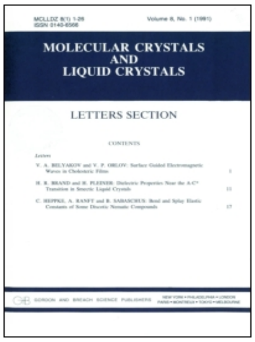

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Investigation for the effect of redeposited Mg particles on the discharge characteristics in an alternating-current plasma display panel

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ABSTRACT
In this paper, the influences of the redeposited Mg particles in the boundary image sticking region on the electron emission of the MgO surface and related discharge characteristics of an alternating-current plasma display panel were examined by using the cathodoluminescence and intensified charge-coupled device techniques. The experimental results showed that the electron emission at the redeposited region of the Mg particles on the MgO surface was intensified and concentrated compared with those for nonredeposited region of the Mg particles, thereby resulting in extremely improving the discharge characteristics in the 42 in high definition (HD) alternating-current plasma display panels (ac-PDPs) with a He (35%)-Xe (11%)-Ne contents.

KEYWORDS
Plasma display panel; redeposited Mg particles; boundary image sticking; scanning electron microscopy (SEM); cathodoluminescence (CL); intensified charge-coupled device (ICCD); infrared (IR)

1. Introduction

It is well known that the surface state of the MgO layer is crucial to effect of the discharge characteristics in an alternating-current plasma display panels (ac-PDPs). The MgO layer plays an important role as a protective layer and electron emission layer due to its strong resistance to ion sputtering and high secondary electron emission coefficient [1,2]. We previously reported that the sputtered Mg particles away from the MgO surface were predominantly redeposited onto the phosphor layers of the cells in the discharge region [3–9]. Meanwhile, even without sustain discharge, Mg particles could be transported to the adjacent cells near the discharge region where the sputtered particles were redeposited onto another MgO surface. This phenomenon could cause the significant effect on the sustain and reset characteristics [3–11], known as a boundary image sticking. However, the discharge characteristics of the Mg particle redeposition and the electron emission response of the MgO surface were not fully explored in previous studies [12,13].

Accordingly, this study used cathodoluminescence (CL) measurements to investigate the detailed changes in the MgO surface characteristics induced by redepostion of Mg particles

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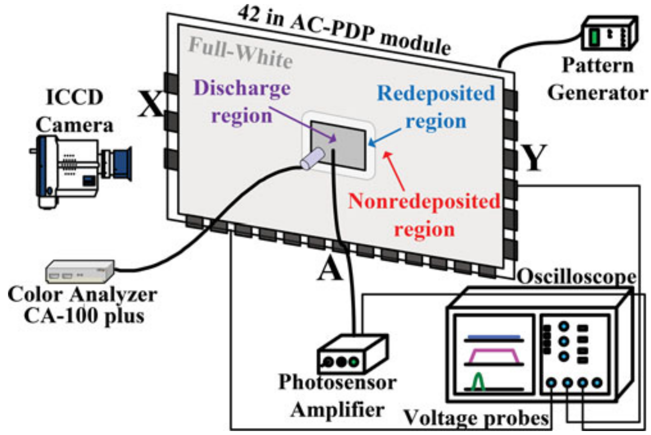

Figure 1. Schematic diagram of experimental setup employed in this paper.

onto the MgO surface, and further examined the resultant changes in the IR (infrared) emissions using the intensified charge-coupled device (ICCD) technique.

2. Experiment

Figure 1 shows the schematic diagram of experimental setup employed in this study. The commercial 42-in. XGA grade AC-PDP module with a box barrier rib was used as a test panel, which was controlled via three functional sets of electrodes A, X, and Y. The A electrode was used for cell addressing, while the X and Y electrodes controlled the sustain and scan modes, respectively. The test panel has a composition of Ne-He (35%)-Xe(11%) with the pressure of 420 Torr. An MgO thin film was deposited onto the dielectric layers via ion-plating evaporation, with an oxygen flow rate of 220 standard cubic centimeters per minute (sccm) and a hydrogen flow rate of 60 sccm. The detailed specifications for the test panel are listed in Table 1. The IR emission was measured by a photo-sensor amplifier (Hamamatsu C6386) and a color analyzer (CA-100 Plus) measured changes in the color temperature and luminance.

Figure 2 shows the conventional driving waveforms, including the selective reset, address, and sustain period. The frequency of sustain pulse was 200 kHz and a duty cycle was 50%. The square-shaped target image, as shown in Fig. 1, was displayed for 200 hours at peak luminance to produce the desired conditions in both the discharge and nondischarge regions, after that the entire panel was immediately switched to an all-white background [3–5].

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

Front panel		Rear panel	
ITO width	220 μm	Barrier rib width	60 μm
ITO gap	85 μm	Barrier rib height	125 μm
Bus width	55 μm	Address width	95 μm
Pixel pitch		912 μm × 693 μm	
Barrier rib type		Closed rib	
Gas Pressure		420 Torr	
Gas chemistry		Ne-Xe (11%)-He (35%)	

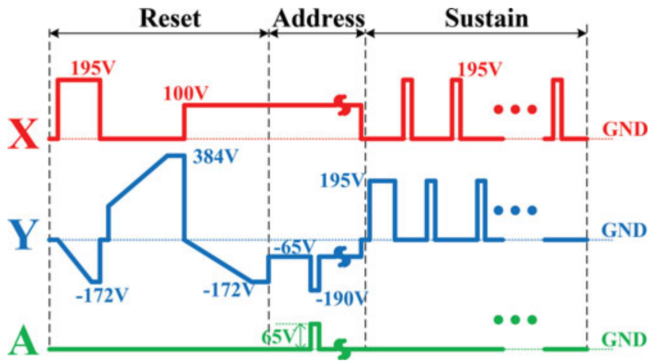

Figure 2. Schematic diagram of driving waveform used in this paper.

3. Results and discussion

Figure 3 the (a) plane SEM image and the (b) panchromatic CL intensity image on the MgO surface measured from the nonredeposited region (this is 'reference case') and redeposited region. As shown in the SEM image of Fig. 3 (a), the redeposited Mg particles are clearly seen on the MgO surface in the redeposited region. As shown in the CL intensity images of Fig. 3 (b), the dark image region means no detection of the electron emission. Meanwhile, the bright image region means detection of the electron emission. Therefore, it can be inferred that the electron emissions were evenly emitted from the whole MgO surface in the nonredeposited region. Whereas, it should be noticed that the electron emissions were intensified and concentrated due to the redeposited Mg particles in the redeposited region.

The defect levels of MgO film were measured via visible range radiation (1.8 – 3.5 eV) by the CL technique. As the electron beam penetrates deep into the MgO film, most of the signals

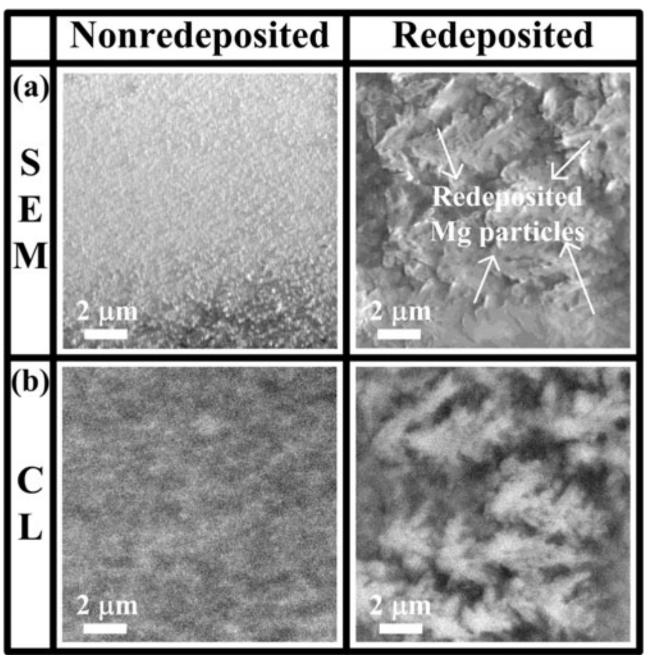

Figure 3. Comparison of plane SEM and panchromatic CL images on MgO surface measured from nonredeposited and redeposited region of Mg particles on MgO surface.

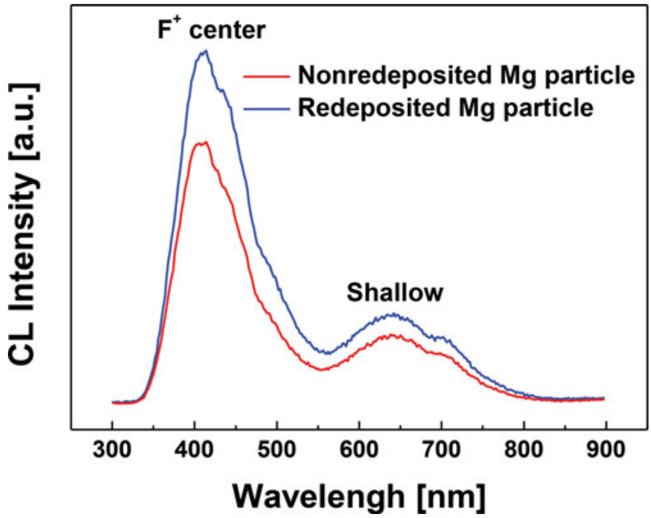

Figure 4. Comparison of CL spectra intensities measured from nonredeposited and redeposited regions of Mg particles on MgO surface.

are coming from the defects located deep inside the MgO film [14]. Figure 4 shows the changes in the intensity of CL spectra were measured from the nonredeposited and the redeposited regions of the MgO surface. As shown in Fig. 4, the F^+ center peak (410 nm) with a level of 3.02 eV was related to the secondary electron emission, whereas the shallow peak (638 nm) with a level of 1.94 eV was related to the electron emission from the shallow level. The F^+ center and shallow level peaks of the CL intensity in the redeposited region were increased compared with that in the nonredeposited region. It implies that the electron emissions are increased due to the redeposited Mg particles both from the F^+ center and shallow level in the redeposited region.

Figure 5 shows the (a) plane SEM image and the (b) panchromatic CL intensity image on the MgO surface measured from the MgO single crystal powder (or crystal emissive layer (CEL)). As shown in Figs. 5 (a) and (b), the electron emissions from the MgO single crystal powder on the MgO surface was also intensified and concentrated. The experimental results in Figs. 3 and 5 indicated that the MgO surface characteristics induced by redepostion of Mg particles were similar to that of the deposition of the MgO single crystal powder on the MgO surface [15–17].

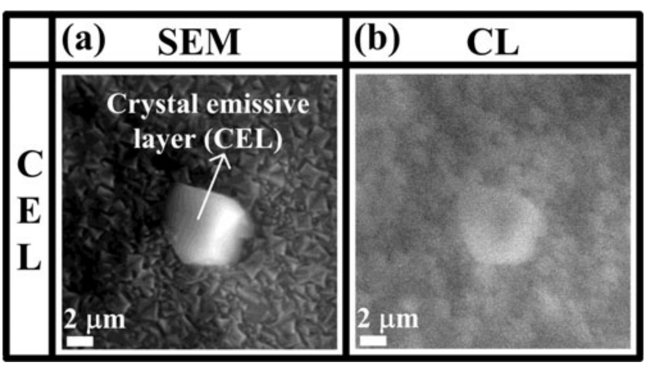

Figure 5. Comparison of plane SEM and panchromatic CL images on MgO surface measured from region of MgO single crystal powder (or crystal emissive layer (CEL)) on MgO surface.

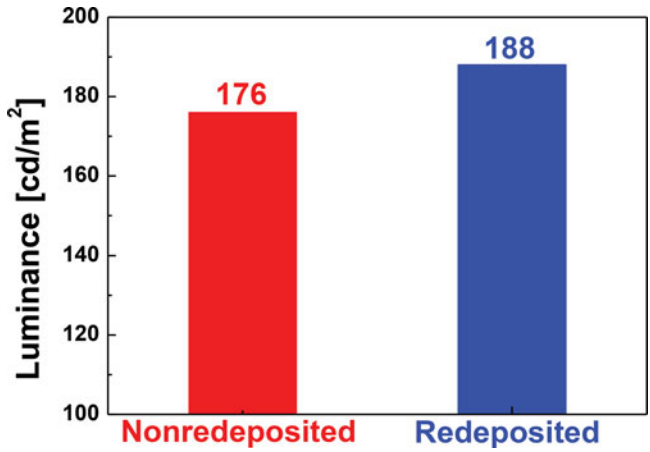

Figure 6. Comparison of luminance measured from nonredeposited and redeposited regions of Mg particles on MgO surface under full-white background.

Figure 6 shows the luminance of the nonredeposited and the redeposited regions. The luminance of the redeposited region was higher than that of the nonredeposited region. Figure 7 shows the formative (T_f), and statistical address delay time (T_s) of the nonredeposited and the redeposited regions. As shown in Fig. 7, the T_f and T_s of redeposited Mg particles were lower than those of nonredeposited region. The redeposited Mg particles, which was verified by the increase in the F^+ center and shallow level peaks in the CL intensity, increased defect levels in the MgO layer and led to a decrease in T_f and T_s, respectively. The higher luminance and lower address delay time indicated that the discharge characteristics were improved due to the redeposited Mg particles on the MgO surface.

Figure 8 shows the temporal waveform of IR (823 nm and 828 nm) emissions obtained from the nonredeposited and redeposited regions during the sustain period. As shown in Fig. 8, the discharge of the redeposition region is fast ignited due to the redeposited Mg particles, comparing to that of the nonredeposited region, which is corresponding to the result of Fig. 7. And also, the intensity of the redeposition region is stronger than that of the nonredeposition region. Therefore, it can be inferred that the electron emissions are enhanced due to

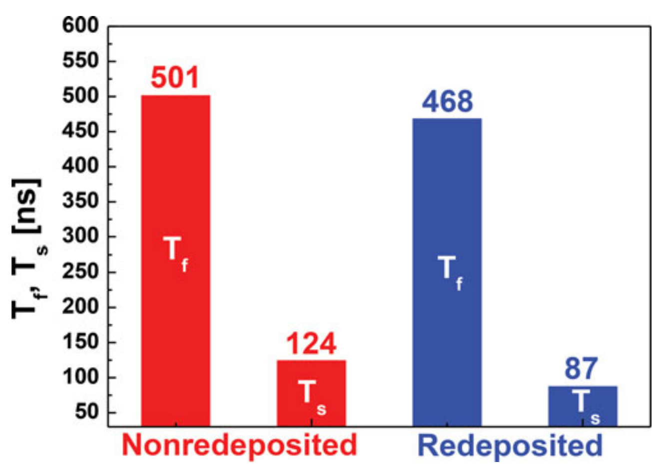

Figure 7. Comparison of formative and statistical address delay times (T_f and T_s) measured from nonredeposited and redeposited regions of Mg particles on MgO surface during address period.

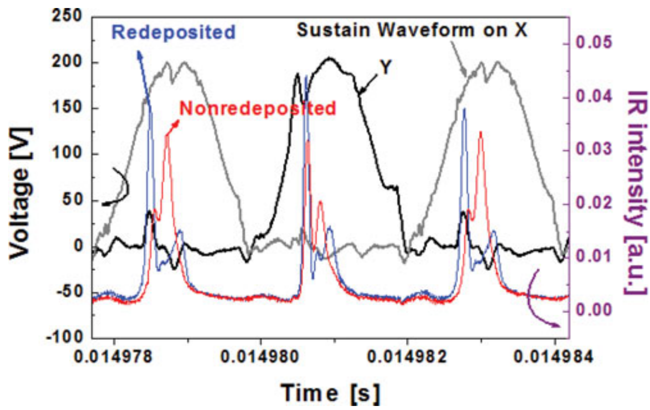

Figure 8. Comparison of IR (823 nm and 828 nm) emission intensities measured from nonredeposited and redeposited regions of Mg particles on MgO surface during sustain period under full-white background.

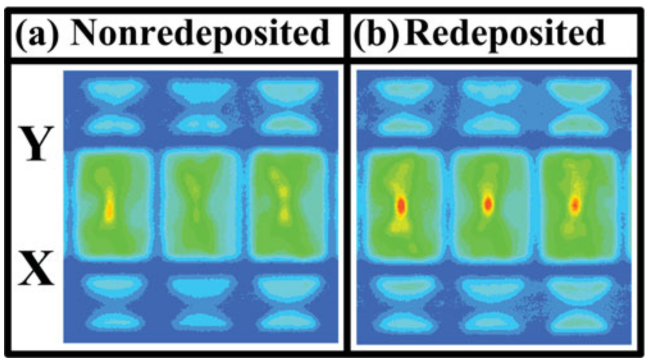

Figure 9. Comparison of IR emission profiles by use of focus mode of ICCD measured from nonredeposited and redeposited regions of Mg particles on MgO surface during sustain period under full-white background.

the redeposited Mg particles, thereby reducing the discharge delay time and intensifying the sustain discharges.

Figure 9 shows the comparison of IR emission profiles measured by ICCD operating in focus mode in the (a) nonredeposited and (b) redeposited region. The IR emission profiles of the ICCD image of the redeposited region were also observed to be intensified compared with that of the nonredeposited region. Consequently, these experimental results confirm that the redepostion of Mg particles on the MgO surface can enhance the MgO surface state similarly to injecting an MgO single crystal powder on the MgO surface, thereby contributing to improve the discharge characteristics of the PDP-TV.

4. Conclusions

This paper investigates the influences of the redeposited Mg particles on the electron emission of the MgO surface and related discharge characteristics of ac plasma display panel using the cathodoluminescence and intensified charge-coupled device techniques. The discharge characteristics of the redeposited region were improved due to the redeposited Mg particles compared with that of the nonredeposited region. Accordingly, the strong sustain discharge was efficiently initiated and intensified during the sustain period due to the enhancement of the electron emissions from the redeposited Mg particles. The use of redepostion of Mg particles on the MgO surface can modify the MgO surface state as MgO single crystal powder on the MgO surface, thereby contributing to improving the discharge characteristics.

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References

[1] Yoon, S.-H., Hong, C.-R., Ko, J. J., Yang, H.-S., & Kim, Y.-S. (2009). *J. Soc. Info, Disp.*, *17*, 131.
[2] Okada, T., Naoi, T., & Yoshioka, T. (2009). *J. Appl. Phys.*, *105*, 113304.
[3] Park, C.-S., Tae, H.-S., Kwon, Y.-K., & Heo, E. G. (2007). *IEEE Trans. Electron Devices*, *54*, 1315.
[4] Park, C.-S., Tae, H.-S., Kwon, Y.-K., & Heo, E. G. (2007). *IEEE Trans. Plasma Science*, *35*, 1511.
[5] Park, C.-S., Tae, H.-S., Kwon, Y.-K., Heo, E. G., & Lee, B.-H. (2008). *IEEE Trans. Electron Devices*, *55*, 1345.
[6] Park, C.-S., Kim, J. H., Jang, S.-K., Tae, H.-S., & Jung, E.-Y. (2010). *J. Soc. Inf. Disp.*, *18*, 606.
[7] Park, C.-S., & Tae, H.-S. (2010). *Appl. Phys. Lett.*, *96*, 043504.
[8] Park, C.-S., Tae, H.-S., & Chien, S.-I. (2011). *Appl. Phys. Lett.*, *99*, 083503.
[9] Park, C.-S., Kim, S.-Y., Jung, E.-Y., & Tae, H.-S. (2011). *Jap. J. Appl. Phys.*, *50*, 070210.
[10] Moine, B., & Bizarri, G. (2008). *J. Soc. Inf. Disp.*, *16*, 55.
[11] Jeon, M. J., Chung, M. S., Lee, S. C., Lee, K. S., Kim, J. S., & Kang, B. K. (2009). *Displays*, *30*, 39.
[12] Park, C.-S., & Tae, H.-S. (2009). *Applied Optics*, *48*, F76.
[13] Park, C.-S., Kim, J. H., Tae, H.-S., Lee, S.-H., Seo, J. H., & Kim, J.-K. in *Digest of Technical Papers of the 29th International Display Research Conference/Eurodisplay 2011* (Society for Information Display, Arcachon, 2011), p. 294.
[14] Park, C.-S., Tae, H.-S., Jung, E.-Y., Seo, J. H., & Shin, B. J. (2010). *IEEE Trans. Plasma Science*, *38*, 2439.
[15] Naoi, T., Lin, H., Hirota, A., Otani, E., & Amemiya, K. (2009). *J. Soc. Info. Disp.*, *17*, 113.
[16] Kim, J. H., Park, C.-S., Tae, H.-S., & Lee, J. H. in *Digest of Technical Papers of 2010 Society for Information Display International Symposium* (Society for Information Display, Seattle, 2010), p. 1599.
[17] Kim, J. H., Park, C.-S., Park, H.-D., Tae, H.-S., & Lee, S.-H. (2013). *J. Nanoscience and Nanotechnology*, *13*, 3270.