# PWDAS-26

# AGING OF PHOTOMETRIC AND COLORIMETRIC QUANTITIES OF HIGH-POWER LIGHT-EMITTING DIODES

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## Introduction

One of the main reasons why high-power Light-Emitting Diodes (LEDs) are replacing the traditional light sources today is their long lifetime. Manufacturer of high-power LEDs typically report a best lifetime of 50 000 h which is the period of time where the LED maintains 70% of its luminous flux. This period corresponds to almost 6 years of permanent operation and is usually obtained by extrapolation from much shorter measurement intervals taken under idealized conditions with respect to current and temperature. The aging or degradation of the light output of such devices depends not only on the forward current and on the temperature, but also on the encapsulate, e.g. the degradation of the plastic lens [1,2]. It obviously affects the stability of their radiometric, photometric and colorimetric quantities, which may be different for each type of LED.

At the PTB, our aim is to study – within the scope of a collaboration project with the company ZETT OPTICS GmbH – the stability of the photometric and colorimetric quantities, e.g. the luminous intensity and chromaticity, of high-power LEDs over a long period of time (~2-3 years). Here, our main interest is to determine the capability of high-power LEDs to be used (i) in medical applications and (ii) as a light standard source for photometry and colorimetry and (iii) to provide experimental data to validate or improve existing extrapolation methods of LED lifetime behavior.

## Measurement set-up

The measurement set-up consists of two rotating stages where the sensor heads and the LEDs under test are placed (see Figure 1). It has a capability for 40 LEDs. The LEDs are mounted individually on a special holder which also acts as a temperature controlled active heat-sink. By means of a heat transistor and a temperature sensor placed right behind the LED star PCB, the LEDs may be thermoelectrically stabilized. If necessary, a ventilator placed on the holder rear is active to extract the remaining heat [3].

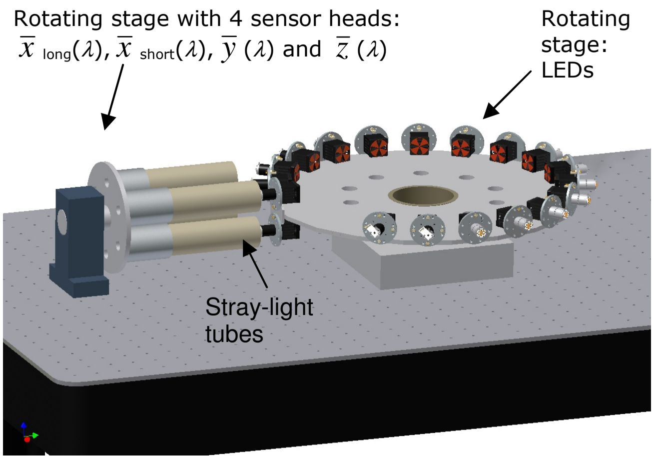


*Figure 1 Measurement set-up to determine the aging of high-power LEDs*

A set of four sensor heads, equipped with different filters which fit the color-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$ and $\bar{z}(\lambda)$, is used to determine the photometric and colorimetric quantities. Here, in order to obtain a better signal ratio, $\bar{x}(\lambda)$ is achieved by means of two sensor heads, each one optimized for $\bar{x}_{short}(\lambda)$ and $\bar{x}_{long}(\lambda)$, respectively.

All sensor heads are thermoelectrically stabilized, e.g. at 35 °C. Here, a calibration of the sensor heads for photometric quantities is not necessary because in this case these are used in a relative way. Instead, the stability of the measurement system is checked periodically by means of an incandescent lamp and standard low-power LEDs. However, in the case of colorimetric quantities a calibration of the heads is required. The measurement system is fully automated.

Results

The experiment is carried out as follows: a set of 20 high-power LEDs is divided into 5 groups, each one with 5 LEDs of the same model, from different manufacturers. Three LEDs from each group are continuously operating whereas the fourth is active only once a day for just 15 min., which simulates a short term LED operation. The fifth LED is maintained without being operated under ideal ambient conditions ($T$ = 25 °C and $H$ = 45%) in the laboratory. The temperature of all LEDs under operation is stabilized at 40 °C ± 1°C, which is the spected temperature in the applications of these LEDs. The LEDs are operated at a constant current of 80% of the maximum value specified by the manufacturer. The measurements are taken every two hours.

As an example, the chromaticity coordinates $x$ and $y$ of a warm and a cool white LED are shown in Figures 2 (a) and (b), respectively. These were obtained by referencing the measurements (carried out by the measurement system shown in Figure 1) to an initial value determined by means of an array spectrometer. A variation of the chromaticity coordinates of $\Delta x$ = 0.0012 and $\Delta y$ = 0.0015 for the warm, and $\Delta x$ = 0.0015 and $\Delta y$ = 0.018 for the cool white LED was observed during ~1300 h and ~230 h, respectively. Here, the standard deviation of the relative luminous intensity of both LEDs was less than 0.7%. Different behaviors were observed for some LEDs under test. These will be presented at the meeting.

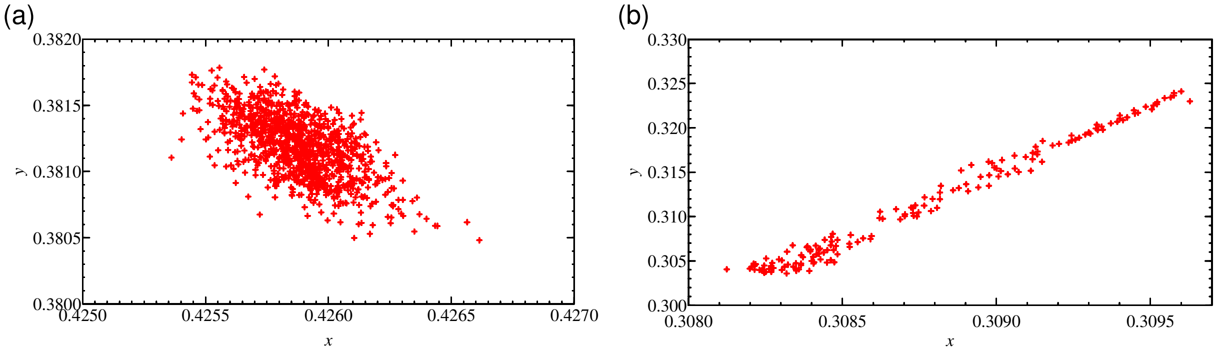


*Figure 2. The chromaticity coordinates x and y of a (a) warm and (b) cool white LED measured over ~1300 h and ~230 h, respectively.*

## Summary

A measurement set-up to determine the stability of the photometric and colorimetric quantities of high-power LEDs has been shown. At the moment, a set of 20 high-power LEDs is being studied. Previous results show that the chromaticity may change for some LEDs, although their luminous intensity is stable. The complete study will be presented at the meeting.

References

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[3] M. Lindemann, *et. al.*, Reliable Photometric and Radiometric Measurements of bare LEDs and High Power LEDs using special Holder, Proceedings of the 10th International Conference on New Developments and Applications in Optical Radiometry (NEWRAD), Daejeon, Korea, 2008.