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High Power UV LED Solutions

Boston Electronics

Application Note

Understanding UV LED Lifetimes

This technical note is intended to introduce how UV LED lifetimes are determined and the parameters which affect them.

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Overview

This technical note is intended to introduce how UV LED lifetimes are determined and the parameters which affect them.

Intended Audience

- Engineers and technologists using Violumas LED products
- Violumas technical Sales Engineers providing support to potential customers

Scope

This technical note provides information on UV LED lifetimes, the methods of generating lifetime data, and parameters which affect UV LED lifetime. Although recommendations for increasing UV LED lifetimes are included, Violumas recommends that standard industry practices must be utilized in conjunction with these recommendations.

Disclaimer

This guide is designed for engineers working with Violumas' LED products. It is the sole responsibility of product designers to choose suitable products and to comply with all relevant standards and safety regulations. Violumas' liability does not extend to any damage or warranty problems that may arise from adherence to these recommendations.

1. Introduction of LED Lifetimes

The term 'LED lifetimes' denotes the period during which an LED retains a specified intensity of light output. All LEDs will suffer from degradation of output throughout their lifetimes. Although LEDs can experience abrupt malfunctions, potentially ceasing to function well before their anticipated lifetimes, the LED lifetime data typically reflects the standard performance of LEDs, excluding unexpected catastrophic failures.

2. Measurement of LED Lifetimes

LED lifetime data is assessed by tracking the optical output of the LED over an extended period, often thousands of hours. This process yields valuable data regarding the LED's durability and the rate at which it deteriorates. Although there are established protocols for testing the longevity of visible LEDs, the absence of specific guidelines for UV LEDs complicates the creation of uniform testing procedures. However, by applying the insights gained from visible LED tests, we can formulate analogous standards for UV LEDs.

First, The LED is placed on a heatsink to maintain a specific junction temperature. LED light output is measured at T=0 and recorded as 100% light output. The output flux measurement is typically performed using an integrating sphere suitable for the specific LED wavelength. (Although not common for manufacturer-generated data, photodiode sensors are sometimes utilized to measure the relative irradiance levels of the LEDs, as an alternative method of tracking light depreciation.) The light output is measured at pre-determined intervals, and the testing is generally stopped when the LED reaches 70% of its initial light output. After this point, extrapolation techniques are often utilized to predict subsequent degradation.

In some cases, accelerated aging tests may be conducted to predict the degradation of an LED, as many lifetime tests can run past thousands of hours.

Understanding the lifespans of LEDs is crucial for the innovation and development of products and systems that incorporate UV LEDs.

LED lifetimes are typically calculated when the LED output drops to 70% of the initial value and this is termed as an L70 measurement.

LT70 for UVA LEDs (for reference only)

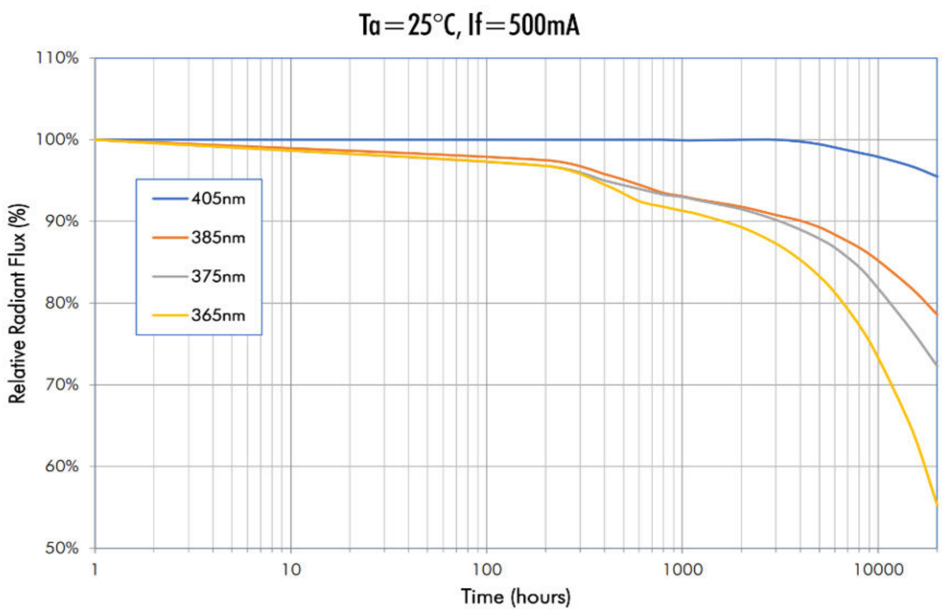

Figure 1: Lifetime data measured over thousands of hours of operating time for UVA LEDs

3. Parameters that Impact LED Lifetimes

Parameters that directly affect device lifetimes and L70 data are the **LED drive current** and the **junction temperature**. Following the LED's initial burn-in period of a specific number of hours, the overall radiant flux output is recorded at the selected drive current and a particular junction temperature.

Most manufacturers present LED specifications based on an ambient temperature of 25°C which is also considered as the junction temperature, as a pulse measurement is used. Yet, in actual product environments, achieving such temperatures may be unrealistic as most applications require constant operation and not pulsed-mode operation, which increases the junction temperature to above ambient levels. An increase in ambient temperature would also lead to a junction temperature increase. So, engineers must design the products keeping in view the ambient temperatures.

Temperature regulation is a critical factor that affects the lifetime of an LED. With visible LEDs, it is commonly understood that a 10° increase in junction temperature can reduce the LED's L70 lifetime by 50%. The junction temperature can be affected by the LED package design and heatsink.

It is therefore crucial to take note of the LED junction temperature in manufacturer-provided lifetime data, so the information can be properly applied to a real-application scenario. If an end user's system is designed to achieve a junction temperature of 70°C but the manufacturer has supplied lifetime data with a junction temperature of 40°C, the manufacturer-provided data will not provide a realistic indication of the LED degradation.

Furthermore, many tests are conducted in controlled environmental settings (typically, in an ambient temperature of 25°C) and the resulting data should be treated primarily as a reference point. It is highly recommended for each end user to conduct one's own lifetime testing, within realistic environmental conditions, to properly understand the expected degradation within a specific system or environment.

Another parameter which affects the lifetime of an LED is the drive current. Most manufacturers will state a recommended drive current for the LED and provide lifetime data generated utilizing this current. If the drive current exceeds the recommended parameter, the lifetime will be shorter, and vice versa.

Generally, lowering junction temperatures and under-driving the LEDs can aid significantly in increasing the lifetime of a UV LED.

4. Role of Lifetimes in Product Design

Designing products with UV LEDs necessitates an understanding of L70 data to guarantee accurate irradiance levels as the LED's optical output declines. It is important to verify lifetimes at the junction temperatures reached for a particular application. The cooling solution for a UV LED light source must be carefully considered, as this will be the critical factor in decreasing the degradation level of radiant flux, by improving heat extraction and lowering junction temperatures.

One way to compensate for an LED's radiant flux degradation would be to design for a lower irradiance requirement initially. This method would involve driving the LEDs at a lower current at the beginning, and increasing the current as the LED degrades over time (Figure 2). Note that the thermal solution must be designed for full current. This way the minimum irradiance would be conserved. Another method that may be applicable for certain applications is to increase exposure times to compensate for the drop in LED output. This may be applicable suitable for disinfection or curing applications where cumulative dosage is important.

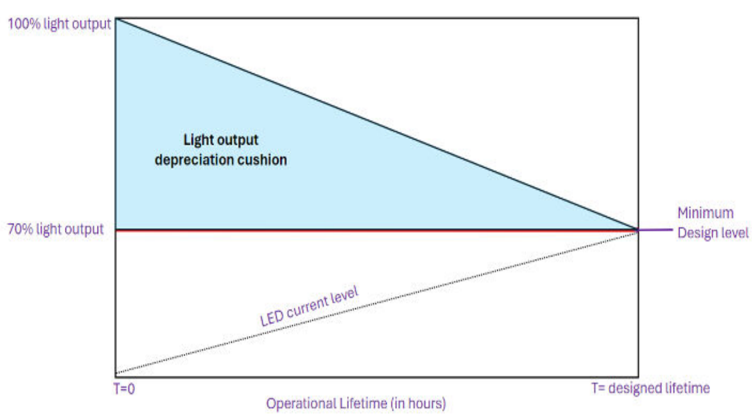

Figure 2: Degradation in light output may be compensated with increasing current.

Summary

LED lifetimes refer to the duration an LED maintains a specified light output before degrading. LEDs rarely fail unexpectedly, and lifetime measurements generally track gradual light reduction rather than sudden failures. Key influences on LED longevity include drive current and junction temperature. Many manufacturers report lifetimes based on an ambient temperature of 25°C, but real-world conditions often result in higher temperatures, accelerating degradation. Managing junction temperature is essential for extending LED life. Engineers can mitigate light degradation by initially operating LEDs at lower currents and gradually increasing current or exposure time as the LED ages, ensuring consistent irradiance.

Have more questions?

If you have questions that are not answered in this document, please contact the Violumas team.

E : info@violumas.com

P : 510-280-8440

A: 1001 Fulton Place, Fremont, CA 94539