Brightness and color of LEDs

Today, many products are manufactured and sold that take advantage of the features such as the compactness and light weight offered by LEDs. They are used in a range of applications where their brightness and color make them useful as light sources, including indicators, lamps and backlights for mobile phone displays. This document provides a more in-depth understanding of basic LED characteristics concerning the brightness and color of LEDs, which should prove useful during the design of products that use LEDs.

Brightness adjustment

Brightness adjustment using current

The brightness of the LEDs can be adjusted by changing the driving current value. Fig.1 shows an example of the correlation between forward current and relative luminous intensity in a Stanley LED.

In the example in Fig.1, if the luminous intensity for 20mA is taken to be 1, value for 10mA is 0.57 and the value for 30mA is 1.36.

Changing the DC forward current is the simplest method of controlling the brightness of LED, but there are several important points for this method.

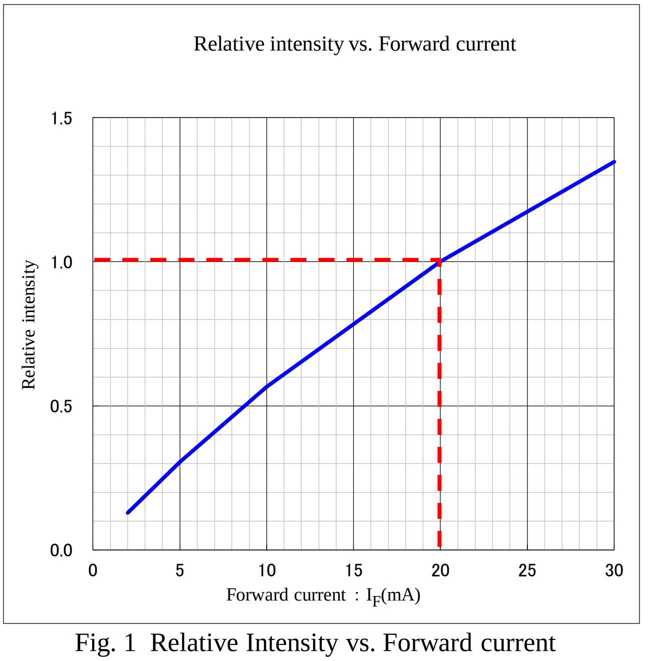

Fig. 1 Relative Intensity vs. Forward current

Influence of current value on brightness

Changes in the forward current have an enormous impact on the LED brightness. For example in Fig.1, a value of 1 at 20mA rises to 1.08 at 22mA. Because the LED reacts so acutely to changes in current, circuits must be designed so that the forward current for the LED fluctuates as little as possible.

Correlation between current and heat emissions

Because electric current is converted to light and heat at the junction between semiconductor materials in an LED, the junction temperature rises when the LED is turned on and lit, reaching its saturation point after a set time. And because rises in the junction temperature lower the efficiency of the LED, the brightness of the saturated LED is not the same as the LED immediately after it lights. Rises in the junction temperature also affect the lifespan of the product.

This variation in brightness between the saturated state and the state immediately after lighting can be very effectively minimize by using substrate materials with good heat dissipation and installing a heat sink. And because these measures are also effective in keeping the junction temperature low, they help to prolong the product lifespan.

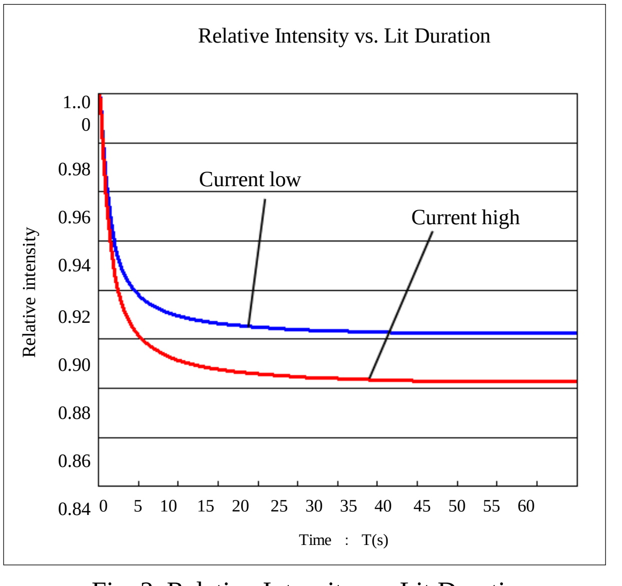

Fig. 2 Relative Intensity vs. Lit Duration

Variations in low-current use

When an LED sorted by Stanley for 20mA is used at a low current such as 2mA, variations tend to become particularly marked. While the technical data published by Stanley describes the characteristics at 2mA, this only illustrates the characteristics for a representative sample. The characteristics should be confirmed using an actual installation.

The effect whereby variations at low currents are larger than those that occur at the standard current is a result of the defects and impurities contained in the LED element. At low currents, the variations caused by the defects and impurities are larger than for higher currents. Note this point when designing and researching LED devices to be used with low currents.

Brightness adjustment by pulse width modulation

Brightness can also be adjusted by varying the width of the pulses used in the pulse drive rather than changing the current. When this method is used, because the forward current itself is not changed, there will be a reduction in the color variations caused by the changes in brightness. Normally, the duty ratio is changed for frequencies of 100Hz or more where there is no visible LED flashing.
Brightness can also be adjusted by changing the pulse width without changing the current. Because the forward current is not changed, a reduction in the color variations caused by the changes in brightness is expected with this method. Slow modulation can also cause flicker. We recommend checking the operation with the actual machine.

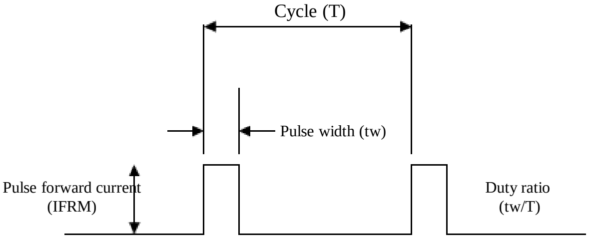

Fig. 3 pulse drive condition

Matching Colors

Color separation

In products that use fluorescent materials, the distance traveled by the light from the element before it emerges from the package varies depending on the angle. This means that the proportions of light from the element and from the fluorescent material also vary depending on the angle, with the result that the color of the package viewed from directly in front is not the same as when it is viewed from an angle. (Fig.4)

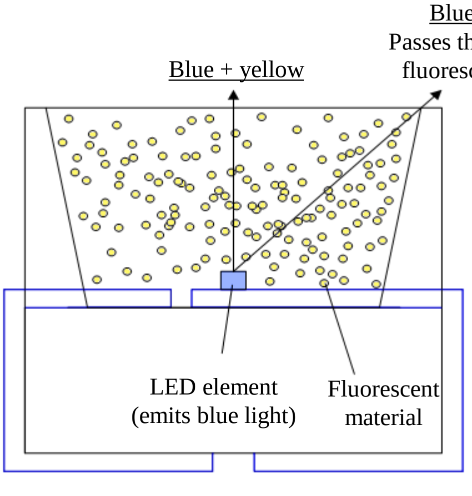

Fig.4 Differences in the proportions of blue and yellow light according to angle

Color classification by Stanley

At Stanley, the color emitted by an LED is stipulated and ranked according to either its coordinates (x, y) in the CIE standard colorimetric system or its dominant wavelength. It is possible for a color to have the same rank but a different spectrum, which can result in products with the same plotted color coordinates having different colors. While there are no instances of the same product having different spectra, it is important to understand that spectral characteristics may differ if different products are used.
Fig.5 shows a typical example of the spectra of LEDs that are both white. If these two were used as backlights for an LCD, the colors seen on the LCD screen would be completely different. This would need to be studied taking the LCD filter characteristics into account.

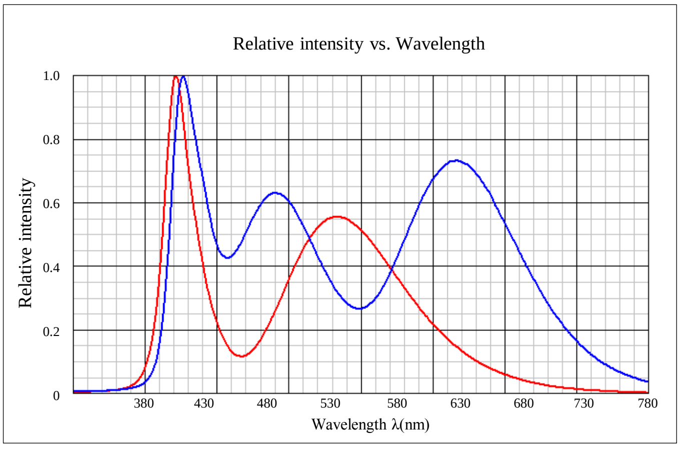

Fig.5 Spectral differences in white LEDs

Correlation between current and color

Changes to the current also result in changes to the colors. Fig.6 shows an example of the correlation between chromaticity and forward current in a white LED product that uses fluorescent material, while Fig.7 shows the correlation between the dominant wavelength and forward current in a blue LED product that uses no fluorescent material. These graphs clearly show how the color can change sufficiently to move the product into a different rank depending on the current. This effect is caused by the elements and fluorescent materials used, and the extent of the changes varies depending on the differences between the products.

To minimize this variation in characteristics, products should be used with the forward current settings selected by Stanley.

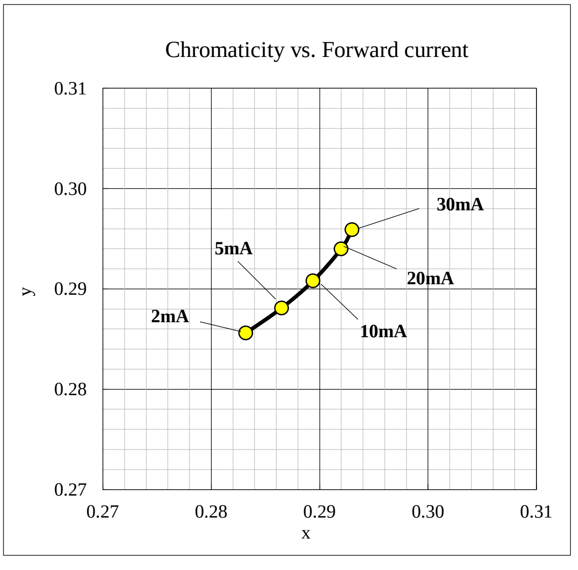

Fig.6 Chromaticity vs. Forward Current

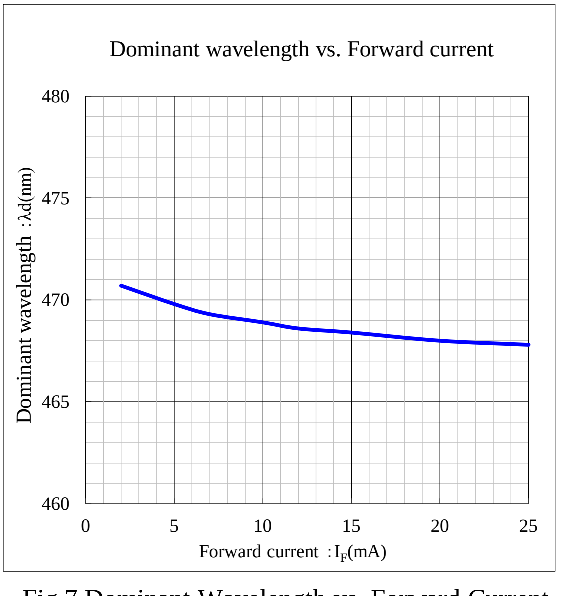

Fig.7 Dominant Wavelength vs. Forward Current

Chromaticity variations due to ambient temperatur

The color of an LED changes in response to the ambient temperature.

This is caused by the element and fluorescent material used. Refer to the technical data when using products under the conditions selected by Stanley at widely differing ambient temperatures.

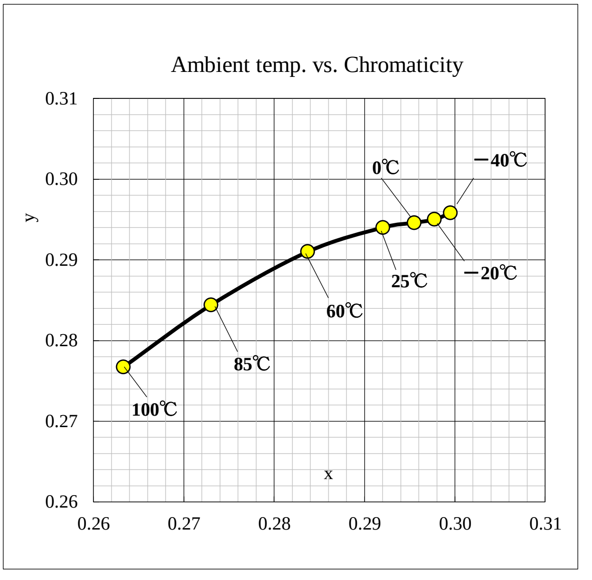

Fig.8 Ambient Temperature vs. Chromaticity

Changes over time

LED color can also change due to factors such as discoloration in the resin as a result of prolonged use. Because the extent of such changes varies depending on the conditions in which the product is used, products that are required to comply with regulations should be trialed in the actual operating conditions to check for problems before they are used.

As stated above, the brightness (luminous intensity) and color (chromaticity) of an LED are highly dependent on forward current. For this reason, Stanley LED products are classified into a number of luminous intensity rankings at shipment.

Stanley V-series products are further classified and organized into luminous intensity and chromaticity rankings designed for applications such as the meters and indicators used in vehicles. Products with names that begin with "V" are available in a range of package types from PCB-type chip LEDs to PLCC packages.

Features of the V Series

・Uses a luminous intensity and chromaticity ranking system that applies to all products regardless of the color emitted or package type.
・Uses luminous intensity rankings that support "half-bin" ranks (rank size: up to 1.2x)

【光度／Luminous intensity】

ランク名 Bin	光度 Iv Luminous intensity (mcd)	
	Min	Max
AX	5.6	6.8
AY	6.8	8.2
AZ	8.2	10

ランク名 Bin	光度 Iv Luminous intensity (mcd)	
	Min	Max
B1	10	12
B2	12	15
B3	15	18
B4	18	22
B5	22	27
B6	27	33
B7	33	39
B8	39	47
B9	47	56
BX	56	68
BY	68	82
BZ	82	100

ランク名 Bin	光度 Iv Luminous intensity (mcd)	
	Min	Max
C1	100	120
C2	120	150
C3	150	180
C4	180	220
C5	220	270
C6	270	330
C7	330	390
C8	390	470
C9	470	560
CX	560	680
CY	680	820
CZ	820	1,000

ランク名 Bin	光度 Iv Luminous intensity (mcd)	
	Min	Max
D1	1,000	1,200
D2	1,200	1,500
D3	1,500	1,800
D4	1,800	2,200
D5	2,200	2,700
D6	2,700	3,300
D7	3,300	3,900
D8	3,900	4,700
D9	4,700	5,600

【ドミナント波長／Dominant wavelength】

Bin	ドミナント波長／Dominant wavelength, λ d (nm)							
A	460 – 464			567 – 570			610 – 613	620 – 626
B	464 – 468	520 – 525		570 – 573			613 – 616	626 – 632
C	468 – 472	525 – 530	558 – 561	573 – 576	583 – 586	603 – 606	616 – 619	632 – 638
D	472 – 476	530 – 535	561 – 564	576 – 579	586 – 589	606 – 609	619 – 622	
E		535 – 540	564 – 567		589 – 592	609 – 612		
F					592 – 595			