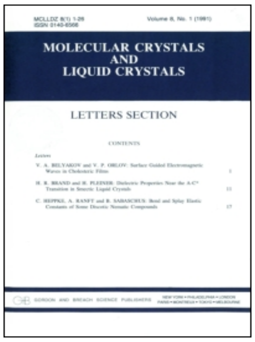

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Molecular Crystals and Liquid Crystals

ISSN: 1542-1406 (Print) 1563-5287 (Online) Journal homepage: http://www.tandfonline.com/loi/gmcl20

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MOLECULAR CRYSTALS AND LIQUID CRYSTALS
2017, VOL. 645, 72–80
http://dx.doi.org/10.1080/15421406.2016.1277477

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Influence of overlapped sustain waveform on panel-aging characteristics based on MgO surface morphology variation in alternating-current plasma display panel

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ABSTRACT

This paper has been investigated the changes in the discharge characteristics and surface morphology of the MgO surface on both the indium thin oxide (ITO) and bus electrodes when the conventional (non-overlapped) and overlapped sustain waveforms are applied during the panel-aging process in alternating-current plasma display panel. For conventional sustain waveform, the strong surface discharge is confined within the ITO electrode, whereas for overlapped sustain waveform, the strong surface discharge is produced and spread toward the end of the bus electrode as well as the ITO electrode. It is demonstrated that the overlapped sustain waveform is a very effective aging waveform that can obtain the uniform surface morphology of the MgO thin film on both the ITO and bus electrodes.

KEYWORDS

Overlapped sustain waveform; plasma discharge; panel-aging; wall voltage variation; surface morphology; MgO thin film; scanning electron microscope (SEM); three-dimensional IR emission; plasma display panel

1. Introduction

Since the initial surface states of the MgO thin film prepared by the ion-plating method have many impurities on the MgO surface, thereby resulting in causing the unstable discharge characteristics in alternating-current plasma display panel (AC PDP) [1, 2]. Therefore, the panel-aging process is necessary to eliminate the initial impurities from the MgO surface. In general, the panel-aging process is achieved by the iterant sustain discharges, required the sufficiently long time (typically few hours) to stabilize the MgO surface due to the ion bombardments. Accordingly, the PDP industry is focused on decreasing the panel-aging process time to reduce the panel fabrication cost. In addition, our previous experiments showed that the variations in the MgO surface with respect to the ion bombardments during the panel-aging process were very important to determine the discharge characteristics such as luminance, color temperature, and wall voltage variation [2,3]. Therefore, the panel-aging process is very important to determine the discharge characteristics of the AC PDP as well as the panel fabrication cost.

One of the methods to reduce the panel-aging process time is simply to use the high sustain voltage during the panel-aging process [4]. However, our previous experimental results show that the high sustain voltage during the panel-aging process causes the unstable discharge due

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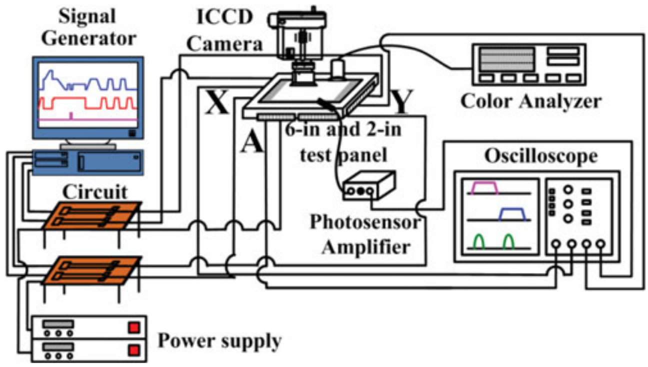

Figure 1. Schematic diagram of experimental setup employed in this study.

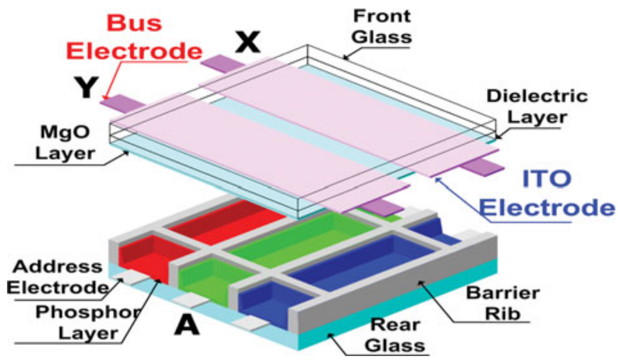

Figure 2. Schematic diagram of single pixel structure in 6-inch HD AC-PDP.

to the occurrence of the self-erasing discharge [4]. Therefore, in order to reduce the panel-aging process time, it is necessary to find the different solutions without increasing the sustain voltage. We have been reported that the discharge characteristics can be improved when the overlapped sustain waveform is applied instead of the conventional (non-overlapped) sustain waveform [5-9]. Accordingly, it has been investigated that the overlapped sustain waveform is suitable to reduce the panel-aging process time in this study.

In this study, we investigated and compared the variation of discharge characteristics, such as luminance, color temperature, wall charge variation, and the surface morphology of MgO, relative to the panel-aging process when the conventional and proposed overlapped sustain waveform were applied to the 6-in. HD grade test panel. And also, in order to investigate the effect of the overlapped sustain waveform, the specially fabricated 2-in test panel is employed to measure the 3-dimentional IR emission by using the image-intensified charge-coupled device (ICCD).

Table 1. Specifications of 6-in. and 2-in. AC-PDP used in this study.

Front Panel			Rear Panel	
ITO width		230 μm	Barrier rib width	55 μm
Gap	ITO	80 μm	Barrier rib height	125 μm
	Bus	420 μm		
Bus width		60 μm	Address width	100 μm
Pixel Pitch			912 μm × 693 μm	
Gas chemistry			Ne-Xe (10%)	
Barrier rib type			Closed rib	

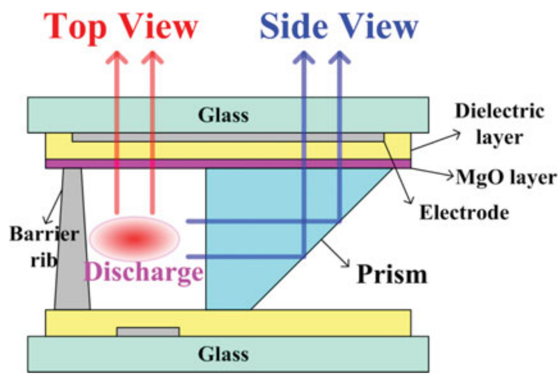

Figure 3. Schematic diagram of single pixel structure in 2-inch test panel having exactly same structure as 6-in. AC-PDP.

2. Experiment set-up

Figure 1 shows the schematic diagram of experimental setup employed in this study. A color analyzer (Konika Minolta, CA-100 plus), signal generator, photo-sensor amplifier (Hamamatsu, C6386), and ICCD camera were used to measure the luminance, color temperature, wall voltage variation, IR emission, and ICCD image, respectively. Figure 2 shows the single

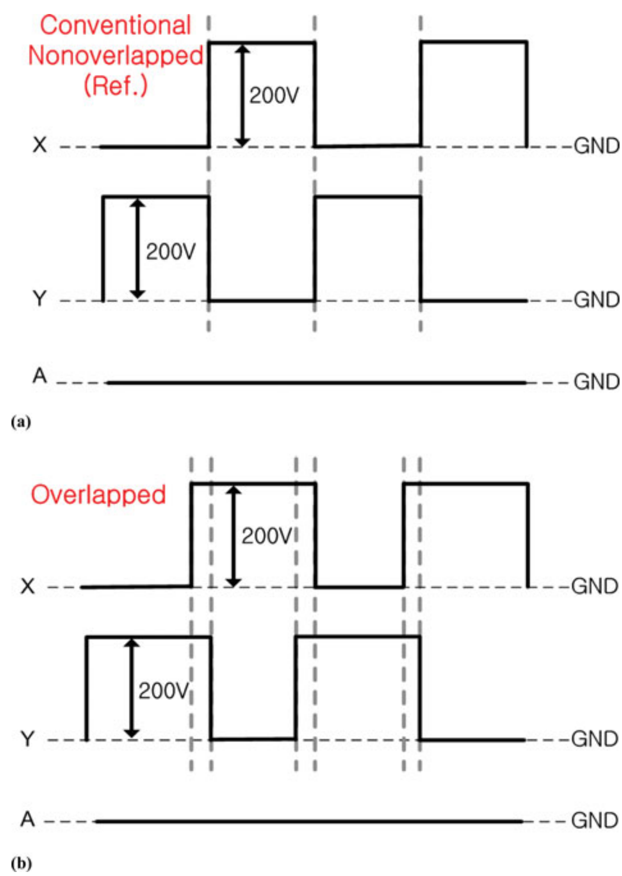

Figure 4. Schematic diagram of applied sustain driving waveforms for panel-aging process used in this study, where (a) is conventional and (b) is overlapped sustain waveforms.

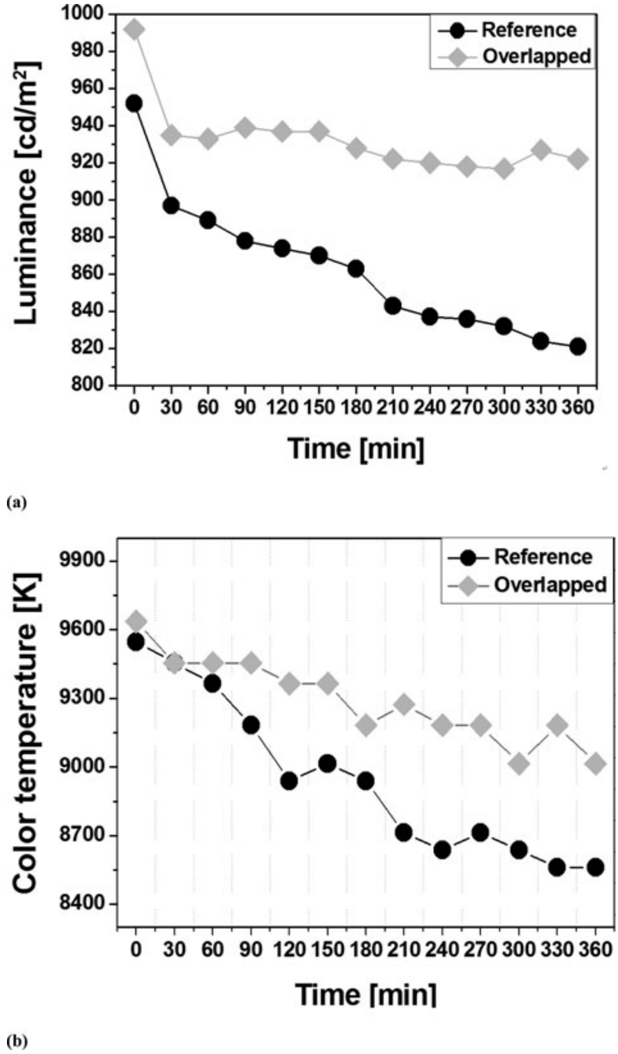

Figure 5. Comparison of (a) luminance and (b) color temperature during the panel-aging process for up to 6 hours on the 6-in. test panels when applying the conventional and overlapped sustain waveforms.

pixel structure of the 6-in. HD grade test panel with three electrodes, where X, Y, and A are the sustain, scan, and address electrode, respectively. The detailed panel specifications are listed in Table 1.

In addition, the 2-in. test panel was specially fabricated without phosphor layer to investigate the three-dimensional IR emission during the plasma discharge. As shown in Figure 3, the 2-in test panel has a polished glass prism to observe the side view of the plasma discharge in a unit cell. The side images reflected by the glass prism were measured simultaneously with the top images [10].

Figure 4 (a) and (b) show the conventional (non-overlapped) and proposed overlapped sustain waveforms with the sustain voltage of 200V and the frequency of 50kHz, respectively, which is applied during 6 hours (i.e., panel-aging process time) in this study. The duty ratios for the conventional and overlapped sustain waveforms were 50% and 60%, respectively.

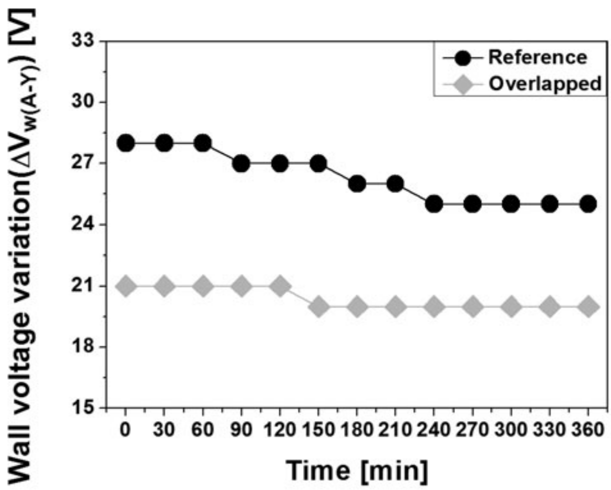

Figure 6. Comparison of wall voltage variation during the panel-aging process for up to 6 hours on the 6-in. test panels when applying the conventional and overlapped sustain waveforms.

3. Results and discussions

3.1. Experimental observation from 6-in. test panel

Figure 5 shows the changes in the (a) luminance and (b) color temperature of the 6-in. test panel when the conventional and overlapped sustain waveforms are applied during the panel-aging process. As shown in Figs. 5 (a) and 5(b), the luminance and color temperature were observed to be decreased continuously during 6 hours when the conventional sustain waveform was applied. While it should be noted that the luminance and color temperature were stabilized very fast when the overlapped sustain waveform was applied.

Figure 6 shows the changes in the wall voltage variation (ΔV_w) between the A-Y electrodes under the MgO cathode condition based on the V_t closed curve measurement during the panel-aging process. The ΔV_w was defined as the variation in the wall voltages from the

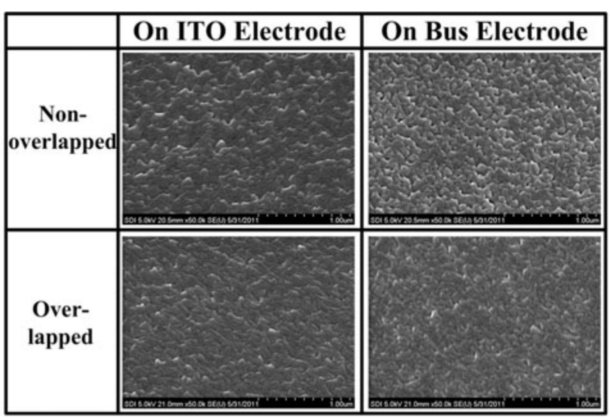

Figure 7. Comparison of SEM images of MgO surface changes on ITO and bus electrodes after panel-aging process when applying the conventional and overlapped sustain waveforms.

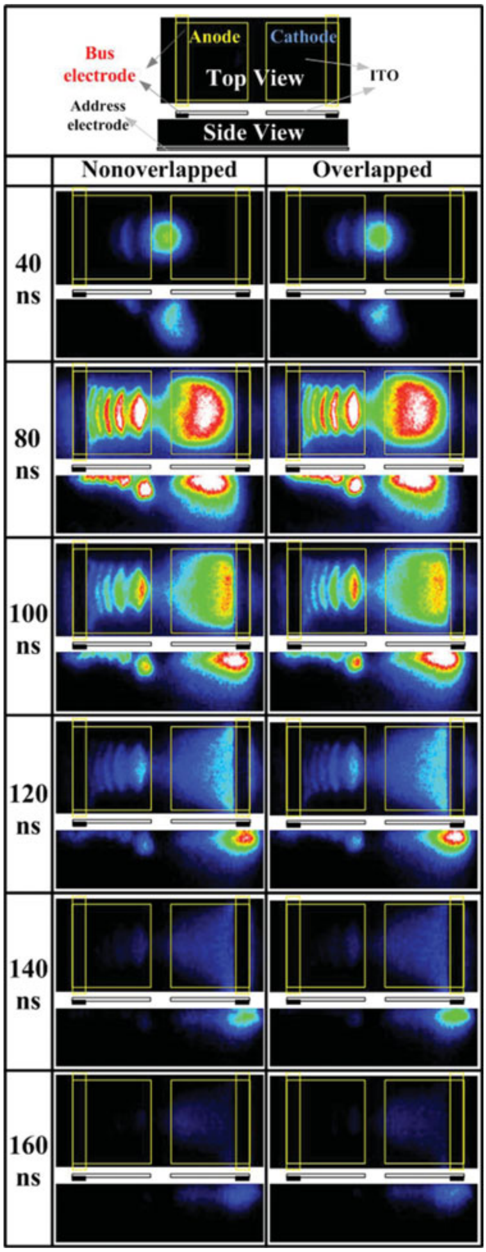

Figure 8. Comparison of top and side ICCD images during the panel-aging process on the 2-in. test panels when applying the conventional and overlapped sustain waveforms.

first to the last scan line between the A-Y electrodes [11]. As shown in Fig. 6, when the conventional sustain waveform was applied, the wall voltage variation was observed to be continuously reduced during the panel-aging process. On the contrary, when the overlapped sustain waveform was applied, the wall voltage variation remained almost constant during the panel-aging process. It can be inferred that the minimizing the wall voltage variation could enhance the stable addressing when the overlapped sustain waveform is applied.

Figure 7 shows the changes in the plane views of scanning electron microscopy (SEM) images of the MgO surfaces on the ITO and bus electrodes of the 6-in. test panel after the

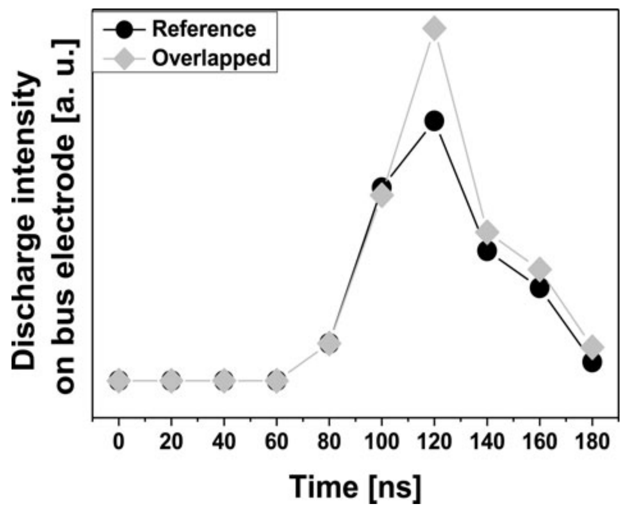

Figure 9. Comparison of discharge intensity on bus electrode under various gate mode times of side ICCD images based on Fig. 8 during the panel-aging process on the 2-in. test panels when applying the conventional and overlapped sustain waveforms.

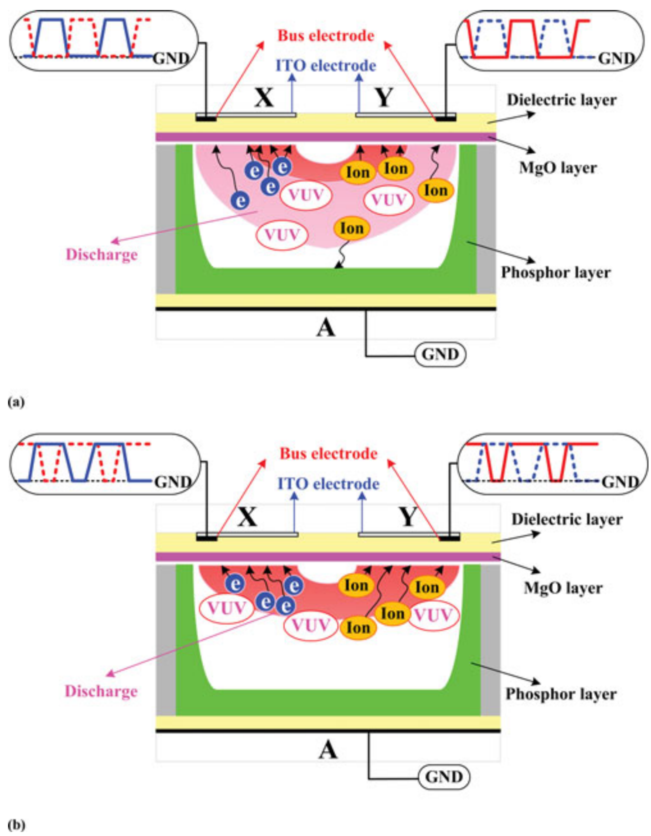

Figure 10. Schematic model of discharge behavior during the panel-aging process in ac plasma display panel when applying the (a) conventional and (b) overlapped sustain waveforms.

panel-aging process. As shown in Fig. 7, when the conventional sustain waveform was applied, the MgO surface morphology on the ITO electrode was observed to be larger than that on the bus electrode. We have reported that the surface morphology of the MgO thin film was getting larger due to the continuous ion bombardment [2,3]. Accordingly, the MgO surface on the ITO electrode was much more bombarded by the ions, compared to that on the bus electrode, implying that the strong discharge was not spread toward the bus electrode. On the other hand, when the overlapped sustain waveform was applied, the MgO surface morphology for both ITO and bus electrodes were observed to be almost the same. Therefore, it can be inferred that, for the overlapped sustain waveform, the MgO surface on both the ITO and bus electrodes was struck severely, implying that the strong discharge was spread toward the bus electrode. The uniform MgO surface on both the ITO and bus electrodes can produce a stable discharge.

3.2. Experimental observation of IR emission from 2-in. panel

As previously described, three-dimensional IR emission was measured with the specially fabricated 2-in test panel to investigate the discharge characteristics relative to the sustain waveform, especially spatial distribution of the discharge on the ITO and bus electrodes. The top and side discharge images were measured simultaneously by using the gate mode of ICCD camera with the IR bandpass filter centered at 823 nm (10-nm bandwidth) [10].

Figure 8 shows the temporal behavior of the top and side IR (823 nm) emission images during the sustain discharge when the sustain waveform was applied to the 2-in test panel. As shown in Fig. 8, the temporal images of top view for the conventional and overlapped sustain waveforms show similar temporal behavior. It should be emphasized that the IR emission on the ITO electrode is intensified when the overlapped sustain waveform is applied, implying that the strong discharge is spread toward the bus electrode, which is corresponding to the result of Figure 8.

Figure 9 shows the intensity of IR emission on the bus electrode relative to the gate mode time of the side ICCD images as shown in Fig. 8. As shown in Fig. 9, it was confirmed that the intensity of IR emission on the bus electrode was intensified after 120 ns when the overlapped sustain waveform was applied. The schematic model of discharge behavior, comparing the conventional and overlapped sustain waveform, is illustrated in Fig. 10.

4. Conclusions

In this work, the overlapped sustain waveform has been adopted to improve the panel-aging process. The variation of discharge characteristics relative to the panel-aging process, such as luminance, color temperature, wall charge variation, IR emission, and MgO morphology, were investigated and compared to the conventional sustain waveform using the 6-in. test panel. When the overlapped sustain waveform is applied, the luminance and color temperature are fast stabilized comparing to the conventional sustain waveform, which means that the panel-aging process time can be significantly reduced. In addition, the wall voltage variation during the panel-aging process is decreased, which is a result in enhancing the stable address.

It was elucidated that the strong discharge was spread toward the bus electrode by using the ICCD experiment with the specially fabricated 2-in test panel. For conventional sustain waveform, the strong surface discharge is confined within the ITO electrode, whereas for overlapped sustain waveform, the strong surface discharge is produced and spread toward the end of the bus electrode as well as the ITO electrode. It is demonstrated that the overlapped sustain waveform is a very effective aging waveform that can obtain the uniform surface morphology of the MgO thin film on both the ITO and bus electrodes.

Funding

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government (MSIP) (No. 2016R1C1B1011918).

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