Electro-Optical Characteristics of External Electrode Fluorescent Lamp depending on Gas pressure and mixing ratio

Hyung Dong Kim[1], Hyun Woo Jeon[2], Chang Ho Lee[2], Jung Hyun Yoon[2], Jae Bum Kim[2], Jong Ho Lim[2], Jong Keun Shin[2],and In Jae Chung[2]
[1,2]**Advance Development Division, LG Display, 642-3, Jinpyung-dong, Gumi-si, Gyungsangbuk-do, 730-726, Korea**
TEL:82-54-478-1337, e-mail: khdhope@lgdisplay.com

Keywords: LCD, Backlight, EEFL

Abstract

We investigated influence of gas pressure and mixing ratio on the electro-optical properties of External Electrode Fluorescent Lamp (EEFL). The experimental results indicated that luminance and efficiency became the maximum at lower gas pressure and Ar mixing ratio.

1. Introduction

LCD TV is one of the highest growing products. According to the latest global TV shipment results, LCD TV shipments worldwide overtook CRT TV shipments. LCD is non light-emitting device, so it needs inevitably backlight and its driving system. Backlight is the part which occupies the one of the biggest part of material cost in Liquid Crystal Display. The larger the screen size becomes, the bigger the weight of backlight cost. Also backlight is one of the most important parts to determine picture quality. There are several requirements for LCD TV from market such as fast moving picture quality, high luminance, high efficiency, lower power consumption and color gamut etc. So innovation on the Backlight technology became very important issue to solve these requirements.

Especially, the study for light source occupying important part of cost and performance in backlight is important. The Cold Cathode Fluorescent Lamp (CCFL) has been used widely as a light source in Backlight. Recently, EEFL has been used mainly in the backlight for LCD TV because EEFL has merits such as multi EEFLs operated by a single inverter, lower power consumption, longer lifetime, lower cost, simple manufacture process, etc. LCD or BLU manufacturer and research groups are concerning about EEFL's technical issues for high luminance, high efficiency, and slim&narrow. [1-7]

There are several factors related to capacitive coupled EEFL's luminous efficiency. Gas pressure and gas mixing ratio influence on the glow discharge characteristics. To find out general trends of discharge characteristics as a function of gas pressure and mixing ratio, we investigated electro-optical characteristics of EEFL. The voltage and current characteristics of the EEFL, for 81 cm (32 inch) backlight, has been examined by changing gas pressure and mixing ratio. Also, the luminance and efficiency of EEFL have been monitored.

2. Experimental

The examined EEFL was the outer diameter of 3 mm with a glass thickness of 0.5 mm and coated by RGB phosphor. The total length was 743 mm for 81cm (32inch) backlight. The electrode length was fixed at 25 mm to exclude the effect of length. We measured discharge voltage, current, luminance, luminous efficiency by changing gas pressure and mixing ratio.

3. Results and discussion

Gas pressure and mixing ratio play a very important role in discharge characteristics of Lamp such as starting voltage, operating voltage, current, luminance, and luminous efficiency.

Figure 1 shows the characteristics of firing voltage by changing the gas pressure. Firing voltage increases gradually as gas pressure increases. The firing voltage of high pressure is higher approximately 380Vrms (28%) than it of low gas pressure. This result is explained by Paschen's law shown in equation (1). As gas pressures increase, the electrons lose the kinetic energy, due to the increase of the number of collision between the electrons and the gas particles. The firing

voltages are considered to increase with the increasing gas pressures.

$$V_f = \frac{\alpha(PD)}{\ln(PD) + \beta} \quad (1)$$

Where V_f is firing voltage, P is gas pressure, D is distance of electrode. The constants α and β depend upon the composition of the gas.

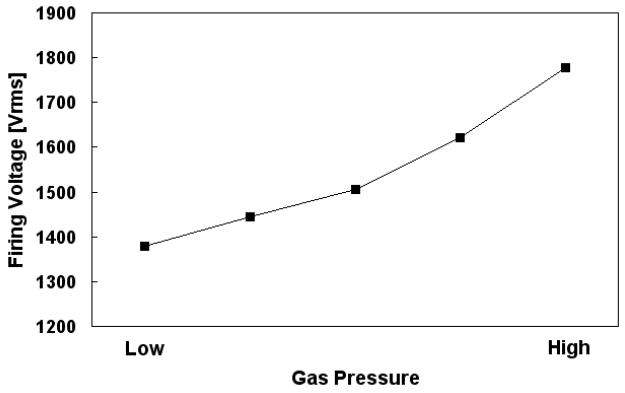

Fig. 1. Firing voltage for various gas pressure

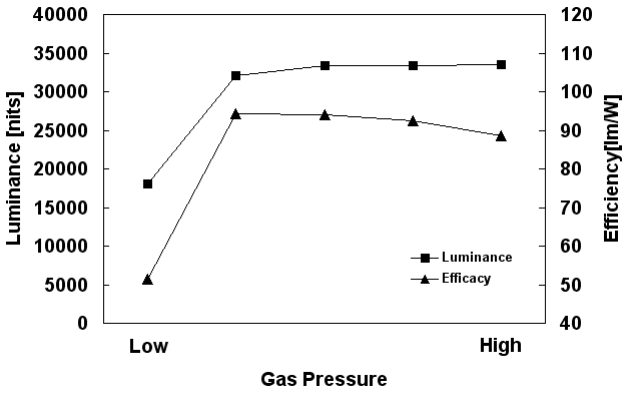

Fig. 2. Luminance and Efficiency vs. Gas pressure

Figure 2 shows characteristics of luminance and efficiency as changing the gas pressure. Operating current and Ar ratio are fixed at 7mA and low respectively. The efficiency of light source is defined by the total luminous flux divided by power consumption. The luminance and efficiency are saturated at the specific gas pressure and dropped dramatically at the lowest gas pressure. These experimental results indicate that the efficiency is optimized in the specific gas pressure. Since the mean free path of electron is too long in a low gas pressure, the electron temperature will be high, so that ionization loss is too high. On the contrary, the mean free path of electron is too short in a high gas pressure, the electron temperature will be low, so that collision loss is too high. [8]

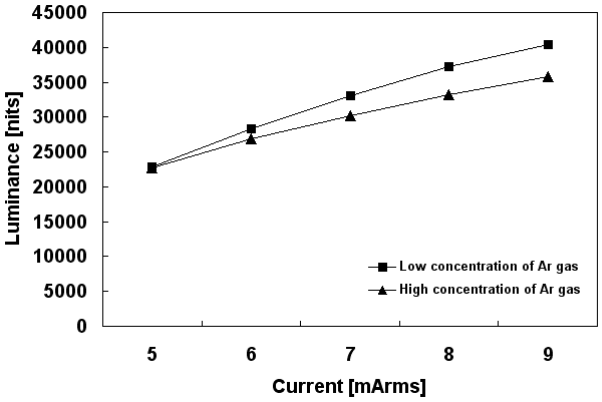

Fig. 3. Luminance vs. Current for Argon concentration in the mixture gases

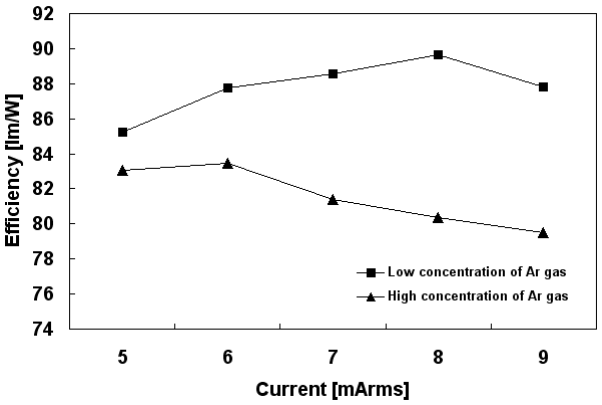

Fig. 4. Efficiency vs. Current for Argon concentration in the mixture gases

Figure 3, 4 shows characteristics of luminance and efficiency as a function of Ne-Ar mixing ratio in fixed gas pressure of 50 torr. In case of low argon concentration, the luminance and efficiency is better than high argon concentration. This trend was observed in other gas pressure. These results are interpreted on the basis of Penning Effect. The discharge space is filled with Ne-Ar mixture gases for Penning effects in addition to a minuscule amount of mercury. As the concentration of argon gas increases the probability that one will be ionized by metastable neon atoms increases. However the ionization coefficient α decreases with higher concentration of argon because of a decreasing probability of forming metastable neon atoms. The probability that electrons collide with argon atoms is higher than the probability

that electrons collide with Ne atoms. The production of excited or metastable argon atoms is not nearly as efficient for producing ions as the production of neon metastable. [8]

4. Summary

In this work, we fabricated several EEFLs and investigated its firing voltage, luminance, luminescent efficiency by changing Ne-Ar gas pressure and mixing ratio. The firing voltage increases with increasing the amounts of Ne-Ar gas pressure. The efficiency and luminance of high Ar concentration are lower than those of low Ar concentrations. The experimental results indicated that luminance and efficiency became the maximum at lower gas pressure and Ar mixing ratio.

5. References

(1 line spacing)

1. T. S. Cho, et al., Japan. J. Appl. Phys. 41, L355 (2002).
2. S. J. Kim, et al., SID'02 Digest, p1511 (2002).
3. T. S. Cho, et al., Japan. J. Appl. Phys. 41, Part 1, No.12, p7518 (2002).
4. T. S. Cho, et al., IEEE Trans. on Plasma Science, 30, No.5, p2005 (2002).
5. B. S. Kim, et al., SID'03 Digest, p1372 (2003).
6. J. B. Kim, et al., SID'06 Digest, 26.3 (2006)
7. J. S. Yoon, et al., IMID'06 Digest, p1289 (2006)
8. J. F. Waymouth, Electric Discharge Lamp, the M.I.T. Press (1971).