3-Dimensional Emission characteristics of an AC PDP Cell

***Jae-Chul Jung*, Dong Cheol Jeong, Hyun Sook Bae and Ki-Woong Whang**
Plasma Laboratory, School of Electrical Engineering #053, College of Engineering,
Seoul National University, Kwanak P.O 151-744, Korea, jjchul@pllab.snu.ac.kr

Abstract

The spatio-temporal variation of Infra Red(IR) emission images were obtained from a real 3-dimensional discharge space of a surface discharge type, alternating current plasma display panel(AC PDP) cell with the Ne-Xe(4%) 400Torr gas mixture. IR emissions were observed in each period of the ADS(Address and Display Separation) driving scheme with ramp initializing waveform using an images intensified charge coupled device(ICCD) camera. The roles of each electrode were identified and it was compared with the results of the discharge simulation and of the wall charge distributions measured by the electro-optic technique.

1. Introduction

Nowadays, the ac PDP is one of the promising flat panel display devices with the sizes larger than 40-inch diagonal and is under active development for its application to Higher Definition Television (HDTV). But they still need further improvements in luminance and luminous efficiency which can be achieved through a better understanding of the fundamental discharge physics in the PDP cell.

There have been many researches to understand the discharge phenomena of an AC PDP cell by observing the emissions from the cell using a high speed ICCD camera in order to design cell structures with higher luminous efficiency and driving waveforms with higher accuracy and speed, because the CCD images give direct information of the discharge dynamic and they are also useful for verifying the result of simulation.[1-5]

In this work, we observed the 3-dimensional IR emission of 823 and 828nm wavelength from a surface discharge type AC PDP cell during reset, address and sustain period of widely used ramp reset driving scheme in a real discharge cell with a Standard Definition resolution. Also we compared the images with the result of simulation and measured wall charge distributions.[6-10]

2. Experimental

The schematic diagram of the observation system has been illustrated in Figure 1. IR emission is observed with a high speed ICCD camera, which works with the gate pulse signal synchronized with the driving pulse.

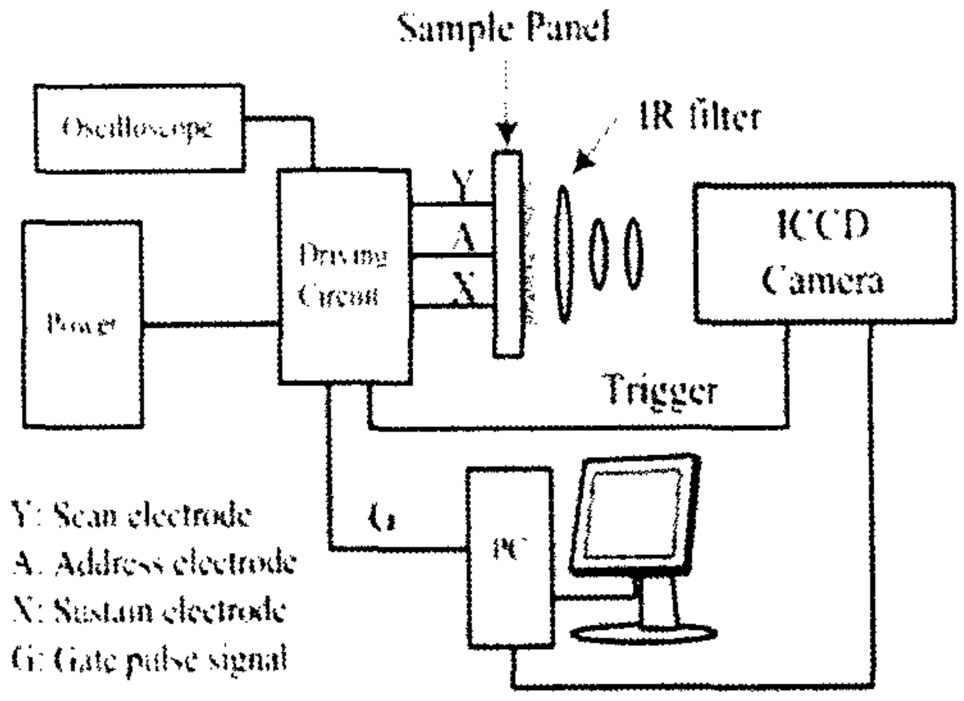


Figure 1. Schematic diagram of the observation system

Figure 2 shows the cross-sectional view of the cell used in our experiment. There are two sustain electrodes running parallel to each other with a gap of 80um and barrier rib of 154um height. The discharge gas is Ne and 4% Xe mixed gas of 400Torr pressure. Thicknesses of the MgO and the dielectric layer were 400nm and 30um respectively. To obtain a side-view image, a polished mirror glass is placed between two substrates as shown in the figure2. Green phosphor was printed on the rear substrate and pixel pitch is 1.08um.

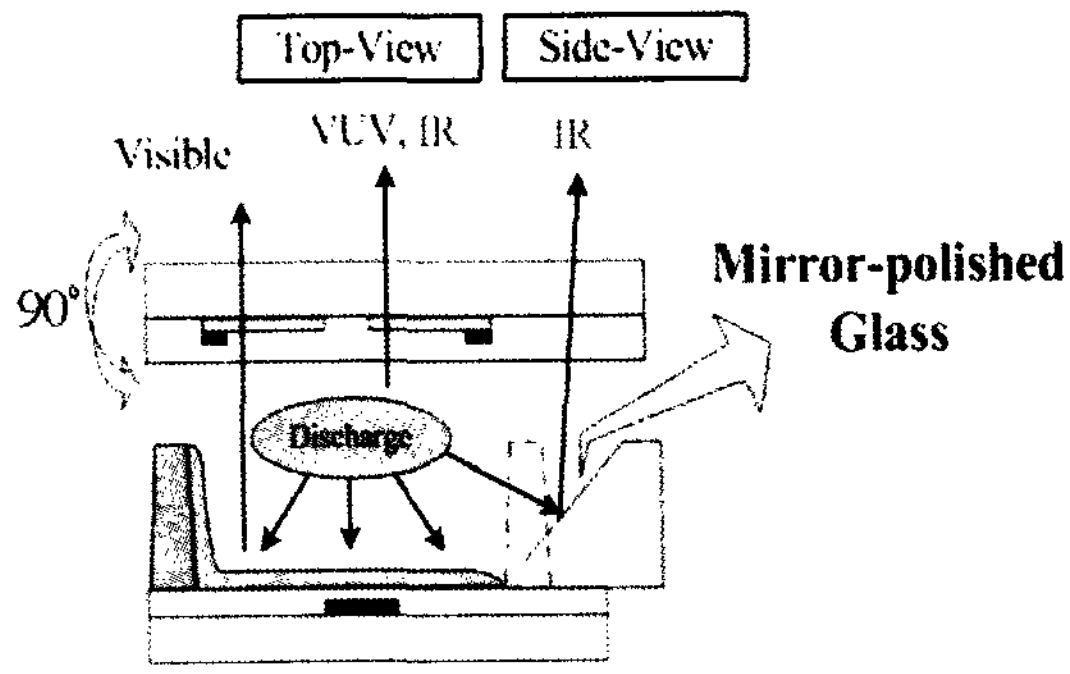


Figure 2. Structure of the sample cell

Figure 3 shows the ramp reset driving waveform and its driving voltage condition used in this study. The ramp rising time is 160us and the ramp falling time is 180us.

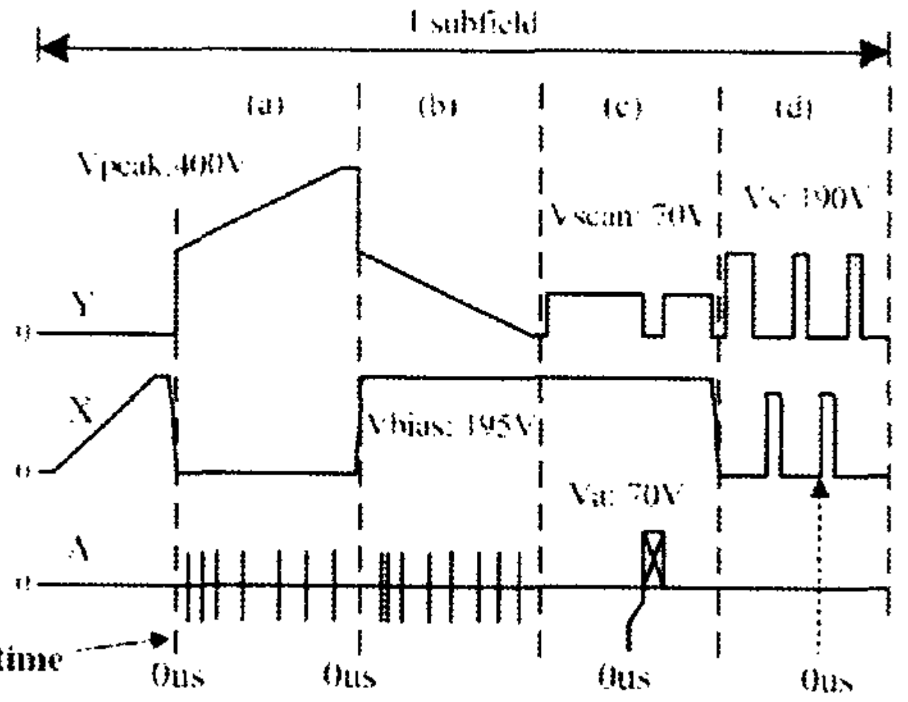


Figure 3. Ramp reset waveform and driving condition

3. Results and discussion

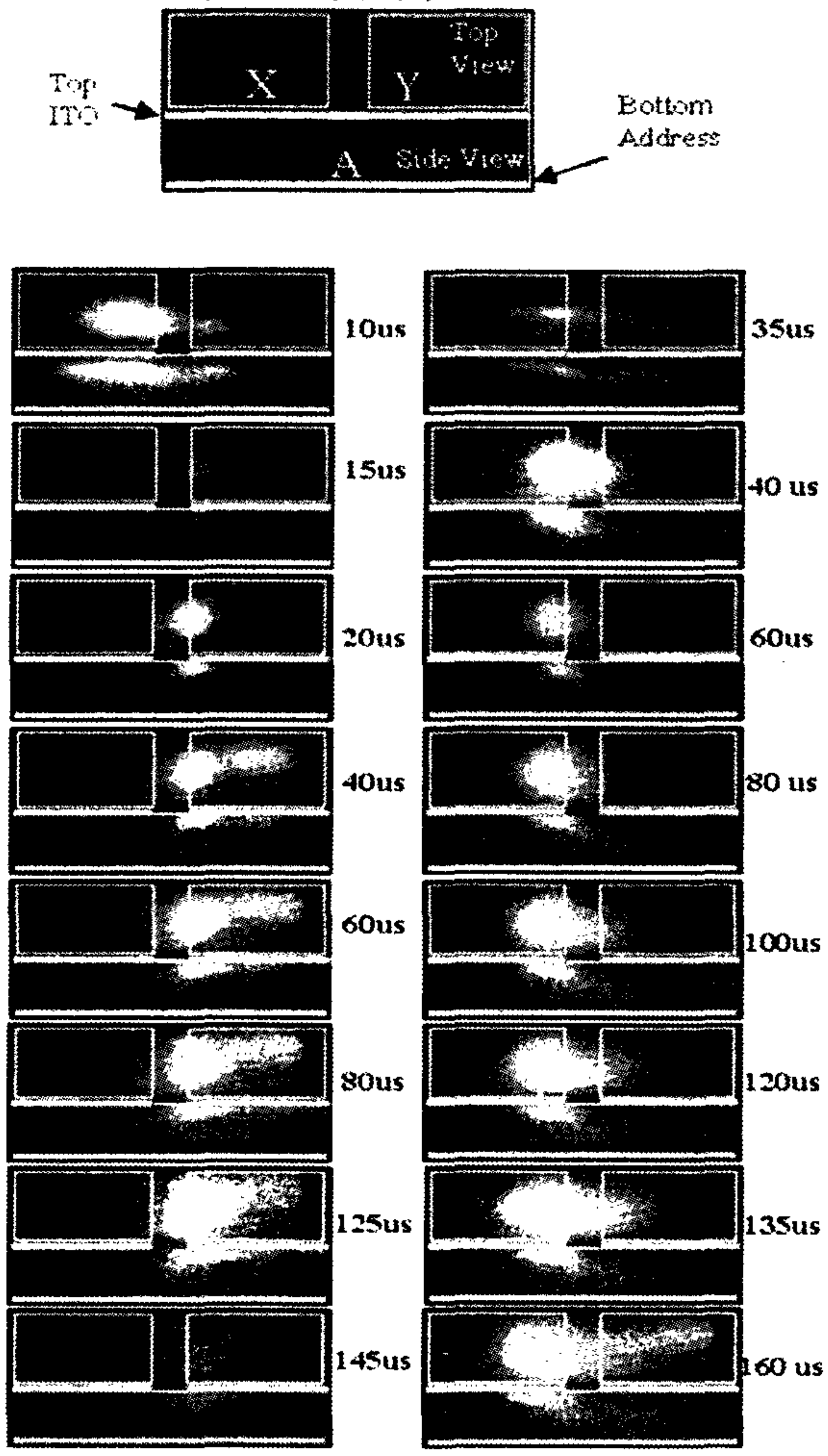
3.1 *3-Dimesional images*

Figure 4 shows the emission images during the 4 different periods of ADS driving scheme. The starting points for the measurement are shown in figure 3. The sustain frequency is 125kHz and the on-time of the sustain pulse is 3us.

In image (a) of the ramp reset rising period, weak discharge between scan(Y) and sustain(X) electrode takes place at 10us. The Y electrode plays the role of anode and X and address electrode(A) those of cathode. After 20us, the IR emission starts to appear in the middle of the inner edge of anode (Y) electrode, and it is getting bigger and brighter in the region near the gap. After 40us, two locally divided emission section on the Y electrode surface are shown. Discharge around the gap is thought to be that between X and Y electrode, while another discharge near the bus electrode is that between Y and A electrode.

In image (b) of the ramp falling period, the X electrode now plays the role of anode. Weak emission begins to appear from the inner edge of the X electrode. Unlike the ramp rising period, as the applied voltage of the electrode Y decreases, the emission region becomes broad in between two electrodes. Also side-view images during the ramp falling period show that address electrode takes part in the discharge. It has been found that a succession of weak discharges take place from the careful analysis of pictures taken at 5us intervals during the ramp reset period (a), (b).

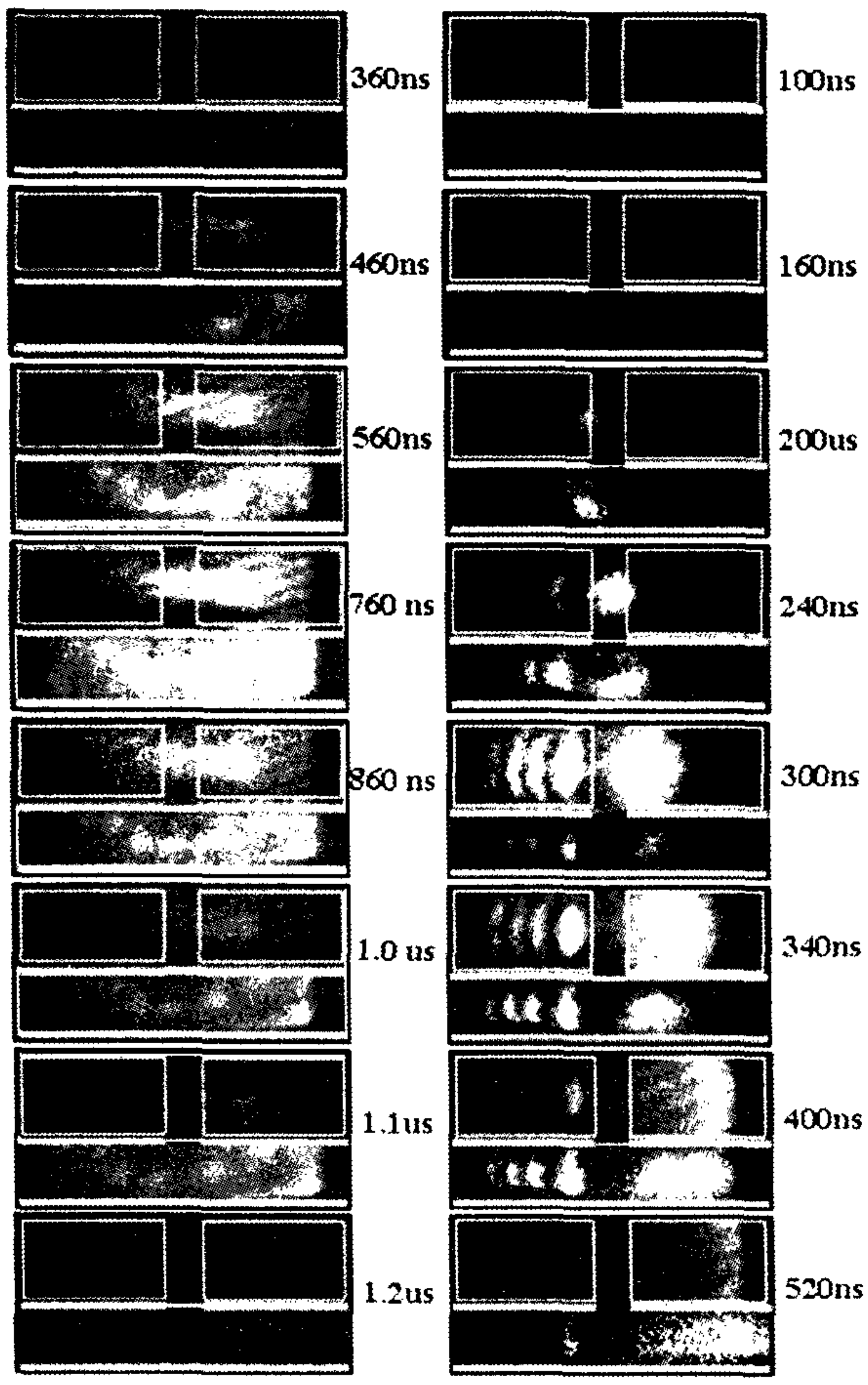
Figure 4. (a), (b)



(a) Ramp rising period *(b) Ramp falling period*

The image (c) shows an addressing discharge taking place between electrode A and Y. Early emission occurs from the address electrode near of gap at 460ns and the discharge spreads toward the electrode(Y) at 560ns. It also shows that the other electrode(X) is also participating in the address discharge.

In image (d) of the sustaining period, the intensity of emission is stronger and the progress of a breakdown is faster because of the accumulated wall charges on the X and Y electrode. At 200ns, the plasma is formed around the inner side of anode electrode and it expands toward the outer cathode surface. Striated emission begins to appear on the anode surface after 300ns. The emission patterns during the ramp reset period as shown in image(a), (b) are quite different from those of address and sustain period as in image(c), (d). The discharges taking place during the ramp reset period are succession of weak discharges while those of address and sustain periods involve all three electrodes.



(c) *Address period* (d) *Sustain period*

Figure 4. Spatio-temporally resolved emission images

3.2 Comparison

Comparison with the results of simulation and wall charge distributions

We examined the result of the time- and space-resolved emission characteristics of IR spectra in each of 4 periods and compared with that of wall charge distribution which was measured by *the Longitudinal Electro-Optic Amplitude Modulation Method* and computer simulation [6-10].

Figure 5 show the wall charge distribution during sustain period in which the red of Y electrode shows ion density and the blue of X electrode shows electron density. At t ≥ 0, the sustain voltage is applied to Y electrode which act as an anode. At 200ns, the measurement shows that the positive charge begins to be diminished while the negative charge remained same but peaks along the barrier ribs. At 400ns, the polarity of wall charge reverses and the plasma is in an after glow state as shown in Figure 4.

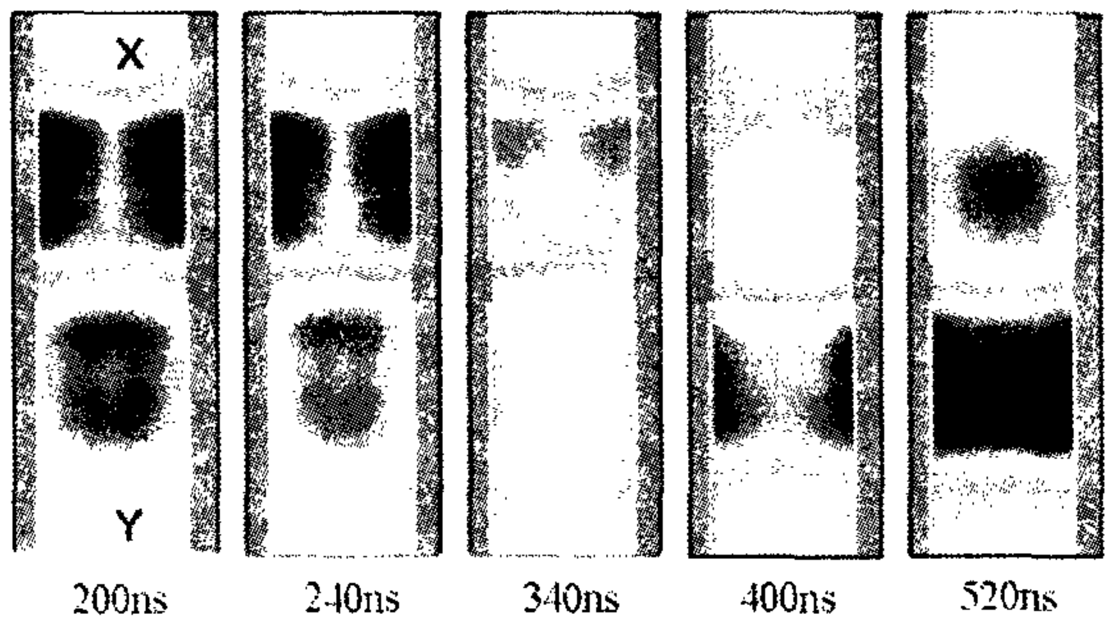
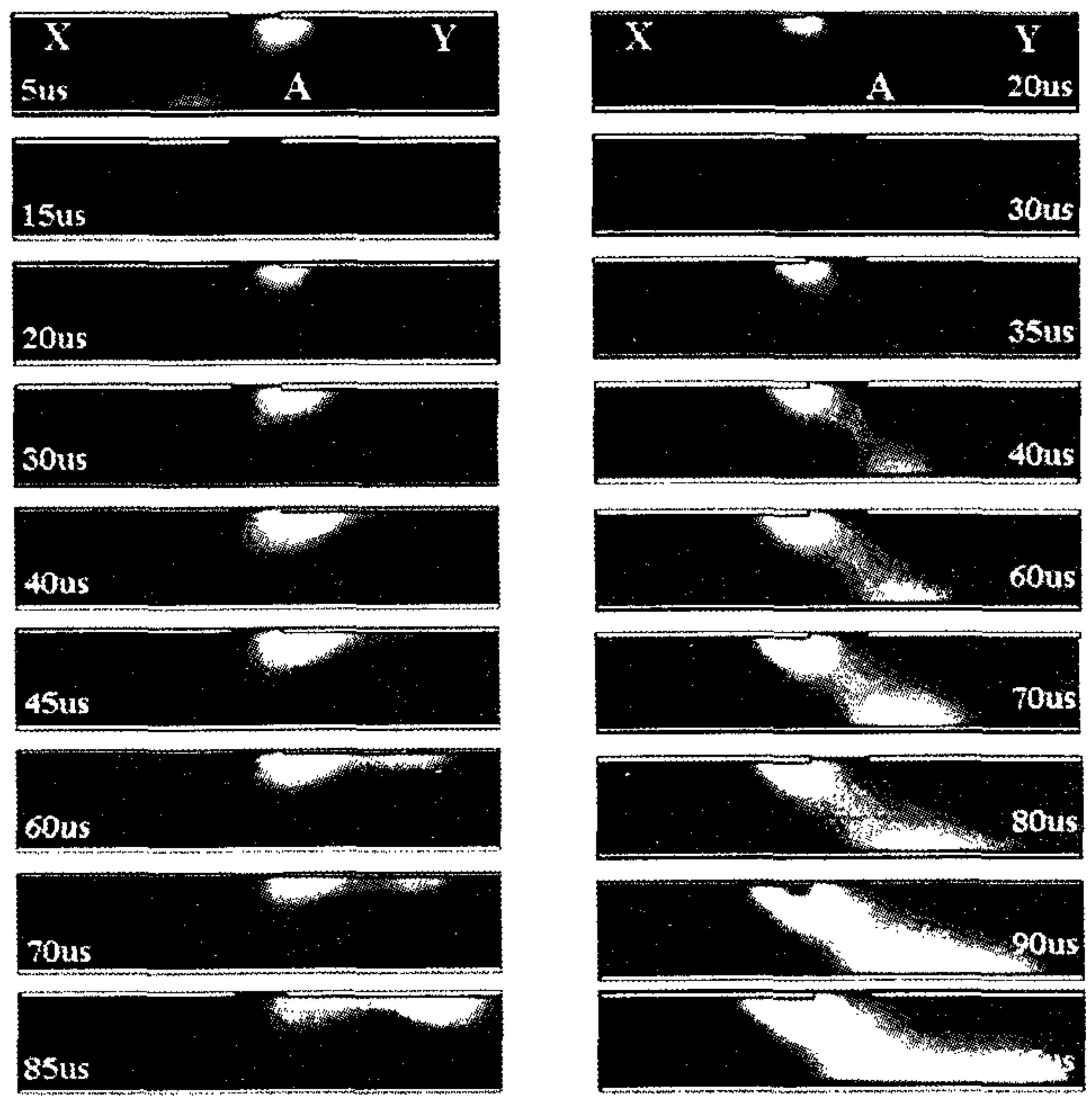


Figure 5. Wall charge distribution during sustain period



(a) *Ramp rising period* (b) *Ramp falling period*

Figure 6. Simulation result of the excited Xe** distribution

Figure 6 show the spatio-temporal distribution by the exited Xe** of the simulation result in ramp reset period which is also similar to the IR emission phenomena observed by ICCD camera. At t ≥ 20us, early weak discharge take place in the region near the gap between the X and Y electrode. As the applied voltage increase, two locally separated emission section on the Y electrode surface are occurred. On the other hand, the emissions in the ramp falling period get broader into the space in between Y and A electrodes. The ramp rising time and falling time are 100us and 120us respectively.

4. Conclusion

We developed a new technique to observe the 3 dimensional emission images in AC PDP cell by applying a mirror polished glass and examined emission characteristics. By a careful analysis of the time- and space-resolved emission pictures, we could identify the role of the each of the 3 electrodes in surface type AC PDP cell precisely. The information obtained from this work would be valuable for designing better cell structures and driving waveforms.

5. References

[1] H. S. Jeong, J. H. Seo, C. K. Yoon, J. K. Kim and K.-W. Whang. *J.Appl. Phys*, vol.85, No.6, pp3092-3096 (1999).

[2] C. K. Yoon, J. H. Seo and K.-W. Whang, *IEEE Trans. Plasma Sci.* vol. 28, No.3, pp. 1029-1034, June(2000).

[3] R.Ganter, J. Ouyang, Th. Callegari, and J. P. Boeuf. *J. Appl. Phys.*, vol. 01, No.3, pp.992-999(2002).

[4] K.Hagiwara, M.Ushirozawa, H.S.Jeong, Y.Tanako and M. Seki. Pp615-618, IDW'99

[5] Y.Shintani, J.C.Ahn, K.Tachibana, T.Sakai. pp817-820, IDW '02.

[6] Hyun-Sook Bae. The master's thesis "An Analysis on the Discharge Characteristics through Numerical Simulation in an AC Plasma Display Panel", Department of Electrical Engineering, Seoul National University, Korea (2003)

[7] Dong Cheol Jeong, Woo Joon Jeong, ki Woong Whang. pp739-742 EURODISPLAY 2002

[8] Dong Cheol Jeong, Woo Joon Jeong, ki Woong Whang. Pp721-724 IDW'02 (2002)

[9] Ki Woong Whang, Dong Cheol Jeong, SID03. DIGEST (2003)

[10] Dong Cheol Jeong, Ki Woong Whang. IMID'03. DIGEST (2003)