LUXEON
never before possible

LUXEON® Rebel

Reliability Data

Introduction

This reliability datasheet summarizes the reliability performance of LUXEON® Rebel. Overall product reliability depends on the customer's drive conditions and adherance to recommended assembly practices.

LUXEON Rebel is designed for high volume assembly, featuring JEDEC 1 MSL sensitivity, PB-free reflow soldering capability, and full compliance with EU Reduction of Hazardous Substances (RoHS) legislation.

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PHILIPS

LUMILEDS
LIGHT FROM SILICON VALLEY

Packaging

LUXEON Rebel incorporates many of the packaging advances of the LUXEON Flash high-power LED family and adds a silicone lens.

The fundamental packaging philosophy of LUXEON Rebel attaches the LED chip to a metallized ceramic substrate that provides a high-efficiency thermal path to extract heat from the active region of the LED. Metal pads on the underside of the ceramic substrate are designed to be reflow-soldered to printed circuit pads with high thermal conductivity, which in-turn conduct the heat generated within the LED chip to an external heatsink. Hence, LUXEON Rebel has a 3-pad package comprising an anode pad, a cathode pad and an electrically insulated thermal pad. The primary electrical connections from the LED chip are connected to the anode and cathode pads. On the top of the package is a soft, clear silicone lens.

Two different LED fabrication technologies are used in the LUXEON Rebel product family. The red, red-orange, and amber LUXEON Rebel packages use Aluminum Indium Gallium Phosphide (AlInGaP) chip technology. The white, green, cyan, blue and royal blue LUXEON Rebel packages use Indium Gallium Nitride (InGaN) chip technology. These two distinct fabrication technologies require somewhat different packaging.

Figure 1 illustrates the internal construction of the AlInGaP LUXEON Rebel package. The LED chip is bonded to the metallized ceramic substrate using a high-temperature, Pb-free eutectic bond. Note that AlInGaP LUXEON Rebel has the cathode on the top of the die, which is connected to the metallized ceramic substrate using a gold wire. A clear silicone lens is molded over the LED chip and gold wire.

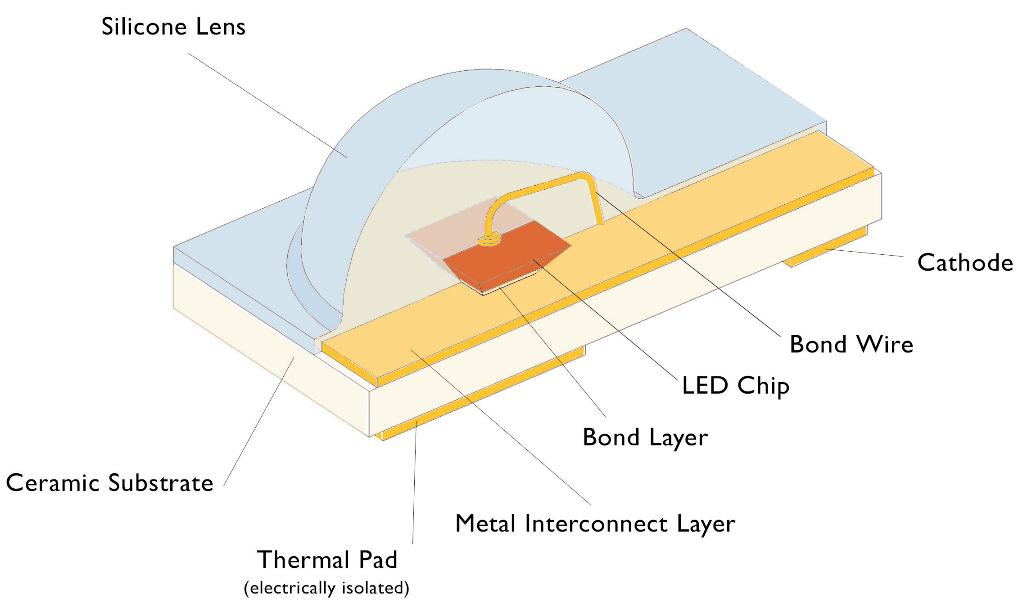

Figure 1.

Packaging, Continued

Figure 2 illustrates the internal construction of the InGaN LUXEON Rebel package. Note that the LED chip is mounted on top of the metallized ceramic substrate using gold-to-gold interconnects. A separate silicon chip is also mounted on the metallized ceramic substrate. This chip protects the LED chip from electrostatic discharge (ESD). A clear silicone lens is molded over the LED and silicon chips.

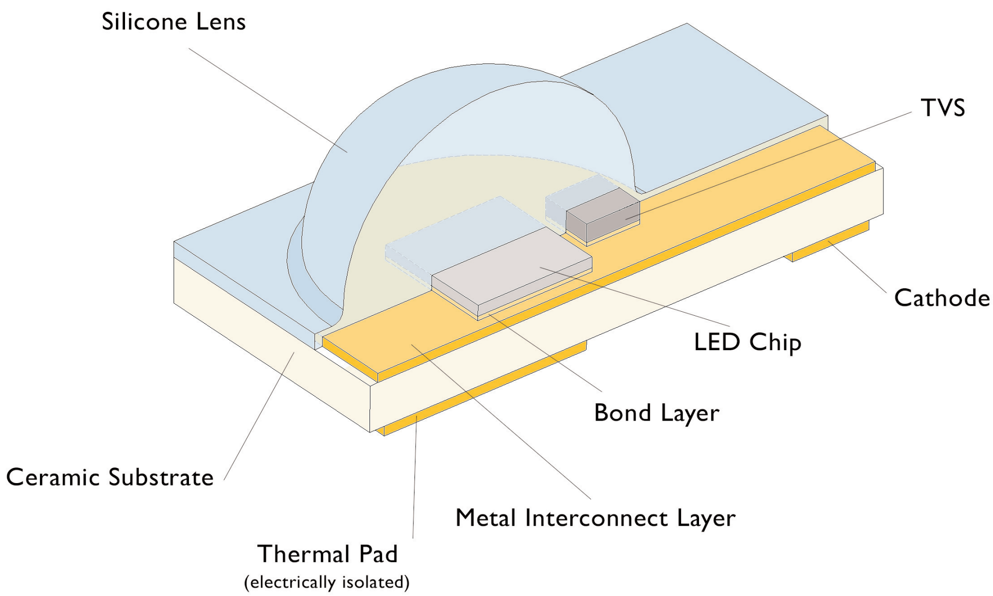

Figure 2.

Figure 3 illustrates the internal construction of the white LUXEON Rebel package. A white LUXEON Rebel uses a blue InGaN chip. Then a yellow phosphor conformal coating is applied over the LED chip.

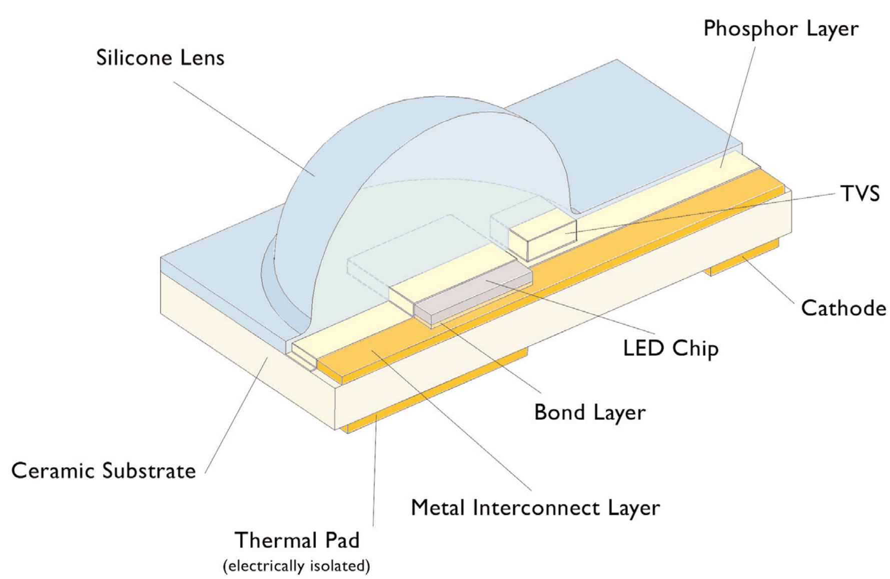

Figure 3.

LUXEON Rebel Qualification Reliability Testing

Philips Lumileds conducts extensive reliability stress testing before the introduction of a new product to ensure that the product meets the reliability expectations of all intended markets. The development of LUXEON Rebel included extensive operational life-time testing, environmental testing and mechanical testing. Table 1 summarizes the tests applied.

Table 1. Operating life, mechanical, and environmental tests performed on the LUXEON Rebel package.

Stress Test	Stress Conditions	Stress Duration	Failure Criteria	Results
High Temperature Operating Life (HTOL)	85°C, I_F = max. DC [1]	1000 hours	Note 5	0 failures
Room Temperature Operating Life (RTOL)	55°C, I_F = max. DC [1]	1000 hours	Note 5	0 failures
Low Temperature Operating Life (LTOL)	-40°C, I_F = 700mA [1]	1000 hours	Note 5	0 failures
Wet High Temperature Operating Life (WHTOL)	85°C/85%RH, I_F = max. DC [1]	1000 hours	Note 5	0 failures
Powered Temperature Cycle (PTMCL)	-40°C to 120°C, 18 minutes dwell, 42 min transfer (2 hour cycle), 5 minutes ON/5 minutes OFF, I_F = 700mA. [1]	500 cycles	Note 5	0 failures
Non-Operating Temperature Cycle (TMCL)	-40°C to 120°C, 15 minutes dwell/15 min transfer [2]	500 cycles	Note 5	0 failures
Non-Operating Thermal Shock (TMSK)	-40°C to 110°C, 20 minutes dwell, <10s transfer [2]	500 cycles	Note 5	0 failures
High Temperature Storage Life (HTSL)	150°C, non-operating [2]	1000 hours	Note 5	0 failures
Low Temperature Storage Life (LTSL)	-55°C, non-operating [2]	1000 hours	Note 5	0 failures
Mechanical Shock	1500G, 0.5ms pulse, 5 shocks each 6 axis [3]		Note 6	0 failures
Variable Vibration Frequency	10-2000-10Hz, log or linear sweep rate, 20G for approximately 1 minute, 1.5mm, each applied three times per axis over 6 hours [3]		Note 6	0 failures
Variable Vibration Frequency	10-55-10Hz, 1.5mm excursion, 55-2000Hz, 1 octave per minute, 10G, three times per axis [3]		Note 6	0 failures
Random Vibration	6G RMS, 10-2000Hz, 10 minutes per axis [3]		Note 6	0 failures
Solder Heat Resistance (SHR)	Three Pb-free reflow solder profiles, included in JEDEC Level 1 tests [4]		Note 6	0 failures
Autoclave	121°C, 100%RH, 15psig [4]	96 hours	Note 6	0 failures
JEDEC Level 1 MSL	Precondition at 85°C and 85%RH for 168 hours, followed by three Pb-free reflow solder profiles. First reflow needs to be completed between 15 minutes and 4 hours after 85C/85% 168 hour stress is completed. [4]		Note 6	0 failures

Notes for Table 1:

1. Units soldered to a stress board using Pb-free reflow process. The temperature of the stress board and heatsink is kept constant at the temperature noted. Max. DC = 1A for InGaN Luxeon Rebel and 0.7A for AlInGaP Luxeon Rebel.
2. Units soldered to stress board without heatsink (Pb-free reflow process).
3. Units soldered to printed circuit board prior to test (Pb-free reflow process)
4. Units stressed loose.
5. A failure is an LED that is open, shorted, or loses more than 50% of its initial light output.
6. A failure is an LED that is open or shorted.

LUXEON Rebel Lumen Maintenance

LEDs experience a gradual reduction in light output during operation. This phenomenon is called light output degradation, and may stem either from a reduction in the light-emitting efficiency of the LED chip or a reduction in the light transmission of the optical path within the LED package.

The LUXEON Rebel package has improved lumen maintenance as compared to the LUXEON I and III packages due to packaging enhancements and an improved LED chip. The packaging enhancements improve lumen maintenance, especially at higher junction temperatures. In addition, the improvements to the LED chip allow maximum operation of the InGaN LUXEON Rebel up to 1A, and AlInGaP LUXEON Rebel up to 700mA.

Figure 4 shows the long-term lumen maintenance of the royal-blue LUXEON Rebel at case temperature 85°C (junction temperature approximately 125°C) at 1A. Operation at lower drive currents and junction temperatures is expected to further improve the long-term lumen maintenance.

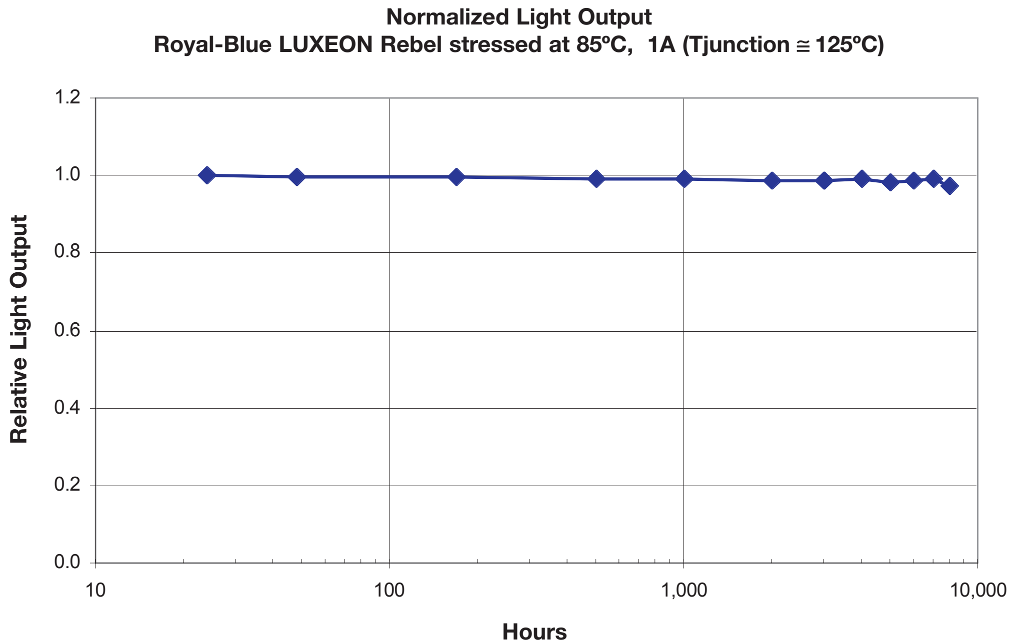

Figure 4. Lumen maintenance of royal-blue LUXEON Rebel.

Figure 5 shows the long-term lumen maintenance of the white LUXEON Rebel at case temperature of 85°C (junction temperature approximately 110°C) at 0.7A. Operation at lower drive currents and junction temperatures is expected to further improve the long-term lumen maintenance.

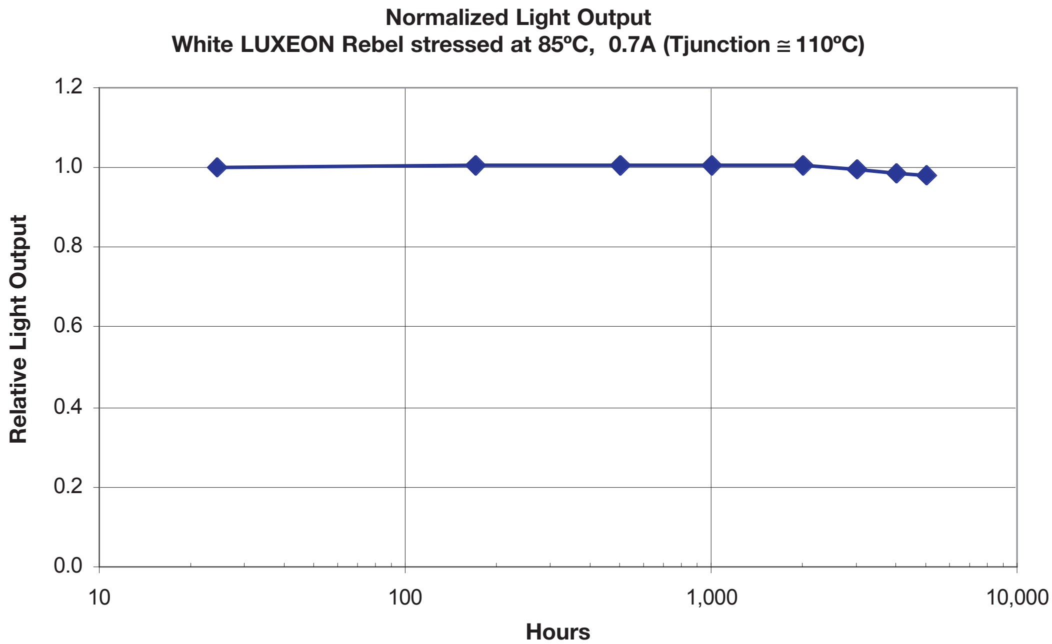

Figure 5. Lumen maintenance of white LUXEON Rebel.

LUXEON Rebel Lumen Maintenance, Continued

Figure 6 shows the long-term lumen maintenance of the red-orange and amber LUXEON Rebel LEDs at case temperature 85°C (junction temperature approximately 100°C) at 0.35A. Operation at lower drive currents and junction temperatures is expected to further improve the long-term lumen maintenance.

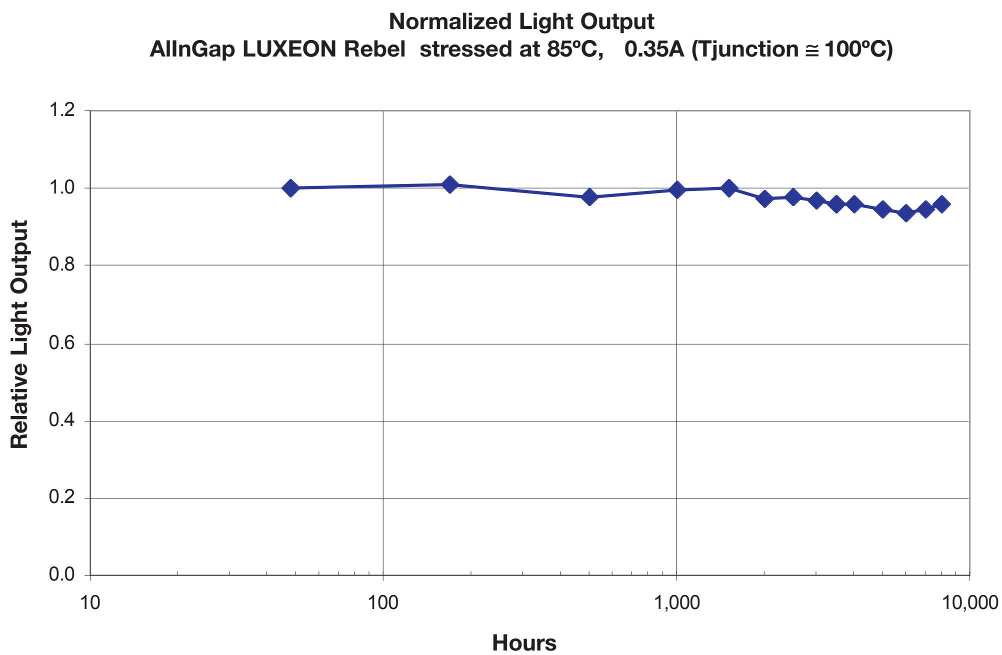

Figure 6. Lumen maintenance of mixed red-orange and amber LUXEON Rebel.

LUXEON Rebel Lifetime Predictions

The LUXEON Rebel product family was stressed over a wide range of drive currents and junction temperatures in order to predict useful lifetimes under various operating conditions. To aid understanding, these predictions incorporate the same terminology applied to conventional lighting technologies. For example, many light sources display little change in light output as the lamp is stressed, until the unit fails catastrophically. As a result, failure rates are often expressed in terms of the time by which a certain percentage of the population is expected to have failed. For example, a B10 value for any given lamp denotes the time by which 10% of the population is expected to fail.

However, noting that the light output of an LED tends to degrade gradually as the device is stressed, its efficacy may fall to an unacceptable level long before total failure occurs. Such a condition may be described as a lumen maintenance failure. To facilitate comparison of the LUXEON Rebel family with other lighting devices using conventional technologies and other LEDs, Philips Lumileds also expresses LUXEON reliability with reference to a threshold for lumen maintenance failure. For example, L70 defines a lumen maintenance failure as any unit producing less than 70% of its initial output. Since light output degradation is defined as (1—lumen maintenance), a failure criteria of L70 means that any unit with more than 30% light output degradation would be classified as a failure.

Using this terminology, Philips Lumileds has estimated the expected lifetimes of the LUXEON Rebel product family as a function of drive current and junction temperature. For example, the lifetime at (B10, L70) is the expected stress time at which 10% of the population is expected to have either failed catastrophically (i.e. opens or shorts) or has degraded by more than 30% from the initial light output. The next eight graphs provide the data for LUXEON Rebel.

The (Bxx, Lyy) graphs were generated by conducting a series of reliability tests at a number of different reliability stress board temperatures and drive currents. Note that the LUXEON Rebels are mounted on a reliability stress board which is mounted on a heat-sink plate. Then the temperature of the heat-sink plate is kept constant during the test. The junction temperatures of these tests were estimated using the following assumptions:

InGaN LUXEON Rebel
$R\theta_{\text{J - THERMAL PAD}}$ = 10C/W (per data sheet)
$R\theta_{\text{THERMAL PAD - HS PLATE}}$ = 7.3C/W

AlInGaP LUXEON Rebel
$R\theta_{\text{J - THERMAL PAD}}$ = 12C/W (per data sheet)
$R\theta_{\text{THERMAL PAD - HS PLATE}}$ = 4.5C/W

Table 2. Estimated Temperature Rise, Junction to Thermal Pad.

Forward Current	AlInGaP	InGaN
0.35A	12ºC	10ºC
0.4A	14ºC	12ºC
0.5A	18ºC	15ºC
0.6A	23ºC	19ºC
0.7A	28ºC	23ºC
1A	Beyond maximum ratings	34ºC

Figures 7 and 8 show the expected (B50, L70) lifetimes at a 90% confidence interval for InGaN (ie white, blue, cyan, and green) LUXEON Rebel as a function of junction temperature and thermal pad temperature, respectively.

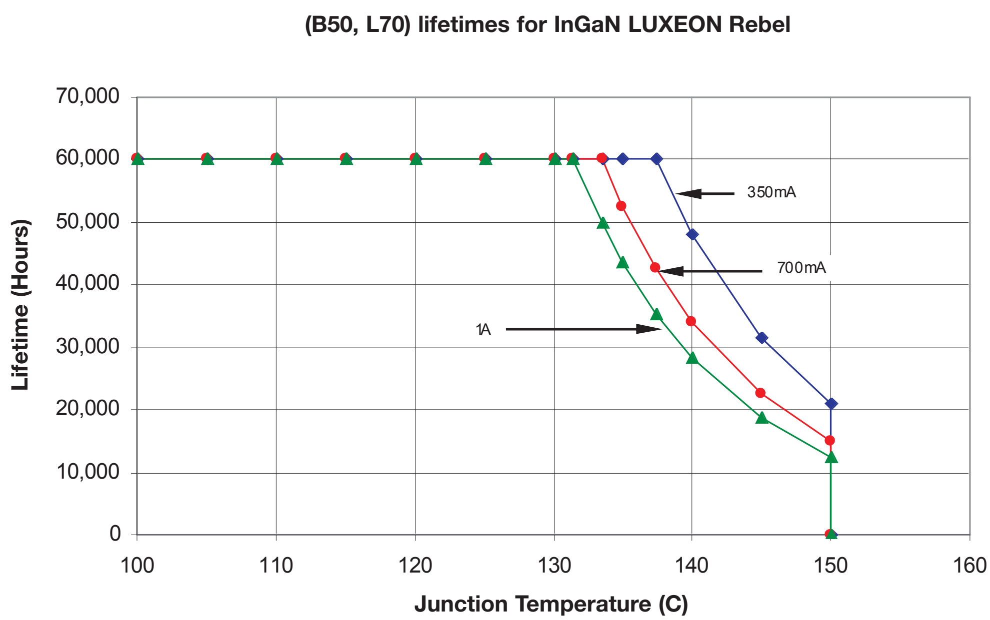

Figure 7. Expected (B50, L70) lifetimes for InGaN LUXEON Rebel.

LUXEON Rebel Lifetime Predictions, Continued

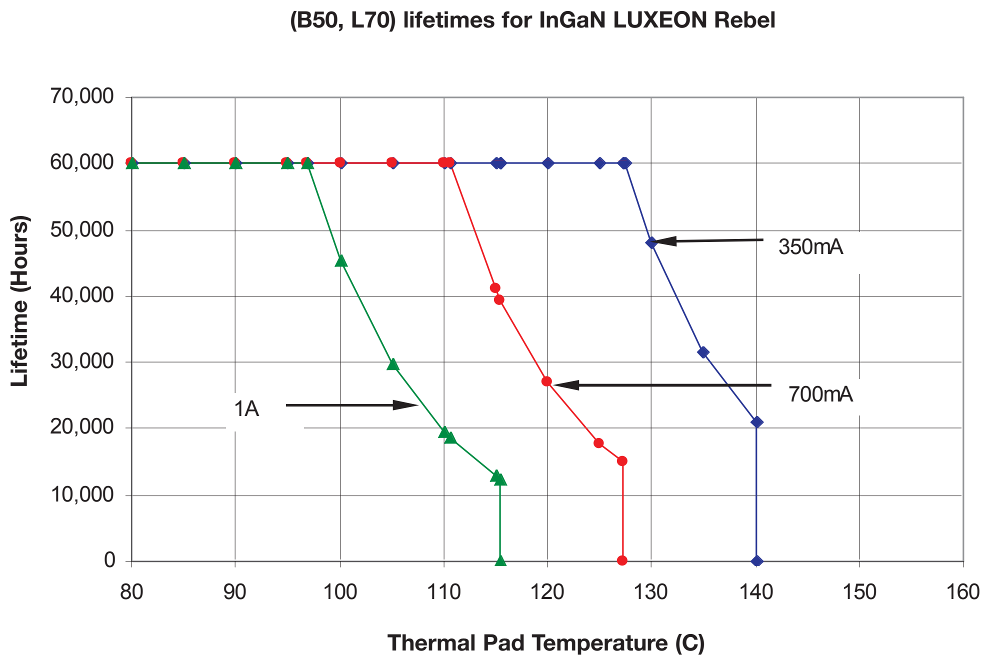

Figure 8. Expected (B50, L70) lifetimes for InGaN LUXEON Rebel.

LUXEON Rebel Lifetime Predictions, Continued

Figures 9 and 10 show the expected (B10, L70) lifetimes at a 90% confidence level for InGaN (ie white, blue, cyan, and green) LUXEON Rebel as a function of junction temperature and thermal pad temperature, respectively.

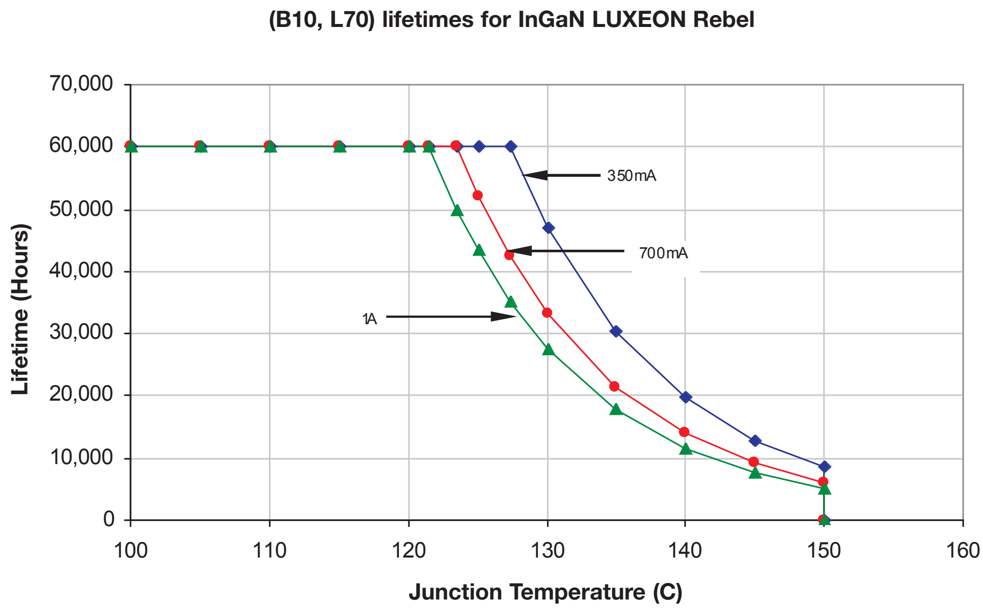

Figure 9. Expected (B10, L70) lifetimes for InGaN LUXEON Rebel.

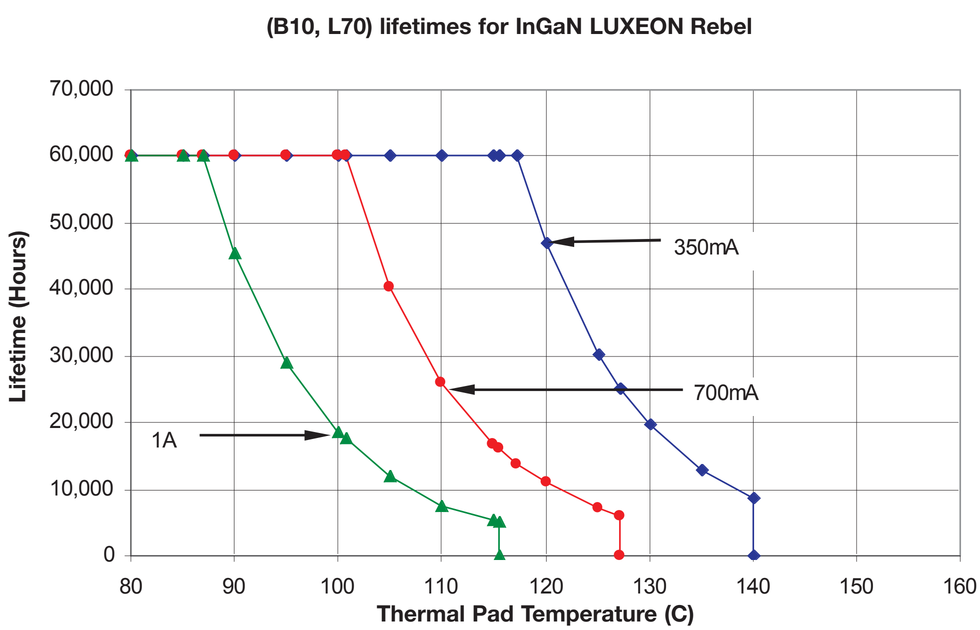

Figure 10. Expected (B10, L70) lifetimes for InGaN LUXEON Rebel.

Figures 11 and 12 show the expected (B50, L70) lifetimes at a 90% confidence level for AlInGaP (ie Amber, Red-orange, and Red) LUXEON Rebel as a function of junction temperature and thermal pad temperature, respectively.

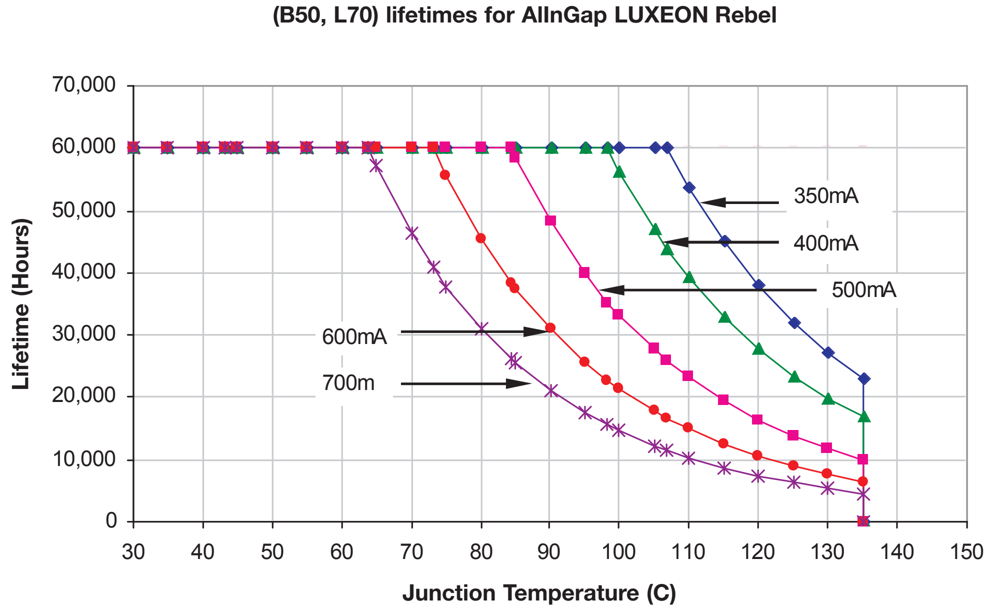

Figure 11. Expected (B50, L70) lifetimes for AllnGaP LUXEON Rebel.

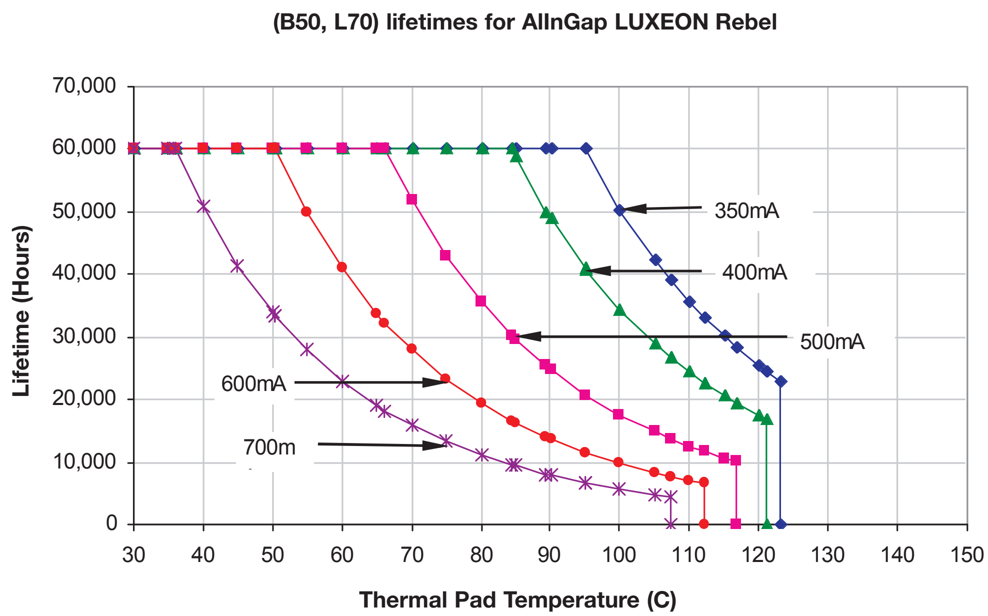

Figure 12. Expected (B50, L70) lifetimes for AllnGaP LUXEON Rebel.

LUXEON Rebel Lifetime Predictions, Continued

Figures 13 and 14 show the expected (B10, L70) lifetimes at a 90% confidence level for AlInGaP (ie Amber, Red-orange, and Red) LUXEON Rebel as a function of junction temperature and thermal pad temperature, respectively.

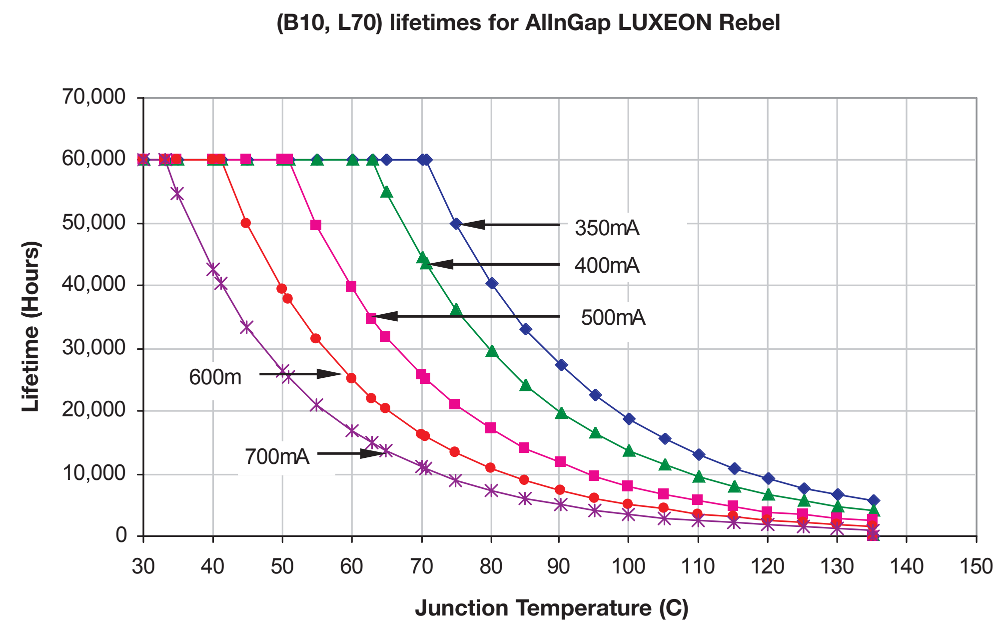

Figure 13. Expected (B10, L70) lifetimes for AlInGaP LUXEON Rebel.

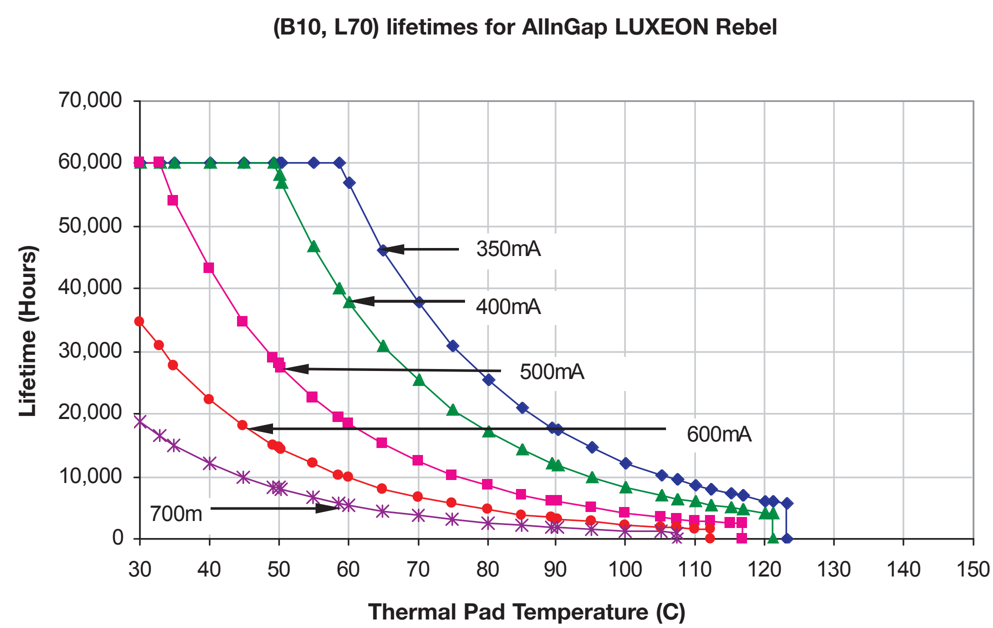

Figure 14. Expected (B10, L70) lifetimes for AlInGaP LUXEON Rebel.

Company Information

LUXEON® is developed, manufactured and marketed by Philips Lumileds Lighting Company. Philips Lumileds is a world-class supplier of Light Emitting Diodes (LEDs) producing billions of LEDs annually. Philips Lumileds is a fully integrated supplier, producing core LED material in all three base colors (Red, Green, Blue) and White. Philips Lumileds has R&D centers in San Jose, California and in The Netherlands and production capabilities in San Jose and Penang, Malaysia. Founded in 1999, Philips Lumileds is the high-flux LED technology leader and is dedicated to bridging the gap between solid-state LED technology and the lighting world. Philips Lumileds technology, LEDs and systems are enabling new applications and markets in the lighting world.

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