Boundary Image-Sticking Phenomena in AC Plasma Display Panel

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Abstract: When displaying the square-type image with peak luminance for about 500 hours in 42-in. PDP-TV with high Xe (15 %) content, the halo-type boundary image sticking was observed in the non-discharge region adjacent to the discharge region. The halo-type boundary image sticking phenomenon is due to the re-deposition of the Mg species on both the MgO and phosphor layers in the non-discharge region adjacent to the discharge region. In this paper, the two kinds of solutions to remove a boundary image sticking of an ac plasma display panel are introduced. One solution is to completely recover the boundary image sticking cells by means of full white-aging process. The other solution is to prohibit inherently the production of the boundary image sticking by sealing the PDP panel under a vacuum condition.

OCIS codes: (000.2190) Experimental physics; (310.3840) Materials and process characterization

1. Introduction

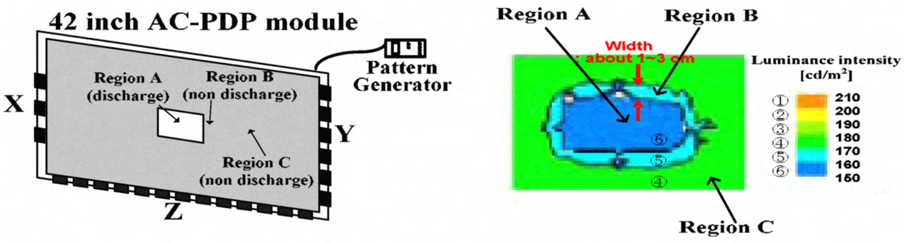
The realization of a high quality plasma display panel (PDP) requires an urgent solution to the image sticking or image retention problems induced in the PDP cells when strong sustain discharges have been repeatedly produced during a sustain period [1], [2]. Image retention means a temporal image sticking that is easily recoverable through a minor treatment, whereas image sticking means a permanent sticking that is not recoverable even through severe treatment. The image sticking is known to be induced even in the non-discharge cells adjacent to the discharge cells, which is called a halo-type boundary image sticking. The main culprit for inducing the permanent image sticking is deeply related to the Mg species sputtered from the MgO surfaces of the discharge cells due to the severe ion bombardment during a sustain discharge [2]. The re-deposition of the sputtered Mg species on the phosphor layer in the discharge cells, or the re-deposition of the sputtered Mg species on another MgO surface of the non-discharge cells adjacent to the discharge cells, can alter the reset or sustain discharge characteristics, thus causing an image sticking or boundary image sticking [2].

In this paper, the effects of the full-white aging discharge on the recovery of boundary image sticking for the panel fabricated by the conventional sealing method were investigated. In addition, the effects of the vacuum sealing method on the boundary image sticking phenomenon were also examined. The SEM images of MgO layer and Mg-profiles of phosphor layer in the cells of the non-discharge region adjacent to the discharge region were observed in comparison with the non-discharge region far away from the discharge region for two cases.

2. Phenomena of Halo-type Boundary Image-Sticking in 42-in. AC-PDP

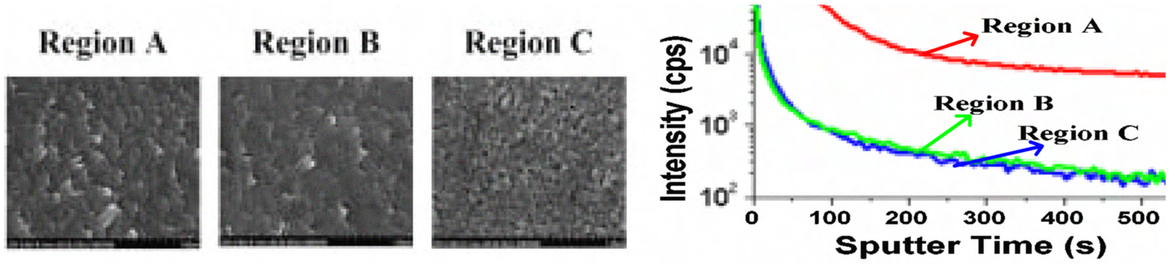
Fig. 1 (a) shows the optical-measurement systems and commercial 42-in. ac-PDP module with three electrodes used in the experiment, where X is the sustain-, Y is the scan-, and Z is the address-electrode. To produce the boundary image sticking, the entire region of the 42-in. panel was changed to a dark background (about 0.1 cd/m2) or full-white background (about 175 cd/m2) image immediately after displaying a square-type image (region A) at peak luminance (about 1000 cd/m2) for about 500 hours. The conventional driving method with a selective reset waveform was adopted. The frequency for a sustain period was 200 kHz, and the sustain voltage was 206 V. In the absence of any image sticking phenomenon, the luminance in Fig. 1 (b) would be almost the same among the three regions, A, B, and C. However, as shown in Fig. 1 (b), the three regions exhibited a different luminance with the full-white background due to the image sticking induced by the iterant strong sustain discharge in region A. Even though no sustain discharge was produced in region B, the image sticking phenomenon was still observed, and since the region formed a circular shape, it was hereinafter referred to as ‘halo-type’ boundary image sticking.

To investigate the reason for the halo-type boundary image sticking, the SEM and TOF-SIMS were measured in regions A, B, and C, respectively. Fig. 2 (a) shows the SEM images captured for regions A, B, and C. Although the cells in region B were non-discharge cells, their morphology was almost similar to that for the cells in the discharge region (region A). Theoretically, the morphology of the MgO surface should not change if the cells are not discharged. Nonetheless, a change was observed in the morphology of the MgO surface of the non-discharge cells



(a) (b)

Fig. 1. (a) Schematic diagram of experimental setup employed in this paper and (b) imaging pattern showing luminance difference among regions A, B, and C measured from 42-in.panel using imaging colorimeter with full-white background: region A indicates image sticking cells, while region B indicates halo-type boundary image sticking cells.



(a) (b)

Fig. 2. (a) Comparison of SEM images of MgO surface changes in regions A, B, and C and (b) comparison of Mg-profiles of red phosphor layer for regions A, B, and C measured using TOF-SIMS analysis.

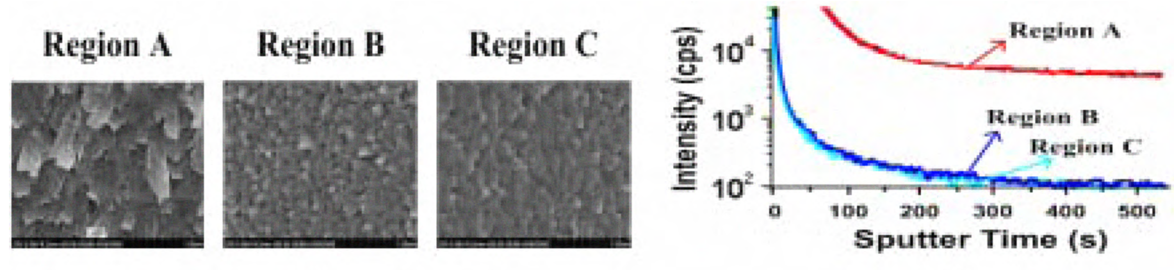
(region B), presumably due to the re-deposition of the MgO sputtered by the iterant strong sustain discharge in the discharge region A adjacent to the non-discharge region B. Fig. 2 (b) shows the comparison of the Mg-profiles on the red phosphor layer for regions A, B, and C using a TOF-SIMS analysis. As shown in Fig. 2 (b), the Mg intensity in regions A and B shifted upward compared to that in region C, indicating that the Mg was re-deposited onto the phosphor layer. Although the sputtered Mg species were predominantly re-deposited in the discharge region A, there was also a slight re-deposition in the non-discharge region B adjacent to the discharge region A. As a result, the SEM and TOF-SIMS analyses confirmed that the halo-type boundary image sticking phenomenon was due to the re-deposition of MgO on both the MgO and phosphor layers in the non-discharge region adjacent to the discharge region.

3. Solution to Halo-type Boundary Image Sticking

To reduce the boundary image sticking, two kinds of methods are proposed. One method is to completely recover the boundary image sticking cells by means of full-white aging process in case that the boundary image sticking has been produced. The other method is to prohibit inherently the production of the boundary image sticking by sealing the PDP panel under a vacuum condition.

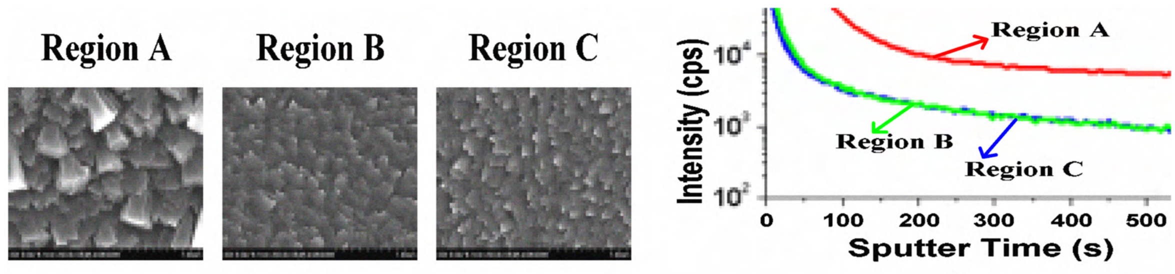
A. Full-White Aging for Recovering Boundary Image Sticking

Before full-white aging discharge, as shown in Fig. 2 (a), the morphology of the MgO surface in region B was similar to that in region A with a relatively large grain size. This phenomenon in region B seemed to occur due to the re-deposition of the Mg transported from region A, where the MgO surface was sputtered during the iterant strong sustain discharge. During the full-white aging discharge, the ions bombarded the MgO surfaces in all three regions: A, B, and C. As shown in Fig. 3 (a), the resultant MgO surface in region A, i.e. the image sticking region, became rougher with a larger grain size. However, in region B (the boundary image sticking region), the MgO surface revealed a smaller grain size after the full-white discharge with a similar surface morphology to the MgO layer in region C. In regions B and C, the sustain discharges were simultaneously produced for 100 hours under the full-white aging discharge condition, yet the ion bombardment was less intense than that under the 500-hour sustain discharge for displaying the test image with a 1% display area. Thus, the surface morphologies of the MgO layers in regions B and C became similar as a result of the full-white aging discharge, as shown in Fig. 7 (b). Therefore, the



(a) (b)

Fig. 3. (a) Comparison of SEM images of MgO surface changes in regions A, B, and C and (b) comparison of Mg-profiles for red phosphor layer in regions A, B, and C based on TOF-SIMS analysis after full-white aging discharge.



(a) (b)

Fig. 4. (a) Comparison of SEM images of MgO surface changes in regions A, B, and C and (b) comparison of Mg-profiles for red phosphor layers in regions A, B, and C using TOF-SIMS analysis in test panels fabricated using vacuum sealing process.

SEM images in Fig. 3 (a) confirmed that the simultaneous ion bombardment under the full-white aging discharge caused the MgO surfaces in regions B and C, especially the re-deposited MgO surface in region B, to equalize. Before the full-white aging discharge, the Mg intensity in regions A and B shifted upward compared to that in region C, as shown in Fig. 2 (b), indicating that the Mg was re-deposited on the phosphor layer. As shown in Fig. 3 (b), however, after the full-white aging discharge, the Mg intensity in region B was almost similar to that for the cells in region C, indicating that the 100-hour full-white aging discharge contributed to recovering the boundary image sticking.

B. Prohibition of Boundary Image Sticking Using Vacuum Sealing Method

Fig. 4 (a) shows the SEM images of the MgO surface captured from the regions A, B, and C of the test panel fabricated by the vacuum sealing method. As for the test panel fabricated by the vacuum sealing method, the morphology in region B is almost similar to that in region C after the 500-hour sustain discharge. Fig. 4 (b) also shows the Mg-profiles on the red phosphor layer for regions A, B, and C of the test panel fabricated by the vacuum sealing method. As shown in Fig. 4 (b), the Mg intensity in region B is almost similar to that of the cell in region C, which means that the vacuum sealing method contributes to prohibiting the production of the boundary image sticking.

4. Conclusion

When displaying the square-type image with peak luminance for a long time in PDP-TV, the image sticking appears even in the non-discharge cells adjacent to the discharge cells, which is called a boundary image sticking. Two kinds of methods are proposed to reduce the boundary image sticking.

5. References

[1] H.-S. Tae, C.-S. Park, B.-G. Cho, J.-W. Han, B. J. Shin, S.-I. Chien, and D. H. Lee, "Driving waveform for reducing temporal dark image sticking in AC plasma display panel based on perceived luminance," *IEEE Trans. Plasma Science*, Vol. 34, No. 3, pp.996-1003, 2006.

[2] C.-S. Park, H.-S. Tae, Y.-K. Kwon, and E. G. Heo, "Experimental observation of halo-type boundary image sticking in AC plasma display panel," *IEEE Trans. Electron Devices*, Vol. 54, No. 6, pp.1315-1320, 2007.