Discharge Characteristics of Counter Electrode Discharge Cells of PDP

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Abstract
In this study, a stripe type counter electrode discharge cell for PDP was attempted to realize high luminance efficiency and low firing voltage for fine pitch discharge cells. The cells were prepared using electroplated Cu/Ni electrodes coated with glass dielectric layer. The discharge behaviors of such cells were observed. These results indicate that the counter electrode discharge cells have different discharge behavior compared with coplanar cells, which may affect the luminance efficiency of the panel.

1. Introduction

There have been continuing demands for increased resolution of PDP TVs, especially with the advancements of competing devices such as LCDs and projection TVs. Increased resolution of PDP, however, reduces volume of the discharge cells and that leads to decreased luminance and luminance efficacy of PDP. The luminous efficacy of Full HD AC PDPs of 40 inch diagonal size is expected to be less than 1 lm/watt. Varieties of new cell designs are proposed as well as new ideas on driving scheme, discharge gas compositions, MgO protection layer, efficiencies of phosphors, etc. One of the efforts to solve this problem is to use counter electrode discharge cells.

Recently Asai et. al.[1] reported that the use of counter electrode discharge cells with 450 ㎛ discharge gap can lead to an significant improvements in luminous efficacy, up to 3.7 lm/watt. In these cells, sustaining and scan electrodes are embedded inside barrier ribs such that the discharge occurs between opposite barrier ribs. This arrangement of electrodes makes full use of discharge volumes inside the cells and therefore, the luminance and luminance efficacy of high resolution TVs may be enhanced recently, even at higher resolutions. The discharge cells used in the report were closed-type rectangular ones that are very complicated in structure and difficult for manufacturing. In addition, the discharges between

The sustaining electrodes were imbedded between the surfaces of short axis of the rectangular cells. For higher discharge efficiency, the discharge route should occur preferably along long axis of the rectangular cells to utilize its characteristics. Finally, evacuation air from the discharge cells during sealing and tip-off process may be problematic since the height of barrier ribs is much higher than conventional PDPs.

In this study, a new counter electrode discharge cells was prepared to investigate its discharge behavior. The counter electrode discharge cells were prepared by electroplating Cu/Ni pattern and their discharge characteristics were examined using ICCD. These results indicate that discharge cells of the counter electrode discharge cells have significantly different discharge behavior that may affect its luminance efficiency and stability of discharge.

2. Experimental

Counter electrodes of the discharge cells were formed by electroplating Cu on glass substrate which was patterned with DFR in a stripe pattern. The electrode was then coated with Ni as a diffusion barrier against the reaction with glass dielectric materials. Height and width of the electrodes was 80μm and 50μm, respectively. Pitch of the electrodes was 200μm. The thickness of Ni layer was approximately 2μm. The electrodes were then coated with dielectric layer via osmotic pressure coating process. The details of the process can be found elsewhere [2]. After sintering of the dielectric layer, MgO protective layer was formed by electrophoresis process. In this process, MgO nano-size powder suspension was used.

The front substrate patterned with counter electrodes was sealed with rear plate that is equipped with barrier ribs to observe discharge behavior using ICCD. Fig. 1 shows a schematic illustration of the test panel prepared from this study.

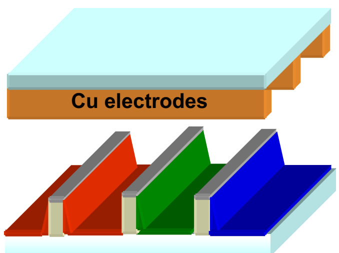
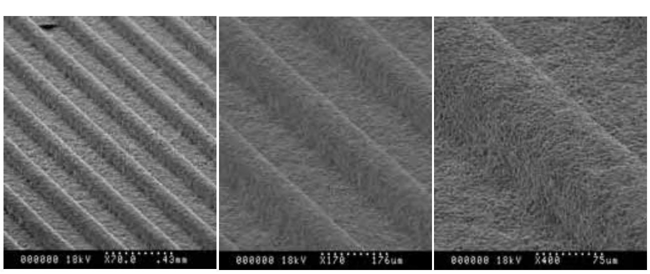


Fig. 1. Schematic illustration of counter electrode discharge cells used in this study.

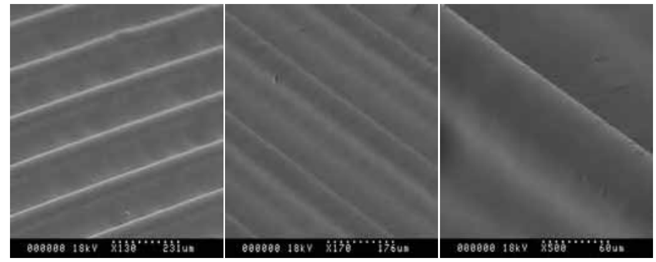
3. Results and Discussion

3.1. Preparation of counter electrode discharge cells

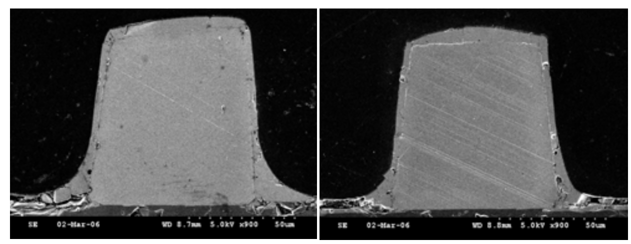
Figure 2 shows SEM images sustaining counter electrodes with transparent dielectric layer coated. Under as coated condition, a layer of glass frit was formed on the electrodes and surface of glass substrate (Fig. 2(a)). After sintering of the layer at 580°C for 30 min., continuous glass layer became formed on surface of the electrodes (Fig. 2(b)). With counter electrode(Cu) without Ni diffusion barrier, a significant degree of reaction occurred, resulting in crack and pore formation in the coated layer. As shown in Fig. 2(b), uniform layer without such defects was formed by the sintering process. Fig. 2(c) shows SEM micrographs of cross section of such electrodes.



(a)



(b)

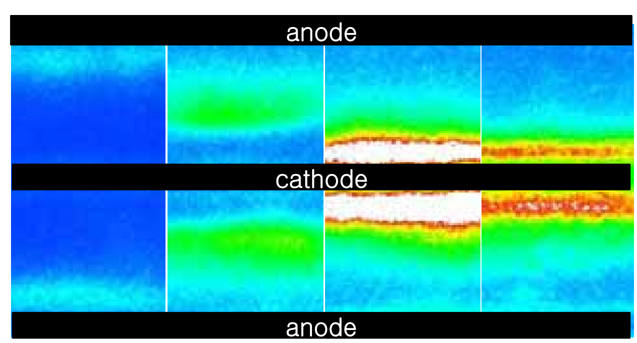


(c)

Fig. 2. SEM micrographs of stripe type cells : (a) prior to sintering (b) after sintering at 560°C for 1 hours and (c) morphology of electrode cross section.

3.2. Discharge behavior of counter electrode discharge cells

Figure 3 shows ICCD images of the discharge panel filled with Ne-4%Xe discharge gas. The images were obtained under gated operation mode. The images shows two discharge cells facing each other.



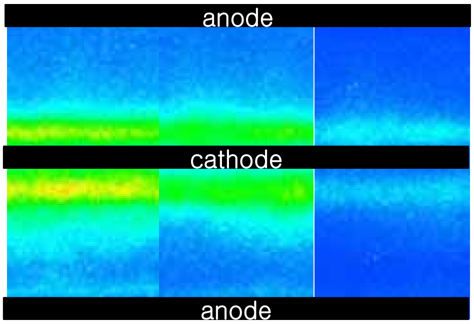
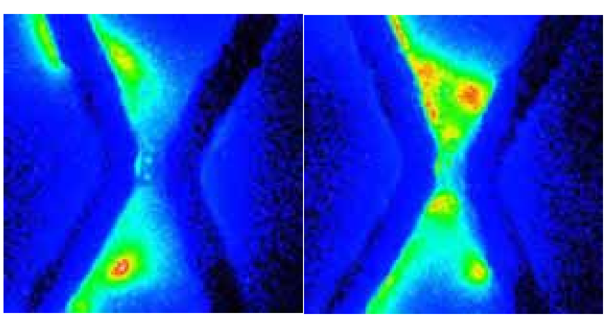


Fig. 3. ICCD images of glow discharge of counter electrode test panels filled with Ne-4%Xe discharge gas.

As noted from the figure, the discharge started from the anode and propagated towards cathode which is located middle of the images. Instead of typical filament-like discharge path which usually observed with long-gap counter electrodes, uniform discharge was obtained with the cells.

The propagation of discharge front from anode to cathode was also observed with meander type counter electrode discharge cells as shown in Fig. 4. As shown in the figure, the discharge started at the narrow gap of the counter electrodes and propagated to wider channel (Fig. 4(a)). After some time, strong near-IR emission was observed near the surface of cathode as shown in Fig. 4(b).



(a) (b)

Fig. 4. ICCD discharge images of meander type counter electrode discharge cell: (a) initial state and (b) final state.

When Xe content was increased to 10%, the discharge behavior of the counter electrode discharge appeared slightly different from that with Ne-4%Xe. As shown in Fig. 5, discharge behavior of the cells was similar to those of the panel with Ne-4%Xe gas except that luminance near anode region at the final stages of the discharge. Typical striation pattern that usually observed with coplanar discharge cells was not observed with the counter electrode discharge cells. Instead, very diffuse near-IR emission was observed. It is not clear how this discharge behavior will affect luminance efficiency of the cells.

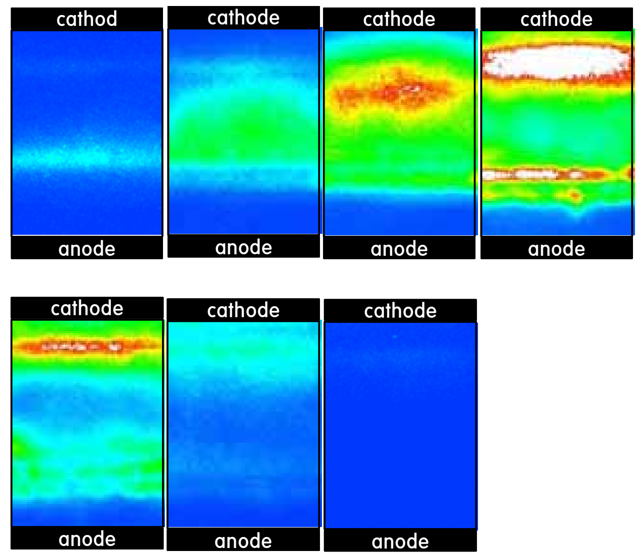


Fig. 5. ICCD images of glow discharge of counter electrode test panels filled with Ne-10%Xe discharge gas.

4. Conclusion

In this study, counter electrode discharge cells were prepared by electroplating Cu/Ni pattern and their discharge characteristics were examined using ICCD. These results indicate that discharge cells of the counter electrode discharge cells have significantly different discharge behavior and that may influence the luminance efficiency and stability of discharge.

5. References

[1] H. Asai, S. Mori, K. Sato, S. Ajisaka, A. Oku, K. Ikesue, S. Mori, K. Tanaka, N. Kikuchi, M. Iijima, M. Kobayashi, S. Sakamoto, I. Sumita, SID'05 Technical Digest, pp.210 -213

[2]. S.-S. Oh, D.-Y. Park, T.-J. Chang and Y.-S. Kim, SID'04 Technical Digest, pp. 499-501