Improvements of the discharge time lag using TiO$_2$ or MgO powder in plasma discharge cell

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Abstract. In order to decrease the discharge time lag, we modified the surface charge by adding liquefied TiO$_2$ or MgO powder on MgO layer in front glass and on the phosphor in rear glass in plasma discharge cell. Both the discharge voltage and the discharge time lag characteristics were measured from 4 inch test panel. The result of the proposed method using the TiO$_2$ or MgO powder shows that the statistic time lag is improved by about 35%.

Keywords: discharge time lag, TiO$_2$ or MgO powder, plasma discharge cell

1 Introduction

The plasma discharge cell is a flat panel display that utilizes a gas discharge in a low vacuum with a Xe-Ne gas mixture$^{1,2}$. The plasma discharge cell is consisted of glass substrates, electrodes, a transparent dielectric layer, and MgO protective layer. The MgO thin film is usually used as the dielectric layer in the plasma discharge cell due to its low sputtering yield and work function, excellent plasma resistance, and high secondary electron emission coefficient$^{3,4}$. As a driving method for a PDP, ADS (address-display separated) driving method has been used widely$^5$. The addressing time lag is defined as the sum of the discharge time lag and the duration of the discharge current$^6$. The MgO protective layer which is used so far is not considered to meet the demands of advanced full HD PDP requiring higher operational speed. In this study, TiO$_2$ powder is added as an additive to improve the discharge characteristics, and invest the effect of TiO$_2$. Thus, we changed the surface charge by adding liquefied TiO$_2$ or MgO which are formed on MgO layer and the phosphor in the plasma discharge cell.

2 Experimental methods

Figure 1 shows the principal structure of the plasma discharge cell. In an AC-PDP, discharge electrodes are coated with a lead-rich glass dielectric layer, followed by a thin protective film for which Magnesium oxide (MgO) is usually used. We made 4 in. test panels which has the same cell size as that of a 42-inch PDP with XGA grade
(1024 x 768), and the results shown in this report are the average of these three test panels. The 3g TiO$_2$ or MgO powder were mixed with alcohol 1 liter (0.3 wt.% TiO$_2$ and MgO). Table 1 shows the position of liquefied TiO$_2$ in the plasma discharge cell. The liquefied TiO$_2$ or MgO powder is formed by using a spray method. We fabricate the test panels which are added to the liquefied TiO$_2$ and MgO. The change of MgO crystal structure could influence the discharge characteristics of MgO protective layer. We measured the firing voltage, sustain voltage and addressing discharge time lag of each sample.

**Fig. 1.** The schematic diagram of AC-PDP

**Table 1.** The position of liquefied TiO$_2$ in the plasma discharge cell

<table>
<thead>
<tr>
<th>number</th>
<th>Position of liquefied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>Without liquefied TiO$_2$ and MgO</td>
</tr>
<tr>
<td>Sample 2</td>
<td>liquefied TiO$_2$ On the MgO layer in front glass</td>
</tr>
<tr>
<td>Sample 3</td>
<td>liquefied TiO$_2$ On the phosphor in rear glass</td>
</tr>
<tr>
<td>Sample 4</td>
<td>liquefied MgO On the MgO layer in front glass</td>
</tr>
<tr>
<td>Sample 5</td>
<td>liquefied MgO On the phosphor in rear glass</td>
</tr>
</tbody>
</table>
3 Experimental Results

Figure 2 shows the static driving characteristics (firing voltage and sustain voltage). The firing voltage of the “Front + MgO” and the “Front + TiO₂” on the dielectric were increased about 2~4 V compared with that of the “Standard”. The sustain voltage of the “Front + TiO₂” was increased about 8V compared with that of the “Standard”. The firing voltage of the “Rear + MgO” and the “Rear + TiO₂” were increased about 1~4 V compared with that of the “Standard”. The sustain voltage of the “Rear + TiO₂” was increased about 18V compared with that of the “Standard”. The “Front + TiO₂” and “Rear + TiO₂” was influenced TiO₂ effect. The effect of TiO₂ have relative low the second electron emission coefficient compared MgO. Thus firing voltage and sustain voltage were increased.

The light waveform measured in addressing period of the each case in applying to ADS. To detect the light during addressing discharge, avalanche photodiode module was used as a highly sensitive light detector. Discharge time lag is composed formative time lag and statistical time lag. The number of applied pulse is about 2000.

Figure 3 shows the discharge time lag as each case. Dispersion of light waveform, that is, statistical discharge delay of the “Front + MgO” is similar to the “Standard” and formative discharge delay is similar to it. However, statistical discharge delay of the “Front + TiO₂” is decreased about 40% compared with the “Standard” and formative discharge delay is similar to it. The statistical discharge delay of the “Rear + MgO” is decreased about 40% compared with the “Standard” and formative discharge delay is similar to it. From discharge time lag we can see that MgO powder on the phosphor layer makes address discharges more intensive and uniformity. Especially, the statistical time lag of the MgO on the phosphor is improved about 40% compared with the “Standard”.

![Fig. 2. The discharge voltage (firing voltage $V_f$, sustain voltage $V_s$)](image-url)
4 Conclusions

In this paper, the selected materials such as MgO or TiO₂ powder are sprayed between the dielectric layer and MgO thin film. The selected materials are also sprayed on the phosphor in order to improve discharge time lag. The statistical discharge time lag is seriously correlated with the ion electro-negativity of the materials between discharge electrodes such as MgO layer or phosphor. However, the formative time lag is not influenced on the materials by introducing MgO or TiO2 powder on the phosphor and MgO thin film.

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References