WICOP

Introduction

This application note addresses the recommended assembly and handling guidelines for the WICOP series of LEDs. The WICOP series are Direct SMT LEDs, that due to their small size and construction, require special assembly and handling.

This application note outlines the handling and assembly procedures that are, required to ensure reliable manufacturing, high lumen output and long lumen maintenance lifetime.

Scope

The assembly and handling guidelines in this application brief apply to the following products with the part number designations as described below.

Z8 YXX-WA-CN	
XX	Designates packaging size (22 for 2.21x2.21mm size, 19 for 1.81x1.81mm size, 15 for 1.41x1.41mm size, 11 for 1.14x1.14mm size)
A	White Color (0 for Cool, N for Neutral, W for Warm)
N	Designates CRI (7 for CRI min.70, 8 for CRI min. 80, 9 for CRI min. 90)

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1. Component

1.1 Description

The WICOP Series of LEDs are based on Direct SMT LEDs. They are ultra-compact, high-power, surface mount white LEDs. Each WICOP LED consists of high brightness InGaN LED chip with a thin layer of silicone to protect the LED chip and phosphor from environment. An ESD diode is not included in the package.

The bottom of the WICOP LEDs have three different sized solder pads for the anode and cathode as shown in Figure 1.

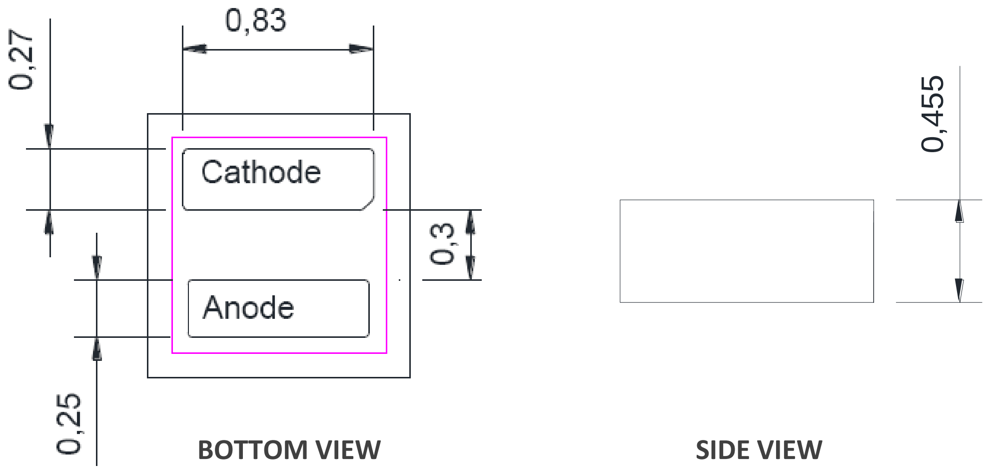


Figure 1-1. WICOP Z8Y11 Solder Pad Dimensions.

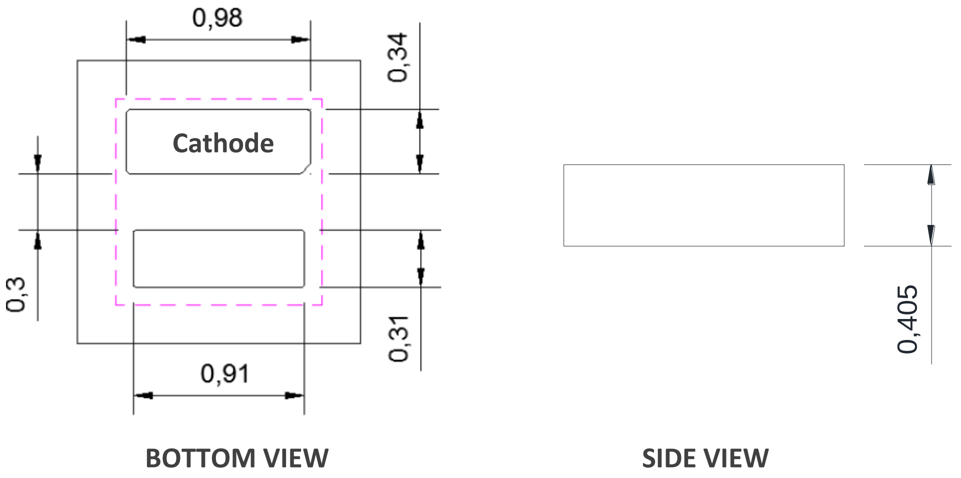


Figure 1-2. WICOP Z8Y15 Solder Pad Dimensions.

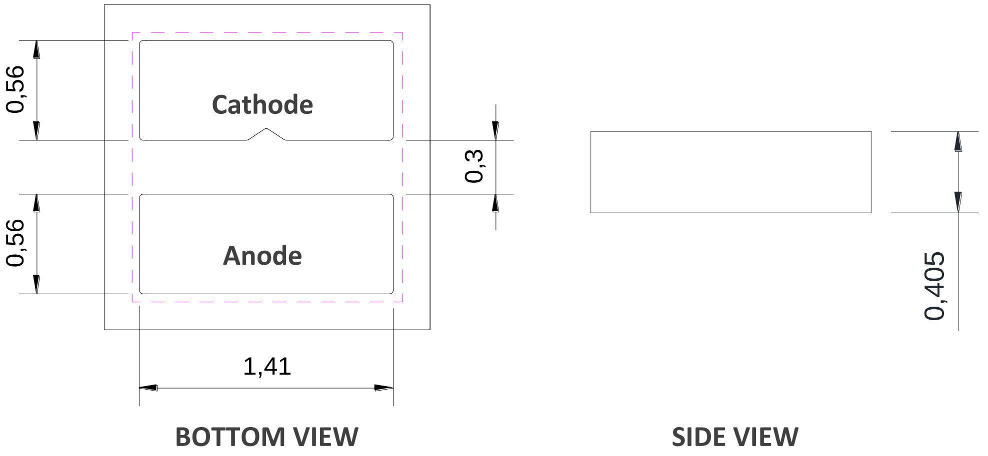


Figure 1-3. WICOP Z8Y19 Solder Pad Dimensions.

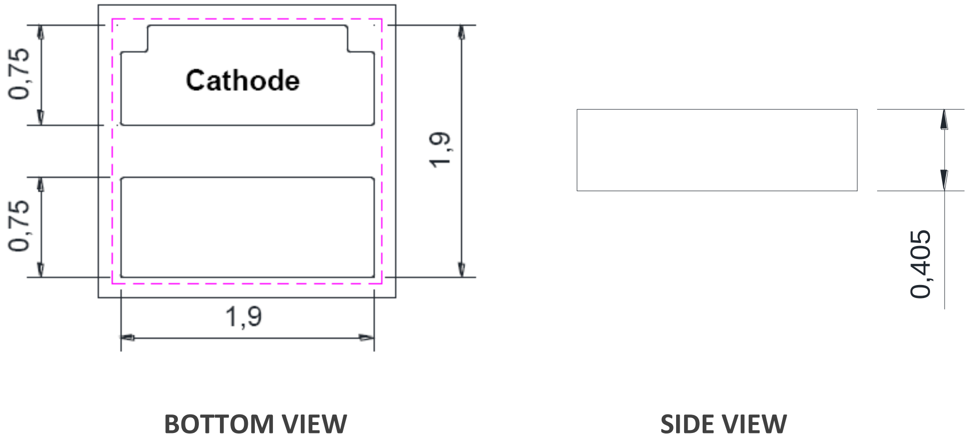
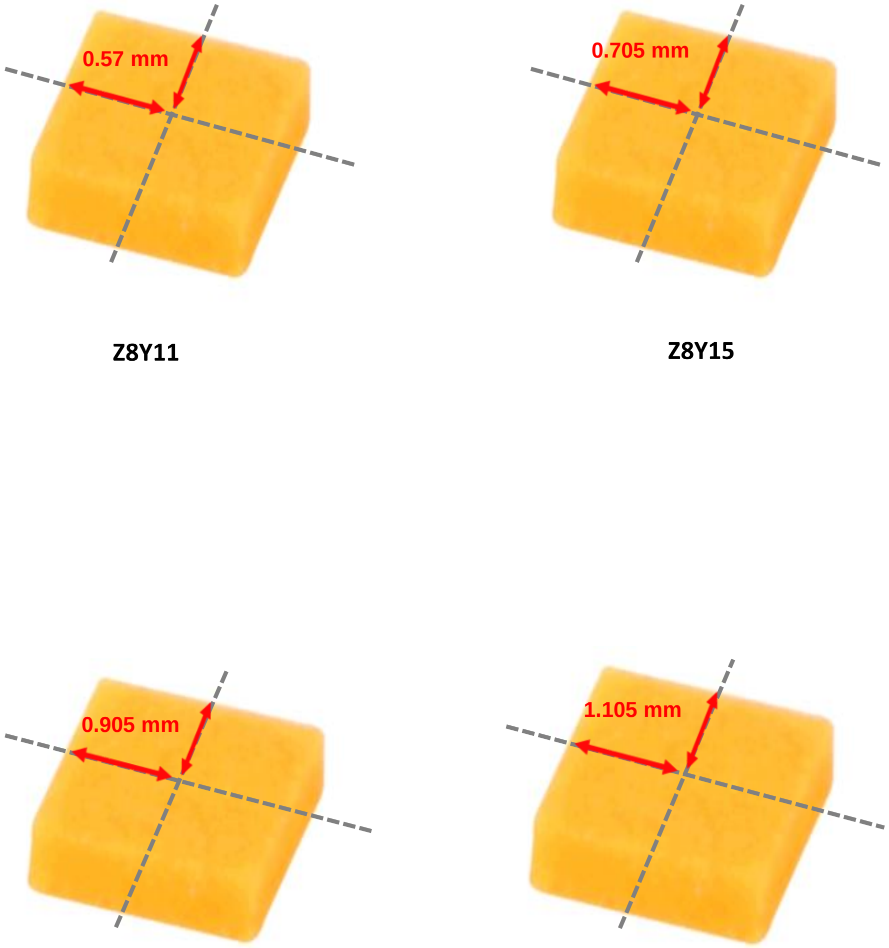


Figure 1-4. WICOP Z8Y22 Solder Pad Dimensions.

1.2 Optical Center

The theoretical optical center of WICOP from the edges of the part. The optical center of the Z8Y11 is 0.57mm, Z8Y15 is 0.705mm, Z8Y19 is 0.905mm and Z8Y22 is 1.105mm(see Figure 2).



Z8Y11 **Z8Y15**

Z8Y19 **Z8Y22**

Figure 2. Optical Centers of the WICOP Series

1.3 Handling Precaution

Improper handling of WICOP may damage the LED and can impact the overall performance and reliability. In order to minimize the risk of damage to the LED during handling, WICOP should only be picked up by automated SMT machine or vacuum tweezers. At no times should metal tweezers be used to handle the LEDs as shown in Figure 3a. Also plastic tweezers can be use to handle the LEDs as shown in Figure 3b.

When handling finished boards containing WICOP, do not touch the surface of the LED with fingers or any other material . Do not apply pressure on the top or sides of the LED. And avoid all contact to the LED. Do place the boards with the LED on the bottom side, on a table or not stack multiple boards on top of each other as shown in Figure 3c on left.

Since the silicone layer of the LEDs is soft, abrasion may cause catastrophic failure of the LED as shown in Figure 3c on right.

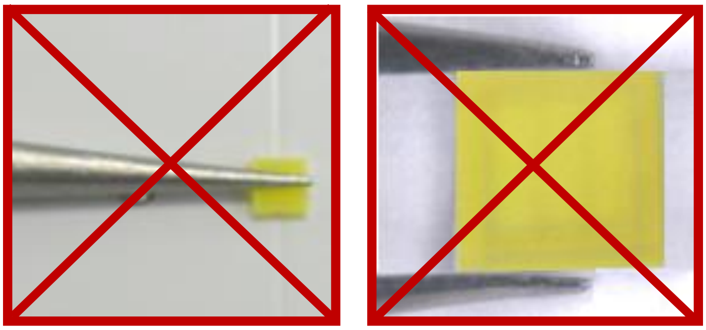


Figure 3 (a). Incorrect handling of WICOP LEDs

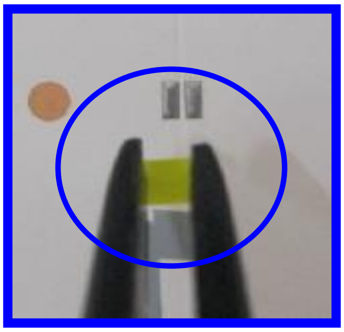


Figure 3 (b). correct handling of WICOP LEDs with plastic tweezers

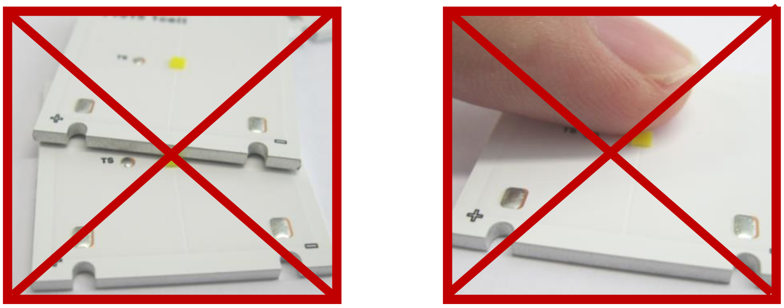


Figure 3 (c). Incorrect handling of WICOP LEDs

1.4 Cleaning

The WICOP should not be exposed to dust and debris. Excessive dust and debris may cause a decrease in LED performance. In the event that the surface of a the LED requires cleaning, a compressed gas duster at a distance of 15 centimeter (6 inch) away will be sufficient to remove the dust and debris or an air gun with 20 psi (at nozzle) from a distance of 15 centimeter (6 inch).

1.5 Electrical Isolation

The WICOP contains two electrical pads on the bottom of LED with a spacing of 0.3mm. In order to avoid any electrical shocks and/or damage to the WICOP, board designs need to comply with the appropriate standards of creeping distance.
Please see details on 2.1 sections.

1.6 Mechanical Files

Mechanical drawings for WICOP Series (2D and 3D) are available upon request.
Please contact to each local sales person.

2. Printed Circuit Board Design Guideline

WICOP is recommended to be soldered onto a Metal Core PCB (MCPCB) for optimal performance and to designed to minimize the overall thermal resistance between the LED and the heat sink.
Also WICOP is recommended to be open PSR between Anode and Cathode for reduce LED fail shown in Figure 4. If there is PSR layer, it may be possible to occur soldering defects like solder balls on it or it may have chances to make short defect by flux residue.

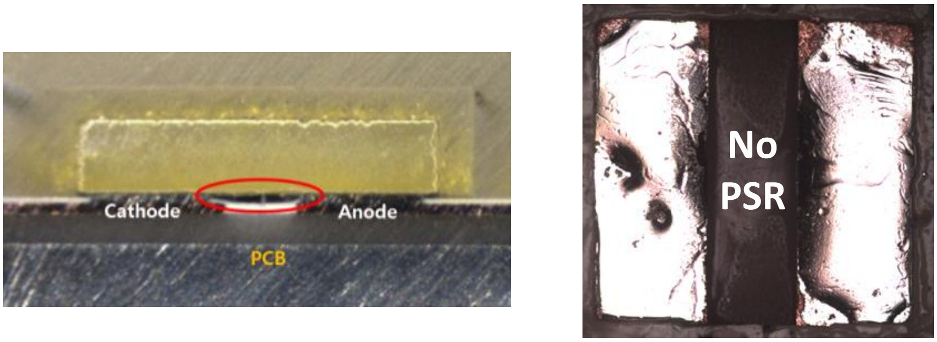


Figure 4. Recommended open PSR between Anode and Cathode.

2.1 WICOP Solder Footprint

For proper operation, the WICOP anode and cathode need to be soldered onto corresponding pads on a PCB. The size of the pads and the corresponding size of the solder footprints are shown in Figure 5.

The electrical pads of the WICOP also serve as thermal pads between the LED and the PCB. To enhance heat dissipation from a WICOP into the PCB, we recommend extended the copper area around each electrode as possible, when user do artwork the circuit.

Also, SMT quality is very important. There are some quality issues – Voids, Solder ball, cold solder, tilt (rotated) and so on - when devices(like WICOP2) are soldered on the board (like PCB). For example, voids are often occurred when the SMT condition (with PCB solder pad design or reflow condition is not proper) are not enough. Some reasons in voids are lack of out-gassing when it is soldering. So it need to consider design on the PCB or check the reflow profile. Those are reference only about PCB pad design in Figure 5, sometimes it should be modified in each user’s various interfaces.

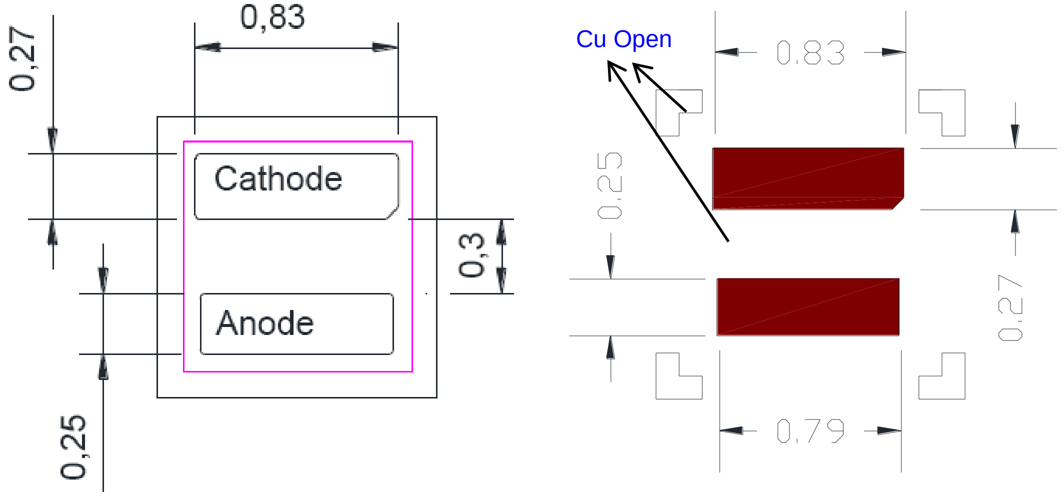


Figure 5 (a). Referenced PCB Footprint for. Y11 All dimensions in mm.

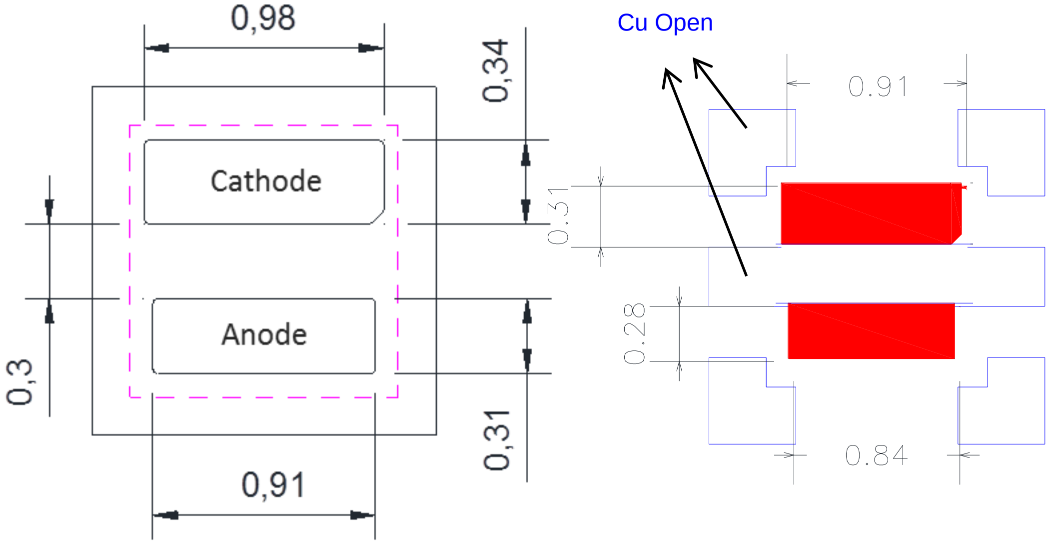


Figure 5 (b). Referenced PCB Footprint for. Y15 All dimensions in mm.

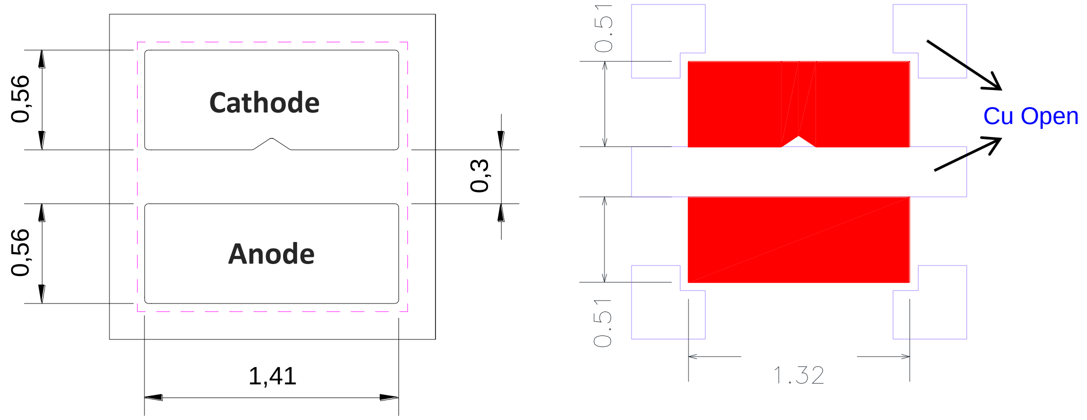


Figure 5 (c). Referenced PCB Footprint for. Y19 All dimensions in mm.

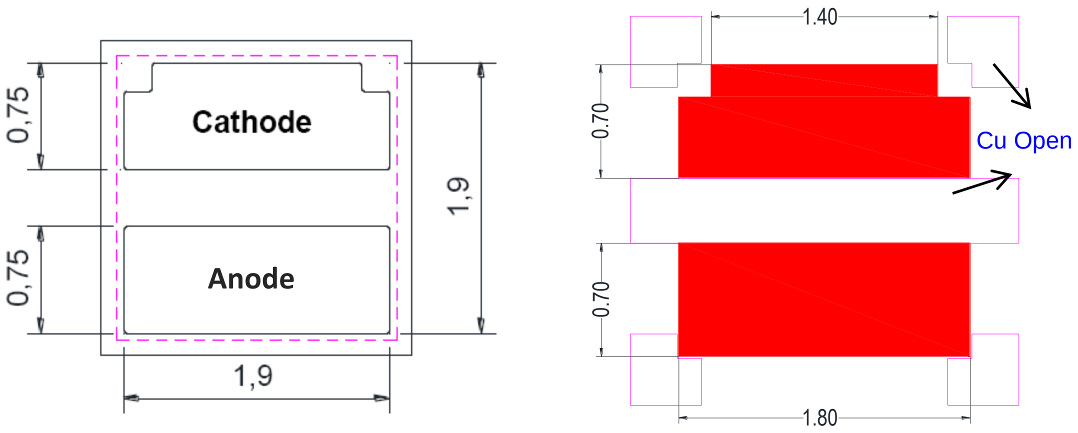


Figure 5 (d). Referenced PCB Footprint for. Y22 All dimensions in mm.

2.2 Silk Color

The performance of an WICOP can be impacted by the color of the silk screen used on the PCB. There may be able to have an efficacy loss due to optical absorption by a black color, because WICOP is Chip Scale Package. It is recommended to either use yellow color for the silk screen or not to use any markings around a WICOP as shown in Figure 6.

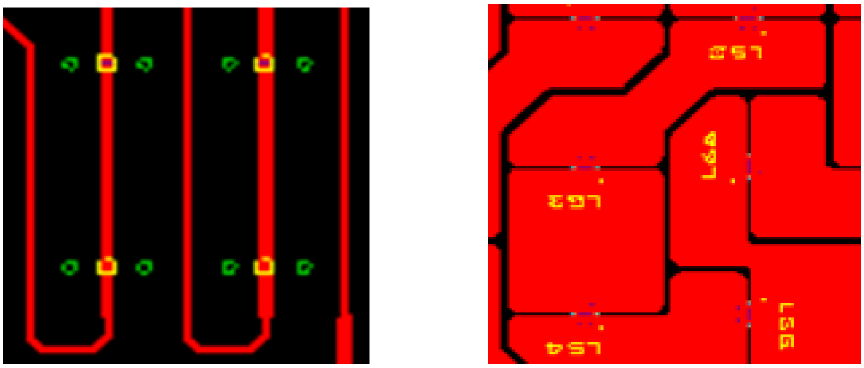
X

O

Figure 6. WICOP Silk color Recommendations

2.3 PCB Artwork

The PCB design for the WICOP Series can impact the thermal performance of the end product.
Figure 7 shows two different artwork designs for the same circuit.
The red pattern indicate the copper traces. Wide copper traces should be used to allow a robust thermal path for the anode and cathode pads.



Only traces
Not recommended

Recommended

Figure 7. PCB layout recommendations

2.4 PSR (Photo Solder Resist)

Seoul Semiconductor recommends a PCB with high optical reflectivity PSR for the WICOP. Because of the radiation pattern of the LED, the reflectivity of the PCB (PSR) can impact the optical efficacy. It is recommended that the reflectivity of the PSR is greater than 80%.
And Seoul Semiconductor recommends a PSR below :
① P/N : RPW-8000-xx (Tamura) ② SFR-6A-B2603S (Sekisui)

2.5 Minimum Spacing

Seoul Semiconductor recommends a minimum edge to edge spacing between adjacent WICOP of 0.2mm. The spacing of multiple WICOP can impact the performance of a LED system in two ways.

1) *Heat dissipation* : Close spacing of the LEDs may limit the PCB's to ability to dissipate the heat from the LEDs.

2) *Optical Absorption* : Close spacing of the LEDs could impact the light output due to optical absorption or cross talk between adjacent LEDs.

More information on this can be found in the array guidelines(Section 5).

3. Thermal Measurement Guidelines

This section provides general guidelines on how to determine the junction temperature of a WICOP in order to verify that the junction temperature in the actual application does not exceed the maximum allowable temperature specified in the datasheet.

The typical thermal resistance RΘjs between the junction and the thermal pad for WICOP is specified in their respective datasheet. For a WICOP, both of the electrode pads serve as thermal pads. With this information, the junction temperature T_j can be determined according to the following equation:

$$T_j = T_S + R\Theta js \bullet P_{electrical}$$

In this equation $P_{electrical}$ is the electrical power going into the WICOP and T_S pad is the temperature at the bottom of one of the WICOP electrodes or solder point temperature, assuming both WICOP electrodes are connected to copper pads on the PCB.

Due to the size of the WICOP, it may be difficult to measure the thermal pad temperature directly. Therefore, a practical way to determine the WICOP junction temperature is by measuring the temperature T_s of a predetermined sensor pad on the PCB close to the WICOP with a thermocouple as shown in Figure 8.

To ensure accurate readings, the thermocouple must make direct contact with the copper of the PCB onto which the WICOP electrode pads are soldered, i.e. any solder mask or other masking layer must be first removed before mounting the thermocouple onto the PCB.

Figure 8. Recommended Ts configuration

The following guidelines help determine appropriate Ts location in a densely packed array application in order to approximate the maximum junction temperature in the WICOP array:

a. If there is no symmetry in the copper layout of the PCB, it is best to place the Ts point next to the electrical pad (anode or cathode) where heat spreading into the PCB is most impeded. This is typically the electrode with the least amount of copper.

b. If different drive currents are used for each WICOP, it is generally best to measure the temperature next to the LEDs which consumes the most amount of electrical power.

The thermal resistance RϴJs between the WICOP junction and T_s point was experimentally determined to be typical 3K/W for a WICOP of the 1.5mm thick Al-MCPCB board (2oz copper or 80~100µm thick 5W/m·K dielectric layer).

LED board configurations with a larger number of closely packed WICOP may require additional thermal modeling to determine the pad temperature of the LEDs in the center of the array which are not easily accessible.

4. Array Process Guideline

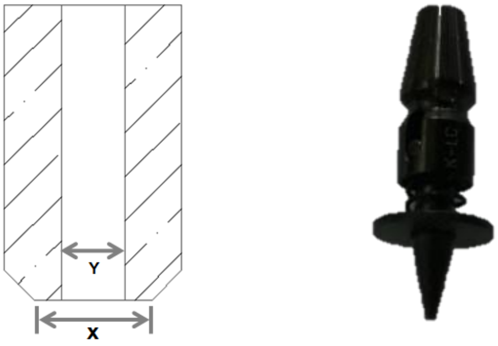
4.1 Stencil Design

The appropriate stencil design for WICOP is included in the PCB footprint design (see Figure 5). The recommended stencil thickness is 80um for Y11 and Y15, 100um for Y19 and Y22, and its aperture ratio is 65 to 70%. Keeping the stencil pattern aperture ratio to 656% to 70% prevents the solder paste leakage from accidentally bridging the anode and cathode pads, which are only spaced 300um apart (See 2.1 WICOP Solder Footprint).

4.2 Pick-and-Place

Automated pick and place equipment provides the best handling and placement accuracy for WICOP. Figure 9 shows pick and place nozzle designs.
Based on these pick and place experiments, Seoul Semiconductor recommends to customers to take the following general pick and place guidelines :

1. The tip of the nozzle should be positioned on the flat surface above the LED chip area.
2. The nozzle tip should be clean and free from any particles.
3. During setup and any initial production runs, it is a good practice to inspect the top surface of the WICOP under a microscope to ensure the emitters are not accidentally damaged by the pick and place nozzle.



Items	Y11	Y15	Y19 / Y22
Outer diameter X	0.75~0.95 mm	1.2~1.6 mm	1.6~1.75 mm
Inner diameter Y	0.38~0.5 mm	0.5~0.65 mm	0.95~1.05
Materials	Rubber or Ceramic		

Figure 9. Pick and place nozzle design and dimensions

4.3 Solder Paste

Seoul Semiconductor recommends to use no-clean solder paste, SnAgCu (tin/silver/copper) of solder paste compositions. Solder alloy size should be recommended to Type 4 or Type 5. Also, Seoul Semiconductor recommends solder cream below :

P/N : M705-GRN360-K2-V (Senju) – Type 4
OM385SM (Alpha) – Type 5

4.4 Stencil Printing

The recommended stencil thickness is 0.08~0.10mm. For good quality stencil printing, there are several important factors for consideration.

1. The stencil opening wall should be smooth, free from debris, dirt and burr.

2. The stencil surface should have uniform thickness throughout the stencil plate.

3. Positional tolerance between the stencil plate and the PCB should be small enough to ensure that the solder paste is not printed outside the footprint.

4. WICOP package is small but it's not too small comparing with other electric device – one of them is 0.2x0.4 mm. But if user want to enhance solder pass out mask open area, SSC recommend Aculon Nanoclear to improve. Please contact to Alpha branch at each local to find further information.

P/N : Aculon Nanoclear (Alpha)

Items		Remark
Squeeze conditions	Pressure	2.5-5.0Kgf/㎠
	Distance	2-4mm
	Velocity	20-100mm/sec
Stencil mask	Thickness	0.08~0.10mm
Vacuum		0.5±0.05mpa
Solder paste area		60~75%
X, Y Tolerance		±150 um

Table 1. Stencil mask and soldering information.

4.5 Pick up Test (Mount Machine Reference)

Seoul Semiconductor conducted to get parameters about SMT mount machine. But note that these results should be used for reference only. Seoul Semiconductor cannot any guarantee for these parameter values.

Maker	HANWHA (SAMSUNG)	Remark
Part Number	SM482	
Machine Appearance		
Tested Nozzle	Outer : Φ 1.2 mm Inner : Φ 0.65 mm 	
Push Condition [*1]	0.47 mm Pick-up Delay time : 30 ms Place Delay time : 30 ms	
Machine Accuracy	± 0.05 mm	

[*1] Push condition is not recommendation value but experienced setting value.

4.6 Soldering

A standard SMT reflow profile can be used to WICOP. An example of the reflow conditions is shown in Figure 10 and Table 2.

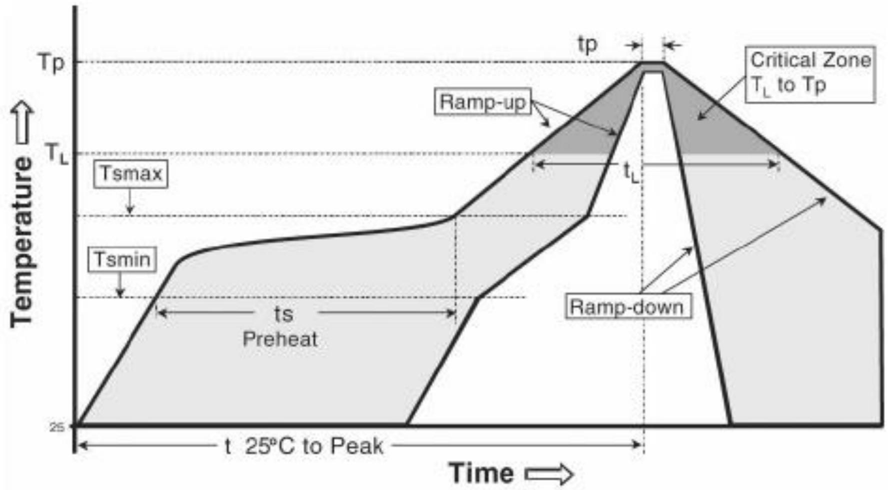


Figure 10. Solder reflow profile.

Table 2. Recommended reflow conditions

Profile Feature	Pb-Free Assembly
Average ramp-up rate (Tsmax to Tp)	3° C/second max.
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (Tsmin to Tsmax) (ts)	 150 °C 180 °C 80-120 seconds
Time maintained above: - Temperature (TL) - Time (tL)	 217~220°C 80-100 seconds
Peak Temperature (Tp)	250~255℃
Time within 5°C of actual Peak Temperature (tp)2	20-40 seconds
Ramp-down Rate	6 °C/second max.
Time 25°C to Peak Temperature	8 minutes max.
Atmosphere	Nitrogen (O2<1000ppm)

- **Table parameters established based on SMIC: M705-GRN360-K2-V (solder paste)**

Caution

(1) Re-soldering should not be done after the LEDs have been soldered. If re-soldering is unavoidable, LED`s characteristics should be carefully checked before and after such repair.
(2) Do not put stress on the LEDs during heating.
(3) After reflow, do not warp the circuit board.
(4) After reflow, do not clean PCB by water or solvent.
(5) We recommend on/off(@0.1~1mA)

Recommendation

(1) We recommend TOV/IR Test 1.8v~2.1v at 1uA (per LED)

During the reflow heating process, the state and action of the solder paste change more or less as follows :

1) First Ramp-up :

By elevating the temperature, flux starts evaporating. Evaporation rates differ depending on the boiling point of each flux employed. In general, the softening point of solder paste is at around 100 ℃. Thus, when the ramp-up rate is too steep, it softens the solid of the flux whilst a large portion of the flux remains and makes the solder paste watery, and can be cause of slumping → solder beading and bridging.

2) Pre-heat stage :

This stage is required to volatize the flux completely and distribute the heat uniformity to the substrate. The flux becomes soft like liquid, and uniformly encapsulates the solder particles and spread over the substrate, preventing them from being re-oxidized. Also, along with the elevation of temperature and liquefaction of the flux, start eliminating the oxide film formed on the surface of each solder particle and the substrate. Once pre-heat stage is not sufficient, issues might be occurred like cold joint.

3) Second Ramp-up and Near Peak Temperature

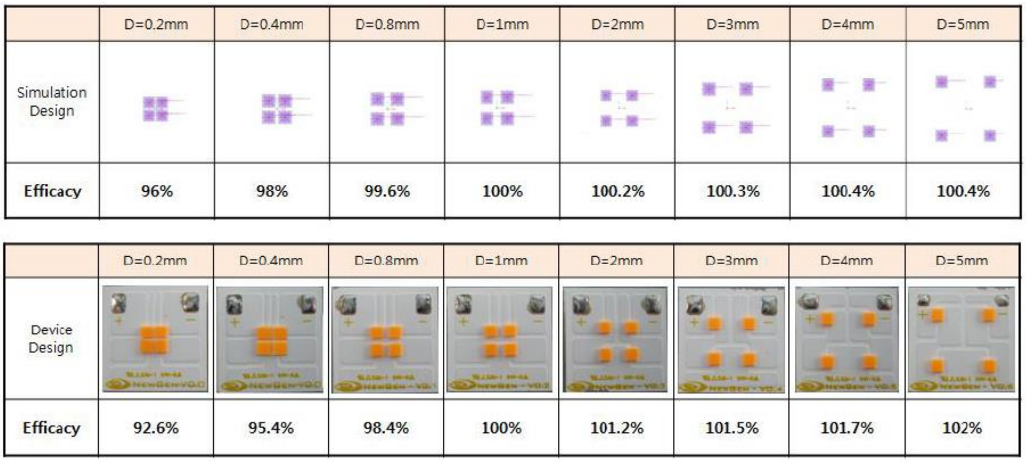
When solder particles melt by reaching their melting point, in reaction with the flux medium, oxide gets eliminated and soldering takes place. A reason why the condition ‘within 5°C of actual Peak Temperature’ is recommended is to secure complete melting of the solder and certain wetting time is required in case some high heat capacity components are mounted.

5. WICOP Array Guide

Seoul Semiconductor recommends a minimum edge to edge spacing between WICOP of 0.2mm. Placing multiple WICOP too close to each other may adversely impact the ability of the PCB to dissipate the heat from the LEDs.

5.1 Efficacy dependency on die spacing

The efficacy of a WICOP array depends on die spacing. There is efficacy loss due to optical absorption by adjacent LEDs. The data indicates above 1mm between die spacing, the efficacy variation is saturated (Figure 11).
For this test case, the WICOP array was operated at 2W/Pkg. The PCB used was a 1.5mm thick Al-MCPCB, 15mm X 15mm size board with 2oz copper.



	D=0.2mm	D=0.4mm	D=0.8mm	D=1mm	D=2mm	D=3mm	D=4mm	D=5mm
Simulation Design								
Efficacy	96%	98%	99.6%	100%	100.2%	100.3%	100.4%	100.4%

	D=0.2mm	D=0.4mm	D=0.8mm	D=1mm	D=2mm	D=3mm	D=4mm	D=5mm
Device Design								
Efficacy	92.6%	95.4%	98.4%	100%	101.2%	101.5%	101.7%	102%

Figure 11. Simulation and device configurations

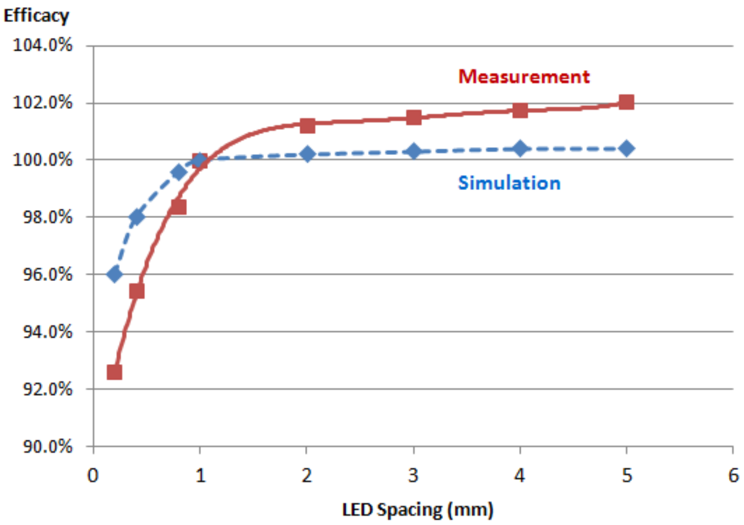


Figure 12. Simulation and Device test results.

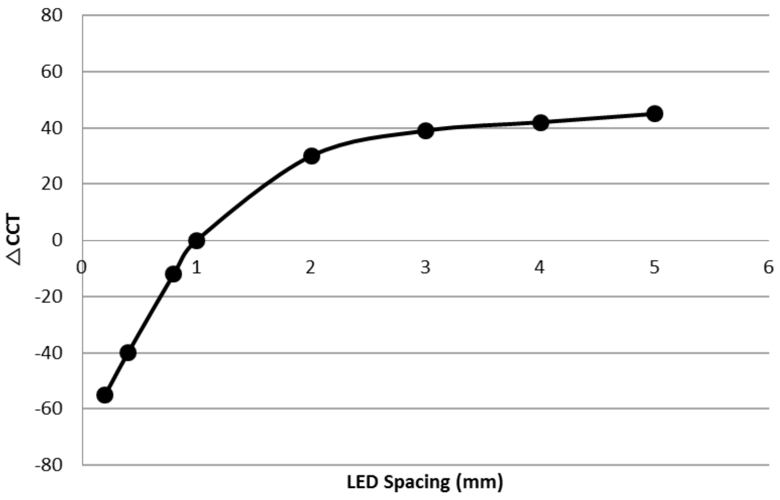


Figure 13. Device test results.

The results of a simulation based on optical absorption by adjacent WICOP and actual measurements are shown in Figure 12 and Figure 13. The losses shown in the simulation do not take into account thermal effects only simulate the cross talk between the LEDs. The measurement were taken at 25°C with pulse condition with 2W operation. Simulation and device measurement results show some difference, but the efficacy variation trend is similar. This measured difference can be attributed to small differences in the LED flux or the assembly process.

The results can apply to all of the WICOP PKG.
◆ Applicable Series Model Numbers.
* SZ8-Y11-Wx-Cx-A / SZ8-Y11-Wx-Cx-B / SZ8-Y11-Wx-Cx-C
* SZ8-Y15-Wx-Cx / SZ8-Y19-Wx-Cx / SZ8-Y22-Wx-Cx

5.2 Junction temperature dependency on die spacing

Placing multiple WICOP too close to each other may also adversely impact the ability of the PCB to dissipate the heat from the LEDs. Board configurations with numbers of closely packed WICOP may require additional thermal modeling to determine the junction temperature. Figures 14 and 15 show the thermal simulation results of various LED spacing.

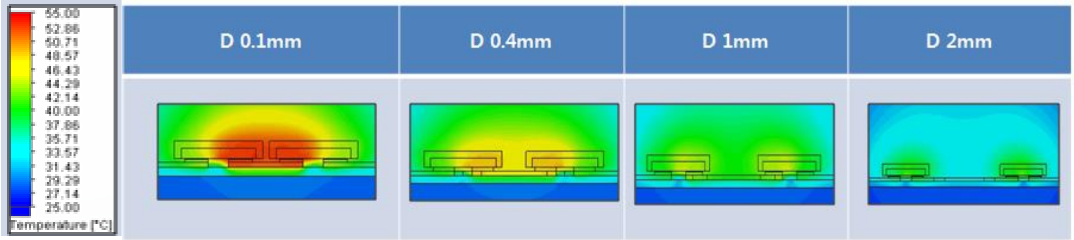
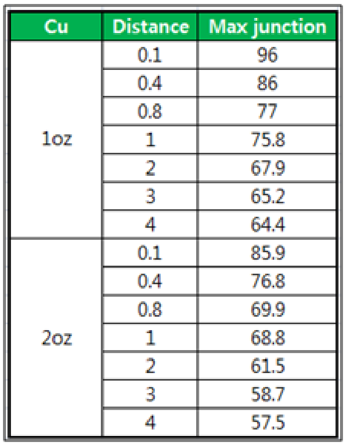


Figure 14. Thermal simulation configurations.



Cu	Distance	Max junction
1oz	0.1	96
	0.4	86
	0.8	77
	1	75.8
	2	67.9
	3	65.2
	4	64.4
2oz	0.1	85.9
	0.4	76.8
	0.8	69.9
	1	68.8
	2	61.5
	3	58.7
	4	57.5

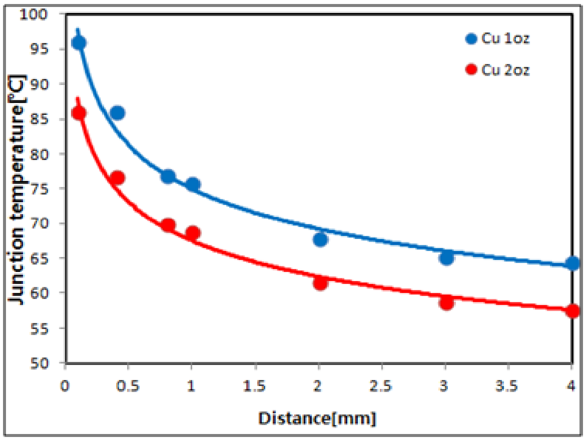
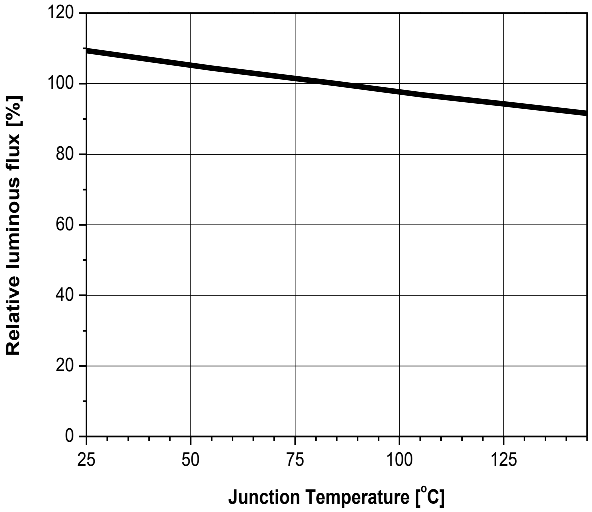


Figure 15. Thermal simulation results depend on WICOPs' distance.

6. WICOP Characteristics Graph

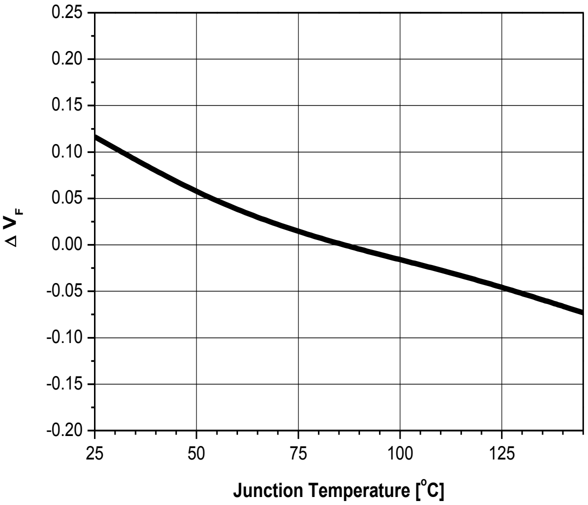
6.1 WICOP Z8Y22 Characteristics Graph

◆ Junction Temperature vs. Relative Luminous Output , Current = 700mA



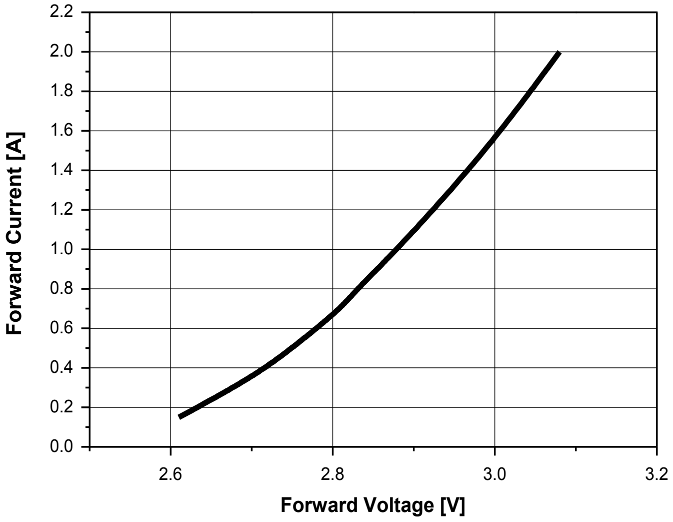
Response: Flux vs Temperature	
Temperature	Relative Flux[%]
25	109.4
55	104.4
85	100
105	96.9
125	94.3
145	91.6

◆ Junction Temperature vs. Relative Forward Voltage , Current = 700mA



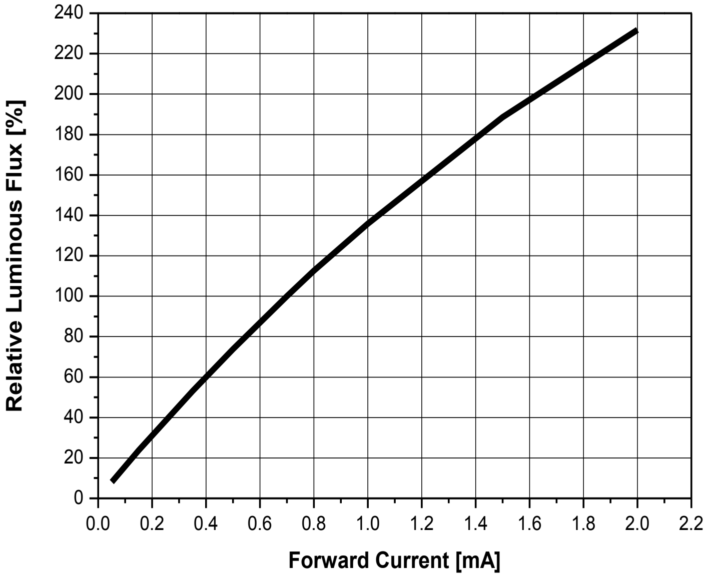
Response: VF vs Temperature	
Temperature	Relative Voltage
25	0.12
55	0.04
85	0
100	-0.02
125	-0.05
145	-0.07

◆ Forward Current vs. Forward Voltage , TJ = 85℃



Response: Voltage vs Current	
Voltage	Current [mA]
2.61	150
2.70	350
2.75	500
2.81	700
2.83	800
2.88	1000
2.99	1500
3.08	2000

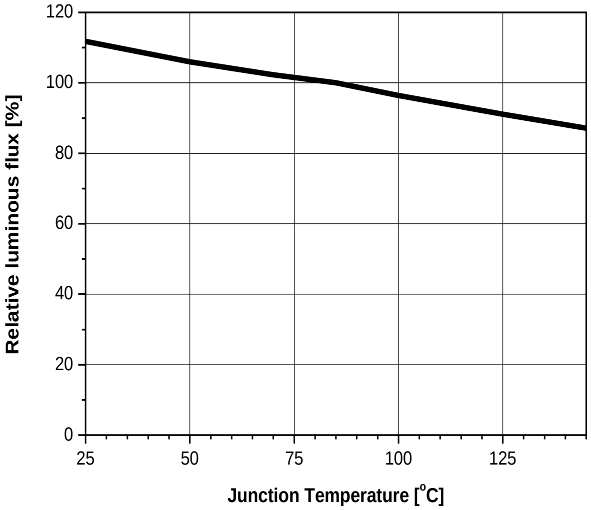
◆ Forward Current vs. Relative Luminous Flux , TJ = 85℃



Response: Flux vs Current	
Current [mA]	Relative Flux[%]
150	23.9
350	53.1
500	73.9
700	100
800	112.6
1000	135.9
1500	188.6
2000	231.8

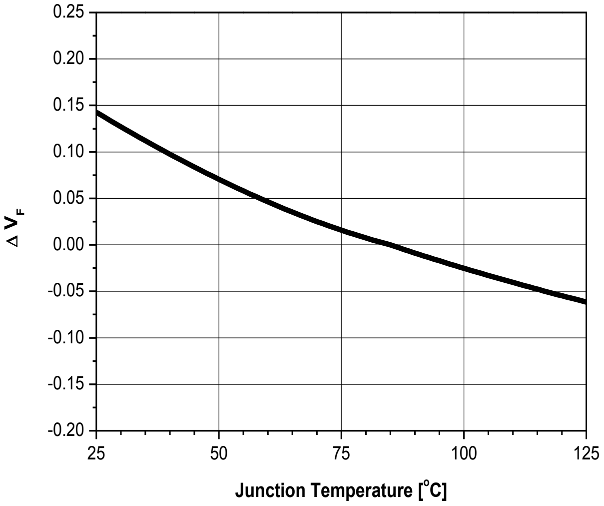
6.2 WICOP Z8Y19 Characteristics Graph

◆ Junction Temperature vs. Relative Luminous Output , Current = 700mA



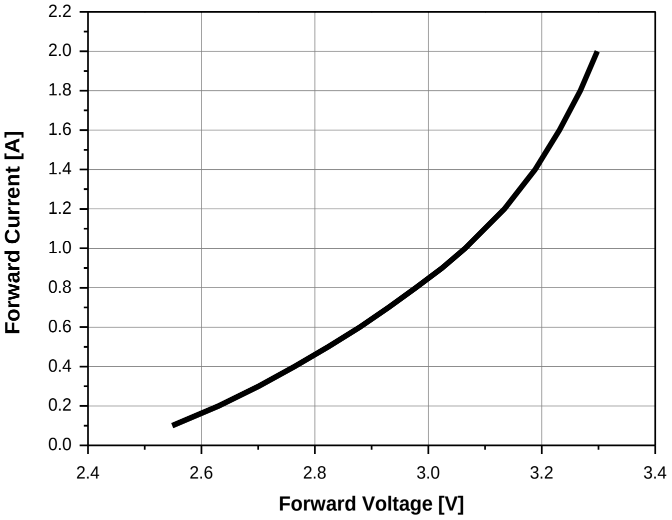
Response: Flux vs Temperature	
Temperature	Relative Flux[%]
25	111.8
50	106.0
70	102.3
85	100
100	96.4
125	91.1
145	87.1

◆ Junction Temperature vs. Relative Forward Voltage , Current = 700mA



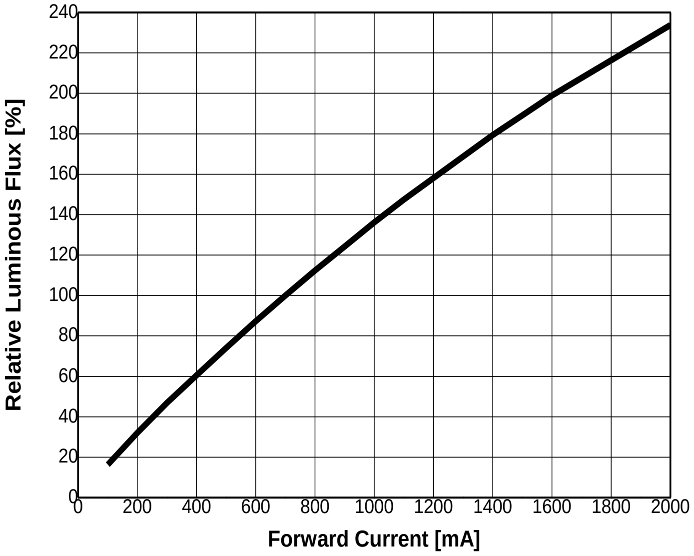
Response: VF vs Temperature	
Temperature	Relative Voltage
25	0.14
50	0.06
70	0.02
85	0
100	-0.03
125	-0.06
145	-0.09

◆ Forward Current vs. Forward Voltage , TJ = 85℃



Response: Voltage vs Current	
Voltage	Current [mA]
2.55	100
2.70	300
2.82	500
2.93	700
3.07	1000
3.19	1400
3.23	1600
3.27	1800
3.30	2000

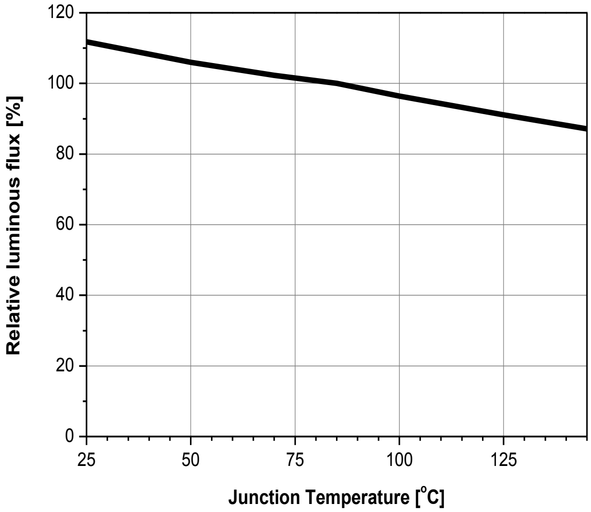
◆ Forward Current vs. Relative Luminous Flux , TJ = 85℃



Response: Flux vs Current	
Current [mA]	Relative Flux[%]
100	16.2
300	46.9
500	74.1
700	100
1000	136.1
1400	179.4
1600	198.9
1800	216.3
2000	233.7

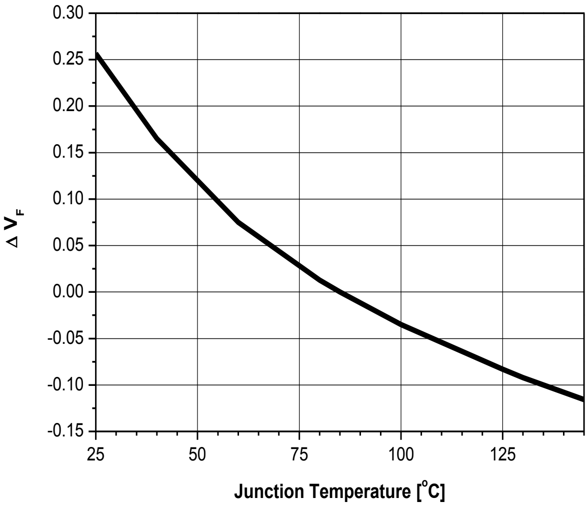
6.3 WICOP Z8Y15 Characteristics Graph

◆ Junction Temperature vs. Relative Luminous Output , Current = 700mA



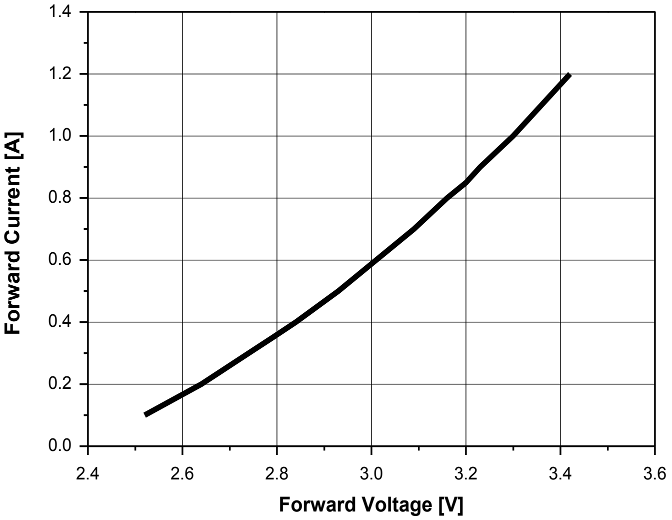
Response: Flux vs Temperature	
Temperature	Relative Flux[%]
25	111.8
50	106.0
70	102.3
85	100
100	96.4
125	91.1
145	87.1

◆ Junction Temperature vs. Relative Forward Voltage , Current = 700mA



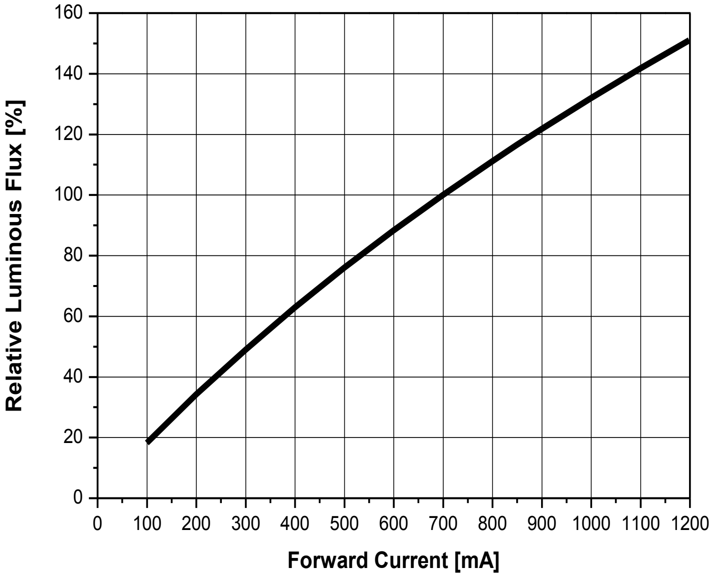
Response: VF vs Temperature	
Temperature	Relative Voltage
25	0.26
40	0.17
60	0.08
80	0.01
85	0
100	-0.04
125	-0.08
145	-0.12

◆ Forward Current vs. Forward Voltage , TJ = 85℃



Response: Voltage vs Current	
Voltage	Current [mA]
2.52	100
2.64	200
2.79	350
2.93	500
3.09	700
3.30	1000
3.36	1100
3.42	1200

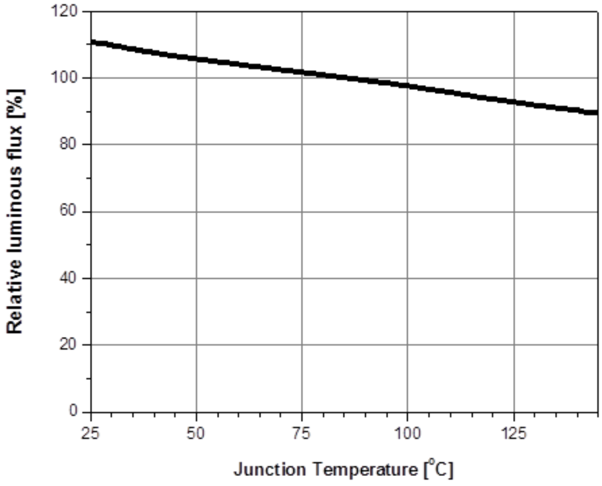
◆ Forward Current vs. Relative Luminous Flux , TJ = 85℃



Response: Flux vs Current	
Current [mA]	Relative Flux[%]
100	18.2
200	34.3
350	56.0
500	76.0
700	100
1000	131.9
1100	141.6
1200	151.0

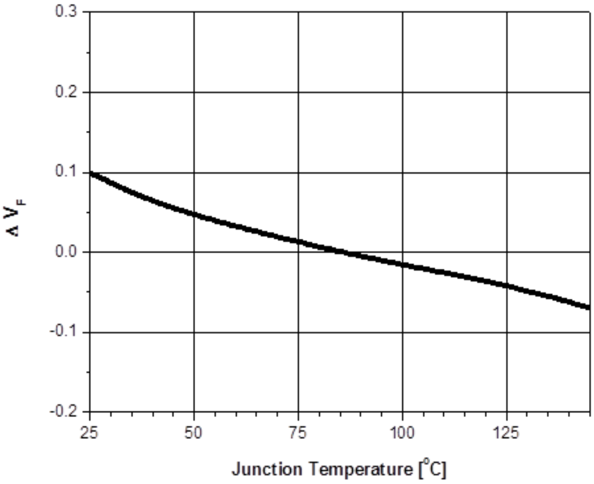
6.4 WICOP Z8Y11-A Characteristics Graph

◆ Junction Temperature vs. Relative Luminous Output , Current = 150mA



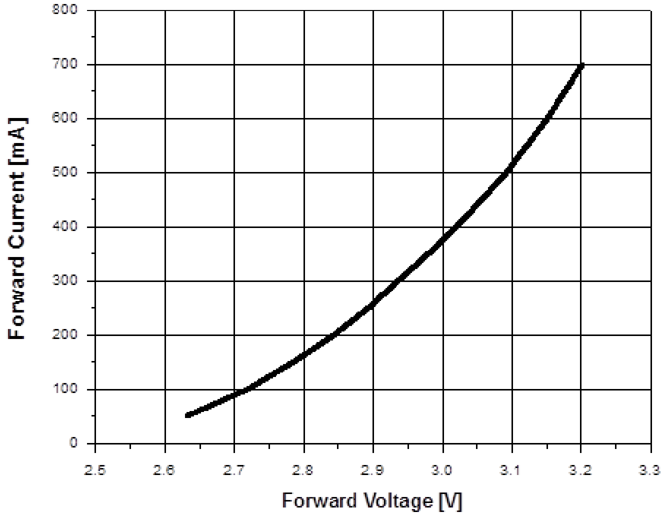
Response: Flux vs Temperature	
Temperature	Relative Flux[%]
25	111.1
40	107.3
60	104.0
85	100
105	97.7
125	92.5
145	89.4

◆ Junction Temperature vs. Relative Forward Voltage , Current = 150mA



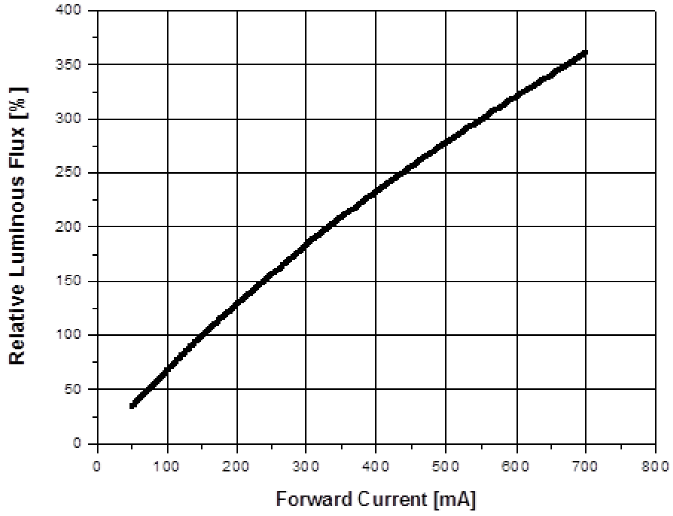
Response: VF vs Temperature	
Temperature	Relative Voltage
25	0.10
40	0.06
60	0.03
85	0
105	-0.02
125	-0.04
145	-0.07

◆ Forward Current vs. Forward Voltage , TJ = 85℃



Response: Voltage vs Current	
Voltage	Current [mA]
2.63	50
2.72	100
2.79	150
2.89	250
2.98	350
3.09	500
3.15	600
3.20	700

◆ Forward Current vs. Relative Luminous Flux , TJ = 85℃



Response: Flux vs Current	
Current [mA]	Relative Flux[%]
50	33.7
100	67.3
150	100.0
200	128.7
300	184.3
350	209.5
500	280.2
700	361.1

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Company Information

Seoul Semiconductor (www.SeoulSemicon.com) manufacturers and packages a wide selection of light emitting diodes (LEDs) for the automotive, general illumination/lighting, Home appliance, signage and back lighting markets. The company is the world’s fifth largest LED supplier, holding more than 10,000 patents globally, while offering a wide range of LED technology and production capacity in areas such as “nPola”, "Acrich", the world’s first commercially produced AC LED, and "Acrich MJT - Multi-Junction Technology" a proprietary family of high-voltage LEDs.

The company’s broad product portfolio includes a wide array of package and device choices such as Acrich and Acirch2, high-brightness LEDs, mid-power LEDs, side-view LEDs, and through-hole type LEDs as well as custom modules, displays, and sensors.

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