The effect of sustain discharge gap variation in AC PDP with high Xe content

Hyun Sook Bae and Ki-Woong Whang
Plasma Laboratory, School of Electrical Engineering, Seoul National University, San 56-1, Shinlim-dong, Kwanak-gu, Seoul 151-744, KOREA
Phone: +82-2-880-9554, Email: kitty@pllab.snu.ac.kr

Abstract

We investigated the effect of sustain electrode gap variation with high Xe content in an ac Plasma Display Panel through two-dimensional numerical simulation to understand the inherent high luminous efficiency mechanism. For the low Xe content, the optimal sustain electrode gap turned out to be about 200㎛, but with higher Xe content, the VUV generation efficiency increased as the electrode gap increases beyond 200㎛. We found that it is due to higher electron heating efficiency in the cathode sheath under the condition of long electrode gap and high Xe content.

1. Introduction

Recently, PDPs(Plasma Display Panel) with gas condition of high Xe content (>10%) and with cell geometry of long sustain electrode gap have attracted considerable attention, because they show high luminous efficiencies [1-2].

The theoretical explanation for the cause of the luminous efficiency improvement with the increase of Xe content had been suggested previously [3]. The high luminance with increasing electrode gap was explained by the long discharge path [4]. On the other hand, some papers reported that the improvement in the luminous efficiency for longer electrode gap is explained through the positive column theory [5-6].

However, because of no satisfactory explanation for the mechanism of the improved luminous efficiency with the increase of the electrode gap, a numerical simulation study has been carried out to elucidate the mechanism.

Fig. 1 shows the schematic diagram of ac PDP cell used in our computational simulation. The cell pitch of a sub-pixel is 810 μm, and the typical barrier rib height is 140 μm, which includes the phosphor thickness of 10 μm. The width of sustain electrodes is 260 μm, but the gap of sustain electrodes changes from 60 μm to 280 μm. The address electrode on the rear plate is covered with a 20 μm dielectric layer, while the sustain electrodes on the front plate is covered with a 30 μm dielectric layer.

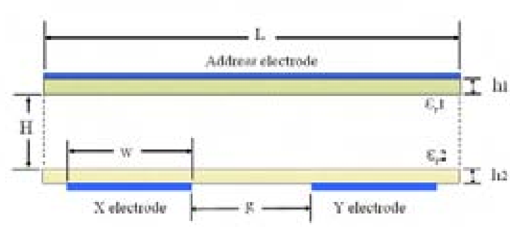
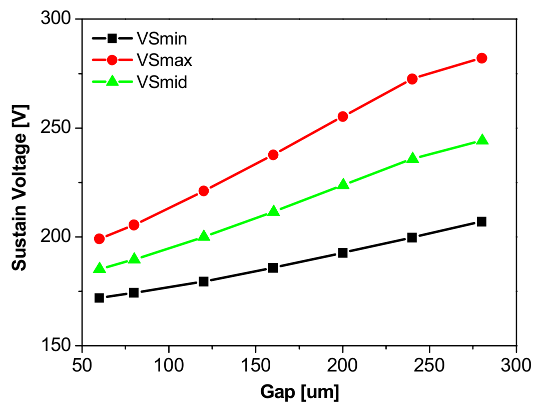


Fig. 1 Schematic of the simulated PDP cell

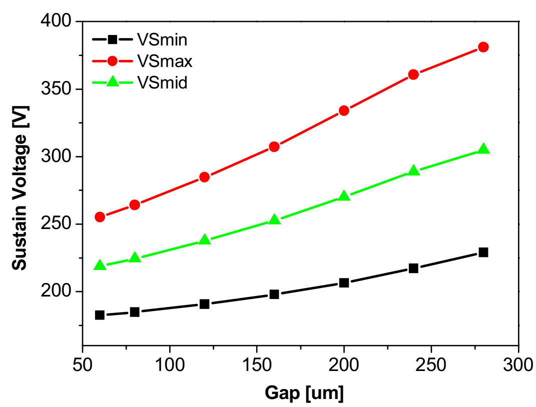
In the numerical simulation, we used the two-dimensional local field approximation (LFA) model, and the detailed description of the code can be found elsewhere [7].

2. Results

In this paper, we investigated the change of luminous efficiency with the sustain electrode gap variation from 60 to 280 μm under two gas conditions, Ne-Xe [5%] and Ne-Xe [20%].



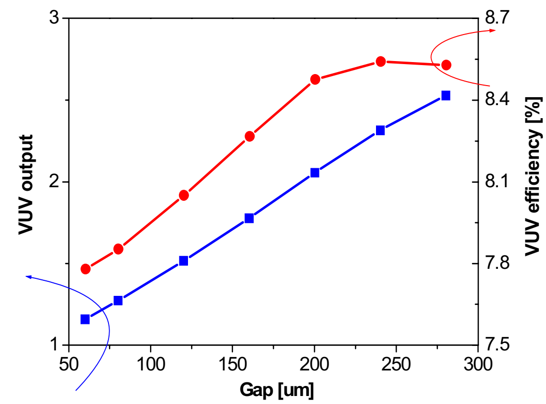
(a)



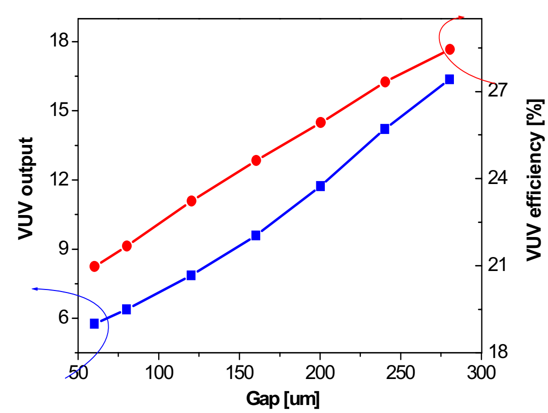
(b)

Fig. 2 Sustain voltage for sustain discharge gap variation (a) Ne-Xe [5%] and (b) Ne-Xe [20%]

Fig. 2 shows the simulation result of the sustain voltage change for sustain electrode gap variation in two gas conditions, where we can see that the sustain voltage increases with the increase of electrode gap.



(a)

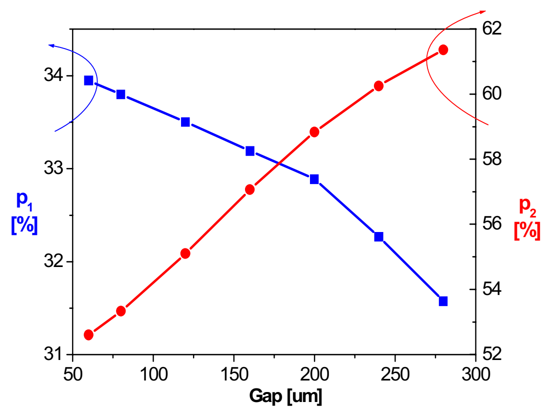


(b)

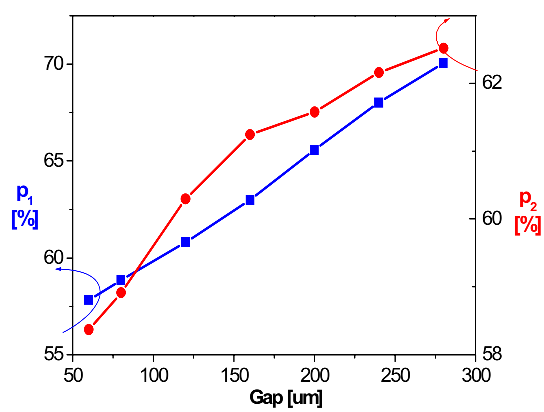
Fig. 3 VUV output and generation efficiency for sustain discharge gap variation (a) Ne-Xe [5%] and (b) Ne-Xe [20%]

Fig. 3 shows the VUV output and generation efficiency with the electrode gap variation. For the low Xe content case of Ne-Xe [5%], the improvement of luminous efficiency ceases for the gap above 200 μm. However, with the higher Xe content of Ne-Xe [20%], the VUV generation efficiency increases as the electrode gap increases without saturation unlike with the case of low Xe content.

In order to understand the mechanism for this discharge characteristic of higher increment in the improvement of luminous efficiency for longer gap in high Xe content, a detailed analysis of luminous efficiency has been carried out.



(a)



(b)

Fig. 4 Two partial efficiencies for sustain discharge gap variation (a) Ne-Xe [5%] and (b) Ne-Xe [20%]

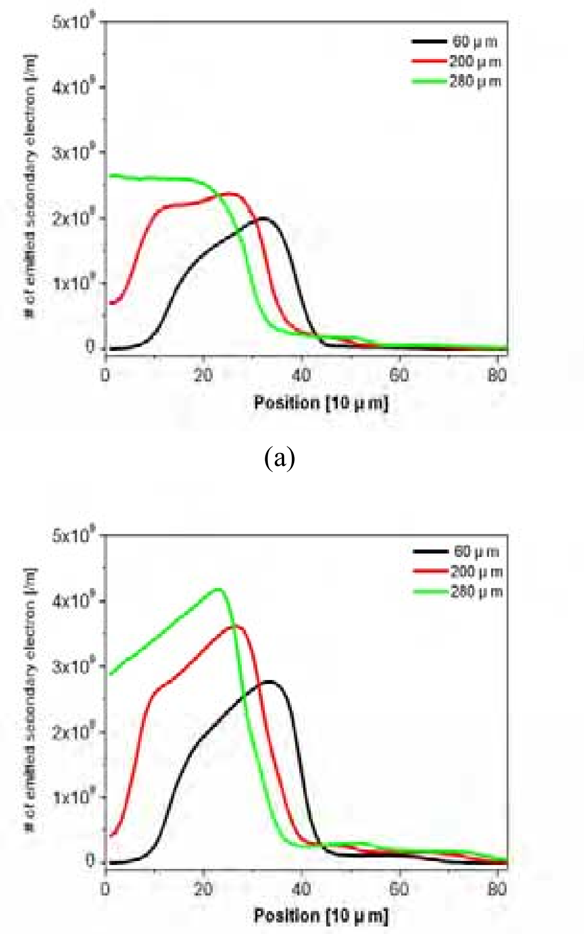
Fig. 4 shows the change of electron heating efficiency, ρ_1, and excitation efficiency by electrons, ρ_2, with the sustain electrode gap variation. The excitation efficiency by electrons increases with the electrode gap increase in both of gas conditions. However, the electron heating efficiency shows a different tendency between two Xe content cases.

For the high Xe content, the electron heating efficiency increases with longer electrode gap, but it decreases with increasing electrode gap for low Xe content, which might be due to more electric power input into the electrons under high Xe content.

The reason why the power input into electrons increases with longer gap geometry in high Xe content can be explained by the number of emitted secondary electrons in Fig. 5.

Fig.5 shows the total number of emitted secondary electrons. Although there are more Xe ion flux in the discharge region, Ne ion has much higher secondary electron emission coefficient. From the previous results shown in Figs. 2, a longer electrode gap results in higher sustain voltage. Thus, as the electrode gap increases, Ne ion plays more important role in emitting secondary electron, and it results in more secondary electron emission with longer gap.

Under the high Xe gas condition, the flux of secondary electron emission from cathode region increases greatly as the electrode gap increases. The more secondary electrons are emitted from the cathode, the more electrons experience the high field of cathode sheath, and the higher electron to ion density ratio in space is obtained. Consequently, this increases the electron heating efficiency under high Xe and long gap conditions.



(a)

(b)

Fig. 5 Number of emitted secondary electron (a) Ne-Xe [5%] and (b) Ne-Xe [20%]

3. Conclusion

Still now, the detailed analysis on the mechanism of the improved efficiency with the increase of the electrode gap has not been reported. The numerical analysis shown in this paper might shed more lights on the understanding of the mechanism.

The optimal sustain electrode gap was revealed out to be about 200 μm for the low Xe content, but with higher Xe content, the VUV efficiency increased as the electrode gap increased above 200 μm. This discharge characteristic can be elucidated by higher electron heating efficiency in the strong cathode sheath field under the condition of long electrode gap and high Xe content.

4. References

[1] G. Oversluizen, S de Zwart, S. van Heuden, and T. Dekker, "Dependence of PDP efficacy on the gas pressure", *IDW'00*, pp.631-634, 2000

[2] Nam Hoon Shin, Kyo Sung Lee, Sang Cheol Song, Bhum Jae Shin, K. C. Choi, "High luminous efficacy AC PDP with auxiliary electrodes", *IDW'05*, pp.1457-1460, 2005

[3] Woo Joon Chung, Bhum Jae Shin, Tae Jun Kim, Hyun Sook Bae, Jeong Hyun Seo, and Ki-Woong Whang, "Mechanism of High Luminous Efficient Discharges With High Pressure and High Xe-Content in AC PDP", *IEEE Trans. Plasma Sci.* Vol.31, No.5, pp.1038-1043, 2003

[4] T. Akiyama, M. Ueoka, "Evaluations of Discharge Cell Structure for Color AC Plasma Display Panels", *ASID'95*, pp.377-380, 1995

[5] L. Weber, United States Patent N° 6184848B1, 2001

[6] D. Piscitelli, Th. Callegari, R. Ganter, L. C. Pitchford, J. P. Boeuf, "Understanding and Optimization of PDPs from Diagnostics and Models", *IDW'01*, pp.825-828, 2001

[7] Jeong Hyun Seo, Woo Joon Chung, Cha Keun Yoon, Joong Kyun Kim, and Ki-Woong Whang, "Two-Dimensional Modeling of a

Surface Type Alternating Current Plasma Display Panel Cell : Discharge Dynamics and Address Voltage Effects", *IEEE Trans. Plasma Sci.* Vol.29, No.5, pp.824-831, 2001