18.2: Reduction of Permanent Image Sticking on Dark and Bright Images in 50-in. Full-HD AC-PDPs Using RF-Plasma Treatment on MgO Layer

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Abstract
The characteristics of the MgO layer are known to be an important parameter that affects the permanent image sticking in an ac-PDP. In this paper, to reduce the permanent image sticking of 50-in. full-HD ac-PDP with He (35%) - Xe (11%) contents, RF-plasma treatments on the MgO layer are examined under various gases for plasma treatment. As a result of monitoring the difference in the display luminance and normalized luminance between the discharge and non-discharge regions under the dark and bright backgrounds, the Ar and Ar > O_2 plasma treatments can reduce the permanent image sticking on dark and bright images in an ac-PDP.

1. Introduction
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 PDP cells when strong sustain discharges are repeatedly produced during a sustain period [1]-[5]. While image retention is only temporal and easily recoverable, image sticking is permanent and not recoverable. The sputtering phenomenon on the MgO surface caused by the ion bombardment during an iterant strong sustain discharge causes severe aggravation for both the MgO surface and the phosphor layer, eventually resulting in an image sticking problem [3, 4]. Our research is based on the concept that the ion bombardment on the MgO surface during a sustain discharge will vary depending on the characteristic of the MgO layer in PDP cells. In this paper, the RF-plasma treatment on the MgO layer with various plasma gas compositions is adopted to improve the hardness of MgO layer. The resultant changes in the permanent image sticking characteristics on the dark and bright images, such as the display luminance and normalized luminance, were examined in comparison with the non-plasma treatment on MgO layer in the 50-in. full-HD ac-PDP with He (35%) - Xe (11%) contents.

2. Experimental Setup
Figure 1 shows the optical-measurement systems and 50-in. full-HD ac-PDP module with three electrodes used in the experiments, where X is the sustain electrode, Y is the scan electrode, and A is the address electrode. A color analyzer (CA-100 Plus) and pattern generator were used to measure the luminance. To produce the permanent image sticking, the entire region of the 50-in. test panel was changed to a dark and full-white backgrounds after displaying a square-type image (discharge region A) at a peak-white pattern. Using the automatic power control system of the PDP, 850 sustain pulses were alternately applied to the X and Y electrodes during one TV field (=16.67 ms) to display a square-type test image a

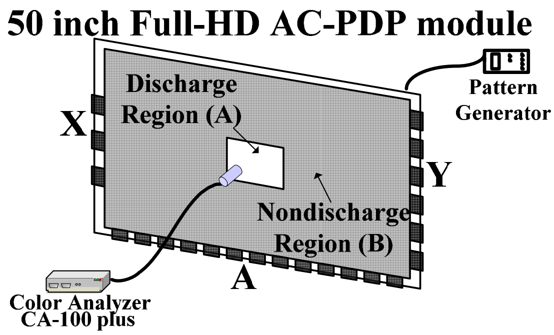

Figure 1. Schematic diagram of experimental setup employed in this research.

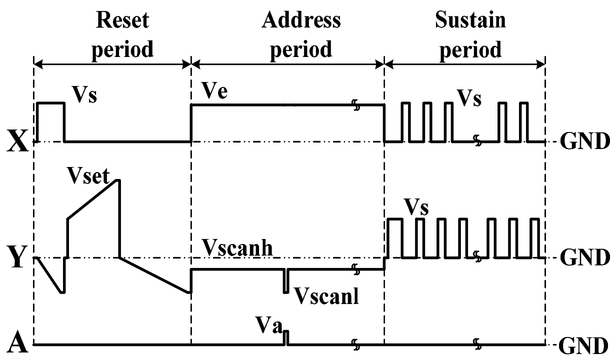

Figure 2. Schematic diagram of conventional driving waveform used in this study.

Table 1. Optimal voltage levels applied to test panels with different plasma treatment condition.

[V]	Vs	Vset	Vscanh	Vscanl	Ve	Va
Ref. #1, #2	206	325	-55	-175	95	65
O_2>Ar #1, #2 Plasma treatment	206	325	-55	-175	95	65
Ar Plasma treatment	196	315	-55	-175	95	65
Ar>O_2 Plasma treatment	201	320	-55	-175	95	65

Figure 3. RF plasma equipment used for plasma treatment system.

Table 2. Specifications of plasma treatment condition employed in this research.

Plasma treatment condition (Set-up)	
Plasma type	RIE (Reactive ion etching) plasma generator
Vacuum pump	Dry pump (base pressure : 4.3 mTorr)
RF (13.56 MHz) input power	4 kW
Operating pressure	100 mTorr
Process time	30 mins

Table 3. Specifications of various plasma treatment gas compositions employed in this research.

Plasma treatment gas compositions	
Ref. #1, #2	Non plasma treatment
O_2>Ar #1, #2 Plasma treatment	O_2 (201sccm) + Ar (22sccm)
Ar Plasma treatment	Ar (240sccm)
Ar>O_2 Plasma treatment	Ar (189sccm) + O_2 (21sccm)

1 % display region within the entire region of the 50-in. panel. The full-white background (entire region) means that 270 sustain pulses were alternately applied to the X and Y electrodes per one TV field. Otherwise, the dark background (entire region) means that just a weak reset discharge were produced. After displaying a square-type image (discharge region A) from 0 to 1000 hours, the entire region of the 50-in. test panel was displayed and the luminance difference between discharge (A) and non-discharge (B) regions was observed, represent the 'permanent image sticking on dark and bright image'. The luminance difference in the discharge region (A) increased with an increase of displaying time of the square-type image. A normalized luminance was used to evaluate the effect of RF-plasma treatment on the aggravation of permanent image sticking on dark and bright images which was defined as the ratio of the luminance difference in the discharge region (A). Thus, a normalized luminance of 1 means there is no luminance difference between the discharge (A) and non-discharge (B) regions, implying no image sticking. Figure 2 shows the driving waveforms, including the reset, address, and sustain periods, employed to compare the permanent image sticking characteristics of the 50-in. full-HD test panels fabricated using the RF-plasma treatment on the MgO layer with variable plasma gas compositions. The frequency for the sustain period was 200 kHz. A driving method with a selective reset waveform was also adopted, and the gas chemistry in the experiment was Ne-Xe (11 %)-He (35 %) under a pressure of 430 Torr. Our previous experimental results show that the Ar and Ar >O2 plasma treatments can reduce the firing voltage which is caused by a increase in the secondary electron coefficient of MgO layer [6]. Therefore, the different voltage levels of the driving waveforms were applied to each test panel due to the different firing condition, as listed in Table 1. Figure 3 shows the RF-plasma equipment used for the plasma treatment system. Tables 2 and 3 show the specifications of the RF-plasma treatment condition and various plasma treatment gas compositions employed in this research, which were exactly the same, except for the plasma treatment gas composition. The detailed panel specifications are listed in Table 4. The RF (13.56 MHz) input power and the process time for plasma treatment are 4 kW and 30 minutes, respectively [6]-[8].

Table 4. Specifications of 50-in. FHD AC-PDP used in this study.

Front Panel		Rear Panel	
ITO width	210μm	Barrier rib width	50μm
ITO gap	70μm	Barrier rib height	120μm
Bus width	70μm	Address width	85μm
Pixel pitch		576×576μm	
Gas chemistry		Ne-Xe (11%)-He (35%)	
Gas pressure		430 Torr	
Barrier rib type		Closed rib	

3. Experimental Results and Discussion

3.1. Display Luminance

Tables 5 and 6 show the luminance difference between the discharge region (A) and non-discharge region (B) under a dark background (Table 5) and a full-white background (Table 6) after an iterant 1000-h strong sustain discharge with a square-type image, as shown in Fig. 1, measured from 50-inch full-HD panels using RF-plasma treatment on MgO layer with variable gas compositions: Ref. (non treatment), O_2>Ar, Ar, and Ar>O_2 plasma treatments. As shown in Tables 5 and 6, in the cases of O_2>Ar plasma treatment, the luminance difference between the

Table 5. Changes in luminance in discharge region (A) and non-discharge region (B) under dark background after iterant 1000-h sustain discharge measured from 50-inch full-HD panels using RF-plasma treatment on MgO layer with variable gas compositions.

Panel	Luminance [cd/m^2]		
	Region A [L_1]	Region B [L_2]	Δ L [=|L_2-L_1|]
Ref. #1	0.22	0.18	0.04
Ref. #2	0.19	0.22	0.03
O_2>Ar #1	0.19	0.21	0.02
O_2>Ar #2	0.28	0.21	0.07
Ar	0.15	0.16	0.01
Ar>O_2	0.21	0.22	0.01

Table 6. Changes in luminance in discharge region (A) and non-discharge region (B) under full-white background after iterant 1000-h sustain discharge measured from 50-inch full-HD panels using RF-plasma treatment on MgO layer with variable gas compositions.

Panel	Luminance [cd/m^2]		
	Region A [L_1]	Region B [L_2]	Δ L [=|L_2-L_1|]
Ref. #1	131.8	165.3	33.5
Ref. #2	135.9	181.6	45.7
O_2>Ar #1	132.0	168.2	36.2
O_2>Ar #2	115.0	140.3	25.3
Ar	125.0	134.0	9
Ar>O_2	139.5	148.0	8.5

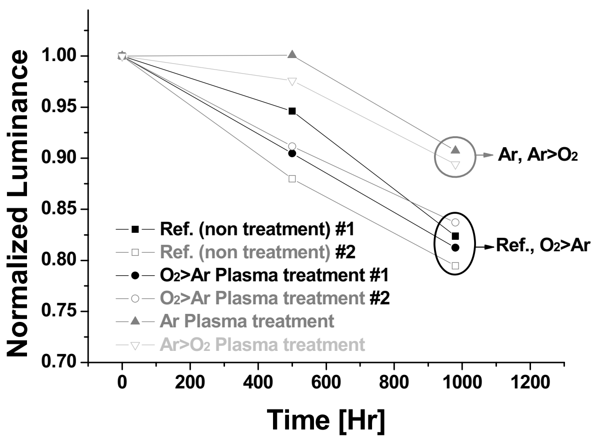

Figure 4. Normalized luminance in region A relative to display time of square-type measured from 50-inch full-HD panels using RF-plasma treatment on MgO layer with variable gas compositions.

discharge region (A) and non-discharge region (B) under a dark and full-white backgrounds were almost the same in comparison with the non plasma treatment (Ref. panel). However, in the cases of Ar and Ar>O_2 plasma treatments, the luminance difference between the discharge region (A) and non-discharge region (B) under a dark and full-white backgrounds were remarkably reduced in comparison with the non plasma treatment (Ref. panel). It is expected that the Ar and Ar>O_2 plasma treatments will contribute to reducing the permanent image sticking on dark and bright image of the ac PDP-TV.

3.2. Normalized Luminance

Figure 4 shows the changes in the normalized luminance in the discharge region (A) measured under a full-white background immediately after a period time of displaying the square-type image for up to 1000 hours on the 50-in. test panels using RF-plasma treatment on MgO layer with variable gas compositions. As mentioned previously, the normalized luminance in Fig. 4 was calculated by the luminance difference in the discharge region (A) under a full-white background. As shown in Fig. 4, the normalized luminance decreased with an increase in the display time of square-type image. It indicates that the permanent image sticking on bright image became worse with an increase in the number of sustain discharges. In the cases of Ar and Ar>O_2 plasma treatments, after an iterant 1000-h strong sustain discharge with a square-type image, the normalized luminance was increased in comparison with the non plasma treatment (Ref. panel) and O_2>Ar plasma treatment. These experimental results showed that the reduction of the permanent image sticking using the Ar and Ar>O_2 plasma treatments could be attributed to the less prohibition of a visible conversion from the vacuum ultraviolet of the phosphor layers caused by more decrease Mg deposition onto the phosphor layers [3, 4].

4. Conclusion

In this paper, to reduce the permanent image sticking of 50-in. full-HD ac-PDP with He (35%) - Xe (11%) contents, RF-plasma treatments on the MgO layer are examined under various gases for plasma treatment. As a result of monitoring the difference in the display luminance and normalized luminance between the discharge and non-discharge regions under the dark and bright backgrounds, the Ar and Ar>O_2 plasma treatments can reduce the permanent image sticking on dark and bright images in an ac-PDP. Thus, it is expected that these experimental results will help reduce the problem of permanent image sticking in PDP-TVs.

5. References

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