New Front Plate Structure of ac-PDP using Aluminum Fence-Type Electrode Coated with Anodic Aluminum Oxide

Mi-yeon Lee, Sang-Hoon Yoon**, and Yong-Seog Kim***

Abstract

A new front plate structure of ac-PDP using fence-type aluminum electrode coated with anodic aluminum oxide was investigated. In this structure, ITO and glass dielectric layer were eliminated and expensive Ag BUS electrode was replaced with aluminum. Test panels were prepared using the new structure and their luminance and discharge characteristics were examined. These results indicate that the new structure provide a new way of cost reduction and enhancement of performance of ac-PDPs

Keywords : Fence-type electrode, Anodic aluminum oxide, PDP

1. Introduction

With remarkable advancements in image qualities and luminance efficiency of flat panel displays such as LCDs and PDPs in recent years, the cost competitiveness of flat panel displays has become the most critical factor that determines the success or failure of the devices. Among the various materials used for ac-PDPs, glass substrate and Ag electrode make up more than half of the total material costs of the device. Therefore, in order to reduce materials cost of PDPs, one of the obvious choices would be to replace expensive Ag electrode with cheaper metals such as aluminum. Additionally, this replacement of electrode material would eliminate the yellowing phenomenon of glass, which is due to diffusion and precipitation of Ag into glass [1]. With the aluminum electrode, therefore, it will be possible to use the conventional soda lime glass substrate since the diffusion of aluminum into the substrate would be minimal. For that purpose, of course, the sintering temperature of the glass frits should be reduced such that the glass substrate can be used.

One of the other advantages of replacing Ag electrode with aluminum is that generic dielectric layer forms on the surface of electrode by anodizing process. The anodizing process, which has been used to form dense oxide layer (anodic aluminum oxide, AAO) on the surface of aluminum, magnesium, and titanium mainly for protecting against corrosion and colorization, is being used recently to form dielectric layer for electrical applications such as film capacitors.[2-4] Therefore, it would be more economical the conventional transparent dielectric layer is replaced with the AAO layer. This replacement will make the transparent dielectric layer, Ag and ITO electrode, unnecessary, and hence reduce materials and processing costs of the panel, significantly.

In this study, a new structure for front plate of ac-PDP is proposed. In this structure, fence-type aluminum electrode coated with anodic aluminum oxide was explored (Fig. 1). The fence-type aluminum electrode was patterned from the aluminum foil bonded to glass substrate and anodized to form anodic aluminum layer as the dielectric layer. The layer could be grown thick enough to serve as dielectric barrier layer for the dielectric barrier glow discharge of ac-PDPs.

Table 1. Discharge characteristic of fence-type aluminum electrode coated with anodic aluminum oxide with Ne-4%Xe discharge gas

First cell on	full cell on	First cell off	full cell off
163v	175v	155v	141v

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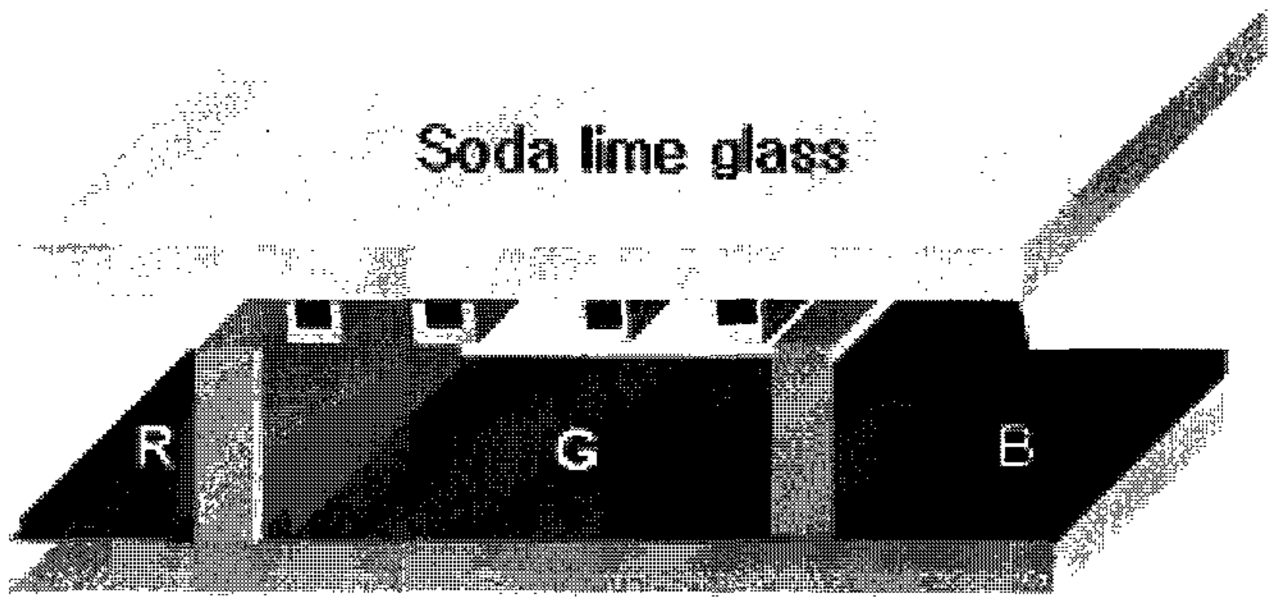


Fig. 1. A schematic illustration of discharge cell with fence-type aluminum fence electrode coated with anodic aluminum oxide layer.

With this structure, the glass dielectric layer of the front glass plate may be eliminated. The elimination of the glass dielectric layer should reduce the processing steps as well as processing costs. In addition, it may enhance luminance efficiency of the panels since loss of scattered light through the dielectric layer would become negligible and the plasma intensity be higher with increased electric field with the structure.

Thus, in this study, a possibility of new front plate structure with fence-type aluminum electrode coated with anodic aluminum oxide as dielectric layer was explored. Test panels were prepared with the structure and its luminance and other discharge characteristics were examined.

2. Experimental

Fig. 2 shows the processing steps employed in preparing fence-type aluminum electrode coated with anodic aluminum oxide layer. Firstly, aluminum foil that is 18μm thick was bonded with glass substrate. For the bonding layer, green tape containing glass frits were used. The aluminum foil, then, was coated with AZ-601 photo resist and patterned in the form of fence-type electrode by chemical etching process. After the etching step, the sample was heated to 540°C to facilitate chemical bonding between the glass layer and aluminum foil. After the bonding, the sample was immersed in an etching solution of the bonding glass and the bonding glass exposed was chemically etched. Subsequently, the electrode pattern was anodized in a solution of oxalic acid 0.3M at 18°C to form the anodic aluminum oxide. The thickness of the oxide after the anodizing was approximately 4~5μm. The oxide layer on the electrode was observed to be very uniform in thickness and dense in structure.

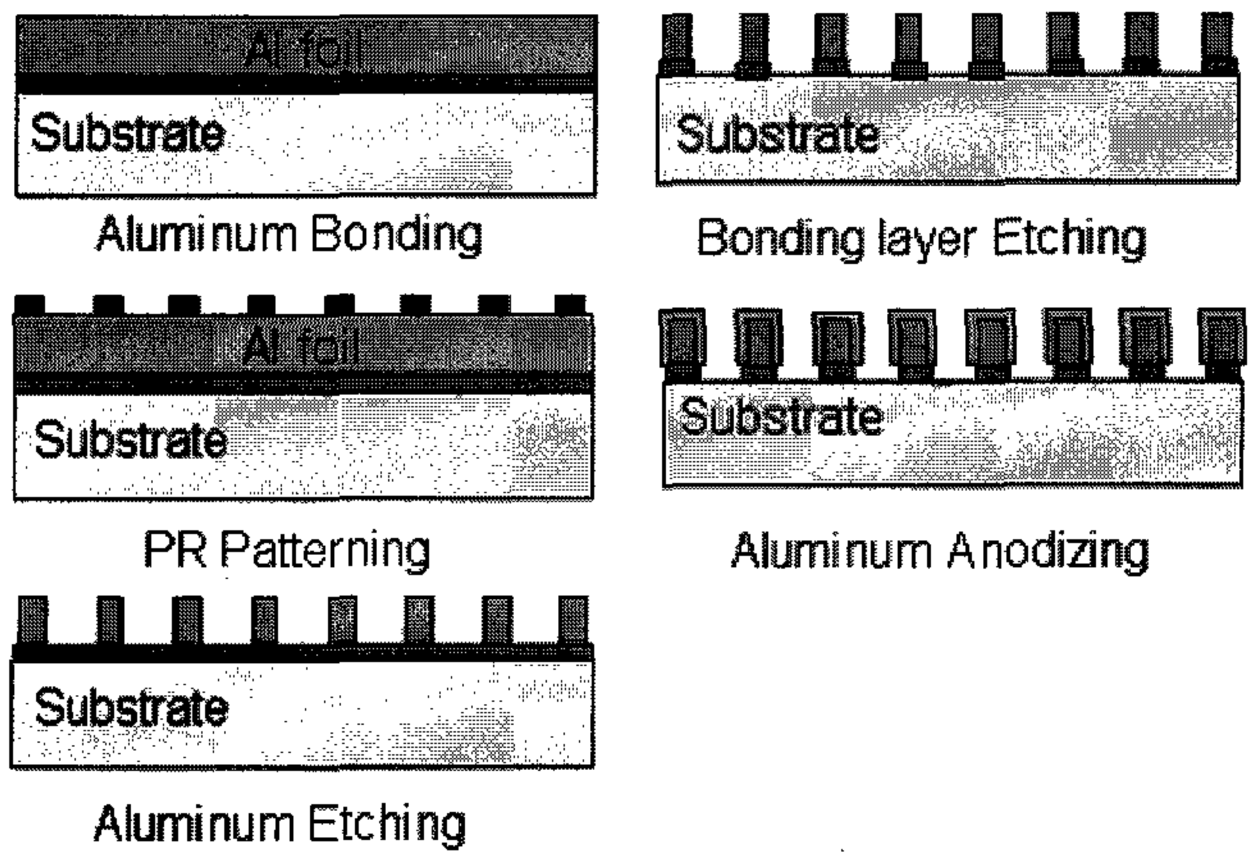


Fig. 2. Processing steps of preparing fence-type aluminum electrode coated with anodic aluminum oxide layer

In order to increase the breakdown voltage of the anodic aluminum oxide dielectric layer, a barrier type oxide layer was formed with the anodized layer via high voltage anodizing in an ammonium adipate electrolyte. In this anodizing, the voltage was 400 volt and 400~500nm thick barrier layer was formed.[5]

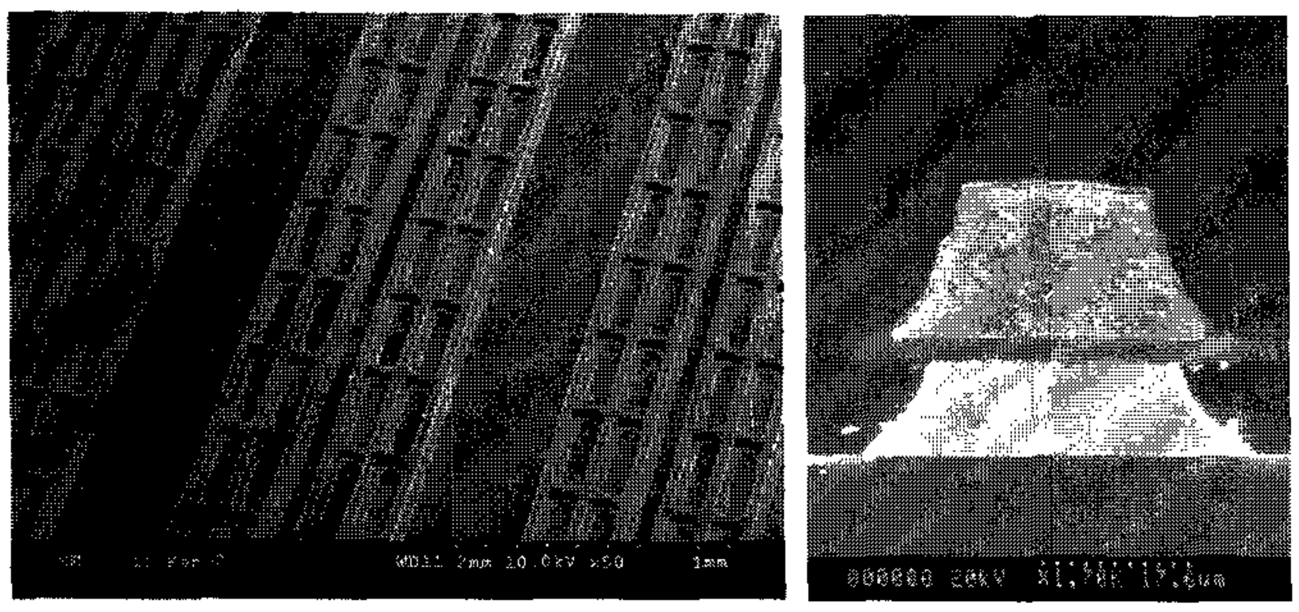
The front plate was coated with MgO thin film via e-beam evaporation process. The front plate and rear plate were sealed together to prepare test panels. The rear panel has stripe type barrier ribs and was coated with Zn_2SiO_4:Mn green phosphor. The panel size was 2 inch in diagonal and the discharge cells has a resolution of VGA grade of 42 inch panel.

3. Results and discussion

3.1 Preparation of fence-type aluminum electrode coated with anodic aluminum oxide layer

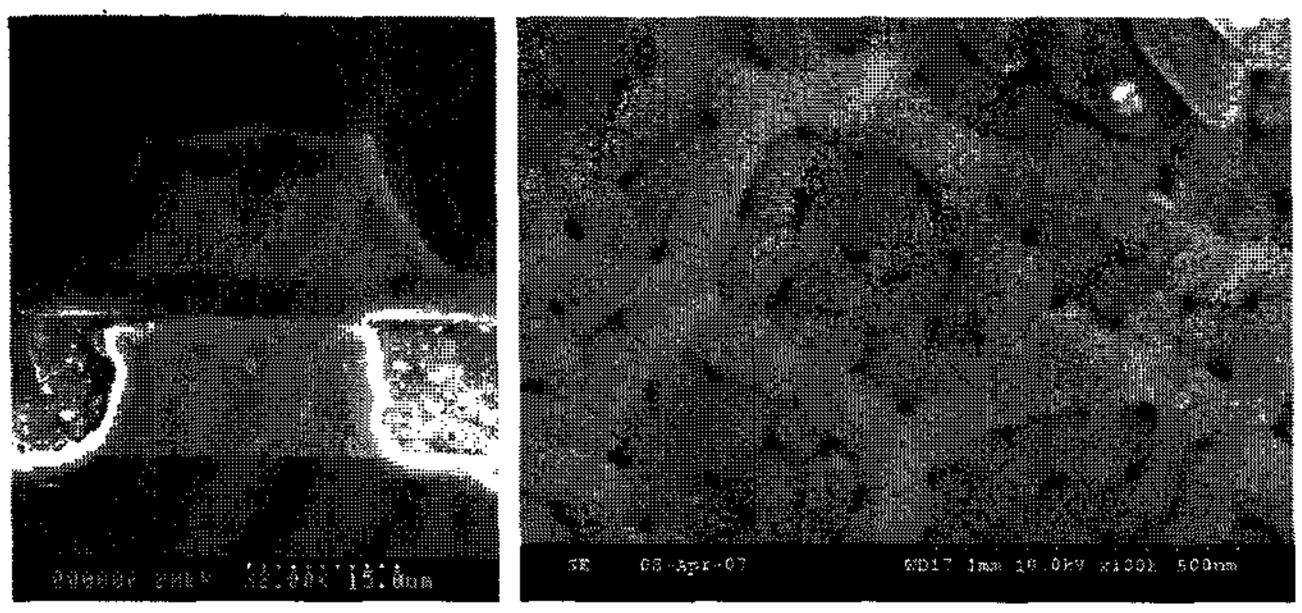
Fig. 3 shows the top and cross sectional view of aluminum electrodes after etching process. As shown in the figure, aluminum electrode pattern was formed fairly uniformly. Cross sectional image (Fig. 3(b)) shows that aluminum and bonding glass layers are tightly bonded together and does not show any defects. At the aluminum and bonding glass interface, anodic aluminum oxide layer was formed in order to enhance bond strength between the two materials by chemical reaction.

Fig. 4 shows the anodic aluminum oxide layer formed on the aluminum electrode after the chemical etching process via anodization process. As noted from the figure, a uniform anodic aluminum layer was formed during the process.



(a) (b)

Fig. 3. SEM Images of aluminum electrode after chemical etching steps: (a) top and (b) cross sectional view



(a) (b)

Fig. 4. SEM images of anodized aluminum electrode: (a) cross sectional and (b) surface view.

In order to determine the appropriate thickness of the anodic aluminum oxide layer, the effect of layer thickness on dielectric breakdown voltage were investigated. As shown in Fig. 5, the breakdown voltage increased linearly with the thickness of the layer. Thus, in this study, the anodic aluminum oxide layer thickness was 8 μm.

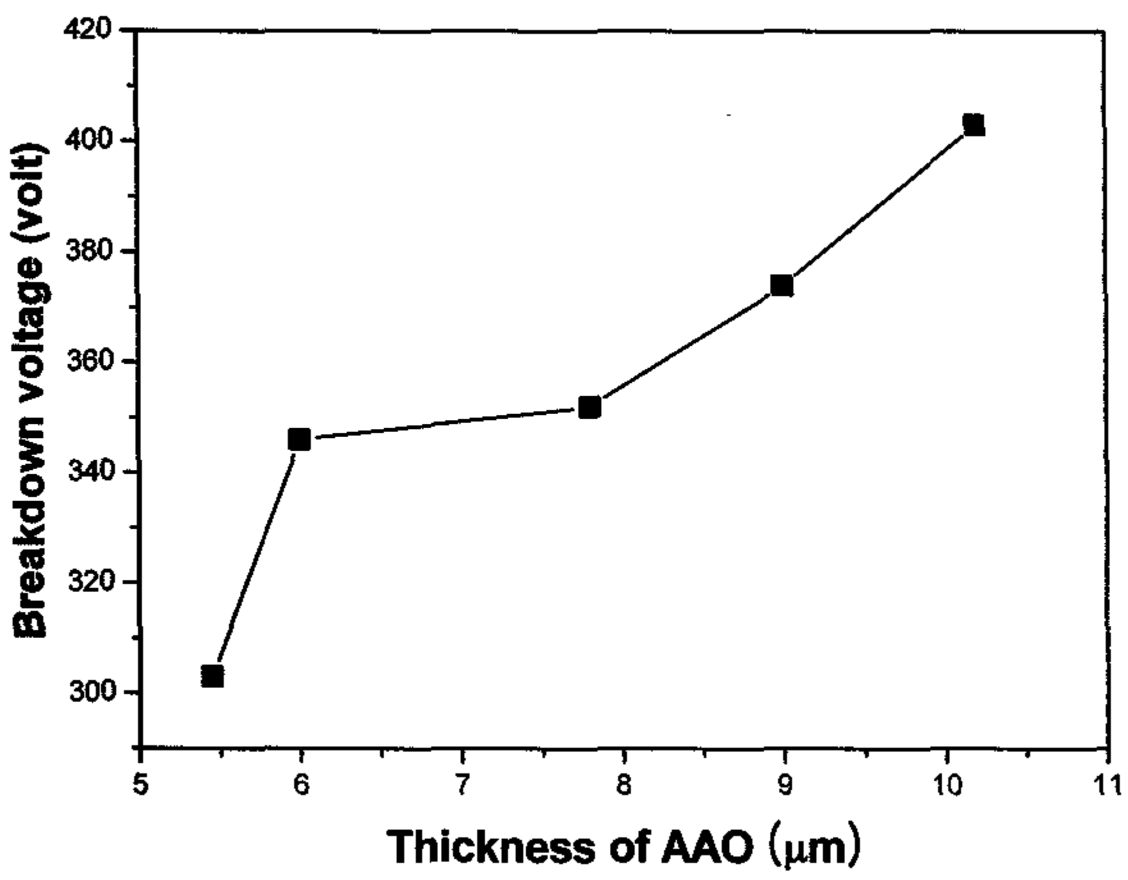


Fig. 5. Effect of AAO thickness on the breakdown voltage of AAO dielectric layer.

3.2 Discharge characteristic of test panel with fence-type aluminum electrode coated with anodic aluminum oxide layer

Fig. 6 shows the 2-inch test panel with aluminum electrode with anodic aluminum oxide dielectric layer during glow discharge. As can be seen from the figure, the panel emit green light uniformly over the surface of the test panel. With this specific panel, the first cell on voltage was about 163V and full cell on was 175 volt. The voltage difference between the first cell on and the full cell on was similar to or smaller than the conventional test panels with Ag electrode coated with glass dielectric layer. This shows that the uniformity of test panel is as good as the conventional panels.

Fig. 7 shows ICCD images of 2-inch test panel during glow discharge. The upper part of the fence electrode is cathode and the bottom part of the electrode is anode. As shown in the figure, the glow discharge started at the electrode gap and negative glow propagated along the surface of the cathode as in the conventional dielectric barrier discharge. The striation on anode surface was not observed with this test panel.

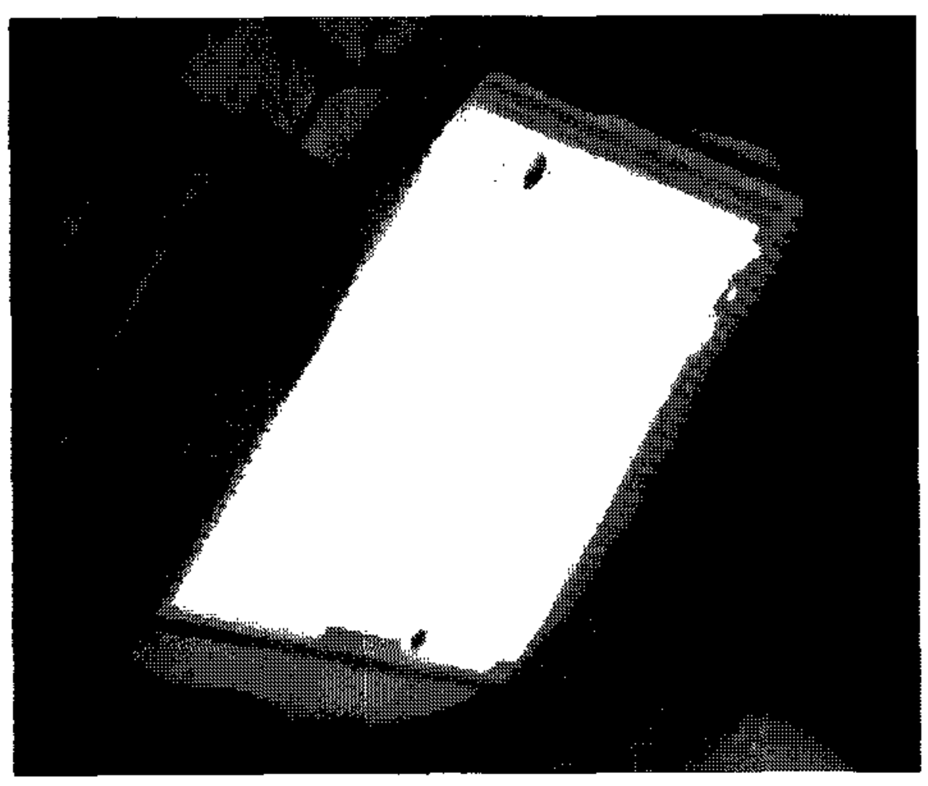


Fig. 6. 2-inch test panel during luminance measuring test

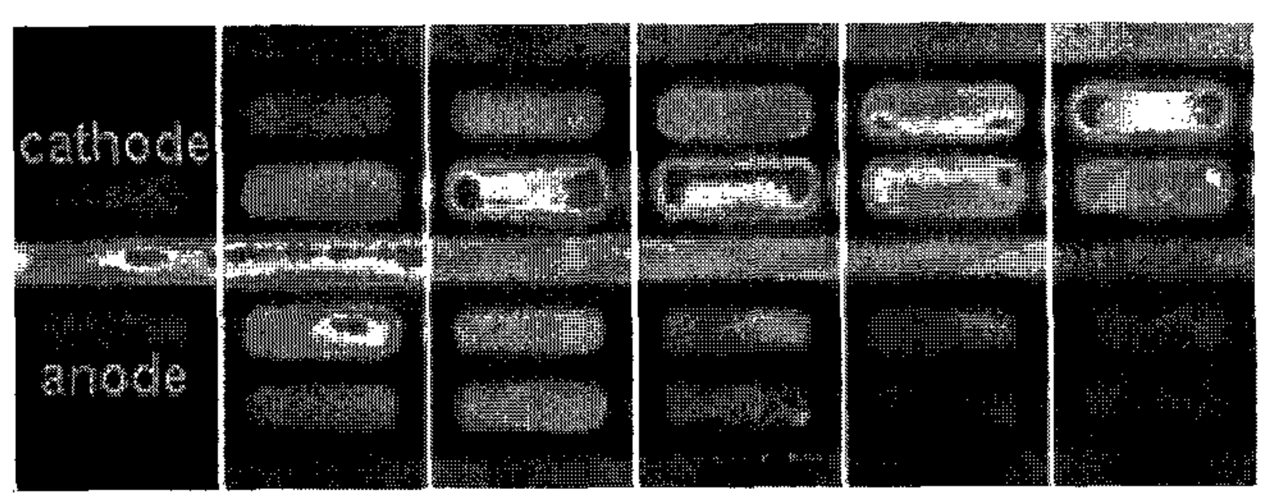


Fig. 7. ICCD images of glow discharge of aluminum fence-type aluminum electrode coated with anodic aluminum oxide. The discharge gas was Ne-4%Xe.

Luminance of the test panel was measured and compared with conventional panels (Fig. 8). As shown in the figure, the luminance of the test panel with anodic aluminum oxide layer appeared to be similar to that conventional test panels that use Ag electrode with glass dielectric layer. In this study, the luminance efficiency was not estimated since the capacitance of the anodic aluminum oxide dielectric layer was not optimized. These results suggest that the aluminum sustaining electrode with anodic aluminum oxide layer may be applicable in front glass structure of ac-PDPs.

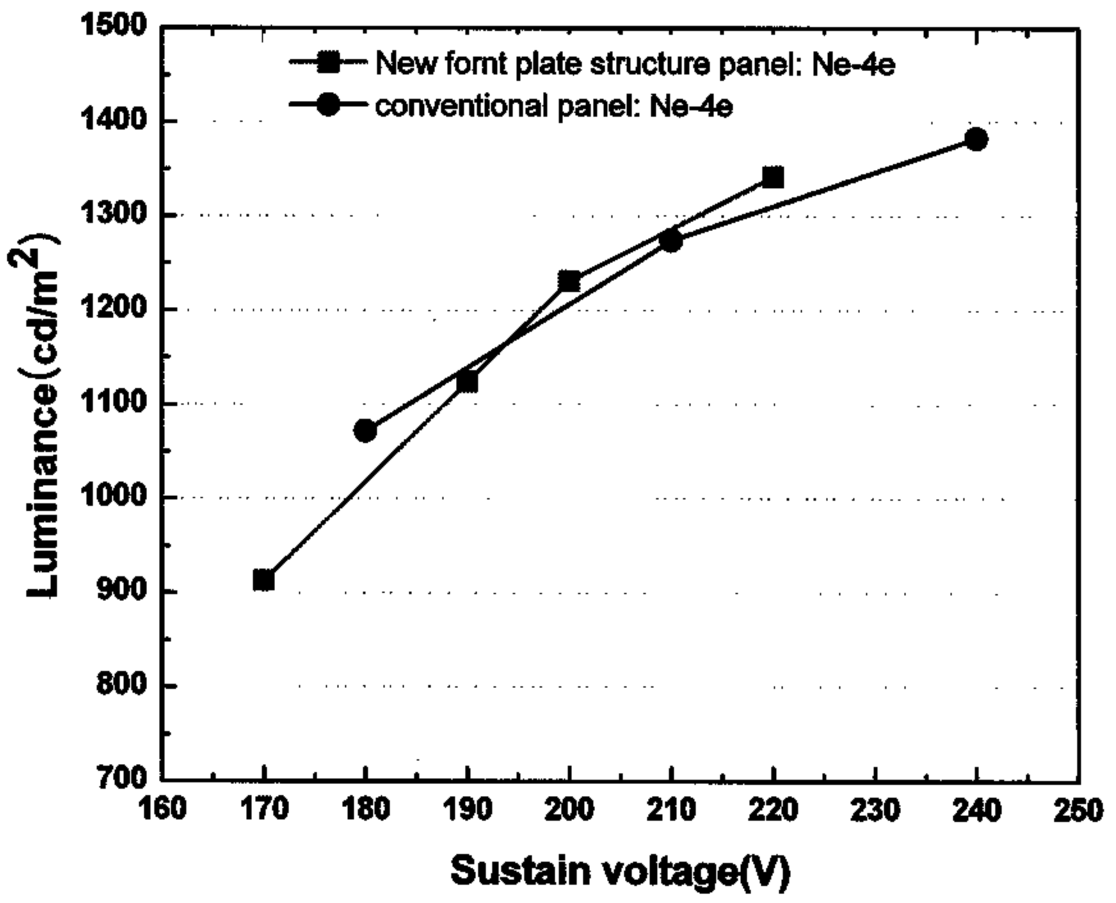


Fig. 8. Luminance of test panels with anodic aluminum oxide layer. The luminance of conventional test panel using Ag electrode with glass dielectric layer is also shown in the figure for comparison.

4.Conclusion

A possibility of new electrode structure of front plate of ac-PDPs was explored in this study. For the structure, aluminum electrode coated with anodic aluminum oxide layer was used as dielectric layer for dielectric barrier glow discharge. The results indicate that fence-type aluminum electrode with anodic aluminum oxide layer may be used for ac-PDPs and that could reduce the processing and materials costs ac-PDPs significantly.

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