A New pattern Diffuser for LCD Backlight Application

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Abstract

In this work, a plastic diffuser which has a surface similar to Sinusoidal wave profile for application of LC D backlighting is proposed. This new pattern diffuser is achieved the values of the transmission efficiency an d diffusion efficiency all over 70%, and it also has the value about gain over 1.1. Additionally, this new patter n diffuser has high uniformity when we put it in the LCD backlight module and its thickness is only 2mm. With these foregoing properties, this diffuser film can widely applied to LCD displays systems etc.

1. Introduction

Light diffusing films are widely used in backlig ht module of LCD-TV and other backlighting app lications in recent years [1,2]. Generally, backlight module may be classified into two categories in t erms of the location of the light source inside a LCD module, i.e. edge lighting and direct lighting. To make good brightness uniformity and high lum inance, the direct lighting backlight module is co mprised of several kinds of optical materials, such as a reflective film, diffusing plate, diffusing sheet, brightness enhancement film (BEF), and reflective polarizer film. Each optical material has special f unctions in a LCD backlight module. For example, the function of the diffusing plate and diffusing fi lm is used for making uniform brightness by spre ading the lights. The bright enhancement film (B EF), also called 'prism film', collect the uniforml y diffused lights, and reflective polarizing film wo rk polarization recycling of the lights, and therefo re enhance the LCD panels brightness. Recently many researchers have investigated a large amount of efforts to obtain a backlight module which has high transmission efficiency, high diffusion efficiency and high gain [5]. However, what is to obtain the foregoing properties of the direct lighti ng backlight module have been very difficult. The reason comes from the significant difference in lu minance between the spaces of CCFLs, so that h ow to achieved high transmission efficiency, high diffusion efficiency, high gain and also has high uniformity has been a big issue in a backlight module technology

2. Experimental

In the beginning, we simulated and analyzed the diffuser by using the ASAP software. The simulation profile of diffuser is shown in Fig. 1, the diffuser is designed to have one surface similar to Sinusoidal wave profile, and the other side is designed to have a surface similar to prism profile. When we change the period and depth about the surface similar to Sinusoidal wave profile of diffuser, we can get the different values of transmission efficiency, diffusion efficiency and gain. The uniformity result of simulation is shown in Fig 2, the uniformity of the simulation result is achieved 89%.According to the best results about the period and depth of the surface similar to Sinusoidal wave profile of diffuser from the simulation, we used a CO_2 laser system with a xy scanning laser head to engrave the same period and depth about the surface on the surface of a plastic substrate. The surface similar to Sinusoidal wave profile of diffuser engraved by CO_2 laser system is shown in fig 3.The beam diameter (FWHM) is adjusted to be 180mm. By controlling the scanning speed and power intensity, the micro-grooves with certain period and depth can be obtained. The 10.6 mm is suitable to burn on the plastic substrate, for example, PMMA and polymeric plate because it can directly vaporize the plastic material. Moreover, the main grooves are covered with random-spread substructure, which is induced from the plastic shrinkage under high temperature. The random roughness will be helpful to diffuse light uniformly under incoherent illumination. After that, we disposed the surface of the plastic substrate on one side of a optical substrate with a first UV forming adhesive therebetween, and then, a surface similar with prism structural layer is disposed on the other side of the optical substrate with a second UV forming adhesive therebetween. The sample of the new pattern diffuser is shown as fig 4.Wherein by adopting characteristics of the quasi-sinusoidal structure and prism structure, light generated from the backlight can further diffused into the a liquid crystal panel, thereby improving light diffusion efficiency, transmission and gain. The diffusion efficiency, DE, that evaluate the diffusion ability of a diffuser is defined as

$$DE = \frac{I(20^0) + I(70^0)}{2 * I(5^0\ )} \text{ x } 100\% \quad (1)$$

The transmission efficiency, TE, that is the percentage of incident light that passes through the diffuser is defined as

$$TE = \frac{\text{Tranmission light}}{\text{Incident light}} \times 100\ \% \ (2)$$

The value of Gain is the nits we measured from the new pattern diffuser divided by the nits we measured from a standard diffuser, which is defined as

$$Gain = \frac{\text{The nits from the new pattern diffuser}}{\text{The nits from the standard diffuser}} \quad (3)$$

Fig 5.is the 10cm x 10cm standard diffuser, the nits we measured from the center is more than 5000nits, the uniformity of this standard diffuser is 97%

Table 1 shows the values of diffusion efficiency, transmission efficiency and gain with different periods of surface which similar to Sinusoidal wave profile combine with the surface similar to prism shaped in the top of diffuser plate..

3. Results and discussion

In this work, we can simulation and analysis the diffuser by using the ASAP software. When we change the period and depth about the surface similar to Sinusoidal wave profile of diffuser, we can get the different values of transmission efficiency, diffusion efficiency and gain. If a surface similar to a prism shaped in the top of diffuser plate, and a surface similar to Sinusoidal wave profile shaped in the bottom of the diffuser, we can get the values of transmission efficiency and diffusion efficiency to achieve 70％, and the value of gain can exceed 1.1

Fig.1 is the diffuser plate with the surface similar to a prism shaped in the top of diffuser plate, and a surface similar to Sinusoidal wave profile shaped in the bottom of diffuser plate. The uniformity result of simulation is shown in Fig 2, the uniformity of the simulation result is achieved 89 %.According to the result of simulation, we chose the period and depth which can get high transmission efficiency, diffusion efficiency and gain, and then, we made the sample of the new pattern diffuser which is shown in fig 4 , Table 1 is the different values about the transmission efficiency, diffusion efficiency and gain with different period and depth of the surface similar to Sinusoidal wave profile combine with the surface similar to prism shaped in the top of diffuser plate. The prism angle of the surface similar to prism shaped in the top of diffuser plate is smaller than 90 degree. Fig 3 is the profile which we used a CO_2 laser system to engrave the 400um period and 200um depth on the surface of a plastic substrate.

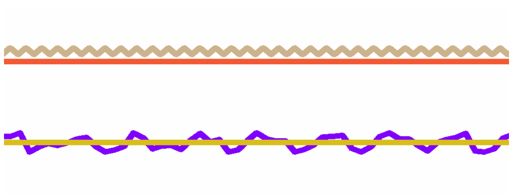

Fig 1.The simulation profile of diffuser with prism and Sinusoidal wave profile

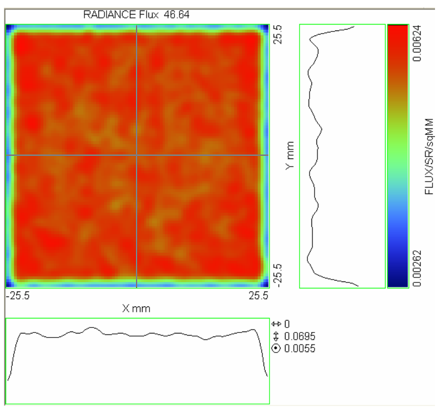

Fig 2.the simulation result of the new pattern diffuser

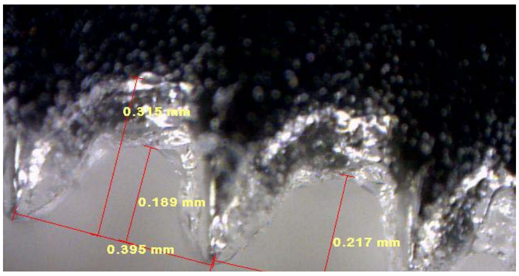

Fig 3.the surface similar to Sinusoidal wave profile of diffuser

Fig 4.The sample of the new pattern diffuser

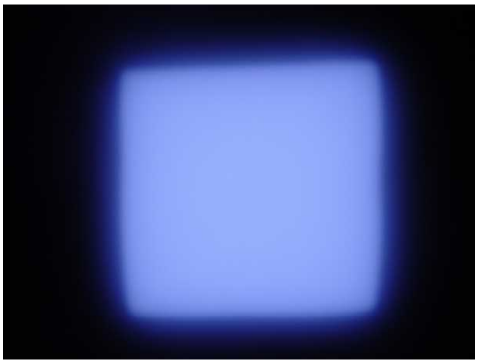

Fig 5.The 10cm x 10cm standard diffuser

Period	diffusion efficiency	transmission efficiency	Gain
200um	75.21%	73%	1.17
300um	53.04%	49%	0.91
400 um	98.41%	42%	0.98

TABLE 1.The values of diffusion efficiency, transmission efficiency and gain

4. Summary

With changing the surface structure, we can get different transmission efficiency, diffusion efficiency and gain when combined the surface similar to a prism shaped in the top of diffuser plate. Moreove r, the transmission efficiency, diffusion efficiency and gain of the new pattern of the proposed diffu ser are better than that of a conventional bead-em bedded diffuser. It is also suitable to use hot press or roll to roll process to mass produce the diffuser for application of LCD backlight with extremely lower cost than that of a conventional diffuser.

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5. References

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