Backlight for Large-area LCD-TVs with External Electrode Fluorescent Lamp

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Abstract

A direct light type backlight for large-area LCD-TVs using External Electrode Fluorescent Lamps (EEFLs) has been developed. The brightness was 450cd/m²(nit) and the luminous uniformity (max/min) was 1.3. The mechanical design of backlight was optimized and the reliability of lamps was secured. As a result, the possibility of backlight with EEFLs for large area LCD-TVs was sufficiently proved.

1. Introduction

Liquid Crystal Displays (LCDs) have been at the head of flat panel displays. But LCDs need backlight to show images on the screen. Several light sources such as Fluorescent Lamps (CCFL, EEFL Flat Lamp), LEDs and CNT (Carbon nano tube) have been developed for backlights. Among these light sources, the most conventional one is Cold Cathode Fluorescent Lamp (CCFL).

The main properties required for the backlight of LCD-TVs are large size, high brightness and long life time. To satisfy large size and high brightness, several direct light type backlights have been developed. But for long life time, EEFLs have been strong candidate because two electrodes, located at both ends of lamp, exist on the outer surfaces of the discharge tube.

In this paper, the mechanical structure of backlight and some reliability problems (such as pinhole and ozone) of lamps are discussed. Solutions for these problems are suggested. As a result, the possibility of backlights with EEFLs for large area LCD-TVs was proved.

2. Experimental

For 30-inch LCD-TVs, since the backlight with EEFLs has 16 lamps, which is the same number as CCFLs, lamp pitch (distance between two lamps) is not essential factor. But fundamentally, CCFL and EEFL have different electrode structures. Therefore, from the viewpoints on the mechanical design, the mechanical structures of holding lamps are quite different. Especially, because non-lighting area of EEFL is wider than that of CCFL, EEFL has critical demerit on narrow bezel. So it was essential problem to find optimal holding structure of lamps for satisfying narrow bezel without increase of luminous uniformity. To find this structure, an optical simulation was carried out by using ASAP (BRO, Inc.) simulator.

Next, to apply EEFL to a backlight, it was essential to secure the reliability of lamps. Two problems, pinhole and ozone, are studied here. For pinhole problem, the geometrical shapes of lamps and the forming processes of the external electrodes were analyzed by SEM (S-4000, Hitachi). And for ozone problem, the concentration of ozone generated from the Liquid Crystal Module (LCM) using EEFL backlight was measured with an ozone monitor (EG-2001T2, EBARA) under the following chamber conditions; volume of chamber is 28.5 m^3, temperature 23.3 °C, humidity 33%RH.

3. Results and discussion

3.1 Mechanical design of LCM

Before optical simulation, some critical factors should be determined. These factors are shown from the cross sectional diagram of the backlight in Fig. 1, where w is length of bezel, h height between bottom and diffusing plate, l length of external electrode, and θ slope of the inside wall. Since the external electrodes (length l) are non-lighting region, dark area could be seen around the bezel. The values of w and h are fixed by dimension of CCFL backlight. So, only θ is the main parameter.

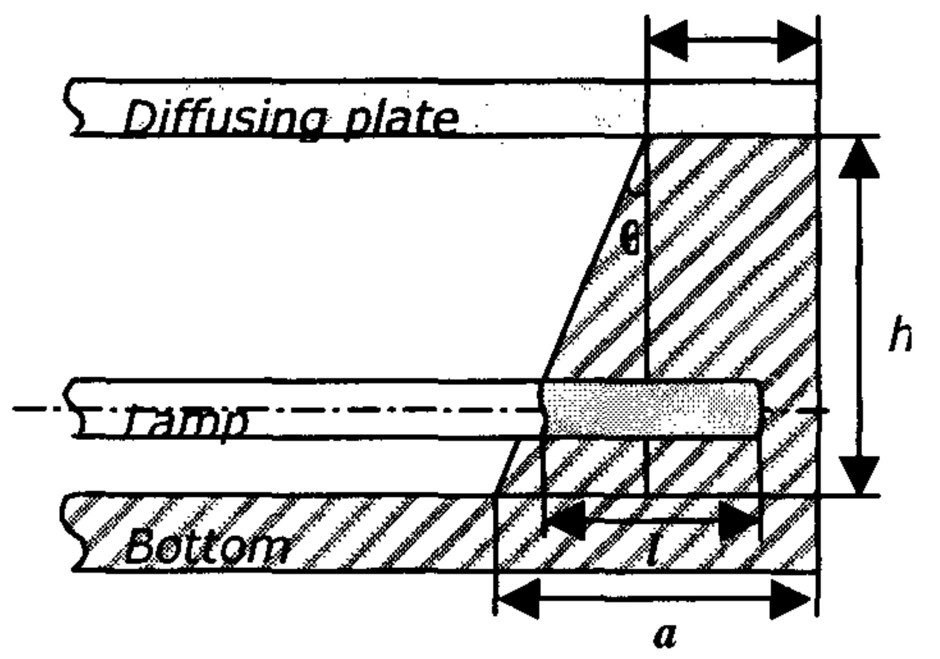
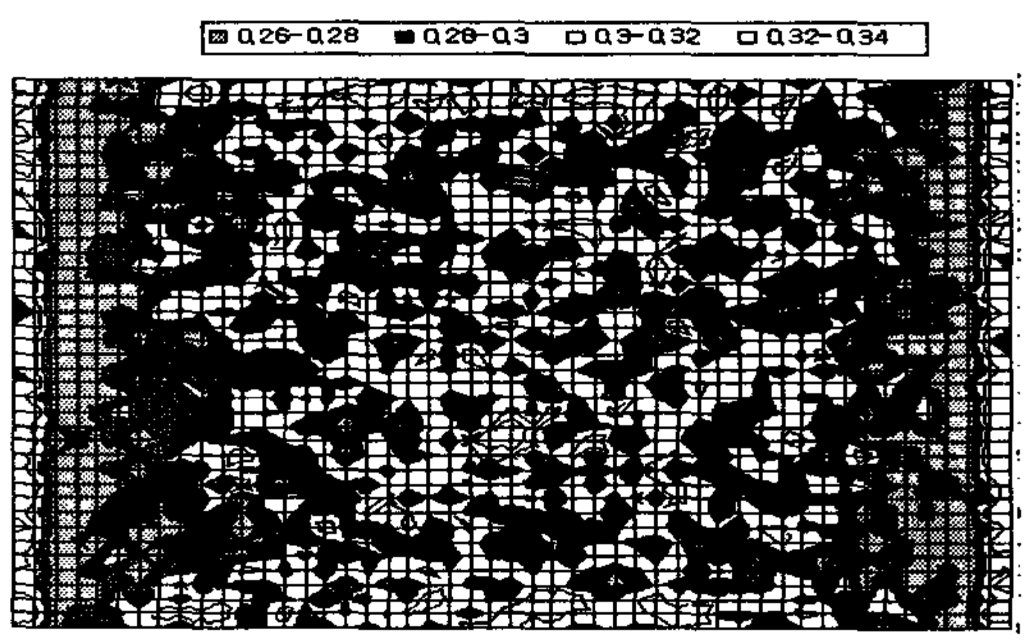
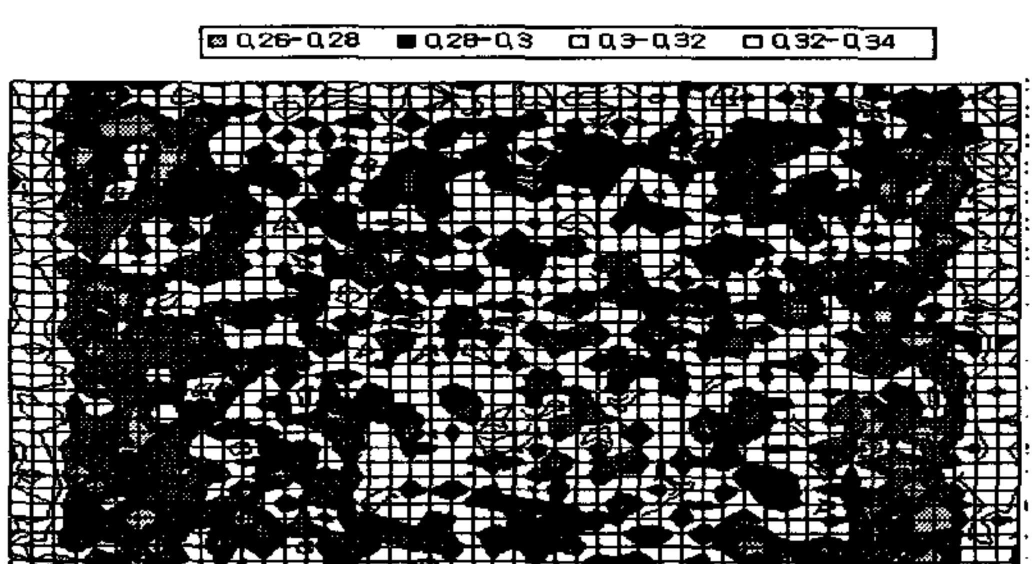


Figure. 1 The cross sectional diagram of the backlight

Fig.2 shows the results of the optical simulation using ASAP simulator, where different colors mean different brightness at the surface of the backlight. When the slope (θ) was 34°, the dark lines could be easily distinguished as shown in Fig.2 (a), but once the slope was changed to 18°, they were almost disappeared (shown in Fig. 2 (b)).



(a) The dark lines at the both side of LCM were appeared when the slope was too small. (θ=34°)



(b) The dark lines were disappeared when the slope was changed to bigger. (θ=18°)

Figure 2. Light simulation result using ASAP program

From the results of Fig. 2, the smaller the slope (θ) is, the better the uniformity is. On the other hands, the smaller the slope (θ) is, the wider the bezel (w) is. Therefore, for given bezel length (this length is the same as CCFL backlight), optimal range of θ was found as 20° to 22°.

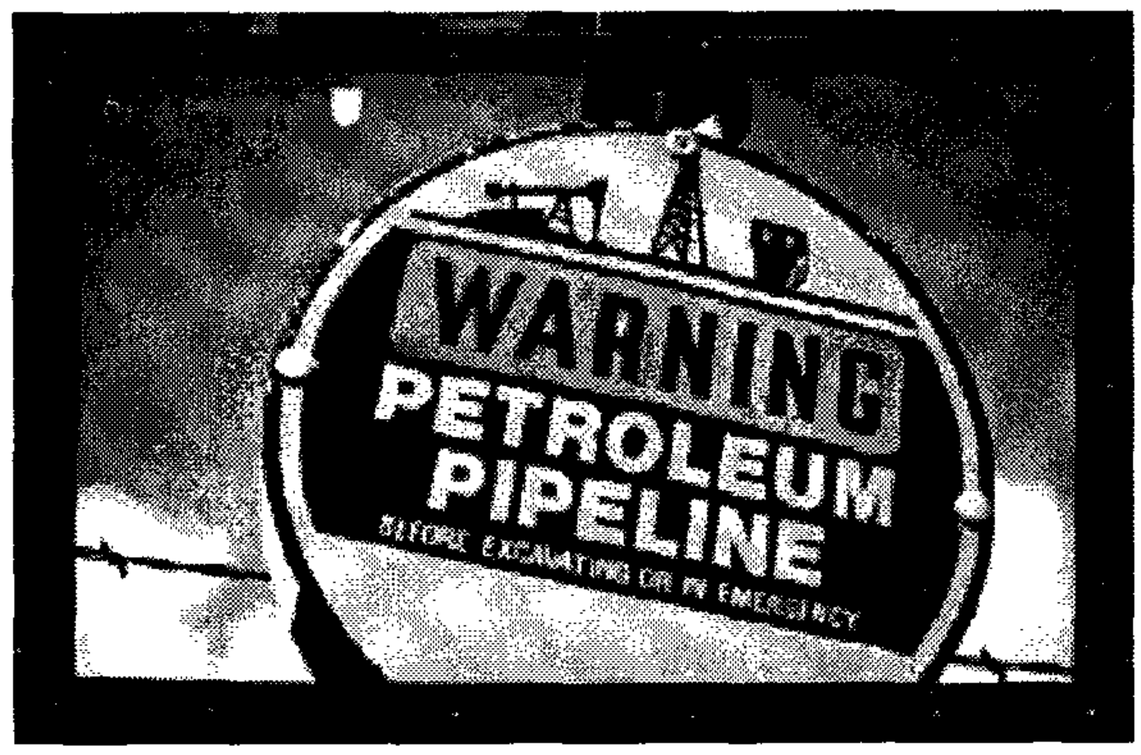


Figure 3. LCM with EEFL backlight

The 30-inch LCM with EEFL backlight which is adapted above results was shown in Fig. 3. The luminance is over 450 nit and the luminous uniformity is under 1.3, which meet the specifications of the LCD-TVs.

3.2. Reliability of lamps

In general, since the discharge mechanism of EEFL is based on the capacitive coupled electric field, the operating voltage of EEFL is much higher than that of CCFL. Higher voltage can increase the possibility of occurrence of some reliability problems such as pinhole and ozone.

Pinhole is one of dielectric breakdown phenomena which makes a small hole around the closing end of a lamp so that the mixed gases in the lamp come out through the hole and, as a result, the lamp cannot emit light any more.

In this study, we found that there are two major causes of pinhole generation. One is the forming process of the external electrodes and the other is the shape of the bead glass of lamps.

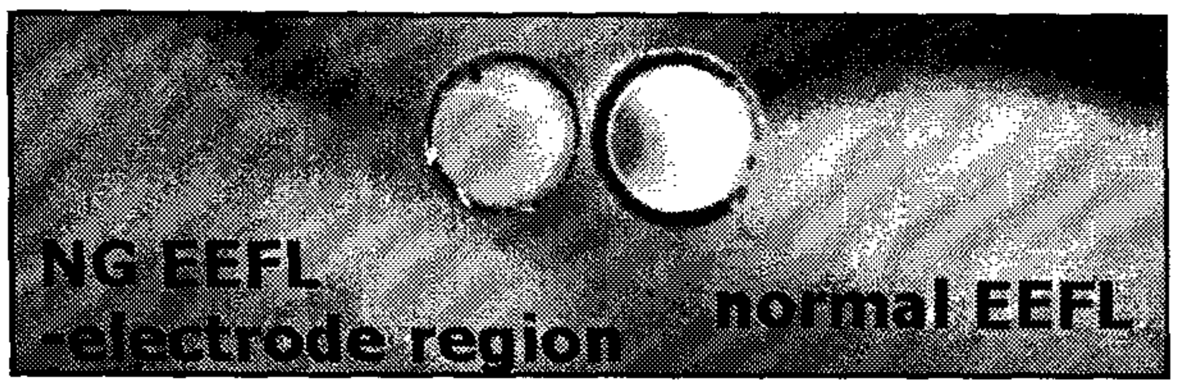
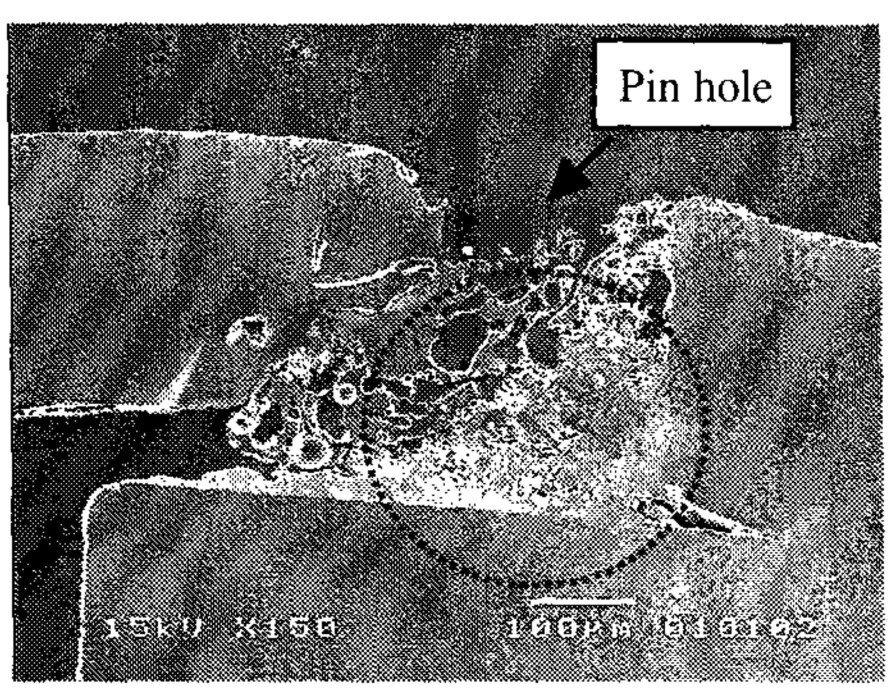


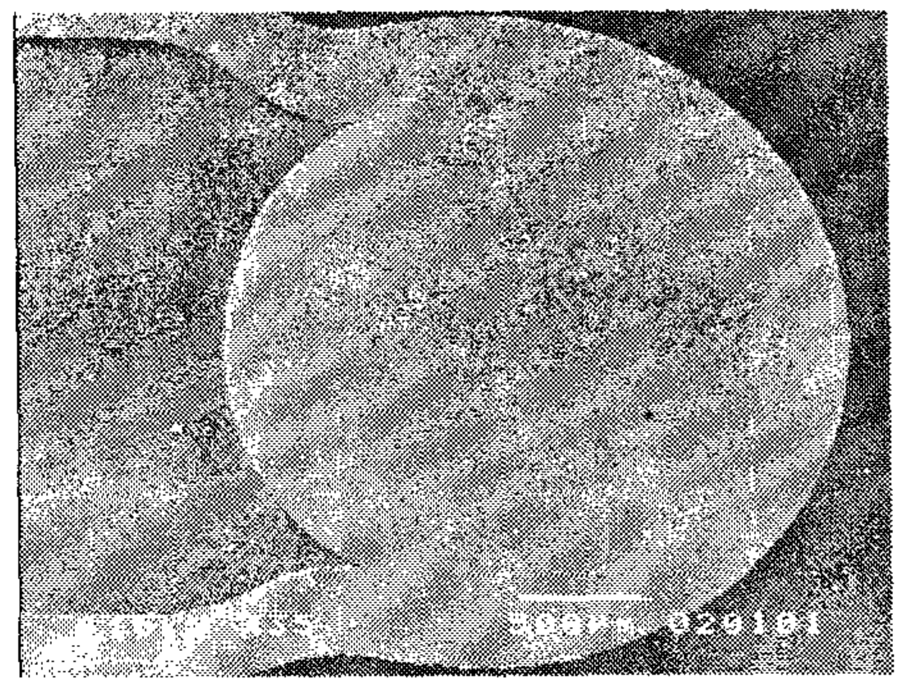
Figure 4. The extremely eroded lamp glass by sand blasting during plating process

At first, there are several processes to form the external electrodes at both ends of a lamp. Among those processes, plating process needs a pretreatment such as sand blasting to increase the adhesion between the electrodes and lamp glass. However, since sand blasting could cause severe problems in flatness of the glass thickness, pinhole could occur at the point where the glass had been blasted too much. Fig.4 shows the cross sections of normal lamp and pinholed lamp. From this figure, it is found that the glass thickness of pinholed lamp is mush thinner than that of normal lamp

At second, as for the shape of bead glass, pinhole occurred at the closing end of a lamp where a narrow gap was formed between lamp glass and bead glass as shown in Fig.5 (a). This is because the electric field tends to be concentrated on the sharp edges (circle in Fig.5 (a)). The bead glass is a small piece of glass in the shapes of rod, cylinder and ball which is used to close a lamp after charging the discharge gases. The narrow gap could be removed by changing the shapes of bead glass as shown in Fig.5 (b).



(a) Rod type bead glass where the pin hole occurred at the gap between lamp glass and bead glass



(b) Ball type bead glass which is the stable structure for pin hole

Figure 5. The shapes of bead glasses and pinhole generation

After eliminating sand blast process and changing bead glass from rod shape to ball shape, the pinhole didn't occur any more

As for ozone, it is possible that ozone could be generated from the backlight using EEFLs because the driving voltage is considerably high. And it could be dangerous if its concentration is over the environmental standard.

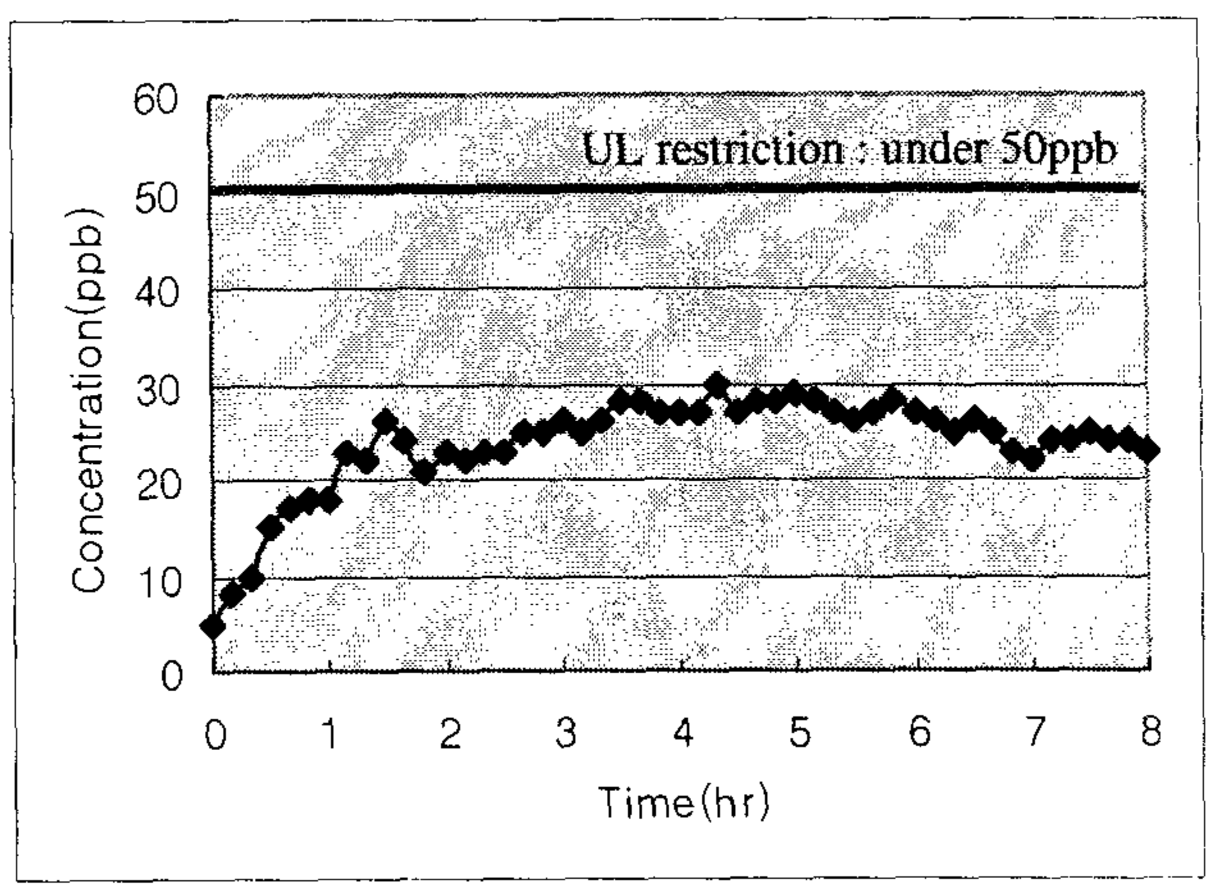


Figure 6. Ozone concentration measured from the LCM using EEFL backlight

But, since there is no environmental standard related to the ozone generation for LCD TVs, to evaluate the level of ozone concentration, we adopted the standard for air cleaners which restricts the peak concentration of ozone under 50ppb.

Fig.6 shows the ozone concentration measured from the 30-inch LCM using EEFL backlight. From this figure, the peak concentration of ozone from the LCM was 30ppb which is under the limitation of environmental standard.

4. Conclusion

Among the many advantages of EEFLs, long lifetime and simple structure could be more highlighted if they can be used as the light source of a backlight for large area LCD-TVs.

We successfully developed the 30-inch. LCM with EEFL backlight and solved the reliability problems of EEFLs as well. From this study, it is sure that EEFL backlight is a strong candidate for large area LCD-TVs in the near future.

5. References

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