P-204: Micro Lens Array Generator for Laser Illuminated Projection Displays

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Abstract

In this paper, Laser light source can be a potential illumination light source for projection display, due to its feature of low source etendue and high degree of polarization. In order to make a conversion from a circular Gaussian beam profile to a rectangular uniform distribution, a microlens array generator has been proposed as a compact solution. The result shows a promising performance from a double microlens array generator.

1. Introduction

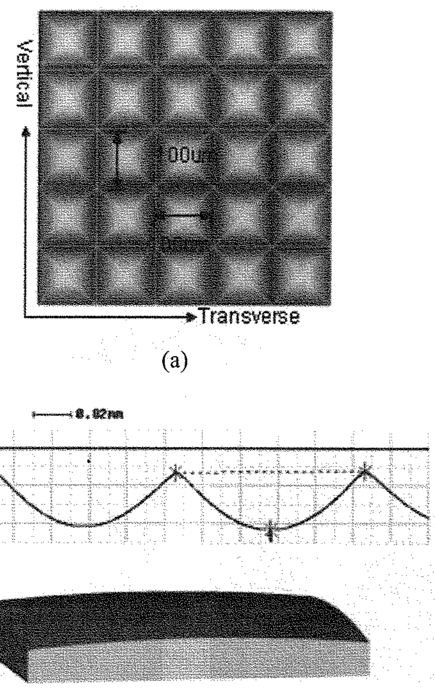
The traditional light source for projection displays are high intensity discharge (HID) lamps, whose spectrum contains fixed ratio of red, green and blue content, which consequently results in low color efficiency or low color saturation. It is also difficult to modulate light source in time frame, due to its mechanism of emission. Recently, light emitting diodes is becoming a potential light source for projector applications. However, the problem with LEDs is low light collection efficiency, mainly because the total lumen per unit area and per unit solid angle of LED is relatively low compared to the HID lamps. The other approach of solid state illumination for projectors is diode laser. Although the coherency of laser source might result in speckle on the screen, it is possible to eliminate it by modulating laser or using passive optical components to average out the speckle. The advantage of laser source for projector application is low diverging angle, which means low source etendue and high light collection efficiency on the microdisplays. For liquid crystal projectors, polarized light of laser source will significantly reduce the complication of optical design, and low diverging angle will also give high contrast.

A laser beam normally has a circular or elliptical cross section with a size of about 2mm in diameter. In order to expand and reshape the beam as well as redistribute the energy to make a uniform illumination on the microdisplay, a complicated and bulky optical system is normally required. In this paper, a micro lens array generator, which traditionally is used for splitting laser beam energy into an array of spots with equal energy has been proposed as an compact solution to make laser beam energy uniformly shine on the microdisplay.

An array generator in most cases is a two dimensional array of repeated optical structure[1,2,3]. The far field pattern diffraction patterns of laser beam passing through an array generator are normally an array of bright spots, so as the name called. And in many applications, the array generator are designed so that every spot can have the same energy, which also implies that an array generator has the function of evenly distributing the laser source energy, and hence a potential solution for obtaining a uniform illumination from laser source. Although the far field pattern is an array of bright spots, the near field pattern has the energy distribution much more spreading, which is available for microdisplay illumination.

2. Micro Lens Array Generator

All The proposed array generator is a lenslet array with a pitch of 100mm, and a thickness of 3um. The surface profile is shown in Figure 1. The material is UV Resin cured on PET substrate.



(a)

(b)

Figure 1. The feature of lenslet array generator

In this experiment He-Ne laser has been used for light source. Different pattern will be generated at different distance from the array generator. The experiment setup is shown in Figure 2.

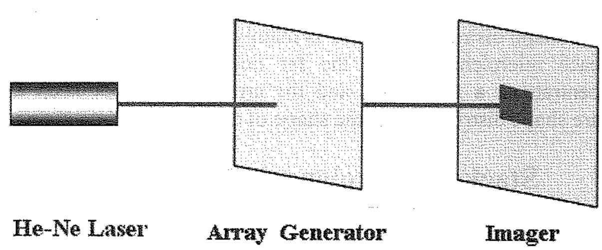


Figure 2. The experiment setup

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3. Result

The far field pattern measured at 2m away is shown in Figure 3.

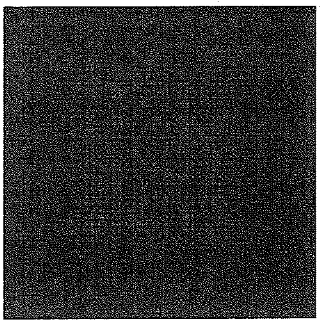
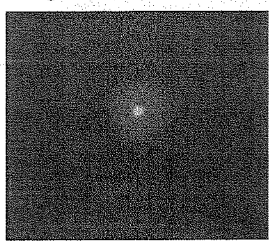
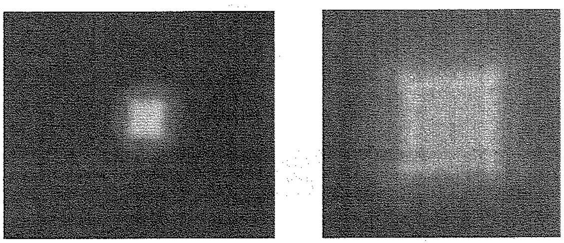


Figure 3. Far field diffraction pattern of lenslet array generator (405mmx405mm)

The near field diffraction pattern measured at 0mm, 50mm, and 100mm are shown in Figure 4.



(a)



(b) (c)

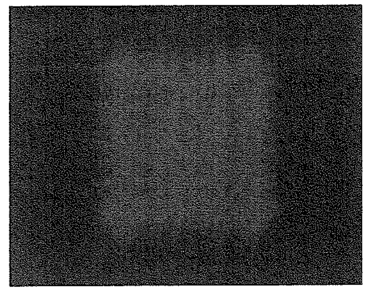
Figure 4. Near field diffraction pattern of lenslet array generator (a) 0mm(1mm) (b) 50mm(11mmx11mm) (c)100mm(21mmx21mm)

It has been shown that the laser beam energy distribution varies with distance, which is nearly a circular shape as original laser beam right at the micro lenslet array, and become more and more square shape distribution which is mainly influenced by the shape of each microlens, and at the far field, the energy becomes concentrate at a few spots, and the array of the spot keep the square shape distribution as the shape of each lenslet.

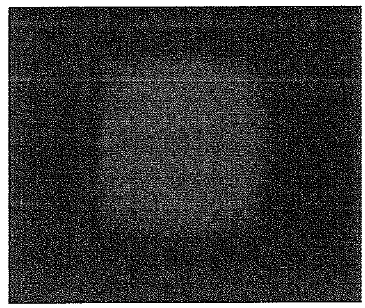
4 Stacked Microlens Array

Using a 0.7" microdisplay as a design target, the distance between the micro lens array (MLA) and the microdisplay should be 85mm. At this distance, the near field diffraction pattern still shows dark areas which deteriorate the uniformity of illumination, as shown in Figure 5(a). This can be improved by using a stack of MLA.

However, the distance from the stacking of double MLA must be changed to 56mm to just cover a 0.7" microdisplay, and the pattern is shown in Figure 5(b).



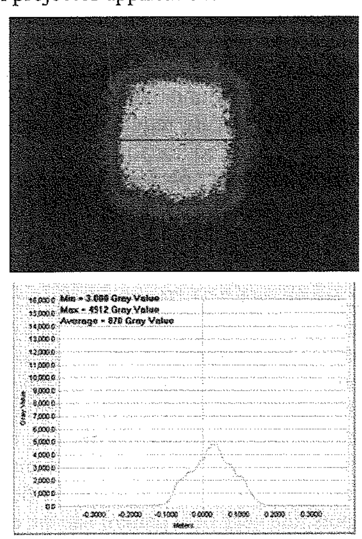
(a)



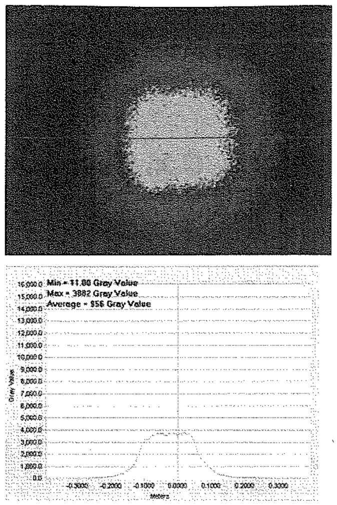
(b)

Figure 5. Near field diffraction pattern of micro lens array for microdisplay illumination (a) single MLA (b) double MLAs

It has also been shown that the lateral shift of the two MLAs will affect the uniformity. Figure 6 shows two different patterns with different lateral shift of the two MLAs, as well as their cross sectional uniformity. Figure 6(b) shows the best illumination pattern obtainable, which is nearly a flat top distribution over 0.7" area and indicate the feasibility of using MLA for laser illumination in projector application.



(a)



(b)

Figure 6. The diffraction pattern of double MLA with different lateral shift

5. Laser illuminated projector engine with MLA

Laser is a coherence light source with low diverging angle, and the diffraction pattern will not change much with respect to the distance between laser head and the MLA. Therefore, a laser illuminated projector engine has been designed and constructed as Figure 7 shows, where the optical paths of RGB channel are different. A set of red and green diode laser and a diode pump blue laser are used as the illumination light source. Their light paths are combined with dichroic plates before illuminating on the MLA. The result has shown that there is no significant dispersion at the edge of the illumination patch after passing through the double MLA. The total feature size of the projector engine is 120X5mm. With the progress on blue diode laser, this architecture will be a potential solution for compact projector.

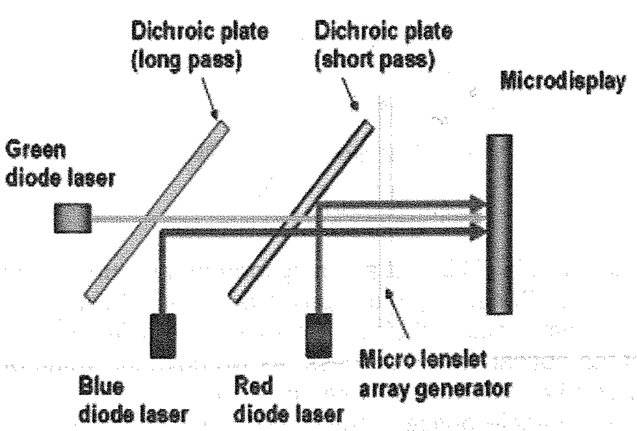


Figure 7. Laser illuminated projector engine

Figure 8. shows the prototype of the laser illuminated projector engine with only green and red diode laser. The total feature size of the projector engine is 150x5mm.

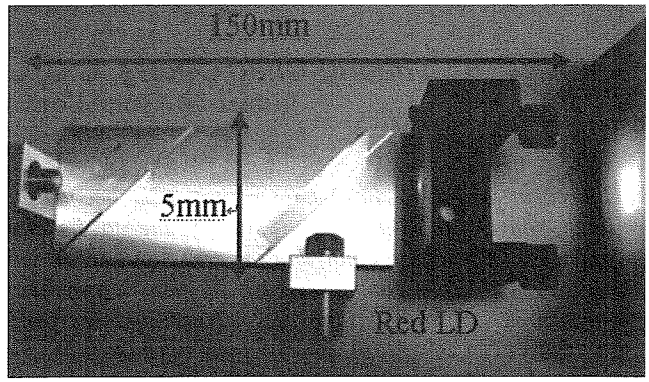


Figure 8. Prototype of the laser illuminated projector engine

6. Conclusion

The proposed double microlens array generator has been shown as a viable compact optical solution to provide a uniform illumination with any shape and aspect ratio from a laser light source, which will be a potential alternative as a light source for future light valve projection displays. The light source features low etendue and polarized light, which is significant for simplifying optical design and improving optical performance of projectors. The compact architecture of the projector engine based on MLA and diode laser makes it especially suitable for mini-projector.

7. References

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