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# Control of Initial Wall Charges for Multi-Luminance of an AC Plasma Display Panel

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A new driving waveform is proposed to control the initial wall charges for multi-luminance during the reset-period. The luminance levels are measured based on the variation in the initial wall charge under a constant sustain pulse condition in an AC Plasma Display Panel cell. To control the initial wall charges, We applied an auxiliary address pulse during wall charge generation and redistribution parts in the reset-period. As a result, we observed that the luminance levels could be varied under the same sustain pulse conditions within a luminance level ratio of one or two in the case of different initial wall charge conditions.

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## I. INTRODUCTION

A He-Ne-Xe plasma is produced in the micro-discharge cell of an alternate current plasma display panel (AC-PDP) provided that the gap voltage is greater than the breakdown voltage of the He-Ne-Xe gas [1]. In general, the luminance from the micro-discharge cell with the He-Ne-Xe gas mixture is proportional to the intensity of the gap voltage. The gap voltage is the sum of the external voltage applied to the electrodes plus the wall voltage induced by the wall charges accumulated in the cell [2]. Accordingly, the gap voltage increases if either the external voltage or the wall voltage increases. Thus, if the discharge is repeated only one or two times, the luminance may vary, depending on the various wall voltages, even if the external voltage remains constant. This means that different initial wall charges can produce different luminance levels in a PDP cell even under a constant external voltage condition. In the conventional PDP driving scheme, as the luminance level of the PDP is controlled by the pulse-number modulation method using the subfield in one TV-field so that the number of sustain pulses determines the gray level, the PDP-TV has a linear electro-optical transfer characteristic [3]. Generally, the luminance level of the second subfield should be twice that of the first subfield due to the difference in the sustain pulse number. However, the luminance level is not a linear electro-optical transfer characteristic in the conventional driving scheme, especially in the low gray level as in the first subfield with one or two sustain pulses, because the luminance due to the reset and the address discharges is included with the sustain discharge. For example, if the luminance applying one sustain pulse is 1 cd/m$^2$, whereas the luminance applying the reset and the address pulses is 1 cd/m$^2$, when the first subfield has 2 sustain pulse and second subfield has 4 sustain pulse, the total luminance in the first subfield is 3 cd/m$^2$ and that in the second subfield is 5 cd/m$^2$. Actually, the luminance difference between the first and the second subfields is not a factor of two. On the other hand, in the high gray level, such as the seventh or eighth subfield, the luminance difference between the seventh and the eighth subfields is almost a factor of two due to the large number of the sustain pulses. This luminance level deteriorates the low gray level expression.

It was reported that the auxiliary pulse controlled the wall charge and the luminance level during the sustain-period [4-6]. In the current paper, two kinds of multi-luminance methods were proposed to control wall charges and to improve the low gray-scale expression using the auxiliary address pulse during the reset-period. The luminance levels are measured based on variations in the initial wall charge under a constant sustain pulse condition in the AC-PDP cell.

## II. EXPERIMENT

Figure 1 shows the ADS driving scheme for 1 TV-field (a) and conventional driving waveform composed of reset-, address-, and sustain-periods during the first subfield (b). To control expression of the first gray level, the address pulse is not applied from the second to eighth subfield. As with the other driving conditions, an address

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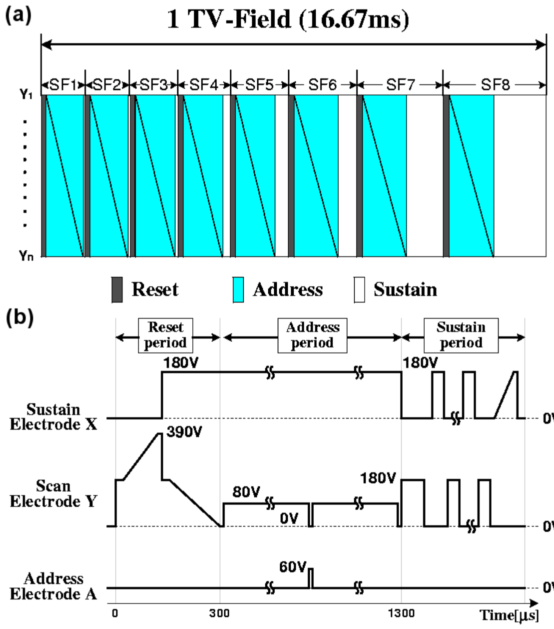


Fig. 1. (a) ADS driving scheme for 1 TV-field and (b) conventional driving waveform composed of reset-, address-, and sustain-periods during the first subfield.

pulse width of 2 $\mu$s and sustain frequency of 200 kHz are used.

Figure 2 shows the wall voltage variation between the scan and the address electrodes (a) using the wall charge distribution model (b) during reset- and address-periods in the case of a conventional driving waveform. First, it was assumed that the wall voltages among the three electrodes were zero. Though the scan Y voltage increases up to 180 V, the discharge is not induced because the firing voltage is over 190 V. In Fig. 2(a)-(ii), as the scan Y voltage increases from 180 V to 390 V, a weak discharge is induced, and wall charges are accumulated on each electrode due to the rising-ramp waveform. At the end of the rising-ramp waveform, the wall voltage between the scan Y and the address A electrodes becomes 200 V. In step (iii), though the external sustain X and scan Y voltages change abruptly, the wall voltage and wall charge distribution do not change due to insufficient gap voltage, which is the sum of the external and the wall voltages, to produce discharge. From the third to fourth step, the wall voltage between the sustain X and the scan Y electrodes becomes zero whereas the wall voltage between the scan Y and the address A electrodes becomes 190 V [7]. As the wall voltage between the sustain X and the scan Y electrode has to become zero to prevent misfiring the discharge during the sustain-period, the driving waveform of the sustain X and scan Y cannot be altered. Therefore, as the wall voltages are determined by the external voltages between the scan Y and the address A electrodes, the variation in the amplitude of the auxiliary address voltage at the rising and falling-ramp waveforms during the reset-period can control the

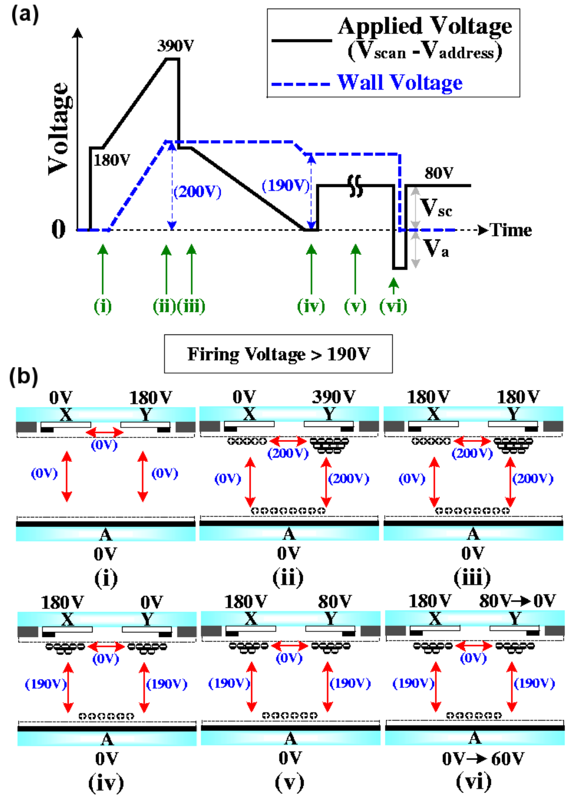


Fig. 2. Applied and wall voltage variation between scan and address electrodes (a) using the wall charge distribution model (b) during reset- and address-periods in the case of conventional driving waveform.

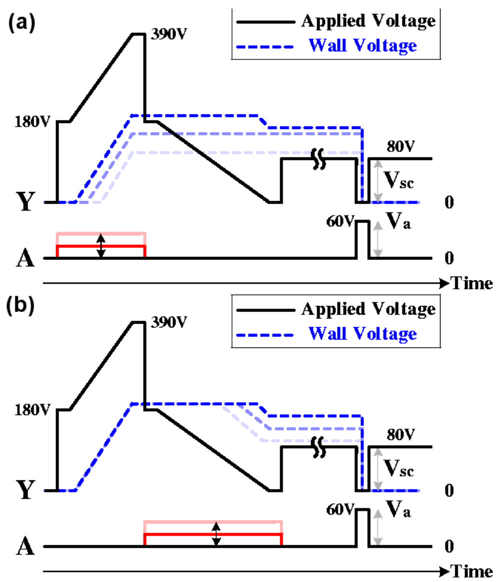


Fig. 3. Method for controlling the wall charge when a positive address pulse is applied to the address electrode during (a) wall charge generation and (b) wall charge redistribution.

wall charges before the address-period. When the scan and address pulses are applied to the electrodes simul-

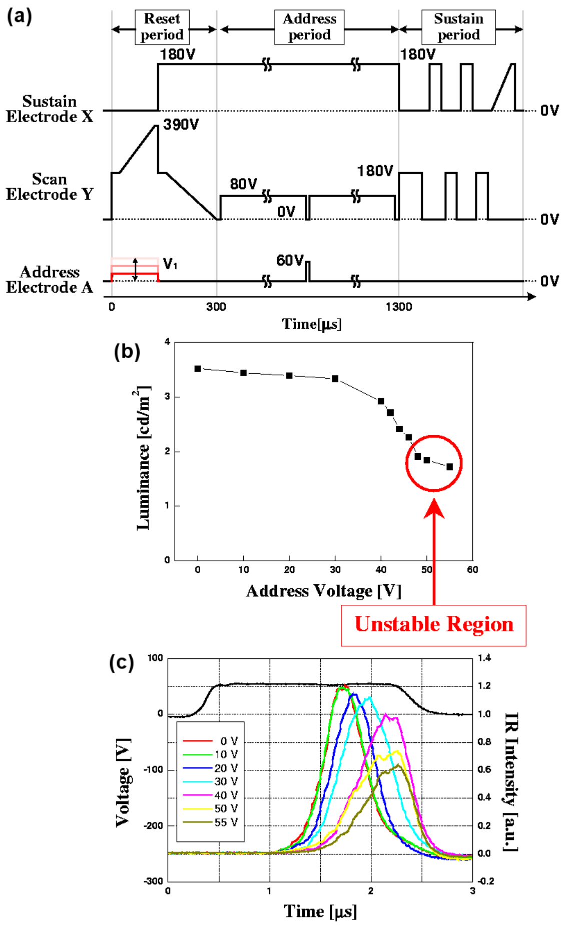


Fig. 4. (a) Driving waveform applied to the auxiliary address pulse during wall charge generation to control wall charges for the address discharge in the first subfield when the auxiliary and the address pulses are not applied in the other subfields and the changes in the (b) luminance and the (c) IR waveform with increasing amplitude of the auxiliary address pulse.

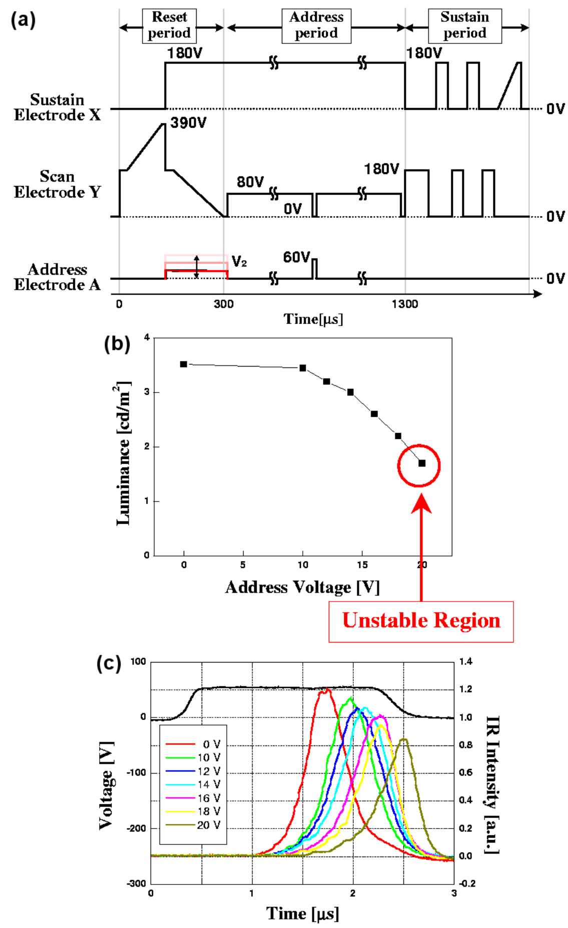


Fig. 5. (a) Driving waveform applied to the auxiliary address pulse during wall charge redistribution to control wall charges for the address discharge in the first subfield when the auxiliary and address pulses are not applied in the other subfields and the changes in the (b) luminance and the (c) IR waveform with increasing amplitude of the auxiliary address pulse.

taneously, the address discharge can be produced by the accumulated wall charges, as shown in Fig. 2(a)-(vi). Since this address discharge intensity, which is controllable by the previous wall charge condition, also affects the sustain discharge, the luminance level can be varied by the initial wall charge under a constant sustain pulse condition.

For a conventional driving waveform, the reset-period is composed of wall charge generation and redistribution. By controlling the wall voltage levels in wall charge generation and redistribution, the address discharge intensity and the luminance level can be controlled. When a positive address pulse is applied to the address electrode during wall charge generation [Fig. 3(a)] and wall charge redistribution [Fig. 3(b)], the wall charges can be controlled. In this experiment, the luminance and the infrared waveform were measured with increasing in the amplitude of the auxiliary address voltage during wall charge generation and redistribution when the first gray level, *i.e.*, the first subfield, was selected.

## III. RESULTS AND DISCUSSION

Figure 4(a) shows the driving waveform applied to the auxiliary address pulse during wall charge generation to control wall charges for the address discharge in the first subfield whereas the auxiliary and address pulses are not applied in the other subfields. Figures. 4(b) and (c) indicate the changes in luminance and IR waveform, respectively, with increasing amplitude of the auxiliary address pulse. As the amplitude of the address voltage increases, the luminance and the IR intensity tend to decrease. However, an unstable discharge region was found because of insufficient wall charges to produce an address discharge.

Similarly, the auxiliary address pulse was applied during wall charge redistribution, as shown in Fig. 5(a). As the amplitude of the address voltage increases, the luminance and the IR intensity also tend to decrease and an unstable discharge region was found [Fig. 5(b), (c)].

These two kinds multi-luminance methods suggest an improvement in the low gray-scale expression by controlling wall charges without increasing the number of subfields. In addition, this luminance control method is suitable not as a cell-by-cell method, but as a column-by-column method, in address cells.

## IV. CONCLUSION

The luminance levels could be varied under the same sustain pulse conditions within a range of the luminance-level ratio of about one to two luminance level ratio when different initial wall charge conditions were used. This kind of multi-luminance is quite useful for improving low gray-scale expression, which is one of the critical issues for the realization of a high-quality image AC-PDP.

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