Dependence of Xe Plasma Flat Fluorescent Lamp On the Electrode Gap and Dielectric Layer Thickness

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Abstract

In this work, a coplanar-type plasma flat fluorescent lamp having cross type of electrode was fabricated by screen printing and sealing technique. Cross type of electrode with a dielectric layer were screen-printed on a rear glass plate, and then fired at 550°C. Phosphor was printed on and fired at 450°C. Finally, the lamp was sealed by frit glass at 450°C. The lamp of cross electrode type was studied depending on the electrode gap and the thickness of dielectric layer.

1. Introduction

LCD has taken the largest market share in flat panel display industry due to its superior properties such as large scalability with economic price, lightweight, and slimness. LCD is largely composed of liquid crystal panel, backlight unit, and driving circuit. Among them the backlight is becoming more important because of its larger energy consumption in larger-sized LCD. In addition, the conventional backlight, i.e. cold cathode fluorescent lamp (CCFL), contains mercury, which is ecologically hazardous. There have been many studies to overcome the problems [1-3]. A flat fluorescent lamp (FFL) has excellent uniformity of luminance. However, the lower luminance and luminance efficiency of FFL has not been solved yet. Some studies about gas pressure, design factors of electrodes, driving frequency, dielectric shape etc. of FFL were reported elsewhere. [4, 5]

In this work, we studied luminance and efficiency of coplanar type FFL as a function of electrode gap and dielectric layer thickness.

2. Experimental

Figure 1 shows the schematic diagram of fabrication process. Silver electrodes for good conductivity and low work function and a dielectric layer having a high reflexibility were screen-printed and fired at 550℃. White phosphor composed of 33% red [Y_2O_3:Eu], 33% green [$LaPO_4$:Ce,Tb], and 34% blue [$BaMgAl_{10}O_{17}$:Eu] phosphors was screen-printed and then panel was sealed with crystalline frits at 450℃. This panel was pumped out under the pressure of 10^{-3} torr at 150℃ for 60 min to completely remove organic residues. The dimensions of the designed FFL and the pressure of Xenon gas in FFL were varied and characterized.

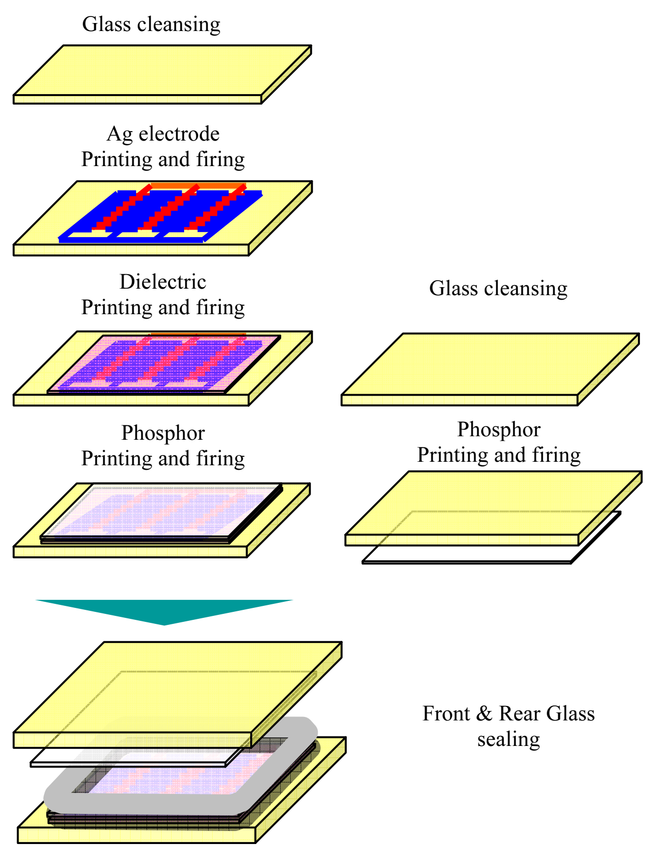

Fig. 1. Schematic diagram of fabrication process

3. Results and discussion

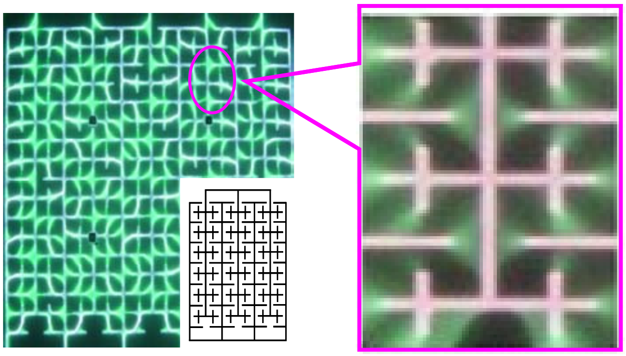

Fig. 2. Structure of cross electrode type in coplanar FFL

Figure 2 shows the structure of the cross type electrode of FFL we studied. As shown in Fig. 3, the higher the xenon pressure in the lamp the higher firing voltage should be required. As the gap of electrodes is wider, the firing voltage was also increased.

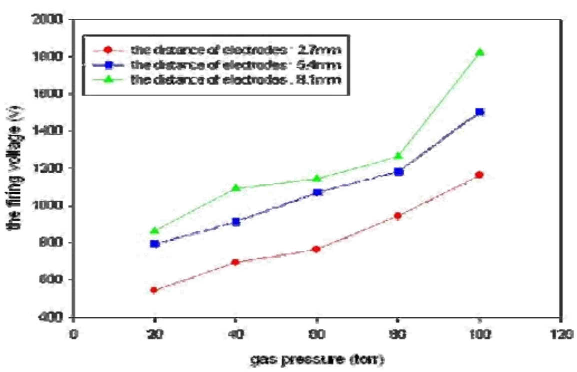

Fig. 3. Curve of firing voltage with increase in Xenon gas pressure.

The firing voltage (V_f) is defined from Paschen's law as below.

$$V_f = \frac{Bpd}{\ln\left\{\frac{Apd}{\ln(1+\frac{1}{\gamma})}\right\}} \quad (1)$$

$$\gamma\left[\exp\left\{\int_0^{x1}\alpha(x)dx\right\}-1\right]=1 \quad (2)$$

Where, γ is Townsend secondary coefficient, x is the length of the discharge path (that is; distance between electrodes), and α is Townsend primary coefficient (or named the ionization rate). Consequently, Paschen's law is the function of gas pressure (P) and distance between electrodes. Therefore, the higher gas pressure in the lamp the higher firing voltage should be applied. As the gap of electrodes is wide, firing voltage was increased.

The luminance of FFL was almost linearly increased as the Xe pressure increased. The higher luminance is anticipated for the larger gap of the electrodes because discharge path is lengthened. But actually as shown in Fig. 4, the gap of electrodes is wider, the luminance was conversely decreased. Because the gap of electrodes was short, the number of cell were increased and the plasma was almost uniform around between electrodes.

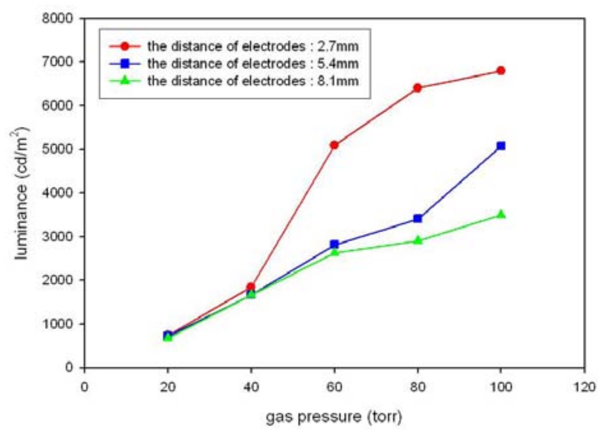

Fig. 4. Curve of luminance with increase in Xenon gas pressure.

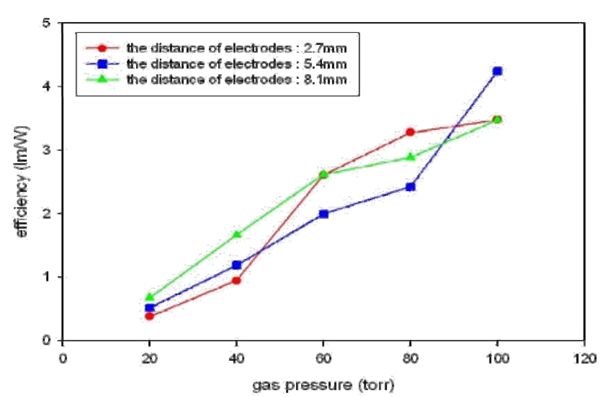

Fig. 5. Curve of efficiency with increase in Xenon gas pressure((a)2.7mm,(b)5.4mm(c)8.1mm).

As shown in Fig. 5, the higher the Xenon pressure in the lamp the higher efficiency was obtained. And so, although the luminance was improved with increase in gap distance, the efficiency was decreased due to power consumption, which is proportional to electrode area. Increment of the luminance reinforced the efficiency and the increment of power consumption offset the efficiency. Owing to interaction of two factors, the luminance was the best for FFLs having 8.1 mm gap under 40 torr and having 2.7 mm gap at 60~80 torr. Totally the efficiency of the panel having 5.4mm distance of electrodes was the best.

4. Summary

The cross type of FFL was assembled and characterized. This cross electrode type obeyed Paschen's law. As the gap of electrodes using Xe gas is wider, the firing voltage was increased and the luminance was decreased. The efficiency was different at 20~100 torr respectively.

5. Acknowledgements

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6. References

1. Shahid Rauf, *J. Appl. Phys*., **85(7)**, 3460 (1999).
2. S. M. Lee, Y. Cho, S. K. Jung, B. H. Jeong, Y. C. Jeong, M. G. Kwak, and S. H. Sohn, *IMID'06 Technical Digest*, p.675 (2006).
3. C. C. Liang, C. N. Huang, B. N. Lin, C. H. Fu, T. H. Tsou, W. Y. Lin, M. H. Lin, and Y. S. Kuo, *IMID'06 Technical Digest*, p.1202 (2006).
4. J. Park and S. Lim, *IMID'06 Technical Digest*, p.1330 (2006).
5. M. Noborio, T. Yoshioka, Y. Sano, and K. Nunomura, *SID'94 Technical Digest*, p.727 (1994).