Improvement of Discharge Characteristics in AC Plasma Display Panel Using Lead-free and Low Permittivity Rear Dielectric Layer

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ABSTRACT

In this paper, the lead-free and low permittivity rear dielectric material (ZnO-B_2O_3 glass system) was adopted to remove the lead-oxide (PbO) ingredient and improve the discharge characteristics, and the resultant change in the discharge characteristics, such as the luminance, and luminous efficiency, address power consumption, were examined in comparison with that of the lead-oxide (PbO) containing glass system rear dielectric material in the 50-in. HD PDP. In the rear panel fabricated by the ZnO-based dielectric material, the luminous efficiency is improved by about 7 %, and address power consumption is reduced by 20% or more.

1. INTRODUCTION

In the structure of AC plasma display panel (PDP), a dielectric layer is formed on both rear and front panels to protect the address and bus electrodes of AC PDP. In the case of dielectric layer on the rear panel (rear dielectric layer), a high reflectance is required since the visual light is seen through the reflection of the rear panel of PDP.

The rear dielectric layer is physically protecting and reflecting dielectric layer for insulation of address electrode. However, in an AC PDP, like the front dielectric layer, the rear dielectric layer also plays a role in accumulating the wall charges on the dielectric surface. Thus, the rear dielectric and front dielectric layers are the major factor for determining the cell capacitance, so that their memory effects play a significant role in AC PDP driving [1]. These dielectric characteristics of the front or rear dielectric layers are mainly determined by their material composition ingredients.

The PbO, that is a major essential ingredient in the rear dielectric layer, has widely been used for a low soften temperature point and stability in spite of the toxic material. Recently, to meet the international environment regulation, that is RoHS (Restriction of the use of certain Hazardous Substance in EEE), an intense study to remove the toxic material in PDPs has been made. The PbO ingredient can be substituted for Bi_2O_3, ZnO, P_2O_5 ingredient, and so on. The Bi_2O_3(Bismuth-Oxide) and ZnO(Zinc-Oxide) ingredient have been studied steadily as a substitute of PbO [2,3]. In fact, presently, the ZnO is applicable to the dielectric layer of rear panel. In case of ZnO-B_2O_3 (Zinc-Borate) type, its

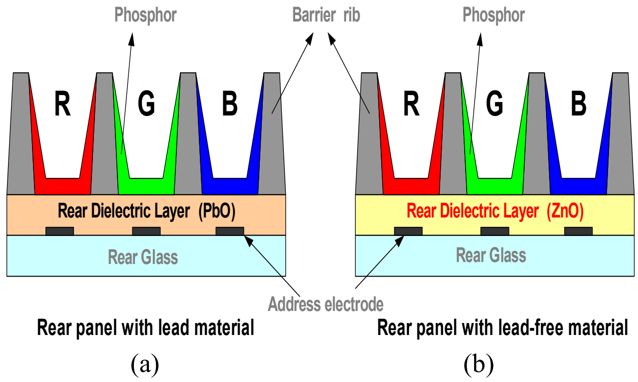


Fig. 1. Schematic diagram of (a) conventional rear panel with lead (PbO-based) material and (b) conventional rear panel with lead-free (ZnO-based) material employed in this research.

permittivity becomes lowered due to the material characteristics. The permittivity of PbO is equal to 22, whereas the permittivity of ZnO is equal to 9.

Accordingly, this paper investigates the rear lead-oxide free dielectric material characteristics with a low permittivity. In particular, the effects of the rear lead-oxide free dielectric material characteristics with a low permittivity on the PDP discharge characteristics are examined intensively.

2. EXPERIMENTAL SETUP

In order to verify the characteristics of the lead-free and low permittivity of rear dielectric layer, we fabricated the 50-in HD test panels including the rear dielectric material with two kinds of ingredients, respectively, as shown Fig. 1. One panel consists of the PbO-SiO_2 containing glass systems, whereas the other panel consists of the ZnO-B_2O_3 containing glass systems. Furthermore, for this experiment, we fabricated the 50-in HD PDP test modules.

Table 1.(a) shows the compositions composing the rear dielectric layer. The permittivity of the PbO-SiO_2 (PbO-based) containing glass systems in the conventional rear dielectric material was about 20, whereas the permittivity of the ZnO-B_2O_3 (ZnO-based)

Table 1. (a) Compositions PbO-based and ZnO-based rear dielectric layer(RDL) and (b) the properties of PbO-based and ZnO-based rear dielectric layer (RDL) employed in this study

Lead Containing glass system (PbO-based RDL)	Lead-free glass system (ZnO-based RDL)
PbO, SiO_2, B_2O_3, Al_2O_3 , Filler	ZnO, B_2O_3, BaO, SiO_2 , Al_2O_3,CuO, Filler

(a)

	Permittivity	thickness	Capacitance
PbO-based	20	15 um	1.33 A
ZnO-based	13	11 um	1.18A

(b)

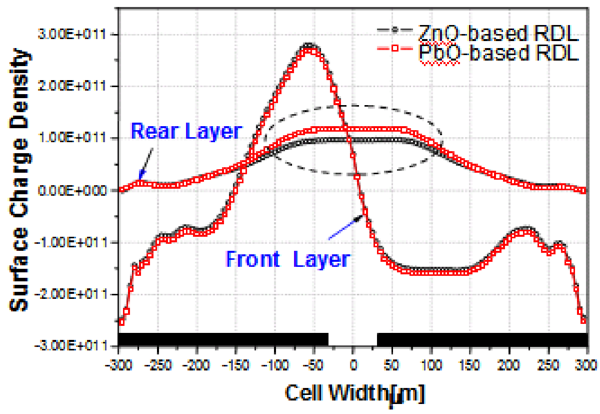


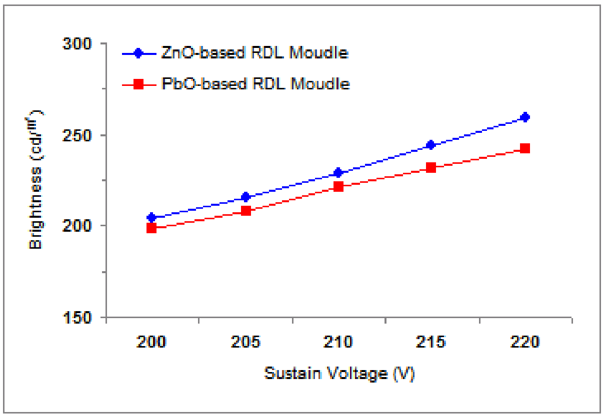
Fig. 2. Simulation results of surface wall charge density in two different test panels fabricated by PbO-based RDL and ZnO-based RDL.

containing glass systems in the rear dielectric material was about 13. As shown in table 1.(b), to modify the capacitance of both the rear panel comprising the PbO-based rear dielectric layer (RDL) and the rear panel comprising the ZnO-based RDL, the thickness of PbO-based RDL and ZnO-based RDL were 15 um, and 11 um, respectively, which were thiner than that of the PbO-based RDL. In this case, the rear panel capacitances in the PbO-based RDL and ZnO-based RDL were 1.33 A(A means unit area), and 1.18 A, respectively.

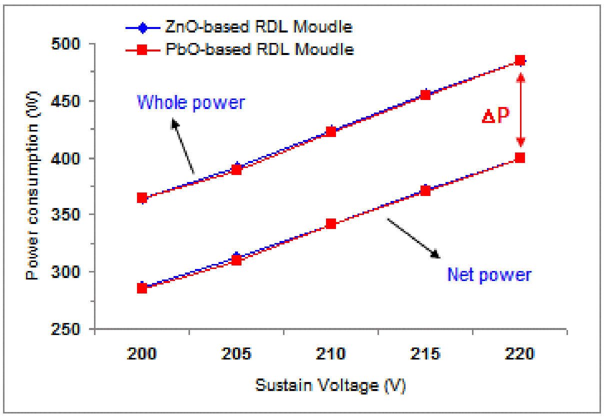
In order to accurately evaluate the capacitance changes of the rear panel, the other conditions were all the same with two different panels. The discharge characteristics for two different panels fabricated by using the PbO- based RDL and the ZnO-based RDL were examined.

3. RESULTS AND DISCUSSION

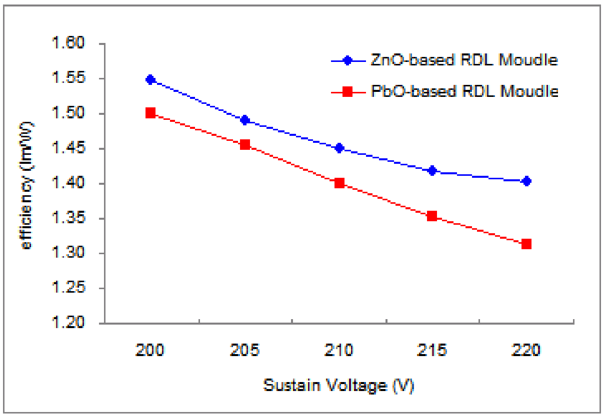
Fig.2 shows the simulation results of the surface wall charge density after the sustain and address discharge are produced in the test panels fabricated by the PbO-based



(a)



(b)



(c)

Fig. 3. Comparison of discharge characteristic in two different test panels fabricated by PbO-based RDL and ZnO-Based RDL: (a) brightness (b) whole and net power consumption (ΔP means react power) (c) luminous efficiency relative to sustain voltage.

RDL and ZnO-based RDL. The simulation results were consistent with the expected results. In the rear panel side, the surface charges in the ZnO-based RDL was a little more reduced than that of in the PbO-based RDL, but there was not almost change in the front panel side. A change in the rear panel capacitance induced by the ZnO-based low permittivity RDL has an influence on the charge accumulation capability in the rear panel.

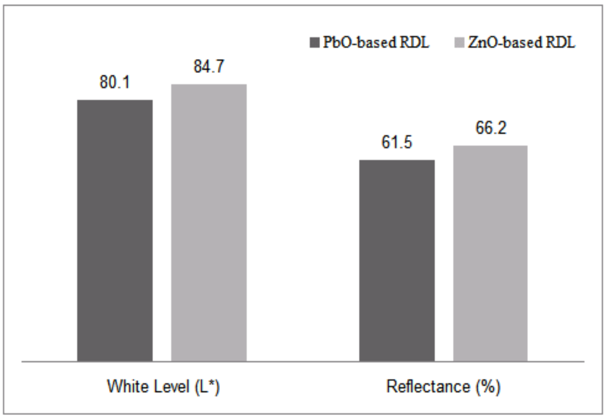


Fig. 4. Comparisons of (a) white value (L*) and (b) reflectance (R, @550nm) with respect to each rear dielectric material.

Fig. 3 shows the comparison of the discharge characteristics in the two different test panels fabricated by PbO-based RDL and ZnO-based RDL. For two cases, the brightness is compared in Fig. 3(a), the power consumptions in Fig. 3(c). The corresponding luminous efficiencies relative to the sustain voltage are compared in Fig. 3(c). As shown in Fig. 3(c), the luminous efficiency in the ZnO-based RDL case was improved about by 3 to 7 %. The whole power consumption including the reactive power (ΔP) and the net power of each module was almost similar, as shown in Fig. 3(b). However, the brightness in the ZnO-based RDL case was higher than that of the ZnO-based RDL case, implying that the brightness of the module fabricated by the ZnO-based RDL was more increased, even though the power consumption of two kinds of modules were similar each other, as shown in Figs.3(a) and (b).

The higher brightness in the ZnO-based RDL case would be mainly due to the higher white level (L*) and reflectance in the ZnO-based RDL case than the PbO-based RDL case.

Fig.4 shows the comparison of the white level (L*) and reflectance(R) with respect to two different rear dielectric materials such as the ZnO-based RDL and PbO-based RDL. In Fig. 4, the higher number of the white level (L*) means the higher whiteness, and the higher number of the reflectance (R) means the higher reflectivity. In the ZnO-based RDL case, the white level (L*) was approximately 6 % and reflectance(R) was around 8 %, which were higher than those of the PbO-based RDL case. The increase in the white level (L*) and reflectance(R) can enhance the reflectance efficiency of a visible light in the discharge space, thereby resulting in the brightness improvement.

Fig. 5 shows the various test patterns displayed for measuring address power consumption according to address input signal: (a) test pattern 1: full white pattern, (b) test pattern 2: full red pattern, (c) test pattern 3: full green pattern, (d) test pattern 4: full blue pattern, (e) test

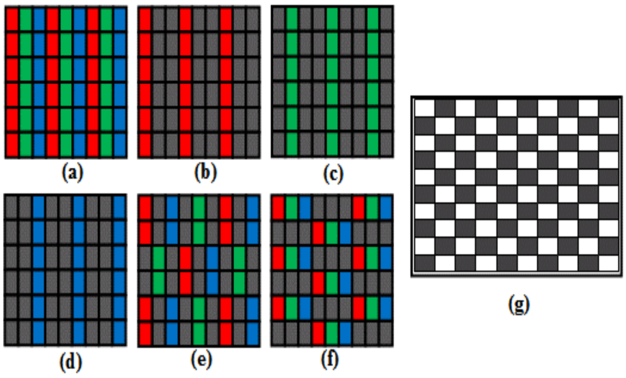


Fig. 5. Various test patterns displayed for measuring address power consumption according to address input signal: (a) test pattern 1: full white pattern, (b) test pattern 2: full red pattern, (c) test pattern 3: full green pattern, (d) test pattern 4: full blue pattern, (e) test pattern 5: two cell on-off pattern, (f) test pattern 6 : one-pixel on-off pattern, and (g) test pattern 7 : chess pattern by 10×10.

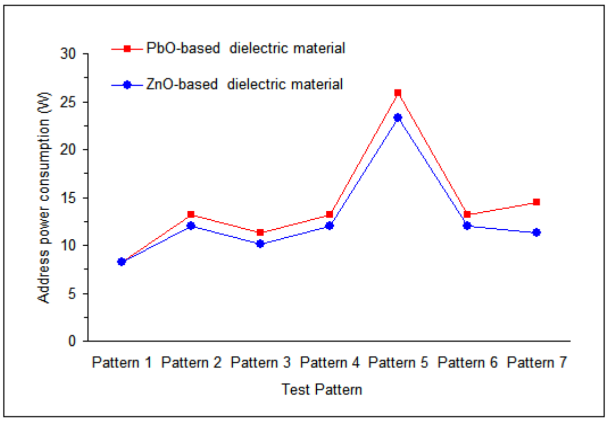


Fig. 6. Comparisons of address power consumption in two different test panels fabricated by PbO-based RDL and ZnO-based RDL (applied voltage conditions : Va = 63 V, Vs = 205 V)

pattern 5: two cell on-off pattern, (f) test pattern 6 : one-pixel on-off pattern, and (g) test pattern 7 : chess pattern by 10×10.

Fig. 5 shows the comparison of the address power consumption in the two different test panels fabricated by the PbO-based RDL and ZnO-based RDL. In order to input the various signals to the address electrode, a digital video generator (VG-828, Astrodesign Inc.) was used. According to the signal pattern sent to the address electrode, the address power was less consumed about by 20 % in the ZnO-based RDL case than the PbO-based RDL case. This decrease in the address power consumption mainly resulted from the address current reduction. In the full-white pattern in which the input data signals to the address electrode were not varied, the address power consumptions were almost the same for

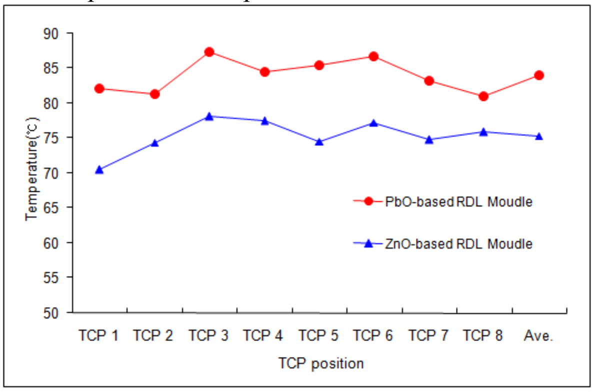


Fig. 7. Changes in the heating temperature relative to TCP position in two different test panels fabricated by PbO-based RDL and ZnO-based RDL.

two cases. On the other hand, in the test pattern in which lots of input data signals to the address electrode were varied, the address power consumption was reduced considerably in the ZnO-based RDL case. It is known that the address power is strongly related to the TCP (Tape Carried Package) heating generation of address electrode terminal. Consequently, the address power reduction in case of adopting the ZnO-based RDL causes a temperature drop by TCP heating generation. Fig. 7 shows the changes in the heating temperature relative to the TCP position in two different test panels fabricated by the PbO-based RDL and ZnO-Based RDL. As shown in Fig. 7, the heating temperature was reduced about by average10 % in the ZnO-based RDL case. This reduction of the TCP heating temperature is very significant because a low cost material can be used in the AC- PDP thanks to the use of the TCPs with low heating resistance.

4. Conclusions

In this paper, the improvement of discharge characteristics is investigated in the AC-plasma display panel using lead-free and low permittivity dielectric material. In particular, the improvement of the luminous efficiency is made in the AC-PDP using the low permittivity dielectric material. The characteristics of ZnO containing glass system of PbO-free are introduced. As mentioned above, the ZnO containing glass system of PbO-free was developed as environmentally friendly material for international environment regulations, which is RoHS. The low permittivity property can decrease the temperature of interconnection (TCP) by reducing the address electrode power and current. In addition, the ZnO-based RDL has increased the panel brightness, thus resulting in improving the luminous efficiency.

5. REFERENCES

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