Development of High Efficiency PDP Driven by RF Pulses

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Abstract

The conventional AC PDP has a relatively low efficiency which is close to 1.5 lm/W. If the AC sustain period is replaced by the RF sustain period, due to oscillating and low electric field, almost 60% of the supplied energy is spent by Xe excitation [1]. The efficiency of RF PDP can be 4~5 times higher than that of AC PDP. In this paper, we will present the RF PDP that is a new type of PDP. A new display method in PDP using RF pulses is suggested and applied on a 4-inch-diagonal Panel (hereinafter 4" panel). Even though there were many researches in RF discharge, there was not enough research for display application.

Now we propose the RF PDP that is a new display field and we will expect to do more research in this field.

Introduction

In RF discharge, the plasma can be sustained at a low electric field due to the oscillating motion of electrons. Due to the low electric field, the electron mean energy in RF plasma is less than the energy in AC plasma. Therefore, the efficiency of energy conversion into Xe excitation in RF plasma can be much higher than that in AC Plasma. In this paper, we show a new hybrid type PDP; the plasma is formed due to AC writing pulses, and then it can be sustained due to RF sustaining pulses. Several technical issues such as structure, driving method, system and efficiency will be presented. RF discharge status means that the plasma particles (especially electrons) oscillated between two electrodes thereby the RF Power in the electrodes. If it is used for the display, we get a better display method than conventional AC PDP does. Effective points are the improving of efficiency by higher brightness and lower power consumption etc.

This paper is about the driving method for RF PDP based on the RF discharge principle it is mentioned above.

Experiment & Result

1) AC discharge Vs. RF discharge

The efficiency of conventional AC PDP is close to 1.5 lm/W. As the AC discharge starts between two sustain electrodes the accelerated electrons give their energy to neutral molecules and ionize them. Ions and electrons travel along the electric fields and reach each electrode. The incident ions and electrons build up the wall voltage and the discharge stops due to reduction of the electric field in the air gap. Some of energy is stored in dielectric layer as wall voltage. But the most of the discharge energy is lost due to wall loss and recombination. This is the why the efficiency of AC discharge is relatively low.

The frequency of RF discharge is much higher than that of AC discharge. In case of RF discharge the electric field changes to the opposite direction before charged particles reach the electrodes. Like this way they oscillate between the electrodes. The wall loss is so small that the efficiency of the RF discharge is high. The AC discharge must regenerate the charged particles at each sustain pulse but the RF discharge only maintain them. Hence the RF sustain voltage is lower than the AC sustain voltage. The low RF sustain voltage is proper to excite the Xe molecules but the AC voltage is too high to excite them efficiently.

Most of all the advantage of RF discharge is high efficiency. As electron energy is lower than that of AC discharge, more energy is deposited to excite the Xe molecule. Fig.1 show the comparison between AC and RF discharge of green phosphor. At the same power the peak intensity of RF discharge is 10 times higher than that of AC.

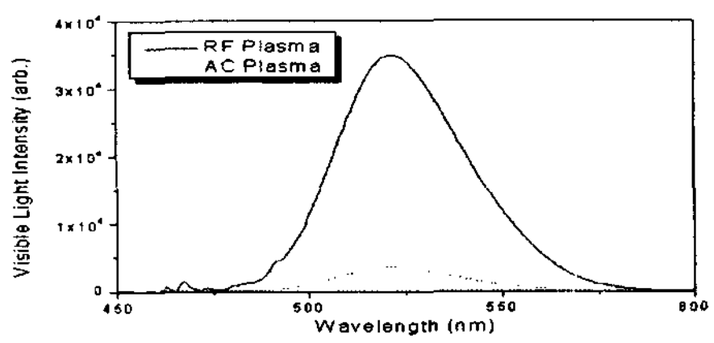

Fig 1. The peak intensity of green phosphor at the same power Ne-Xe(4%), 400Torr

Another characteristic of RF discharge is its good color purity. Strong orange peak(582nm) can be observed in the AC discharge. It looks like pink at the white color. Therefore the color purity of blue and green can be problem. However the visible light of RF discharge is dark white.

2) The Cell structure

Fig. 2 shows the cell structure of the RF PDP. The RF discharge is sustained between RF electrode and SCAN electrode. The AC discharge is ignited between SCAN electrode and DATA electrode. The phosphor is deposited on barrier rib and the MgO on the surface of the rear plate. The RF electrode is parallel to SCAN electrode and perpendicular to the DATA electrode. The charged particle is supplied by the AC discharge to ignite RF discharge. The gap between the RF electrodes is much bigger than the AC electrodes. To confine the charged particles the gap must be comparable to the oscillating distance.

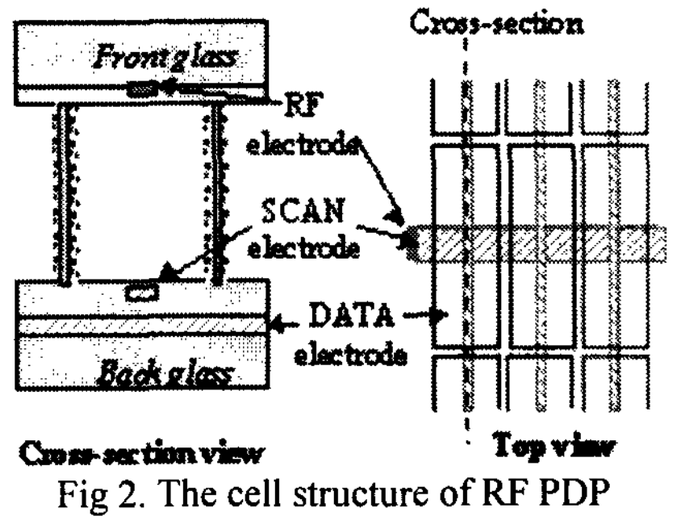

Fig 2. The cell structure of RF PDP

3) The driving circuitry

Fig.3 shows the circuit diagram for the RF PDP driving. The address pulses and data pulses are passed through the LPF but the RF is suppressed. In the opposition, The RF is passed through the HPF but the AC pulses are suppressed. If the HPF does not suppress the AC frequencies well, the scanning will fail

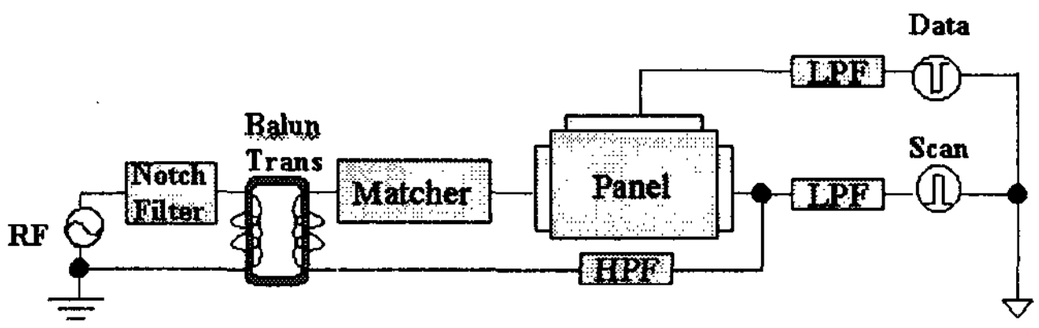

Fig 3. The circuit diagram for RF driving

Accordingly, the scan electrode can be used for the RF electrode by the HPF and with its own duty. One of the important design technologies is to prevent the interference between RF and AC in the system. For the purpose of that, The transformer, which is the Balun transformer was designed[2]. The Balun transformer works for preventing AC noises into the RF Amp. In the front of the Balun, RF swings with ground level. However, after Balun, RF has no reference level to swing. That is, the Balun transformer transmits the RF power to the panel without the ground level.

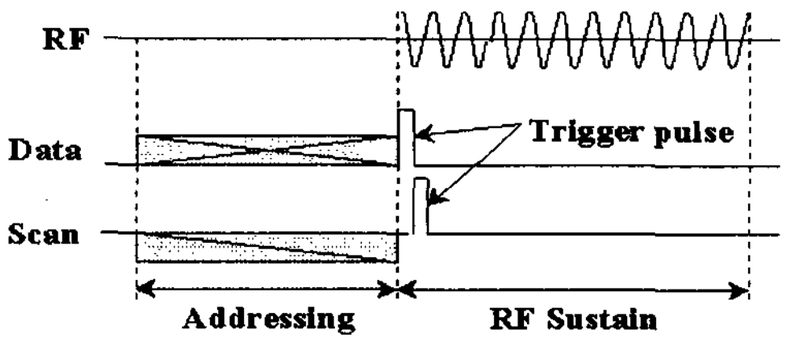

Fig.4 The waveform of RF display

Fig.4 shows the driving waveform. For the purpose of the ignition of the RF discharge, to making many priming particles (especially electrons) in the space is more effective than a wall charge. Therefore, it has needed another discharge pulse, which can remake the priming particles inner cell and that is the triggering pulse. When the priming particles, which are due to the trigger discharge are remade, the RF power is supplied. Simultaneously, Electrons start to oscillate between the two electrodes by force of the RF power. So the RF power should be supplied within the time of priming particles exist inner space. Accordingly, It is possible that RF discharging can occur in lower power than self-firing power. The number of pulses(period) are limited only for the ignition of RF discharging. As we known in the AC PDP, The sustain discharging do not occur without address discharging. In the same, RF discharging is not occurring without trigger discharging. In addition, the trigger discharging is due to the address discharging. Accordingly, Selective RF sustain is possible

3) The gray scale display (RF switching)

The controller switches the RF, which consists of 8 bits. Each bit has a different ON period, which is dependent on the gray scale to display. The RF switching is a simple technology but it is not easy to get good performance. Because it is required a time delay to raise RF from off level to working level. The lower the bit levels the bigger the time delay's effect. In this experiment, The idea is adapted that the RF maintains at a certain level during the RF off period. To raise the RF from a certain level to the working level is faster than from zero level to the working level. Of course, a certain level(referenced level) is decided that can not affect the RF discharge.

4) The matching

The impedance matching should be considered in this experiment. It is not a simple problem that impedance matching against active load. However, in this experiment, the matching point is decided that the panel is full ON. The display experiment that adopted the conditions mentioned above was a success.

5) The efficiency

The biggest advantages of RF PDP are it's high brightness and high efficiency. So it is measured that the brightness and the efficiency of RF PDP. In condition that without the addressing. It means that for the measurement, the only continuous RF is supplied to RF sustain discharge.(no RF switching)

Watt	BRT (cd/m^2)	Efficiency
15	1,884	1.93

Table.1 The measurements of RF PDP

Table.1 shows the measurements of these experiments. The power was 15 watts with full white test pattern. This result shows that RF PDP is compatible with conventional PDP

6) The display pictures

Fig.5 show the successful display of RF PDP. These pictures are color static images. The left side is the display of the symbol mark of our company and the right side is the display of the 32 gray scale levels with RF switching (The RF power was 20W). In addition, the 64 gray scale levels display also successful in the experiments.

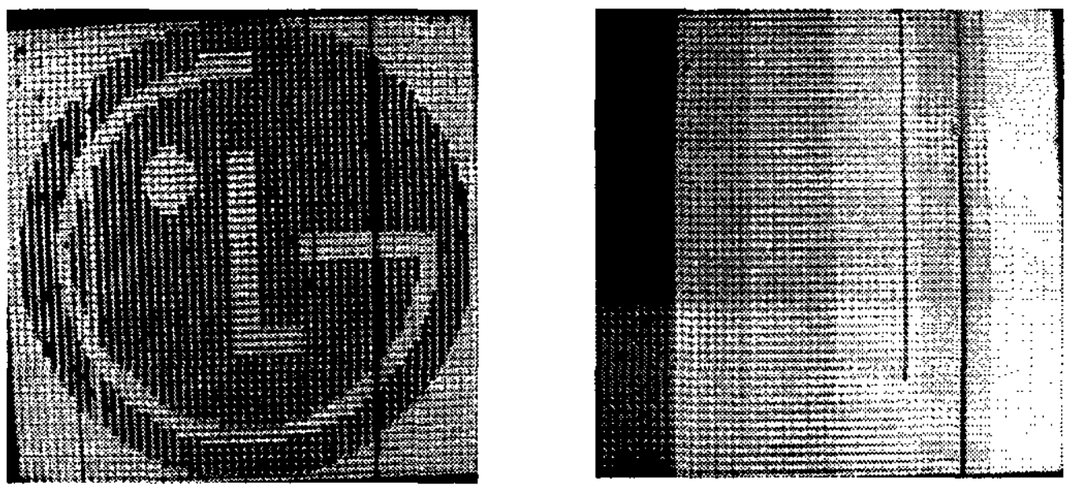

Fig.5 The display pictures

Conclusion

The purpose of our research was to prove the possibility of RF PDP. In addition, it has proved that the RF PDP has potential as a new display field. This experiment which is the first try opens a new display field, which is valuable.

However, as the mentioned above, The RF display is incipient. Therefore, we can expect that the RF display will be the new display field in the near future.

References

1) J. P. Boeuf et al., "Efficiency of Radio Frequency Excited Plasma-Displays Cells Model Predictions", submitted in IDW'99, 1999
2) Peter Vizmuller, "RF Design Guide", Artech House, 1995, pp.69 ~ 75