New Structure to Enhance the Light Efficiency in LCoS Optical Engine

Chi-Wei Huang, ***Chi-Neng Mo, Shih-Min Wu***

Chunghwa Picture Tubes, Ltd. Central Research Institute,Taoyuan, Taiwan
+886-3-3675151 ext. 3483
huangchiw@mail.cptt.com.tw

Abstract

The exploitable efficiency of UHP is very important in a projection system. We always use lens array for light shaping and energy distribution transformation in conventional projection system. Because of the limitation of arc gap and F/# of elements, the utilize efficiency is always dismal. In this paper we try to bring out a new method to reduce the sparkle formed on the PS converter and enhance the system efficiency.

1. Introduction

In resent years, large size display became a famous consumer product, especially in United State and China. But the downcast of system efficiency is the Achilles' heel of rear projection TV with Microdisplay panel. In this paper we try to establish a new illumination system for the enhancement of system efficiency.

2. Conventional Structure of Illumination System in 3-Panel LCoS Optical Engine

There are four subordinate systems in a projection optical engine; illumination, color management, modulation and projection, whatever in rear or front projection system. UHP lamp with parabolic shape, lens arrays, condenser lens and collimator lens compose a regular illumination system in conventional 3-panel LCoS optical engine, as shown in Fig.1.

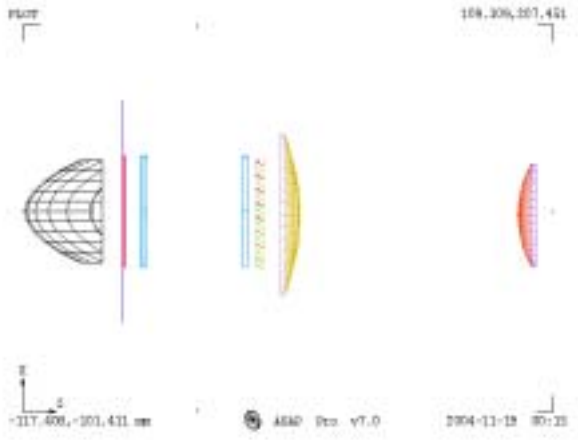

Fig.1. Conventional Illumination System

By the manipulation of the illumination system we can transform the distribution and shape of light. The light source is the arc gap in UHP that is not an ideal point source. As the light propagate from arc gap, it will pass lens array 1 and lens array 2 and form a sparkle on the PS converter, as shown in Fig.2.

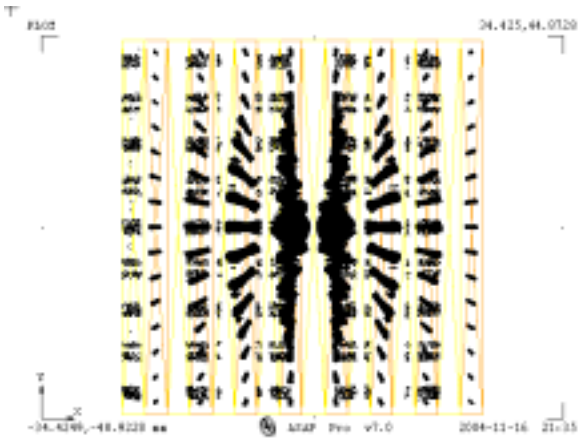

Fig.2. Distribution of Sparkle on PS Converter

In conventional projection system we use a black mask for keeping away from the useless light transmit into PS converter in wrong position. The function of PS converter is transforming the unpolarized incident light into all P-polarized or S-polarized state.

Fig.3. shows the relationship between light propagation and PS converter. As shown in the Fig.3, we can observe that the sparkle of light is much bigger than the incident plane, especially in the middle area of PS converter and the phenomenon bring out the waste of light flux about 6.12% with simulation an ideal model with ASAP. We can see the entrance of PS converter entrammels the efficiency of light transmittance and transformation.

Because of the limitation in the length of arc gap and curvature of lens array in fabrication, sparkle of undue size will induce the damage of PS converter. Thus it will reduce the efficiency of light. These sparkles also spill the polarized light with wrong state even we have a black mask between lens array and PS converter.

In next section we try to add a special optical element and solve these imperfections. This new architecture also enhances the system without lamp module's addition in watt.

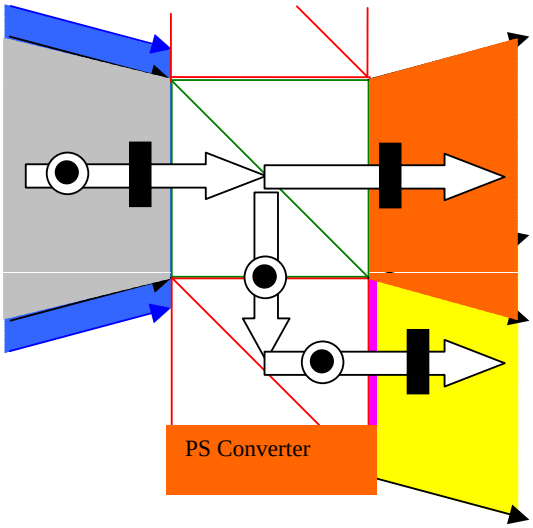

Fig.3. Light Propagation in PS Converter

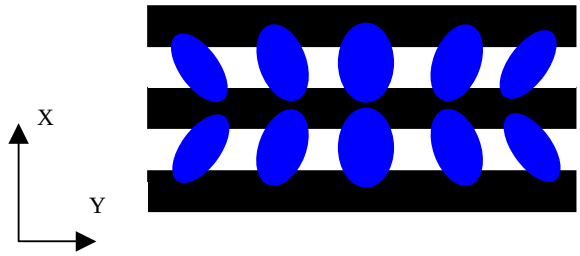

Fig.4. Sparkles with PS Converter

3. Light Sparkle with Cylinder Lens

As shown in Fig.4. , all the light sparkles just only undue along X-axis, but along Y axis there's enough space to contain the sparkles' shape. As we know, cylinder lens can converge the light in only one axis. Refrain from the spread-out of light along orthographic dimension (Y axis); we establish a cylinder lens array between lens array and PS converter, as shown in Fig.5.

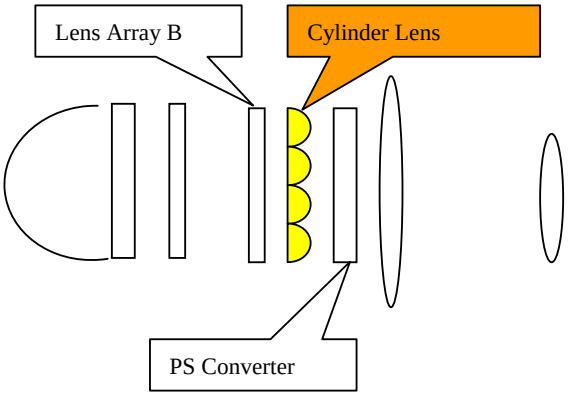

Fig.5 Illumination System with Cylinder Lens

Fig.6 is light distribution on the front surface of PS converter in new structure with cylinder lens array. Compare with Fig.3 and Fig.7, we can know that cylinder lens array reshapes the sparkles along X axis obviously.

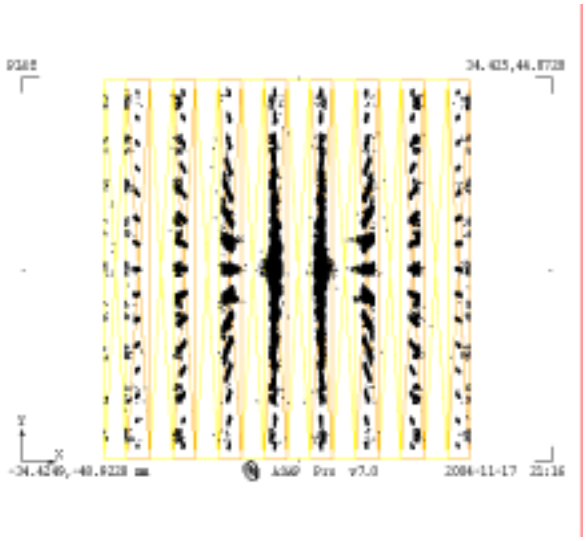

Fig.6. Light Distribution with Cylinder Lens

With the simulated result in ASAP, we try to change the curvature of the cylinder lens and find out the relationship between light efficiency behind the PS converter and curvature of cylinder lens. We simulated this model with 300,000 rays and total input flux with 8000. The result is that we can almost keep the energy that is absorbed by PS converter in conventional illumination system as shown in Table.1 and Chart 1.

Table.1

R. of Cylinder	Flux on Condenser	System Eff.
5	7767.65	97.10%
10	7732.82	96.66%
15	7601.05	95.01%
20	7530.37	94.13%
25	7489.50	93.62%
30	7460.54	93.26%
35	7439.57	92.99%
none	7318.52	91.48%

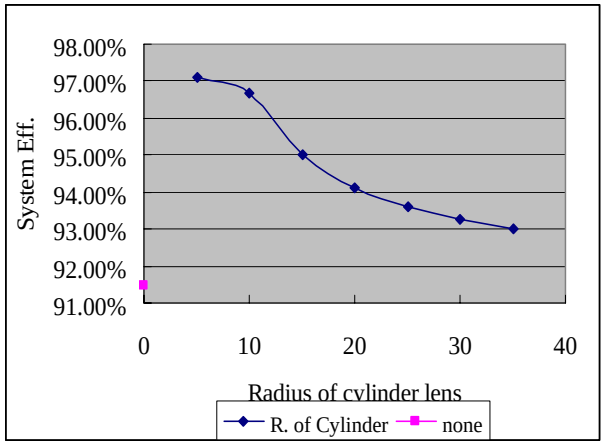

Chart.1

We also figure out the energy flux absorbed by the black mask as shown in table.2 and chart. 2. By the variation of absorbed efficiency we also can observe that cylinder lens do bring into full play with the enhancement of system efficiency.

Table.2

R. of Cylinder	Absorb by PSC	Absorb Eff.
5mm	2.20	0.03%
10mm	64.58	0.81%
15mm	196.53	2.46%
20mm	267.22	3.34%
25mm	308.08	3.85%
30mm	337.05	4.21%
35mm	358.01	4.48%
none	479.12	5.99%

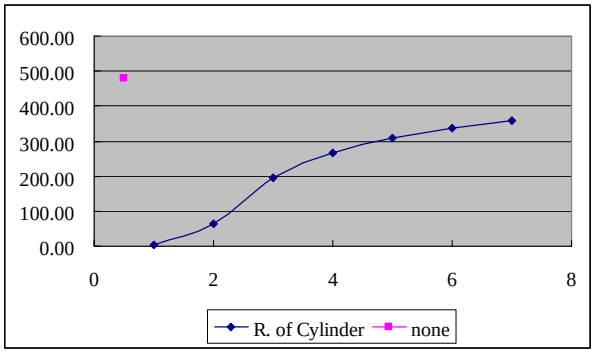

Chart.2

4.Conclusion

It's very good to improve the total efficiency without any extra input energy. By the result of simulation with in ASAP, we improve that cylinder lens array do help the transformation efficiency of PS converter about 5%. With matched condenser and collimator lens, we can also keep the uniformity on which place we want to expose with light.

7. References

[1] "Modern Optical Engineering" Wiley-SID，New York，3rd Edition

[2] "Optical System Design" Wiley-SID，New York，1st Edition

[3] " Projection Displays" Wiley-SID，New York，1998

[4] "Fundamentals of Optics"， Wiley-SID，4th Edition

[5] Yan-Zou Chen, IDMC 2005, 814-816

[6] US Patent 5,418,583

[7] US Patent 6,527,393

[8] US Patent 6,092,901