Development of High Performance Backlight Unit Employing EEFL

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Abstract

The 17" Backlight Unit (BLU) employing twelve EEFLs (External Electrode Fluorescent Lamp) has been developed for LCD-TV. The characteristics of the EEFL BLU without dual brightness enhancement film (DBEF) were equivalent to those of CCFL (Cold cathode Fluorescent Lamp) BLU employing eight CCFLs with DBEF. Luminance, power consumption and uniformity were 12,000nits, 32watt and 80%, respectively. The inverter of EEFL Backlight Unit is composed of 2 transformers and driven by the sinusoidal waveform.

1. Introduction

The application of the TFT-LCD has been rapidly expanded to the LCD-TV, which requires high luminance, low cost and long lifetime. In order to achieve these requirements, a direct light type of BLU with several CCFLs directly under the TFT-LCD panel has been used. However, the conventional BLU has limitation on cost and luminance.

The new BLU has been developed for LCD-TV by employing external electrode fluorescent lamp (EEFL). An external electrode naturally forms a capacitor at each end of the lamp, which makes the EEFL possible to be operated in parallel. In conventional CCFL BLU, the parallel driving is practically not used because of the unbalanced current problem. The external electrode plays an important role to prevent overcurrent due to the wall charge of the lamp glass [1, 2], so that the EEFL backlight unit can be driven in parallel.

Since the EEFL is driven in parallel, several lamps can be connected to single transformer of the inverter that results in cost reduction, simple and solder-free lamp assembly. Moreover, the lamp manufacturing process of the EEFL is much simpler than that of the conventional CCFL.

In this paper, the new design of the EEFL BLU is introduced. In order to meet luminance requirement of LCD-TV, the target luminance of the EEFL BLU is determined to 12,000 nits considering the transmittance of the TFT-LCD panel. This BLU shows high luminance, low cost and low power consumption, environment-friendly characteristics and long lifetime that are suitable for the LCD TV application.

2. Experiments

The external electrode at each end of the lamp forms a capacitor with plasma discharge and dielectric material. One conductive side is the external electrode and the other side is plasma discharge. Also, the lamp glass is working as a dielectric material to form the capacitor. Fig1. shows the equivalent circuit of the EEFLs.

Figure 1 The equivalent circuit of the EEFL.

External electrode can be made using various kinds of manufacturing methods such as Al taping, metal plating of Cu, Ag, Ni and ITO and metal socket.[3] Each method has its own advantages and disadvantages. We carried out various experiments to find out the best method for the formation of the external electrode. Based on our experiments, metal socket with internal adhesive material was selected.

The length and outer diameter of EEFL are chosen to 397mm and 2.6mm, respectively, in order to fit the mechanical specification of the BLU. The gas pressure of the EEFL is related to power consumption and luminance. 60 Torr has been selected to be an optimum gas pressure.

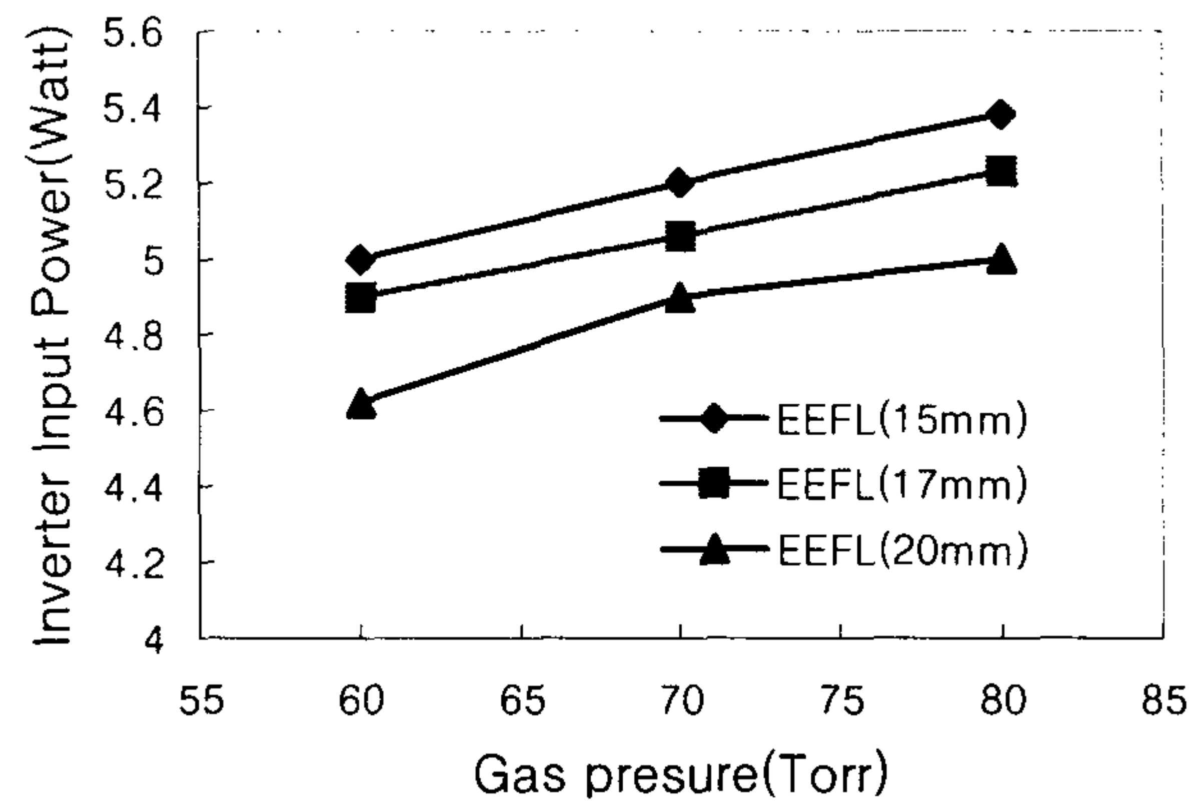


Figure 2 Power consumption vs. electrode length

In general, the luminance efficiency increases as the length of the external electrodes increases. The length of the external electrode is selected to 17mm for an optimum luminance efficiency and narrow bezel of module unit. Fig. 2 shows the relationship between power consumption and electrode length.

The EEFLs are connected each other through a metal clip without soldering. Therefore, lamp assembly is simple and environment-friendly.

The output voltage waveform of the inverter is sinusoidal to reduce EMI, and operated in 60kHz. The luminance of lamp and BLU are measured by BM-7 of TOPCON.

3. Results and discussion

Fig.3 shows the luminance efficiency of the EEFL at different current level. As lamp current increases, the luminance efficiency increases at first, and then decreases slowly after a lamp current of 5 mA. In EEFL, 4~5mA are desirable in order to get the best efficiency.

Fig. 4 shows the efficiency comparisons of the EEFL BLU and the CCFL BLU with same sheet configuration. The sheets are consists of a DBEF, prism sheet, diffuser sheet and diffuser plate. Because of the optical recycling effect of the DBEF, the luminance of the BLU employing DBEF is converted to be compared with that of the BLU without DBEF. The experimental result shows that the luminance efficiency of the EEFL is higher than that of CCFL. Especially, in 25~35W region, EEFL shows the best luminance efficiency.

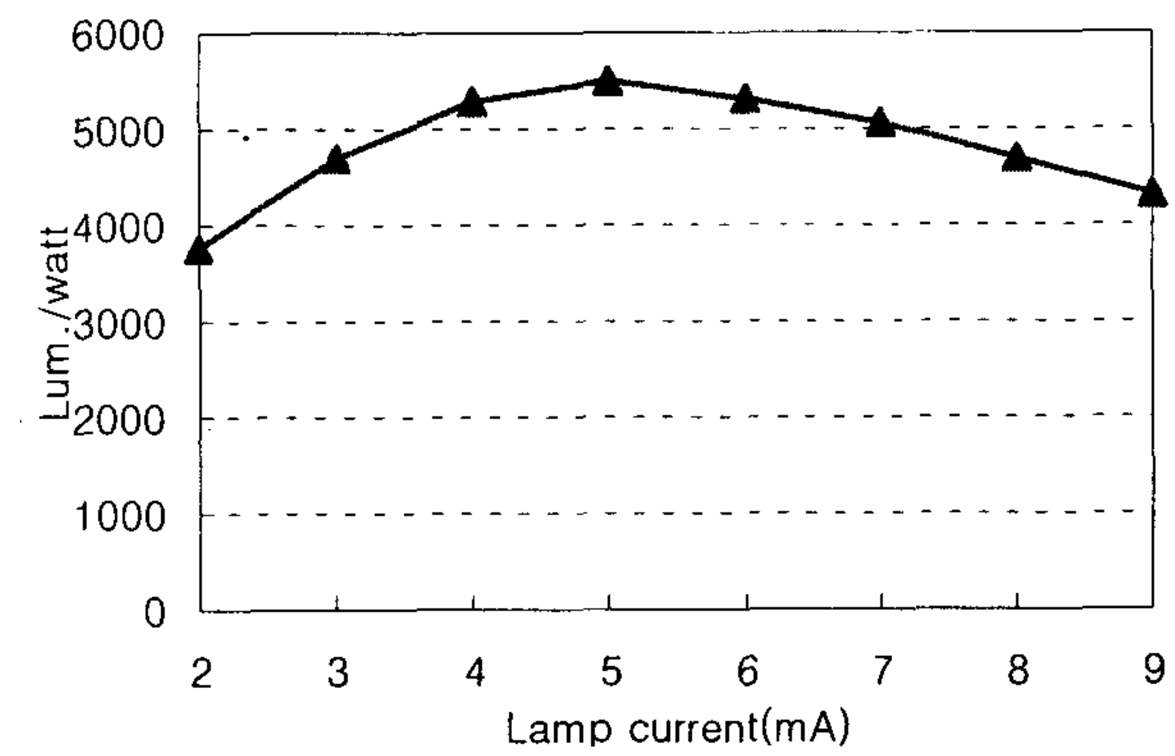


Figure 3 Luminance efficiency vs. lamp current

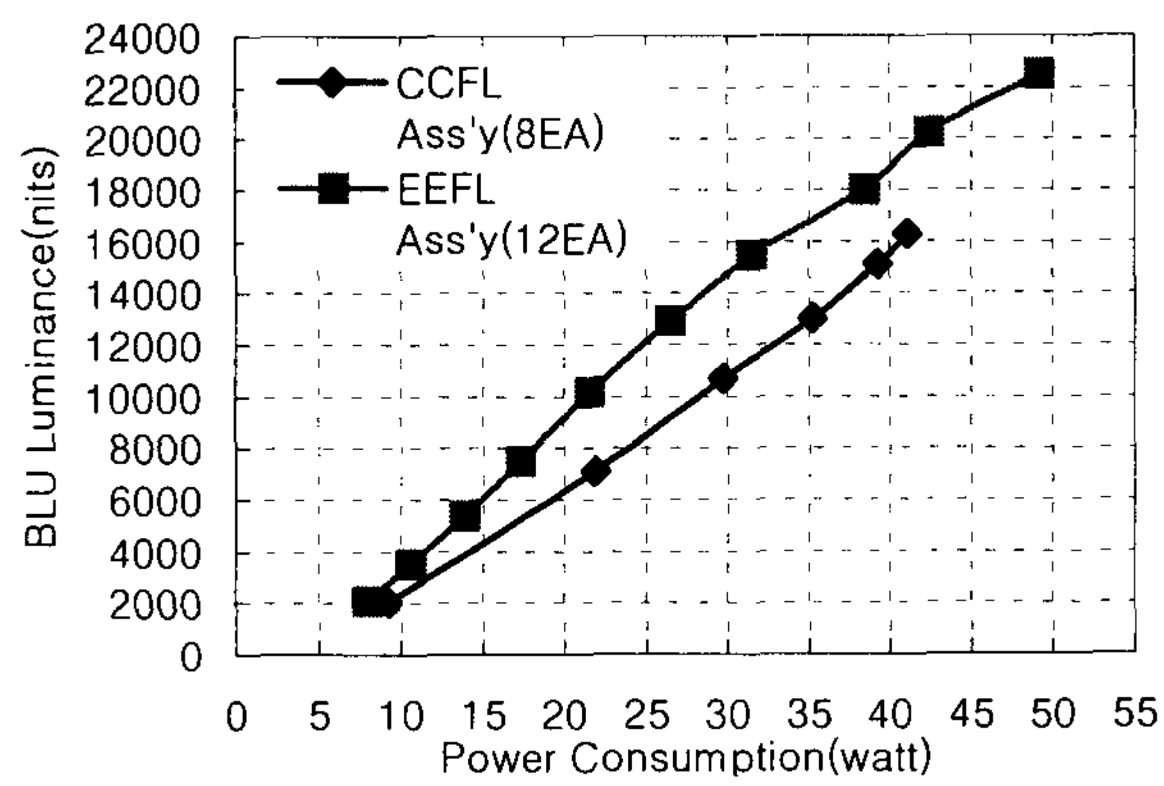


Figure 4 Luminance efficiency comparisons with same sheet configuration.

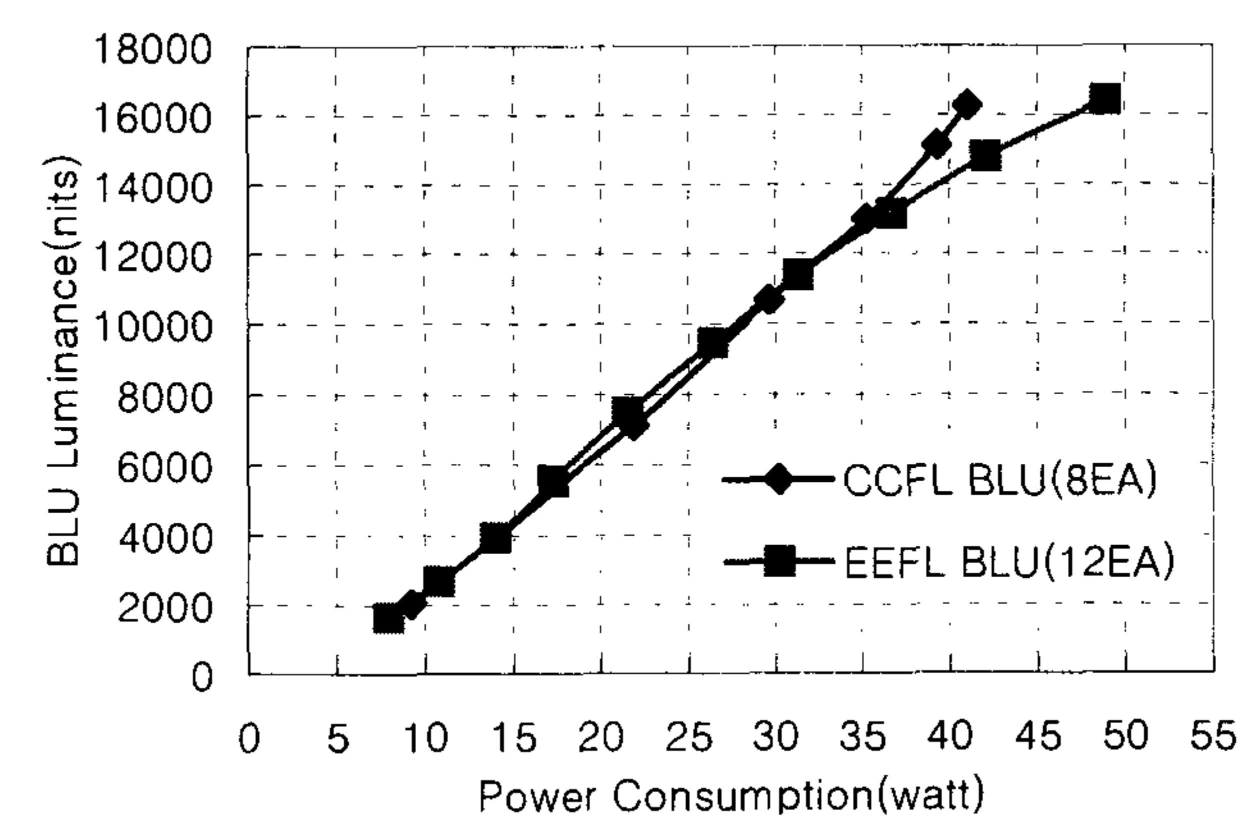


Figure 5 Luminance efficiency comparisons with different sheet configuration

Fig. 5 shows the BLU luminance as a function of the power consumption with the different sheet configuration. At a 32W of power consumption, the lamp current is 4.5mA for EEFL, and 6mA for CCFL. Since the EEFL BLU can get the target luminance for LCD-TV without DBEF, the cost is reduced dramatically. In order to improve the uniformity and achieve the target luminance, a prism sheet is employed in the both EEFL and CCFL BLU. The new sheet configurations are shown in Table 1.

	EEFL BLU	CCFL BLU
Sheet Configuration	Protector Sheet Prism sheet Diffuser sheet Diffuser plate	DBEF Prism sheet Diffuser sheet Diffuser plate Reflector

Table 1. The new sheet configuration for EEFL

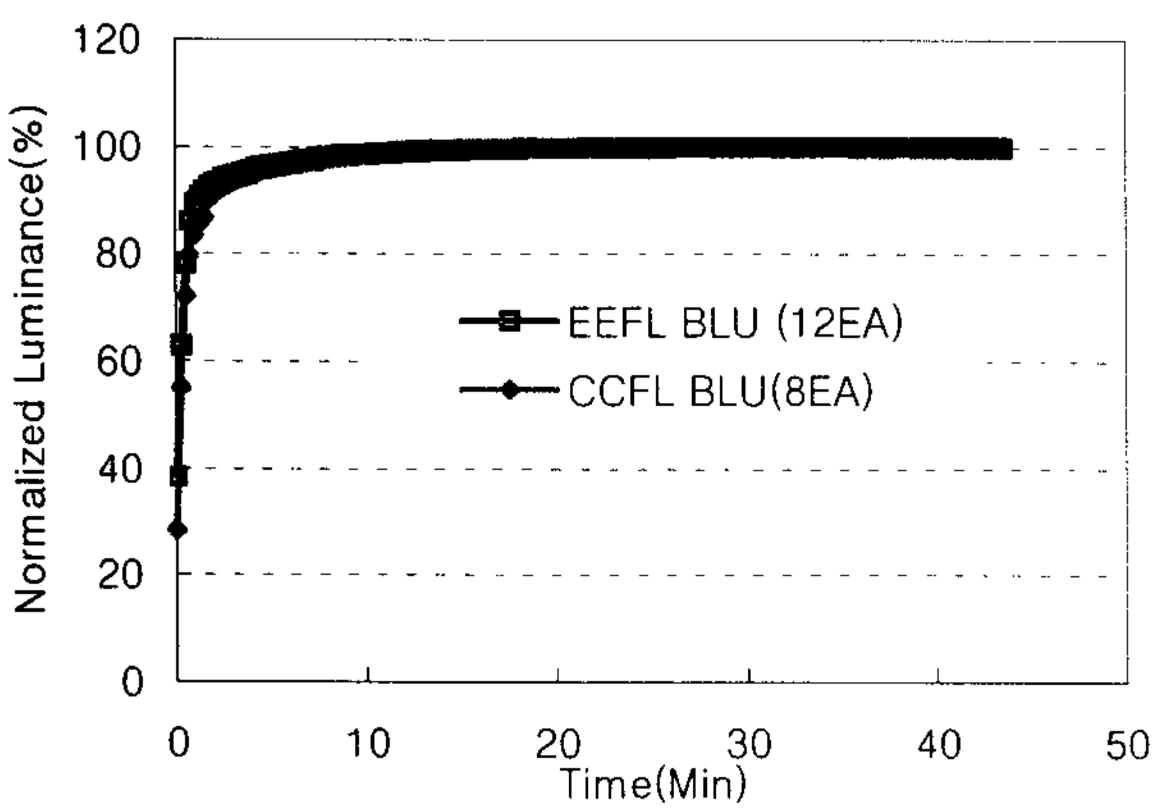
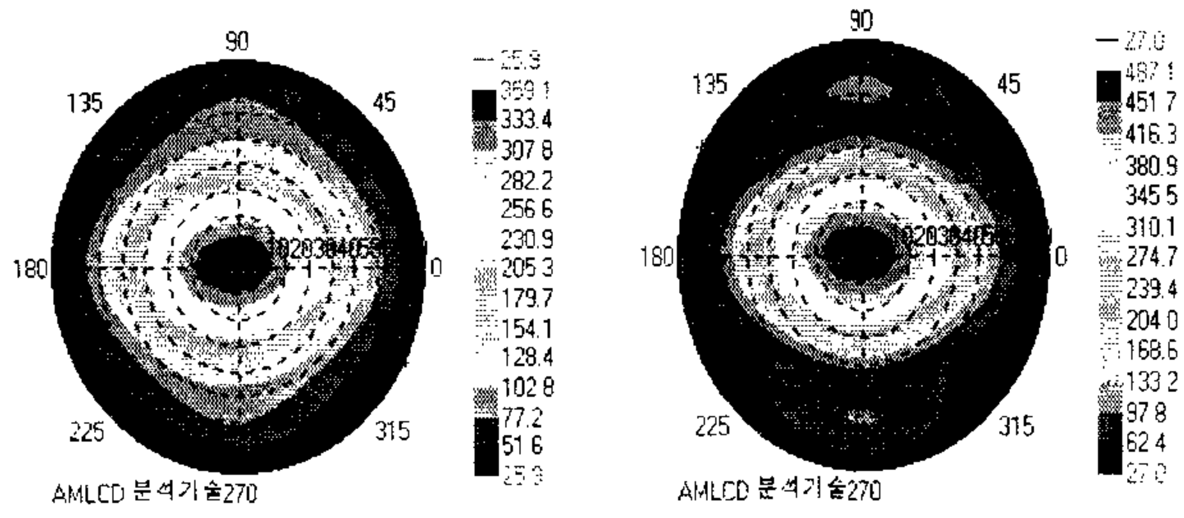


Figure 6 Luminance saturation characteristics comparison.

The luminance saturation characteristic is an important factor for the BLU design. It should not have any overshoot or delay. The number of lamps, the length of the external electrode and the power consumption determine the luminance saturation characteristic. Fig. 6 shows the luminance saturation characteristic comparison between the EEFL BLU and the CCFL BLU. The almost identical normalized luminance curve indicates that the EEFL BLU is designed in optimum condition.



(a) (b)

Figure 7. Viewing angle characteristics of luminance on PVA panel. (a) with CCFL BLU (b) with EEFL BLU

Fig. 7 shows the viewing angle characteristics of luminance on PVA panel. The viewing angle analysis result demonstrates that the viewing angle of the panel with EEFL BLU is narrower than that of the panel with CCFL BLU. However, it shows higher contrast ratio.

4. Conclusion

The 17" BLU employing twelve EEFLs was developed for LCD-TV. The optimum conditions were developed for lamp only, lamp assembly, inverter and sheet configuration of BLU. The characteristics of the EEFL BLU without DBEF were equivalent to those of CCFL BLU with DBEF. Luminance efficiency and uniformity were 99lm/w and 80%, respectively. The inverter in EEFL BLU is composed of 2 transformers and driven by the sinusoidal waveform.

5. References

[1] Y. Baba et. "A 100,00 0-cd/m2, Capacity Coupled Electrodeless Discharge Backlight with High Efficacy for LC TVs" SID 01 DIGEST pp. 290~293

[2] H S Kim et. "LCD Planar Backlight Employing the external electrode fluorescent lamps Driven by square pulses form switching inverter" SID 01 DIGEST P-36 p.687

[3] Y. Takeda et."High Reliabilty External Electrode Mercury Fluorescent Lamp for aLC TV's Backlight" " SID 02 DIGEST P-40 pp.346~349