# A Modified Ramp Reset Waveform for High Contrast Ratio in AC PDPs

**Jae-Sung Kim**, Jin-Ho Yang**, Chang-Hoon Ha, and Ki-Woong Whang***

### Abstract

In general, the background light that is produced during the reset period deteriorates the dark room contrast ratio in AC PDP. In this paper, we propose a modified ramp reset pulse that can reduce the background light to an imperceptible level. In the new reset waveform, the discharges between the scan and sustain electrodes are minimized by applying a positive bias voltage to the sustain electrode and only the weak discharges between the scan and address electrodes are found to occur during the reset period. We also adopted the MgO coated phosphor layer to improve the address voltage margin that was reduced when the bias voltage in the modified ramp reset waveform was applied.

As a result, the address voltage margin of 45 V which is the same level of the conventional method was ortained and the dark room contrast ratio was improved up to 7500 : 1.

**Keywords** : AC PDP, contrast ratio, ramp reset, MgO coated phosphor

## 1. Introduction

PDP has many merits as a display device. It is thin, light and can be easily enlarged up to 60 inches. In this regard it is expected to become one of the most important display devices of the next generation digital TV. However, it also has many drawbacks, such as the low contrast ratio and the noise produced from the moving images.

In general, a reset discharge is needed to stabilize the address discharge and to overcome the non-uniformity of discharge cell. But, on the other hand, it produces background light that is not related to the picture image that is displayed, and the background light in turn deteriorates the contrast ratio.

To overcome this problem, many efforts have been put in to reduce the background light during the reset period. For example, the number of reset pulse per frame has been reduced and weak discharges were used instead of strong ones during the reset period [1]. But, the background light still remained to be perceptible in a dark room, which in turn deteriorates the picture quality of dark image.

In this paper, we propose a modified ramp reset pulse to reduce the discharge between the scan and sustain electrodes. At the same time, an MgO coating on the phosphor layer is adopted to solve the narrow voltage margin caused by the weakening of reset discharges between the scan and sustain electrodes.

As a result, we were able to improve the contrast ratio dramatically, and obtain the same level of voltage margin as that of the conventional method.

## 2. Simulations and Experiments

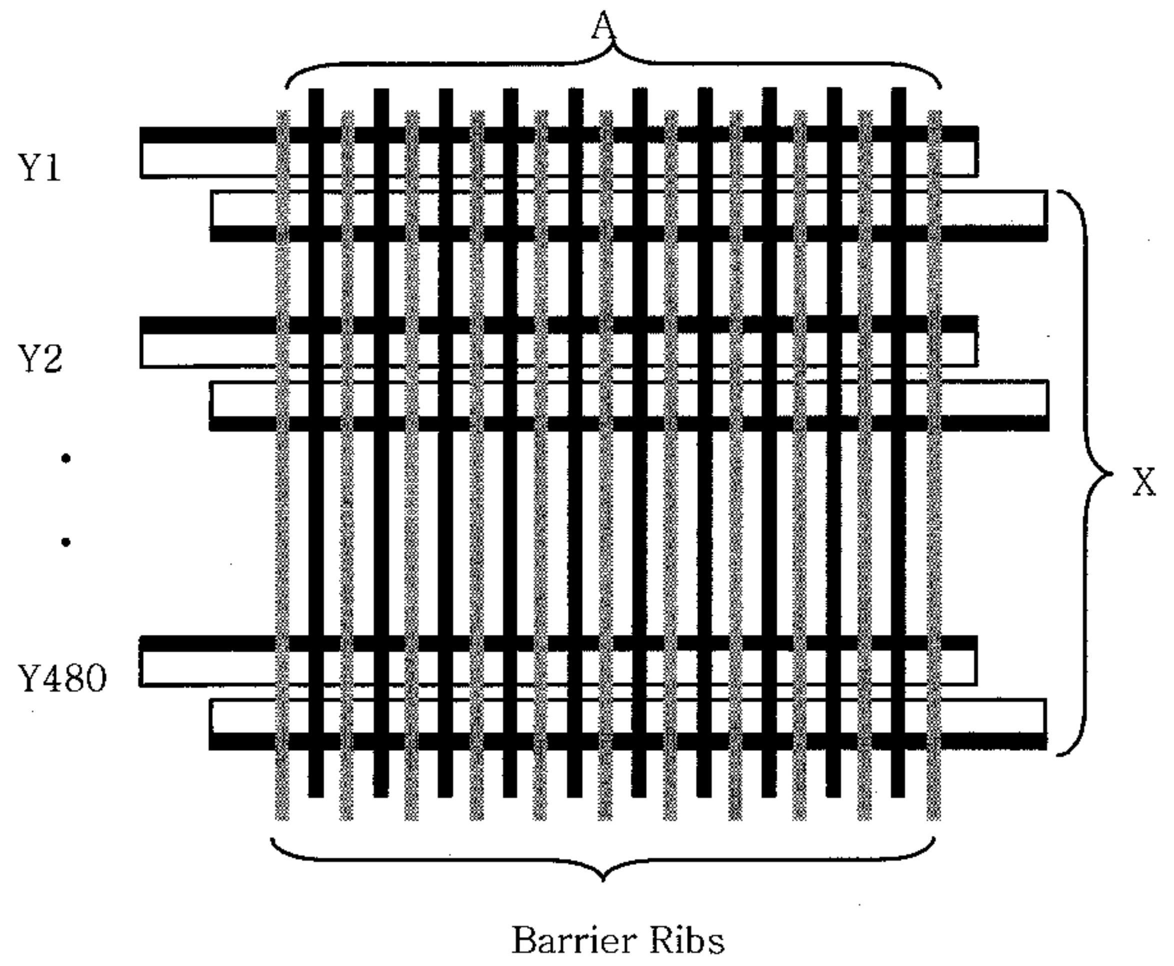
The active size of panel used in this experiment was 2 inches in diagonal and had the conventional coplanar structure with three electrodes. The schematic view of panel electrodes and driving voltage waveforms used in

Manuscript received November 27, 2002; accepted for publication December 25, 2002.
*Member, KIDS : **Student Member, KIDS
Corresponding Author : Jae-Sung Kim
School of Electrical Engineering, Seoul National University San 56-1, Shinlim-dong, Kwanak-gu, Seoul 151-742, Korea.
**E-mail** : kimjs2@pllab.snu.ac.kr **Tel** : +2 880-7253
**Fax** : +2 880-1792

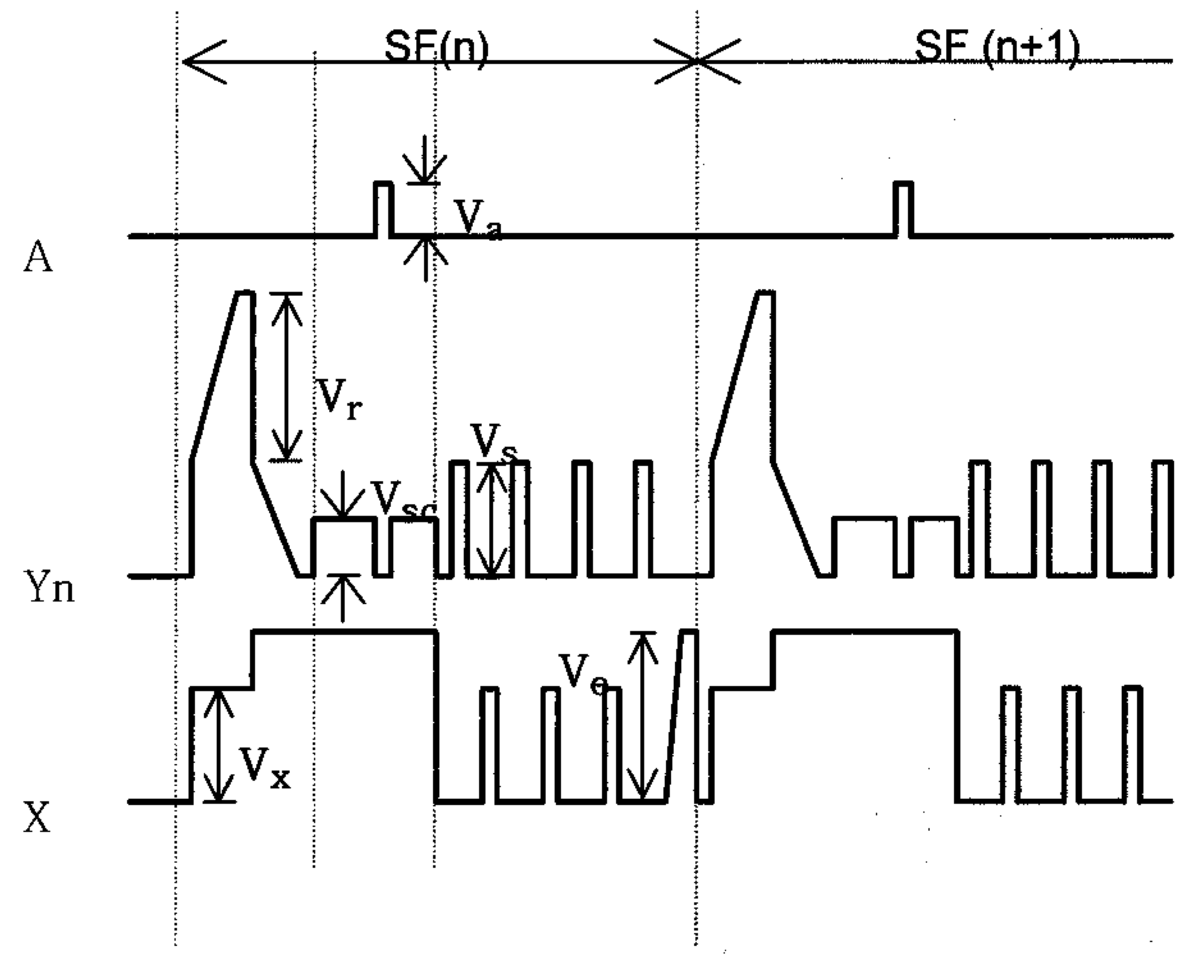
this experiment are shown in Fig. 1 and the detail panel specifications and the voltage levels are shown in Table1.

**Table 1.** The panel specifications and driving voltage levels used in the experiment.

| **Panel specifications** | | **Voltage levels** | |
|---|---|---|---|
| Pixel pitch | 1.08 ㎜ | $V_a$ | 70 V |
| Thickness of dielectric layer | 30 ㎛ | $V_r$ | 180 V |
| Rib Height | 140 ㎛ | $V_{sc}$ | 70 V |
| Thickness of MgO | 4000 Å | $V_s$ | 160 V |
| Phosphor | R: $(Y,Gd)BO_3$:Eu<br>G:$Zn_2SiO_4$:Mn<br>B:$BaMgAl_{10}O_{17}$:Eu | $V_e$ | 170 V |
| Gas mixture | Ne-Xe 4%, 400 Torr | $V_x$ | 0~170 V |




(a)




(b)

**Fig. 1.** Panel structure and driving voltage waveform. (a) Schematic view of electrodes and (b) Proposed modified ramp reset waveform.

Fig. 1. shows that the voltage waveform of scan electrode is ramp shaped and the voltage of sustain electrode is biased at the positive voltage level ($V_x$) and the address voltage is grounded during the reset period. The bias voltage of sustain electrode is introduced to optimise the reset discharge and minimize the light output during the reset period.

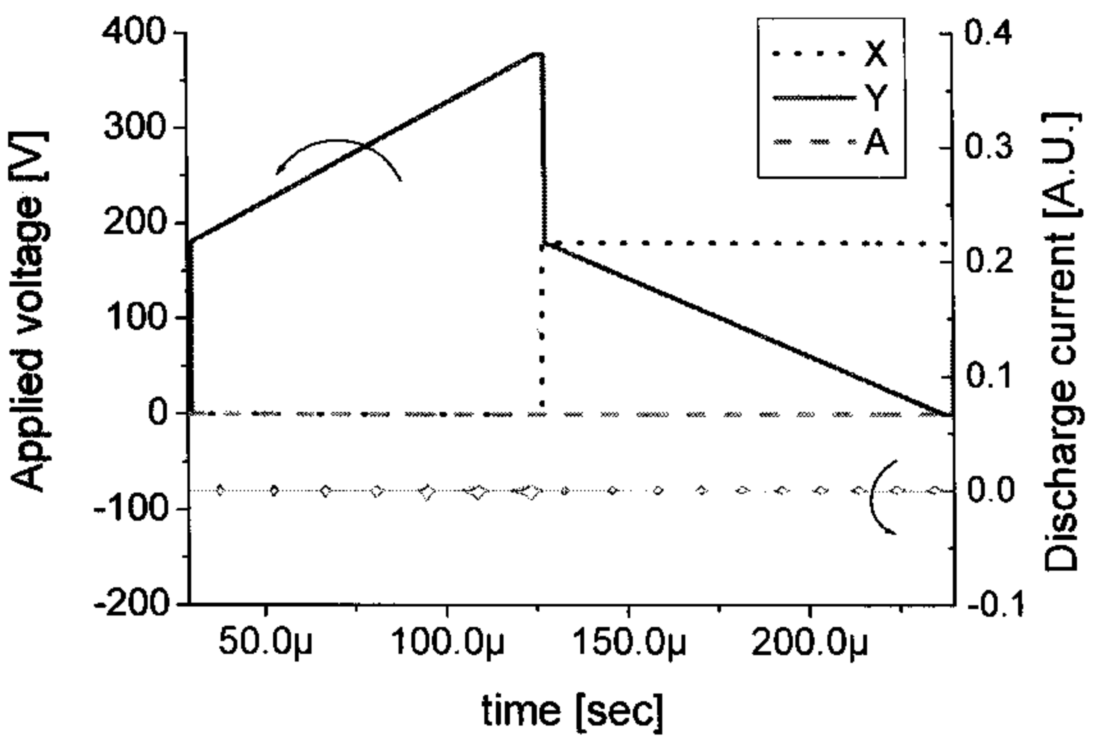
To investigate the discharge mechanism of reset pulse, a 2D simulation was also used, which is based on the fluid model of plasma. [2]

In the case of ramp-reset pulse, there were many weak discharges during the reset period. These discharges can be divided into two different kinds of discharges. One is a discharge between the scan and sustain electrodes while the other is a discharge between the scan and address electrodes.

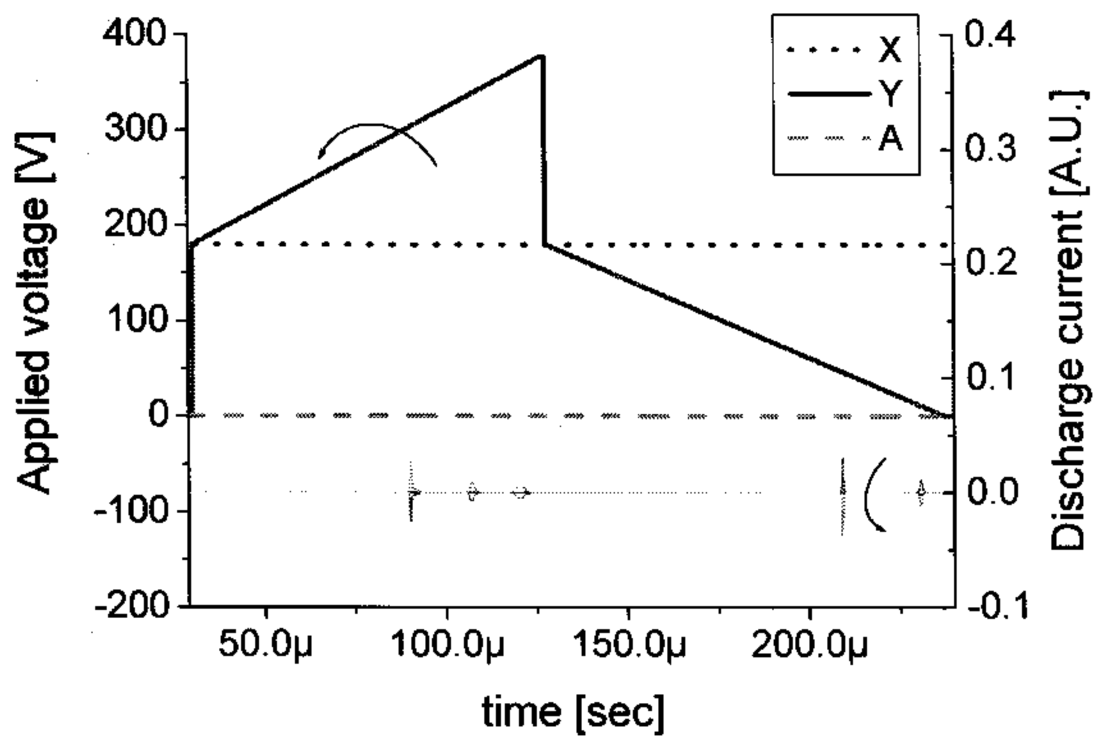
To get a stable address discharge between scan and address electrodes in the address period, there needs to be enough wall charges between scan and address electrodes produced by reset pulse.

If the firing voltage between the scan and address electrodes is $V_{fya}$, the applied address voltage is $V_a$, and the wall voltage between scan and address electrodes which is produced by reset pulse is $V_w$, the sum of $V_a$ and $V_w$ must be greater than $V_{fya}$ for stable addressing and the discharges between scan and address electrodes are more important than the discharge between scan and sustain electrodes during the reset period to get this wall voltage for stable addressing.

The basic idea behind the new modified ramp reset pulse is as follows. If there is enough discharges between scan and address electrode, the discharges between the scan and sustain electrodes during the reset period, which are relatively less important than the discharge between the scan and address electrodes to make a wall voltage for stable addressing, can be reduced, and it is possible to obtain an improved contrast ratio by applying a bias voltage on the sustain electrode, because most of the discharges between the scan and sustain electrodes can be eliminated during the reset period, as shown in Fig. 2.




(a)




(b)

**Fig. 2.** Simulation results of discharge current waveform as a function of $V_x$ in a ramp up period.

Fig. 2 shows the simulation results of ramp-reset pulse as a function of the bias voltage ($V_x$) of sustain electrode during ramp up period. As shown in Fig. 2, in the case of $V_x$=0 V, the reset discharges are seen to occur between scan and sustain electrodes and between scan and address electrodes. But in the case of $V_x$=180 V, the discharges between scan and sustain electrodes were reduced and the discharges mainly occurred between scan and address electrodres. We can see from the simulation results that it is possible to minimize the background luminance by applying the bias voltage ($V_x$).

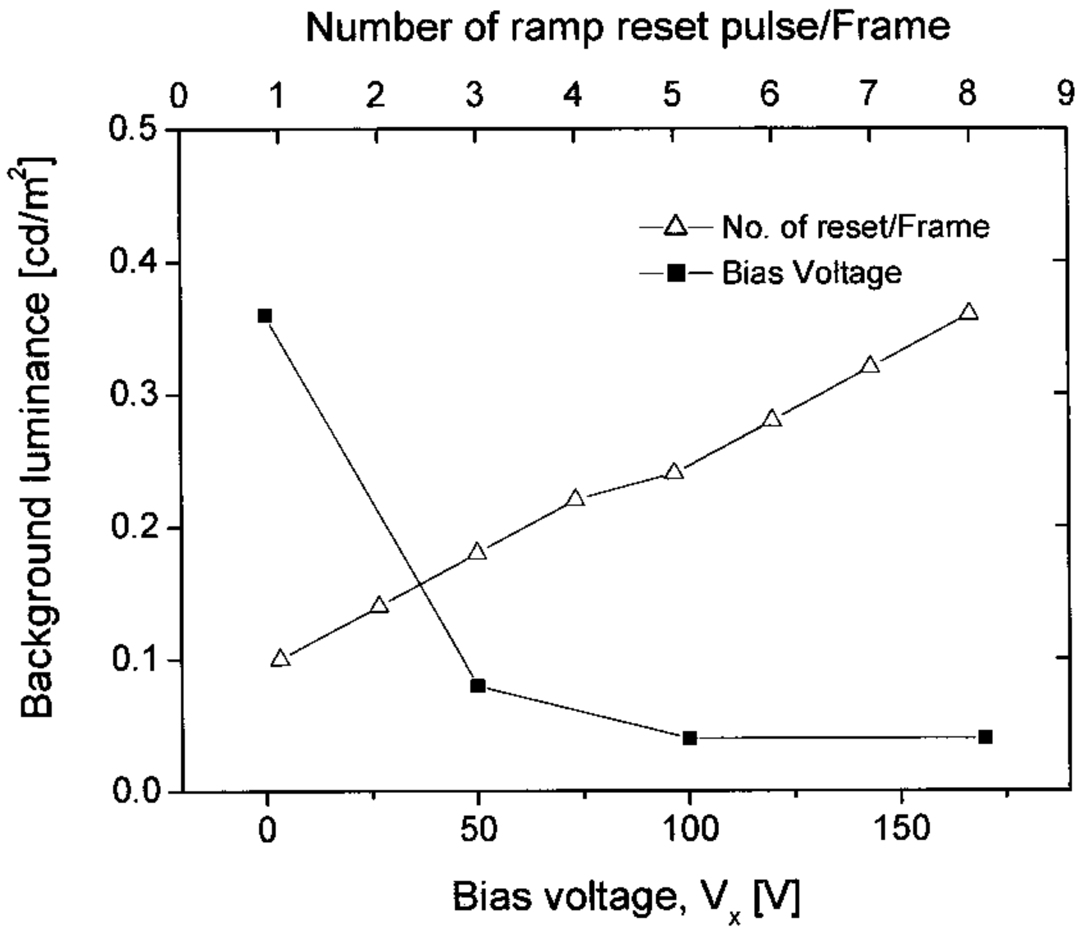



**Fig. 3.** Experimental results on background luminance according to bias voltage ($V_x$) and number of reset pulse per frame.

In the panel experiments, the contrast ratio was improved dramatically and it showed less background luminance than the only one ramp reset pulse per frame, as illustrated in Fig. 3 and this, in turn, brought about a high contrast ratio of more than 3000:1, which is the highest value reported and obtained from the one ramp reset per frame previously. [3] In Fig. 3, the background luminance according to the number of reset pulses per frame is shown and in this case, the minimum value was 0.1 cd/m$^2$ but if we apply the bias voltage ($V_x$), it can be reduced to 0.04 cd/m$^2$. Therefore, applying the bias voltage is regarded to be a more effective way of reducing background light and increasing the dark room contrast up to 7500:1, which can be simply calculated from the peak luminance (300 cd/m$^2$) and background luminance (0.04 cd/m$^2$).

We also adopted the MgO coating on the phosphor layer to improve the voltage margin characteristics which may be affected by the weakened discharges between scan and sustain electrode.

## 3. Results and Discussion

In general, there is a trade off relation between the voltage margin and contrast ratio according to the reset pulse. Therefore, if there are enough reset discharges before the addressing, the margin of address voltage is enlarged while the background light is intensified and contrast ratio is deteriorated. So, we need to optimise these two characteristics.

In these experiments, the contrast ratio was improved by applying the bias voltage to the sustain electrode during the ramp up period. However, the discharge occurred only between the scan and address electrodes and it was affected by the secondary electron emission characteristics of phosphor, which is worse than those of MgO. Therefore, the firing voltage seens to be increased and especially in the green cell, it is impossible to initialize the discharge cell at the normal reset voltage showing a narrow voltage margin.

To improve the address voltage margin as well as contrast ratio, we coated a very thin layer of MgO ~100Å on the phosphor layer by using the conventional electron beam evaporation method and investigated the contrast ratio and voltage margin characteristics as follows.

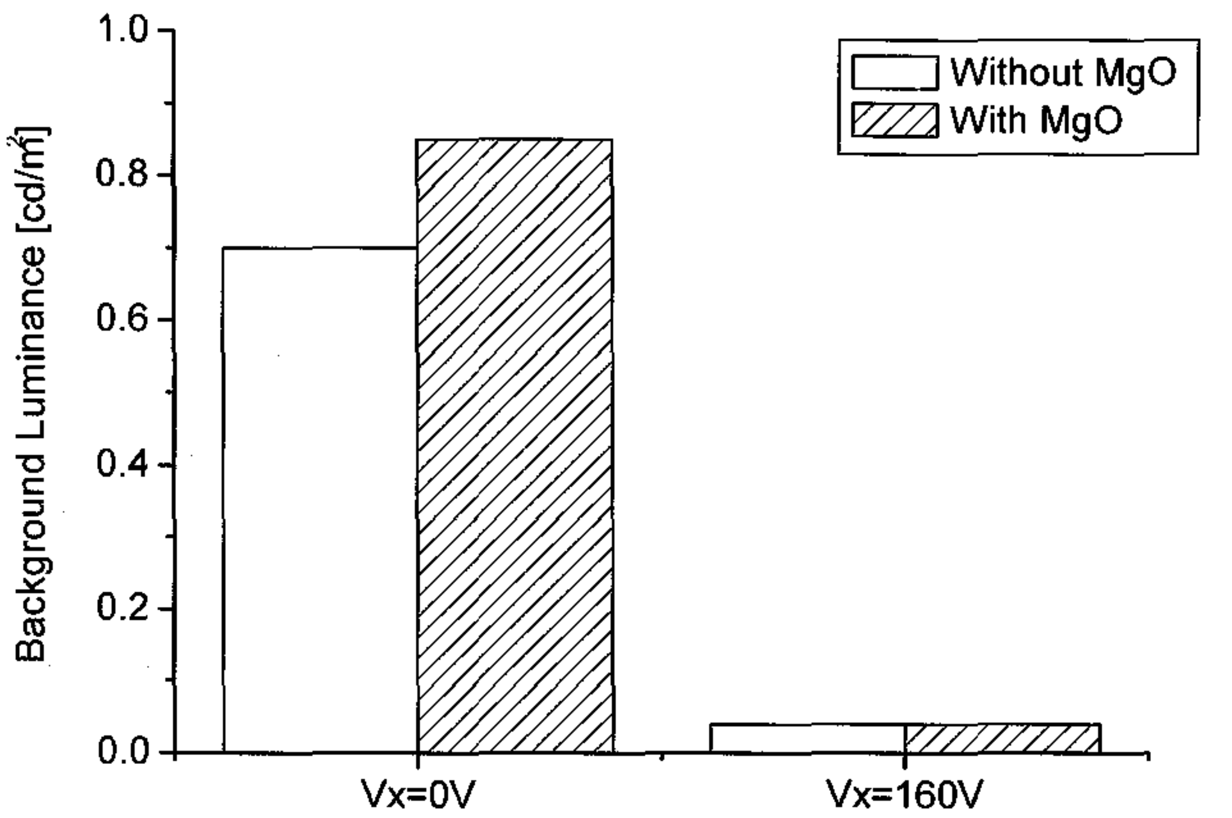
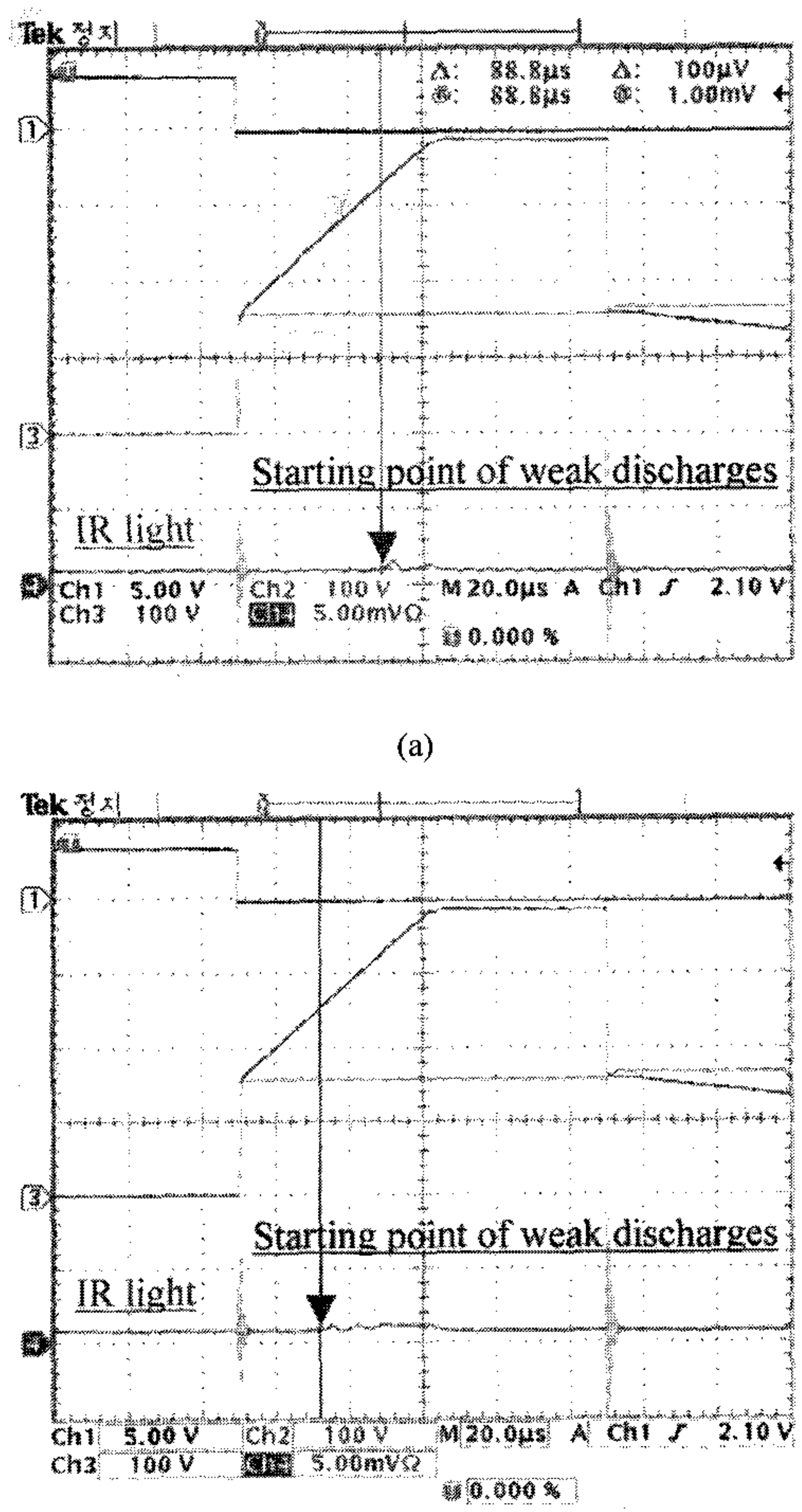



**Fig. 4.** Background luminance with respect to the bias voltage for the case where MgO was coated and another that is not on the phosphor layer.

### 3.1 Contrast ratio

As shown in Fig. 4, in case of $V_x$=0 V, the background luminance of MgO coated phosphor was slightly increased because the MgO coating on the phosphor layer enhances the discharges between scan and address electrodes, however, in the case of $V_x$=160 V, the background luminance of MgO coated phosphor was maintained at 0.04 cd/m$^2$. We do not have the relevant data to explain this phenomenon exactly but our assumption is that in case of $V_x$=160 V, the luminance of background was too low to detect with a photometer (BM7) and most of all discharges during the reset period occurred between scan and address electrodes. These can be blocked by the bus electrodes because it is widely known that the discharges between scan and address electrodes are initiated at the vicinity of bus electrode. [4] Therefore, the reduction in the background light was bigger than expected and in turn could achieve the same high contrast ratio of 7500 : 1 by applying the bias voltage even in MgO coated phosphor.




(a)

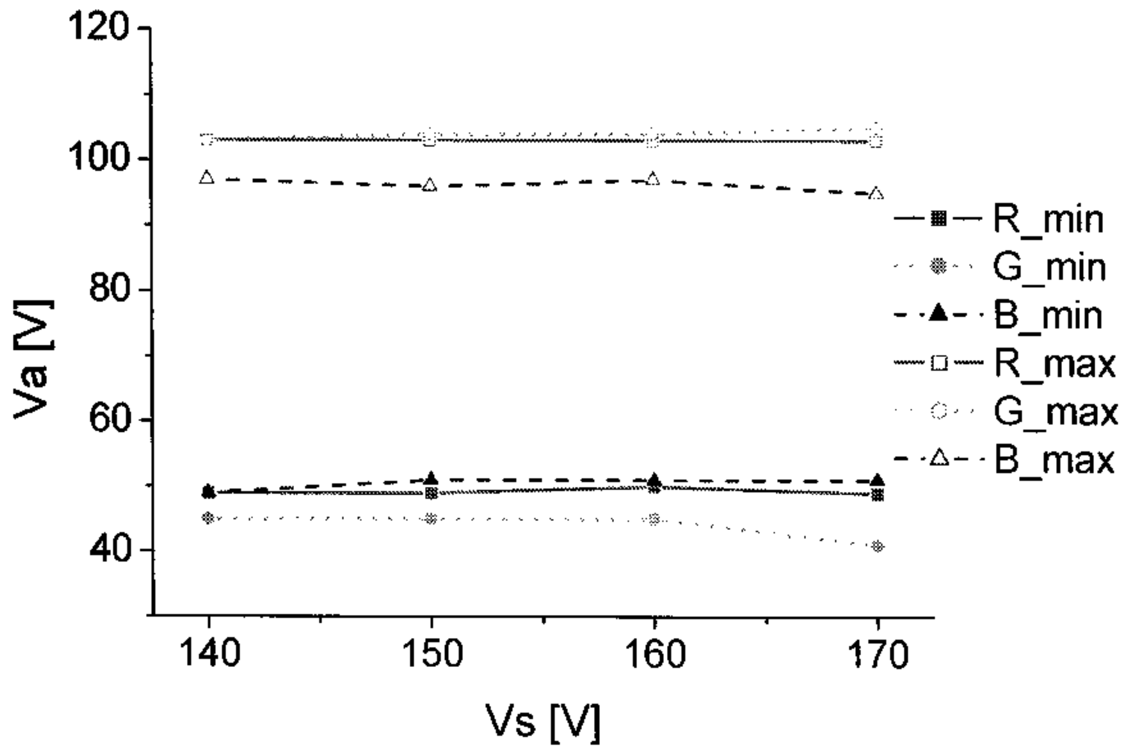
(b)

**Fig. 5.** Measurement of IR signal to confirm the effect of MgO coating on the discharge between scan and address electrode in case of $V_x$=160 V. (a) Without MgO coating on phosphor layer and (b) With MgO coating on phosphor layer.

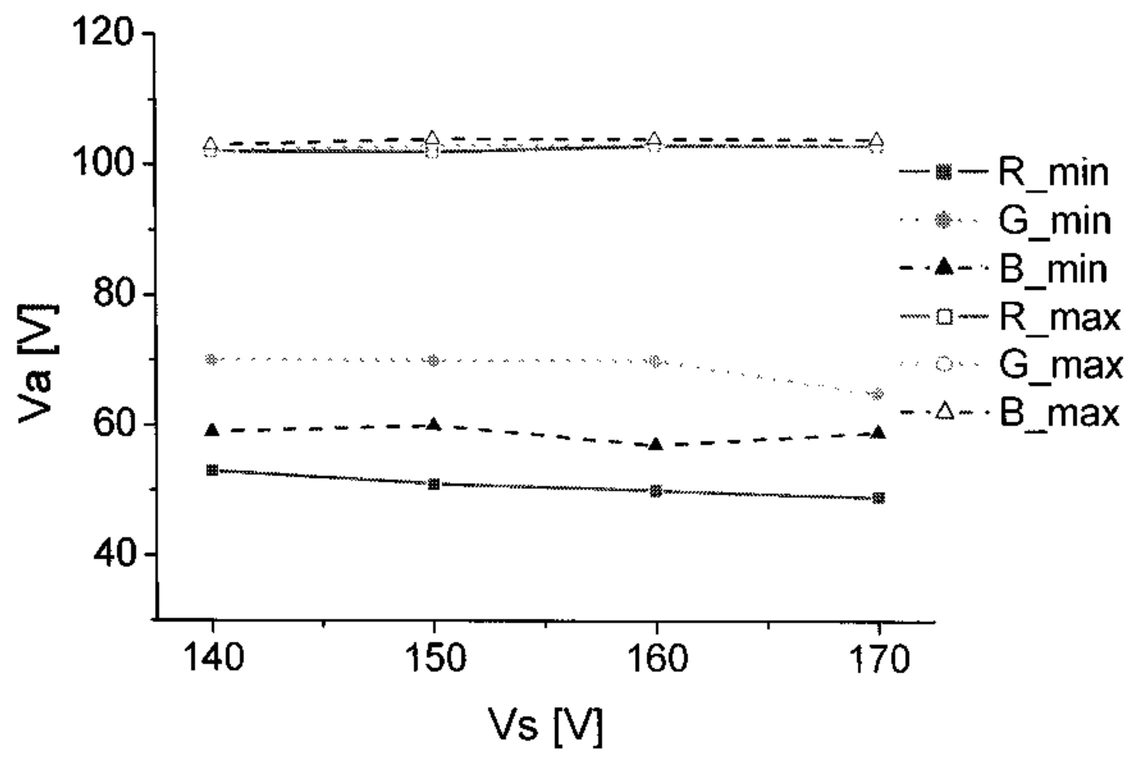
### 3.2 Driving voltage margin

To investigate the effect of MgO coating on the phosphor layer on voltage margin, we measured the dynamic voltage margin and compared the discharge characteristics during the reset period measuring the start point of discharge between scan and address electrodes.

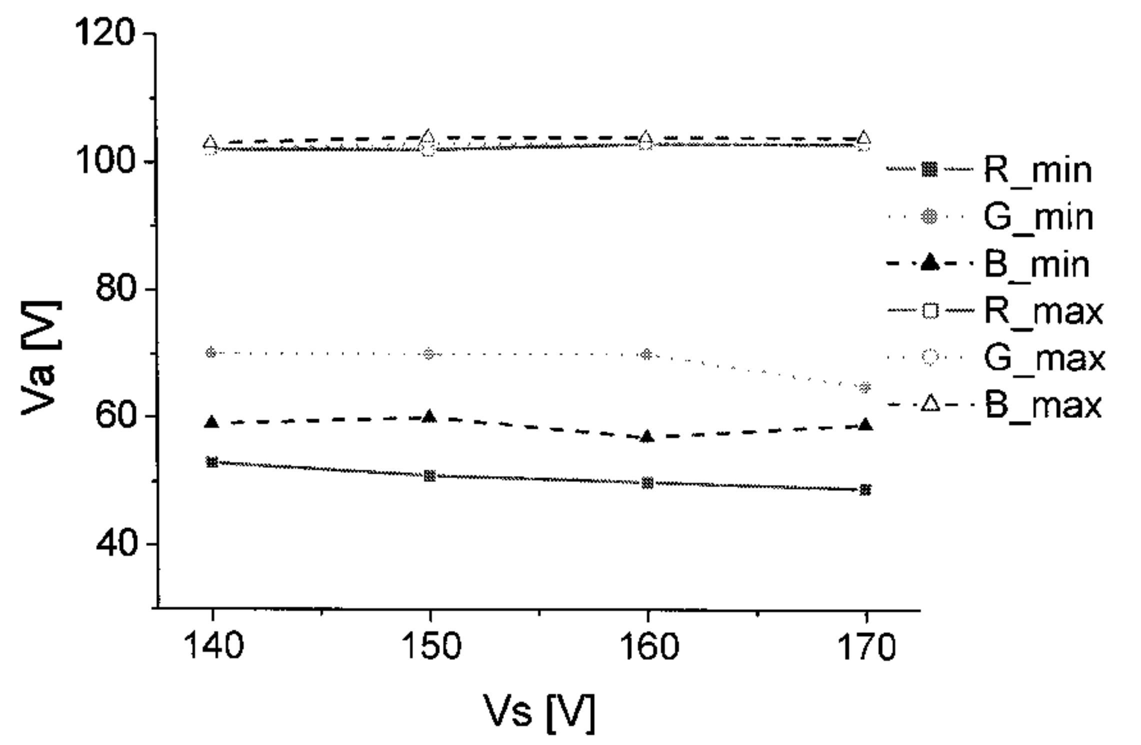
In Fig. 5, the IR (Infra Red) light output is measured by photodiode to detect the starting point of the discharge between scan and address electrodes and it shows weak discharge starting earlier in case of MgO coated phosphor because MgO coating is known to reduce the firing voltage between scan and address electrodes.




(a)




(b)




(c)

**Fig. 6.** Effect of MgO coating on the voltage margin (a) $V_x$=0 V and without MgO coating on phosphor layer, (b) $V_x$=160 V and without MgO coating on phosphor layer, and (c) $V_x$=160 V and with MgO coating on phosphor layer.

In Fig. 6, applying the bias voltage to sustain electrode reduced the address voltage margin especially in green cell from 59 V to 33 V, however in case of MgO coating on the phosphor layer, it is recovered to the same level of voltage margin compared to the conventional method.

With MgO coating on the phosphor layer in the back plate, the discharge between the scan and address electrodes starts at the lower voltage range and is able to accumulate enough wall charge between the scan and address electrodes, as shown in Fig. 5. As a result, it shows the same voltage margin (45 V at $V_s$=150 V) compared to the conventional case ( 45 V at $V_s$=150 V) in Fig. 6.

In general, it is known that the MgO layer absorbs the VUV (Vacuum Ultra Violet) light. Therefore if it is coated onto the phosphor layer, it reduces the brightness. However, since it is very thin in this experiment, it minimizes the reduction of brightness and ensures stable addressing regardless of the difference in the R, G, B cell, and in turn enhances the life time of panel, as shown in the previous work. [5]

## 4. Conclusion

A new modified ramp reset waveform is proposed to improve the dark room contrast ratio and a real black image is presented. In the new waveform, the discharges between the scan and sustain electrodes can be reduced by applying a positive bias voltage to the sustain electrode and only weak discharges between the scan and address electrodes are seen to occur during the reset period. As a result, the dark room contrast ratio was successfully obtained up to 7500 : 1.

We also adopted a MgO coated phosphor layer to improve the address voltage margin that was reduced when the bias voltage was applied in the modified ramp reset waveform. The address voltage margin of 45 V which is the same level of the conventional method was obtained.

Using this new modified ramp reset waveform, the real black image can be obtained even in a dark room, and without having to reduce the voltage margin.

## References

[ 1 ] Larry F. Weber, in Asia Display 98, (1998), p.15.

[ 2 ] Jeong Hyun Seo, Woo Joon Chung, Cha Keun Yoon, Joong Kyun Kim, and Ki-Woong Whang, IEEE Trans. Plasma Science, **29**, 824, (2001).

[ 3 ] T. Kurata, S. Masuda, M Kawachi, Y. Ito, T. Wakitani, USP6294875, (2001).

[ 4 ] C.H. Park, D.H. Kim, S.H. Lee. J.H. Ryu, and J.S Cho, IEEE Trans. Electron Devices, **48**, 1082, (2001).

[ 5 ] Chang Hoon Ha, Thesis of Master degree, Seoul National University, (2002).