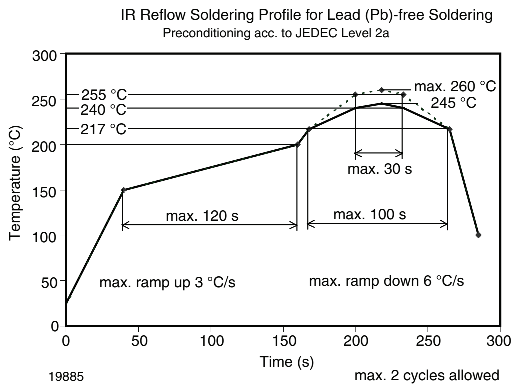

Fig. 22 - Recommended SnPb IR-reflow Soldering Profile

Manual Soldering

The device is not released for manual solder process due to undefined heat load. Therefore manual solder or de-solder process should be limited to failure analysis and R & D applications.