Improvement of luminous efficiency through new cell structure and driving pulse

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Abstract

We have suggested several plasma display panel (PDP) cell structures for high luminance and low power consumption by our two-and three-dimensional fluid simulation codes. Generally, to improve luminous efficiency and discharge efficiency, it is known that it is lucrative to use long discharge path and to form low electric field. However, the problems are how to implement them effectively in the small PDP cell. Therefore, unlike conventional model, we suggest Front Three Electrodes (FTE) model. In this model, we tried to make long and U-shaped discharge path by geometry changes and driving pulse variations. Consequently, from our simulation results based on the model above, luminous efficiency has improved about 2.6 times.

1. Introduction

Plasma display panels (PDPs) have considered one of the most attractive candidates for large area and high definition television display devices. However, PDPs are recently much challenged by other display devices such as Liquid-Crystal Display (LCD) and Organic Light-Emitting Diode (OLED), because 50 " class LCD TV has already been published by several major LCD makers and OLED has also been steady technical improvements by persistent efforts and study. PDP certainly has many advantages like thin, flat, wide view angle, and large screen size, but PDP's low efficiency is the most critical drawback making it difficult to reach a dominant position over other display devices [1]. Therefore, improving its low luminous efficiency is very urgent more than anything else. So we suggest Front Three Electrodes (FTE) model showing good luminous efficiency through cell structure changes and driving pulse variations.

2. Simulation Conditions

Our fluid simulation codes use 3 main equations, i.e., continuity, Poisson and momentum transfer equations with drift-diffusion approximation [2, 3, 4, 5]. The continuity and Poisson equation are solved by ADI and SOR method. As using the semi-implicit method, we can use large simulation time steps without losing accuracy [2].

Figure 1 shows the general actual coplanar AC-PDP cell of one pixel and our simulation model based on 1080 × 210 μm is represented in Fig. 2. Gas pressure is 500Torr, and gas composition is 96% neon (Ne) and 4% xenon (Xe). The number of grids for numerical calculation is 62×42 for two-dimensional cases and 62×42×24 for three-dimensional simulations, respectively. All data here are obtained in steady states on sustain period.

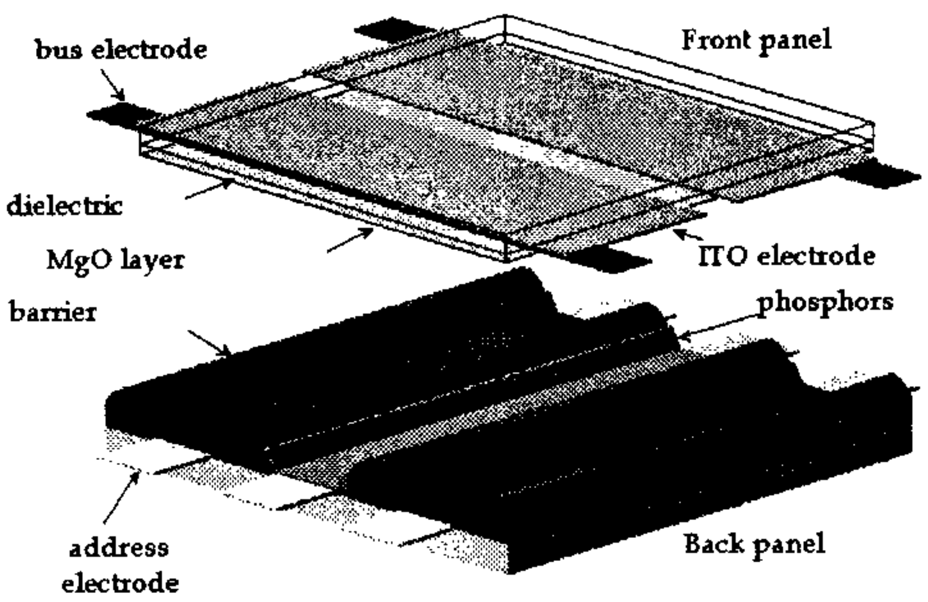

Figure 1 Schematic diagram of the single pixel in the conventional AC-PDP

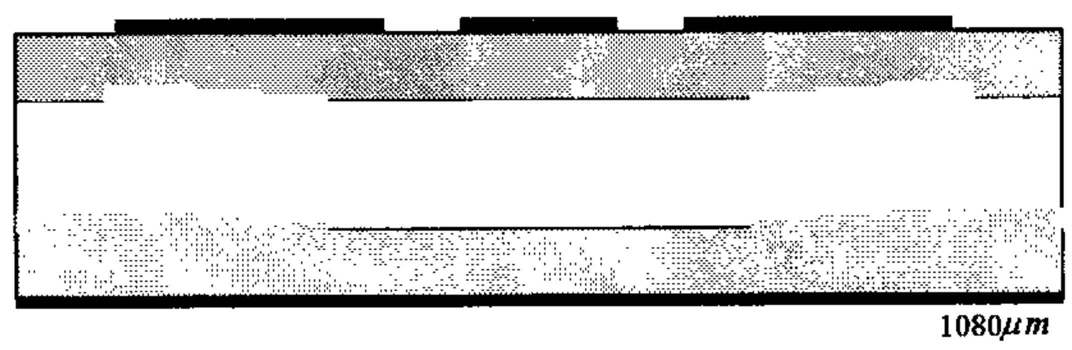

Figure 2 Cross-sectional structure of Front Three Electrodes (FTE) model

3. Results and discussion

In AC-PDP, general discharging characteristics can be largely sorted as three cases. For example, when the gap between two sustain electrodes is small, low driving voltage is needed to operate the cell, but the efficiency is also low. For this reason, if we increase the gap size, we can obtain high efficiency, but high driving voltage is required. Therefore, we insert an extra electrode between the two electrodes to meet low driving voltage and high efficiency at the same time. Fig. 3 shows its details [6].

However, it is not so simple to satisfy all condition we have mentioned until now. First of all, there are geometrical changes, so conventional driving pulse is not of use any more. Thus, we have to apply different driving waveforms to the new AC-PDP model.

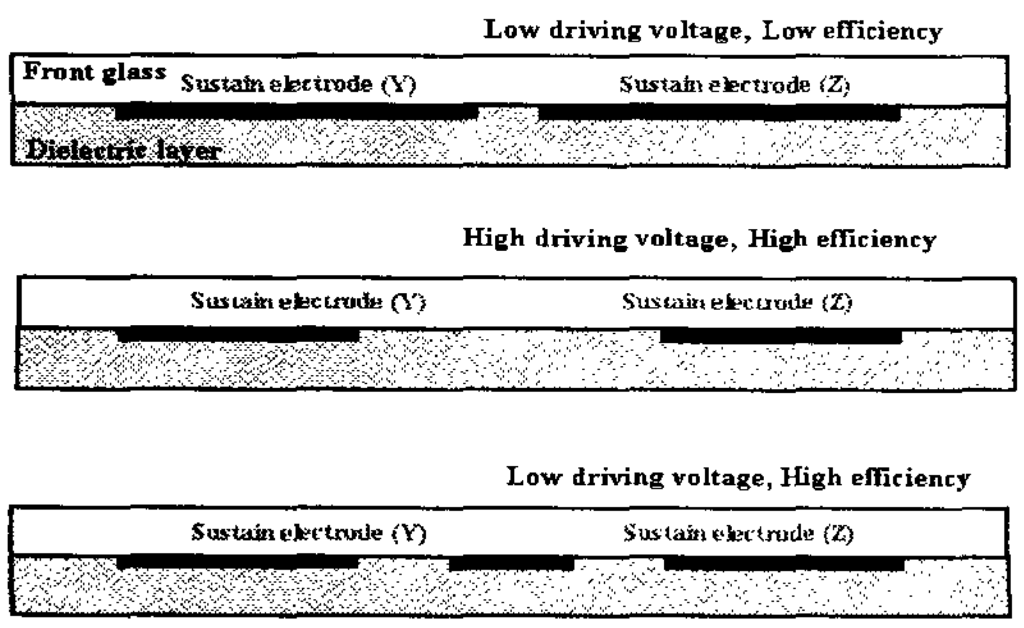

Figure 3 Discharging characteristics based on the gab size between two sustain electrodes.

As shown in Fig. 4, we use floating electrodes in an extra electrode and an address by applying half of the sustain voltage. The sustain electrode's waveforms are the same as the conventional coplanar AC-PDPs except for the case2 in Fig 4. The reason why we use the floating electrode in extra electrode is that the down-sweeping discharge path is located in center of the cell. Actually, we can control somewhat the position of it by the variation of voltage level of the extra electrode

Despite our these kinds of efforts, unfortunately, the driving voltage range remained considerably high, so we manipulated pulses and we obtain the complicated driving waveform in Fig. 4 (b) compared to Fig. 4 (a), (c). The changes at the end of on-time period of driving pulses play very critical roles in lowering the operating voltage through changing the polarity of wall charges on the extra electrode part.

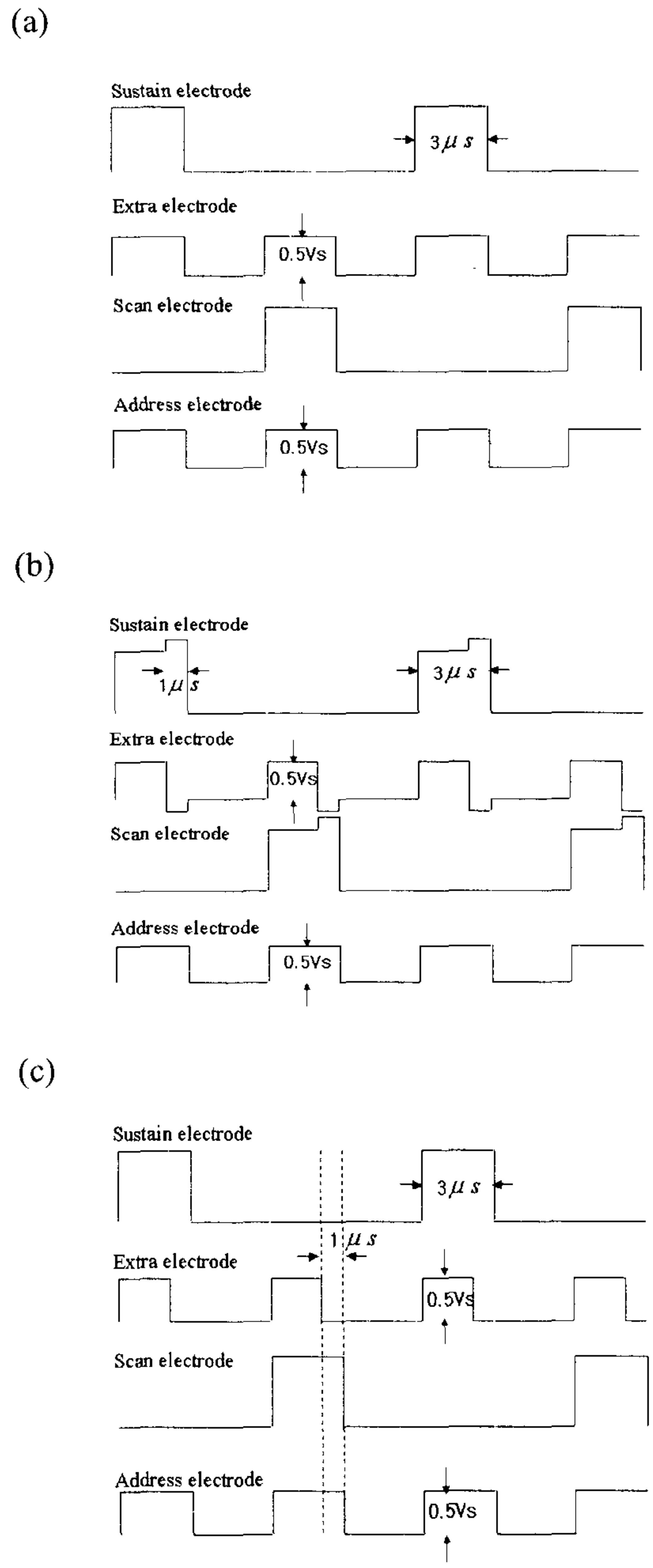

Figure 4 Driving pulses in sustain period; (a) case 1, (b) case2, (c) case3.

Namely, the changed polarity of wall charges makes it easy to discharge when next pulse is applied to the electrodes because the direction of the electric field by the changed polarity is the same as that of the E-field of next pulse, nevertheless main discharge still occurs between the two sustain electrodes. This is the key of FTE model.

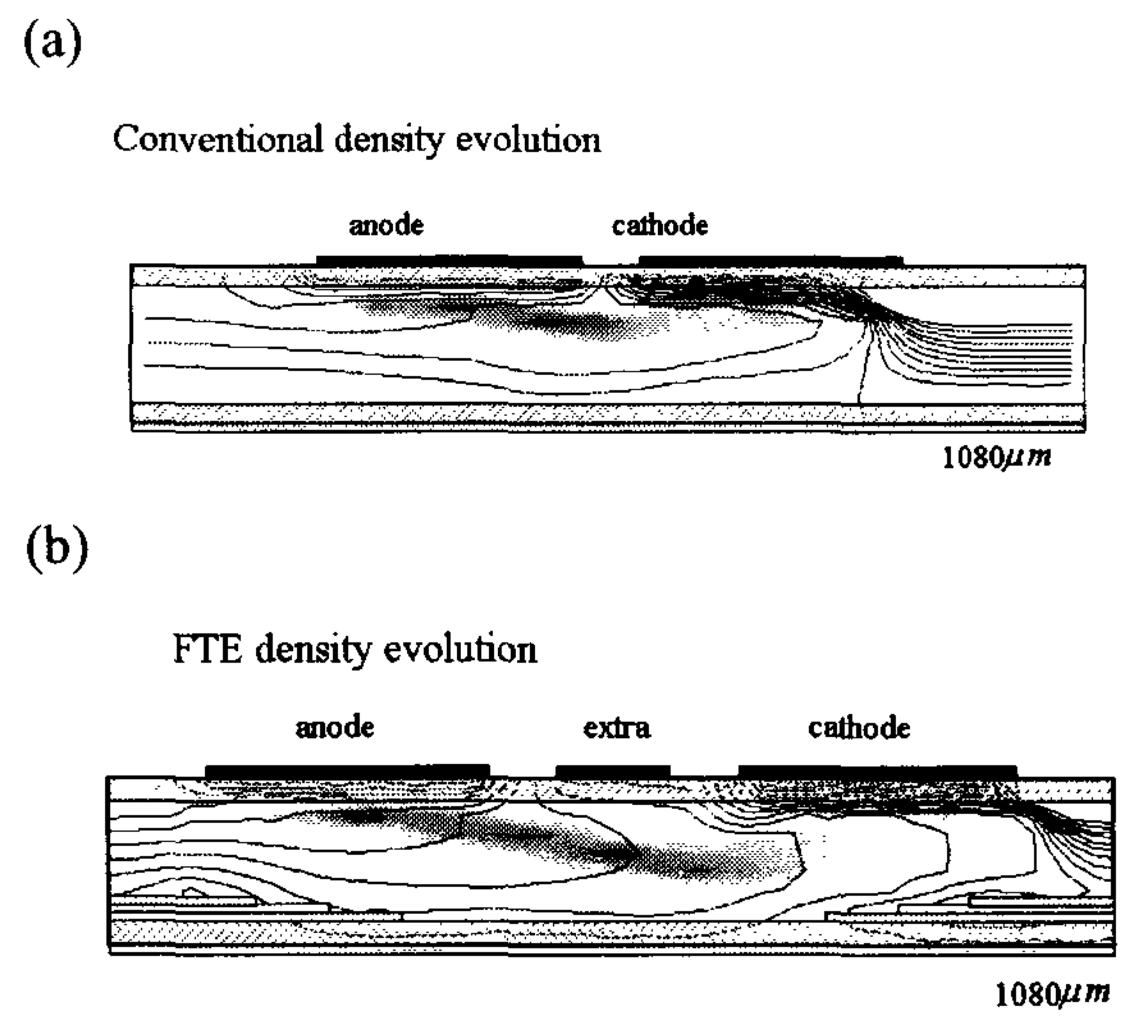

Figure 5 Xe*($^3P_1$) density distributions and potential profiles in AC-PDP cells; (a) Conventional model, (b) FTE.

Figure 5 shows the Xe*($^3P_1$) density distributions among the important excited species like Xe*, Xe** and Xe_2* in conventional model and FTE [7]. Unlike conventional case, FTE model has relatively long down-sweeping density distribution of Xe*($^3P_1$). This kind of density distribution is very favorable to change excited species into visible photons on the phosphor, specially, in the center region. To enhance luminous efficiency, we use two more trials. One is removing the dielectric layer of front panel a little by at a time to make a strong electric field at edge of sustain electrodes as seen in Fig. 2 and the other is we pile up the lower dielectric bit by bit to compensate the distances between the creation points of excited species and phosphor.

We can find remarkable improvement in luminous efficiency in FTE model as compared to the normal coplanar AC-PDP model in Fig. 6, but still we have to consider another key factor here because our ultimate purpose is to design high efficiency and low power consumption cell. So we select the best-accorded one among the three cases between efficiency and power consumption.

Unfortunately, it is not so simple problem, because there is trade-off between power and efficiency. Fig. 7 shows the power consumption in each case. Nevertheless, we choose the case2, because power reduction is somewhat possible through patterned electrodes like T-shaped and Bullet-shaped (BS) electrode [8, 9].

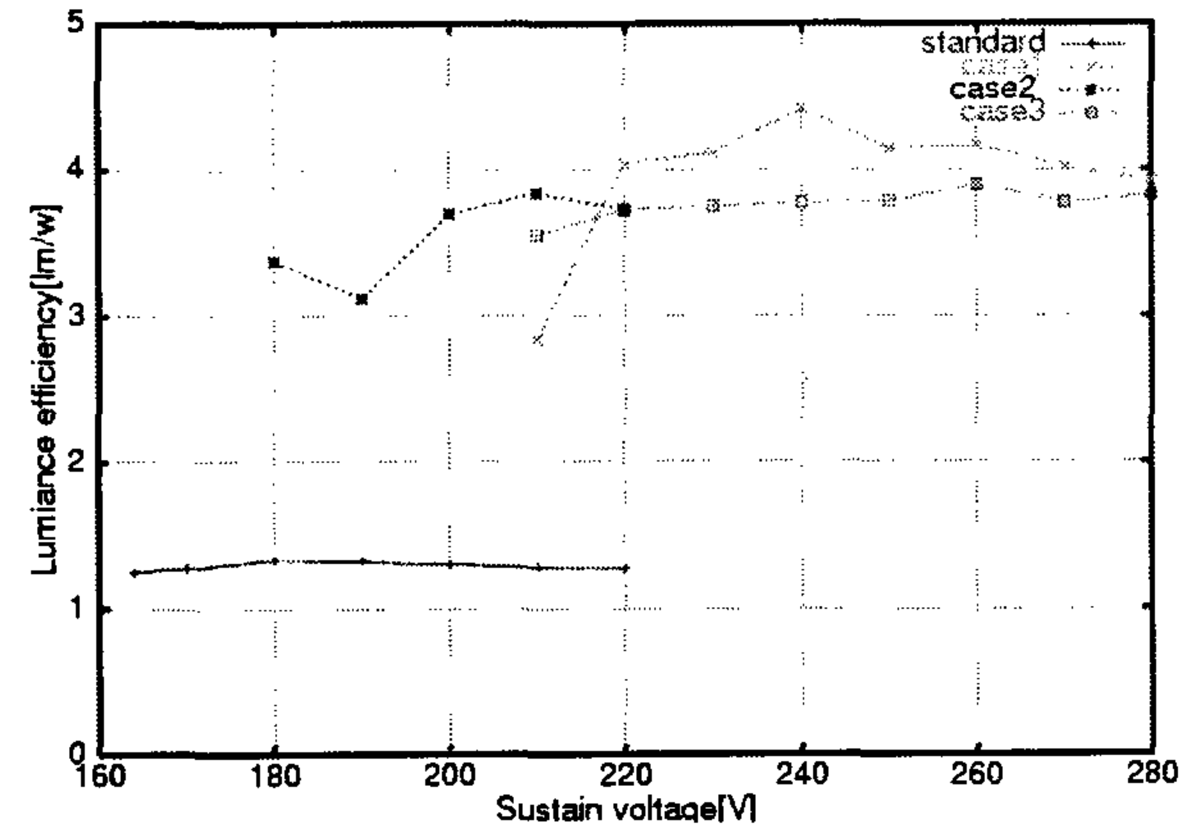

Figure 6 Luminous efficiency of conventional model and FTE.

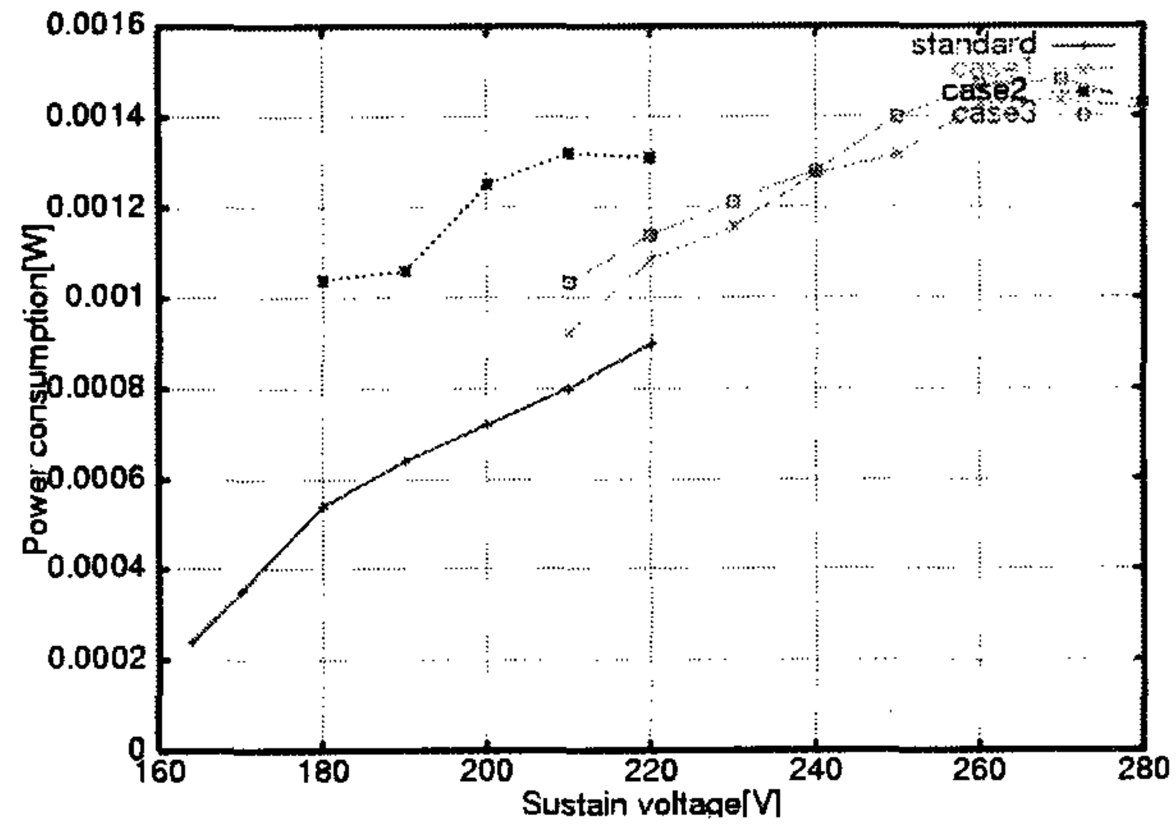

Figure 7 Power consumption comparison between conventional model and FTE.

4. Conclusion

In order to increase luminous efficiency, there are largely three methods such as the long arch-shaped discharge path, low electric field, and reducing power consumption. In this paper, we use two methods to do it. Firstly, we use long down-sweeping discharge path in the center of the cell by the removed dielectric layer in front panel and the floated extra electrode. Secondly, to move the operating voltage to a low level, we use wall charge control. That is we apply a certain amount of extra voltage to the extra and sustain electrode to change the polarity of wall charges at the end of on-time period. Through this handing, the direction of the electric field and that of the electric field in next pulse remain the same. Thus, we can move the high driving voltage range like case1 and case2 to low level as shown in case2 of Fig. 6. In conclusion, through the FTE model, we can obtain about 2.6 time improvement in terms of luminous efficiency compared conventional AC-PDP cell.

5. Acknowledgement

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5. References

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