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Electro-optical characteristics of micro dielectric barrier discharge by adding tio_2 or mgo powder

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Abstract- For a higher definition discharge cell, the method of high speed addressing is necessary. In order to modify the surface charges, the liquefied TiO_2 or MgO powder is added on MgO layer in front glass and on the phosphor in rear glass in micro barrier discharge. Both the electro-optical properties and the discharge time lag characteristics were measured from 4 inch. test panel, such as the discharge voltage, current, luminance, luminous efficacy and discharge time lag. As the results, the statistic time lag is improved by about 35 %.

Keywords- dielectric barrier discharge, TiO_2 or MgO powder, discharge time

1. Introduction

A micro dielectric barrier discharge (MDBD) is confined to a volume less than 1 ㎜³ is an effective method to generate and maintain a stable low temperature glow discharge at atmospheric pressure. One of the applications of a MDBD is in developing AC-PDP (alternating current plasma display panel). [1]

Figure 1 shows the schematic diagram of a discharge cell in AC-PDP, and the tri-primary colors are obtained from the red-green-blue (RGB) phosphors excited by vacuum ultraviolet photons emitted from the gas discharge. The PDP is consisted of glass substrates, electrodes, a transparent dielectric layer, and MgO protective layer. The Magnesium Oxide (MgO) has crystal structures of NaCl type, and is known as a thermally and chemically stable material. 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 [2, 3]. In addition, MgO is transparent in visible region due to its wide band gap energy (~ 7.8 eV) [4].

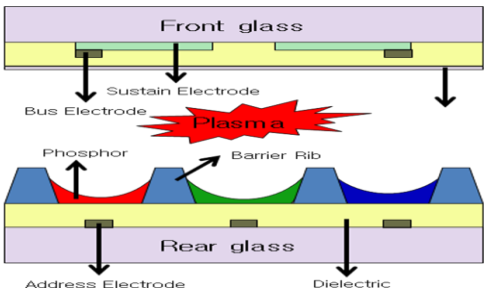

Fig. 1. The schematic diagram of AC-PDP

Recent progress of digital high definition (HD) broadcasting requires much higher image quality and resolution. For full HD PDP, there has been some technical point at issues as follows panel manufacturing process for much fine cell structure, and high speed addressing for the increased number of scan lines [5]. As a driving method for a PDP, ADS (address display separated) driving method has been used widely [6]. In the ADS driving method, a picture of one frame is divided into eight subfields and each subfield has reset, address and sustain periods. However, one of the most important troubles in ADS driving method is that the address time is too long. Therefore, the slow addressing speed becomes a big issue in the case of HD TV which has 1080 scan lines. The addressing time lag is defined as the sum of the discharge time lag and the duration of the discharge current [7]. If the addressing time is decreased, the sustain period for displaying images should be extended. 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. Currently, in order to solve the problems, many researches on improvement of MgO have been intensively studied for several years. Especially, improvement of characteristics of full HD PDP has been tried through alteration of MgO surface using oxide additives such as TiO_2, $Al2O_3$, SiO_2. TiO_2 is chosen due to be different blow off charge and ion electronegativity, as compared with MgO [8, 9,10].

In this study, TiO_2 or MgO powder is added as an additive to improve the electro-optical characteristics and discharge time lag. Therefore, we changed the surface charge by adding liquefied TiO_2 or MgO which are formed on MgO layer and the phosphor in AC-PDP.

2. Experimental methods

We made 4 in. test panels which has the same cell size as that of a 42-inch PDP with XGA grade (1024 x768). In order to improve the accuracy of the experiment, we made three test panels for each experiment and the results shown in this report are the average of these three test panels. Table 1 shows the specification of a 4-inch test panel.

Table 1. The specification of a 4-inch test panel

Working - gas: Ne + Xe(8%) 400 Torr			
Front glass		Rear glass	
Thickness of dielectric layer	30㎛	Width of address electrode	100㎛
Width of electrode	270 ㎛	Thickness of white back	20㎛
Electrode gap	60 ㎛	Height of rib	130㎛
		Pitch of rib	270㎛

The static discharge characteristics are investigated by applying 10 ㎑ sustain pulses to the Y and Z electrodes. The discharge time lag are investigated while applying the address-display separate (ADS) wave form which is shown in figure 2. The total period of eight subfield which includes rising time of 100 ㎲ during the reset-period and falling time of 150 ㎲ during the reset-down period is 16.3 ㎳. The total address time is 1 ㎳, which is the same condition as a 50-inch commercial PDP, and one pulse period of an address pulse is about 3 ㎲. We measured the addressing dis-charge time lag in 0.3 ㎳. The experimental equipment is composed of signal generator, driving circuit, and oscilloscope. The measurements of voltage and current waveform were carried out with a digital storage oscilloscope and a current probe. The voltage at which the first cell turns on while sustain voltage is increasing is called the "V_f" and the voltage at which a cell turns off while sustain voltage is decreasing is called the "V_s". The voltage margin indicates the difference multiplication of sustain voltage and the difference of V_f and V_s. Also, the luminance of the samples is detected by the luminance colorimeter (BM-7, Tocon Co.). We measured the firing voltage, static margin, luminance, luminous efficacy, the current waveforms and addressing discharge time lag of each sample.

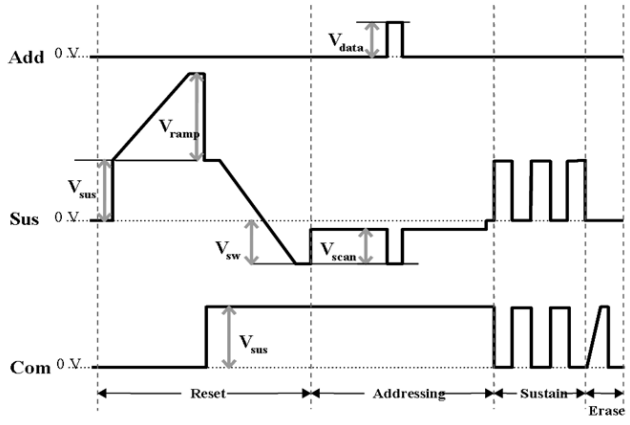

Fig. 2. The schematic diagram driving waveform for ADS

Table 2 shows the position of liquefied TiO_2 in the plasma discharge cell. The 3g TiO_2 and MgO powder were mixed with alcohol 1 liter (0.3 wt.% TiO_2 and MgO). The liquefied TiO_2 and 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. [11]

Table 2. The position of liquefied TiO_2 in the plasma discharge cell

number	Position of liquefied
Sample 1	Without liquefied TiO_2 and MgO
Sample 2	liquefied TiO_2 On the MgO layer in front glass
Sample 3	liquefied TiO_2 On the phosphor in rear glass
Sample 4	liquefied MgO On the MgO layer in front glass
Sample 5	liquefied MgO On the phosphor in rear glass

3. Experimental Results

Fig. 3 shows the static driving characteristics (firing voltage and sustain voltage). The static discharge characteristics are investigated by applying 20 ㎑ square pulses to the sustain electrodes of front plate. The firing voltage of the "Sample 4" and the "Sample 2" on the dielectric were increased about 2~4 V compared with that of the "Sample 1". The sustain voltage of the "Sample 2" was increased about 8V compared with that of the "Sample 1". The firing voltage of the "Sample 5" and the "Sample 3" were increased about 1~4 V compared with that of the "Sample 1". The sustain voltage of the "Sample 3" was increased about 18V compared with that of the "Sample 1". The "Sample 2" and "Sample 3"was influenced TiO_2 effect. The effect of TiO_2 have relative low the second electron emission coefficient compared MgO. Thus firing voltage and sustain voltage were increased.

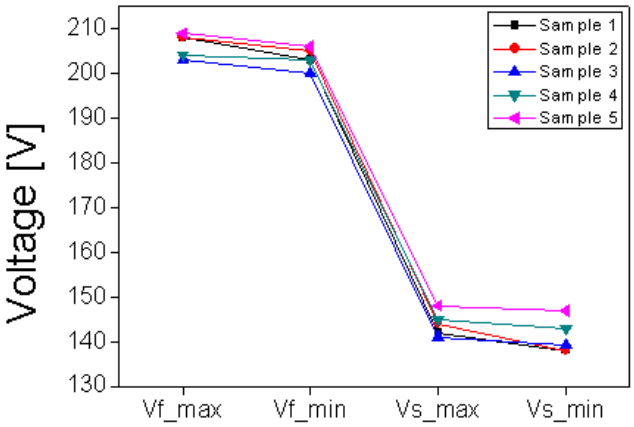

Fig. 3. The discharge voltage (firing voltage V_f, sustain voltage V_s)

Fig. 4 shows the variation of normalized discharge current as voltage changes. In this figure, the discharge current of the "Sample 4" and "Sample 2" are higher about 1%~2% than that of "Sample 1". The discharge current of the "Sample 5" is higher about 1% than that of the "Sample 1" and the discharge current of the "Sample 3" is lower about

1% than that of the "Sample 1". Therefore the MgO and TiO_2 material did not give influence at the discharge current.

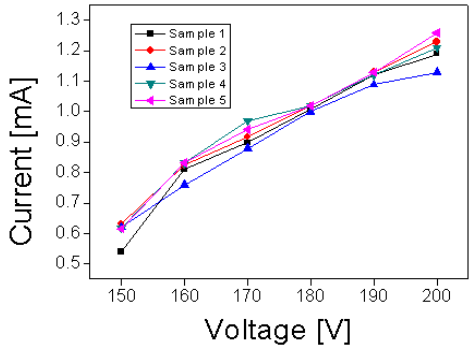

Fig. 4. The discharge current characteristic of samples

Fig. 5 shows the variation of normalized luminance as voltage changes. In this figure, the luminance of the "Sample 4" is increased about 2% compared with that of "Sample 1" and the "Sample 2" is similar to the "Standard". The MgO and TiO2 material did not give influence at the luminance. The luminance of the "Sample 5" is lower about 9% than that of the "Sample 1" and "Sample 3" is lower about 10% than that of the "Sample 1". These results are that visible ray is hided from the MgO powder and the TiO_2 powder.

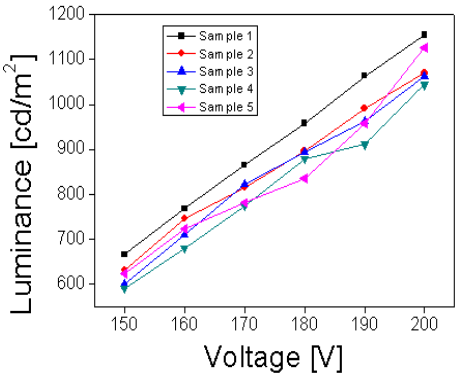

Fig. 5. The luminance characteristic of samples

Fig. 6 shows the variation of normalized luminous efficiency as voltage changes. In this figure, the luminous efficacy of the "Sample 4" is increased about 1~2% compared with the "Sample 1" and the "Sample 2" is decreased about 1%~2% compared with the "Sample 1". Specially, ±2% is error range. Thus, this result is indicating that MgO and TiO_2 have a little effect on luminous efficacy. Therefore suggested method is as good as "Sample 1". Also, it is possible to ADS drive waveform without changing voltage applied electrodes. The luminous efficacy of the "Sample 5" is decreased about 8% compared with the "Sample 1" and the "Sample 3" is decreased about 10% compared with the "Standard". Efficacy's decrease appeared by luminance's decrease. 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.

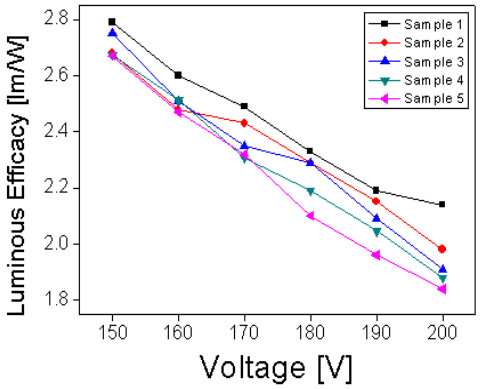

Fig. 6. The luminous efficacy characteristic of samples

Fig. 7 shows the discharge time lag as each case. Dispersion of light waveform, that is, statistical discharge delay of the "Sample 4" is similar to the "Sample 1" and formative discharge delay is similar to it. However, statistical discharge delay of the "Sample 2" is decreased about 40% compared with the "Sample 1" and formative discharge delay is similar to it. The statistical discharge delay of the "Sample 5" is decreased about 40% compared with the "Sample 1" 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 "Sample 1". These results can be explained as follows. The negative charge of TiO_2 powder influenced to MgO thin film. The applied voltage is much larger than blowup charge of materials. Thus formative time lag is same in 3 cases of these experiments. However, the blow-up charge of the MgO thin film is changed from positive charge to neutral charge and neutral charges of materials are reduced electron losses by the drift and diffusion. Therefore the seed electrons have an effect on wall charges and charged particles are in the cell and existed the longer time. Thus statistical time lag is reduced in case of neutral charge of phosphor layer.

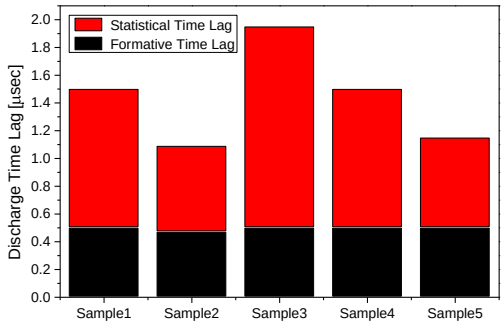

Fig. 7. The discharge time lag in addressing period

4. Conclusions

In this paper, the selected materials such as MgO or TiO_2 powder are spayed be-tween the dielectric layer and MgO

thin film. The selected materials are also sprayed on the phosphor in order to improve discharge time lag. The effects of selected materials are compared with "Standard". At the coplanar discharge, the results may be summarized as follows. First, the firing voltage of the TiO_2 powder on the phosphor and between the dielectric layer and MgO thin film are both higher 4V than that of conventional materials. Besides, the sustain voltage of the TiO2 powder on the phosphor is higher 18V and TiO_2 powder between the dielectric layer and MgO thin film is higher 12V than that of conventional materials because the TiO_2 has the relative lower secondary electron emission coefficient. The luminance and luminous efficacy of the MgO and TiO_2 powder on the phosphor are decreased than that of conventional materials because the MgO or TiO_2 powder on the phosphor has an effect on decreased transmission of a visible ray. And a few selected materials are not influenced at discharging current. Second, the statistical discharge time lag is seriously correlated with the ion electronegativity 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 TiO_2 powder on the phosphor and MgO thin film. Third, the formative time lag is same at all of the experimented cases. However, the statistical time lag decreased 40% in case of the MgO powder on the phosphor and TiO_2 powder between the dielectric layer and MgO thin film than that of the "Standard". High-speed addressing technology is involved the improvement of the discharge characteristics of a panel. From these results, proposed method for AC-PDPs will be usable. If the proposed methods are used for AC-PDPs, it shows cost-reduction for driving circuit, increase of luminance and image quality, because proposed methods has improvement of the number of the subfield and sustain pulses.

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