Design of flat fluorescent lamp(FFL) channel for LCD TV backlight unit by optical simulation

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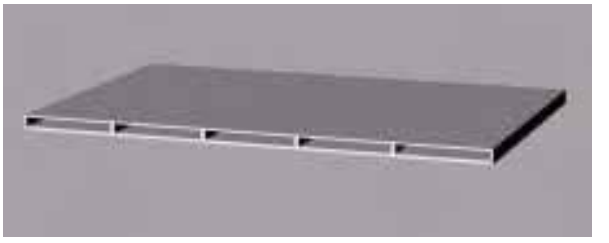
Abstract

The channel shape of FFL(Flat Fluorescent Lamp) was designed by optical simulation. It was possible to design and manufacture the channel in any shape using glass forming. The best suitable brightness uniformity of 83.7% was achieved.

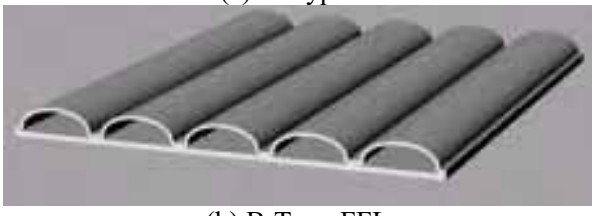
1. Introduction

Cold cathode fluorescent lamp(CCFL) and external electrode fluorescent amp are mainly used as light sources of LCD TV.[1] LCD TV requires high brightness. Therefore LCD TV should use the vertical lighting type BLU. This narrow tube lamp is located under the LCD panel. In case of CCFL/EEFL vertical lighting type BLU, many lamps are required for high brightness and uniformity. Additionally many related parts and inverters are required for CCFL/EEFL lamps. But when FFL is used as light source for LCD TV, the light from FFL can be used efficiently and the number of the parts and inverters can be reduced. This is reason why the development of FFL is necessary.[2]

It is necessary to form the glasses with mold at high temperature to form channels for FFL.[3] Fig. 1 shows one of the possible shapes of FFL. Fig. 2 shows the brightness uniformity of FFL with different channel shapes. The brightness uniformity varies depending on the channel shapes as shown in Fig. 2.



(a) A-Type FFL



(b) B-Type FFL

Fig. 1. Channel shapes of FFL

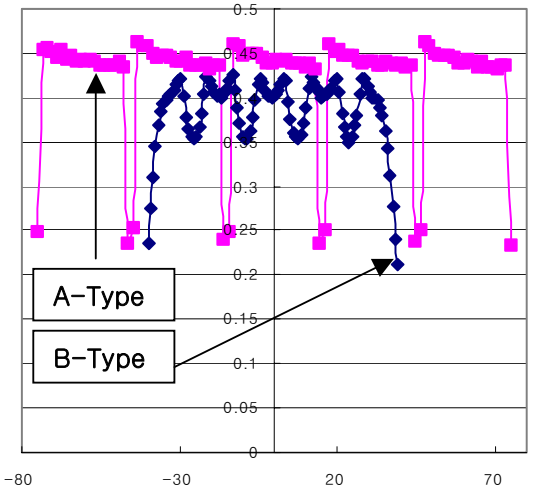


Fig. 2. Brightness uniformity on FFL channel shapes

The brightness uniformity of FFL depends on channel shape, height of channel, and distance between channels of FFL. The best channel shape can be designed by optical simulation.

2. FFL Channel Design

The optical property of glass and phosphor of FFL should be known for the channel design by optical simulation. The optical property means transmittance, reflectance, the index of refraction and the diffuser characteristics. Especially, the diffuser characteristics of the phosphor are investigated by measurements. For the simulation, the transmittance, and reflectance scattering characteristics should be measured. Fig. 3. shows the outline for measurement of scattering characteristics.

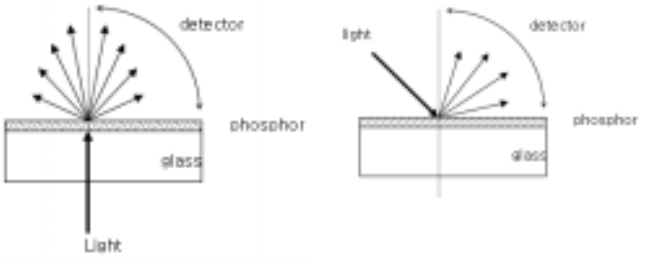


Fig. 3. Outline for measurement of scattering characteristics of phosphor (a) the outline for measuring transmittance of the scattered light. (b) the outline for measuring the reflection of the scattered light.

The light emitted from phosphor depends on the channel shape of FFL. At first, the change of R-value in Fig. 4(a). is simulated. If R is large, straight area is large but if R is 0, there is an ellipse structure without straight area. While the uniformity was 56.7% when the straight area is 10mm, the uniformity was 83.7%, with R = 0. Fig. 5. shows the variation of uniformities depending on R value. The better uniformity is achieved with smaller R value. It means when the area is ellipse structure, the brightness uniformity increases.

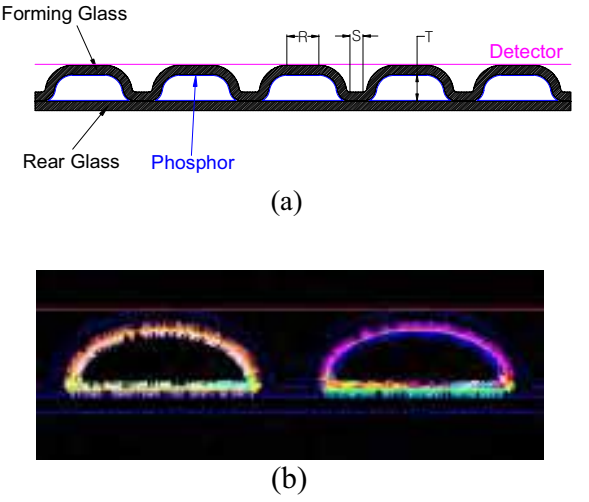


Fig. 4. (a) Schematic diagram of FFL structure. (b) Phosphor emitting lights in both direction.

3. Simulation Results

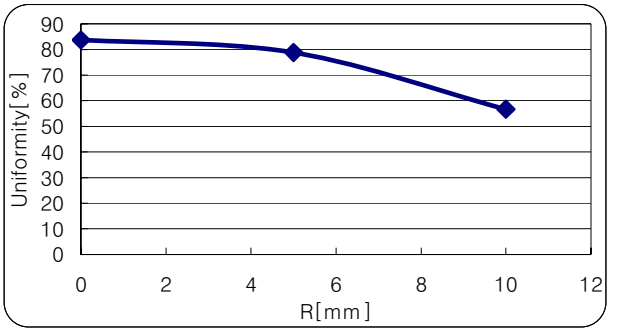


Fig. 5. Uniformity variation depending on channel structure.

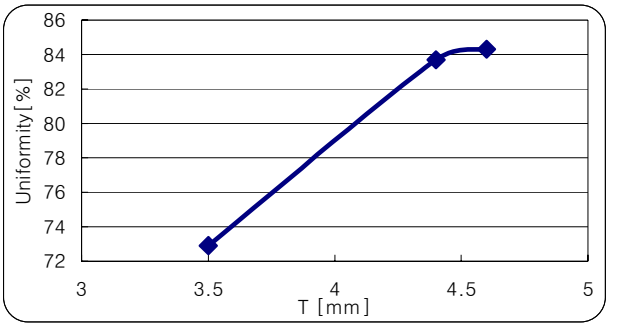


Fig. 6. Simulation results depending on height of FFL's channel. The variation of uniformity depends on the height of channel.

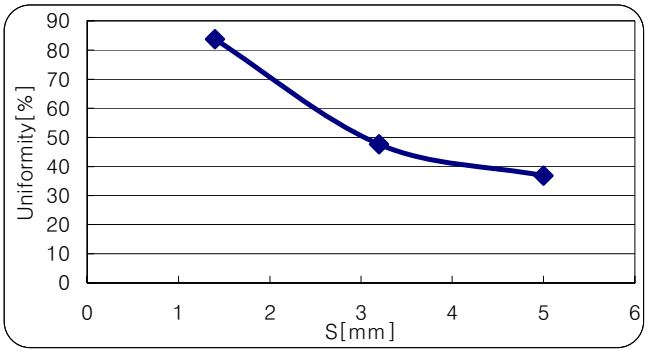


Fig. 7. Simulation results depending on sealing width between channels in FFL. The variation of the uniformity depends on sealing width.

Subsequently, uniformity of FFL depending on the change of the T-value was simulated as shown in Fig. 4(a). When the T is large, the channel shape is close to circle. FFL looks more flat with small value of T. The simulated result shows that uniformity was 72.9% when the channel height is 3.5mm. The uniformity of 84.3% was obtained if the value of T was 4.6mm. Fig. 6. shows the variation of uniformities depending on the height of channel. As the height of the channel is larger, that is, the shape of FFL looks close to circle, it is found that the uniformity increases. The channel height of FFL was chosen to be 4.4mm in this paper.

Finally, the uniformity of FFL based on the variation of S- value in Fig. 4(a) was obtained by simulation. Larger value of S means that the sealing area of the channel is wider. It means that there will be wide non-emitting area if the value of S becomes large.

The uniformity of 36.9% was obtained if the sealing width was chosen to be 5mm. The uniformity of 83.7% was obtained if the sealing width was chosen to be 1.4mm.

Fig. 7. shows the variation of the uniformity depending on distance of the sealing area. The brightness uniformity increases, as the sealing width of the channel becomes smaller.

Additionally, the brightness uniformity decreases rapidly as the sealing width become wider. It is shown in Fig. 7 that the sealing width should be small to achieve higher uniformity of brightness. The sealing width was chosen to be 1.4mm in this paper to obtain high uniformity.

4. Conclusion

The channel shapes of FFL was designed to achieve the best uniformity by optical simulation. Fig. 8. shows the FFL channel shape designed as the light source for backlight in LCD TV. The channel shape designed was chosen to have the elliptical structure for the highest brightness uniformity. The channel height was 4.4 mm with consideration of the brightness and uniformity. The sealing width between channels is 1.4mm, which is the minimum distance available in the glass forming mold.

Fig. 9. shows the simulation result of the luminance distribution. The highest brightness uniformity of 83.7% was obtained by the simulation from the channel shape of FFL shown in Fig. 8.

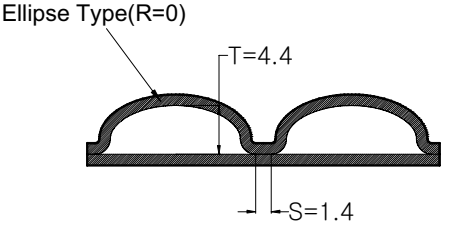


Fig. 8. Optimum channel shape of FFL used for luminance uniformity simulation

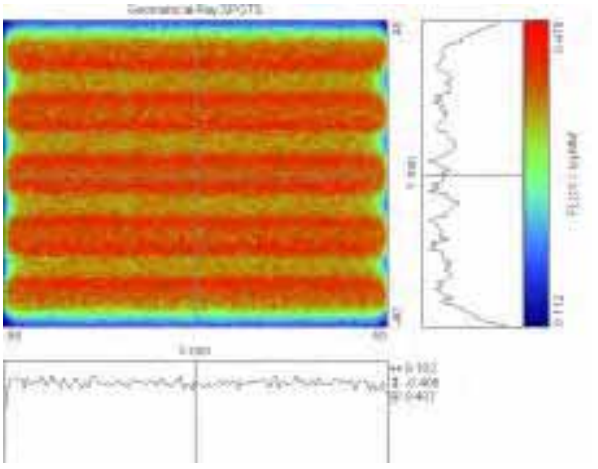


Fig. 9. Luminance distribution of FFL.

4. Acknowledgements

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5. References

[1] D.H. Gill, H.S. Song, J.H. Kim, S.J. Kim, S.B. Kim, T.Y. Kim, D.G. Yu, J.H. Koo, E.H. Choi, and G.S. Cho, SID 05 DIGEST, 1312~1315(2005).

[2] J.W. Hur, T.J. Kim, and S.K. Lim, SID 00 DIGEST, 1033~1035(2000).

[3] L. Hitzschke, F. Vollkommer, and K.D. Bauer, SID 04 DIGEST, 1322~1325(2004).