Observation of the Spatiotemporal Variation of Wall Charge Distribution during Reset Period in an ac PDP cell

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Abstract

We measure the spatiotemporal wall charge distributions on sustain and address electrodes during reset period in an ac PDP cell using the longitudinal electro-optic amplitude modulation method. We apply several reset waveforms like as ramp, exponentially growing and high voltage pulse, and compare the wall charge characteristics on address electrode as well as sustain electrodes for each reset waveforms.

1. Introduction

Reset of wall charge is one of the most important operations in a driving of ac plasma display panel (ac PDP). It makes wall charge states of each cell same level independent of previous state (on or off) of them, thus gives a uniform breakdown condition for each cells. Moreover, it reduces address voltage by making a sufficient wall voltage between address and scan electrodes. But the emission during reset period gives a useless background luminance. The key point of understanding of reset operation is to know how the wall charges over each electrode change during reset discharge.

We previously reported that the Pockels effect could be a good technique to measure the wall charge characteristics. [1][2] We applied this technique to measure the spatiotemporal wall charge distributions during reset discharge to understand the operating characteristics of them.

Measurement of wall charge distributions using Pockels effect is possible by measuring the variations of the polarization of the light passing through the Pockels crystal which replaces the dielectric layer in an ac PDP cell.[3] In this experiment, we used the longitudinal electro optic modulation method with BSO single crystal.

Fig. 1. shows the configuration of longitudinal electro-optic amplitude modulator. The total transmittance of the measurement system according to the voltage induced across the crystal is,

$$T = \sin^2\frac{\Gamma}{2} = \sin^2\left(\frac{\pi}{4} + \frac{\pi}{2}\frac{V}{V_\pi}\right)$$

where V is the voltage across the BSO plate, and V_π is the half-wave voltage of BSO crystal given by

$$V_\pi = \frac{\lambda}{2n_o^3 r_{41}}$$

where λ is the wavelength of the light, n_o the normal refractive index of the BSO crystal, and r_{41} the Pockels coefficient. The half wave voltage of BSO crystal is about 4kV for the wavelength of 632.8nm.

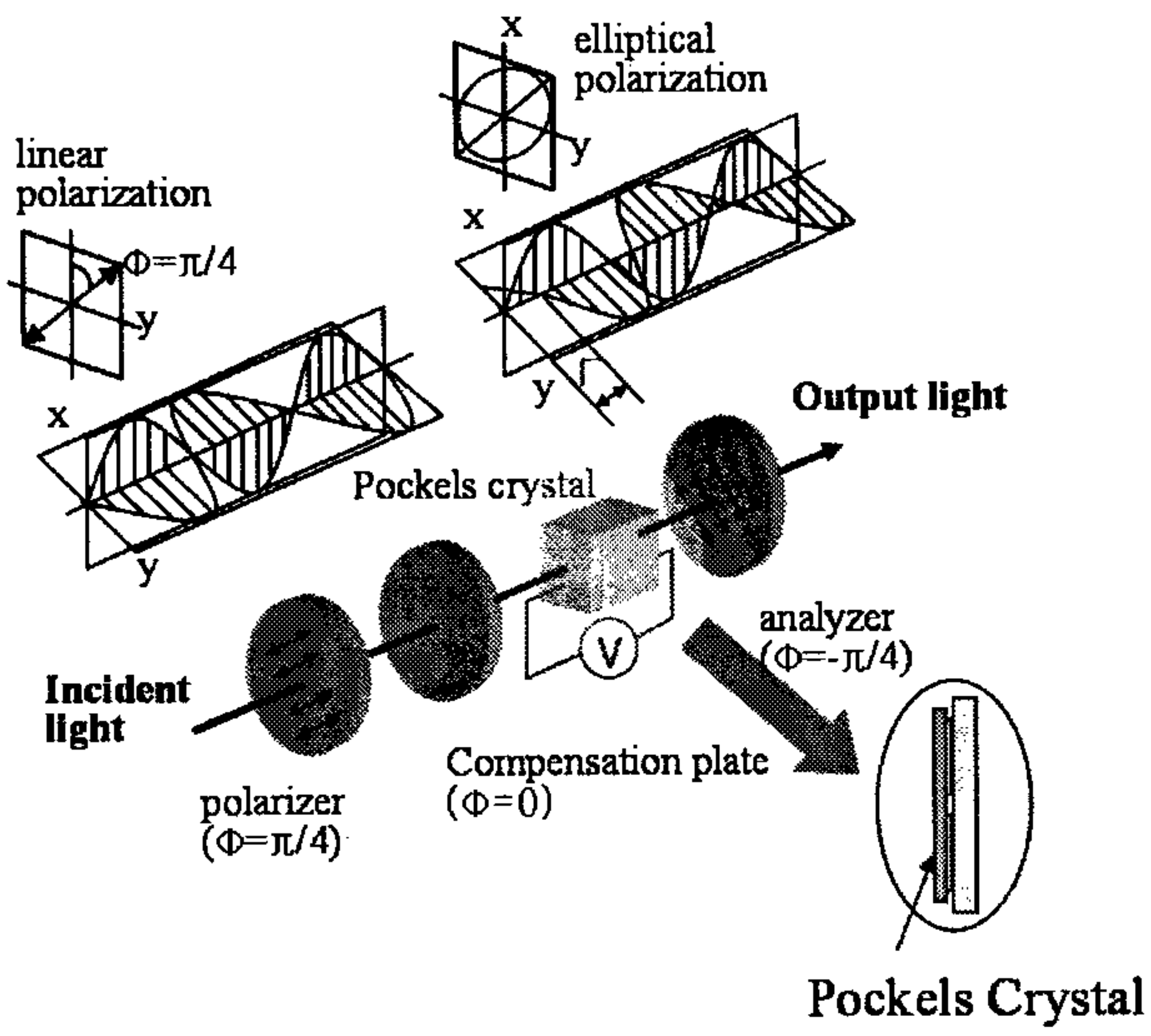
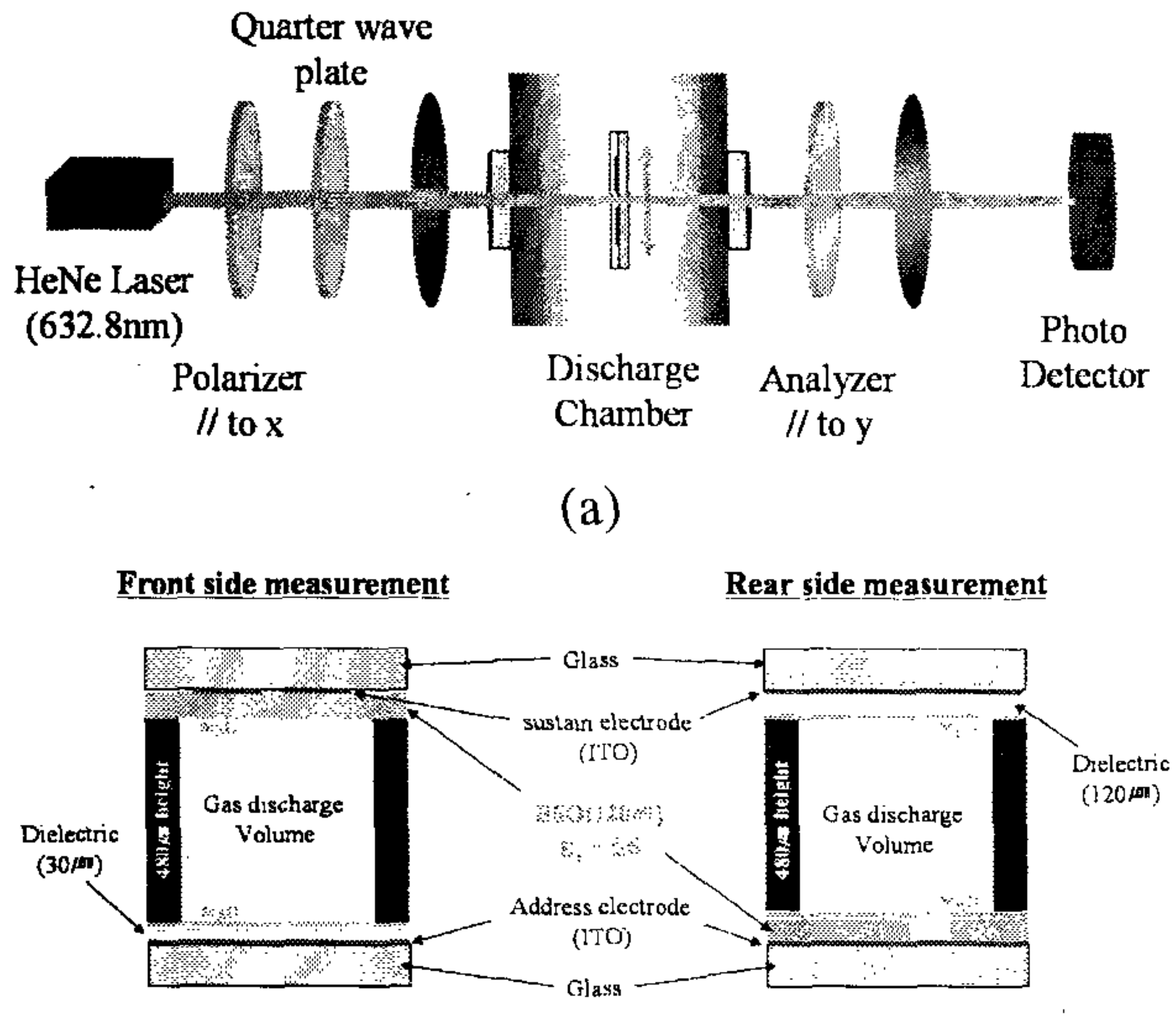


Fig. 1. Configuration of longitudinal electro optic modulator

2. Experimental

Figure 2 (a) shows the schematic of the wall charge distribution measurement system. The configuration is based on the longitudinal amplitude modulator using the Pockels effect. The light source is a high stable HeNe laser, and the detector is a photo diode. For amplitude modulation, a polarizer and an analyzer are placed in the optical path. To obtain the spatial distribution, a sample holder in the discharge chamber can be moved across the sustain electrodes.



(b)

Fig. 2. System configuration and measurement samples (a) system configuration (b) measurement samples

Fig. 2 (b) shows the measurement sample. The dimensions of the cell are 4 times lager than those of typical VGA grade one. We used two samples to measure the complete wall charge distributions on sustain electrodes as well as on address electrode.

One sample has Pockels crystal on the sustain electrodes to measure the wall charges on sustain electrodes, and the other one has Pockels crystal on the address electrode to measure the wall charges on the address electrode. MgO coated Pockels crystal, which replace the dielectric layer of typical ac PDP cells, was bonded to the ITO sustain or address electrodes.

We used BSO crystal as a Pockels material. The dielectric constant of BSO crystal is 4 times larger than that of conventional dielectric layer, but it's electrical and optical characteristics are most suitable for wall charge measurement application. (Table. 1) The discharge chamber evacuated to 5×10^{-6} Torr, and then gas filled with Ne+Xe4%, 100 Torr.

Table 1. Pockels Crystals

	Half wave voltage (λ=1um) [kV]	Dielectric constant	Transmission range [nm]	Resistivity [Ωcm]
CdTe	1.6	9	>900	$>10^2$
$LiNbO_3$	1.8	43	>540	$\sim10^{16}$
ZnTe	2.2	10	>570	$10^7 \sim 10^8$
GaAs	4.9	13	>950	10^8
BSO	**3.1**	**56**	**>450**	$\mathbf{10^{14}}$

3. Results and discussion

Figure 3. shows a driving waveforms and wall charge densities at fixed points over sustain and address electrodes during sustain, high voltage reset and address period with address discharge. The sustain frequency is 25kHz, duty is 25%, and voltage is 300V. During sustain discharge 100V DC bias is applied to the address electrode. The high voltage reset pulse is applied to the X electrode at t=2.6msec, and address discharge is occurred at t=4.3msec, and then sustain discharge start at t=5.8msec.

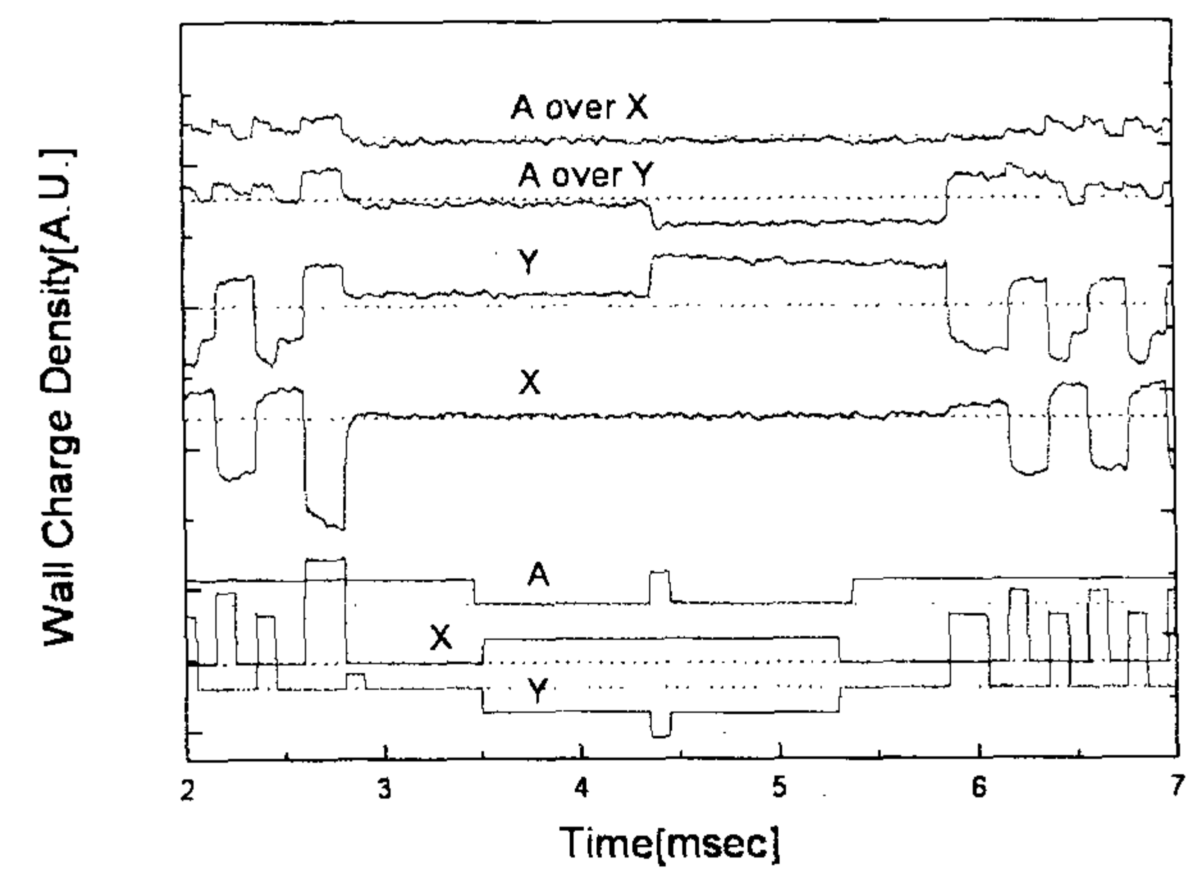


Fig. 3. Wall charge densities during sustain, high voltage reset and address discharge

During sustain discharge, more electron wall charges are accumulated on the X or Y electrode than ion wall charges because a part of ion charges are accumulated on address electrode during sustain on period. But during sustain off period, a discharge is occurred between address and sustain electrodes, which reduces the wall charges.

After high voltage reset pulse, the wall charges over each electrode are almost removed by self erasing discharge. After address discharge between address and Y electrode, the ion wall charges are accumulated over the Y electrode, the electron wall charges over the address electrode over Y electrode, and no wall charges on the X and address electrode over the X electrode. And first sustain discharge is occurred between address and Y electrode. During this discharge period, some wall charges are accumulated over the X electrode. The wall charges over all electrodes are stabilized after several sustain pulses.

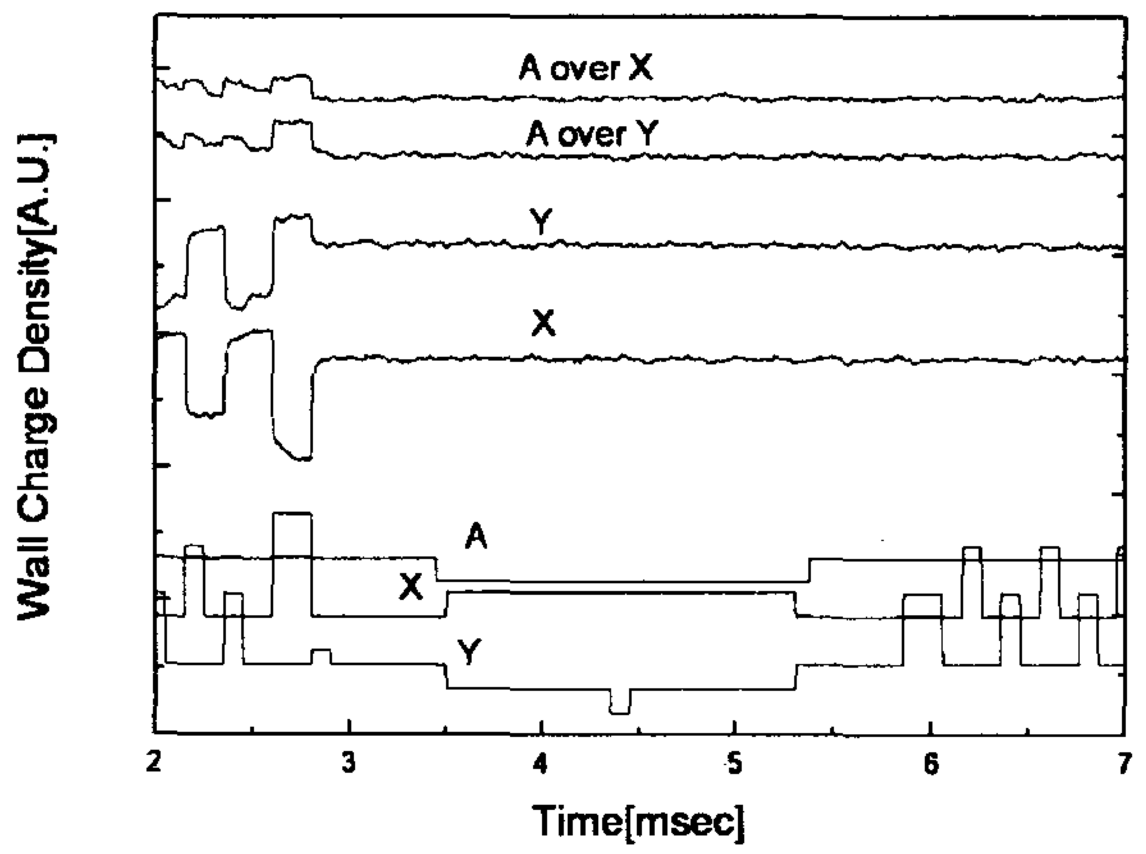


Fig. 4. Wall charge densities during sustain, high voltage reset and address period without address operation

Fig. 4 shows the driving waveforms and wall charge densities at fixed points over sustain and address electrodes during sustain, high voltage reset and address period without address operation. The driving waveforms are same with the Fig. 3. except for the address pulse. Because the wall charges are almost removed by self erasing, the sustain discharge cannot occurred without address one.

Fig. 5 shows the wall charge distributions during high voltage reset period. After high voltage reset discharge, a large amount of electron wall charges is accumulated over the X electrode, and ion wall charges are accumulated over the Y and address electrodes. These wall charges make a strong electric field to make a discharge without external applied voltage. Hence the wall charges are almost removed by self erasing in off period.

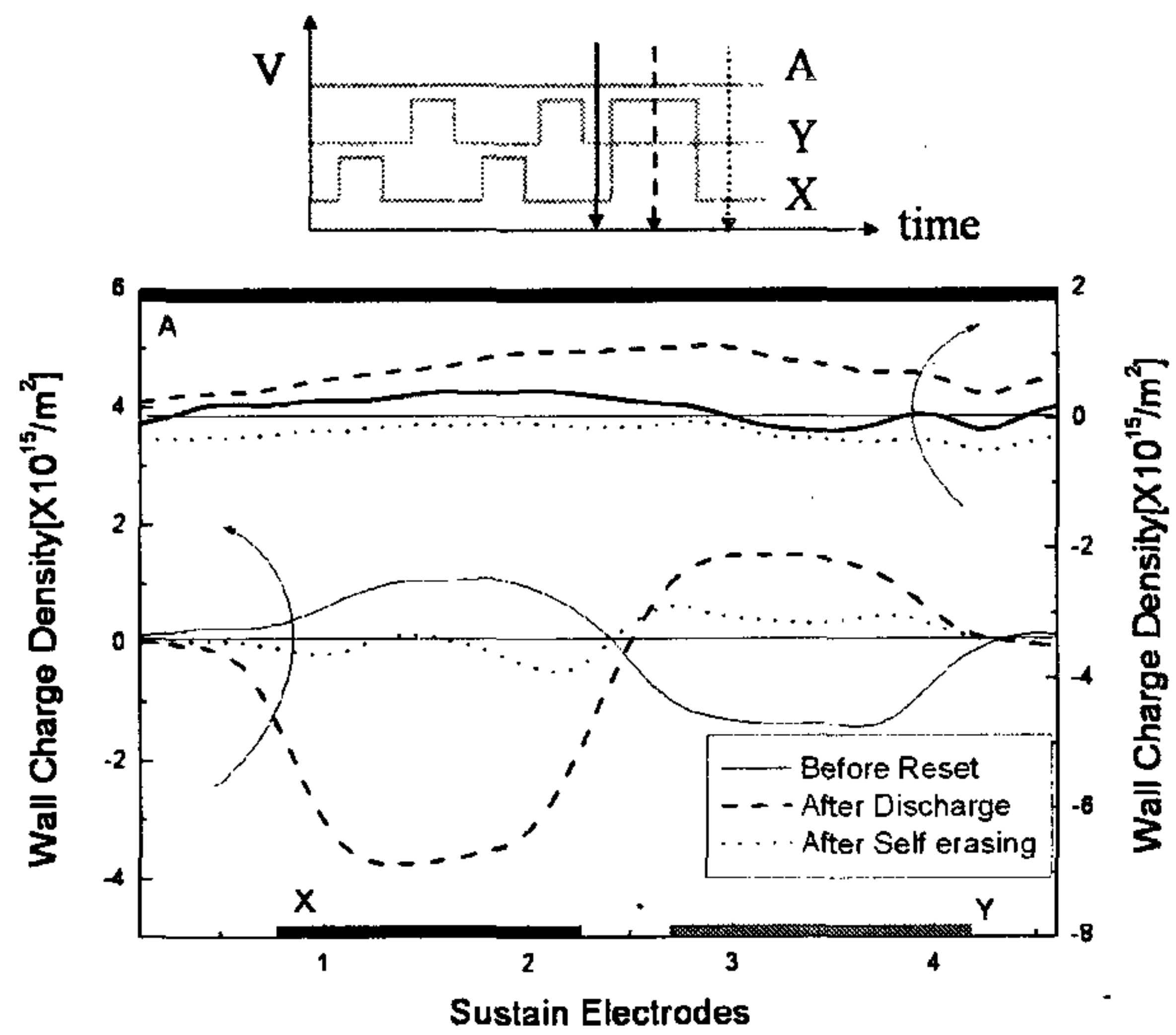


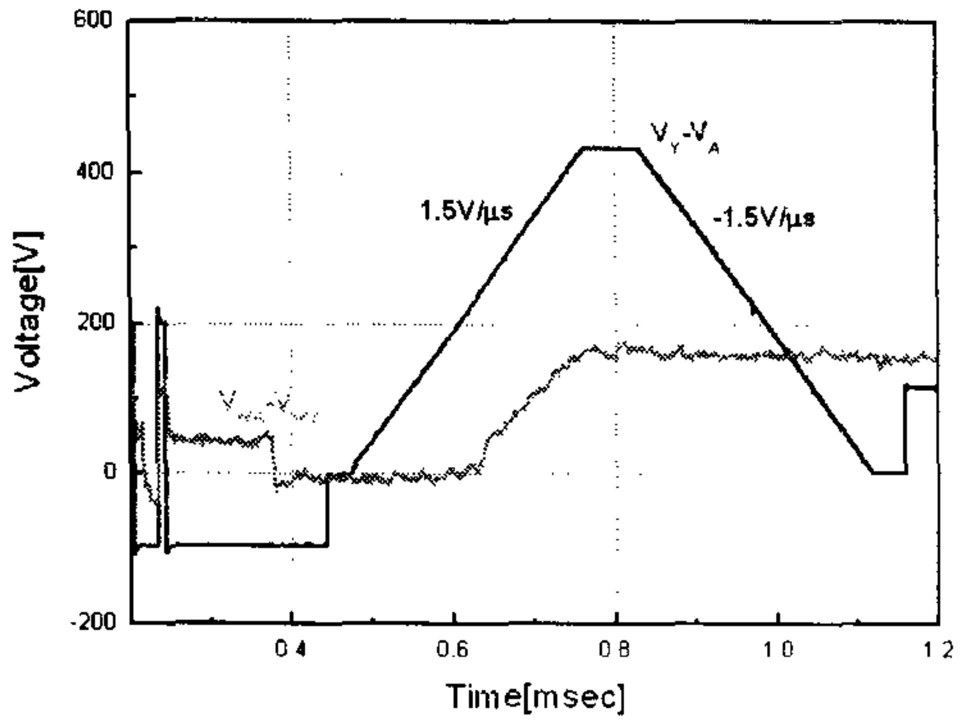
Fig. 5 Wall charge distributions during high voltage reset

Fig. 6 shows the temporal wall voltage variation when a ramp type reset waveform is applied. Fig. 6 (a) shows the voltage difference applied to the address and Y electrode (V_y-V_a), and corresponding wall voltage between them (V_{wa}-V_{wy}). Fig. 6 (b) shows the voltage difference applied to the X and Y electrode (V_y-V_x), and corresponding wall voltage between them (V_{wx}-V_{wy}). The ramp up and down speed is $\pm 1.5V/\mu s$.

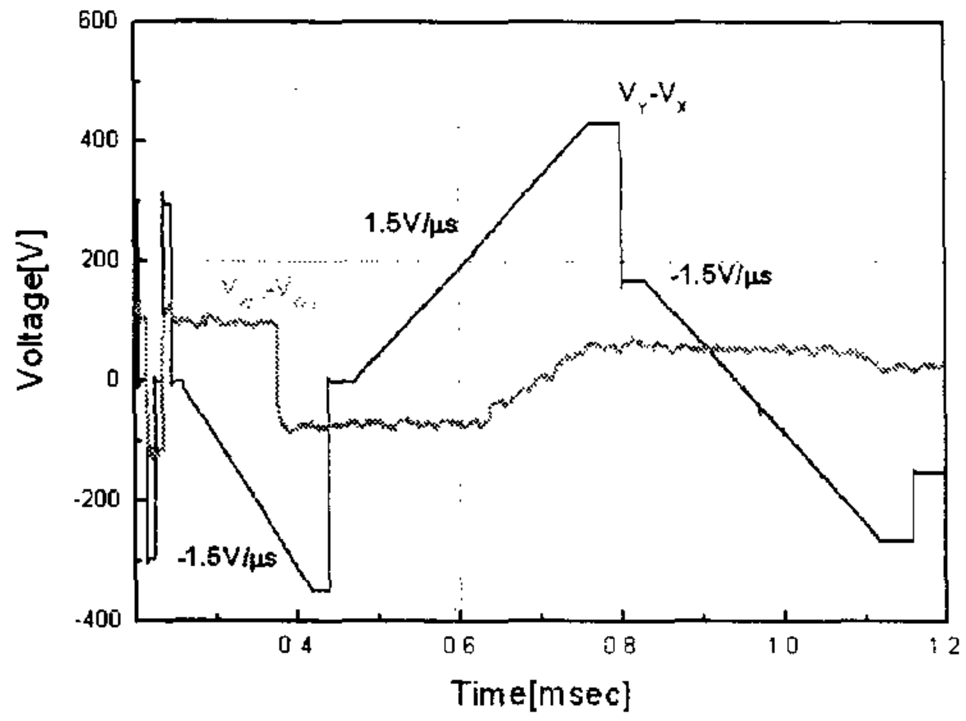
Before ramp reset waveform is applied to the electrodes, a ramp erase pulse is induced to the X electrode. Despite of the slow rising speed of erase pulse, the strong discharge is occurred.

The wall voltage is changed slowly due to the weak discharge during ramp up and down period. The rise speed of wall voltage is slightly slower than that of applied voltage during ramp up period. After reset period, the wall voltage between X and Y electrode is almost zero, but the wall voltage between address and Y electrode is not. This is due to the difference of the terminal voltage between the address and the Y electrode and between the X and Y electrode..

Fig. 7 shows the wall charge distributions during ramp reset. After reset period the ion wall charges are accumulated on the address electrode, and the electron wall charges are on X and Y electrodes. After address discharge, the wall charge state over the X electrode is not changed, but those over the address and Y electrode are reversed.



(a)



(b)

Fig. 6. Applied voltage and wall voltage during ramp reset period (a) between address and Y electrodes (b) between X and Y electrodes

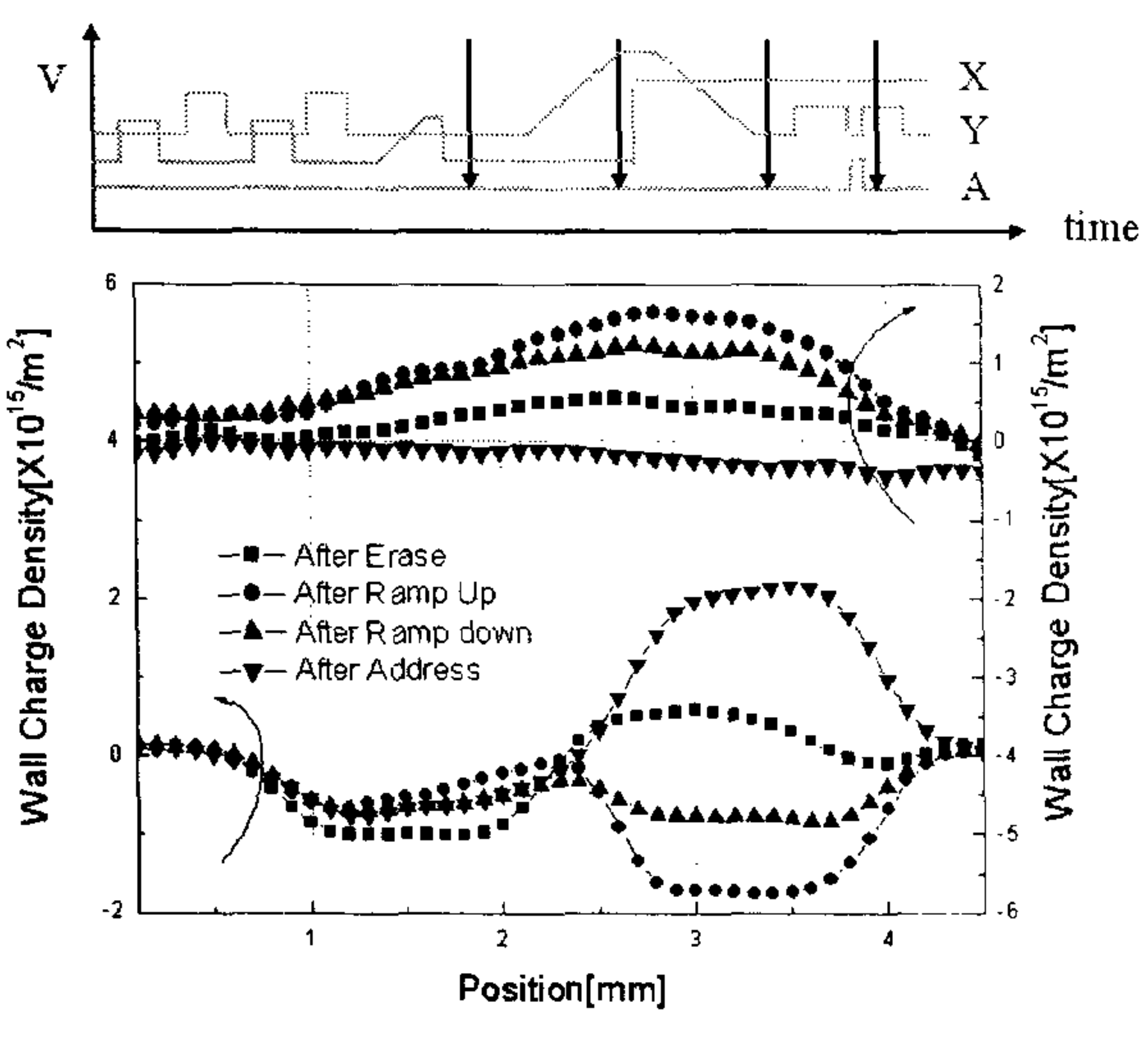


Fig. 7. Wall charges distribution during ramp reset period

4. Conclusion

Wall voltage and wall charge distribution during reset period were measured using electro optic effect. Ramp and high voltage reset pulses are applied to compare the spatiotemporal wall charge characteristics.

When a high voltage reset pulse is applied, wall charges over each electrode are almost removed by self erasing discharge during off period. But when a ramp reset waveform is applied, the wall charges over each electrode are not removed and maintain a voltage drops between address and Y electrode and between X and Y electrode according to the waveforms applied to the electrodes.

5. References

[1] D.C. Jeong et al, "Measurement of the Spatiotemporal Wall Charge Distribution in an AC PDP Cell by the Longitudinal Electro-Optic Amplitude Modulation Method", Proc. EURODISPLAY 2002, pp.739

[2] D.C. Jeong et al, "Measurement of the Spatiotemporal Wall Charge Distribution in an AC PDP Cell by the Longitudinal Electro-Optic Amplitude Modulation Method", Proc. IDW 02, pp.721

[3] Amnon Yariv, "Optical Waves in Crystals", Text book, John Wiley & Sons, Inc., 1984