A study of static characteristics of New gas mixture in AC-PDP

Shi-Ok Kwon
Nano-electronic and Future Technology Laboratory, School of Electrical and Electronic Engineering, Chung–Ang University, Seoul 156-756

Ji-Sun Kim, Bong-Kyu Joung, Ho-Jung Hwang
Nano-electronic and Future Technology Laboratory, School of Electrical and Electronic Engineering, Chung–Ang University, Seoul 156-756

Abstract
The effects of addition of D_2 to conventional gases on the discharge characteristics were investigated in this work with the aim of improving the voltage margin, the wall charge and the jitter. The addition of an extremely small gas-inlet amounts of D_2 increased the number of electrons which improves the Xe^* density and Xe_2^* density. As a result, the voltage margin, the jitter and the wall charge increased.

1. Introduction
Min *et al*. [1] reported that the addition of Ar or Kr generates the Penning effect electrons through the Penning effect: (Ne* + Ar ? Ar^+ + e + Ne, Ne* + Kr ? Kr^+ + e + Ne, Ar** + Xe ? Xe^+ + Ar + e, Kr** + Xe ? Xe^+ + Kr + e, etc.) [2]. The ionization energy level of D_2 is similar to that of Ar or Kr. Therefore, we can anticipate that the Penning effect of D_2 is similar to that of Ar or Kr. Hickman *et al*. [3] and Khan *et al*. [4] reported that the addition of H or D increase the ionization ratio. They also reported that the total ionization ratio of the addition of D is higher than that of the addition of H. Therefore, in order to find a new penning gas and an optimal gas-inlet mixture, we added a small gas-inlet amount of D_2 to Ne (92 %)-Xe (8 %). The addition of D_2 generates Penning electrons through the Penning effect: (Ne* + D_2 ? D_2^+ + e + Ne, D_2** + Xe ? Xe^+ + D_2 + e, etc.). Penning electrons also improve the luminance and luminous efficiency. The Penning electrons are caused by first ionizations due to collisions with other particles; then, the increase in the number of electrons Xe* density due to electron collisions with Xe atoms. The increase in the Xe* density decreases the power consumption due to an increase in the wall charge and improves the luminance through more emission of 147 nm photons [5]. As a result, Penning electrons improve the luminance and the luminous efficiency. Therefore, to understand the Penning effect, we experimentally measured the firing voltage, the sustain voltage, the wall charge, the luminance, and the luminous efficiency for Ne (92%)-Xe (8%)-D_2 (%) and He (70%)-Ne (27%)-Xe (3%)-D_2 (%).

2. Experiment Configuration and Method
Figure 1 shows the apparatus used for the gas-discharge-characteristic-measurement. The active size of panel used in this experiment is 3.5 inches in diagonal and it has the conventional coplanar structure with three electrodes.

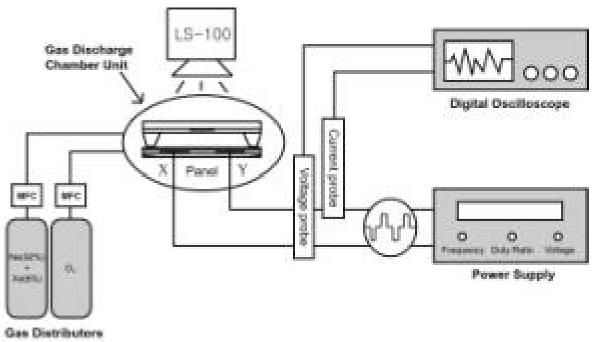


Figure 1 Schematic diagram of Gas-Discharge-Measurement System.

The test panel is composed of the rear glass, the front glass, the three-ITO electrode, the dielectric layer, the MgO protective layer, the barrier rib, and the phosphor. The sustain electrode and scan electrode that are covered with 30 µm thick dielectric layers are parallel to each other in the front glass. A 0.5 µm thick MgO protective layer is deposited on the dielectric layer using an electron beam evaporation method. The sustaining discharge in AC-PDP occurs between the parallel sustaining electrodes of sustain and scan that are separated by 100 µm. The electrode width is maintained at 260 µm and the cell pitch is set at 1080 µm. On the rear glass, the address electrodes of 100μm width and barrier rib of 120 μm height are perpendicular to the two sustaining electrodes. The test panel put into the vacuum chamber and sustained the vacuum up to 10^{-6} Torr with the diffusion pump and rotary pump. The vacuum chamber was also connected to the four mass flow controllers that can mix the conventional gases (Ne-Xe or He-Ne-Xe) with a small gas-inlet amount of D_2. In the chamber, the gas pressure was measured with a baratron gauge in the low vacuum condition and with an ionization gauge in the high vacuum condition.

The power was provided to the test panel in the vacuum chamber through the power supply (PDS2000, FTlab). The luminance was measured by LS-100 (Minolta). The luminous efficiency, the voltage, and the current are measured by voltage probe (P6139A, Tektronix) and alternative-current probe (P6021, Tektronix) which are connected to digital oscilloscope (TDS3034, Tektronix). We set the test panel conditions at a driving frequency 83 kHz, a duty ratio 30 %, a pressure 400 torr and have reproduced the experiment five times, respectively.

3. Results and Discussion

Figure 2 shows the sustain voltage as functions of gas-inlet concentration of D_2 added to Ne-Xe and He-Ne-Xe.

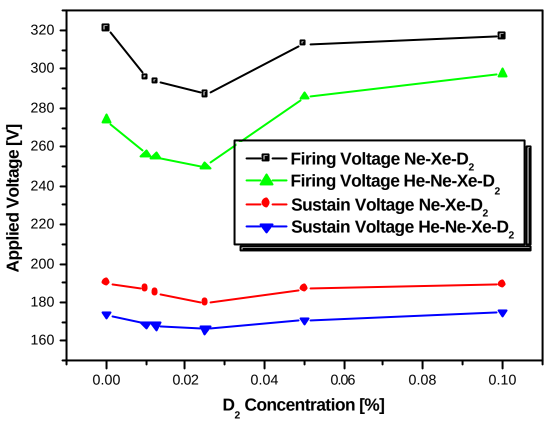
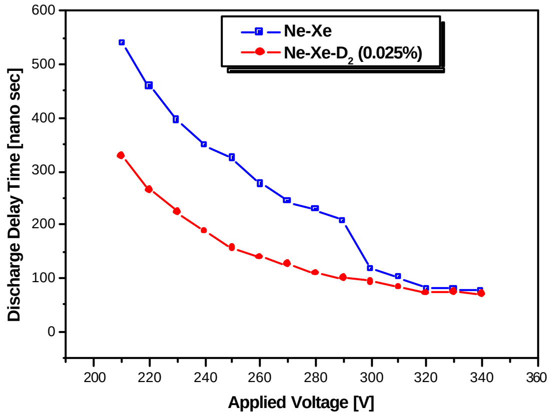
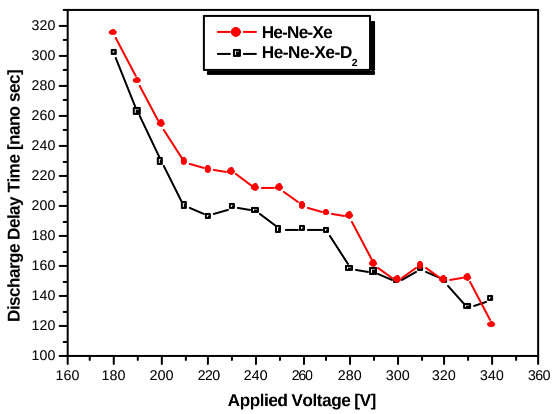


Figure 2 Sustain voltage as functions of gas-inlet concentration of D_2 added to Ne-Xe or He-Ne-Xe.

In both cases, the increase of the gas-inlet concentration of D_2 tended to the increase of the sustain voltage. However, when the gas-inlet concentration of D_2 was below 0.05 %, the sustain voltage decreased. When the gas-inlet concentration of D_2 was 0.025% in Ne-Xe, the sustain voltage maximally decreased by 10 V, respectively. When the gas-inlet concentration of D_2 was 0.025% in He-Ne-Xe, the sustain voltage most decreased 8 V, respectively. However, the firing voltage of both cases (Ne-Xe-D_2 and He-Ne-Xe-D_2) was almost constant. Therefore, the voltage margin was improved. It is worth noting that a decrease in the sustain voltage is influenced by the increase in the number of Penning electrons for a small gas-inlet amount addition of D_2 [6]



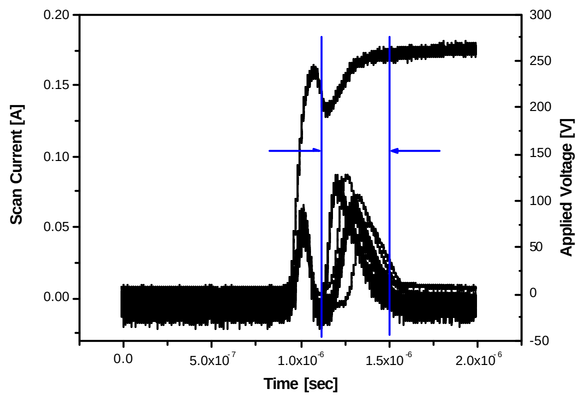
(a) Ne-Xe



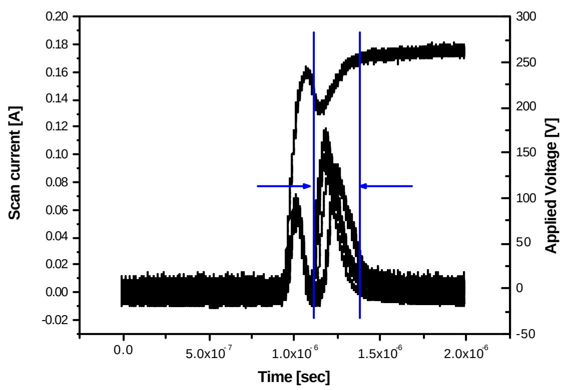
(b) He-Ne-Xe

Figure 3 Discharge delay time as a function of the applied voltage

Figure 3 shows the discharge delay time as a function of the applied voltage. In Fig. 4(a), when the gas-inlet concentration of D_2 added to Ne-Xe was kept constant at 0 or 0.025 %, the discharge delay times was shorter than it was for Ne-Xe by 30 ~ 120 nano-seconds. However, when the applied voltage increased over 300 V, the discharge delay times of both cases were similar. In Fig 4(b), when the gas-inlet concentration of D_2 added to He-Ne-Xe was kept constant at 0 or 0.025 %. Although the gas-inlet amount of D_2 was 0.025 %, the discharge delay times of both cases were similar.



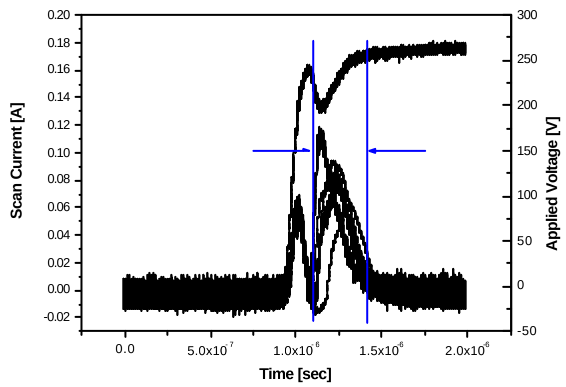
(a) Ne-Xe



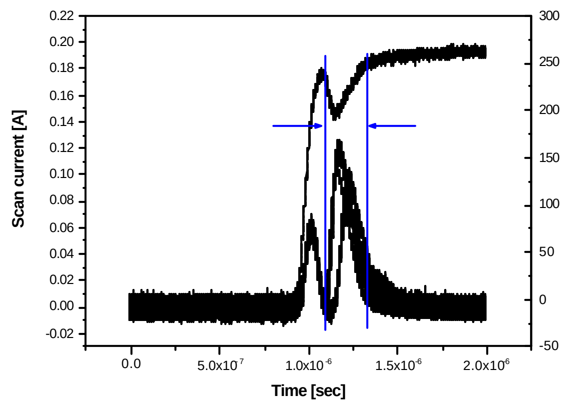
(b) Ne-Xe-D_2

Figure 4 Comparison of the jitter when the gas-inlet concentration of D_2 (0.025%) added to Ne-Xe

Figure 5 and 6 show the comparisons of the jitter when the gas-inlet concentration of D_2 added to Ne-Xe and He-Ne-Xe was kept constant at 0 and 0.025 %. In the both cases, when the gas-inlet concentration of D_2 was 0.025%, the jitter was decreased. Therefore, the image quality of PDP is improved. To understand the effect of adding D_2, we measured the wall charge in a cell. The accumulated wall charge on the dielectric surface decreased the sustain voltage, which in turn decreased the power consumption in the cell. We conclude that the accumulation of the wall charge plays a role in improving efficiency.



(a) He-Ne-Xe



(b) He-Ne-Xe-D_2

Figure 5 Comparison of the jitter when the gas-inlet concentration of D_2 (0.025%) added to He-Ne-Xe.

These results demonstrate that some improvements are measured wall charge, voltage margin, and jitter in PDP cell when a small proportion of gas-inlet concentrates of D_2 (about 0.01 – 0.05%) are added to conventional gases (such as Ne-Xe and He-Ne-Xe).

4. Conclusion

In summary, we mainly considered the effect for small addition of D_2 at the high pressure (400 torr). We experimentally investigated the improvement of the voltage margin, jitter, and wall charge through a small gas-inlet addition of D_2 to Ne-Xe and He-Ne-Xe gases in PDP. When a small proportion of gas-inlet concentrates of D_2 (about 0.01-0.025%) is added to conventional gases (such as Ne-Xe and He-Ne-Xe), we found that the number of electrons increase due to the Penning effect as well as an increase in Xe^* and Xe_2^*. We also observed that the wall charge increased proportionately with the increase in electron density due to the Penning effect. Specifically, when the gas-inlet concentrations of D_2 added to Ne-Xe were about 0.01-0.025% at the 400 torr, the firing voltage decreased by 34 V, the sustain voltage decreased by 10 V and the wall charge increased by 21 ~24%. The discharge delay time was shorter than it was for Ne (92%)-Xe (8%) by 30-120 nano-seconds. It is also noted that when the gas-inlet concentrations of D_2 added to He (70%)-Ne (27 %)-Xe (3%) were about 0.01-0.025 % at the 400 torr, the firing voltage decreased 24 V, the sustain voltage decreased by 8 V and the wall charge increased by 34 ~ 45%.

7. References

[1] B. K. Min, S. H. Lee and H. G. Park, J. Vac. Sci. Technol. A **18**, 349 (2000).

[2] S. J. Lee, J. K. Lee, S. U. Kwon, T. W. Kim and H. J. Hwang, J. Korean Phys. Soc. **42**, 938

[3] A. P. Hickman and H. Morgner, J. Chem. Phys. **67**, 5484 (1978).

[4] P. Khan, H. R. Siddiqui and P. E. Siska, J. Chem. Phys. **95**, 3371 (1991).

[5] B. K. Min, H. Y. Choi, S. H. Lee and H. S. Tae, J. Vac. Sci. Technol. B **19**, 7 (2001).

[6] J. H. Seo, H. S. Jeong, J. Y. Lee, C. K. Yoon J. K. Kim and K. W. Whang, J. Appl. Phys. **88**, 1257 (2000)