Discharge characteristics of a Flat Fluorescent Lamp(FFL) containining Penning gases

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Abstract

We developed a Flat Fluorescent Lamp(FFL) with a high luminance by using the same discharge mode as PDP. Our FFL has the simple and unique structure where the glass substrates are used as dielectric layers. The panel has a striped line shape of 7 inch diagonal size. The Xe-Ne-He mixture gas was used to generate the plasma, and the gas discharge characteristics under both total gas pressure and partial gas pressure were investigated. The panel showed a maximum high luminance 7,270cd/m^2 under bias of 20KHz pulse of 3KV.

1. Introduction

The size of LCD TV is growing by virtue of the technology progress of LCD TV. As its size grows, the role of the backlight on the LCD TV is of much importance. At present, the serious problems of the backlight are the high electricity consumption, the high price, and the insufficient luminance characteristic due to the increasing number of the lamps. Developing the oncoming generation of LCD backlight units has been focused to solve these problems. Currently, improving the luminance and luminance efficiency of the panel is a main concern of the LCD backlight industry. The mercury-free FFL is known to be one of the next generation LCD Backlight unit devices. Recently, panel fabrication process, phosphor and discharge cell structures gas mixtures have been investigated in order to improve the insufficient FFL luminance. In the view point of the gas discharge, the efficiency of the mercury-free FFL is determined by the energy on Xe excitation and interaction between VUV and phosphor. In this paper, we fabricated the 7 inch diagonal FFL and investigated its optical characteristics such as luminance, PL spectrum, color coordinates as the functions of the total gas pressure and the mixing ratios of Xe gas. Our FFL has a peculiar structure without dielectric layers by using the glass substrate as dielectrics.

2. Experiments

Figure 1 and Figure 2 represent the cross-sectional structure of the FFL developed in this study. The ribs with a stripe line shape are formed by sandblasting the rear glass substrate. The ITO electrode and metal electrode are formed at the outside of the front and rear glass substrates, so that we could removed the conventional dielectric layers.

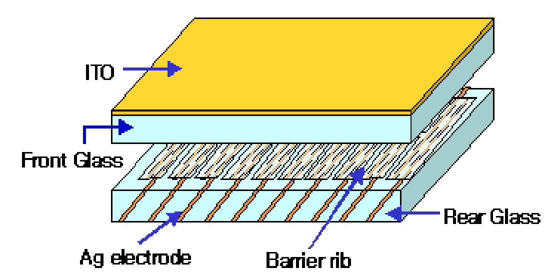

Figure 1. Structure of FFL

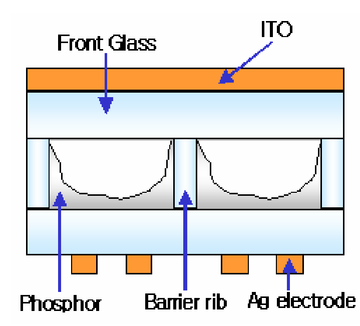

Figure 2. Cross-section of FFL

The fabrication process of FFL panel is similar to that of the PDP panel but the former is simpler because the any process for the dielectric layer is not needed. Finally, the gas discharge characteristics, PL spectrum, and color coordinates of the fabricated FFL panel were investigated by help of the laboratory made discharge test equipment.

3. Results and discussion

The FFL panel needs the strong white light emitted from the phosphors. The phosphors excited by the vacuum ultraviolet (VUV) generated in the gas discharge. Xe gas has been used currently for VUV source in FFL. But it is known that the penning gas is more desirable because a firing voltage increases when only Xe gas is used. This is why we used the Xe, Ne, He mixed gas in our FFL.

Figure 3 shows that the firing voltage of our FFL increases with increasing Xe gas pressures. The firing voltage also increases with increasing of total gas pressures as shown in Figure 4. These results are in good agreement with Paschen's law. With the increasing gas pressures, the electrons lose the kinetic energy, due to the increase of the number of collision between the electrons and the gas particles. For this reason, the firing voltages were considered to be increased with the increasing gas pressures.

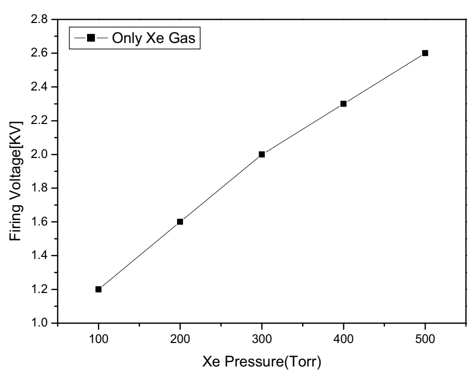

Figure 3. Firing voltages as Xe pressure

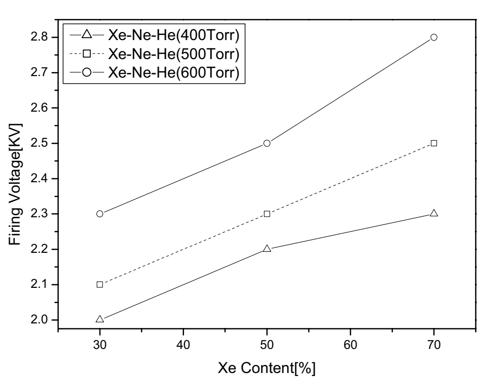

Figure 4. Firing voltages as total gas pressure

Figure 5 is a discharging picture of our FFL panel emitting the white light.

Figure 5. Discharging picture of the FFL

Figure 6 shows luminance characteristics according to the voltages, measured in the samples which are filled with only Xe gas. As the Xe pressures increase, the luminance and firing voltage also increase. As the voltages increase, the electrons in discharge cell will get higher energies and excitations of phosphors actively happen. This will lead to an increase of luminance, seen in the low voltage region of the figure 6. On the contrary to this, the decrease of the luminance can be explained by the ionization of the discharge gases. In higher voltage region, the ionization can happen more easily than the excitation of gases, resulting in the decrease of the luminance.

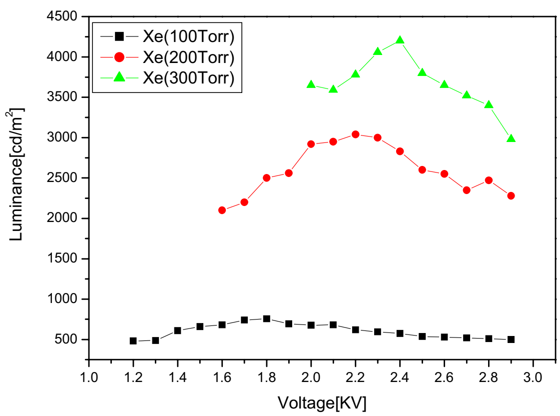

Figure 6. Luminance vs applied voltages under several Xe pressures

Figure 7 shows the luminance characteristics according to applied voltages under several Xe-Ne-He mixture gases. We fixed the total gas pressure at 600torr and the He concentration at 1%, and changed the ratios of Ne to Xe. As the Xe concentration became higher, the luminance and firing voltage.

Figure 8 shows luminance characteristics according to applied voltages under several total gas pressures when the ratio of the Xe-He-Ne mixture gas is 70:29:1. The luminance increased with increasing total gas pressures but the firing voltages also moved to be higher values to the 3kV. The luminance increased with the total gas pressures can be explained by increasing VUV emission with the gas amount.

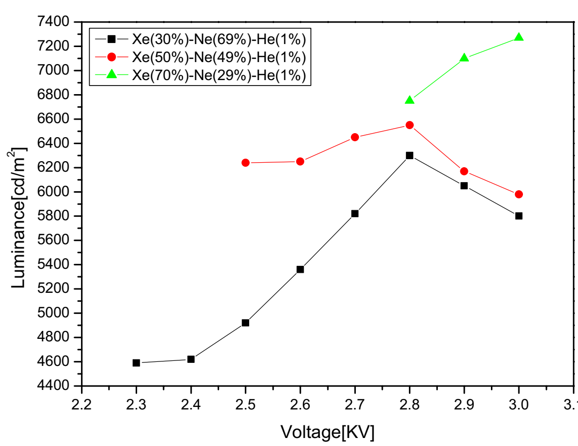

Figure 7. Luminance vs applied voltages under several Xe-Ne-He mixing ratios (Total gas pressure is fixed at 600torr)

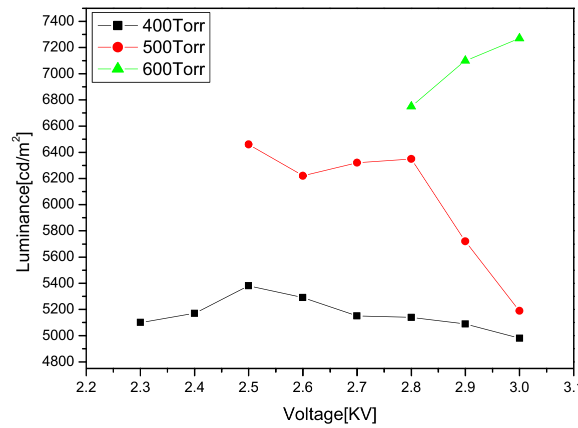

Figure 8. Luminance vs applied voltages under several mixture total gas pressures of Xe(70%)-Ne(29%)-He(1%)

Figure 9 shows the color coordinates of A type (X=0.298, Y=0.243), B type(X=0.313, Y=0.253) and C type(X=0.299, Y=0.248) which is classified by the mixied gas. It is found that the change of Xe amounts makes little influence on the color coordinates

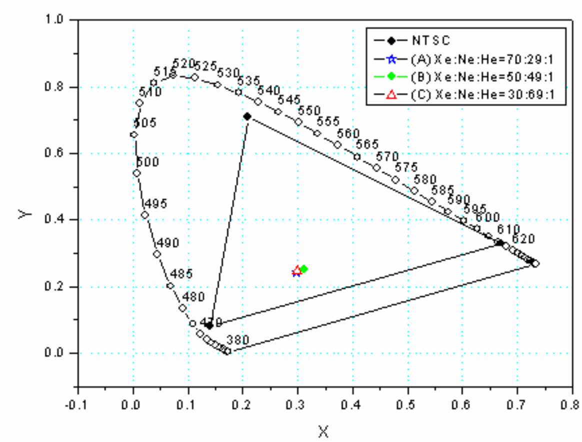

Figure 9. Colors coordinate by Xe-He-Ne mixing ratios

The experimental results reveal that the luminance and firing voltages increased with the increasing amounts of Xe and the total gas pressures. The change of Xe amounts makes little influence on the color coordinates. When the total gas pressure of Xe(70%)-Ne(29%)-He(1%) was 600torr, the FFL panel showed the maximum luminance of 7,270cd/m^2 under biasing 20kHz pulse of 3kV.

4. Conclusions

We fabricated a simple structured FFL without the dielectric layers, and investigated its electrical and luminescent characteristics under several mixed gas conditions. The main feature is that the luminance and the firing voltages increase with increasing the amounts of Xe and total gas pressures and that the color coordinates are seldom affected by the Xe amounts in FFL. Even though our FFL revealed the maximum luminance of 7,270cd/m^2, available to LCD backlight, the phosphors with higher efficiency are still needed for decrease the drive voltages

5. References

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