High Efficient Positive Column Discharge Driven by New Low Voltage Driving Scheme for AC-PDP

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ABSTRACT

The high efficient positive column discharge with a long gap of 400μm is successfully generated under low operating voltage (170 V) by adopting the new driving scheme for the low voltage positive column discharge. In particular, the effects of the sustain electrode width on the positive column discharge characteristics are examined intensively. It is found that the low voltage positive column discharge can be produced efficiently irrespective of the sustain electrode width. However, the luminance increases with the width of the sustain electrode, whereas the luminous efficiency decreases with the width of the sustain electrode. As a result, under the stable static voltage margin condition, the positive column discharge showing the high luminous efficiency of 2.5 lm/W is obtained at the sustain voltage of 170V and a sustain electrode width of 100μm. Moreover, it is observed that the discharge is successfully addressed without misfiring or undesired firing by the suggested driving scheme.

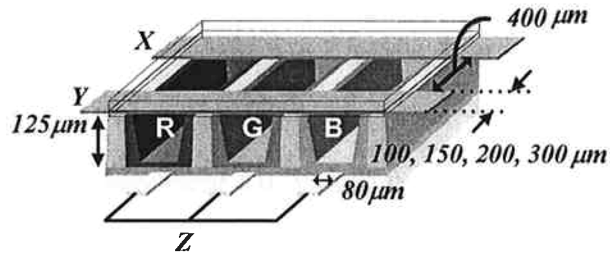

Fig. 1. Cell structure for positive column AC-PDP.

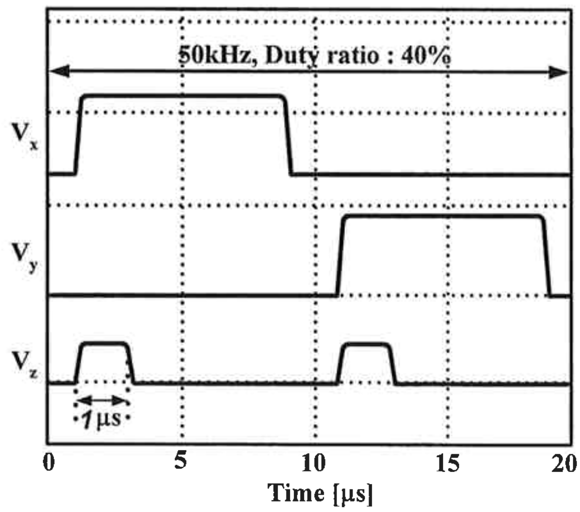

Fig. 2. Applied waveforms for positive column discharge.

INTRODUCTION

Through the enormous researches in recent years, PDP is already in the process of mass production and taking large market in flat panel display area. Nevertheless, the low luminous efficiency of PDP is still a big problem. Thus, recently, the researches about improving the luminous efficiency of PDP have been being performed widely. As a matter of fact, the improvement of the luminous efficiency has been achieved through the modification of cell structure (Delta cell structure, SDR cell structure, etc.), new gas chemistry (high Xe content, etc.) or new driving method (auxiliary address pulse, etc). However, In spite of these wide and deep studies, the luminous efficiency of PDP is still far away from that of CRT. Since it is so, it is thought that the improvement of luminous efficiency under the restriction of short discharge gap (80~120 μm) gradually faces its limit. Thus, the demand on the

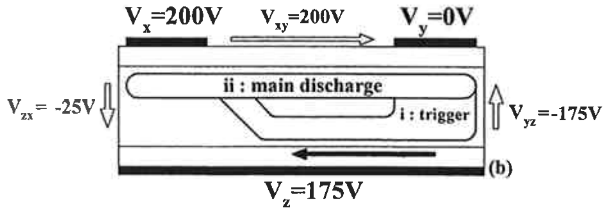

Fig. 3. Simple mechanism of low voltage generation of positive column.

new cell structure with the new driving scheme, especially, in a wide gap structure grows to take another way to improve the luminous efficiency in AC-PDP. Even though the discharge physics of positive column in micro-discharge cell is still ambiguous, it is well-known that the luminous efficiency of the discharge can be improved when the discharge is produced in the longer discharge gap with a positive column region like the luminous efficiency of the luminescent lamp is quite high. However, the firing and sustaining voltages increase in proportion to the length of the long discharge gap and they could affect the luminous efficiency. Recently, regarding the positive column discharge, lowering firing and sustaining voltages and earning better luminous efficiency using negative sustaining voltage in AC-PDP is proposed as well as several modified ideas using auxiliary electrodes [1][2][3]. However the operating voltage is still high. In this reason, the long gap discharge with a positive column is known to be not easily applicable to the current PDP with micro-discharge cells.

In this paper, the positive column discharge is generated by a low operating voltage with the discharge gap of 400μm applying an additional voltage on the address electrode. In particular, the effects of the sustain electrode width on the positive column discharge characteristics are examined intensively. In addition, the dynamic driving characteristics are observed by the suggested driving scheme including total write & erase, addressing, and sustain period.

EXPERIMENT

A 7-inch test panel filled with a gas mixture of

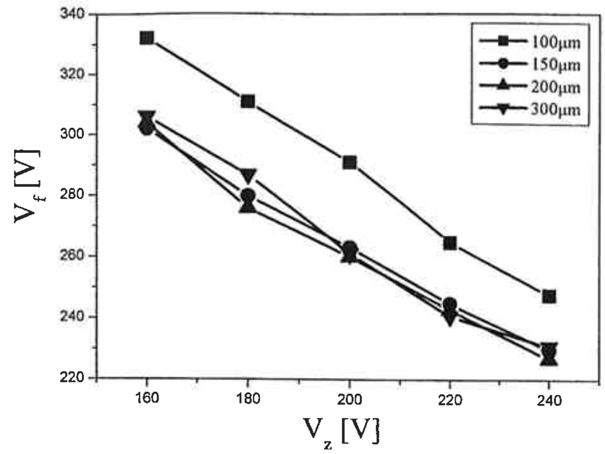

Fig. 4. Firing voltages with sustain electrode(X, Y) widths.

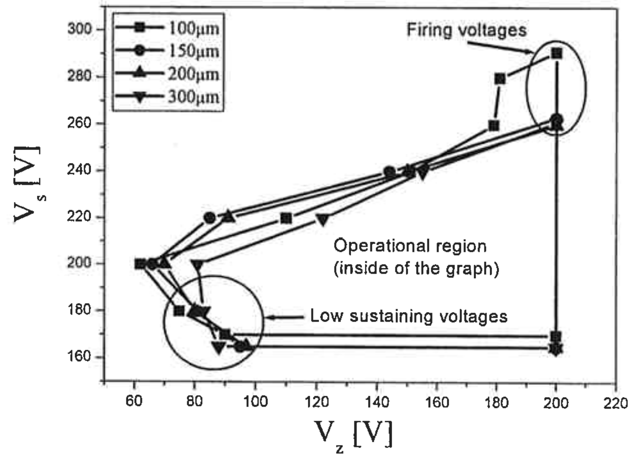

Fig. 5. Sustaining voltages with sustain electrode (X, Y)width.

Ne-Xe (5 %) at a pressure of 500 Torr is employed in the current study, and the cell structure of a single pixel is shown in Fig. 1. The discharge gap between the two sustain electrodes(X and Y) is fixed at 400 μm. The height of the closed type barrier rib is 125μm. Conversely, The width of the sustain electrodes (X or Y) is varied from 100 μm to 300 μm: *i.e.*, 100 μm, 150 μm, 200 μm, and 300 μm for the current experiment, while the width of the address electrode (Z) is fixed at 80 μm. Fig. 2 shows the voltage waveforms V_x, V_y, and V_z applied to the sustain electrodes X and Y and address electrode Z, respectively. V_x and V_z with a duty ratio of 40 % are applied at a frequency of 50 kHz. V_z is synchronized with each increase in V_x and V_z. Since most of the discharge process in the

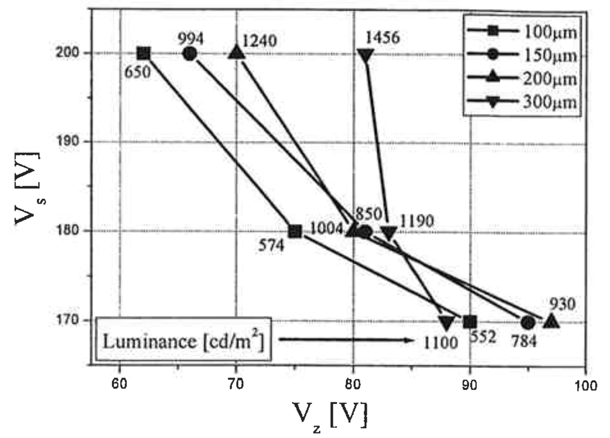

Fig. 6. Luminance with sustain electrode(X, Y)width at various V_s and V_z.

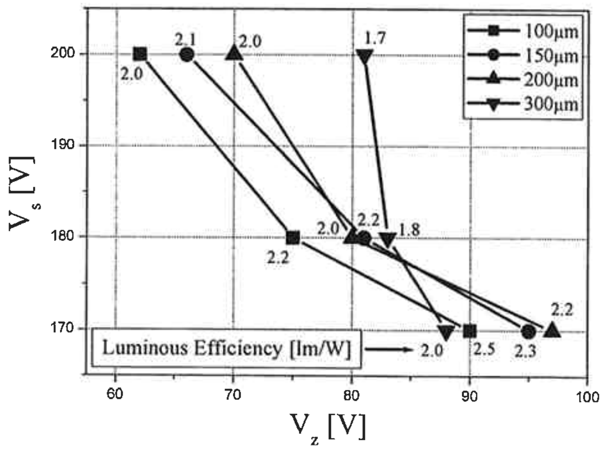

Fig. 7. Luminous efficiency with sustain electrode(X, Y)width at various V_s and V_z.

cell finishes within 1μs [4], the pulse width of V_z is limited to 1μs.

RESULTS AND DISCUSSION

Fig 3 shows simple mechanism of low voltage operation of positive column as we already introduced in [5]. When $V_x \leq 2V_z$, the ignition discharge starts to be produced between Y and Z which has a short distance (125μm), and then the main positive column discharge is generated between X and Y. After the main glow discharge process, the address pulse stops to supply additional electric field. Due to change of the wall charge formation by the support of additional electric field, low voltage operation is possible. Since the ignition discharge for inducing main positive column discharge occurs between Y and Z, the width of the sustain electrodes, X and Y, could affect the firing voltage, sustaining voltage or discharge properties of wide gap structure. Thus, the firing/sustaining voltage and luminous efficiency relative to the sustain electrode width are measured in this study. The firing voltage with the sustain electrode width is shown in Fig. 4. V_f decreases linearly with V_z and when the width is 100μm, V_f is somewhat higher than others. This represents that the sustain electrode width need to be about two times wider than the width of address electrode to get a little lower firing voltage. In addition, Fig 4 also implies that the discharge can be fired at various voltages, for example, (V_f=280V, V_z=180V) or (V_f=260V, V_z=200V) meaning that the firing voltage could be chosen intentionally. Fig. 5 shows the operational region with the electrode width. In each case, the firing voltages are chosen when V_z=200V. Thus, the firing voltages are 291, 263, 260 and 261V for the sustain electrode width of 100, 150, 200, 300μm, respectively. If other firing voltages are chosen from Fig. 4, the operational region below the firing voltage simply changes. Fig 5 clearly shows the low sustaining voltages and the operational region hardly depend on the sustain electrode width meaning that the sustaining voltage is merely affected by the ignition discharge process between X(or Y) and Z. Fig. 6 shows luminance variation with the sustain electrode width at various V_s and V_z . The wider electrode shows a higher luminance as usual. The luminous efficiency with the sustain electrode width at various V_s and V_z is shown in Fig. 7. The narrower electrode shows a higher luminous efficiency. The maximum luminous efficiency of 2.5 lm/W is obtained from the case that the sustain electrode width is 100 μm with the sustaining voltage of 170V. Moreover, when the sustaining voltage decreases, the corresponding luminous efficiency increases in all cases, as the increase in the sustaining voltage causes a very high electron temperature [6]. Fig. 8 shows the driving scheme for confirming addressability, misfiring, undesired firing and dynamic margin in AC-PDP. As a classical ADS driving scheme,

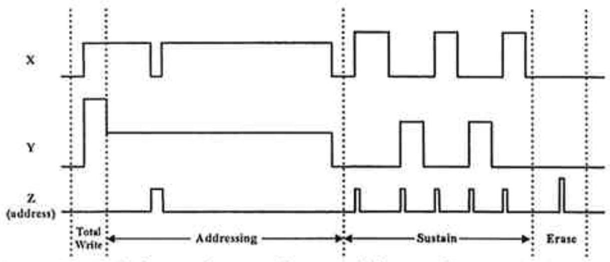

Fig. 8. Driving scheme for positive column AC-PDP.

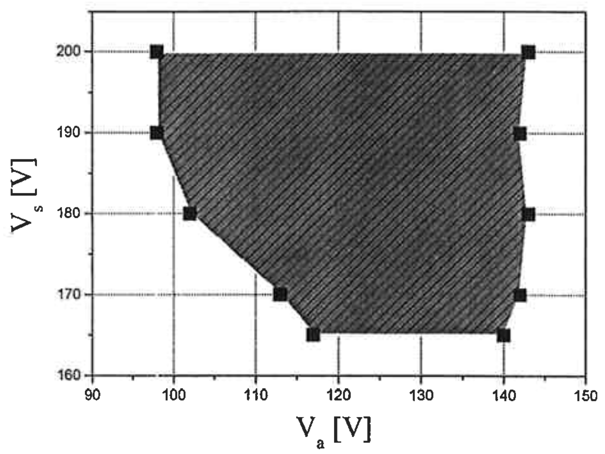

Fig. 9 Dynamic sustain and addressing voltage margin.

the driving scheme for positive column AC-PDP also consist of total write, addressing, sustain, and erase period. However, the total write process and erase process are designed to occurs between the sustain electrode(X, Y) and the address electrode (Z) in the new driving scheme. A characteristic of dynamic sustain and address voltage margin is shown in Fig. 9. The dynamic voltage margin is a little narrower and the addressing voltage is somewhat higher than those of the conventional ADS driving scheme using ramp reset in short discharge gap case. However, consequently, the positive column discharge is successfully addressed at the low sustaining voltage as 170V.

CONCLUSION

The effects of the sustain electrode width on the positive column discharge characteristics are examined intensively. It is found that the high efficiency low voltage positive column discharge can be produced efficiently irrespective of the sustain electrode width. However, the luminance increases with the width of the sustain electrode, whereas the luminous efficiency decreases with the width of the sustain electrode. As a result, under the stable static voltage margin condition, the positive column discharge maintains stably at the sustain voltage of 170V with the luminous efficiency of 2.5 lm/W. Moreover, it is observed that the discharge is successfully addressed without misfiring of undesired firing by the suggested driving scheme.

REFERENCES

[1] Larry F. Weber, United States Patent 6184848B1, 2001.

[2] Jiting Ouyang, Thierry Callegari, Nicolas Lebarq, Bruno Caillier, and Jean-Pierre Boeuf, "Plasma Display Panel Cell Optimization : Modeling and Macro-cell Experiments", *Eurodisplay'02 Digest*, pp.53-56, 2002.

[3] Thierry Callegari, Jiting Ouyang, Nicolas Lebarq, Bruno Caillier, and Jean-Pierre Boeuf, "3D modeling of a Plasma Display Panel Cell", *Eurodisplay'02 Digest*, pp.735-738, 2002.

[4] Ki-Duck Cho, Heung-Sik Tae, and Sung-Il Chien, "Improvement of Color Temperature using Independent Control of Red, Green, Blue Luminance in AC Plasma Display Panel," *IEEE Trans. Electron Devices*, vol. 50, pp. 359-365, 2003.

[5] Hyun Kim, Heung-Sik Tae, and Sung-il Chien, "Long Gap Discharge Characteristis Based on Control of Voltage Distribution among Three Electrodes for Positive Column AC-PDPs," in *Proc. SID Digest*, pp. 40-43, 2003.

[6] Keizo Suzuki, Yoshimi Kawanami, Shirun Ho, Norihiro Uemura, Yusuke Yajima, Noriyuki Kouchi, and Yoshihiko Hatano, "Theoretical Formulation of the Vacuum Ultraviolet Production Efficiency in a Plasma Display Panel." *J. Appl. Phys.*, vol. 88, pp. 5605-5611, 2000.