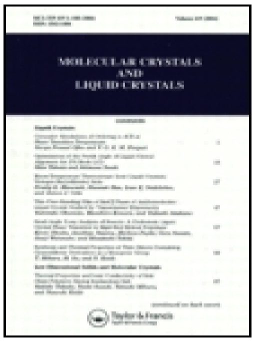
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Effects of Gas Pressure on Temporal Image Sticking in AC Plasma Display Panel

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The temporal dark and bright image sticking phenomenon was examined under various gas pressures in a 42-in. ac-PDP with an He(35%)-Xe(11%)-Ne gas composition. To study the temporal dark and bright image sticking phenomena for various gas pressures, the displayed luminance, IR emission profile, disappearing time, color temperature, panel temperature, and Xe and Ne ions density of temporal dark and bright image sticking were measured relative to the gas pressure. With a decrease in the gas pressure, the temporal bright image sticking was observed to be reduced due to the reduction of the ion bombardments onto the phosphor layer.

Keywords Temporal image sticking; gas pressure; color temperature; panel temperature; luminance; ion bombardment; IR emission; 2-D fluid model

1. Introduction

Plasma display panel is considered to be a suitable device for the flat panel device for digital high definition television. However, the realization of a high-quality plasma display panel (PDP) requires an urgent solution to the problems of image sticking and image retention induced in the PDP cells when strong sustain discharges are repeatedly produced during a sustain period. When the appearance time of the ghost image is relatively short, such a temporal image sticking is also referred to as image retention. Although the iterant strong sustain discharge during a sustain-period is known to induce an image sticking problem, the image sticking phenomenon is not still fully understood [1–4]. As such, this paper investigates on the effects of the temporal dark and bright image sticking under various gas pressures in 42-in. ac-PDP with a He (35%) – Xe (11%)—Ne gas composition. Our experimental observations reveal that the gas pressure can have a significant influence on the temporal image sticking. Accordingly, this paper explores the relation between the temporal dark and bright image sticking and the gas pressure. In particular, the changes in the ion density in the vicinity of the address electrode relative to the gas pressure are examined in order to investigate the influences of the ion bombardment on the temporal bright image sticking.

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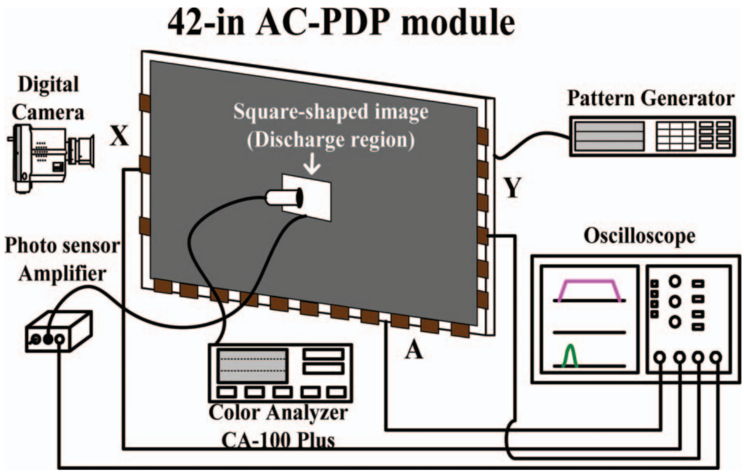


Figure 1. Schematic diagram of experimental setup employed in this study.

2. Experimental Setup

Figure 1 shows the commercial 42-in AC-PDP module with a high definition grade, and the measurement system employed in this study. The color analyzer (CA-100 Plus) and photo-sensor amplifier (Hamamatsu C6386) were used to measure the changes in the luminance, color temperature and IR (infrared) emission during a reset-period and sustain-period, respectively. The pattern generator was used for conversion of the square-shaped image pattern. The gas composition of the test panels was Ne – Xe (11%) – He (35%) and the gas pressure was increased from 100 to 500 Torr. Table 1 lists the detailed specifications for the test panels, which were exactly the same, except for the panel working pressure. To produce a residual image caused by the image sticking, the entire measurement region of panel was abruptly changed to dark and bright backgrounds after displaying the square-shaped image (discharge region) at peak luminance during a 1-minute sustained discharge.

Figure 2 shows the conventional driving waveform including the reset, address, sustain-periods employed in this research to produce the temporal dark and bright image sticking. The sustain frequency was 200 kHz and its duty ratio was 50 %. Different voltage levels for the driving waveforms were applied to each test panel due to the different firing conditions caused by the different gas pressures, as listed in Table 2.

Table 1. Specifications of 42-in. AC-PDP used in this study

Front Panel		Rear Panel	
ITO width	225 μm	Barrier rib width	55 μm
ITO gap	85 μm	Barrier rib height	120 μm
Bus width	50 μm	Address width	95 μm
Pixel Pitch		912 × 693 μm	
Gas chemistry		Ne-Xe (11 %)-He (35 %)	
Barrier rib type		Closed rib	

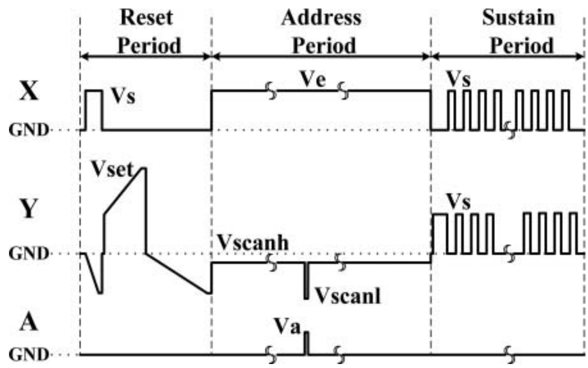


Figure 2. Schematic diagram of conventional driving waveform used in this study.

3. Results and Discussion

3.1 Monitoring of Luminance

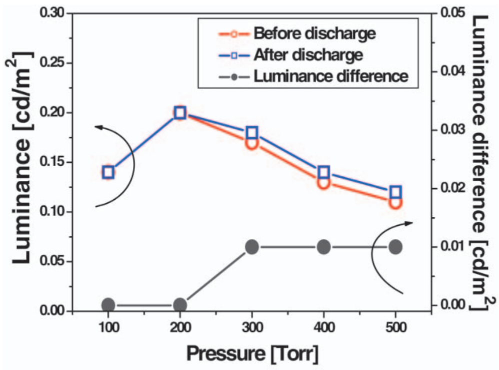
Figure 3(a) and (b) show the difference of the luminance between before and after 1-min. sustain discharge in the square-shaped image under the dark and full-white backgrounds. For dark background condition shown in Fig. 3(a), there was no luminance difference between before and after 1-min. sustain discharge in the square-shaped image below 200 Torr, whereas there was a small luminance difference of 0.01 cd/m^2 between before and after 1-min. sustain discharge in the square-shaped image above 300 Torr. On the other hand, for full-white background condition shown in Fig. 3(b), the luminance difference between before and after 1-min. sustain discharge in the square-shaped image was reduced from 4.9 to 2.01 cd/m^2 as the gas pressure was decreased from 500 to 100 Torr.

3.2 Monitoring of IR Emissions during Reset and Sustain Periods

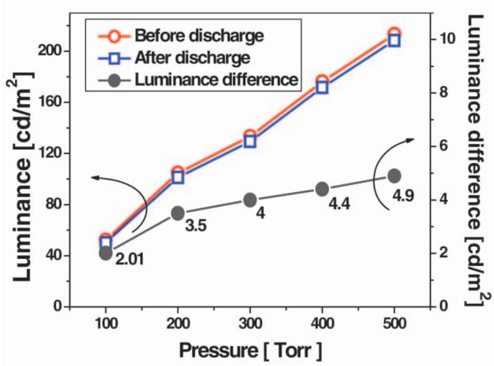
Figure 4(a) shows the changes in the IR (828 nm) emissions measured between before and after 1-min. sustain discharge in the square-shaped image during a reset period on the dark background under the various gas pressures. At a low gas pressure of 100 Torr, it was observed that the IR emission waveforms during a reset period were completely coincided between before and after 1-min. sustain discharge. On the other hand, at a high gas pressure of 500 Torr, the IR initiation during a reset period was shifted to the left after 1-min. sustain discharge, implying that the 1-min. sustain discharge reduced the firing voltage at 500 Torr.

Table 2. Optimal voltage levels of each period applied to test panels

	V_s	V_{set}	V_{scanh}	V_{scanl}	V_e	V_a
100Torr	200	390	−49	−174	95	65
200Torr	187	373	−55	−180	95	65
300Torr	188	374	−60	−185	95	65
400Torr	197	386	−65	−190	95	65
500Torr	213	405	−70	−195	95	65



(a)



(b)

Figure 3. Comparison of luminance difference between before and after discharge in square-shaped image (discharge region) under (a) dark background and (b) full-white background.

Figure 4(b) shows the changes in the NIR (Near Infra Red: 823 nm and 828 nm) emissions measured between before and after 1-min. sustain discharge in the square-shaped image during a sustain period on the full-white background under the various gas pressures. Comparing the two gas pressures, i.e., 100 and 500 Torr, the ignition time and intensity of the NIR emission waveforms were hardly changed between before and after a 1-min. discharge, especially at 100 Torr.

3.3 Monitoring of Color Temperatures and Disappearing Time

Before and after the 1-min. sustain discharge, the color temperatures were measured under dark and full-white backgrounds, as shown in Fig. 5. The 1-min. sustain discharge could vary the color temperature above 300 Torr, especially under the full-white background.

Figure 6 shows the difference in the disappearing-time of the temporal dark and bright image stickings in the square-shaped image while displaying the dark and full-white backgrounds. Assume that the disappearing-time of the temporal image sticking was defined as a time required until the square-shaped image disappears completely, when estimated by means of human eyes at a distance of 1 m in case of 42-in. ac-PDP. The disappearing-time of the temporal image sticking strongly depend on the sustain discharge time. In the real

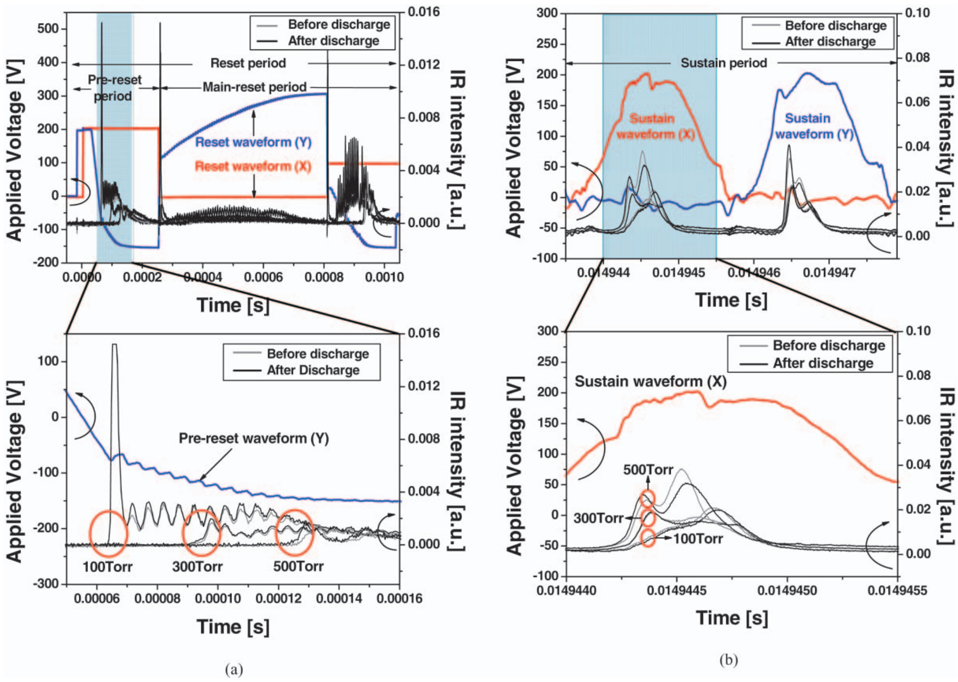


Figure 4. Comparison of IR (828 nm) emissions between before and after discharge in square-shaped image (discharge region) during (a) reset-period and (b) sustain-period under dark and full-white background for various gas pressures.

PDP driving condition, the PDP is considered to be free from the temporal image sticking if the disappearing-time of the 1-min. displayed square-shaped image is below 140 s. Below 300 Torr, the disappearing times of the temporal dark and bright image stickings were observed to be below 110 s, meaning that this test panel was free from the temporal dark and bright image stickings below 300 Torr. In other words, the temporal dark and bright image stickings occurred above 300 Torr, as shown in Fig. 6.

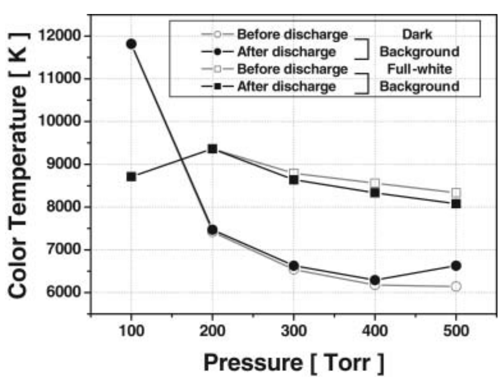


Figure 5. Comparison of color temperatures measured in square-shaped image (discharge region) under dark and full-white background from before and after 1-min sustain discharge.

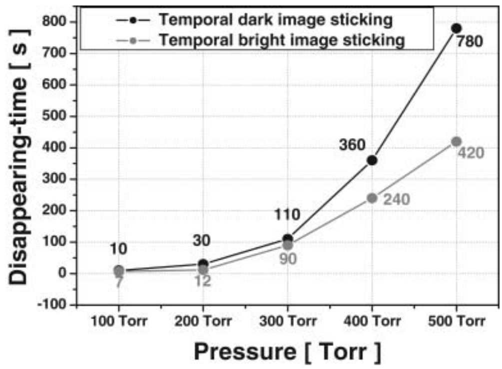


Figure 6. Comparison of disappearing-time of temporal dark and bright image sticking measured in square-shaped image (discharge region) under various gas pressures.

3.4 Monitoring of Panel Temperature

Figure 7 shows the difference in the panel temperature ($\triangle T$) measured from the square-shaped image during 1-min. sustain discharge under various gas pressures. As shown in Fig. 7, during 1-min. sustain discharge, the difference of the panel temperature was increased with an increase in the gas pressure due to the increase in the number of the ion at the high gas pressure. In particular, above 300 Torr, the panel temperature was severely varied.

Consequently, as the gas pressure increases, the number of ion particles within the cell increases, thereby resulting in a rise in the panel temperature and increase in the ion bombardment onto the phosphor layer [7].

3.5 Simulated Result of Xe and Ne ion density under various gas pressures

To identify the increase in the ion bombardment onto the phosphor layer at the high gas pressure, the simulator based on the 2-D fluid model of plasma [5,6] was used in this experiment.

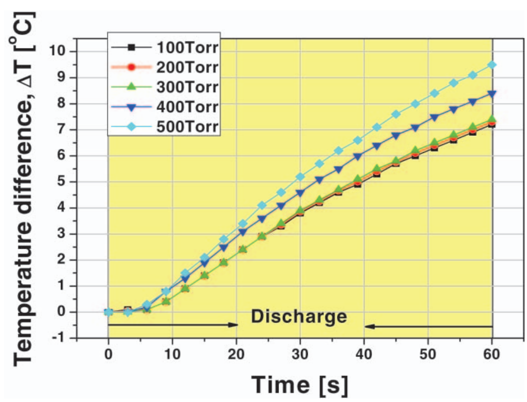


Figure 7. Temperature difference ($\triangle T = \triangle T_{after} - \triangle T_{before}$) measured in square-shaped image before and after 1-min. sustain discharge under various gas pressures, where $\triangle T_{after}$ means temperature measured before 1-min. sustain discharge and $\triangle T_{before}$ means temperature measured after 1-min. sustain discharge.

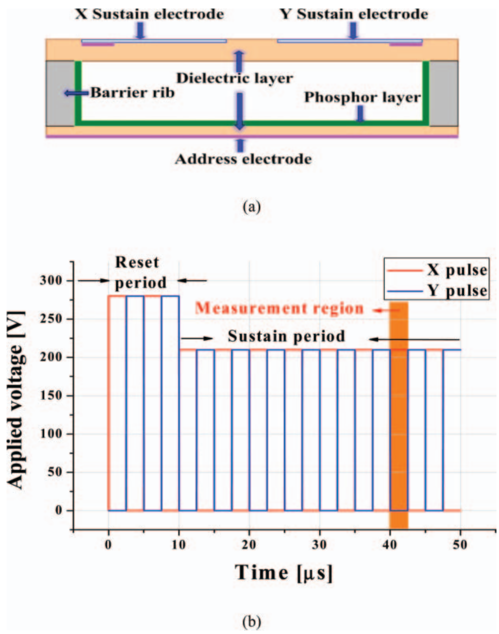


Figure 8. Schematic diagram of (a) cross-sectional view of single cell and (b) driving waveform used in simulation.

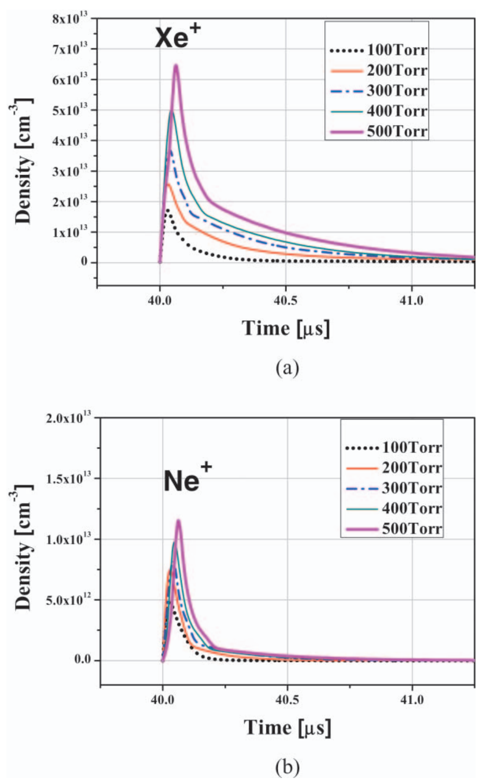


Figure 9. Comparison of (a) Xe and (b) Ne ions density based on simulated results during sustain discharge under various gas pressures.

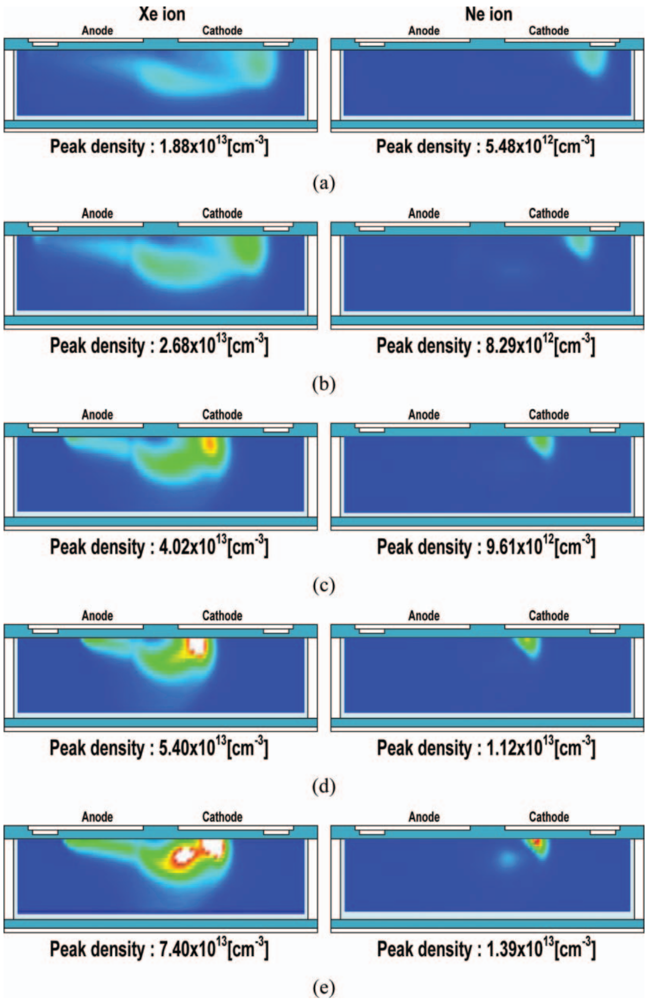


Figure 10. Comparison of Xe and Ne ions density profiles at peak density based on simulated results during sustain discharge under various gas pressures, such as (a) 100, (b) 200, (c) 300, (d) 400, and (e) 500 Torr.

Figure 8(a) show the cross-sectional view of the single cell with a 42-in. HD PDP dimension employed for this simulation. The gas composition was Xe (11%)-Ne (89%) under various gas pressures. In this simulation, the simple driving waveform including the reset and sustain-periods of Fig. 8(b) were applied to the single cell of Fig. 8(a) so as to investigate the discharge characteristics, such as the Xe and Ne ion densities of plasma. In this case, the frequency and duty ratio of the sustain pulse were 200 kHz and 50 %, respectively.

Figures 9 and 10 show the changes in the Xe and Ne ion density profiles obtained from the simulated results during the sustain discharge produced under various gas pressures. As shown in Fig. 9, the density of the Xe and Ne ions was increased with an increase in the gas pressure. The ion density on the address electrode was increased with an increase in the gas pressure. It means that the bombardment of heavier ion was increased onto the phosphor layer. This ion bombardment onto the phosphor layer could facilitate the absorption of hydrate, such as H_2O, produced, thereby aggravating the visible conversion of the phosphor layer [7]. In conclusion, based on the experimental and simulated results obtained using the luminance, IR emission, color temperature, panel temperature, and ion density, the image sticking problem, especially temporal bright image sticking, begins from the hydrate absorption phenomenon on the phosphor layer due to the massive ion bombardment onto the phosphor layer during the sustain discharge [7]. At this time, the amount of ions bombardment onto the phosphor layer strongly depends on the gas pressure. That is, the severe ion bombardment under a higher gas pressure condition causes a rise in the panel temperature and absorption of hydrate onto the phosphor layer, thereby resulting in the deterioration of the temporal bright image sticking.

4. Conclusion

In this paper, the influences of the gas pressure on the temporal dark and bright image stickings were investigated in the 42-in. ac-PDP with an He(35%)-Xe(11%)-Ne(54%) gas composition. To study the temporal dark and bright image sticking phenomena for various gas pressures, the differences in the displayed luminance, IR emission profile, disappearing time, color temperature, panel temperature, and Xe and Ne ions density were measured. As the gas pressure increases, the number of ion particles within the cell increases, thereby resulting in the increase in the ion bombardment onto the phosphor layer and the deterioration of the temporal image sticking at the high gas pressure.

Acknowledgment

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