

High-Design Exterior Light Lens Having Both Excellent Transparency and Homogenous Luminance

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ABSTRACT

An exterior light lens with a unique and finely textured shape was devised, which provides homogenous luminance, and luminance control technology of exterior light by arranging finely textured shape was developed.

Because a die mold with a fine, three-dimensional lens shape is required when mass-producing the lens, we also developed a CAM (Computer Aided Manufacturing) that enables finely textured machining on a free-form surface and automatically produces a smooth machining path on a curved surface.

This new technology allowed us to successfully develop a lens that simultaneously achieves transparency and homogenous luminance, properties not achievable through conventional technology.

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INTRODUCTION

In order to increase the product appeal of a vehicle, it has become desirable in recent years to develop a high-design, low-cost exterior light that uses an LED (Light Emitting Diode) light source [1,2]. Some examples developed by manufacturers to promote the identity of their vehicles include daytime running lights, position lights, and tail lights with high-design surface/solid emission. To meet the high-design requirements for surface/solid emission, it is necessary to freely control and increase luminance in a lens having a free-form surface. However, because the conventional lens design/machining technology is limited in terms of design/machining resolution, the following problems occurred:

1. The size of conventional lens cut was on the order of millimeters and the lens had constant directionality in the reflection angle as a result of being in a wedge shape. These two restrictions led to a large disparity between light-emitting parts with high luminance and those with low luminance, and luminance irregularity was easily noticeable (Fig. 1).
2. When there are few LEDs, luminance decreases as the light source moves further away, and unlit areas are created, giving the appearance of the light source fading out (Fig. 1).
3. In order to make the entire lens emit light :
 - 3-1. Multiple LED light sources are used, which increases the cost (Fig. 2 [1,2]); and
 - 3-2. A milky-white colored lens and a grainy lens are used, which negatively affect the appearance of transparency (Fig. 3).



Figure 1. Appearance of light source fading out and luminance irregularity



Figure 2. LED Array Sample



Figure 3. Milky-white color, grainy lens

DEVELOPMENT GOALS

The development concept for the high-design exterior light lens was a lens having both “transparency” and “homogenous luminance,” which conventional lenses cannot achieve. We therefore established the following development goals:

1. To be able to control the light emitted from the lens to become more intense as the light source moves further away;
2. To prevent a disparity (= luminance irregularity) in the luminance intensity of the light source; and
3. To ensure lens transparency.

Definition and Setting of Target Values

Luminance Rate

Luminance rate is defined as follows (Fig. 4).

Luminance rate = end-luminance / luminance near the light source

Also, when setting the target value(s), we tried to prevent the appearance of the light bulb fading out, which occurs in conventional lenses, by making the end-luminance greater than the luminance near the light source. In other words, our goal for the target value was a luminance rate of 100%.

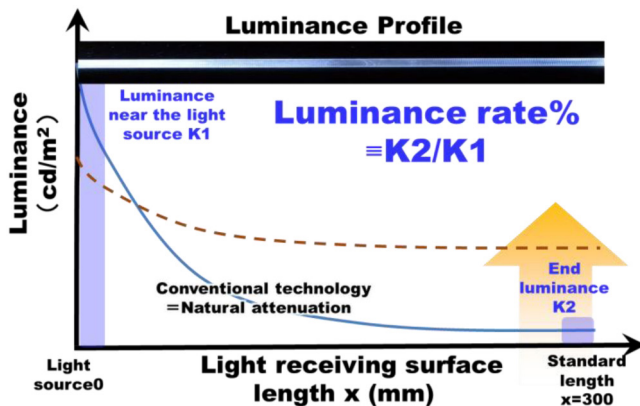


Figure 4. Definition of luminance rate

Luminance Irregularity

Luminance irregularity is defined as follows (Fig. 5).

Luminance irregularity = standard deviation of luminance gradient

In addition, the target value for a luminance profile that prevented luminance irregularity from being visually detected was 1,000 (cd/m²)/mm or less.

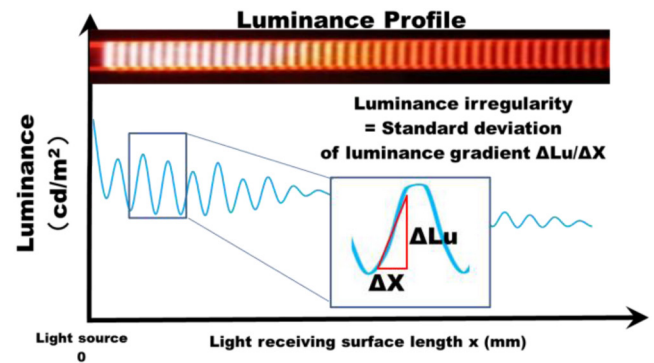


Figure 5. Definition of luminance irregularity

Transparency Index HAZE

The haze value is defined as follows.

$$\text{Haze}(\%) = T_d/T_t \times 100$$

T_d : Diffuse transmittance; T_t : Total optical beam transmittance

The target transparency value at which the lens would be considered transparent was less than 50%.

ACHIEVEMENT METHOD

The issues that we attempted to resolve in this technological development effort were “to determine and design a lens texture shape that achieved both luminance and transparency” and to develop “fine machining technology” for mass-producing the designed shape.

Method-1 Design Technology

The optical analysis software that we used was SPEOS by OPTIS Corporation.

Creating the Shape

The Texture Of The conventional wedge-shaped lens causes high wedge-angle dependency in the light-emitting direction, which makes it difficult to achieve diffuse luminance (= homogenous luminance). By making the lens shape curved, both light emission and diffusion were achieved. The results of tracing light beam using SPEOS are shown in Fig. 6.

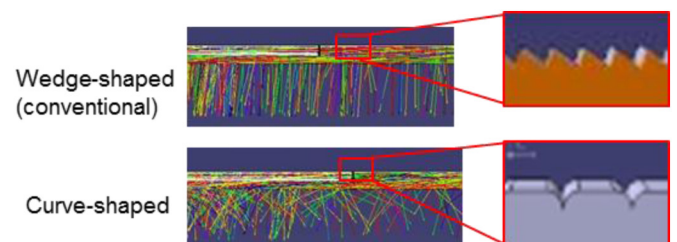


Figure 6. Results of tracing light beam using SPEOS Upper: Wedge-shaped (conventional) Lower: Curve-shaped