

## LED Brightness and Color

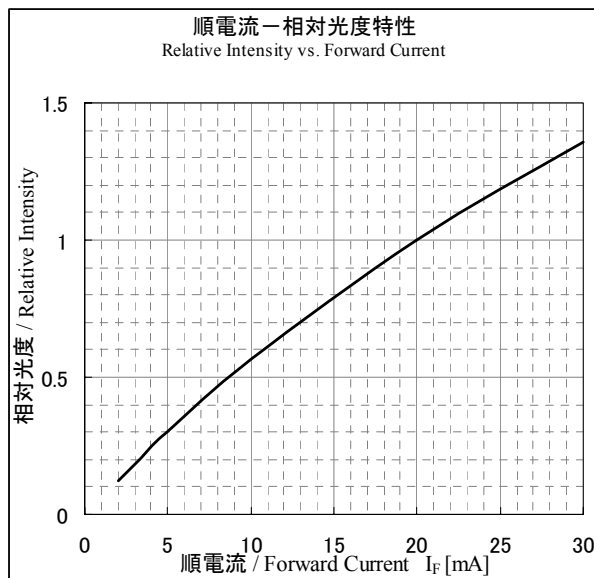
Today, many products are manufactured and sold that take advantage of the features such as the compactness and light weight offered by LEDs. They are used in a range of applications where their brightness and color make them useful as light sources, including indicators, lamps and backlights for mobile 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

It is easy to see how the brightness of an LED can be adjusted by changing the electric current. Graph 1 shows an example of the correlation between forward current and relative luminous intensity in a Stanley LED.

In the example in Graph 1, if the luminous intensity for 20 mA is taken to be 1, value for 10 mA is 0.57 and the value for 30 mA is 1.36. Changing the DC forward current in this way is the simplest means of varying the brightness of an LED, but there are several aspects of this method in which care is needed.



Graph 1 Relative Intensity vs. Forward Current

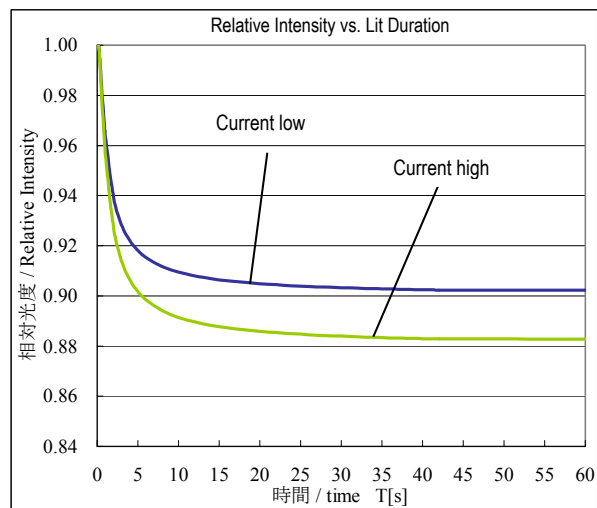
#### Extent to which brightness is influenced by current

Changes in the forward current have an enormous impact on the LED brightness. For example, in the figure above, a value of 1 at 20 mA rises to 1.08 at 22 mA. 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.



Graph 2 Relative Intensity vs. Lit Duration

#### Variations in low-current use

When an LED classified by Stanley for 20 mA is used at a low current such as 2 mA, variations tend to become particularly marked. While the technical data published by Stanley describes the characteristics at

2 mA, 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 using 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 100 Hz or more where there is no visible LED flashing.

According to the response speed of the element and fluorescent material, extremely rapid modulations may give rise to color changes and may inevitably cause some flickering. It is advisable to check operation with the actual installation when this method is considered.

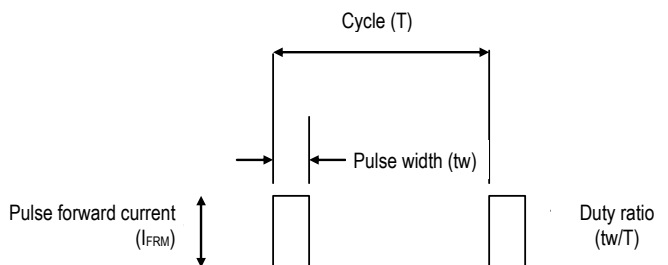


Fig. 1

## 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. 2)

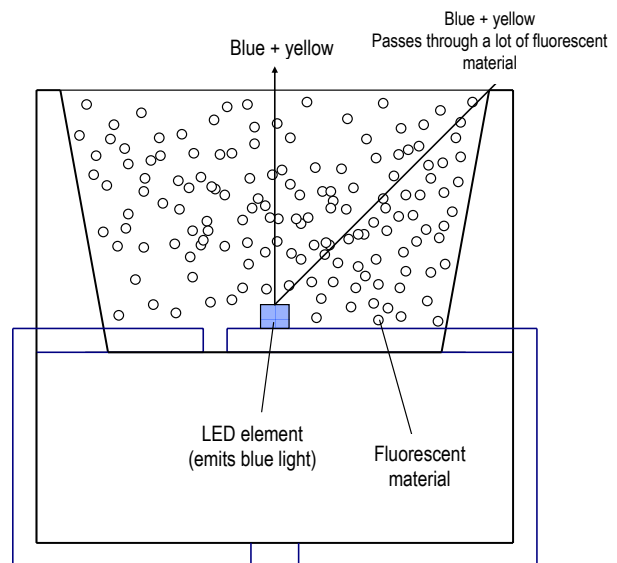


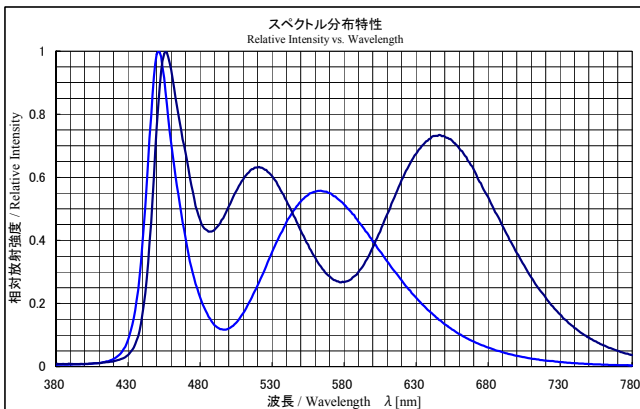
Fig. 2 Differences in the proportions of blue and yellow light according to angle

At Stanley, we have succeeded in developing products in which this color separation is suppressed and are expanding our product line as needed. The characteristics data for these products is available as technical data. Check this information to confirm its suitability for products being considered.

### 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.

Graph 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.

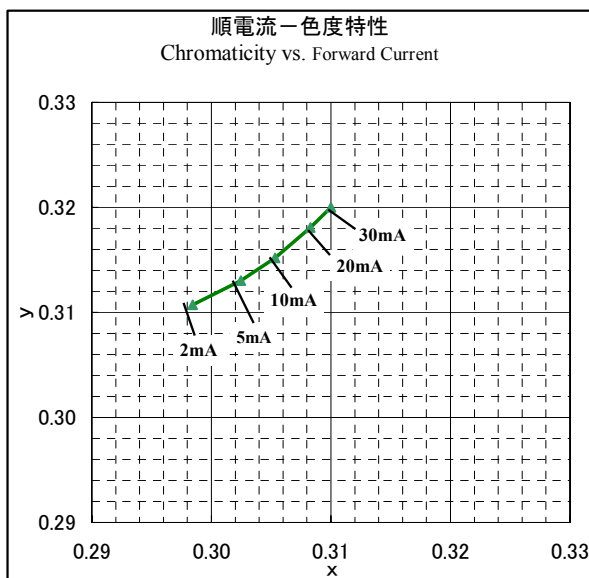


Graph 5 Spectral differences in white LEDs

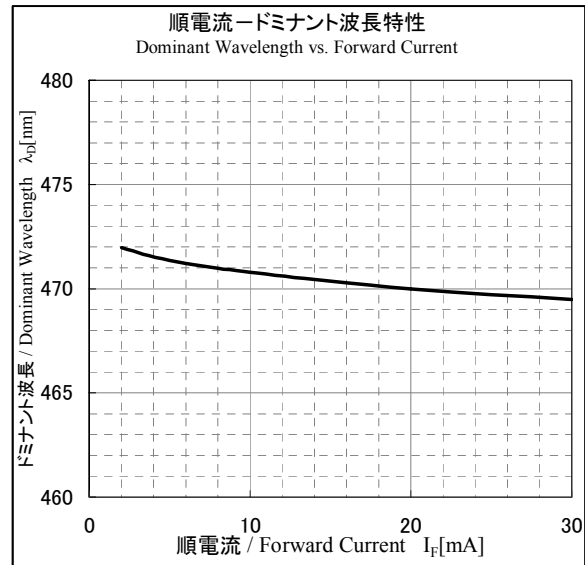
**Correlation between current and color**

Changes to the current also result in changes to the colors. Graph 3 shows an example of the correlation between chromaticity and forward current in a white LED product that uses fluorescent material, while Graph 4 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.



Graph 3 Chromaticity vs. Forward Current

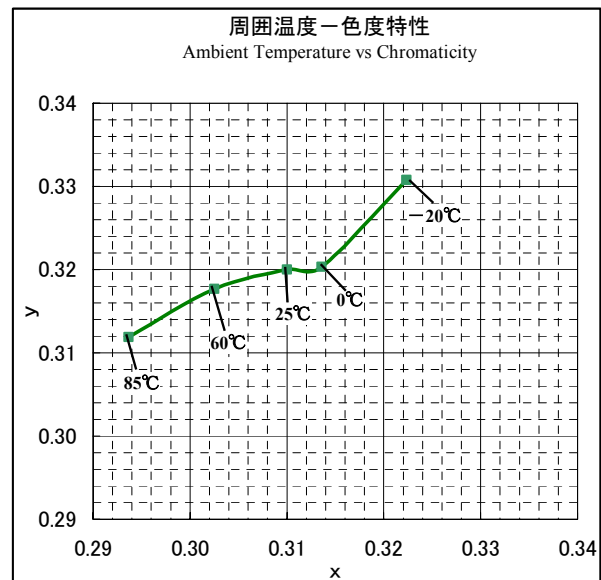


Graph 4 Dominant Wavelength vs. Forward Current

**Chromaticity variations due to ambient temperature**

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.



Graph 5 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)