Effects of the Xe content on the electro-optical properties in the mercury-free Flat Fluorescent Lamp

Kyu-Yong Chung[1], Sang-Mok Lee, Yoon-Chul Jeong[2], and Sang-Ho Sohn

[1] Dept. of Physics, Kyung-Pook National University, Deagu, Korea

TEL: +82-16-442-0428, *e-mail:* yong0428@yahoo.co.kr

[2] R&D Center, HEESUNG Electronics ltd., Deagu, Korea

Keywords : Backlight unit, Flat fluorescent lamp, Mercury-free, Xenon, Neon

Abstract

Xe content is one of important factors related to characteristics of the mercury-free flat fluorescent lamp. The electro-optical properties of lamp were investigated for wide range of Xe content in Xe-Ne mixing gas. The maximum luminance of 9,289 cd/m^2 and efficacy of 3 lm/W was obtained with Xe 90 %.

1. Introduction

Backlight unit (BLU) with cold cathode fluorescent lamp (CCFL) is widely used for LCD TV. The CCFL by mercury plasma has excellent luminance and efficacy. But it has some problems. The Mercury causes environment pollution and fatal disease on the human body. As LCD TV becomes wider, the number of CCFL, which is needed in the BLU, is increased. Thus the number of inverter, which drives the CCFL, is increased. These problems cause the falloff of the luminance uniformity and efficacy.

The Mercury-free flat fluorescent lamp (FFL) is a kind of new type BLU to solve above-mentioned problems [1]. The minimum luminance for BLU requires being 10,000 cd/m^2. But FFL does not meet the requirement yet. The electro-optical characteristics of FFL depend on materials and the structure of lamp, wave forms of driving voltage, discharge gases and etc. We focused on characteristics of gas mixture, and made an experiment on influence of Xe content in Xe-Ne mixing gas.

2. Experimental

Figure 1 shows the structure of 7 inch diagonal size an opposed discharge type FFL, which consists of metal and transparent electrodes, front and rear dielectric layers, phosphor layers and discharge space. The barrier rips are formed by sand-blast method. Both of electrodes are formed externally. Metal electrodes are made of silver paste. Transparent electrode is commercial ITO glass, sheet resistance of which is about 9 Ω/□. Front and rear dielectric layers are used of substrate glass, thicknesses of which are 1.1 ㎜and 1.0 ㎜, respectively. The gap of discharge space is 2 ㎜. White phosphor is mixture of Red (41.3 wt%), Green (27.3 wt%) and Blue (31.3 wt%) phosphors. The components of Red, Green and Blue phosphors are $(Y,Gd)BO_3:Eu$, $ZnSiO_4:Mn$ and $BaMgAl_{10}O_{17}:Eu$, respectively. Phosphor layers are made of phosphor paste which is mixture of white phosphor and organic vehicle with specific ratio. Front and rear phosphor layers are formed by screen-print and dispense method, respectively.

The schematic diagram of experiment system is depicted in fig. 2. The vacuum system provides residual pressures lower than 10^{-5} torr. FFL is exhausted and filled with discharge gas through the mixing chamber. The luminance is measured with luminance meter (MINOLTA CS-100A). The power consumption is calculated with values AC voltage and current, which are measured with oscilloscope (TETRONIX TDS-744A) in the drive.

In this experiment, applied voltage is bipolar type AC voltage with frequency of 20 ㎑ and duty ratio of 20 %, and total pressure of mixing gases is fixed at 300 torr.

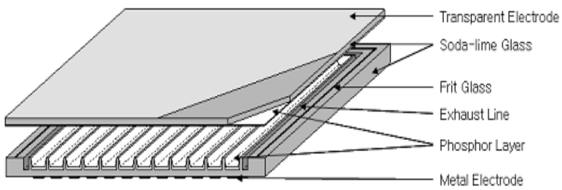

Fig. 1. The structure of an opposed discharge type flat fluorescent lamp.

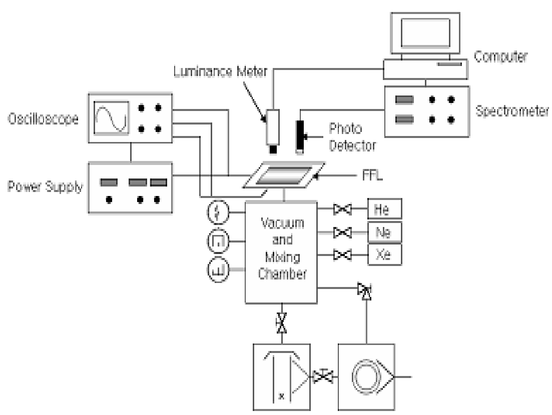

Fig. 2. The schematic diagram of experiment system.

3. Results and discussion

Figure 3 shows the breakdown voltage and sustain voltage as a function of Xe content. As Xe content was increased, both voltages were increased. This result is due to a low coefficient for Xe ions induced secondary electron emission [2, 3]. Wide voltage margin, which is defined as voltage difference between breakdown and sustain voltages, is required for stable driving of FFL. It was appeared broader in mixing gases over 40 % Xe content than in those below 30 %.

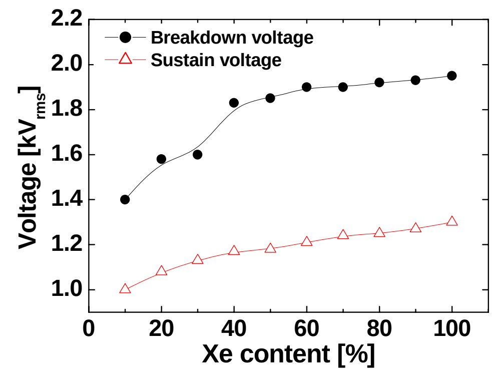

Fig. 3. The breakdown voltages and sustain voltages as a function of Xe content.

Figure 4 shows the luminance and efficacy as a function of Xe content at 2.6 kV_{rms}. As Xe content was increased, not only luminance but also efficacy was increased. The importance is that both of characteristics of FFL with mixing gas over Xe 50 % content are more increased than those in pure Xe. Especially, the luminance of 8,390 cd/m^2 with efficacy of 4.34 lm/W was obtained in FFL with mixing gas of Xe 90 %. Both of characteristics were improved by a factor of over 4 %, compared with the pure Xe cases. Respectively, due to Penning effect.

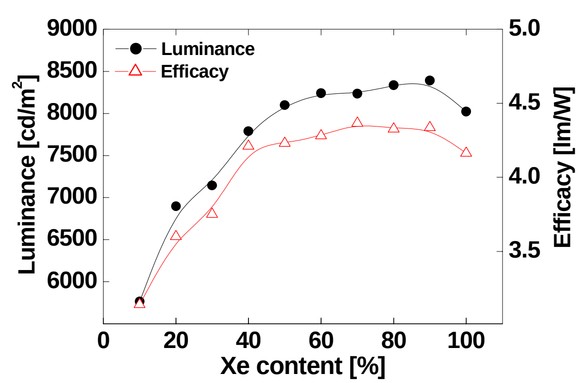

Fig. 4. The luminance and efficacy as a function of Xe content at 2.6 kV_{rms}.

The luminance and efficacy as a function of driving voltage for Xe content are shown fig. 5 and fig. 6, respectively. As driving voltages are increased, the luminance is increased, while the efficacy is decreased. This result is attributed to the fact that the increase rates of the power for increasing driving voltages are larger than those of luminance. Compared with the pure Xe case, the luminance as a function of driving voltage for Xe 40 % is less over all driving voltages, but that for Xe 50 % is similar to the pure Xe case. And the efficacy is more improved in mixing gas with higher Xe content at the same applied voltages. Especially, in mixing gas of Xe 90 %, luminance for same applied voltages is higher than those of other cases. In this case, the maximum value of luminance was 9,289 cd/m^2 at 3.0 kV$_{rms}$, with efficacy of 3 lm/W.

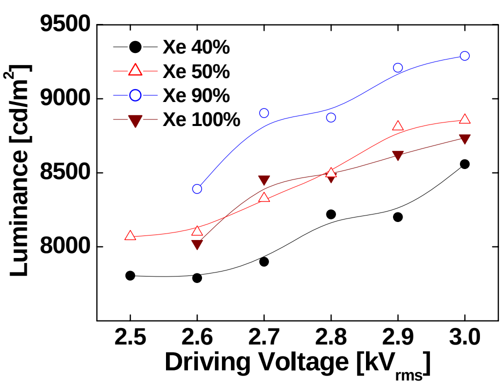

Fig. 5. The luminance as a function of driving voltages for the Xe content.

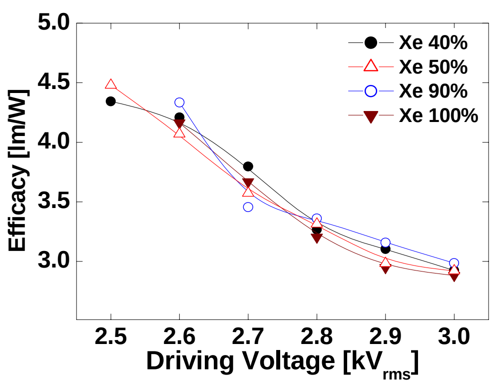

Fig. 6. The efficacy as a function of driving voltages for the Xe content.

4. Summary

In this experiment, we obtained a maximum luminance of 9,289 cd/m^2 in Xe(90%)-Ne(10%) mixing gas. This result can meet the requirement for the luminance of BLU. Thus we confirmed that the mercury-free FFL can be applied as a BLU of LCD TV. The high Xe content is needed for high luminance in the FFL. The electro-optical characteristics such as luminance, efficacy and breakdown voltage in optimized Xe-Ne mixture gases are considerably improved, compared with those in pure Xe. The high driving voltage and the low efficacy of FFL should be still studied. For this, studies of mixing of gases, materials and the structure of lamp are needed.

5. References

1. M. G. Kwak and S. H. Sohn, SID01 Digest, pp391-393(2001)
2. M. F. Gillies et al., J. Appl. Phys. 91, 6315(2002)
3. G. Oversluizen et al., IMID04, 4-2(2004)