# Improvement of Luminous Efficiency in AC Plasma Display Panel with the Pulses Applied to the Address Electrode

*Hyoung Joon Cho, Bhum Joon Kim, Jae Hyun Lee, Kyung Cheol Choi*
**Department of Electronics Engineering, Sejong University, Kwangjin-gu, Seoul,143-747, Korea**
**Tel : +82-2-3408-3904 , E-mail :kyungcc@sejong.ac.kr**

## Abstract

*The discharge characteristics of AC plasma display were investigated as a function of the voltage and the frequency of the pulses applied to the address electrode during sustain period. The maximum sustain voltage of display cell decreased with increasing the frequency of the pulses applied to the address electrode during sustain period. Applying the pulses to the address electrode resulted in improvement of luminance and luminous efficiency at the same time.*

## 1. Introduction

To improve luminous efficiency of plasma display, a lots of efforts have been made during past 20 years. However, the luminous efficiency is still low. There are several ways to improve the luminous efficiency. One of the approaches is the introduction of high efficient discharge mode such as high frequency discharges, hollow cathode mode, townsend discharge, and high xenon contents discharge[1,2,3,4]. The other is to optimize cell structure and driving scheme[6,7]. The former gives drastic improvement of luminous efficiency to PDPs. However, the driving voltage went up too high and the cell structure fabrication was too difficult to be commercialized. The latter resulted in a small improvement of luminous efficiency of PDPs. For the both of them, the exact understanding of plasma physics in a small volume discharge should be made. Up to now, the simulation and the diagnostics tried to explain the phenomena in discharge cell. Direct measurement by using laser is one of the possible diagnostics. However, its application to the display cell in PDPs has the limitation, because of the smallness of discharge volume. Indirect measurement by using pulse technique is simple and applicable to the small display cell[8,9]. In this work, the driving scheme of AC PDPs was modified to improve the luminous efficiency. The pulses were applied to the address electrode during sustain period when address display separated period(ADS) method was adopted to the three electrode surface discharge AC PDPs. Actually, this work is different from the previous work[7]. In the pervious work, the pulses were applied to the address electrode only at the rising time of the sustain pulse. In this work, the time that pulses were applied to the address electrode was independent on the rising and the falling time of the sustain pulses. Also, the simple pulse technique was introduced to measure the space charge decay time[8].

## 2. Experiment

Fig.1 shows the schematic diagram of the AC PDP was in this work. The three electrodes structure with two sustain electrodes and one address electrode was employed. The distance between two sustain electrodes was 80μm. He+Ne+Xe gas-mixture was used as discharge gas and the operating pressure was 400 Torr.

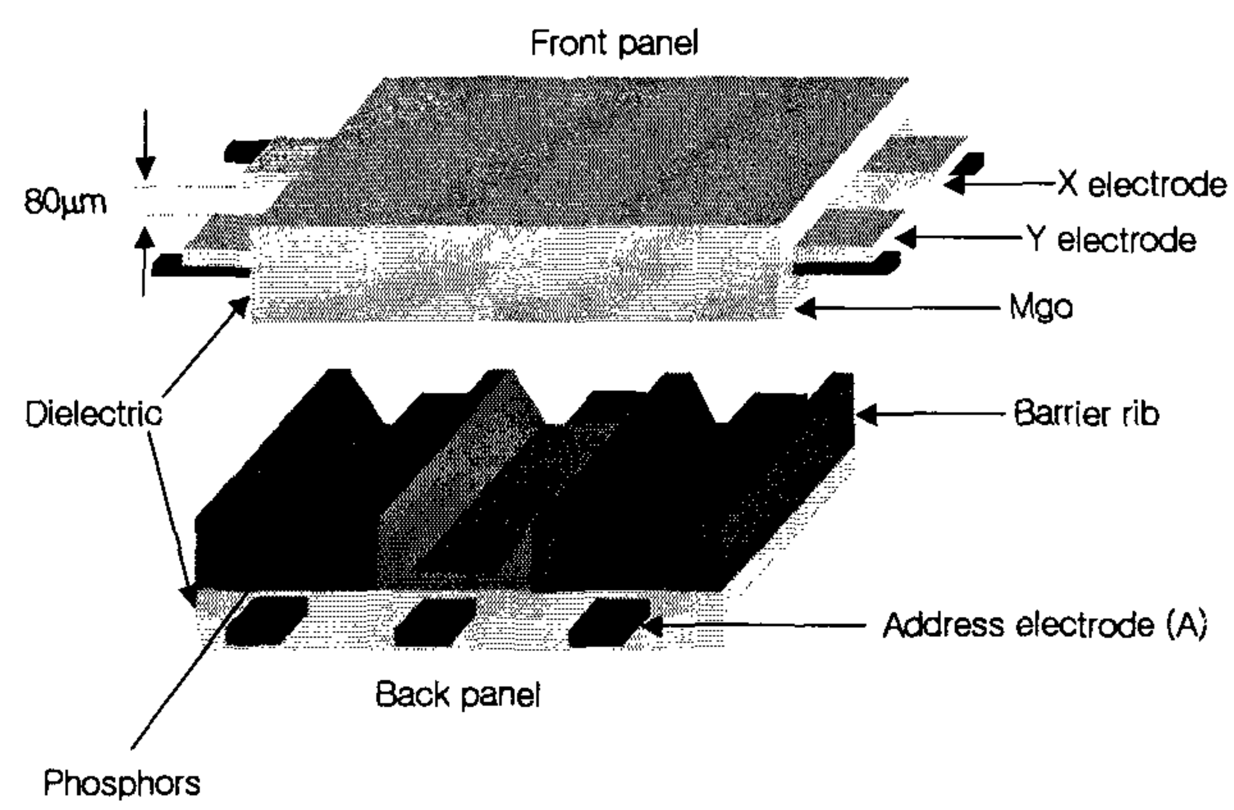
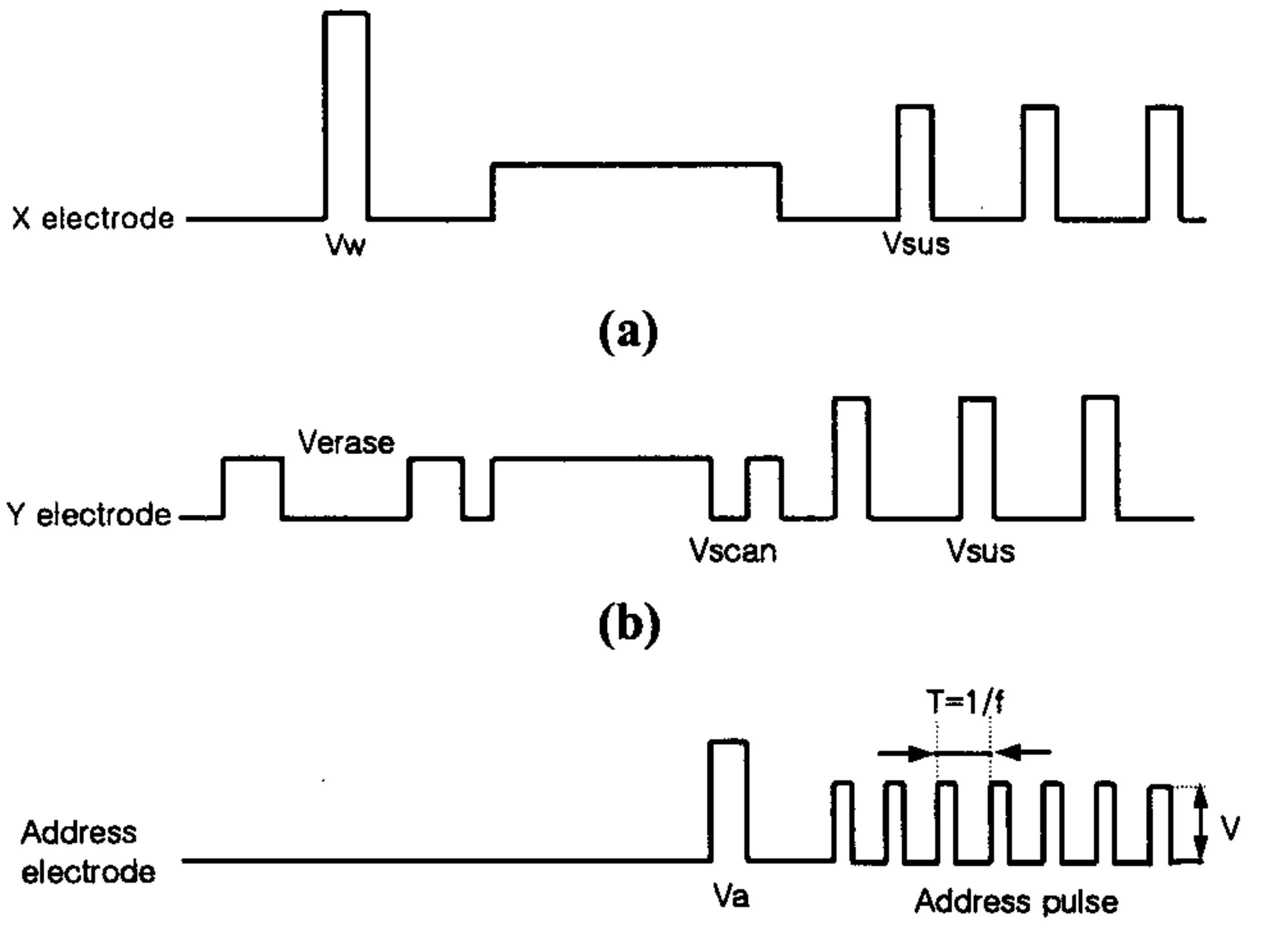



**Fig.1 Cell structure of AC PDP used in this work**

Fig.2 shows the new driving scheme used in this work. The pulse waveform was similar to that of ADS scheme except the sustain period. The pulses as shown in Fig.2 (c) were applied to the address electrode. The frequency and the voltage of the sustain pulse was 25kHz and 200V, respectively. The frequency and the voltage of pulse applied to the address electrode during sustain period were 10kHz~250kHz and 0~100V, respectively.

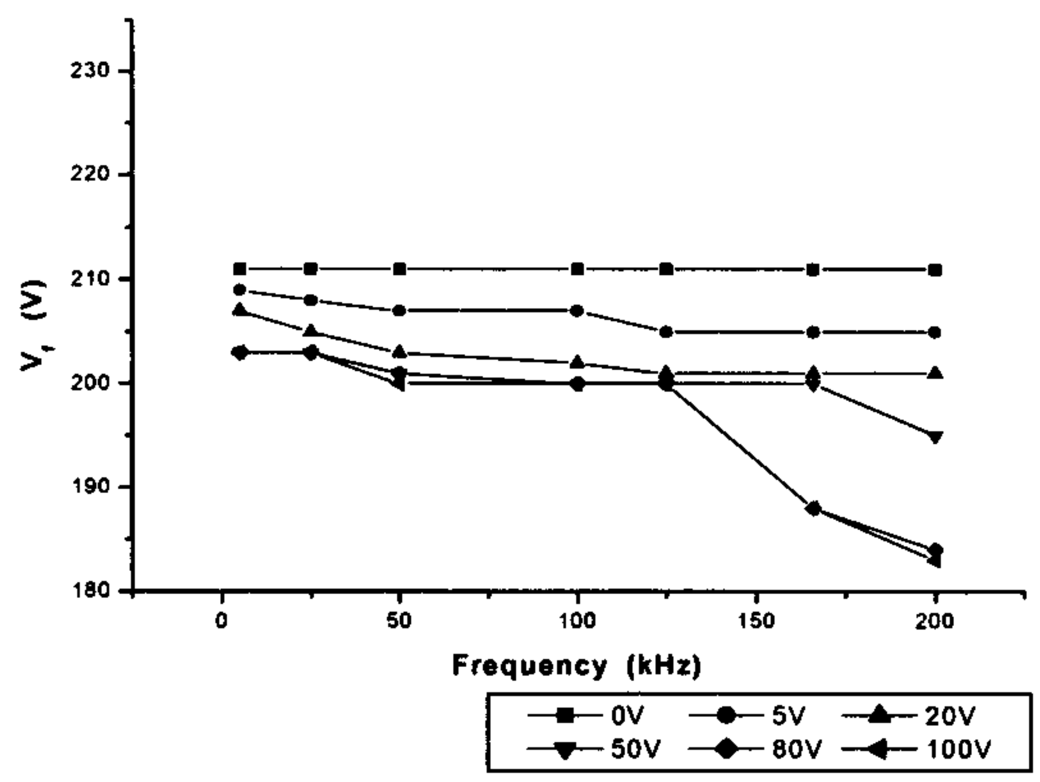



(c)

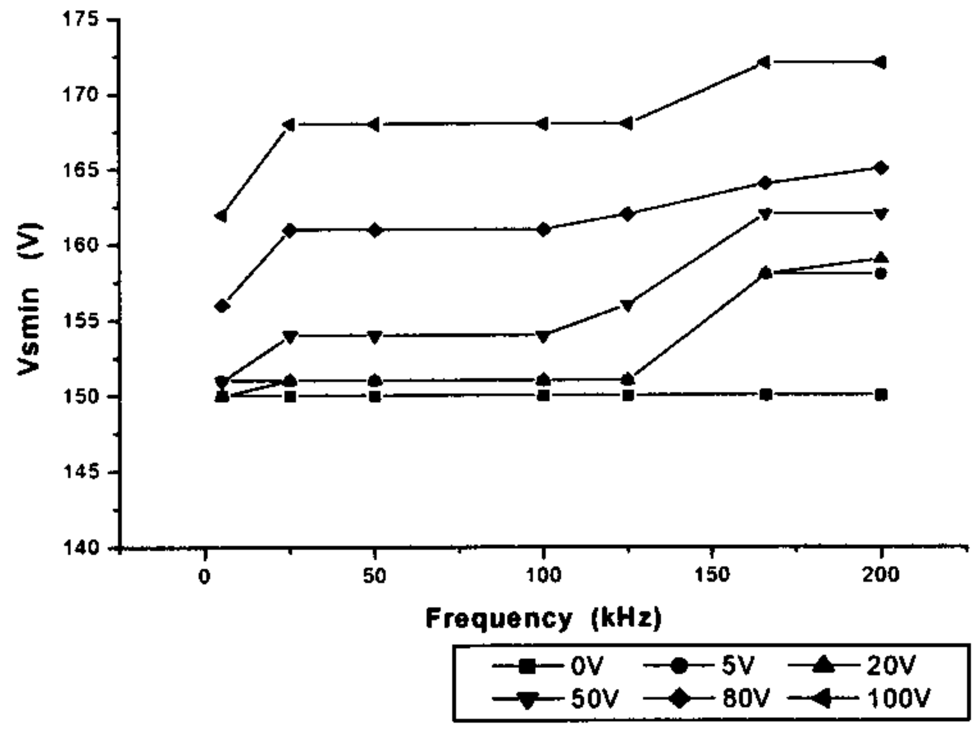
**Fig.2 Pulse waveforms applied to the sustain and address electrode (a) X electrode (b) Y electrode (c) address electrode.**

## 3. Results and Discussion

The firing voltage($V_f$) and the minimum sustain voltage($V_{smin}$) was measured as a function of the frequency and the voltage of the pulses applied to the address electrode. The maximum voltage of the pulse applied to the address electrode during sustain period was within the dynamic memory margin. Fig.3 shows the firing voltage and the minimum sustain voltage of the display cell as a function the pulses applied to the address electrode. The firing voltage decreased with increase of the voltage of the pulse applied to the address electrode. Also, the firing voltage decreased with increase of the frequency of the pulse applied to the address electrode. The minimum sustain voltage increased with increases of the voltage and the frequency of the pulses applied to the address electrode.




(a)




(b)

**Fig.3 (a) Firing and (b) Minimum sustain voltage as a function of the voltage and the frequency of the pulses applied to the address electrode.**

Fig.4 shows the luminance of display cell as a function of the voltage and the frequency of the pulses applied to the address electrode during sustain period. The luminance is related to the excited species. Applying pulse to the address electrode affected the charged particles directly and the excited species indirectly[10]. The higher frequency of pulses resulted in the higher luminance of the display cell.

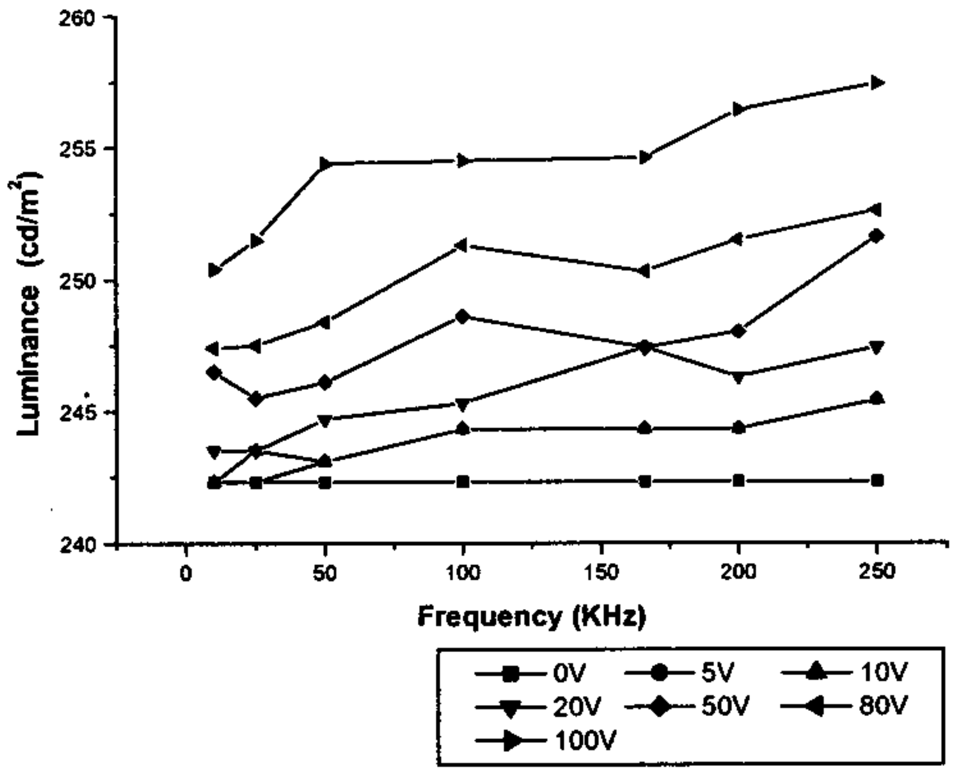



**Fig.4 Luminance as a function of the voltage and the frequency of pulse applied to the address electrode.**

Fig.5 shows the luminous efficiency as a function of the voltage and the frequency of the pulses applied to the address electrode. The higher voltage and frequency gave the higher luminous efficiency to the display cell in AC PDP. Generally, the luminous efficiency decreases when the luminance increases. In this work, the luminous efficiency increased when the luminance increased by using pulses applied to the address electrode. This phenomena can be explained by follows: When the pulse applied to the address electrode during sustain period, the current decreased as shown in Fig.6. Applying pulse controlled the changed and the excited particles. Especially, the excited and meta-stable particles were affected by applying pulse indirectly[10]. The meta-stable particle decay time was measured by using pulse technique[7]. The meta-stable particle decay time was about 30μsec when the pulses were applied to the address electrode. On the other hand, the decay time was about 20μsec without pulse. The delayed meta-stable decay time affected the firing voltage. In AC PDPs, the firing voltage is related to the meta-stable particles and the wall charges. The meta-stable particles with the longer life-time resulted in the lower firing voltage of the periodical pulse discharges. The reason of the lowered firing voltage could be explained by the delayed meta-stable decay time.

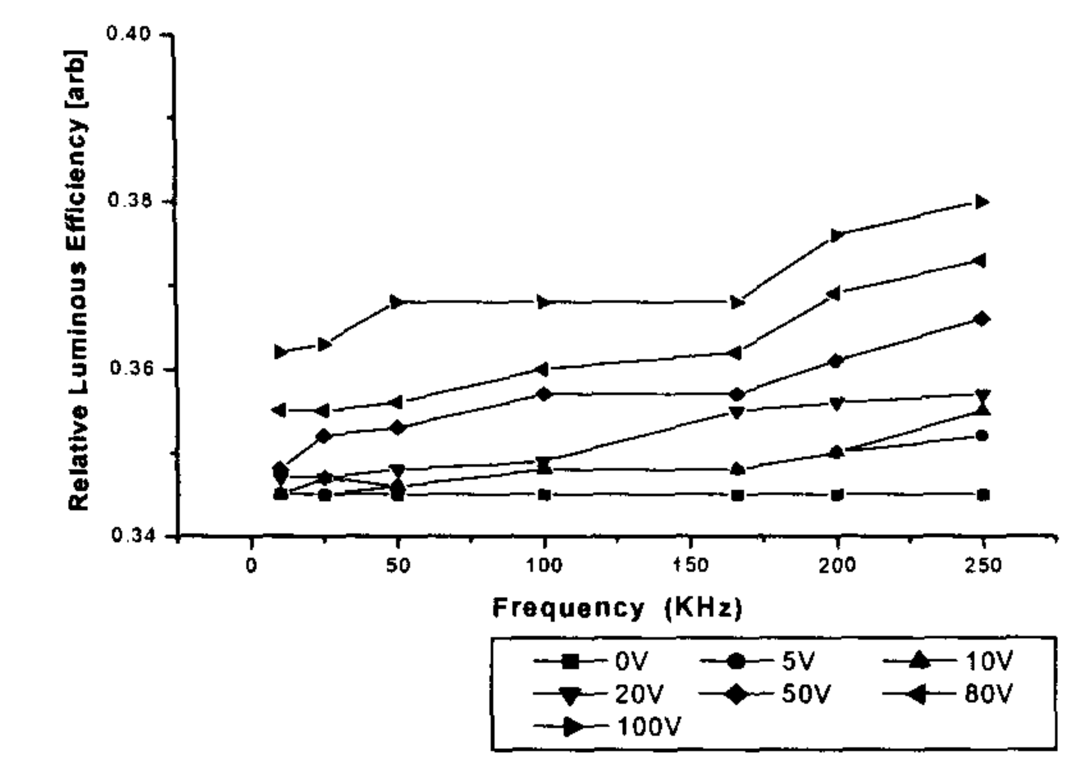



**Fig.5 Relative luminous efficiency as a function of the voltage and the frequency of pulses applied to the address electrode**

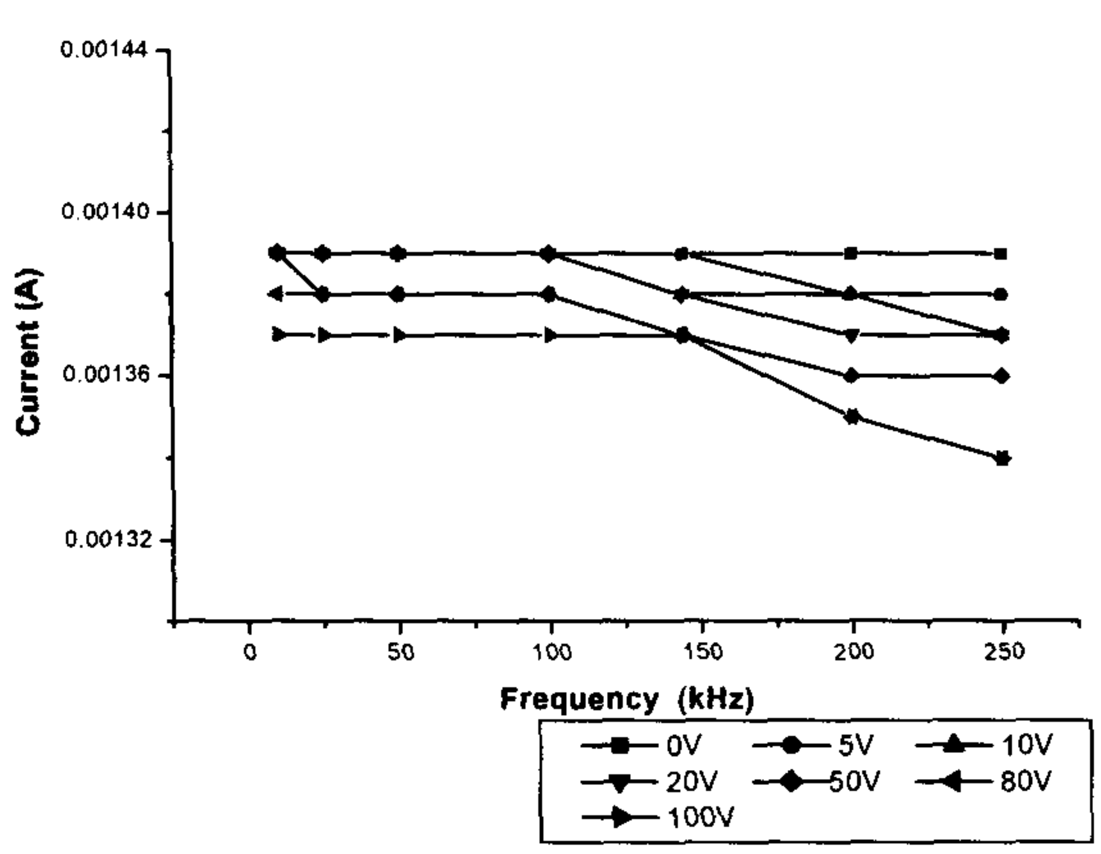



**Fig.6 Current as a function of the voltage and the frequency of the pulses applied to the address electrode**

We also measured the space charge decay time to investigate why the minimum sustain voltage increased. Fig.7 shows the pulse waveform used to investigate the space charge decay time and the firing voltage of space charge effect measuring cell as a function of time Δt2. Hence, Δt2 was defined as the time between the start point of the pulse of space charge source cell and of space charge effect measuring cell.

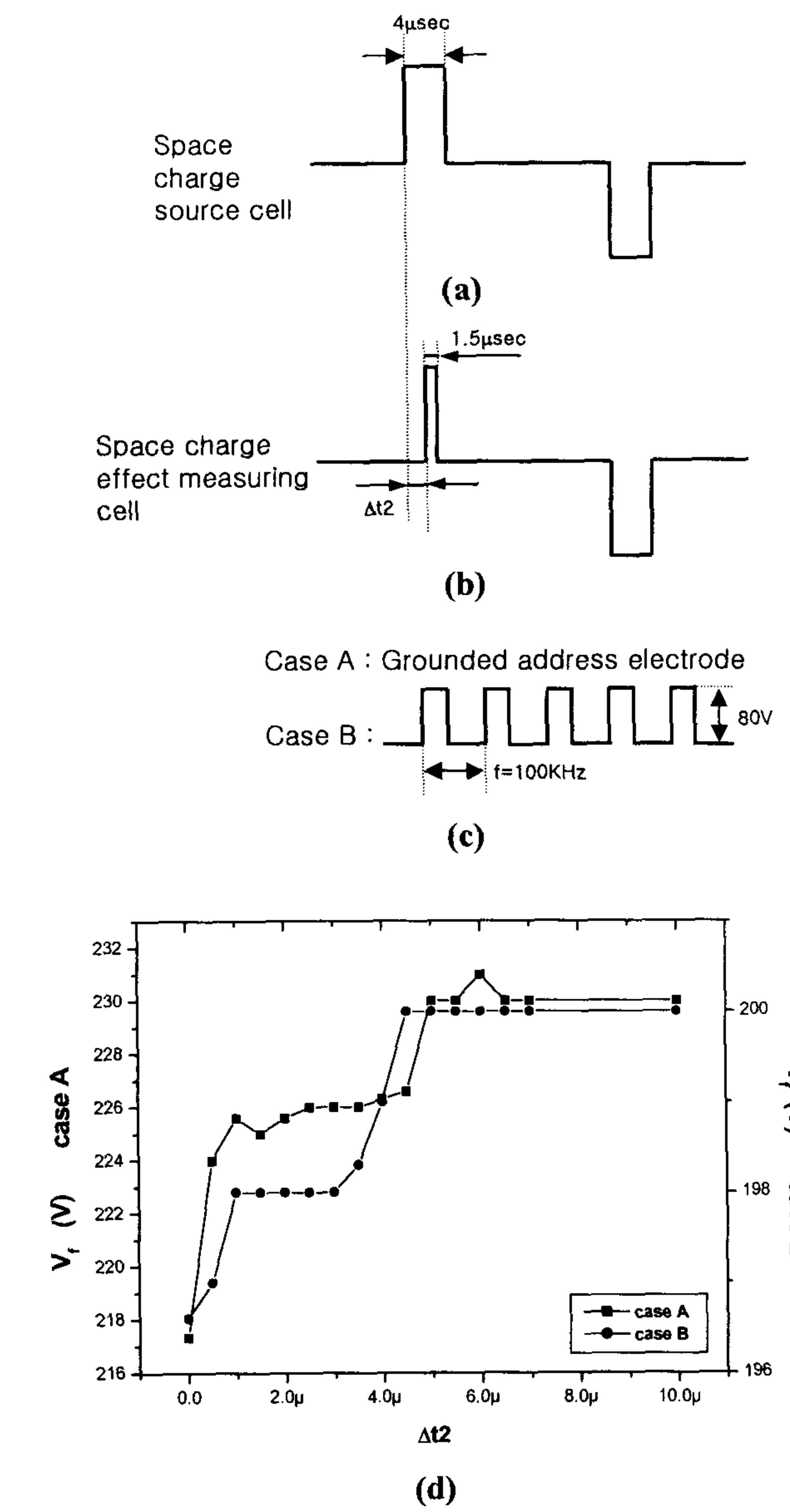



**Fig.7 (a) Pulse waveform applied to the source cell and (b) The space charge effect measuring cell. (c) Case A : grounded address electrode, Case B : pulse waveform applied to the address electrode during the sustain period. (d) The firing voltage of the space charge effect measuring cell as a function of Δt2**

In this pulse technique, the pulse as shown in Fig.7 (a) was applied to the display cell which produced the space charge cell. Then the space charge spread to the adjacent cell. The pulse as shown in Fig.7(b) was applied to the adjacent cell which was affected by the space charges. Finally, the firing voltage of the adjacent cell was measured for two cases as shown in Fig.7(c). From the Fig.7(d), the abrupt change of the firing voltage can be observed. The space charge decay time is defined as the time when the firing voltage changes drastically[8]. When there was no pulse applied to the address electrode, the space charge decay time was about 5μsec. Applying pulse affected on the space charge decay time, which was 4μsec, approximately. This kind of the reduced space charge decay time was one of reasons that the minimum sustain voltage increased.

## 4. Conclusion

In this work, we investigated the discharge and luminance characteristics of the AC PDP when the modified driving scheme was adopted. The firing voltage decreased when the pulses were applied to the address electrode because of the longer meta-stable decay time. The minimum sustain voltage increased because the space charge particle decay time was shortened. It was found that the applying pulse to the address electrode resulted in the improved luminance and luminous efficiency at the same time.

## 5. Acknowledgement

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## 6. References

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