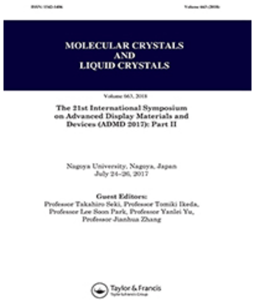

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Modified driving waveform for improving write discharge characteristics in open dielectric structure of AC PDP

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ABSTRACT
The modified driving waveform is proposed to improve the characteristic of the write discharge in the open dielectric structure of the AC type plasma display panel. An open dielectric is a structure in which the sustain discharge is more easily generated by removing the dielectric layer between the electrodes of the upper plate in order to increase the luminance of the AC PDP. Though the sustain discharge easily occurs when the conventional driving method was used for the open dielectric, the characteristic of the writing discharge was relatively poor. Previous studies have suggested a method to improve the characteristics of the write discharge, but it has been disadvantageous in that an excessive reset discharge due to a high voltage causes a low contrast ratio and a high voltage was applied in the negative direction. In this study, threshold voltage (Vt) closed curves of conventional and open dielectric structures were measured and the wall voltage vector inside the cell was analyzed by the applied driving waveform. Based on these results, the modified driving waveform is proposed to improve the write discharge characteristics. Compared with the conventional driving waveform, the write discharge delay time is shortened by about 0.3 μm in each write pulse.

KEYWORDS
AC PDP; discharge delay time; driving waveform; luminance; open dielectric

1. Introduction

Nowadays, the AC type plasma display is on the decline due to the manufacturer's policy, but it has many advantages such as easy manufacturing for large screen, fast response speed, natural color, and so on. However, there were some fatal disadvantages, especially the big problem being low luminance [1]. In order to increase the luminance in the AC PDP, it was possible to increase the number of sustain pulses or increase the voltage, but there was a problem of lowering of power consumption and heat generation. To date, numerous studies have been conducted to improve the material, optimize the discharge gas, modify the driving method, and change the panel structure [2, 3]. Among them, the most effective structure for increasing the luminance was an open dielectric structure [4]. Generally, two electrodes are arranged side by side on the upper plate of AC PDP, and one electrode on the lower plate is arranged vertically with two electrodes of the upper plate. One electrode of the upper plate

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and the electrode of the lower plate serve to select the cell by applying the pulses during the writing period, while the discharge caused by the voltage application on the electrode of the upper plate produces light during the sustain period [5]. Therefore, the increase in luminance depends largely on the intensity and the number of discharges generated between the two electrodes on the upper plate. As mentioned above, in general, when the number of pulses applied to the two electrodes in the upper plate is increased or the voltage is increased, the brightness is increased but another problem occurs.

Below the two electrodes of the upper plate is a dielectric layer, which serves to protect the electrodes from strong plasma discharges. Since the dielectric layer is flatly coated, the electrodes of the upper plate are arranged in parallel without facing each other, so that the discharge between the two electrodes does not occur directly but occurs as a surface discharge in the space of a cell. If some of the dielectric between the electrodes of the upper plate is removed, the discharge will be occurred directly between the electrodes and the brightness will be improved. The open dielectric structure is advantageous in increase of luminance during the sustain period for generating light, but when the conventional driving waveform is applied, a phenomenon different from the conventional one occurs during a reset period for rearranging the wall charges of the cell and the write period for selecting the cell. Specifically, as compared with the surface discharge of the conventional structure, in the open dielectric structure, since the discharge start voltage between the electrodes on the upper plate is lowered, most of the discharge will occur only between the electrodes of the upper plate and it will be difficult to accumulate the wall charge on the lower plate during a reset period. If the amount of the wall charges accumulated on the electrode of the lower plate is reduced, the discharge for selecting the cell during the write period becomes difficult and also the light cannot be generated in the sustain period.

In order to solve these problems, the modified driving method in the previous study had been reported, but the brightness of the black screen was increased by the high applied voltage and the contrast ratio was lowered. In addition, the unnecessarily high scan voltage had to be applied in the negative direction to improve the write discharge [6]. In this study, the conventional and open panel structures are described, and a threshold voltage closed curve (Vt closed curve) is used to investigate the discharge start voltage in each cell. The Vt closed curve is two-dimensionally drawn by measuring the discharge start voltage among three electrodes [7]. Then, when the voltage is applied in each period of the AC PDP, the applied voltage vectors are displayed on the measured Vt closed curve when the voltage is applied in each period of the AC PDP and the corrected driving waveform is presented by investigation and analysis of the problem when the conventional driving waveform is applied to the open panel structure.

2. Open dielectric structure

The cross-sectional view of the 42-inch AC PDP used in this experiment and the panel specifications are shown in Fig. 1 and Table 1. Figure 1 shows a cross-section of a conventional panel structure with three electrodes – the sustain (X) and scan (Y) on the upper plate and the write (W) on the lower plate (a) and an open dielectric structure with the dielectric is removed between the two electrodes of the upper plate (b). The sustain and scan electrodes X and Y on the upper plate are arranged in parallel and the write electrode A on the lower plate is arranged in the vertical direction with the two electrodes of the upper plate, and the barrier rib between the cells were omitted from this figure. Since the surface discharge occurs between the X and Y electrodes during the time when light is generated in the AC PDP, the

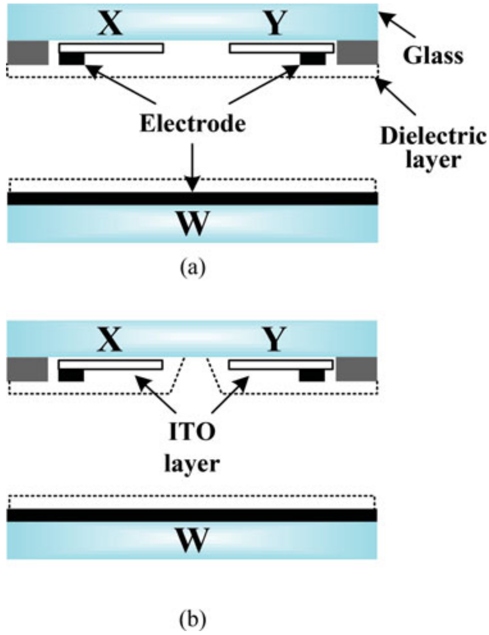


Figure 1. Schematic diagram of conventional (a) and open dielectric structures (b) in one cell of 42 inch AC PDP.

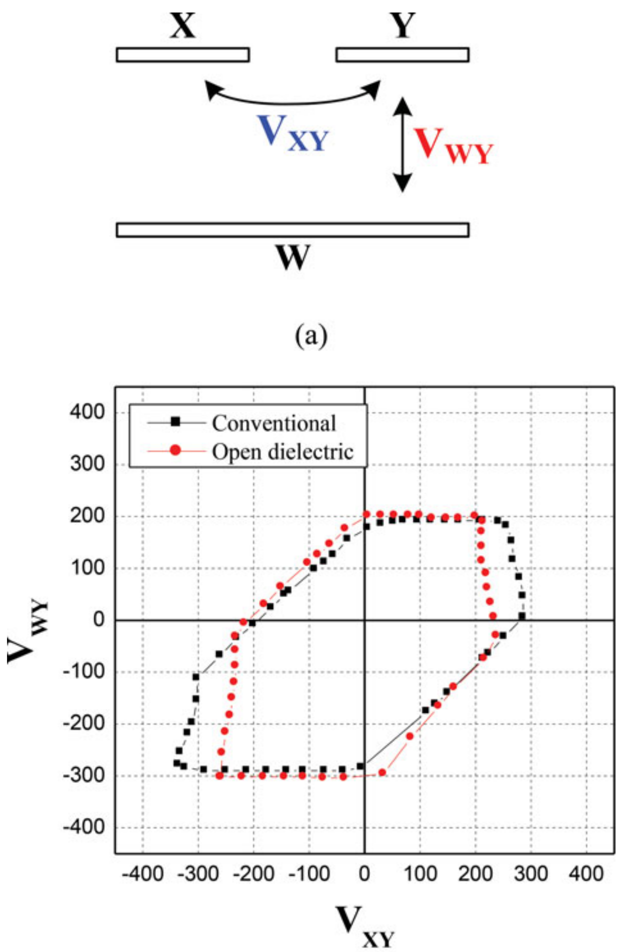
electrodes of the upper plate may be damaged by the generation of strong plasma in the discharge space, so that the electrodes are not directly exposed to the discharge space but protected by a dielectric layer. After the plasma discharge occurs, the VUV excites the phosphors of the lower plate, generating light and seeing light passing through the dielectric and glass. However, although the transparent dielectric is used, the visible light may be reduced and the two electrodes of the upper plate are arranged in parallel without facing each other, so that the sustain discharge is not generated directly but occurs with a surface discharge form in the cell. In order to overcome the disadvantages of the conventional structure, the dielectric is removed from the portion where there is no transparent electrode (ITO) between the two electrodes, so that the discharge is occurred near the discharge as shown in Fig. 1(b). In the conventional structure, since the entire area is covered with the dielectric between the X and Y electrodes, the sustain discharge does not occur directly but spreads in the space. However, in the open dielectric structure of Fig. 1(b), the dielectric between the two electrodes on the upper plate is removed by about 60 μm and the other conditions are the same as the conventional structure. Therefore, in the open dielectric structure, the discharge between the X and Y electrodes will be occurred directly. In the conventional structure, when a voltage is applied to the X and Y electrodes of the upper plate during the sustain period, the discharge are not directly produced due to no facing each other, so a high voltage is needed to generate a discharge. However, since an open dielectric structure is close to a triggering portion, the

Table 1. Specification of AC PDP used in experiment.

Upper plate (μm)		Lower plate (μm)	
Sustain electrode width	110	Write electrode width	150
ITO width	360	Barrier rib width	60
ITO gap	85	Barrier rib height	120
Ne-Xe (15%) gas mixture			

discharge start voltage becomes low because the discharge is easy to occur. On the other hand, due to the low discharge starting voltage, the production of discharge between the two electrodes on the upper plate is easier than in the conventional case, resulting in various problems such as production of a misfiring discharge or induction of a high write voltage.

To investigate the state of a cell inside a new panel, a threshold voltage (Vt) closed curve measurement method is commonly used. Since the Vt closed curve is a curve measuring the discharge start voltage between the three electrodes in two dimensions, the level of the horizontal and vertical axis means the voltage difference between the other electrodes based on one electrode. Here, since the Y electrode is the reference, the voltage difference from the X electrode is horizontal axis, whereas the voltage difference from the W electrode is the vertical axis. That is, the horizontal axis indicates the voltage difference between X and Y electrodes, whereas the vertical axis indicates the voltage difference between W and Y electrodes. Among the three electrodes, the discharge start voltage between two electrodes are measured, and the point indicated by the figure is connected to the threshold voltage closed curve. Figure 2(a) shows the name of the voltage difference among three electrodes, where V_{XY} is the discharge



(b)

Figure 2. (a) Name of voltage between three electrodes. (b) Vt closed curve measured in conventional and open dielectric structure.

start voltage between the X and Y electrodes, and V_{WY} is the discharge start voltage between the W and Y electrodes. Figure 2(b) depicts the Vt closed curves measured in conventional and open dielectric structures, respectively. The positions of the upper and lower dots on the Vt closed curve measured in conventional and open dielectrics are almost similar, but the dots on the left and right of the open dielectric are located further inside. This means that the discharge start voltage between the W and Y electrodes in the open dielectric structure is similar to that of the conventional one, but the discharge starting voltage between the X and Y electrodes is lower. That is, by removing the dielectric between the X and Y electrodes of the upper plate, it is possible to more easily produce the discharge at a low voltage, but the discharge start voltage with respect to the W electrode is not greatly different.

3. Analysis of Vt closed curve

Figure 3 shows the conventional driving waveform applied to the three electrodes used in this experiment. The AC PDP combines the gradations divided into several sub-frames during one TV frame time to display the luminance. Each sub-frame is divided into the reset, write and sustain periods. The reset period serves to remove the wall charges or priming particles accumulated in the cells by the high applied voltage and to accumulate the wall charges on the three electrodes for generating the write discharge. In the write period, the scan waveform are applied to the Y electrode while a high voltage is applied to the X electrode, and the write discharge is generated when a selective write pulse is applied to the A electrode. When a write discharge is produced, wall charges are accumulated inside the cell. Thereafter, when square waveforms are alternately applied to the X and Y electrodes during the sustain period, the light is generated by strong plasma discharge.

Figure 4 shows the applied and wall voltage vectors when the waveform is applied during the reset period on the measured Vt closed curve. The applied voltage refers to the voltages applied from the external circuit as the voltages in Fig. 3, and the wall voltage means the voltage acting between the electrodes due to the generation of wall charges inside the cell. In the conventional driving waveform shown in Fig. 3, since a high voltage is applied to the Y electrode in the form of a rising ramp waveform, the voltage vector is drawn from the position 0 to the lower left direction in the Vt closed curve of Fig. 4 (red line). In the conventional structure of Fig. 4(a), the wall charges are accumulated by the weak discharge between W and Y electrode, and the voltage vector moves to the lower left of the Vt closed curve (blue

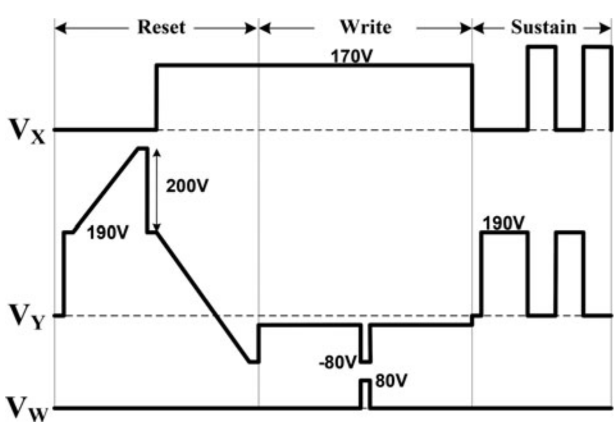


Figure 3. Conventional driving waveform used in experiment.

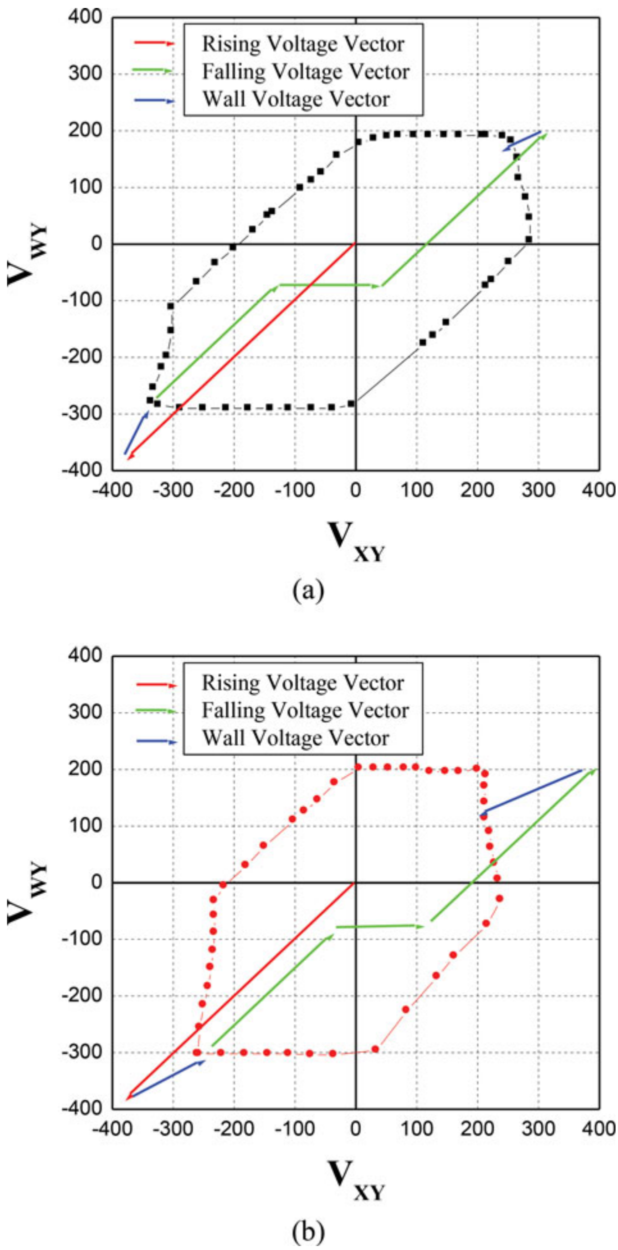


Figure 4. Applied and wall voltage vectors during reset period on measured Vt closed curves: (a) conventional, (b) open dielectric structure.

line) [8]. On the other hand, in the open dielectric structure of Fig. 4(b), since the discharge start voltage between the electrodes on the upper plate is lower than the conventional one, the discharge occur first between the X and Y electrodes and the wall voltage vector moves to the lower left side. Thereafter, when a negative ramp waveform is applied to the Y electrode during the reset period and a positive voltage is applied to the X electrode, the voltage vector shifts to the upper right direction (green line). Comparing the last section of the negative ramp waveform in Fig. 4, it can be found that the wall voltage position in the case of the open dielectric structure is lower than that of the conventional structure. Since the waveform is applied to the W and Y electrodes during the write period, it is necessary to be near the upper right corner of the Vt closed curve to easily generate the write discharge. However, as the position of the wall voltage in the open dielectric is low, the characteristic of the write discharge will be deteriorated and the discharge will be failed in the sustain period in which the light is generated. Therefore, the address discharge should normally occur when the same scan and write pulse is applied until the last wall voltage position is shifted to a position similar to the conventional one during the reset period.

In the open dielectric structure, a proper bias voltage is applied to the X electrode in order to prevent of an excessive surface discharge during the reset period and to generate the discharge first between the W and Y electrodes because the discharge start voltage between the electrodes on the upper plate is lower. As shown in Fig. 5(a), in the condition of the open dielectric structure, 80 V is applied to the X electrode during the rising ramp period of the Y electrode. Thereafter, in order to prevent excessive discharge between the X and Y electrodes

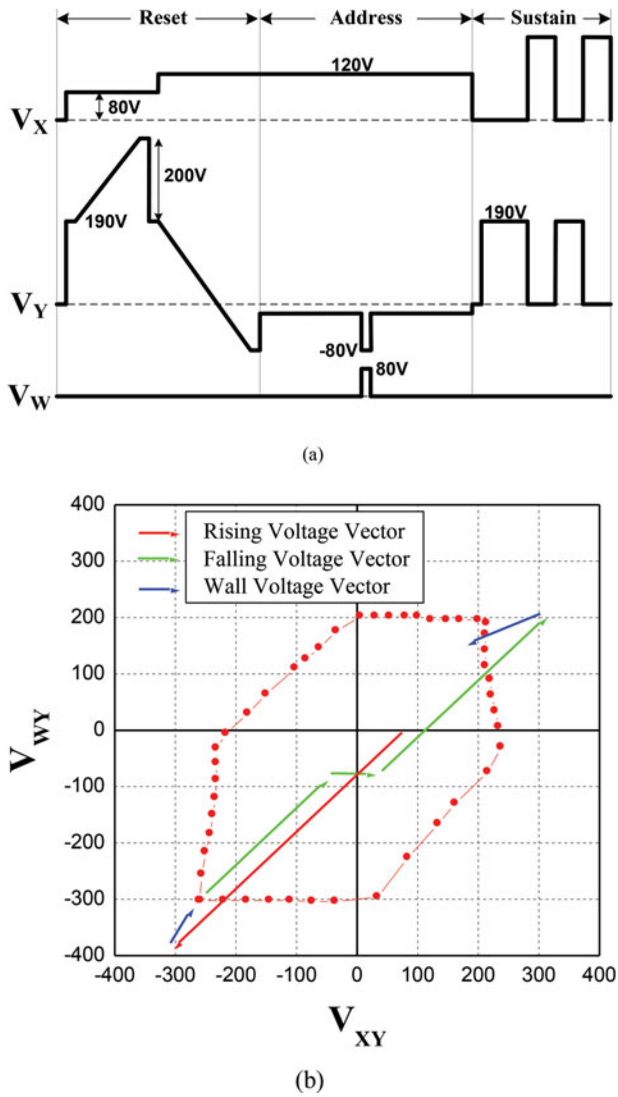


Figure 5. Modified driving waveform to improve write discharge (a) and applied and wall voltage vectors during reset period on measured Vt closed curve (b).

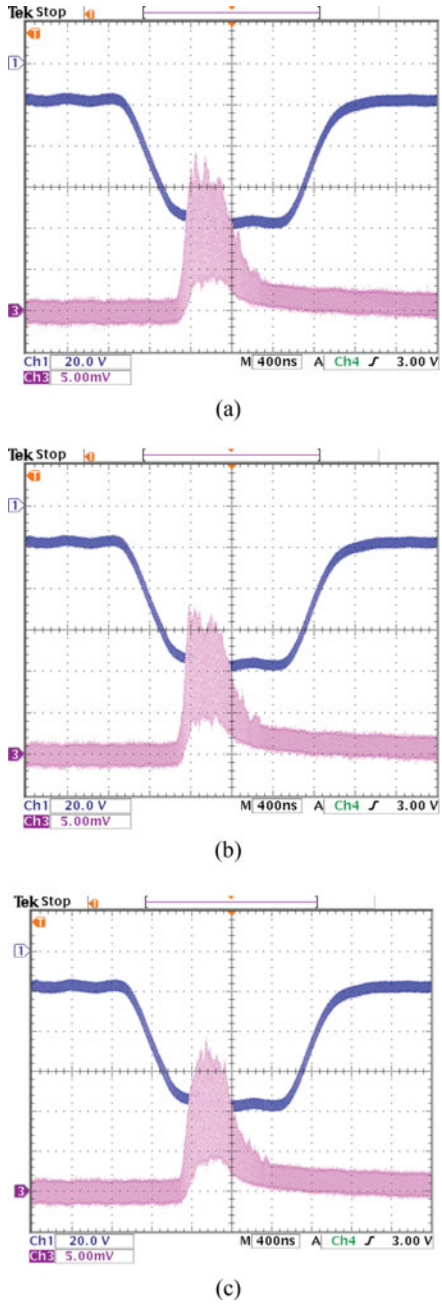
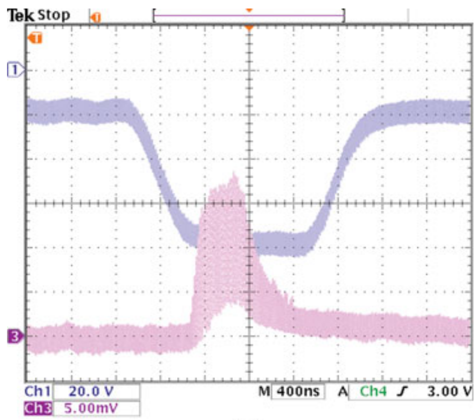
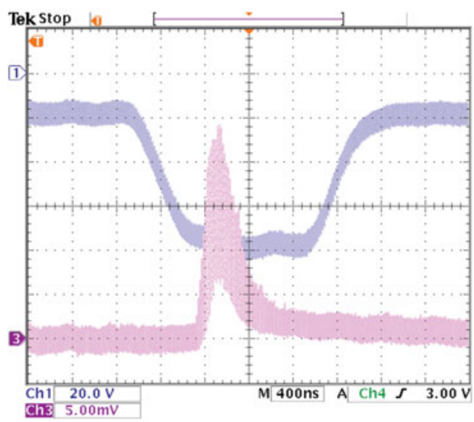


Figure 6. Measured scan and optical waveforms during write period when voltage on X electrode changes from 0 to 80 V during reset period: (a) 0 V, (b) 40 V, and (c) 80 V.

during the falling ramp period of the Y electrode, the voltage of the X electrode is lowered than the conventional voltage. Figure 5(b) shows the direction of the voltage vector when the driving waveform of Fig. 5(a) is applied to the open dielectric structure. Since the voltage of 80 V is first applied to the X electrode, the initial position is shifted to the right. After that, the voltage vector is drawn in the lower left direction by the rising ramp waveform and the reset discharge is occurred first between the W and Y electrodes. Therefore, the wall charges will normally be accumulated similar to the conventional one. Since the voltage of the X electrode is low while the falling ramp waveform is applied to the Y electrode, the voltage vector moves to the right side less than that of the conventional waveform. Comparing with Fig. 4(b), it can be seen that the position of the last wall voltage is raised much.



(a)



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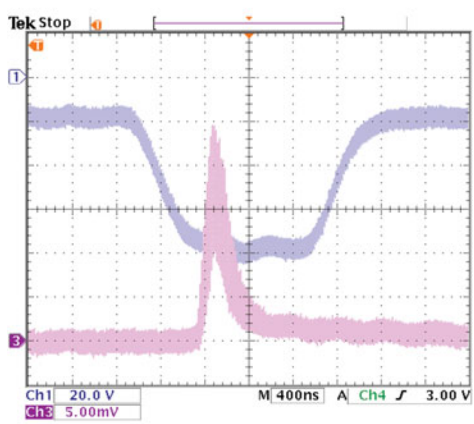

(c)

Figure 7. Measured scan and optical waveforms during write period when voltage on X electrode changes from 170 to 120 V during reset and write period: (a) 170 V, (b) 145 V, and (c) 120 V.

4. Measured optical waveform

Figure 6 shows the measured scan and optical waveforms during the write period when the voltage of the X electrode changes from 0 to 80 V at the time of applying the rising ramp waveform on the Y electrode during the reset period. When the voltages of the X electrodes were 0, 40, and 80 V, scan and optical waveforms were measured during the writing period. The write discharge was not greatly changed by the voltage applied to the X electrode during the reset period. However, as shown in Fig. 5, when a rising ramp waveform was applied to the Y electrode during the reset period, an excessive discharge between the X and Y electrodes was prevented by the voltage applied to the X electrode and discharge between the W and Y electrodes were occurred first. Therefore, the reset discharge was stabilized and the brightness of the black color could be lowered.

Figure 7 shows the measured scan and optical waveforms during the write period when the voltage of the X electrode changes from 170 to 120 V during the reset and write period. When the voltages of the X electrodes were 170, 145, and 120 V, respectively, the scan and optical waveform were measured during the write period. As the voltage applied to the X electrode decreased during the reset and write period, the write discharge occurs more quickly and the intensity was improved. As shown in Fig. 5(b), it is confirmed that the discharge was improved even under the condition of the same write voltage, because the position of the last wall voltage vector rose to the upper side compared with the conventional Fig. 4(b). The delay time of the write discharge was shortened by about 0.3 µm from 1.2 µm to 0.9 µm in one write pulse.

5. Conclusions

In the AC type plasma display, when the conventional driving waveform was applied to the open dielectric structure, the write discharge characteristic was lowered compared with the conventional structure. The reason was that an excessive discharge was occurred between the electrodes on the upper plate during the reset period because the discharge start voltage between the X and Y electrodes on the upper plate was decreased and wall charges were not accumulated on the W electrodes. Therefore, the magnitude and waveform of the voltage should be modified to accumulate the wall charge normally inside the cells of the open dielectric structure. A voltage was newly applied to the X electrode during applying the rising ramp waveform of the reset period on the Y electrode, and the lower voltage than that of the conventional voltage was also applied during the falling ramp waveform on the Y electrode. As a result, it was possible to shorten the discharge delay time per write pulse by about 0.3 µm and improve the discharge intensity.

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