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Behaviour of InGaN LEDs in parallel circuits

Application Note

Valid for:
InGaN LEDs from OSRAM Opto Semiconductors

Abstract

Years ago, the color range of Light Emitting Diodes (LEDs) on the market was limited to the red to green spectrum. Then, blue LEDs were developed and introduced into the market. These blue devices made it possible to build so called “single-chip white” LEDs, using a yellow converter material in combination with a blue die.

Most of the blue and white LEDs use Indium Gallium Nitrite (InGaN) as an epitaxial layer. The wavelength (chromaticity coordinates) of the generated light of these InGaN-based LEDs shows a strong dependency on the driving current. This special property of InGaN-based LEDs must be considered for application solutions.

This application note provides information on the behavior of InGaN LED in parallel circuits in order to help to avoid some common design mistakes made, when using InGaN-LEDs.

Author: Bartling Hanna

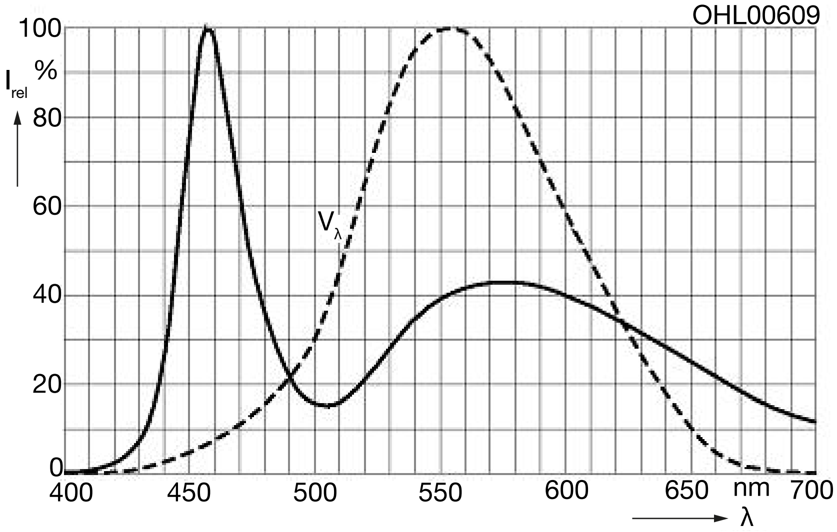
Table of contents

A. InGaN-based white LEDs

To obtain white light, a blue light-emitting die (wavelength 450 nm to 470 nm) is covered with a converter material that is stimulated by blue light and emits yellow light. The human eye detects the mixture of blue and yellow light as white. Because this mixture cannot be described by a simple dominant wavelength (there are two peaks in the spectrum, as shown in Figure 1), color coordinates must be used. The values of these X- and Y-coordinates are calculated using the calculation of chromaticity coordinates (CIE), according to the CIE 15:2004.

Figure 1 shows the relative spectral emission of a typical single-chip white LED together with the response curve of the human eye V(λ). In this case, $I_{rel} = f(\lambda)$, $T_{Ambient} = 25\ °C$, $I_F = 20\ mA$.

Figure 1: Typical spectrum of a single-chip white LED



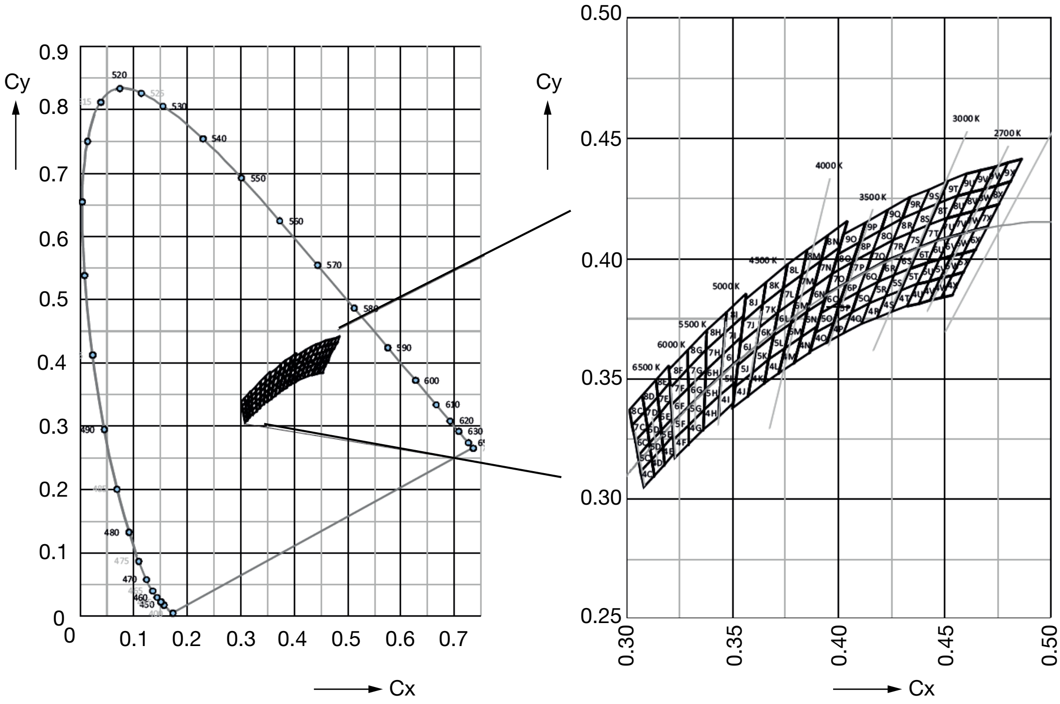
The two main impacts on the color coordinates of the generated white light are:

- The wavelength of the blue die
- The concentration of the converter material.

Therefore, if one or both of these parameters changes, the color coordinates change accordingly.

Figure 2 shows the area within the CIE-diagram in which the color coordinates for the white Mini TOLPED® LCW MVSG.EC from OSRAM Opto Semiconductor LED varies. To avoid the problem of “different” whites in an application using more than one LED, OSRAM Opto Semiconductors LEDs are grouped into bins (see Figure 2, right). Depending on the LEDs the chromaticity coordinates and number of bin can vary. Detailed information can be found in the respective data sheets.

Figure 2: CIE diagram

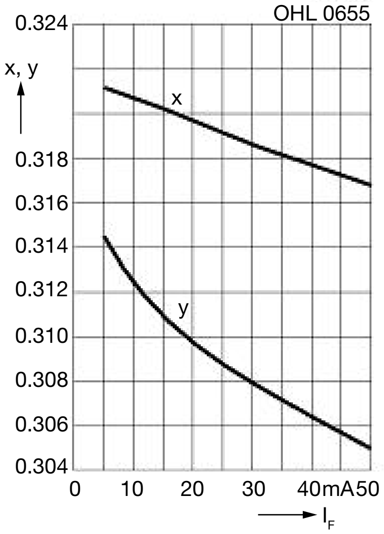


As well as this production-related variation of the color coordinates, the driving condition in an application may also have an impact on the color coordinates of the generated white light. Because the wavelength of an InGaN-based LED (chromaticity coordinates) shifts against the forward current (see Figure 3), there is a color shift in the following instances:

- Dimming of InGaN-based LEDs by varying the forward current
- Using parallel circuits to drive more than one InGaN-based LED

Figure 3 shows the chromaticity coordinate shift of a single-chip white LED in dependency of the forward current (x, y = f (I_F) ; T_A = 25 °C).

Figure 3: Chromaticity coordinate versus forward current



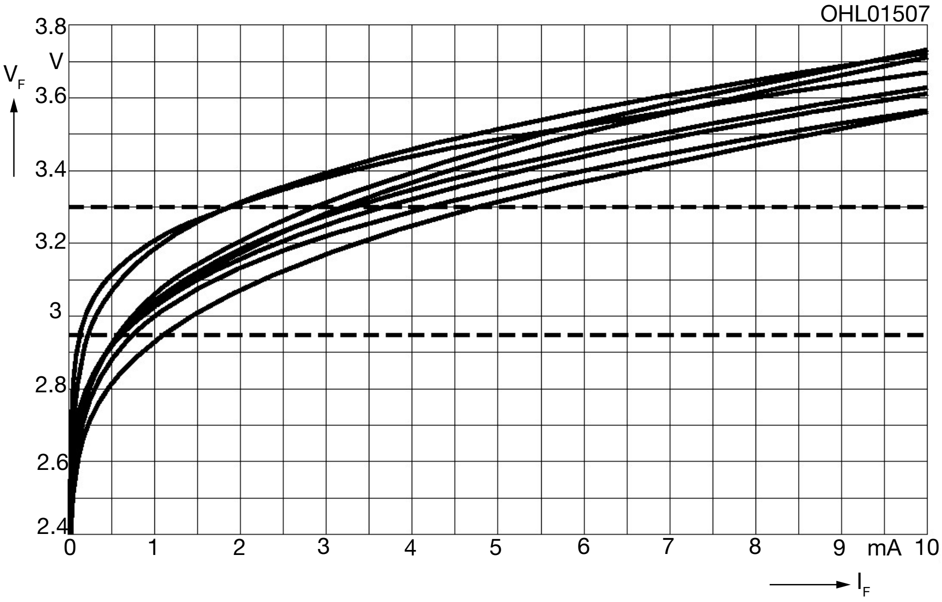
B. Using parallel circuits to drive more than one InGaN-based LED

In contrast to commonly-used standard LED types, InGaN-based LEDs cover a wider variation of forward voltage.

Note: Using LEDs with different forward voltages in a parallel circuit causes different forward currents for each LED. This may lead to a remarkable variation in brightness as well as a shift in chromaticity coordinates.

Figure 4 shows the I-V curves of some randomly selected white LEDs. It is quite apparent that using these devices in a parallel circuit results in differences in brightness as well as a color shift.

Figure 4: Examples of I_F — V_F curves of InGaN-based white LEDs



Example. A forward voltage of 3.3 V (see dashed line at 3.3 V) applied to all of these LEDs in parallel leads to a variation in forward current ranging from 2 mA to 5 mA. Especially in applications using low voltage for parallel circuits, some LEDs may be almost dark. For an example, see the second dashed line at 2.95 V in Figure 4, where the forward current ranges from 0.1 mA to 1 mA. This means that the brightness may vary by a factor of 10. Such a variation in brightness will be recognizable in every application where more than one LED is used.

C. Conclusion

To avoid any application-based color shift or recognizable brightness variation of InGaN LEDs, the use of serial circuits is recommended (such as in combination with step-up converters). For dimming purposes, Pulse Width Modulation (PWM) is an appropriate solution.

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OSRAM Opto Semiconductors GmbH

Head office:

Leibnizstr. 4
93055 Regensburg
Germany
www.osram-os.com