Reciprocal Sustain and Auxiliary Pulse Waveforms Applied to an AC PDP with an Auxiliary Electrode

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Abstract

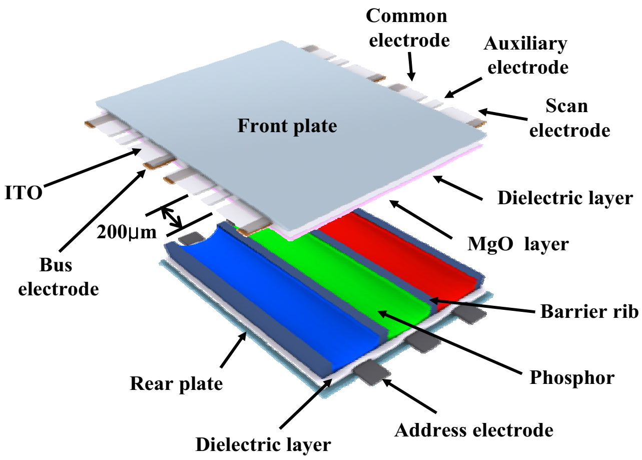
Modified pulse waveforms were applied to an AC plasma display panel with an auxiliary electrode in order to improve the operation voltage margin. Reciprocal sustain pulse waveforms and modified auxiliary pulse waveforms were applied to the sustain and auxiliary electrode, respectively. During the sustain period, the influence of the address electrode on the luminous efficacy of long-coplanar gap discharges was mitigated by application of reciprocal sustain pulse waveforms. Modified auxiliary pulse waveforms maintained the high efficacy obtained from the AC PDP with an auxiliary electrode. The proposed reciprocal sustain and modified auxiliary pulses waveforms can induce stable discharges in long-coplanar gap discharges and can control wall charges with a wider auxiliary pulse voltage margin, thereby enhancing the luminous efficacy of the AC PDP with an auxiliary electrode.

1. Introduction

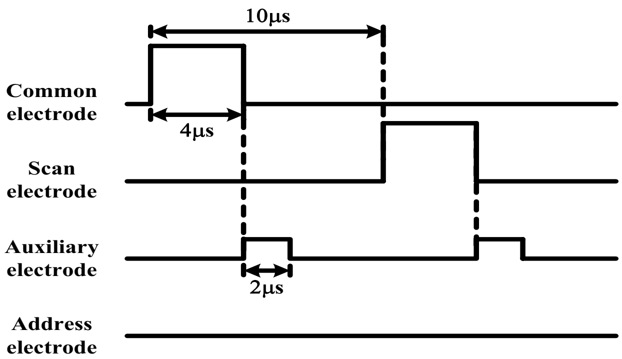
Plasma TVs are currently struggling to compete with LCD TVs in the quest to win the dominant share of worldwide TV markets. Plasma TVs based on AC plasma display panels are known to consume large amount of power. However, the real power consumption of a plasma TV is dependent on APL (Average Picture Level) [1]. The power consumption of a PDP TV is almost the same as that of a LCD TV at an APL of 20 %. New technology such as back light dimming technique is now being developed for LCD TVs in efforts to reduce power consumption. Meanwhile, the power consumption of plasma TVs is determined by the energy efficiency of the plasma display panel. To date, several approaches such as high Xe content discharge and long coplanar-gap have been adopted for the improving luminous efficacy of AC plasma display panels [2,3,4,5]. In our previous work, high Xe contents discharge and a longer coplanar-gap structure relative to the conventional coplanar-gap were integrated with an auxiliary electrode. This newly proposed AC plasma display with an auxiliary electrode showed remarkably high efficacy [5,8]. The mechanism of the newly proposed structure has been studied [6] and an appropriate driving scheme for the new structure was also proposed [7]. The newly proposed AC plasma display with an auxiliary electrode should have greater barrier rib height than the conventional arrangement in order to reduce the effect of the address electrode on sustain discharges. The voltage margin of the newly proposed structure is narrowed to the extent that the driving condition is inferior to that of the conventional technology. In the present work, reciprocal waveforms are applied to an AC plasma display with an auxiliary electrode and a longer-coplanar-gap in order to enlarge the dynamic margin. Related experiment results are also discussed.

2. Highly Efficient AC PDP with an Auxiliary Electrode

Fig.1(a) shows a schematic diagram of the FEEL (Fourth Electrode for enhancing the Excitation rate in a Long coplanar gap) PDP, an AC PDP with an auxiliary electrode while Fig.1(b) shows normal waveforms applied to the FEEL PDP at a sustain pulse frequency of 50 kHz [5]. In the case of a FEEL PDP previously introduced by the authors, the gap between the sustain electrodes was 200 μm, which was longer than that of a conventional AC PDP [5]. An auxiliary electrode with a width of 100 μm is located between the sustain electrodes (scan and common electrode) and is made of indium tin oxide (ITO), a transparent conductor. When the auxiliary pulses, as shown in the fig.1(b), were applied to the FEEL PDP, the luminous efficacy was improved owing to the following reactions: reduction of discharge current and priming effect due to the auxiliary pulses [6]. When the waveforms, as shown in the fig. (b), were applied to each electrode during the sustain period, the maximum luminous efficacy of more than 10 lm/W was obtained in FEEL PDP designed as 42-inch VGA resolutions with closed barrier ribs and green phosphor [8].



(a)



(b)

Fig.1 (a) Schematic drawing of an AC PDP with an auxiliary electrode (normal FEEL PDP) and (b) normal waveforms applied to a FEEL PDP

The gap between the scan and common electrode is longer than that between the address and sustain electrode in FEEL PDPs. Therefore, it is expected that the dynamic margin of FEEL PDPs will be inferior to that of the conventional technology owing to the interaction between the address and sustain electrodes. Fig. 2 shows the dynamic margin of a FEEL PDP with an auxiliary electrode and RGB color pixels when the height of the barrier rib was 150 μm. Note that the sustain voltage margin is relatively narrow. The dynamic margin also decreases with an increase in the voltage of the pulse applied to the auxiliary pulse. Here, Vaux stands for the voltage of the auxiliary pulse. The applicable maximum voltage of the auxiliary pulse is 40 V. The limitation of the voltage of the auxiliary pulse affects the luminous efficacy of the FEEL PDP. Due to the limitation of the applicable voltage of the auxiliary pulse, the luminous efficacy decreases and the driving stability also worsened. Therefore, new driving waveforms are required in order to enlarge the dynamic margin and maintain high efficacy in FEEL PDPs.

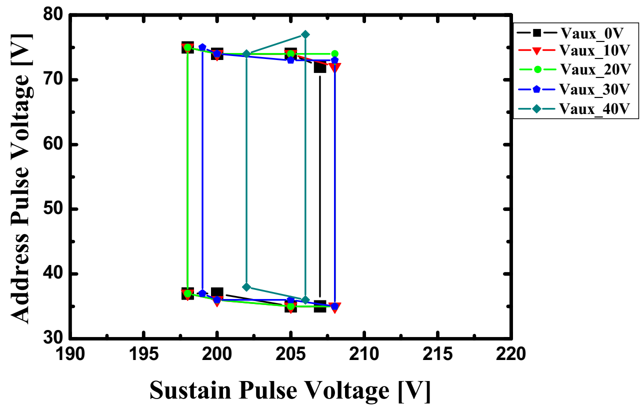


Fig.2 Dynamic margin of a FEEL PDP in accordance with various auxiliary pulse voltages

3. Reciprocal Sustain Pulses Waveforms and Modified FEEL PDP Structure

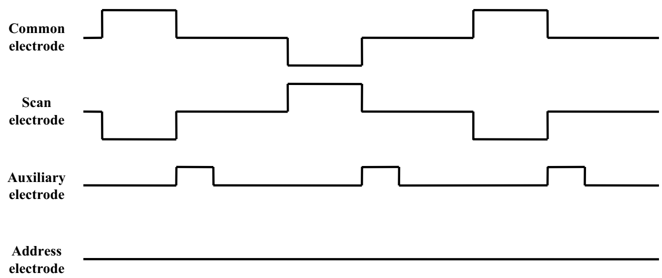


Fig. 3 Reciprocal sustain pulses waveforms and auxiliary pulse waveforms

In order to reduce the effect of the address electrode, the voltage of the sustain electrode should be decreased. However, the sustain voltage increases in the case of FEEL PDP structure because the sustain gap is longer than that of the conventional structure. A simple approach to address this problem is to apply pulse having lowered voltage to sustain electrode. The application of reciprocal sustain pulses, as shown in Fig.3, are one possible solution. The voltage of the reciprocal sustain pulse is half that normal sustain voltage, which cannot induce an interaction between the address and sustain electrodes. However, the auxiliary pulse does not play a role of enhancing the efficacy. When reciprocal sustain pulses and auxiliary pulses, as shown in Fig. 3, are applied to the sustain and auxiliary electrode, respectively, the auxiliary electrode cannot control the positive wall charges that accumulated on auxiliary electrode [6]. The reason for this is that the polarity of the auxiliary electrode is relatively neutral during sustain discharge. In order to obtain high efficacy in a FEEL PDP, the polarity of the auxiliary electrode during the sustain discharge should be negative relative to one of the scan and common electrode.

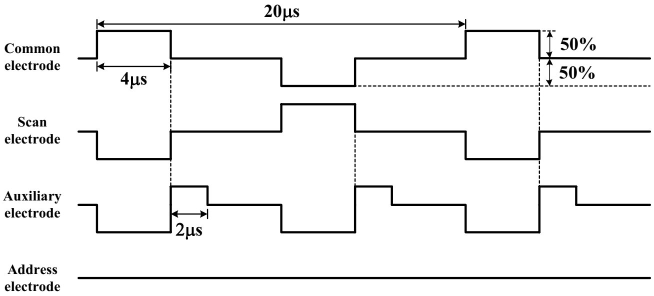


Fig.4 Reciprocal sustain and auxiliary pulse waveforms applied to FEEL PDPs

Fig. 4 shows the reciprocal auxiliary pulse, the polarity of which is the same as one of the scan and common pulse. The auxiliary pulse level is relatively low during the sustain period. When discharges occur between the scan and common electrode, positive wall charges are accumulated on the auxiliary electrode. After sustain discharges, a relatively positive pulse applied to the auxiliary electrode erases some wall charges accumulated on the auxiliary and sustain electrodes. This results in a reduction of the discharge current. The auxiliary pulse can also produce priming particles, which influence the next periodic sustain discharge. As shown in Fig.4, the reciprocal sustain and auxiliary pulse is named "REciprocal Sustain and Auxiliary Pulses waveforms (RESAP)". The magnitude of the downward sustain pulse is the same as that of the upward sustain pulse. From the investigation of reciprocal sustain pulse waveforms, it was found that the effect of the address electrode on sustain discharges can be reduced with an increase in the magnitude of the downward sustain pulse. In this work, the ratio of the downward sustain pulse to the upward sustain is exactly 50%.

In our previous FEEL PDPs, shown in Fig.1 (a), the auxiliary electrodes are made of only ITO. This is not suitable for a large size PDP owing to the low conductivity of ITO electrodes. In this work, the auxiliary electrode is made of both silver and ITO. Fig.5 shows a schematic diagram of the modified FEEL PDP designed with 50-inch XGA resolution. Silver electrodes with a width of 30 μm are formed on transparent ITO electrodes using a photo-sensitive method.

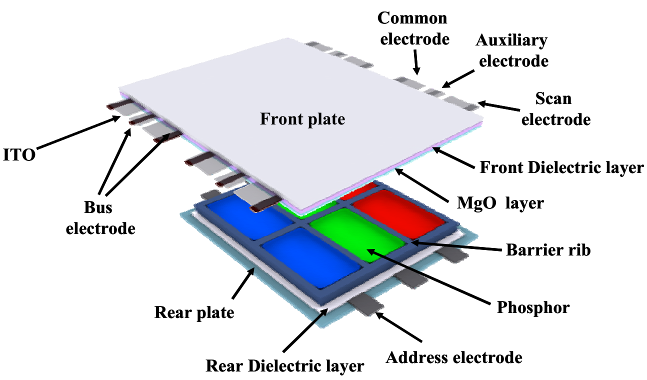


Fig. 5 Schematic drawing of modified structure of FEEL PDPs

As noted in the previous session, the dynamic margin decreases as the voltage of the auxiliary pulse is increased. When the voltage of the auxiliary pulse is more than 50 V, the dynamic margin completely disappeared. The threshold voltage of the auxiliary pulse is affected by the cell geometry including the height of the barrier rib. When the height of the barrier rib is 150 μm, the threshold voltage of the auxiliary pulse becomes 50 V. If the height of the barrier rib increased, the threshold voltage of the auxiliary pulse also increases. The dynamic margin of a FEEL PDP employing the structure shown in the Fig. 5 is investigated when the reciprocal sustain and auxiliary waveforms (RESAP) are applied to the sustain and auxiliary electrode. Fig. 5 shows the dynamic margin in accordance with various voltages of the auxiliary pulse when RESAP waveforms are applied to a FEEL PDP. Compared to the result obtained from previous waveforms, as shown in Fig.1 (b), the dynamic margin is improved by applying the RESAP waveforms when the voltage of the auxiliary pulse is zero. In particular, the voltage margin of the sustain pulse is enlarged. The RESAP waveforms reduce the effect of the address electrode on the sustain discharge during sustain period. As the voltage of the auxiliary electrode is increased, the dynamic margin is reduced; however, the variation of the voltage margin is negligible. From the results, it is concluded that the

RESAP waveforms contribute to stable operation of the FEEL PDP. Furthermore, an increase in the threshold voltage of the auxiliary pulse results in improvement of the luminous efficacy. If higher auxiliary pulse voltage can be applied without discharge between the auxiliary and sustain electrodes, higher luminous efficacy could be obtained [5]. The RESAP waveforms enable application of higher auxiliary pulse voltage, which improves luminous efficacy of the FEEL PDPs by 10 %.

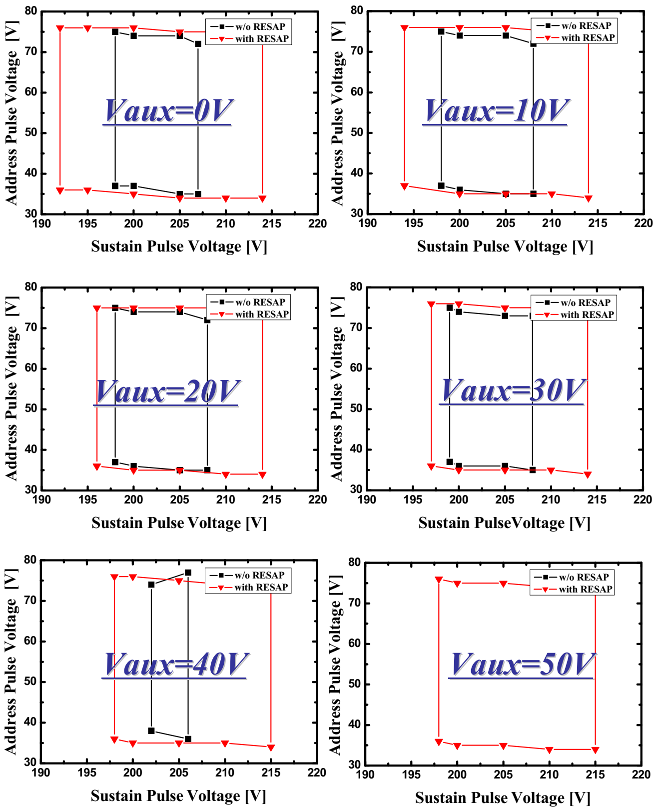


Fig.6 Dynamic margin in accordance with various voltages of the auxiliary pulse when RESAP waveforms are applied to the FEEL PDP

4. Conclusion

Reciprocal sustain and auxiliary pulses (RESAP) waveforms are applied to an AC PDP with an auxiliary electrode and the driving characteristics such as dynamic margin are investigated. In the reciprocal sustain and auxiliary pulse scheme, the polarity of the auxiliary pulse is the same as that of one of the scan and common sustain pulses and the level of the auxiliary pulse is relatively low during the sustain discharges. The RESAP waveforms mitigate the effect of the address electrode on the sustain discharges, because the voltage of the sustain pulse is not sufficient to induce an interaction between the address and sustain electrodes. This means that the height of the barrier rib does not need to be increased in order to obtain high efficacy. The RESAP waveforms provide enough dynamic margin with the AC plasma display panel with an auxiliary electrode and a longer-coplanar gap, resulting in stable driving operation of the FEEL PDP. In addition, the RESAP waveforms contribute to improve the luminous efficacy due to an increase in the voltage margin of the auxiliary pulse.

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References

1. L.F.Weber, “Plasma Display for the Digital Home Theater Market”, *Proceeding of Business Conference SID 2004*, BC9, 2004.
2. W.J.Chung, B.J.Shin, T.J.Kim, H.S.Bae, J.H.Seo, K.W.Whang, “Mechanism of High Luminous Efficient Discharges with High pressure and High Xe Content in AC PDP ”, *IEEE Trans. Plasma Science*, vol.31, no.5, pp1038-1043, 2003.
3. G.Oversluizen, M.klein, S.de.Zwart, S.Heusden, T.Dekker, “Improvement of the discharge efficiency in plasma displays”, *Journal of Applied Physics*, vol.91, no.4, pp2403 -2408, 2002.
4. T.Akiyama, T.Yamada, M,Kitagawa, T.Shinoda, “Analysis of Discharges in High Luminous Efficacy PDP with 5 lm/W”, 2008 Digest of Technical Papers, pp378 -381, 2008.
5. K.C.Choi, N.H.Shin, S.C.Song, J.H.Lee, S.D.Park, "A New AC Plasma Display Panel with Auxiliary Electrode for High Luminous Efficacy", *IEEE Trans. Electron Devices*, vol.52, no.2, pp210-218, 2007.
6. K.H.Cho, S.M.Lee, K.C.Choi, “Wall Voltage and Priming Effect due to Auxiliary Electrode in AC PDP with Auxiliary Electrode”, *IEEE Trans. Plasma Science*, vol.35, no.5, pp1567-1573, 2007.
7. K.C.Choi, C.Jang, J.B.Yun, “Driving Characteristics of a High Efficacy AC Plasma Display Panel with an Auxiliary Electrode”, *IEEE Electron Devices*, vol.55, no.6, pp1338-1344, 2008.
8. S.-M.Lee, K.H. Cho, Kyung Cheol Choi, “Luminous Efficacy of 12 lm/W in an AC PDP in terms of measurement of the Discharge in Ne+20%Xe and Green Cells”, IMID 2007, pp119-122, 2007.