Effect of Self-Erase Discharge on the Luminous Efficacy of Long Gap AC PDPs

Tae Jun Kim, Jae Chul Jung, Hae-Yoon Jung, Ki-Woong Whang
EN420 #53, Plasma Labortory, School of Electrical Engineering & Computer Science, Seoul National University, Seoul, Korea
Phone: +82-2-880-9554, E-mail: ktjycd@gmail.com

Keywords : PDP, Luminous Efficacy, Self-Erase Discharge

Abstract

We studied the effect of self-erase discharge on the luminous efficacy of ac PDPs. We observed through discharge current analysis to confirm that the self-erase discharge occurred mainly between sustain cathode and address electrode, which have an influence on the luminous efficacy. The amount and timing of the self-erase discharge was varied to observe its effect on the luminous efficacy. It has been found that the luminous efficacy could be improved by the self-erase discharge when it is adjusted to occur right before the main discharge in the small gap structure. In the long gap structure, on the contrary, the luminous efficacy could be increased when the self-erase discharge is suppressed. Also, various waveforms to control self-erase discharge are suggested and tested in the panel experiments.

1. Introduction

Self-erase discharge was known usually to occur with voltages higher than the firing voltage but showed beneficial effect such as increasing the luminous efficacy by decreased consuming power [1]. However, the results were obtained by the discharge only between coplanar electrodes with floated address electrode condition. Luminous efficacy improved also by applying short pulses to address electrode that increases the self-erase discharge intensity, [4],[5] but the results were shown only in the small gap structure. When the ground potential is applied to the address electrode, the self-erase discharge could occur mainly between the sustain cathode and address electrode as shown in the measured results of wall charge distribution [2], which is the real driving condition. So we examined the effect of the self-erase discharge on the luminous efficacy and the luminance of ac PDP with the grounded address electrode. The observations were done with varying the electrode gap.

2. Experimental

In this work, we used test panels with the 50 in.-diagonal XGA (1366×768) resolution. The panel had 2 inch-diagonal display area and used monochrome green phosphor ($ZnSiO_4$:Mn). The detailed panel specifications are shown in Table I. Total gas pressure was fixed at 400torr and Ne-Xe gas mixtures were used, with the 4% Xe content. Discharge gap was also varied from 60μm to 200μm. The luminance, luminous efficacy, and discharge current were observed under 25kHz, 45~55% duty, continuous sustaining condition.

3. Results and discussion

A. Self-Erase Discharge Effect in Small Gap Structure

To control the timing and intensity of self-erase discharge, the pulse pause time was changed. Fig. 1 shows that an application of proper pause time applied to small gap cell structure could result in the luminous efficacy improvement in the middle of voltage margin. Especially in the case when the pause time was 650 and 350ns, at which the self-erase discharge is controlled to occur right before the main discharge, the luminance and luminous efficacy increased around the sustain voltage of 190V. But as the sustain voltage increased over 210V, the luminance and efficacy began to decrease.

The luminous efficacy tendency is totally dependent on the variance of the luminance. The luminance is increased because the self-erase discharge initiates main coplanar discharge and elongates the discharge path, which is quite similar to the address auxiliary pulse effect. This pre-discharge also supplied priming particles to the main discharge, which decreased the formative delay time of the main discharge as shown in Fig. 2. When the pause time decreased to 50ns, the self-erase discharge was eliminated, which in turn resulted in a normal luminous efficacy tendency and larger formative delay shown in Fig. 3 than that of the 650 and 350 ns cases. As the sustain voltage increased, the intensity of the self-erase discharge also increased to erase a large amount of wall charges on the Y electrode (cathode) which decreased the luminance at high voltages, so the luminous efficacy did not increase further.

The discharge evolution images are observed using the ICCD camera as shown in Fig. 4. Self-erase enhanced main discharge occurred much faster and showed the larger volume and longer discharge path than that without self-erase.

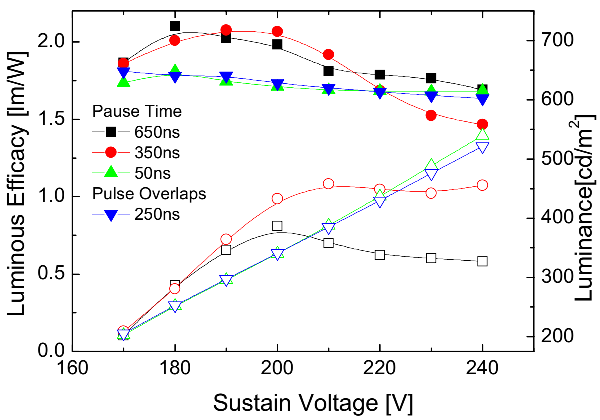

Fig. 1. Luminous efficacy and luminance varying pulse pause time in small gap (60µm) structure.

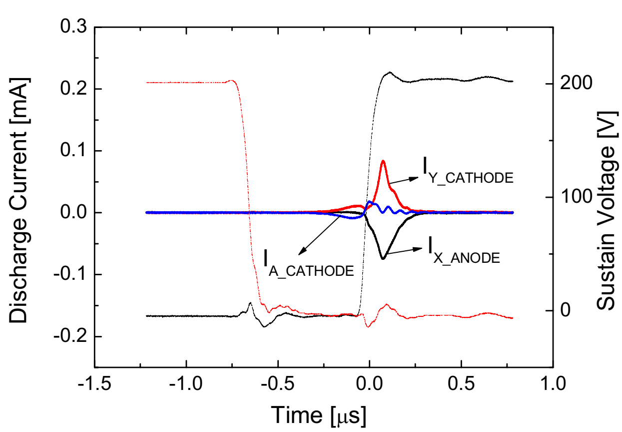

Fig. 2. Discharge current with 650ns pulse pause time.

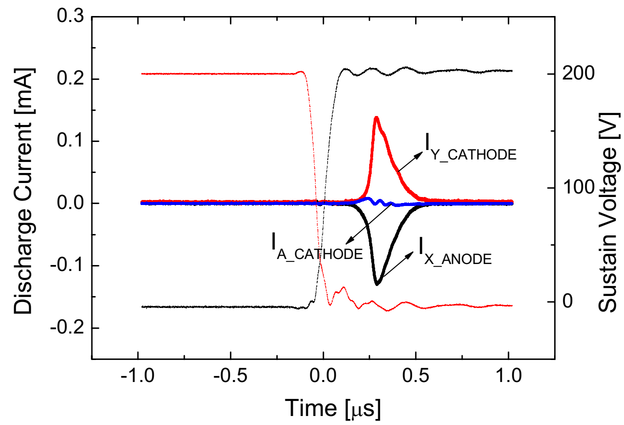

Fig. 3. Discharge current with 50ns pulse pause time.

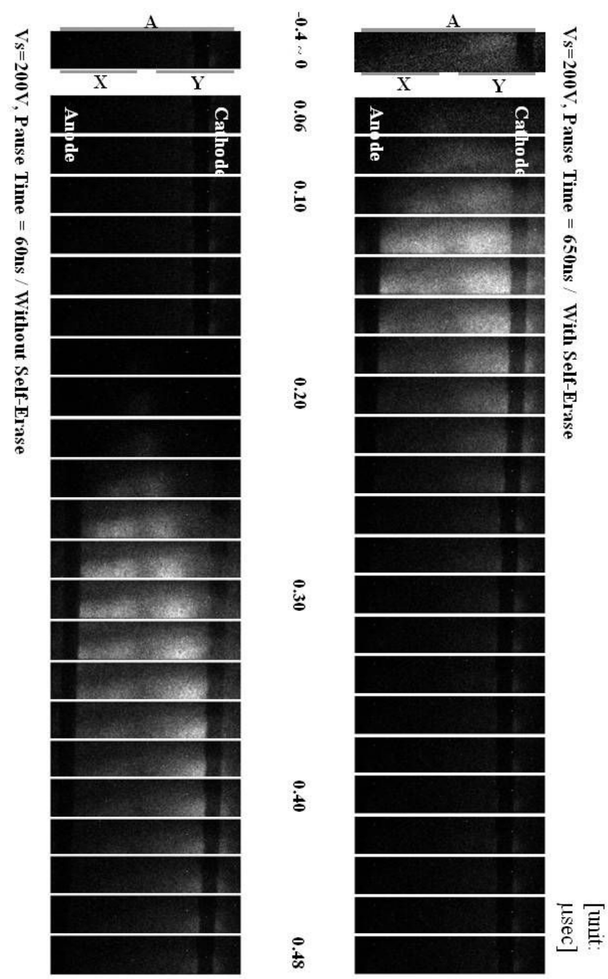

Fig. 4. Sideview IR Discharge images without(left) and with(right) self-erase discharge.

B. Self-Erase Discharge Effect in Long Gap Structure

The effect of self-erase discharge on the luminance and the luminous efficacy was also investigated in the long gap cell structure of which the electrode gap is 200μm. In the long gap cell structure, better luminous efficacy and luminance was obtained when the self-erase discharge was suppressed which is quite contrary to the small gap case as shown in Fig. 5.
When the gap of coplanar electrode increases, the breakdown voltage between X and Y electrode increases while that between Y and Address is almost the same because the barrier rib height and the dielectric layer thickness are not changed. So the self-erase discharge intensity between Y and address electrode in the long gap cell increases to erase much more wall charges on the sustain electrodes than that in the small gap cell structure. As shown in Fig. 6, the self-erase discharge between Y and address electrode occurred much stronger than that in the small gap case shown in Fig. 2. Also the luminance generated by self-erase discharge seems to be blocked by the opaque bus electrode, so the luminance incremental rate with increasing sustain voltage was quite low in the case of 350ns pulse pause time as shown in Fig. 5.

C. Waveforms to Suppress Self-Erase Discharge

Various waveforms can be used to suppress the self-erase discharge as shown in Fig. 8. The first one uses the pulse pause time control used in the previous experiments. Self-erase discharge also has formative delay like other discharges thus the next pulse is applied within the delay time, self-erase discharge decreases or even disappears as shown in the Fig. 2 and 3.

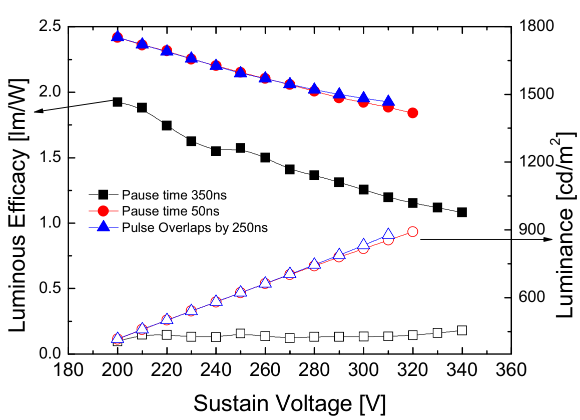

Fig. 5. Luminous efficacy and luminance varying pulse pause time in long gap (200μm) structure.

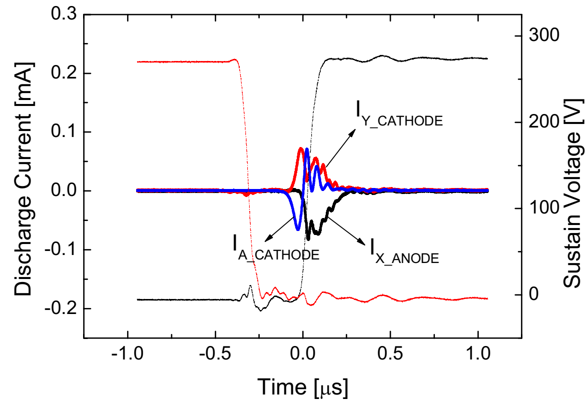

Fig. 6. Discharge current with 350ns pulse pause time in long gap structure.

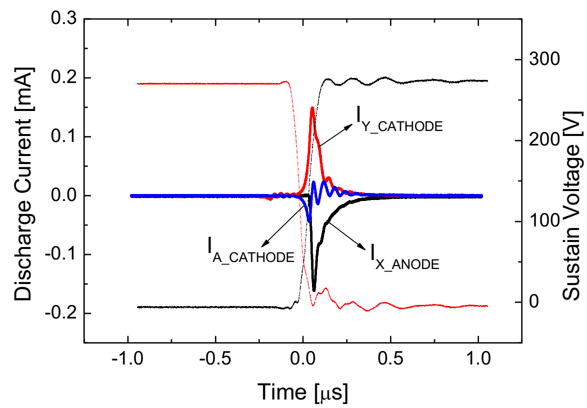

Fig. 7. Discharge current with 50ns pulse pause time in long gap structure.

The second one is the previously suggested negative voltage driving of coplanar electrodes in which condition the address electrode always plays as an anode. In the panel experiment, negative pulse driving resulted in the same tendency of luminance and efficacy like the positive pulse driving with no pause time. The third one is the application of short pulses to the address electrode after the main discharge to erase the ion wall charges on the address electrode, which is same mechanism with the self-erase discharge. The application time and width of the auxiliary pulse must be adjusted to minimize the auxiliary pulse voltage that is effective to suppress the self-erase discharge. The luminance and the luminous efficacy changes when the self-erase discharge decreased with 60V auxiliary pulses are consistent with that by the previous waveforms. However in the long gap structure, the luminous efficacy improvement effect with the fixed auxiliary pulse voltage changed with the sustain voltages as shown in Fig. 9. The address discharge current of the self-erase discharge was observed to decrease as the auxiliary pulse voltage increased as shown in Fig. 10.

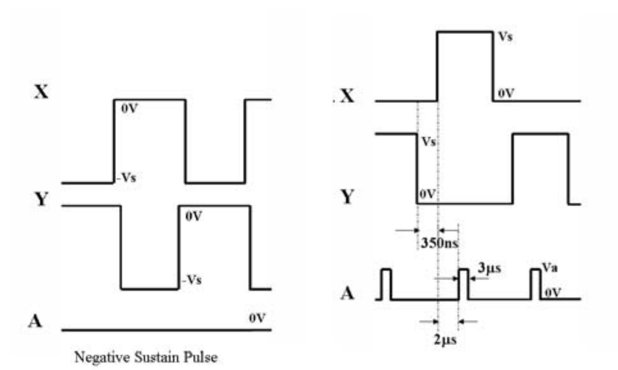

Fig. 8. Waveforms to suppress self-erase discharge; (a) Negative sustain pulse, (b) post discharge address auxiliary pulse.

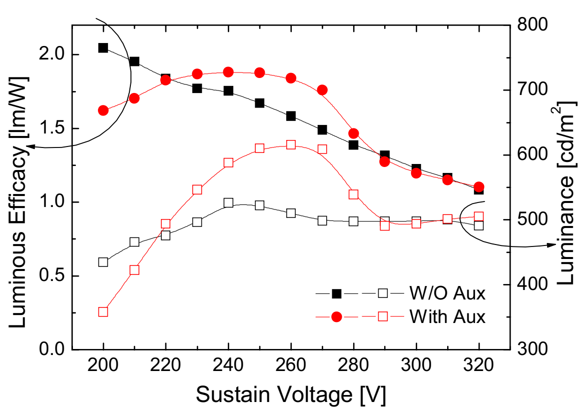

Fig. 9. Luminance and luminous efficacy when the post-discharge auxiliary pulse is applied to address electrode in long gap structure.

4. Summary

In the actual driving condition, the address electrode is grounded in sustain mode. In this condition, the self-erase discharge occurs mainly between sustain cathode and address electrode. This is observed by the discharge current waveform in the pulse pause time and the result is consistent with the previous wall charge distribution measurement.[2] In the small gap conventional structure, the self-erase discharge that is adjusted to occur right before the main discharge could enhance luminance and luminous efficacy in the middle of the sustain margin.

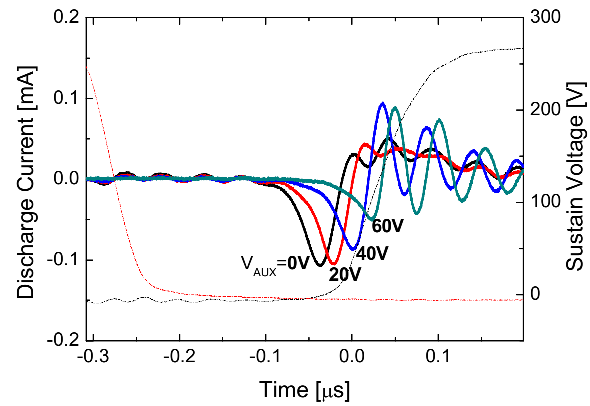

Fig. 10. Address discharge current with increasing auxiliary pulse voltage in long gap structure.

However in the long gap structure, the luminous efficacy increased only by suppressing the self-erase discharge. Because of the excessive ion wall charges on the address electrode, the self-erase discharge is very intense to decrease the wall charges on the sustain cathode substantially, which results in the severe luminance and luminous efficacy decrement. Various waveforms such as the decrement of the pause time, negative voltage pulse and post-discharge auxiliary pulse were suggested, which could suppress the self-erase discharge intensity.

5. References

1. S.-T. Lo and C.-L.Chen, *IEEE Trans. Plasma Sci.*, Vol. 30, No.1, p.428, (2002).
2. D.C.Jeong, H.S.Bae, and K.-W.Whang, *J. Appl. Phys.*, **97**, 013304, (2005).
3. T. Hashimoto and A. Iwata, *SID Digest*, p.540, (1999).
4. H.-S.Tae, K.-D.Cho, S.-H.Jang, and K.C.Choi, *IEEE Trans. Electron Devices.* **48**, No.7, p.1469, (2001).
5. H.-S.Tae, B.-G.Cho, and S.-I.Chien, *IEEE Trans. Electron Devices.* **50**, No.2, p.522, (2003).
6. H.-S. Tae, H. J. Seo, D.-C. Jeong, J. H. Seo, H. Kim, and K.-W. Whang, *IEEE Trans. Plasma Sci.*, **33**, Issue 2, Part 3, p.931, (2005).
7. G. Veronis, Umran S. Inan, **33**, No.2, (2005).