Reduction of Discharge Current of PDP by Pulse Variation and Improvement of Efficiency

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Abstract

The discharge efficiency of PDP generally becomes high as the discharge current is decreased. It is thus shown that by variation of pulse shape, the discharge current can be reduced significantly without losing stable operation of PDP cell. Another method to decrease the discharge current is to tailor the MgO layer. By this technique, the plasma generation in the cathode side region can be reduced without losing the luminance. A two-dimensional fluid code is used to study these phenomena.

Introduction

Plasma display panel (PDP) has been believed as one of the promising future display device. However there are several technical problems to be solved. High production cost and low light efficiency are among a few to name. One of the prime factors to restrict the improvement of efficiency is the inefficient generation of the excited Xe atoms. A large portion of the power is being used in ionization and heating of the neutral particles [1], instead of Xe-excitation.

Generally the discharge efficiency is increased when the discharge current or the driving electric field is small [2]. However the PDP cell cannot be operated stably without sufficiently large current since the wall charges are not acc-umulated enough. In this paper we studied pulse shape variation to reduce the driving electric field and the discharge current, without losing the stable operation of PDP cell.

We also show that the variation of PDP cell structure can lead to significant reduce in the discharge current. By tailoring the MgO region, we control the surface discharge evolution near the cathode region, and make a long path dis-charge which consequently improves the overall efficiency of PDP.

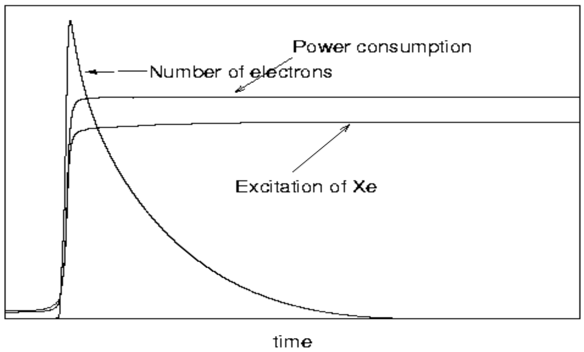

FIG. 1. Time traces; number of electrons, time-integrated power, and time-integrated Xe* generation

Pulse variation

Figure 1 represents a time trace of electrons, power consumption, and the generation of excited Xe during a pulse [3,4]. It is seen that most of the excited Xe atoms are generated during the discharge build-up phase. The power is also consumed mostly during this period because the electric field is much stronger in this regime than during the discharge decaying phase. Therefore the efficiency of PDP is mainly determined by the discharge build-up phase rather than the discharge decaying one. Further it is expected that ignition of discharge by a low electric field should increase the efficiency.

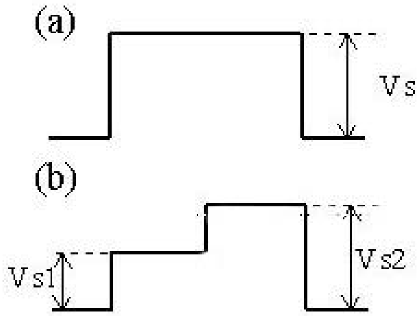

FIG. 2. Pulse shapes. (a) a normal square pulse and (b) a two-tiered pulse

However if the driving electric field is reduced below certain threshold, the number of charged species becomes very small. Consequently wall charges cannot be accumulated enough to sustain the stable operation of PDP cell. To surmount this problem, we used a two-tiered pulse as shown in Fig. 2 (b). The concept of this pulse variation is as follows. The evolution of the discharge is executed by a relatively low voltage (V_{s1}) and the accumulation of the enough wall charges is achieved with a high voltage (V_{s2}). Though the charged particle generation due to V_{s1} is small, sufficient wall charges can be accumulated to sustain the cell due to the strong charge separation by the high voltage V_{s2}.

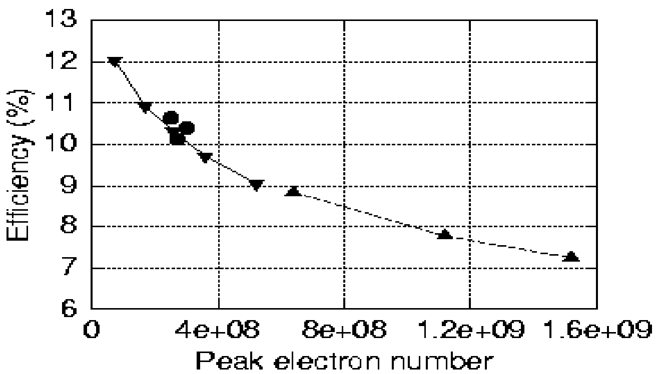

FIG. 3. Efficiency as functions of peak electron number during a pulse for sustaining mode (triangle), decaying mode (inverted triangle), and pulse variation mode (circle).

Figure 3 represent the discharge efficiency as functions of peak number of electrons (N_p) generated during a pulse. N_p is proportional to the discharge current. The efficiency is defined as the energy used in excitation of Xe divided by total power consumption. It is observed that the efficiency is higher for smaller N_p (or lower current). In Fig. 3, triangles represent the stable operation range for normal square pulses (Fig. 2 (a)). The cell cannot be sustained if the generation of electrons becomes lower than certain threshold value even though the efficiency is high in this region (inverted triangles). The circles in Fig. 3 represent examples of pulse variation effect. The cells can be sustained even in the low N_p region where it appeared impossible to sustain the cell with normal square pulses. The efficiency improvement from the normal operation region are about 30 percents in this case, while more improvement can be expected by optimizing the cell geometry and pulse shape.

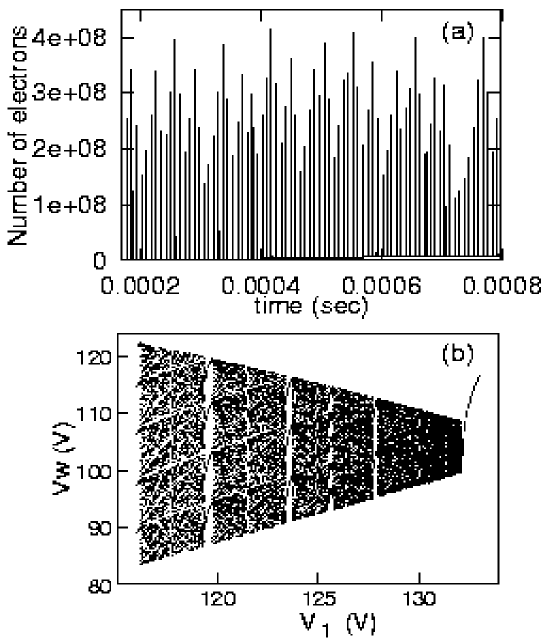

FIG. 4. Irregular pattern of discharge peaks. (a) Time trace of electron number and (b) the phase diagram of discharge peaks.

We observed a nonlinear dynamics using the two-tiered pulse. As the difference between V_{s1} and V_{s2} is increased, the discharge peaks become irregular. Figure 4 (a) represents one example of such irregular pattern and Fig. 4 (b) is the phase diagram obtained when V_{s1} is decreased. The effect of this irregularity on the efficiency of PDP is under further investigation.

Tailoring of MgO Layer

Another method to reduce the discharge current is to control the cathode discharge evolution by tailoring the MgO layer. MgO is well known to have a very high value of secondary electron emission coefficient (SEEC). Figure 5 represents the MgO-tailored PDP cell. The non-MgO region may be coated by other protective layer which has a very low SEEC. In the simulation, we set the SEEC of non-MgO region as zero.

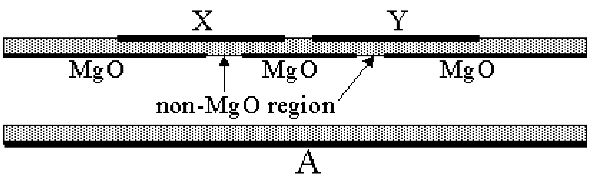

FIG. 5. System schematics of MgO-tailored PDP cell.

The mechanism of reducing the discharge current in MgO-tailored system is as follows. Firstly the discharge occurs near the small region between two sustaining electrodes and eventually extends to the outer sides of the system along the dielectric surface. The discharge extension along the cathode is dominated by the gamma-process, i.e. the secondary electrons emitted by the ion bombardment play an important role during the discharge evolution.

Figure 6 (a) represents the discharge extension in conventional PDP cell. By tailoring the MgO region, some portion of secondary electron emission is diminished and the current is reduced. However this current reduction does not decrease the luminance. That is because a long path discharge occurs near the cathode region. Because

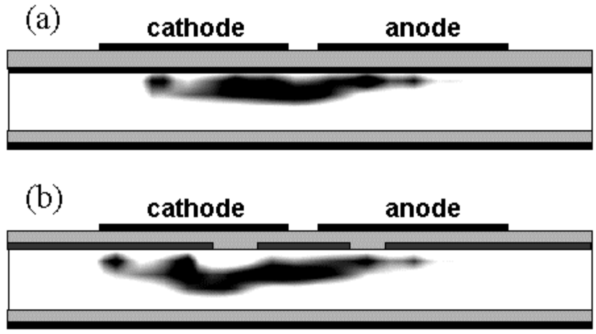

FIG. 6. The plasma distribution at the peak time of discharge for (a) a conventional PDP cell and (b) MgO-tailored system.

the continuous discharge extension near the cathode (see Fig. 6(a)) is blocked by the non-MgO region, the plasma particles trace an arc-shape path. An arc-shape discharge can be observed near the cathode region of MgO-tailored system (Fig. 6 (b)). This long path discharge efficiently generates the excited Xe species without much power consumption.

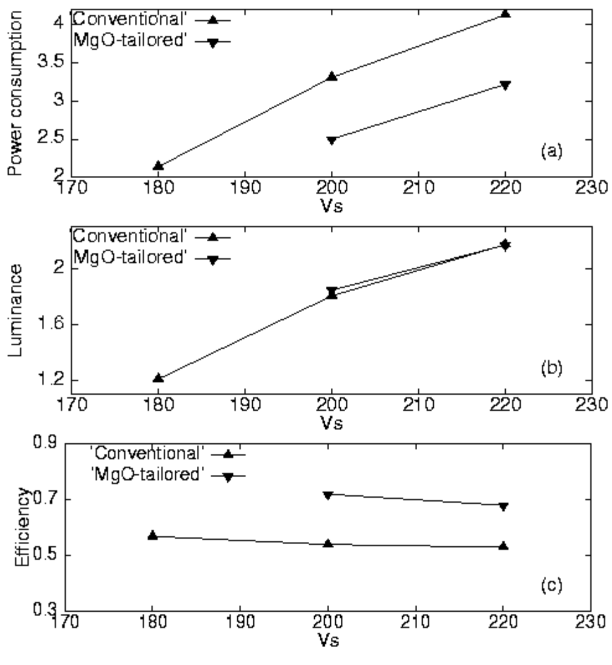

FIG. 7. .The comparison of (a) power consumption, (b) luminance, and (c) luminance efficiency for a conventional and MgO-tailored PDP cell. All the vertical axes have arbitrary units.

The comparison of power consumption and luminance for conventional and MgO-tailored systems are presented in Fig. 7. The power consumption is reduced while the luminance remains almost unchanged. The overall improvement of efficiency is more than 30 percents.

Summary

It is believed that the discharge efficiency is improved when either discharge current is low or electric field is small. Since the PDP utilizes the wall charge effect to sustain the cell, there exists a restriction to lower the discharge current. Such a limitation could be overcome by the pulse shape variation and relatively higher efficiency was achieved. Furthermore nonlinear dynamics in PDP cell was also investigated and its influence on PDP efficiency is under investigation. We also described another method to reduce the discharge current by tailoring the MgO protective layer. The power consumption was lowered down while the luminance remained almost unchanged. This is because the non-MgO region blocks the continuous discharge evolution in the cathode and instead, triggers a long path discharge which is known to be very efficient in generating excited Xe species.

Acknowledgments

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References

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