Behaviour of InGaN LEDs in Parallel Circuits

Application Note

Introduction

Some 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 well in advance for new application solutions. This application Note is intended to enable the reader to avoid some common design mistakes when using InGaN-LEDs.

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 a 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 CIE publication 15.2.

Figure 1: Relative Spectral Emission
$I_{rel} = f()$, T_A=25°C, I_F=20mA
V() = Standard eye response curve

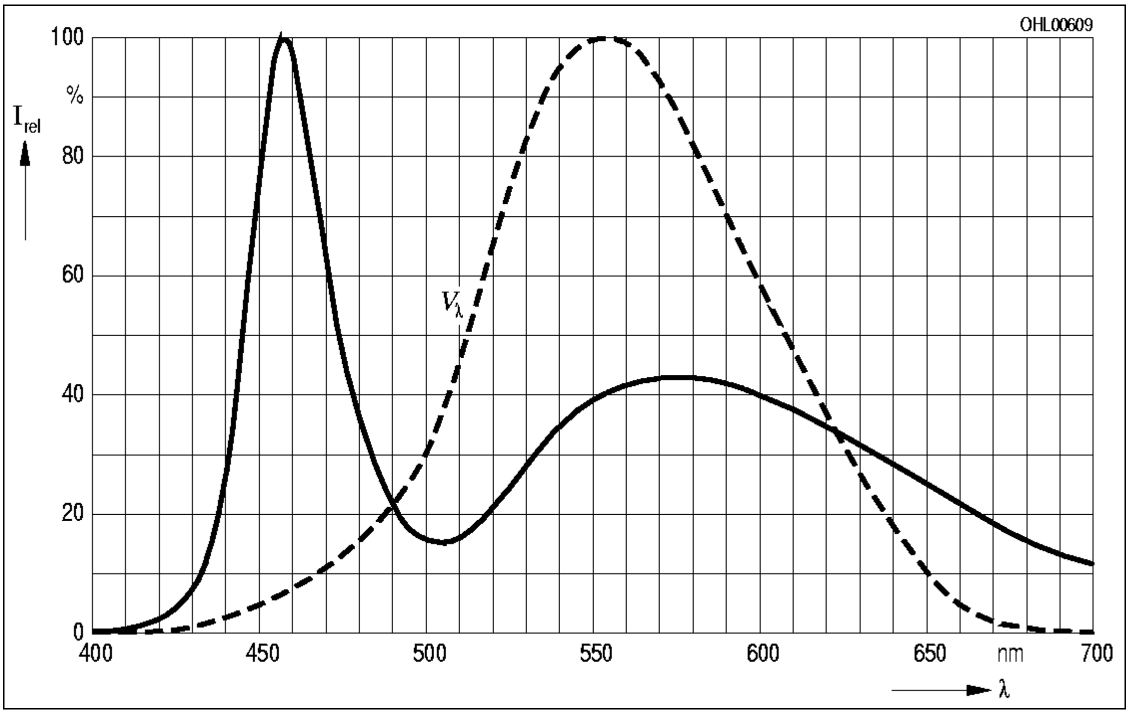

Figure 1 Spectrum of a Single-Chip White LED

OSRAM
Opto Semiconductors

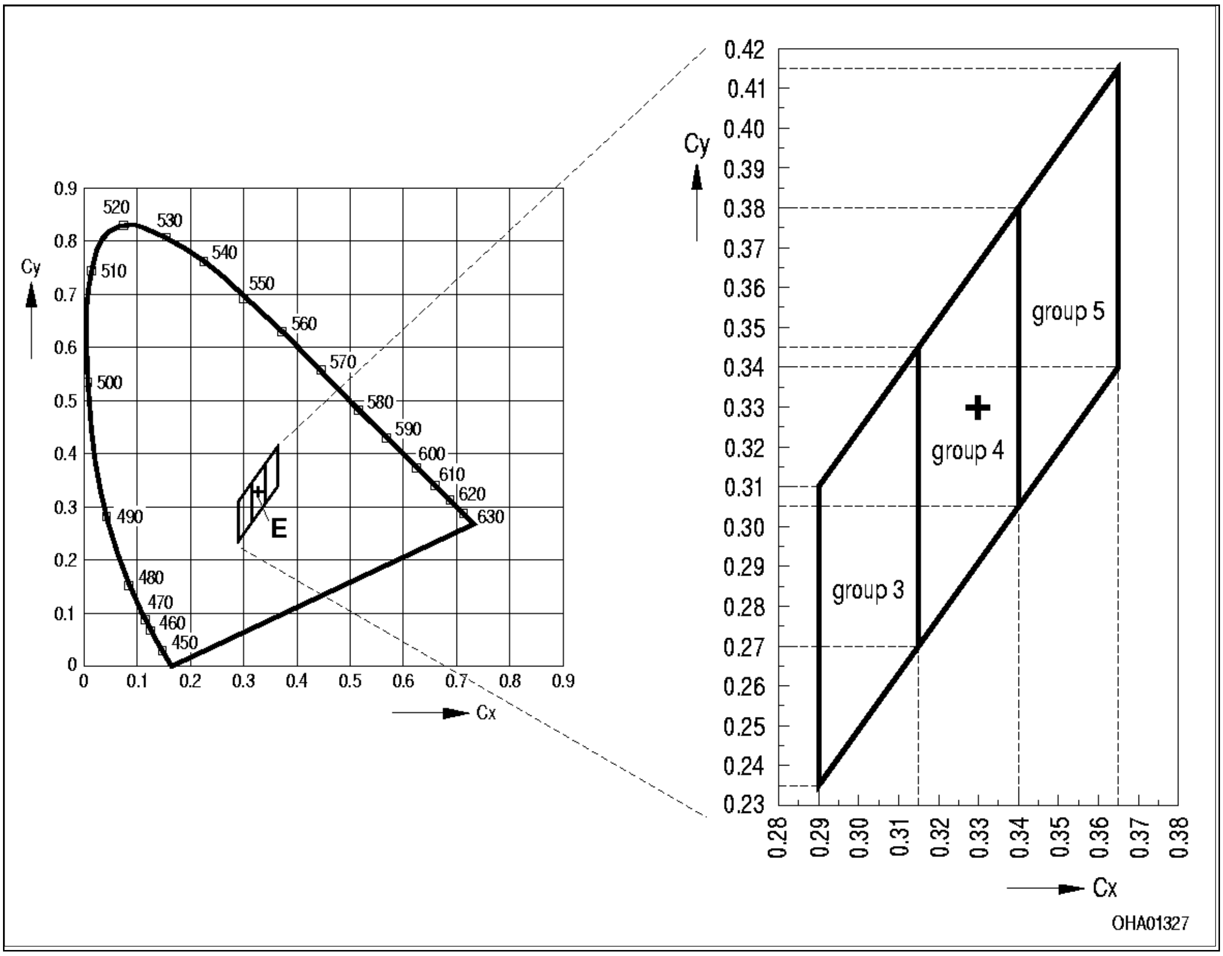

Figure 2

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, top shows the area within the CIE-diagram in which the color coordinates of white Osram Opto Semiconductor LEDs typically vary. To avoid the problem of “different” whites in an application using more than one LED, OSRAM Opto Semiconductors (OSRAM OS) LEDs are grouped into three bins (see Figure 2, right).

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 (see Application Note “Dimming InGaN LEDs”)
- Using parallel circuits to drive more than one InGaN-based LED.

Figure 3: Chromaticity Coordinate Shift
x, y = *f (I* F) *T* A =25°C

OSRAM
Opto Semiconductors

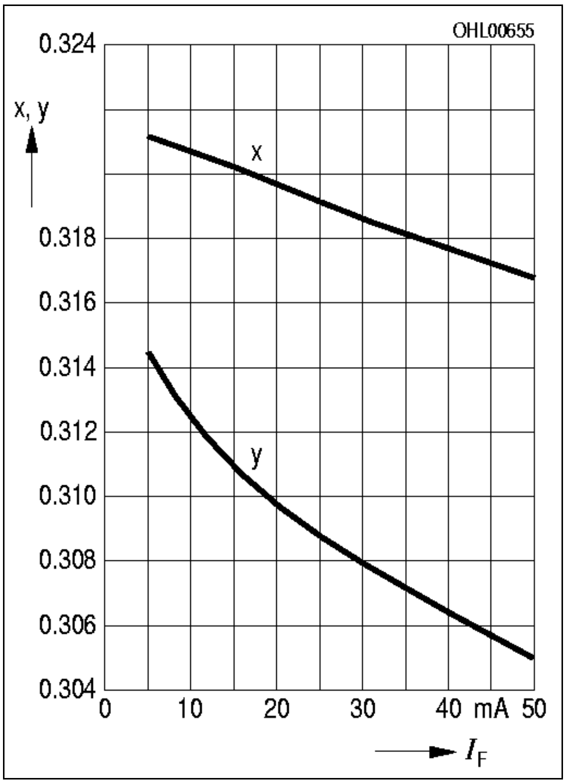

Figure 3 Chromaticity Coordinate Vs. Forward Current

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.

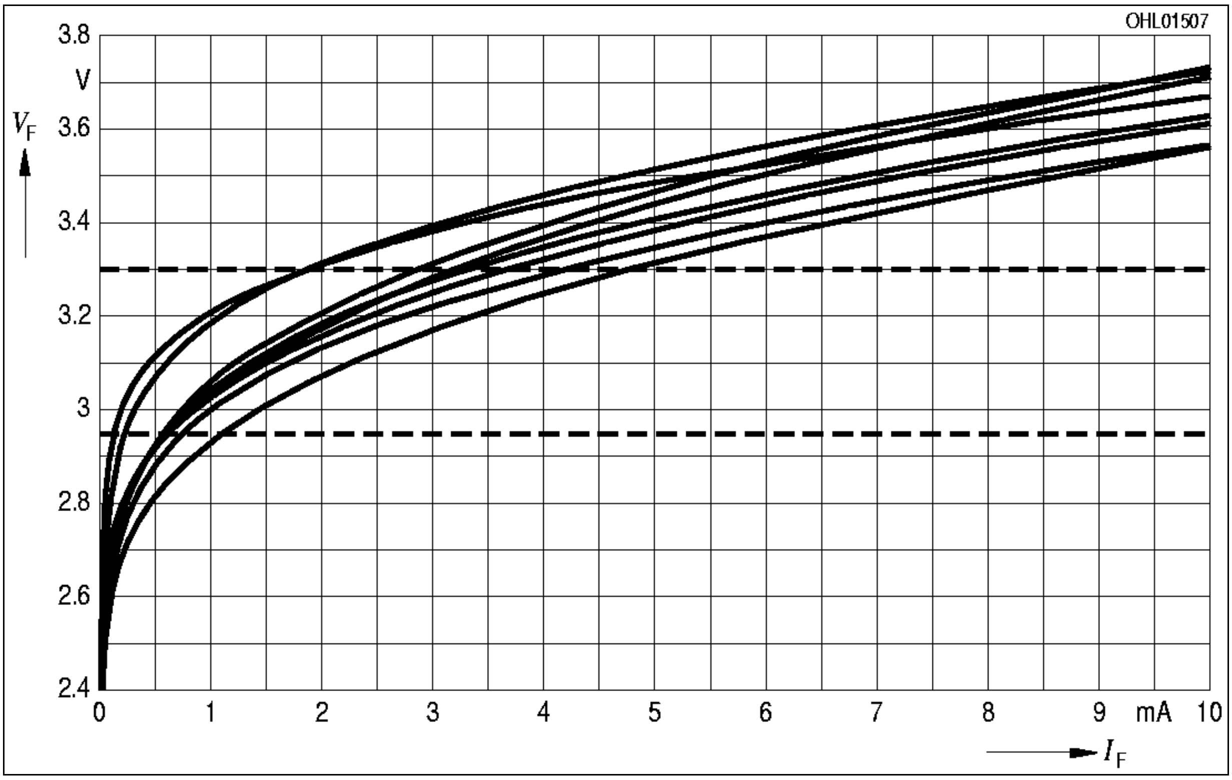

Figure 4 Examples of I_F-V_F Curves of InGaN-based White LEDs

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.

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.

Author: Gerhard Scharf

ABOUT OSRAM OPTO SEMICONDUCTORS

OSRAM, Munich, Germany is one of the two leading light manufacturers in the world. Its subsidiary, OSRAM Opto Semiconductors GmbH in Regensburg (Germany), offers its customers solutions based on semiconductor technology for lighting, sensor and visualization applications. Osram Opto Semiconductors has production sites in Regensburg (Germany), Penang (Malaysia) and Wuxi (China). Its headquarters for North America is in Sunnyvale (USA), and for Asia in Hong Kong. Osram Opto Semiconductors also has sales offices throughout the world.
For more information go to www.osram-os.com.

DISCLAIMER

PLEASE CAREFULLY READ THE BELOW TERMS AND CONDITIONS BEFORE USING THE INFORMATION SHOWN HEREIN. IF YOU DO NOT AGREE WITH ANY OF THESE TERMS AND CONDITIONS, DO NOT USE THE INFORMATION.

The information shown in this document is provided by OSRAM Opto Semiconductors GmbH on an “as is basis” and without OSRAM Opto Semiconductors GmbH assuming, express or implied, any warranty or liability whatsoever, including, but not limited to the warranties of correctness, completeness, merchantability, fitness for a particular purpose, title or non-infringement of rights. In no event shall OSRAM Opto Semiconductors GmbH be liable - regardless of the legal theory - for any direct, indirect, special, incidental, exemplary, consequential, or punitive damages related to the use of the information. This limitation shall apply even if OSRAM Opto Semiconductors GmbH has been advised of possible damages. As some jurisdictions do not allow the exclusion of certain warranties or limitations of liability, the above limitations or exclusions might not apply. The liability of OSRAM Opto Semiconductors GmbH would in such case be limited to the greatest extent permitted by law.

OSRAM Opto Semiconductors GmbH may change the information shown herein at anytime without notice to users and is not obligated to provide any maintenance (including updates or notifications upon changes) or support related to the information.

Any rights not expressly granted herein are reserved. Except for the right to use the information shown herein, no other rights are granted nor shall any obligation be implied requiring the grant of further rights. Any and all rights or licenses for or regarding patents or patent applications are expressly excluded.