Dimming InGaN LEDs

Application Note

Valid for:
InGaN LEDs from OSRAM Opto Semiconductors

Abstract

This application note examines methods for dimming InGaN LEDs with little or no effect on wavelength.

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A. Introduction

While the InGaN technology produces the brightest light output across Blue, Deep blue, Verde, True green and White, it is important to understand that the wavelength of the light emitted depends on the forward current. In order to avoid shifts in the color, the dimming strategy must be considered carefully.

This application note examines methods for the dimming of InGaN LEDs with small or no effect on the wavelength.

B. Technology data

Table 1: Example characteristics of InGaN LEDs at an ambient temperature of T_A = 25 °C e.g. for TOPLED® (Blue, Verde, True Green, White)

Parameter	Symbol	Values				Unit
		Blue	Verde	True Green	White	
Wavelength at peak emission I_F = 20 mA	λ_{peak}	462	504	524	--	nm
Dominant wavelength I_F = 20 mA	λ_{dom}	469 ± 8	505 ± 8	532 ± 4	--	nm
Spectral bandwidth at 50 % $I_{rel\ max}$ I_F = 20 mA	$\Delta\lambda$	24	30	30	--	nm

Table 1: Example characteristics of InGaN LEDs at an ambient temperature of T_A = 25 °C e.g. for TOPLED® (Blue, Verde, True Green, White)

Parameter	Symbol	Values				Unit
		Blue	Verde	True Green	White	
Chromaticity coordinate x acc. to CIE1931 I_F = 20 mA	x	--	--	--	0.33	
Chromaticity coordinate y acc. to CIE1931 I_F = 20 mA	y	--	--	--	0.33	
Forward voltage I_F = 20 mA (typ.)	V_F	2.85	2.70	2.70	3.20	V
(max.)		3.30	3.00	3.00	3.80	V
Reverse current V_R = 5 V (typ.)	I_R	0.01	0.01	0.01	0.01	µA
(max.)		10	10	10	10	µA

Figure 1: Relative spectral emission; $I_{rel} = f(\lambda)$, T_S = 25 °C, I_F = 20 mA

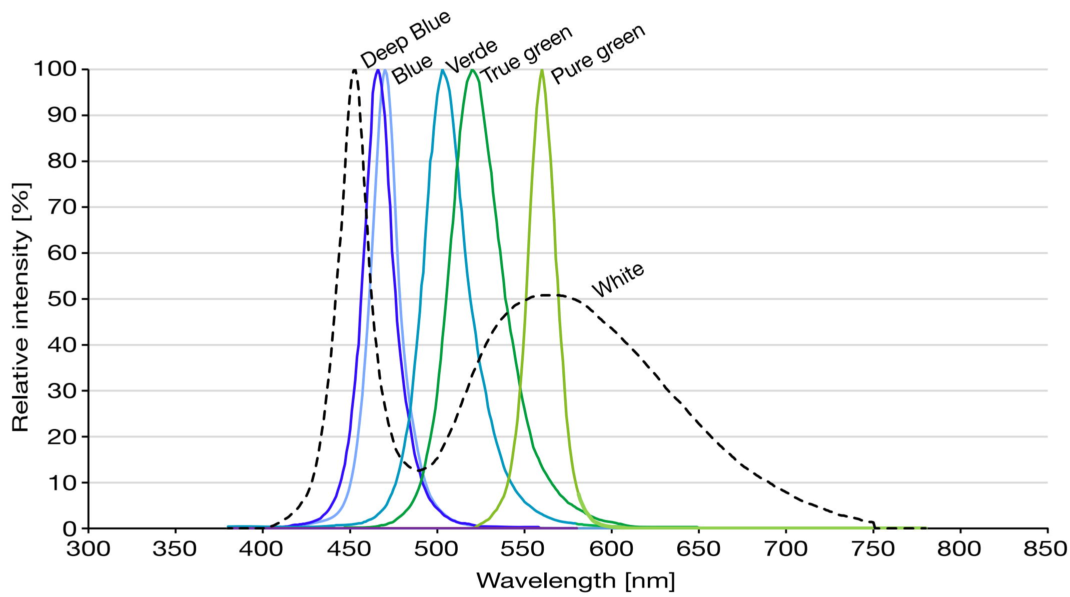


Figure 2: Dominant wavelength $\lambda_{dom} = f(I_F)$, $T_S = 25$ °C

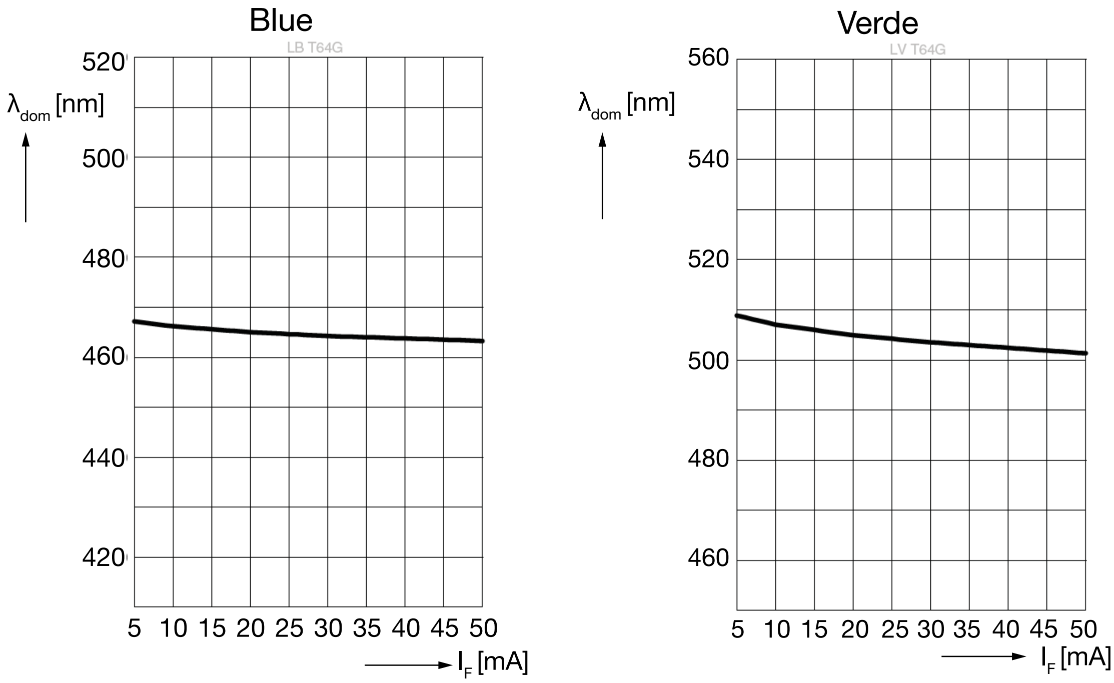
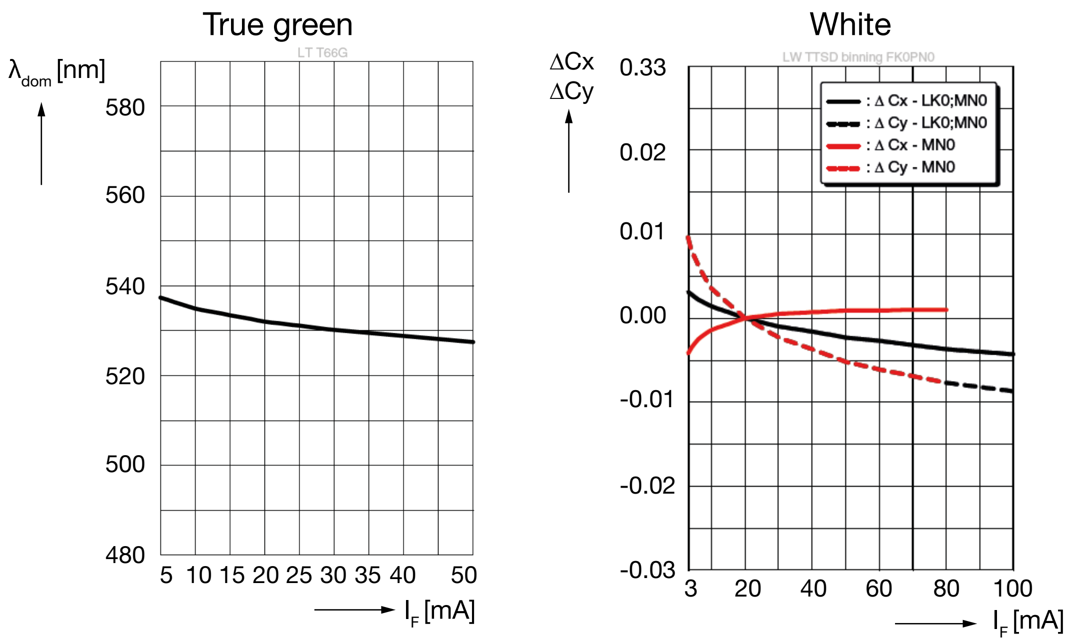


Figure 3: Dominant wavelength $\lambda_{dom} = f(I_F)$, $T_S = 25$ °C (True green) and chromaticity coordinates for White; $x = f(I_F)$, $y = f(I_F)$, $T_S = 25$ °C



C. Dimming by current variation

The most common method of dimming an LED is by varying the forward current according to a function of chip technology (Figures 1). However, due to the unique characteristics of InGaN, varying the current will shift the wavelength (Figures 2 – 3). This effect is proportional to the wavelength, with longer wavelengths undergoing the strongest shift/variation versus current. True green and Verde experience the largest shift, followed by Blue and White. No LED material other than InGaN has this dependency. Conversely, no material other than InGaN emits light in Green, Blue and White as brightly.

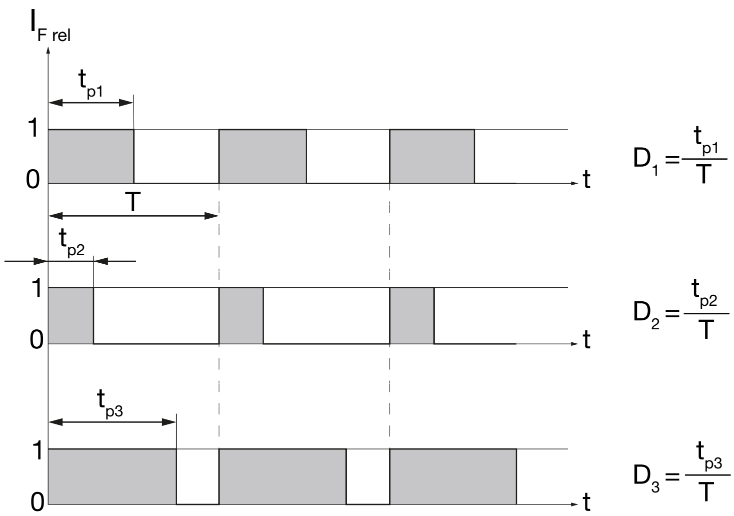
Besides current, temperature also has an effect on wavelength. The relationship is direct, whereby an increase in temperature results in an increase in wavelength (Table 1). Yet by comparison, the influence of the current on the wavelength is much stronger than the influence of the temperature. Subsequently, the effect of temperature can, by comparison, be ignored.

In the end, dimming an InGaN LED by current variation will shift the wavelength. In certain circumstances, and over small ranges, this can be acceptable. In many more cases though, a shift cannot be tolerated. There, by employing Pulse Width Modulation (PWM), an InGaN LED may be dimmed without a wavelength shift.

D. Dimming by PWM

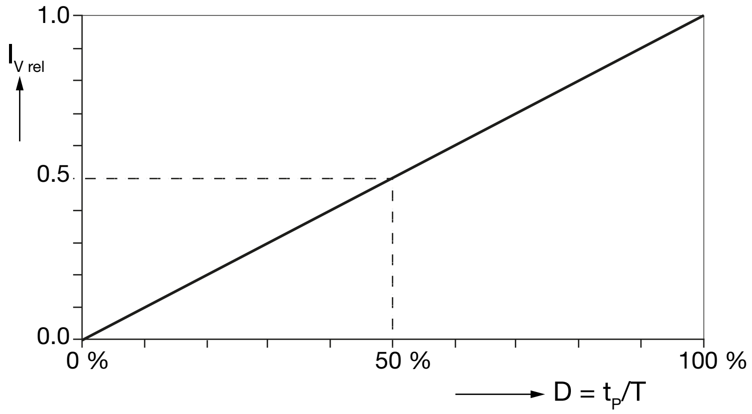
PWM works in the following manner: the forward current (I_F) is kept at a constant value and only the duty cycle (D) is changed. The duty cycle ($D = t_P / T$) expresses the ratio between pulse duration (t_P) and signal period (T). This means the LED is rapidly switched off and on. If the frequency is greater than 200 Hz or better 800 Hz, the human eye cannot perceive the individual light pulses, even in motion. The eye integrates and interprets the light pulses in terms of brightness that can be changed by varying the duty cycle (Figure 4).

Figure 4: Pulse Width Modulation PWM



If the current through one LED does not change, then the brightness will be related to the duty cycles in the following way: $D_2 < D_1 < D_3$

Figure 5: Linearity of brightness versus duty cycle; I_F = 20 mA, f > 800 Hz, T_A = 25 °C



E. PWM with InGaN LEDs

So long as the forward current through an InGaN LEDs remains constant, no wavelength or color shift occur with PWM. Figure 5 illustrates that the brightness of the LED can be changed linearly by varying the duty cycle linearly. This is valid for all available InGaN colors. The maximum attainable brightness of an InGaN LED is limited by the adjusted forward current (at D). Maximum brightness can be adjusted by varying the forward current within the range shown on the data sheet, but this will, as indicated earlier, affect the wavelength emitted.

F. Conclusion

InGaN epitaxial material emits the brightest light across the colors of Blue, Verde, True green and White. However the dominant wavelengths for the colors, as well as the chromaticity coordinates for white, depend on the forward current driven through the LED. Attempting to dim an InGaN LED by the established method of varying either current or voltage will result in a shift in wavelength. InGaN LEDs must be dimmed via pulse width modulation to avoid a color shift for Blue, Verde and True green and a hue shift for White.

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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.

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