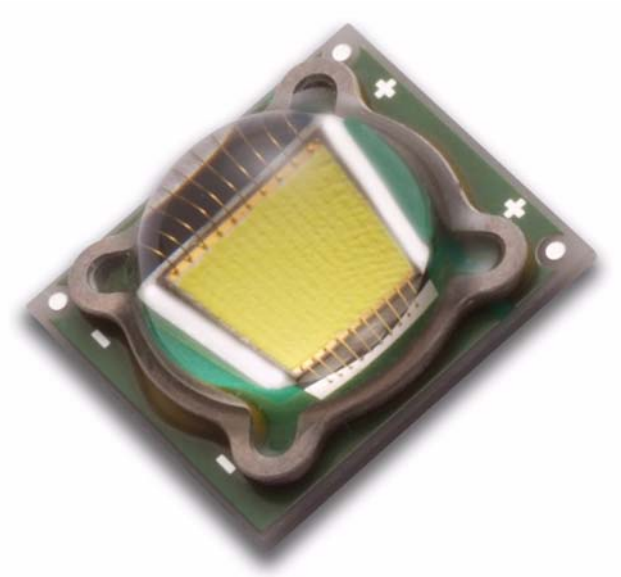
# PhlatLight® White LED Illumination Products

## SST-90 Series



*PhlatLight® LEDs enable a new class of illumination applications.*

### Features

- Extremely high optical output: Over 2,250 lumens from a single chip (white)
- Extremely high efficiency: Over 100 lumens per watt at 350 mA/mm$^2$
- High thermal conductivity package - junction to case thermal resistance of only 0.64 °C/W
- Large, monolithic chip with uniform emitting area of 9 mm$^2$
- Lumen maintenance of greater than 70% after 60,000 hours
- Environmentally friendly: RoHS compliant
- Variable drive currents: less than 1 A through 9 A to full reliability specifications.
- High reliability
- Electrically isolated thermal path

### Applications

- Architectural Lighting
- Retail Lighting
- Residential Lighting
- Consumer Portable
- Spot Lighting
- High Bay Lighting
- Wide Area Lighting
- Street Lighting

### Table of Contents

## Technology Overview

PhlatLight LEDs benefit from a suite of innovations in the fields of chip technology, packaging, and thermal management. These breakthroughs allow illumination designers to achieve efficient light engine designs and deliver high brightness solutions.

### PhlatLight Technology

The name PhlatLight is derived from Photonic Lattice. Photonic lattice technology creates true surface emission from the source, which enables large area LED chips with uniform brightness over the entire LED chip surface. The optical power and brightness produced by these large monolithic chips enable solutions which replace arc and halogen lamps where arrays of traditional high power LEDs cannot.

### Packaging Technology

Thermal management is critical in high power LED applications. With a thermal resistance from junction to case of 0.64°C/W, PhlatLight SST-90 devices have the lowest thermal resistance of any LED on the market. This allows the LED to be driven at higher current densities while maintaining a low junction temperature, thereby resulting in brighter and longer lifetimes. The package is easy to use, and ready to be mounted in the lighting system.

### Reliability

Designed from the ground up, PhlatLight LEDs are one of the most reliable light sources in the world today. PhlatLight LEDs have passed a rigorous suite of environmental and mechanical stress tests, including mechanical shock, vibration, temperature cycling and humidity, and have been fully qualified for use in extreme high power and high current applications. With very low failure rates and median lifetimes that are well above 60,000 hours, PhlatLight LEDs are ready for the most demanding applications.

### Environmental Benefits

PhlatLight LEDs help reduce power consumption and the amount of hazardous waste entering the environment. All PhlatLight products manufactured by Luminus are RoHS compliant and free of hazardous materials, including lead and mercury.

## Understanding PhlatLight Test Specifications

Every PhlatLight LED device is fully tested to ensure that it meets the high quality standards of Luminus' products.

### Multiple Operating Points (3.2 A, 9.0 A)

The tables on the following pages provide typical optical and electrical characteristics. Since the LEDs can be operated over a wide range of drive conditions (currents from less than 1.0 A to 9.0 A, and duty cycle from <1% to 100%) multiple drive conditions are listed.

PhlatLight SST-90 devices are production tested at 3.2 A. The values shown at 9.0 A are for additional reference at other possible drive conditions.

## PhlatLight White Binning Structure

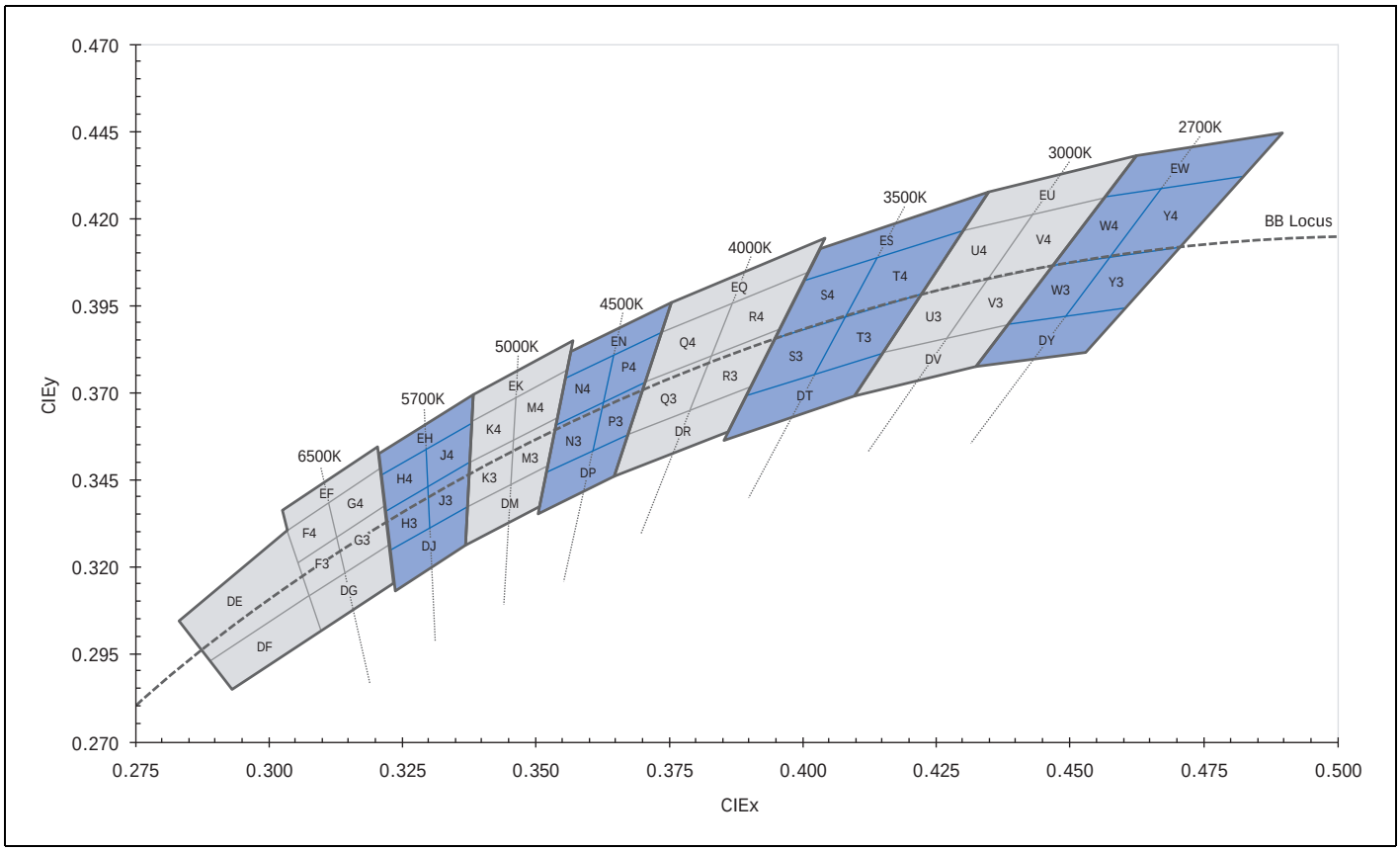
PhlatLight SST-90 White LEDs are tested for luminous flux and chromaticity at a drive current of 3.2 A (0.35 A/mm$^2$) and placed into one of the following luminous flux (FF) and chromaticity (WW) bins:

### Flux Bins

| Color | Flux Bin (FF) | Minimum Flux (lm) @ 3.2 A | Maximum Flux (lm) @ 3.2 A |
|---|---|---|---|
| **W65S** 6500K, Standard CRI (typ. 70) | WK | 600 | 700 |
| | WL | 700 | 850 |
| | WM | 850 | 1,000 |
| | WN | 1,000 | 1,200 |
| **W57S** 5700K, Standard CRI (typ. 70) | WK | 600 | 700 |
| | WL | 700 | 850 |
| | WM | 850 | 1,000 |
| | WN | 1,000 | 1,200 |
| **W45S** 4500K, Standard CRI, (typ. 70) | WJ | 500 | 600 |
| | WK | 600 | 700 |
| | WL | 700 | 850 |
| | WM | 850 | 1,000 |
| **W40M** 4000K, Moderate CRI, (typ. 83) | WJ | 500 | 600 |
| | WK | 600 | 700 |
| | WL | 700 | 850 |
| | WM | 850 | 1,000 |
| **W30M** 3000K, Moderate CRI, (typ. 83) | WH | 425 | 500 |
| | WJ | 500 | 600 |
| | WK | 600 | 700 |
| | WL | 700 | 850 |

## Chromaticity Bins

Luminus' Standard Chromaticity Bins: 1931 CIE Curve



The following tables describe the four chromaticity points that bound each chromaticity bin. Chromaticity bins are grouped together based on the color temperature.

| 6500K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| DG | 0.307 | 0.311 |
| | 0.322 | 0.326 |
| | 0.323 | 0.316 |
| | 0.309 | 0.302 |
| F3* | 0.305 | 0.321 |
| | 0.313 | 0.329 |
| | 0.315 | 0.319 |
| | 0.307 | 0.311 |
| F4* | 0.303 | 0.330 |
| | 0.312 | 0.339 |
| | 0.313 | 0.329 |
| | 0.305 | 0.321 |
| G3* | 0.313 | 0.329 |
| | 0.321 | 0.337 |
| | 0.322 | 0.326 |
| | 0.315 | 0.319 |
| G4* | 0.312 | 0.339 |
| | 0.321 | 0.348 |
| | 0.321 | 0.337 |
| | 0.313 | 0.329 |
| EF | 0.302 | 0.335 |
| | 0.320 | 0.354 |
| | 0.321 | 0.348 |
| | 0.303 | 0.330 |
| DE | 0.283 | 0.304 |
| | 0.303 | 0.330 |
| | 0.307 | 0.311 |
| | 0.289 | 0.293 |
| DF | 0.289 | 0.293 |
| | 0.307 | 0.311 |
| | 0.309 | 0.302 |
| | 0.293 | 0.285 |

| 5700K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| DJ | 0.322 | 0.324 |
| | 0.337 | 0.337 |
| | 0.336 | 0.326 |
| | 0.323 | 0.314 |
| H3* | 0.321 | 0.335 |
| | 0.329 | 0.342 |
| | 0.329 | 0.331 |
| | 0.322 | 0.324 |
| H4* | 0.321 | 0.346 |
| | 0.329 | 0.354 |
| | 0.329 | 0.342 |
| | 0.321 | 0.335 |
| J3* | 0.329 | 0.342 |
| | 0.337 | 0.349 |
| | 0.337 | 0.337 |
| | 0.330 | 0.331 |
| J4* | 0.329 | 0.354 |
| | 0.338 | 0.362 |
| | 0.337 | 0.349 |
| | 0.329 | 0.342 |
| EH | 0.320 | 0.352 |
| | 0.338 | 0.368 |
| | 0.338 | 0.362 |
| | 0.321 | 0.346 |

| 5000K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| EK | 0.338 | 0.368 |
| | 0.356 | 0.384 |
| | 0.355 | 0.376 |
| | 0.338 | 0.362 |
| K3* | 0.337 | 0.349 |
| | 0.345 | 0.355 |
| | 0.345 | 0.343 |
| | 0.337 | 0.337 |
| K4* | 0.338 | 0.362 |
| | 0.347 | 0.369 |
| | 0.345 | 0.355 |
| | 0.337 | 0.349 |
| M3* | 0.345 | 0.355 |
| | 0.353 | 0.362 |
| | 0.352 | 0.349 |
| | 0.344 | 0.343 |
| M4* | 0.346 | 0.369 |
| | 0.355 | 0.376 |
| | 0.353 | 0.362 |
| | 0.345 | 0.355 |
| DM | 0.337 | 0.337 |
| | 0.352 | 0.349 |
| | 0.350 | 0.337 |
| | 0.336 | 0.326 |

* Sub-bins within ANSI defined quadrangles per ANSI C78.377-2008

| 4500k Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| EN | 0.356 | 0.384 |
| | 0.376 | 0.396 |
| | 0.374 | 0.387 |
| | 0.355 | 0.374 |
| N3* | 0.353 | 0.360 |
| | 0.361 | 0.366 |
| | 0.359 | 0.352 |
| | 0.351 | 0.347 |
| N4* | 0.355 | 0.374 |
| | 0.364 | 0.381 |
| | 0.361 | 0.366 |
| | 0.353 | 0.360 |
| P3* | 0.361 | 0.366 |
| | 0.370 | 0.373 |
| | 0.367 | 0.358 |
| | 0.359 | 0.352 |
| P4* | 0.364 | 0.381 |
| | 0.374 | 0.387 |
| | 0.370 | 0.373 |
| | 0.361 | 0.366 |
| DP | 0.351 | 0.347 |
| | 0.367 | 0.358 |
| | 0.364 | 0.346 |
| | 0.350 | 0.335 |

| 4000K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| EQ | 0.376 | 0.396 |
| | 0.404 | 0.414 |
| | 0.401 | 0.404 |
| | 0.374 | 0.387 |
| Q3* | 0.370 | 0.373 |
| | 0.382 | 0.380 |
| | 0.378 | 0.365 |
| | 0.367 | 0.358 |
| Q4* | 0.374 | 0.387 |
| | 0.387 | 0.396 |
| | 0.382 | 0.380 |
| | 0.370 | 0.373 |
| R3* | 0.382 | 0.380 |
| | 0.395 | 0.388 |
| | 0.390 | 0.372 |
| | 0.378 | 0.365 |
| R4* | 0.387 | 0.396 |
| | 0.401 | 0.404 |
| | 0.395 | 0.388 |
| | 0.382 | 0.380 |
| DR | 0.367 | 0.358 |
| | 0.390 | 0.372 |
| | 0.386 | 0.359 |
| | 0.364 | 0.346 |

| 3500K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| ES | 0.403 | 0.411 |
| | 0.435 | 0.427 |
| | 0.430 | 0.417 |
| | 0.400 | 0.402 |
| S3* | 0.394 | 0.385 |
| | 0.407 | 0.392 |
| | 0.402 | 0.375 |
| | 0.389 | 0.369 |
| S4* | 0.400 | 0.402 |
| | 0.415 | 0.409 |
| | 0.407 | 0.392 |
| | 0.394 | 0.385 |
| T3* | 0.407 | 0.392 |
| | 0.422 | 0.399 |
| | 0.415 | 0.381 |
| | 0.402 | 0.375 |
| T4* | 0.415 | 0.409 |
| | 0.430 | 0.417 |
| | 0.422 | 0.399 |
| | 0.407 | 0.392 |
| DT | 0.389 | 0.369 |
| | 0.415 | 0.381 |
| | 0.409 | 0.369 |
| | 0.385 | 0.357 |

| 3000K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| EU | 0.435 | 0.427 |
| | 0.462 | 0.437 |
| | 0.456 | 0.426 |
| | 0.430 | 0.417 |
| U3* | 0.422 | 0.399 |
| | 0.434 | 0.403 |
| | 0.426 | 0.385 |
| | 0.415 | 0.381 |
| U4* | 0.430 | 0.417 |
| | 0.443 | 0.421 |
| | 0.434 | 0.403 |
| | 0.422 | 0.399 |
| V3* | 0.434 | 0.403 |
| | 0.447 | 0.408 |
| | 0.437 | 0.389 |
| | 0.426 | 0.385 |
| V4* | 0.443 | 0.421 |
| | 0.456 | 0.426 |
| | 0.447 | 0.408 |
| | 0.434 | 0.403 |
| DV | 0.415 | 0.381 |
| | 0.437 | 0.389 |
| | 0.431 | 0.377 |
| | 0.409 | 0.369 |

| 2700K Chromaticity Bins | | |
|---|---|---|
| Bin Code (WW) | CIEx | CIEy |
| EW | 0.462 | 0.437 |
| | 0.488 | 0.444 |
| | 0.481 | 0.432 |
| | 0.456 | 0.426 |
| W3* | 0.447 | 0.408 |
| | 0.458 | 0.410 |
| | 0.448 | 0.392 |
| | 0.437 | 0.389 |
| W4* | 0.456 | 0.426 |
| | 0.469 | 0.429 |
| | 0.458 | 0.410 |
| | 0.447 | 0.408 |
| Y3* | 0.458 | 0.410 |
| | 0.470 | 0.413 |
| | 0.459 | 0.394 |
| | 0.448 | 0.392 |
| Y4* | 0.469 | 0.429 |
| | 0.481 | 0.432 |
| | 0.470 | 0.413 |
| | 0.458 | 0.410 |
| DY | 0.437 | 0.389 |
| | 0.459 | 0.394 |
| | 0.452 | 0.382 |
| | 0.431 | 0.377 |

* Sub-bins within ANSI defined quadrangles per ANSI C78.377-2008

## PhlatLight Product Shipping and Labeling Information

All PhlatLight products are packaged and labeled with their respective bin as outlined in the tables on pages 3 and 4. When shipped, each package will only contain one bin. The part number designation is as follows:

**SST** —— **90** —— **WNNX** —— **F11** —— **FF** —— **WW**

| Product Family | Chip Area | Color | Package Configuration | Flux Bin | Chromaticity Bin |
|---|---|---|---|---|---|
| SST:Surface mount | 90: 9.0 $mm^2$ | WNNX: CCT and CRI<br>See Note 1 Below | F11: 10 x 11mm emitter | See page 3 for bins | See pages 4-5 for bins |

Note 1. WNNX nomenclature corresponds to the following:
W = White
NN = color temperature, where:
65 corresponds to 6500K
40 corresponds to 4000K
30 corresponds to 3000K, etc.
X = color rendering index, where:
S (standard) corresponds to a typical CRI of 70
M (moderate) corresponds to a typical CRI of 83
H (high) corresponds to a typical CRI of 92.

Note 2. Some flux and chromaticity bins may have limited availability. Application specific bin kits, consisting of multiple bins, may be available. For ordering information, please refer to page 14 and reference the PhlatLight Binning and Labeling document.

Example: The part label SST-90-W65S-F11-WN-G4 refers to a 6500K standard CRI white, SST-90 emitter, F11 package configuration, with a flux range of 1,000 to 1,200 lumens and a chromaticity value within the box defined by the four points (0.313, 0.338), (0.321, 0.348), (0.322, 0.336), (0.312, 0.328).

Example: The part label SST-90-W30M-F11-WL-U3 refers to a 3000K moderate CRI white, SST-90 emitter, F11 package configuration, with a flux range of 700 to 850 lumens and a chromaticity value within the box defined by the four points (0.422, 0.399), (0.434, 0.403), (0.426, 0.386), (0.415, 0.381).

## Optical and Electrical Characteristics[1]

| White | | | | |
|---|---|---|---|---|
| **Drive Condition[2]** | | **3.2 A** | **9.0 A** | |
| **Parameter** | **Symbol** | **Typical Values at Test Current** | **Values at Indicated Currents[3]** | **Unit** |
| Current Density | j | 0.35 | 1.0 | $A/mm^2$ |
| Forward Voltage | $V_F$ | 3.2 | 3.6 | V |
| Luminous Flux | $\Phi_{V\ typ}$ | 1,000 | 2,250 | lm |

## Common Characteristics

| | **Symbol** | **Values** | **Unit** |
|---|---|---|---|
| Emitting Area | | 9.0 | $mm^2$ |
| Emitting Area Dimensions | | 3 x 3 | mmxmm |
| Forward Voltage Temperature Coefficient[4] | | -2.45 | mV/ºC |

## Absolute Maximum Ratings

| | **Symbol** | **Values** | **Unit** |
|---|---|---|---|
| Maximum Current[5] | | 9 | A |
| Maximum Junction Temperature[6] | $T_{j\text{-}max}$ | 150 | ºC |
| Storage Temperature Range | | -40/+100 | ºC |

*Note 1: All ratings are based on test conditions of Tj=25C, 20 millisecond pulse. See Thermal Resistance section for Tj definition.*

*Note 2: Listed drive conditions are typical for common applications. PhlatLight SST-90-W devices can be driven at currents ranging from <1A to 9A and at duty cycles ranging from <1% to 100%. Drive current and duty cycle should be adjusted as necessary to maintain the junction temperature desired to meet application lifetime requirements.*

*Note 3: Unless otherwise noted, values listed are typical.*

*Note 4: Forward voltage temperature coefficient at current density of 0.35 A/mm2. Contact Luminus for value at other drive conditions.*

*Note 5: Luminus PhlatLight SST-90-W LEDs are designed for operation to an absolute maximum forward drive current density of 1.0 A/mm2. Product lifetime data is specified at recommended forward drive currents. Sustained operation at absolute maximum currents will result in a reduction of device lifetime compared to recommended forward drive currents. Actual device lifetimes will also depend on junction temperature. Refer to the lifetime derating curves for further information. In pulsed operation, rise time from 10-90% of forward current should be larger than 0.5 microseconds.*

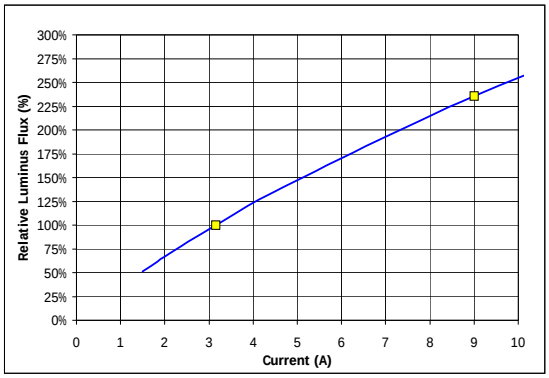
*Note 6: Lifetime dependent on LED junction temperature . Thermal calculations based on input power and thermal management system should be performed to ensure Tj is maintained below Tjmax rating or life may be reduced. Refer to lifetime plots on pg 8 and lifetime and reliability application note for further information.*

*Note 7: CIE measurement uncertainty for white devices is estimated to be +/- 0.01.*

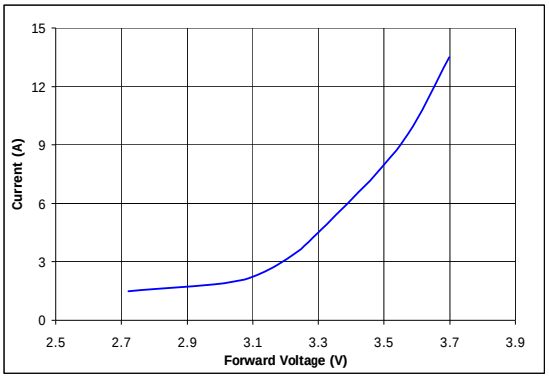
*Note 8: Special design considerations must be observed for operation under 1 A. Please contact Luminus for further information.*

*Note 9: Caution must be taken not to stare at the light emitted from these LEDs. Under special circumstances, the high intensity could damage the eye.*

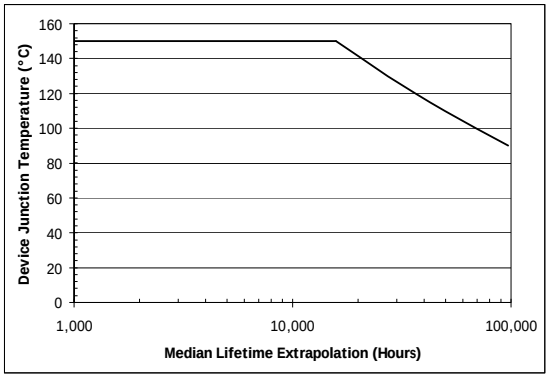
## Relative Output Flux vs. Forward Current[1]



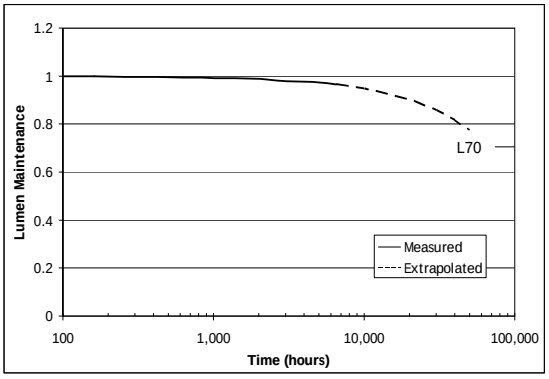

## Forward Current vs. Forward Voltage



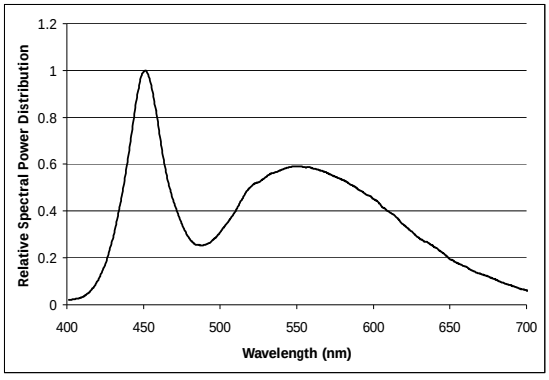

## Mean Lifetime[2]



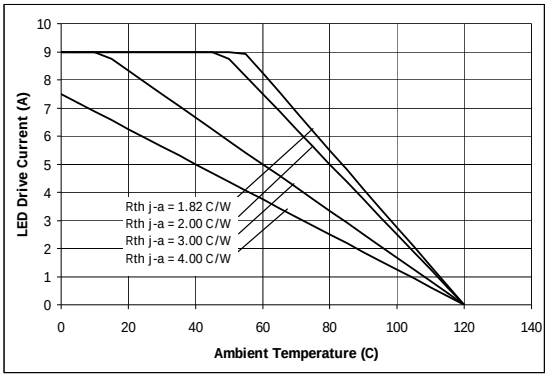

## Lumen Maintenance vs. Time[3]




## Typical Spectrum[4]



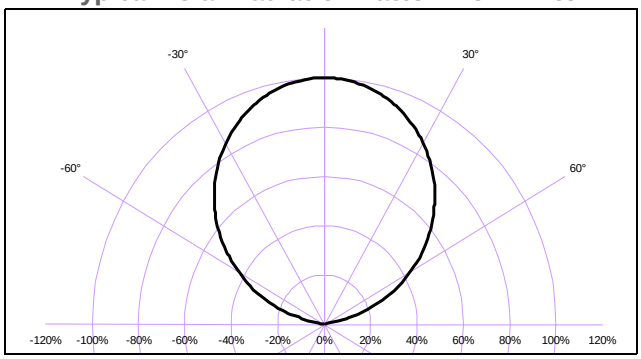

## Current Derating Curve



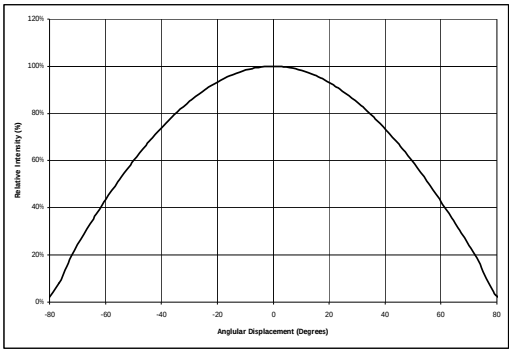

1. *Yellow squares indicate typical operating conditions.*
2. *Mean expected lifetime in dependence of junction temperature at 0.35 A/mm$^2$ in continuous operation. Lifetime defined as time to 70% of initial intensity. Based on lifetime test data of uncoated GaN devices at this time. Data can be used to model failure rate over typical product lifetime.*
3. *Lumen maintenance in dependence of time at 0.35 A/mm$^2$ in continuous operation with junction temperatures of 100 $^{o}$C.*
4. *Typical spectrum at current density of 0.35 A/mm$^2$ in continuous operation.*

## Typical Radiation Pattern

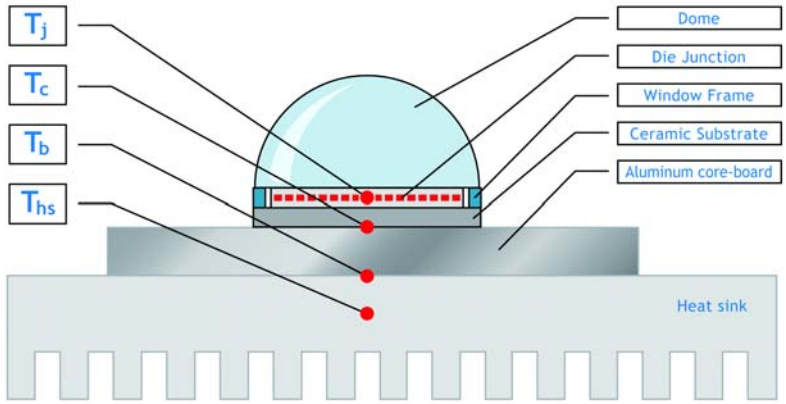
### Typical Polar Radiation Pattern for White




### Typical Angular Radiation Pattern for White




## Thermal Resistance




*$T_{hs}$ definition = 3 mm from core-board*

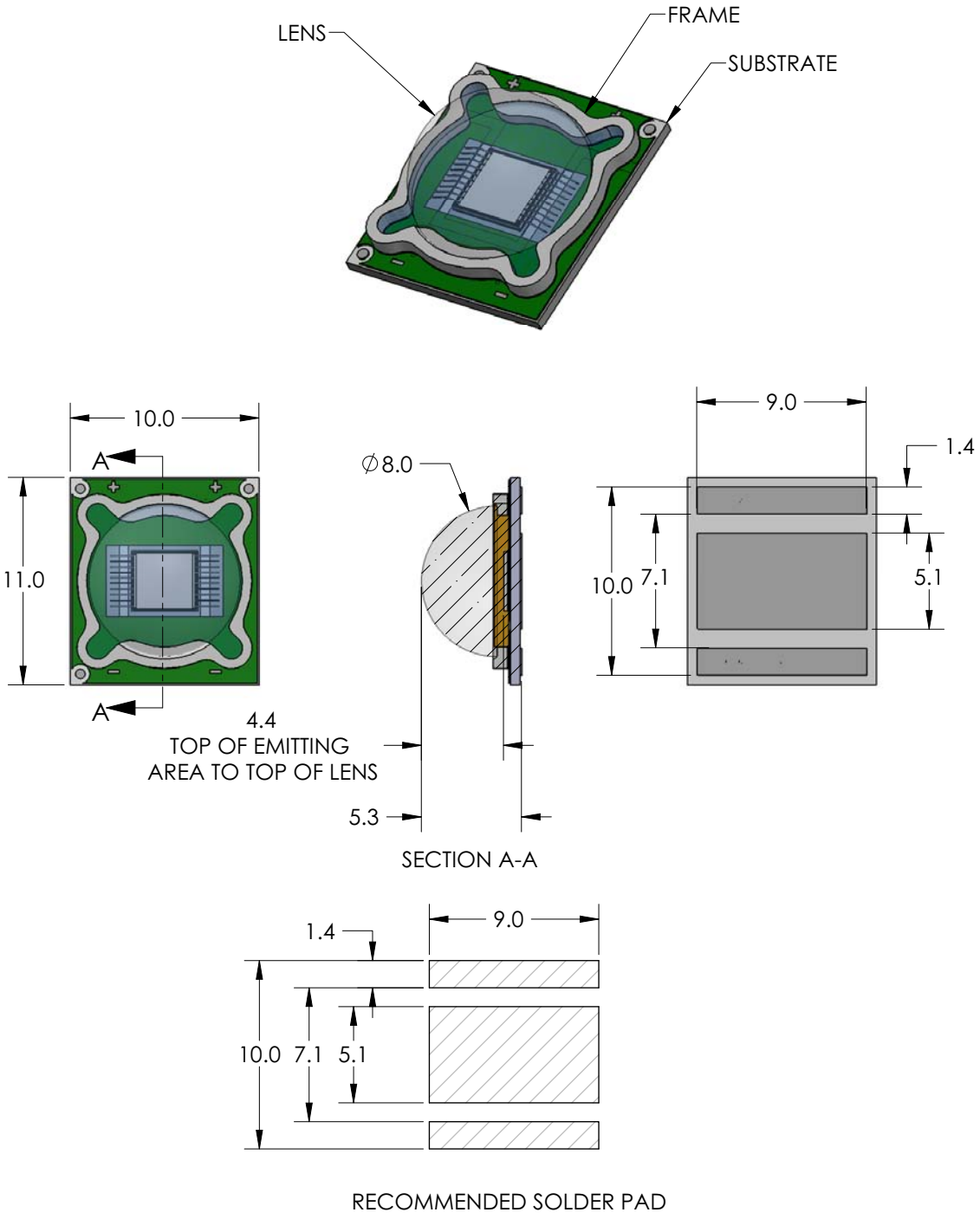
### Typical Thermal Resistance

| | |
|---|---|
| $R_{j\text{-}c}$ [1] | 0.64 ºC/W |
| $R_{j\text{-}b}$ [1] | 2.02 °C/W |
| $R_{j\text{-}hs}$ [2] | 2.15 ºC/W |

*Note 1: Thermal resistance values are based on FEA model results correlated to measured $R_{\theta j\text{-}hs}$ data.*

*Note 2: Thermal resistance is measured using a SAC305 solder, an Al-clad MCPCB, and eGraf 1205 thermal interface material.*

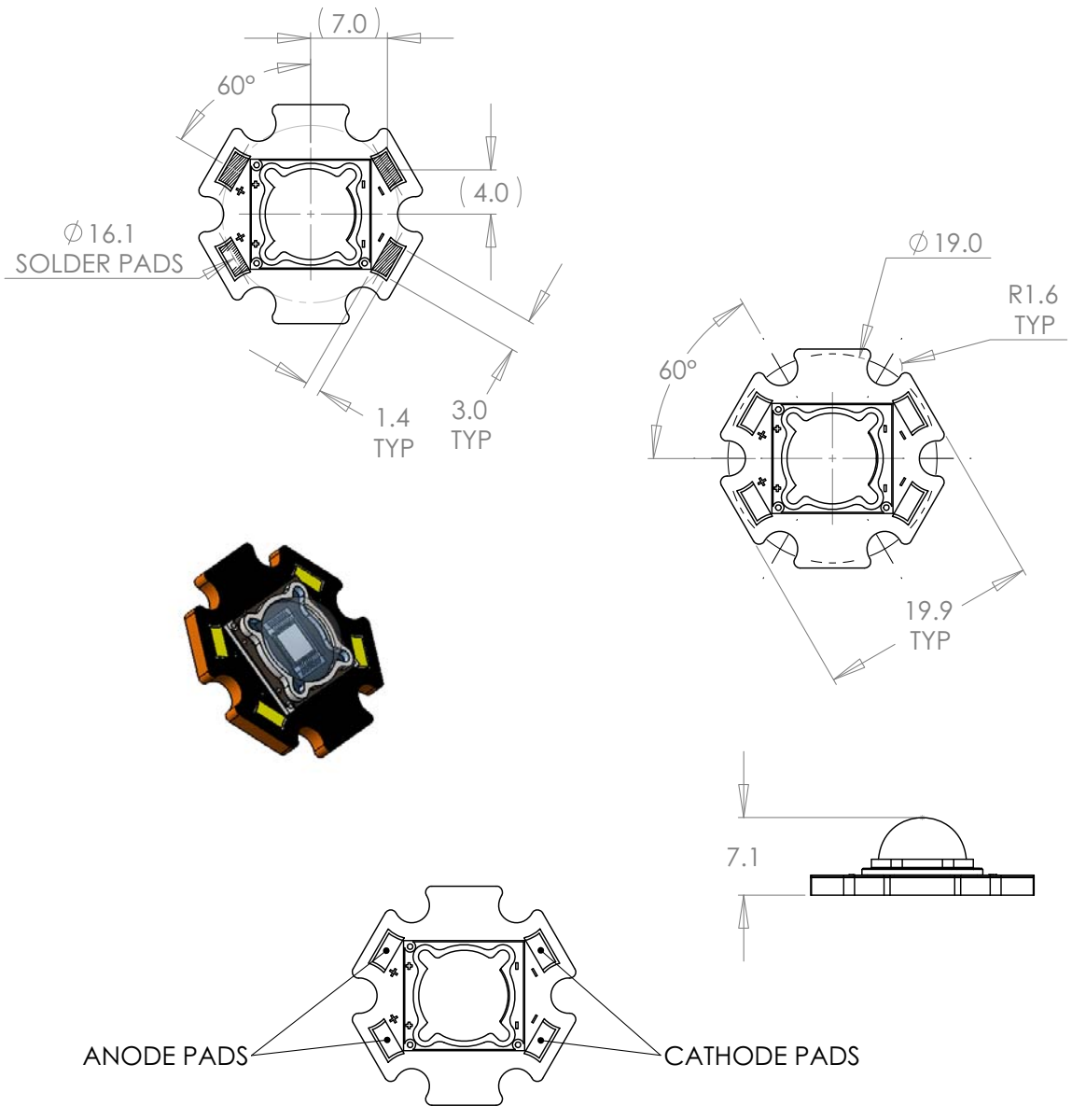
## Mechanical Dimensions - SST-90 Emitter




For detailed drawing please refer to DWG-001359 document

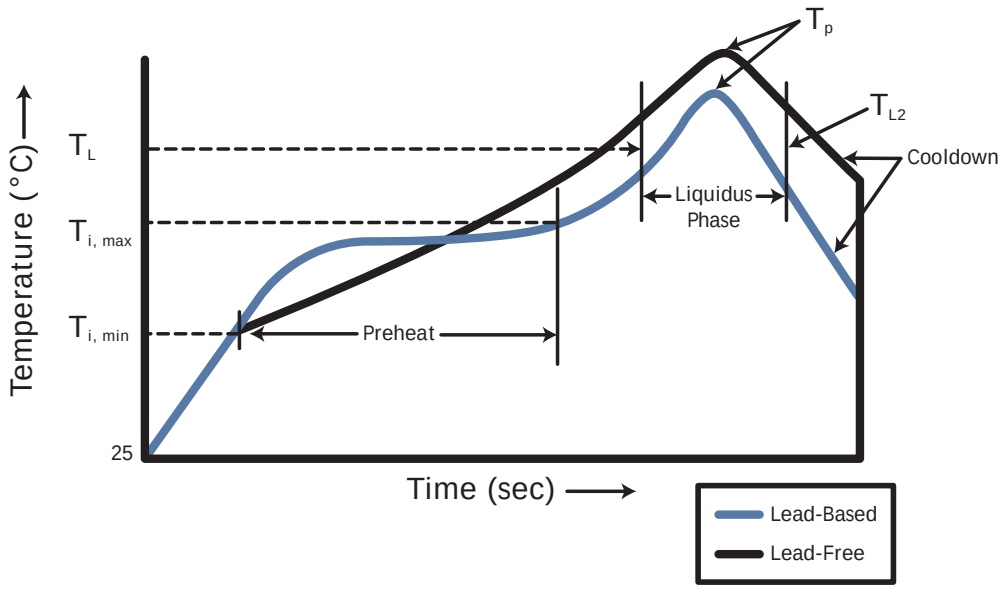
## Mechanical Dimensions - SST-90 Star

PhlatLight SST-90-W devices are available on a star board for prototyping purposes. Please see page 14 for ordering information.




Notes:
1. Recommended mounting screw: M3 or #4
2. All dimensions in millimeters
3. All anode pads on board are interconnected. All cathode pads on board are interconnected

## Solder Profile




| Solder Profile Stage | Lead-Free Solder | Lead-Based Solder |
|---|---|---|
| Rate of Rise | 2°C/sec max | 2°C/sec max |
| Preheat Min Temp ($T_{i,min}$) | 100°C | 120°C |
| Preheat Max Temp ($T_{i,max}$) | 175°C | 130°C |
| Preheat Time ($T_i$,min to $T_{i,max}$) | 90 seconds | 120 seconds |
| Liquidus Min Temp: ($T_L$) | 185°C | 160°C |
| Liquidus to Liquidus Time ($T_L$ to $T_{L2}$) | 30-60 seconds | 30 seconds |
| Liquidus Peak Temp ($T_p$) | 240°C max | 220°C max |
| Cooldown | ≤ 4°C/sec | ≤ 6°C/sec |
| Profile Length (Ambient to Peak) | 4 min | 3.5 - 4 min |

1. *Temperatures are taken and monitored at the component copper layer*
2. *Optimum profile may differ due to oven type, circuit board or assembly layout*
3. *Recommended lead free, no-clean solder: AIM NC254-SAC305*
4. *Refer to soldering and handling application note for further information.*

## Ordering Information

| Ordering Part Number[1,2] | Color | Description |
|---|---|---|
| SST-90-W65S-F11-GK100 | 6500K White | White PhlatLight SST-90 surface mount device consisting of a domed 9mm$^2$ LED mounted on a ceramic substrate. |
| SST-90-W57S-F11-GK200 | 5700K White | White PhlatLight SST-90 surface mount device consisting of a domed 9mm$^2$ LED mounted on a ceramic substrate. |
| SST-90-W45S-F11-GJ400 | 4500K White | White PhlatLight SST-90 surface mount device consisting of a domed 9mm$^2$ LED mounted on a ceramic substrate. |
| SST-90-W40M-F11-GJ500 | 4000K White | White PhlatLight SST-90 surface mount device consisting of a domed 9mm$^2$ LED mounted on a ceramic substrate. |
| SST-90-W30M-F11-GH700 | 3000K White | White PhlatLight SST-90 surface mount device consisting of a domed 9mm$^2$ LED mounted on a ceramic substrate. |
| | | |
| SSR-90-W65S-R11-GK100 | 6500K White | White 6500K PhlatLight SSR-90 evaluation module consisting of a SST-90 surface mount device mounted on an aluminum star board. |
| SSR-90-W57S-R11-GK200 | 5700K White | White 5700K PhlatLight SSR-90 evaluation module consisting of a SST-90 surface mount device mounted on an aluminum star board. |
| SSR-90-W45S-R11-GJ400 | 4500K White | White 4500K PhlatLight SSR-90 evaluation module consisting of a SST-90 surface mount device mounted on an aluminum star board. |
| SSR-90-W40M-R11-GJ500 | 4000K White | White 4000K PhlatLight SSR-90 evaluation module consisting of a SST-90 surface mount device mounted on an aluminum star board. |
| SSR-90-W30M-R11-GH700 | 3000K White | White 3000K PhlatLight SSR-90 evaluation module consisting of a SST-90 surface mount device mounted on an aluminum star board. |

*Note 1: GK100 - denotes a bin kit comprising of all flux and chromaticity bins at the 6500K color point*
*GK200 - denotes a bin kit comprising of all flux and chromaticity bins at the 5700K color point*
*GJ400 - denotes a bin kit comprising of all flux and chromaticity bins at the 4500K color point*
*GJ500 - denotes a bin kit comprising of all flux and chromaticity bins at the 4000K color point*
*GH700 - denotes a bin kit comprising of all flux and chromaticity bins at the 3000K color point*
*See PhlatLight Binning and Labeling document for more information.*
*Note 2: For ordering information on all available bin kits, please see PhlatLight Binning and Labeling document.*

www.luminus.com

The products, their specifications and other information appearing in this document are subject to change by Luminus Devices without notice. Luminus Devices assumes no liability for errors that may appear in this document, and no liability otherwise arising from the application or use of the product or information contained herein. None of the information provided herein should be considered to be a representation of the fitness or suitability of the product for any particular application or as any other form of warranty. Luminus Devices' product warranties are limited to only such warranties as accompany a purchase contract or purchase order for such products. Nothing herein is to be construed as constituting an additional warranty. No information contained in this publication may be considered as a waiver by Luminus Devices of any intellectual property rights that Luminus Devices may have in such information. PhlatLight® is a registered trademark of Luminus Devices, Inc., all rights reserved.

This product is protected by U.S. Patents 6,831,302; 7,074,631; 7,083,993; 7,084,434; 7,098,589; 7,105,861; 7,138,666; 7,166,870; 7,166,871; 7,170,100; 7,196,354; 7,211,831; 7,262,550; 7,274,043; 7,301,271; 7,341,880; 7,344,903; 7,345,416; 7,348,603; 7,388,233; 7,391,059; Patents Pending in the U.S. and other countries.