LED-based illuminated V-core optical engine

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Abstract

LED is promising for the application of specialty illumination. Thiscolor management system, V-core, with LED light sources and the structure of V-core for LCoS projector has been proposed to improve the primary saturation, uniformity and contrast. We designed the high efficient LED modules for high brightness requirement. The LED module can operate in narrow-direction indicator, 12°.

Keywords: LED light source, optical engine, LCoS

1. Introduction

The most of projectors use as light source a high-pressured arc lamp that emits white light. Its bulb is constituted of several materials, two of which are mercury or xenon depending on the type of lamp. The basic principle is to use the white lamp for generating all the colors. But the heat of lamp can result in the deformity of the supporting structure of the optical engine, destroy the coating of optical components, and cause the thermal stress and heat effect variation of LCoS panels, etc.. And the long life time, highly saturated colors, mercury free operation and voltage operation are the major benefits that make LEDs the light source of the future for both general and special light application. By using red, green and blue LEDs as primary light sources, the color efficiency will be largely improved[1][2]. The illumination optics also has a built-in polarization conversion system to retain the polarization efficiency as in the traditional liquid crystal projector engine.

2. System architecture

2.1 LED illumination optics design

This article provides a novel LED-base illumination optics and color management system, V-core, by using LED light sources. However, high power LED always has non-uniformity and large irradiation angle, which makes it difficult to be directly used in the original projection system. Therefore, a suitable optical integrator is necessary to transfer the flux produced by LED to an irradiance uniform target.

To accomplish this goal, the LEDs module system generally uses some kind of flux integration scheme such as collimator lens and reflector cup. We have proposed a reflector cup (shown in figure 1) and a special collimator (shown in figure 2).

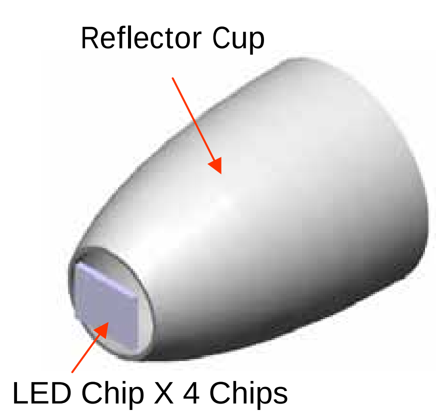


Figure 1. The schematic of reflector cup

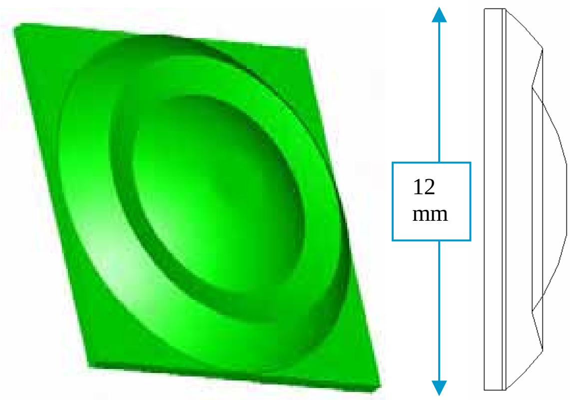


Figure 2. The schematic of collimator lens

In our prototype the dies of the LEDs have a square area of 1x1 mm^2. According to the optical simulation result, the structures of the collimator and the reflector cup have good collimation efficiency, and the aperture size is only 12mm. Each LED module consists of **4** high brightness LED's, Spectral Half-Width 6°.

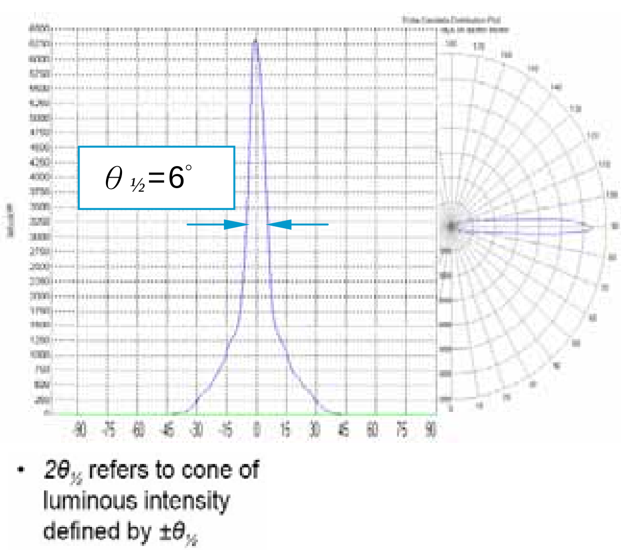


Figure 3. The schematic of the optical simulation

The LED is packaged onto a metal core PCB base without epoxy. This gives it good thermal characteristics while also providing an electrically-neutral thermal path. Capable of offering up to 130% more color gamut for greater color saturation, the module is self-contained with an integrated non-spherical surface lens. Not only the efficiency is high, but also a smaller total aperture size can be achieved.

2.2 Optics design of reflector cup

To collect light from LEDs to match the system configuration, we choose an elliptical surface as the inner reflective surface of the cup. In the ellipsoid, the ray emitted from one focus (f_1) will concentrate on another (f_2) after reflecting by the ellipsoid. (Shown in figure 4)

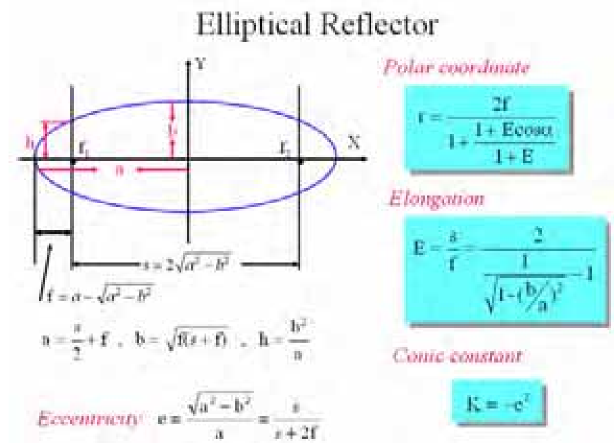


Figure 4. The scheme diagram of the elliptical surface

The reflective surface has several functions as the elliptical model (Shown in figure 5). As following these equations, we calculate the length of the reflector L 12.5mm.

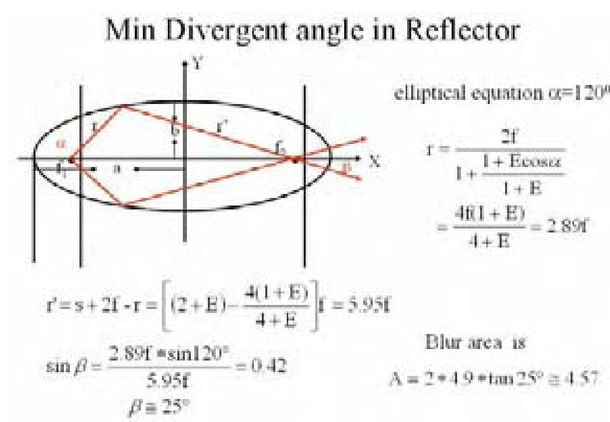


Figure 5a.

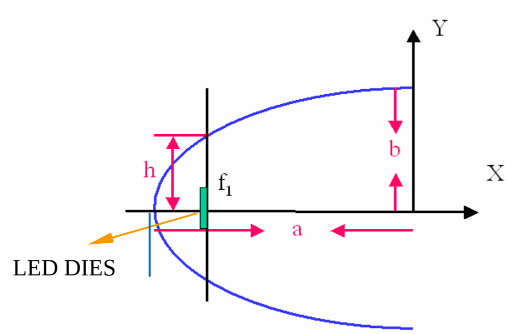


Figure 5b.

Figure 5 The diagram of the elliptical math model in (a)minima divergent angle and(b)

calculating the Elongation of reflector cup

Light engine architecture

We build a light engine using three reflective LCD panels based on LCoS technology. The proposed light engine consists of two different color LED array, two lenslet arrays, consider lenses, a mirror, a color selector, and a V-core color management system. The optical layout is illustrated in figure 6.

Figure 6 shows a schematic of the novel illumination system architecture. The illumination light path can be divided into two segment, one is green LEDs, and the others are red and blue LEDs. The image of each LED on the array is formed by the lenslet, which can be considered as the first stage of mixing light from individual LED and to improve the uniformity.

Light from two different LED array are directed into the V-core color management system. There are two larger and two smaller PBS with proper coating on the light path. The Color Select™ filters separate the color beams (red and blue) into orthogonal polarizations before the PBS to efficiently channel the light through the system.

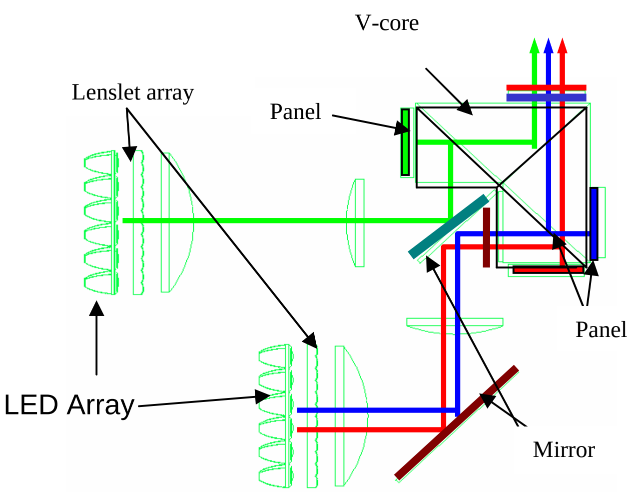


Figure 6. Schematic architecture of the novel illumination system

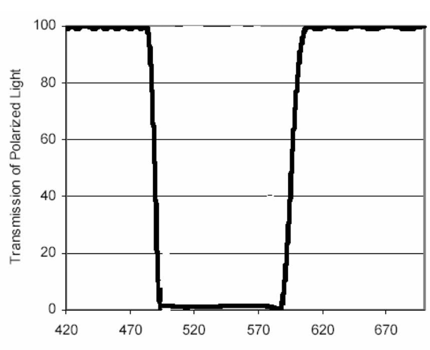
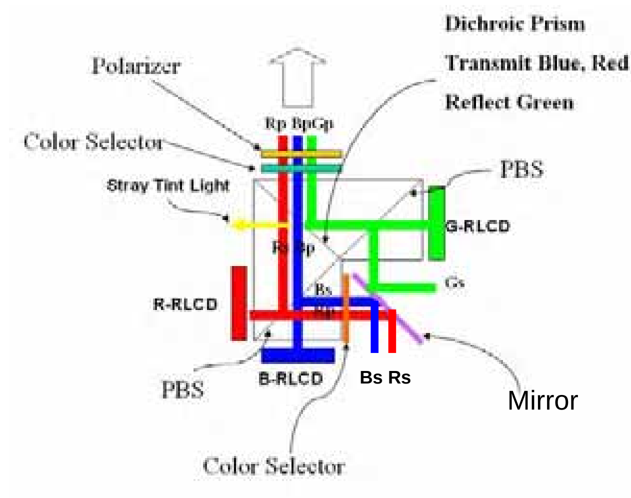


Figure 7. The spectrum of the coating



In this case, V-core is designed to handle the S-polarized incident light. After passing through the panels, the light is combined with a dichroic coating prism (shown in figure 7) and the image is projected on the screen. Figure 8 shows a schematic of the V-core system architecture.

Table 1. is shows that the Optical Efficiency of the V-core light engine. It appears that the efficiency 10.8%is higher than the traditional projector with UHP lamp (Table 2).

Table 1 Optical Efficiency of the V-core light engine

LED V-Core optical engine	
Element Name	Efficiency
Lamp Couple into to illumination	60%
¼q.w.p&polar. (Loss * Gain)	70%
Condenser Lens A	98%
Condenser Lens B	98%
V-Core System	75%
Prism Coupling	80%
Panel	67%
Overfill	90%
Duty Cycle by Electric Field Rate	97%
Panel Couple into Projection lens	90%
Projection Lens	85%
Total Efficiency.	**10.8%**

Table 2 Optical Efficiency of the LCoS light engine

0.7" LCoS Present optical engine	
Element Name	Efficiency
Lamp Couple into to illumination	75%

UV-IR Filter(include UV-IR Cutoff)	85%
Lens Array A	99%
Lens Array B	99%
PS Converter(Loss*Gain)	70%
Fold Mirror	97%
Condenser Lens A	98%
Condenser Lens B	98%
Pre-Polorizer	90%
Color management System	45%
Prism Coupling	80%
Panel	67%
Overfill	90%
Duty Cycle by Electric Field Rate	97%
Panel Couple into Projection lens	90%
Projection Lens	85%
Total Eff.	5.9%

5. Conclusion

We have built a novel color management system, V-core, with LED light sources and the structure of V-core for LCoS projectors have been proposed to improve the primary saturation, uniformity and contrast and show a good uniformity for projector application.

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References

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