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Color and spectral characteristics of white LEDs and their variation during aging

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White LEDs are widely used for LCD display backlighting, including low cost color displays. It is essential for these LEDs to provide stable characteristics through life cycle, especially chromaticity and color rendering. Therefore, care shall be taken for LED aging (including degradation of luminophor coating), because intense degradation will cause invalid color perception, especially when using bichromatic LEDs as backlight source.

Currently, there is not any unified approach for measurement of LEDs photometric and life characteristics. For example, there is international standard for performance requirements of LED modules [1], at the same time, Europe adopted standard [2] and Illuminating Engineering Society developed for United States a separate standard [3]. In this work, the change of colorimetric and spectral parameters during aging of some white LEDs were investigated.

This paper describes experimental results and analysis of LED chips characteristic drift within time and under stress.

For experiment, a set of Philips white LED chips was used and several accelerating factors applied, namely aging in normal work regime for 6000 h; normal work at 50 °C for 1000 h; switching cycles of power supply (70000 cycles of 10 seconds).

Within these tests, several parameters were measured, namely total luminous flux (TLF); chromaticity coordinates; correlated color temperature (CCT); color rendering index (CRI) and the luminescence spectra of LEDs under study. Measurements were made using Bentham Integrating sphere IS1800 with Bentham IDR300-PSL spectroradiometer. LEDs under study were supplied using stabilized power source Extech 6720 and controlled with power analyzer Yokogawa WT210.

All types of tests yield clear tendency of decreasing TLF and increasing CCT and CRI during aging. As an example, chromaticity coordinates drift after 6000 h is shown in Figure 1. It was shown that chromaticity coordinates have drift, but still within 6 step Mac-Adam ellipse. The time dependencies of these parameters have some peculiarities depending on accelerating factor used.

TLF was decreased for 15,7 % over 6000 h aging in normal regime, CCT increased for 1,5 % and CRI increased for 1,2 %. The highest impact on LED chip characteristic was shown under normal work at 50 °C for 1000 h: TLF decreased for 4,1 %, CCT increased for 0,8 % and CRI increased for 0,2 %. Therefore, it will investigated how combination of stress factors (ambient temperature and switching of power supply) will change color and spectral characteristics of white LEDs.

The analysis of luminescence spectra of investigated LEDs show the change of intensity

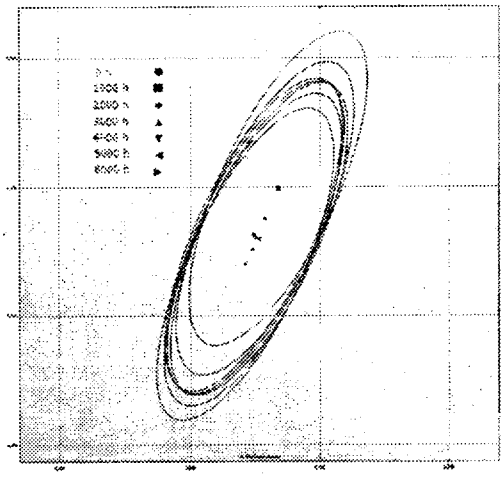

Figure 1: Chromaticity coordinates drift during aging

relation between blue and yellow bands of LED spectrum. Since the blue band originates from diode heterostructure, and the yellow band from the luminophor coating, one may conclude that investigated white LEDs are degraded with lumen output due to faster luminophor degradation that LED chip itself. Blue light component become prevail in overall emission, resulting in invalid color perception if these LEDs are used as backlight sources of color displays.

The relationships between color and spectral characteristics of investigated LEDs as well as pecularities of time dependencies of LED parameters under different aging conditions are discussed in detail.

References

[1] IEC 62717:2014+AMD1:2015+AMD2:2019 LED modules for general lighting - Performance requirements.

[2] EN 13032-4 Light and lighting - Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 4: LED lamps, modules and luminaires.

[3] LM-80-15 Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules.