LED Devices for Vehicle Interior Lighting

1. Introduction

Stanley provides a lineup of LED products for vehicle interior lighting as the “V Series,” with each product number beginning with the letter V. As shown below, these products satisfy the basic performance required of indicators and other vehicle interior lighting. In this document we provide points that should be taken into consideration when designing and contemplating vehicle interior applications for LED devices.

Lighting quality

- Minimal spread of luminosity and color tone (chromaticity) within the range of a luminosity rank
  (E.g.: Luminosity rank: Approx. 1.2-fold greater width (chip LEDs), Approx. 1.5-fold greater width (vertical LEDs))
- Guaranteed tolerance
  Luminosity: ±10%
  Color tone: ±1nm
  Chromaticity: ±0.01
- Reproduction of customer-designated emission color [special color-compatibility]

High brightness in vehicle environments

- Operable in 100˚C temperature
- Selected properties for use under maximum rated current at 85˚C
- Materials and structural design suited for electric conduction in high temperatures

Quality maintenance in vehicle environments

- Storage temperature: –40˚C to 110˚C (120˚C)
- Operating temperature: –40˚C to 100 ˚C
- ESD HBM 1,000V guaranteed
- Materials and structural design that satisfy the above conditions

2. Product Lineup

The V-Series offer a wide lineup of packages as shown in Table 1 for a variety of automotive applications, such as door switches, steering wheel switches, meter backlights, and warning indicators.

	PLCC types	Substrate types	Vertical lamp types
Single color	V□□1104B V□□1107L VF□1104LS	V□□1111C V□□1112H V□□1101W V□□1102W V□□1105W V□□□ 1107WX (*)	V□□38□4X
White (special color)	V□W11□7LS V□□W11□ 8LS V□□W11□ 4LS(－E)	VC □ W11 □ 7W□X (*)	—

*Under development
Table 1

3. Meter Face and Instrument Panel Lighting

Many LEDs are used in vehicles to light automotive clusters, switches, and the HVAC system, but the majority is used to light switches and meter faces.

When using LEDs in the above-mentioned applications, take the following points into consideration.

Brightness

Clusters, switches, and the HVAC system are designed in various sizes and styles, so it is important to select an LED that respectively suits each application.

When illuminating a large area as shown in Fig. 1, we recommend selecting an LED with wide directivity.

However, note that there are slight differences according to the type of components composing the instrument panel.

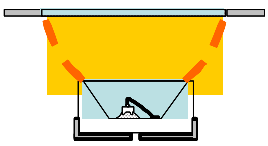

Fig. 1

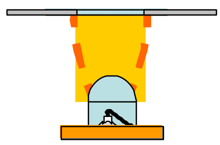

Fig. 2

The distance between the LED and the instrument panel is also a factor to consider when deciding on brightness. If it is far, high brightness is required, because luminosity will decrease. Either adjust the current or select a high-luminosity LED.

Distance to the instrument panel

The intensity of light weakens as the distance from the light source becomes farther. Therefore, if there is some distance from the LED to the instrument panel, brightness will diminish by the time it reaches the instrument panel, and measures such as the following need to be considered to provide the necessary brightness.

1) Select an LED with narrow directivity.

When comparing two LEDs with the same light-emitting elements, the device with the narrower directivity provides a brighter optical axis and could more effectively illuminate the instrument panel.

(E.g.) Substrate-type LED: 2W, 5W, etc.

Vertical LED lamp: 6X, etc.

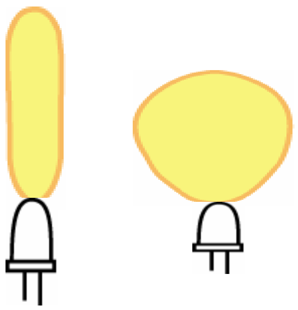

Fig. 3

2) Select a high-luminosity LED.

When comparing two LEDs with the same directivity, the one with the higher luminosity (emission luminosity) more effectively illuminates the instrument panel.

(E.g.) Vertical LED lamp: U Series (super high luminosity LED), etc.

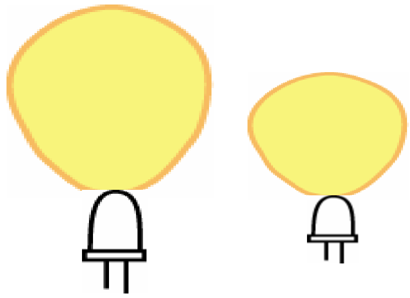

Fig. 4

3) Add a separate optical system near the LED.

An LED could more effectively illuminate the instrument panel by placing a lens between the LED and instrument panel and allowing it to condense the light.

(E.g.) Condensing lens, guiding lens, etc.

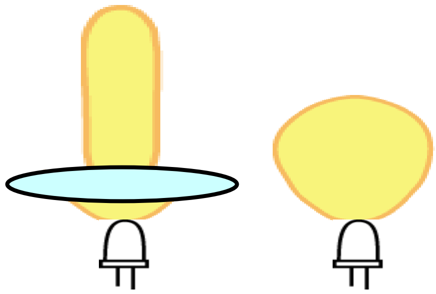

Fig. 5

* Changing the LED package might change how the instrument panel is illuminated or change the appearance of the panel. Sufficiently evaluate and consider this point when designing an LED application.

Color tone

Many diffuser panels are used in the design of clusters, switches, and the HVAC system. When light from an LED passes through the diffuser panel, the color tone (color appearance) may change according to whether the light is transmitted, absorbed, or diffused. An image of this shift in color tone is shown in Fig. 6.

For the reason discussed above, it is necessary to take into consideration the shift caused by the diffuser panel when deciding on LED specifications. For the lighting of meter faces and the instrument panel, brightness also changes along with the shift in color tone that occurs according to the degree of diffusion, thickness, and color of the instrument panel. Therefore, LED specifications should be fixed after deciding on a diffuser panel.

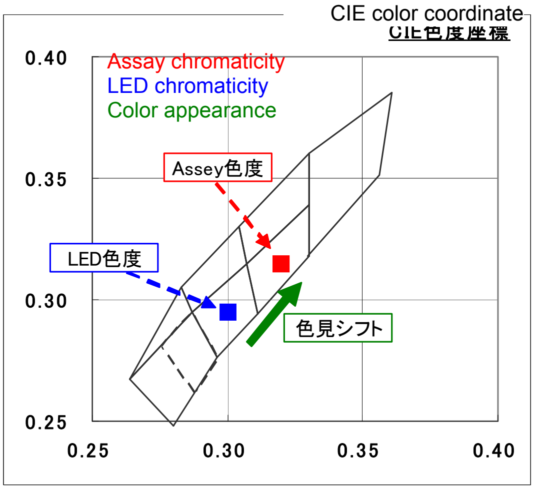

Fig. 6

Light distribution and brightness of an LED vary according to the package.

Fig. 7 shows light distribution and brightness characteristics of each LED package. Refer to this figure when selecting the optimum LED package for your application.

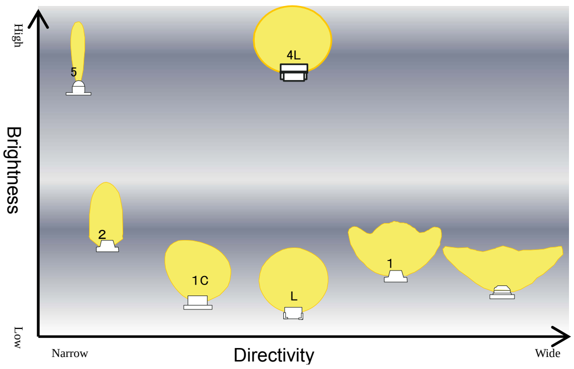

Fig. 7

4. Operating Current and Luminosity/Color Tone (Dominant Wavelength)

LEDs released on the market in recent years are becoming brighter thanks to improvement of the LED element. However, vehicle lighting LEDs, and particularly steering wheel switches are sometimes used with moderate brightness because they enter the driver's field of vision when driving. LED products provide certain luminosity and color tone according to the current designated by their specifications, but in the above case, the LED is operated at a lower current than the standard current specific to the product. If a product that is intended for use at a forward current of about 20 mA is used at currents below 5 mA, luminosity might fluctuate significantly to varying degrees and color tone may also change. Below we provide an explanation of the mechanism of this phenomenon.

Operating current and luminosity fluctuation

LED specifications are generally decided according to the luminosity and color tone that is obtained when a current of 10 to 20 mA is applied, although details differ according to the specifications of each product. Fig. 8 shows the structure of a typical element. The light that is output by the LED is emitted from the active layer. As shown in the figure, the anode electrode (P-electrode) blocks the emitted light, so it is made as small as possible in LEDs with this structure. When a forward bias is applied to the LED, a current flows from the P-electrode side to the active layer via the current diffusion layer. As long as there is a 10 to 20 mA current in the current diffusion layer, the current will spread throughout the element and will be evenly supplied to the active layer, so the amount of light emitted is relatively stable (Fig. 9). On the other hand, if this type of LED is used at low currents between 1 and 5 mA (Fig. 10), the degree of diffusion in the current diffusion layer will be affected by the fluctuation in the element production process, and will also fluctuate. As a result, the current that is supplied to the active layer will also fluctuate, as will the amount of light emitted.

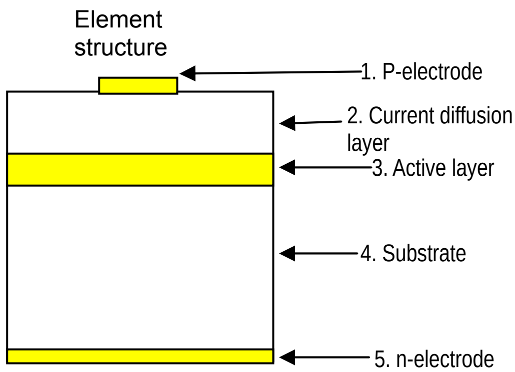

Fig. 8

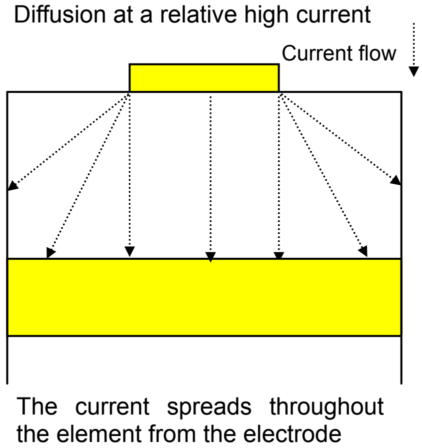

Fig. 9

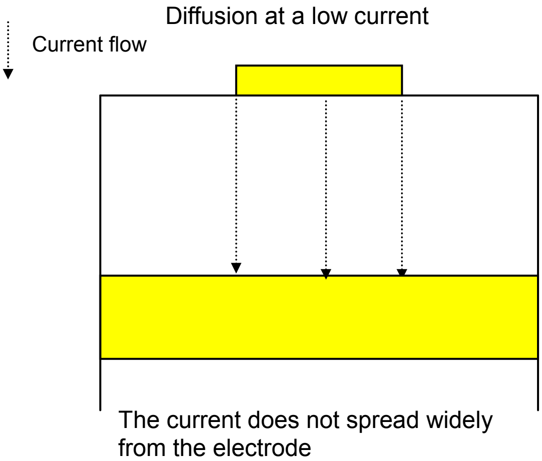

Fig. 10

Even at normal currents between 10 to 20 mA, fluctuations during element production in the LED device cause a fluctuation in the light output. The specifications of an LED are decided according to the luminosity rank that is established according to the fluctuation criteria. Imagine that a fluctuation of 1 to 5 mA in the low-current zone becomes an even larger fluctuation at ordinary current levels.

Due to the mechanism discussed above, LED design needs to take into consideration luminosity fluctuation when it is to be used at low currents.

Operating current and shift in color tone

As with luminosity, color tone is dependent on operating current. Figs. 11 and 12 show band models of LEDs with a single hetero and double hetero structure. In Fig. 11, the LED is operated at a relatively low current, and the energy gap is shown as Eg. In Fig. 12, it is operated at a standard current level, and the energy gap is shown as Eg′. When the operating current is large, the heat from the junction causes the energy gap to change, so Eg′ becomes smaller than Eg. This means that the emission wavelength when operating an LED at a low current is shorter than when it is operated at a standard current level.

Figs. 13 and 14 show band models of LEDs with a quantum well structure. In Fig. 13, the LED is operated at a relatively low current, and the energy gap is shown as Eg1. In Fig. 14, it is operated at a standard current level, and the energy gap is shown as Eg1′ and Eg2. Fig. 14 is operated at a larger current than Fig. 13, so the quantum well is filled with carriers, and light emission in Eg2 becomes dominant compared with Eg1′, which has a higher energy level. As with the hetero structure, the change in energy gap becomes such that Eg1 > Eg1′ due to the thermal effect, but because light emission is dependent on the energy level of Eg2, the relationship becomes such that Eg1 < Eg2. This means that the emission wavelength when operating an LED at a low current becomes longer than when operating at a standard current level.

Above, we have provided an explanation of the mechanism of dependence between luminosity fluctuation caused by operating current and color tone. Please take this into consideration when selecting an optimum LED for your application.

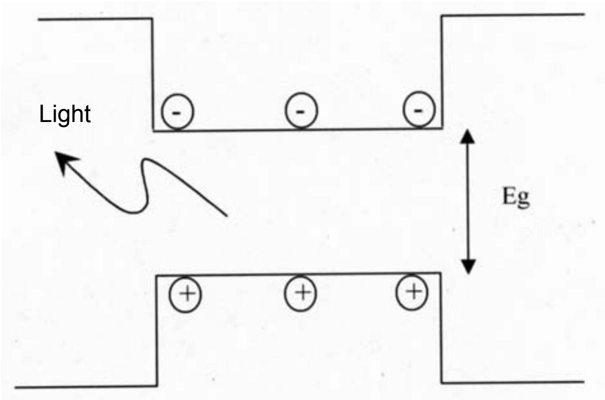

Fig. 11-1

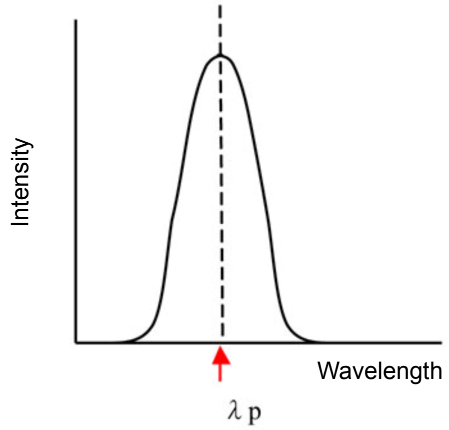

Fig. 11-2

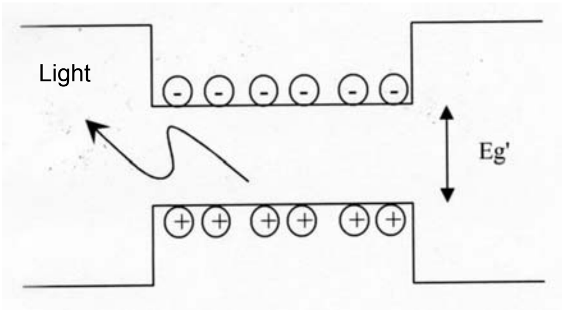

Fig. 12-1

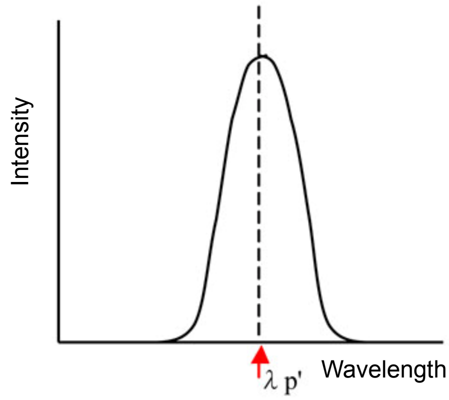

Fig. 12-2

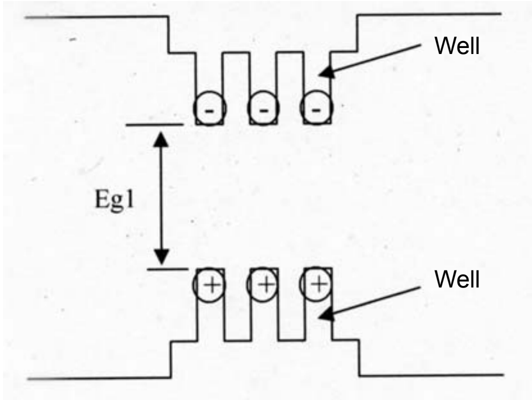

Fig. 13-1

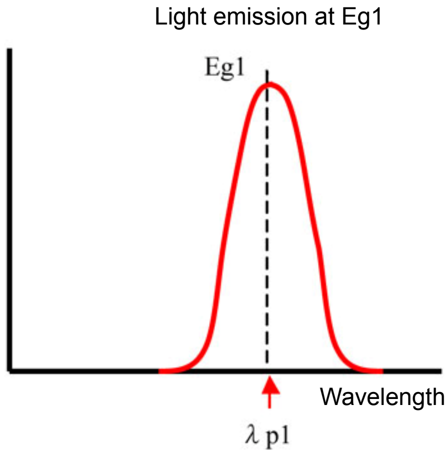

Fig. 13-2

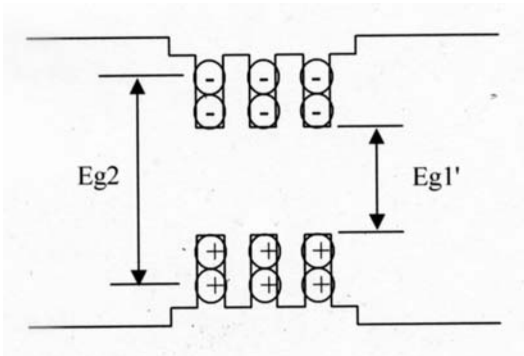

Fig. 14-1

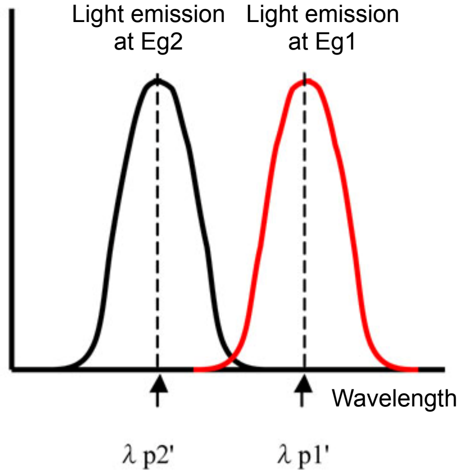
Light emission at Eg2
Light emission at Eg1
Wavelength
λ p2'
λ p1'

Fig. 14-2