A Study on the Temporal Behavior of the Wall Voltage in a surface-type AC panel

Jung Hun Kim, Jun Hak Lee, Young Wook Choi* and Ki-Woong Whang

Plasma Lab. SoEE., College of Engineering, Seoul National University
*Korea Electrotechnology Research Institute, P.O.BOX 20, Changwon, 641-600, Korea

Abstract

Electric fields and the wall voltages in a surface-type AC PDP cell were measured using a Laser Induced Fluorescence Spectroscopy. For the condition of He 100Torr, 200V sustain voltage and 50kHz sustain frequency, the wall voltage dropped from about 50V to about –75V within 1μsec after the main discharge. And the wall voltage decreased with the rate of 10.8V/μsec due to the accumulation of the space charges after 1μsec. But when the operating pressure was 40Torr, it increased with the rate of 4.5V/μsec because the diffusion effect of the wall charge on MgO surface was more dominant than the accumulation effect of the space charges. During the pulse-off period, the wall voltage decreased slightly due to the diffusion of the wall charge. When the sustain voltage was 250V, the self-erasing discharge occurred, and the absolute value of the wall voltage decreased rapidly just after the pulses were off, which was caused by the accumulation of the charges generated by the self-erasing discharge.

Introduction

Plasma display panel (PDP) is the best candidate in the market of large size, wall hanging television displays[1]. But some of the characteristics should be improved, and basic research is needed to guide improvement in such as the luminous efficiency. Understanding the physical mechanism is very important because it helps to solve the problems and provide us the optimal operating conditions. The information on the electric fields induced by the wall charges in an AC PDP cell is very important for understanding the discharge physics and for the operation of PDP cell. But the smallness of PDP cell made it very difficult to measure the electric fields directly. Until now, people mainly depended on the simulation results to estimate its value[2-4] or indirectly estimated the wall voltages[5-6]. But those methods could not provide us the information of the temporal behavior of the wall voltage.

The electric field can be estimated with a high accuracy using the Laser Induced Fluorescence Spectroscopy method[7-11] whichis based on the Stark effect induces splitting in the Rydberg levels of Helium. The change in the excitation wavelength from metastable levels to these Rydberg levels and the consequent fluorescence contains the information on the electric field. In this work, we first measured the electric field and the wall voltage in a surface-type AC PDP cell using laser induced fluorescence spectroscopy method[12] and observed the temporal behavior of the wall voltages.

Experimental Setup

Figure 1 shows the system setup employed in this study. Laser for the excitation (326nm; $1s2s^1S$-$1s9p^1P$) was generated by the second harmonic output of a Nd:YAG laser pumped tunable dye laser. The dye laser radiation had the pulse duration of 10nsec, a spectral width of 0.1cm^{-1} and the output energy of about 2mJ for the wavelengths of interest. The laser beam was focused using a spherical lens and directed into the plasma generated by a surface type AC PDP cell. The diameter of laser beam at the observation point was 100μm. Laser beam was polarized parallel to the front panel of a surface-type AC PDP. Helium (100Torr) was used as the discharge gas. Fluorescence light (447.1nm; $1s2p^3P$-$1s4d^3D$) was detected perpendicularly to the beam and was collected by a lens into a monochromator and the output signals were accumulated with a Boxcar averager and an oscilloscope. The delay time from the Q-switching trigger to the Boxcar averaging time was about 70nsec. The width of gap, electrode and pitch were 160μm, 640μm and 2160μm respectively and the thickness of the dielectric was 30μm. Square pulses were synchronized with the Q-switching signals.

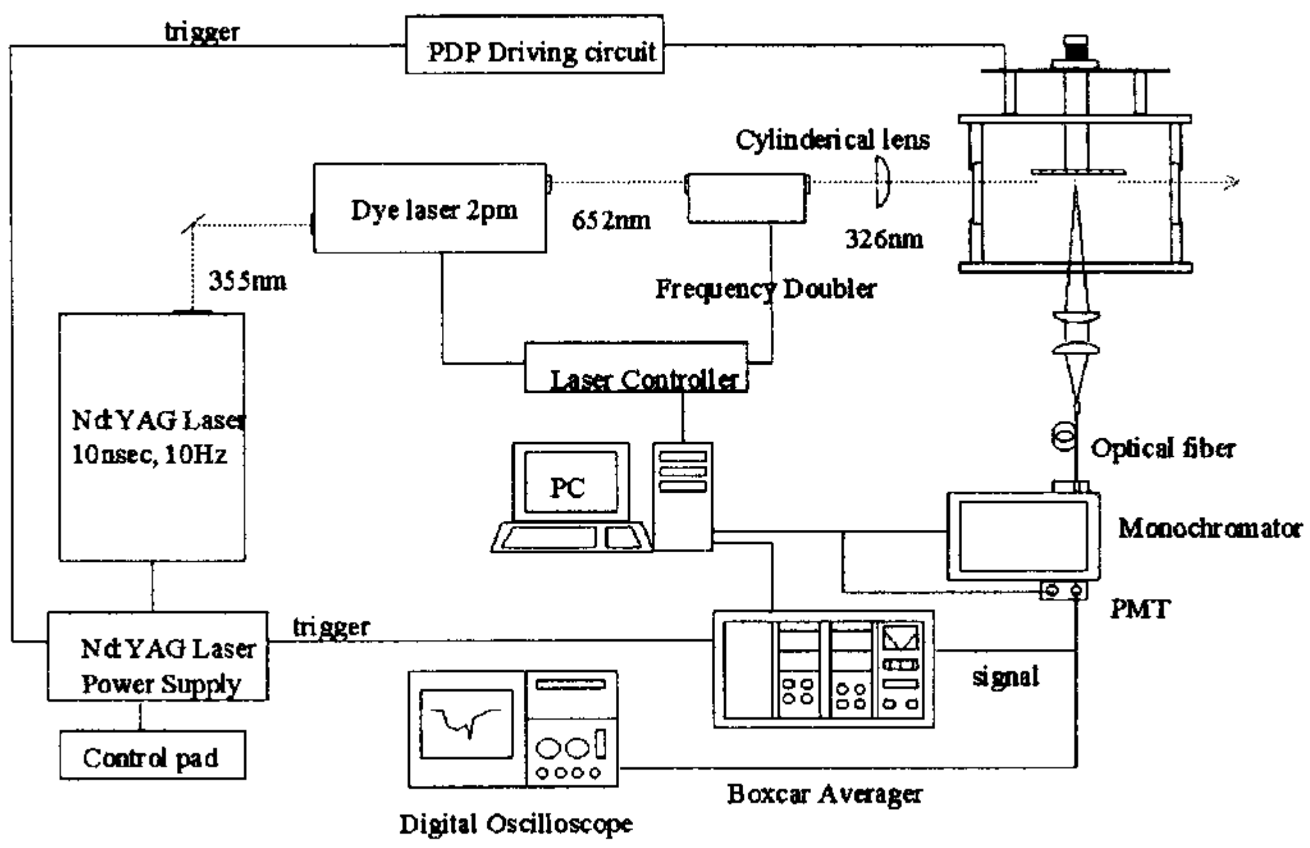

Fig. 1 Experimental Setup

Results and Discussions

Figure 2 shows the temporal behaviors of the plasma emission (447.1nm; He $1s2p^3P$-$1s4d^3D$) measured with the photo-multiplier tube, the electric fields in PDP cell and the estimated wall voltage at the condition of 100Torr He, 200V sustain voltage and 50kHz sustain frequency. The wall voltage was calculated from the electric fields as the maximum voltage. The electric fields inside the PDP cells during the pulse-on period was induced by both the wall charges and the applied voltages to the electrodes while the electric fields during the pulse-off period was induced by the pure wall charges. As soon as the main discharge occurred, the wall voltage changed rapidly to the negative polarity, which was caused by the accumulation of charge generated during the main discharge within 1μsec. After 1μsec the absolute value of the wall voltage increased with the rate of 10.8V/μsec due to the space charge accumulation on MgO surface. The increase did not happen during the pulse-off periods, and instead the wall voltage decreased slightly due to the diffusion effect of the wall charges. It seemed that it depends sensitively on the conditions of the MgO surface.

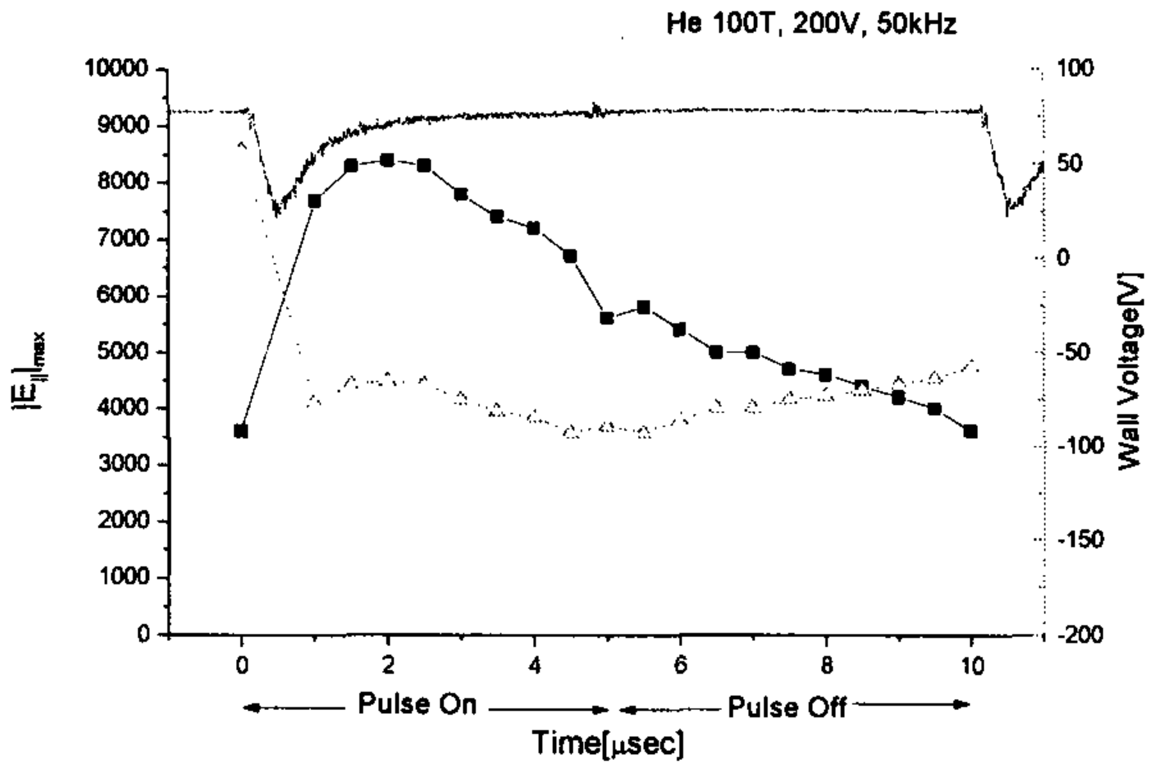

Fig 2. Temporal behaviors of the plasma emission (447.1nm; He $1s2p^3P$-$1s4d^3D$ - line), the electric fields in PDP cell (square) and the estimated wall voltage (triangle) at the condition of He 100Torr, 200V, 50kHz

Figure 3 shows similar results when the sustain voltage was 250V. The plasma emitted the light at the instance of the pulse off. It was smaller than the main discharge but its emission was not negligible. Self-erasing phenomena was happened because the high electric fields generated by the wall charges exceeded the breakdown fields at the instance of the pulse-off. When the self-erasing happened, the wall charges accumulated during the major discharge decreases very rapidly and the wall voltage changed from about –170V to about -80V.

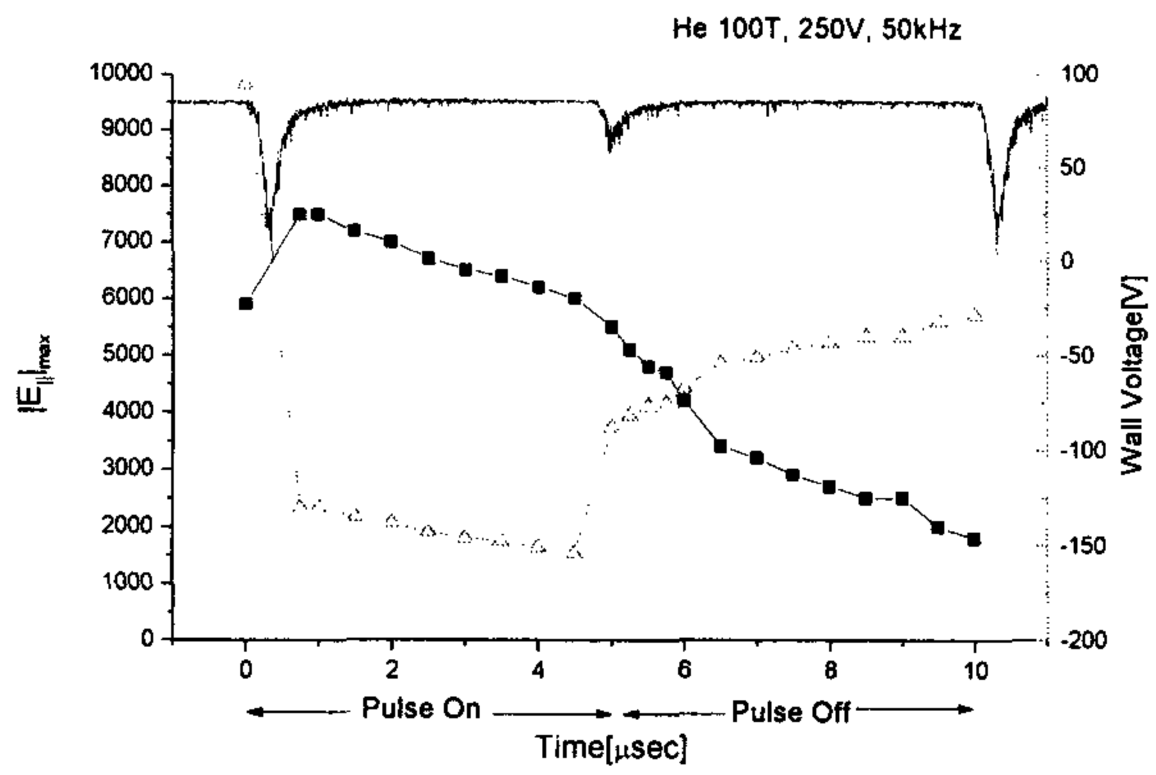

Fig. 3 Temporal behaviors of the plasma emission (447.1nm; He $1s2p^3P$-$1s4d^3D$ - line), the electric fields in PDP cell (square) and the estimated wall voltage (triangle) at the condition of He 100Torr, 250V, 50kHz

Figure 4 shows when the operating pressure was 40Torr. In this case, the absolute value of the wall voltage during the pulse-on period decreased with a rate of 4.6V/μsec. This means that the effect of the accumulating charges on MgO surface was not large because the space charge was not abundant enough at low pressure and the diffusion effect of the wall charge was more important.

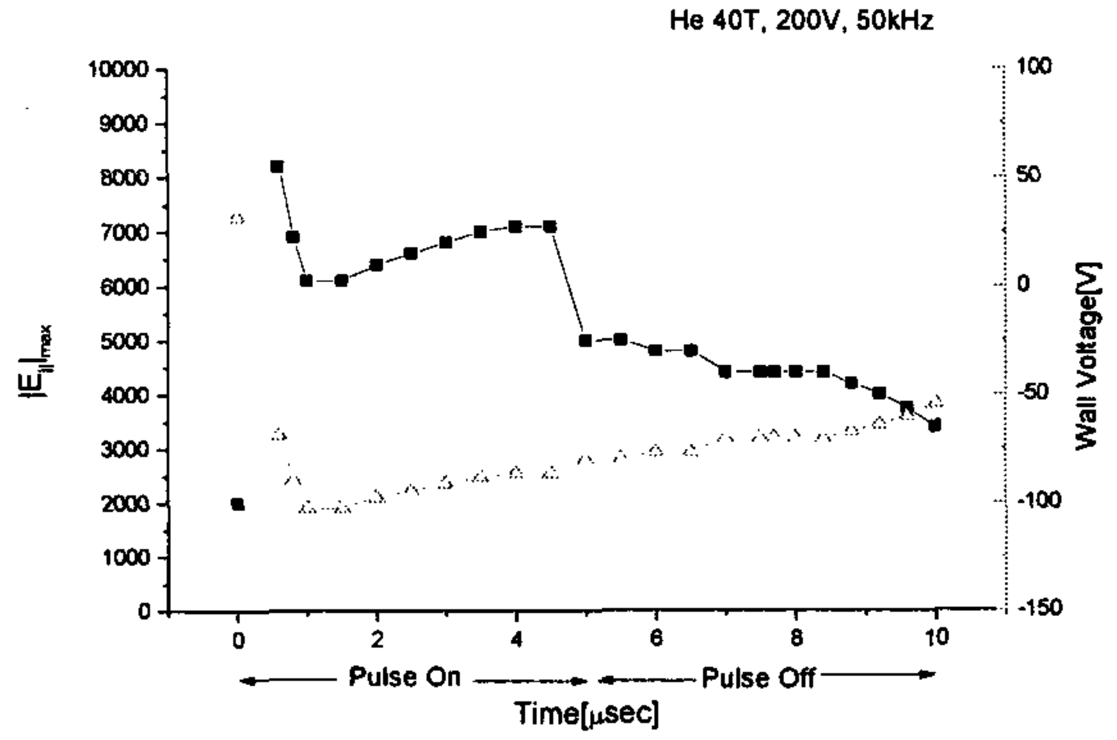

Fig 4. Temporal behaviors of the electric fields in PDP cell (square) and the estimated wall voltage (triangle) at the condition of He 40Torr, 200V, 50kHz

Conclusion

Electric fields and the wall voltages in a surface-type AC PDP cell were firstly measured using a Laser Induced Fluorescence Spectroscopy. The wall voltage changed its polarity very rapidly within 1μsec after the main discharge. And the wall voltage increased due to the accumulation of the space charges after 1μsec or decreased due to the diffusion of the wall charges. During the pulse-off period, the wall voltage decreased slightly due to the diffusion of the wall charge. When the self-erasing discharge occurred, the absolute value of the wall voltage decreased rapidly just after the pulses were off, which was caused by the accumulation of the charges generated the self-erasing discharge.

References

[1] S.Mikohiba, Information Display, 10, 21 (1994)

[2] J.Meunier, Ph.Belenguer and J.P.Boeuf, J.Appl.Phys. **78,** 731 (1995)

[3] C.Punset, J.-P.Boeuf and L.C.Pitchford, J.Appl.Phys. **83,** 1884 (1998)

[4] S.Rauf and M.J.Kushner, J.Appl.Phys. **85,** 3460 (1999)

[5] L.F.Weber, IEEE Transactions on Electron Devices, **ED-24,** 864 (1977)

[6] L.F.Weber, K.W.Warren and G.S.Weikart, Proceedings of the SID, **27,** 173 (1986)

[7] B.N.Ganguly, J.Appl.Phys. **60,** 571 (1986)

[8] B.N.Ganguly, J.R.Shoemaker, B.L.Preppernau and A.Garscadden, J.Appl.Phys. **61,** 2778 (1987)

[9] K.E.Greenberg and G.A.Hebner, Appl.Phys.Lett. **63,** 3282 (1993)

[10] M.D.Bowden, Y.W.Choi, K.Muraoka and M.Maeda, Appl.Phys.Lett. **66,** 1059 (1995)

[11] Y.W.Choi, M.D.Bowden and K.Muaoka, Appl.Phys.Lett, **69,** 1361 (1996)

[12] J.H.Kim, J.H.Lee, Y.W.Choi, J.H.Yang and K.-W.Whang, 6th International Display Workshops, 1999