Some Micro-discharge Characteristics of the cells in ac-PDP

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Abstract

Voltage transfer curves have been used for analyzing the micro-discharge characteristics of cells in ac-PDP. This paper deals with the effect of working gas species, pressure and frequency of applied voltage on the micro-discharge characteristics. Using the mixture gases of He+Xe or He+Ne+Xe, wall voltage steeply varied compared with only He gas, and also voltage margin increased. Discharge voltage and voltage margin increased with increasing Xe percentage, and also wall voltage more steeply varied. In addition, the variation of effective wall capacitance which is significantly dependent on the discharge strength is discussed.

Introduction

In ac-PDP, a micro-discharge occurs between electrodes covered with dielectric layers as shown in Fig. 1. Wall charges, which have accumulated on the dielectric surface during previous discharges, play an important role in driving method of PDP, because the discharge gap voltage is formed by an external applied voltage and the wall voltage due to wall charges.

It is necessary to measure the wall voltage to understand the micro-discharge phenomena and to be able to drive ac-PDPs stably. The behavior of micro-discharge sequence can be analyzed in term of the voltage transfer curve(VTC), which relates change in magnitude of wall voltage during a discharge to the discharge gap voltage at the beginning of the discharge.[2] Therefore, some characteristics of micro-discharge in ac-PDP such as memory margin, addressing/erasing voltage, discharge stability etc, which are important factors in optimal driving of ac-PDP, can be obtained from this voltage transfer curves.[2-3]

In this paper, some micro-discharge characteristics of mixture gases were analyzed with wall voltage transfer curve. The effects of frequency and pressure on wall voltage transfer curves and the change of the effective wall capacitance during a discharge were investigated.

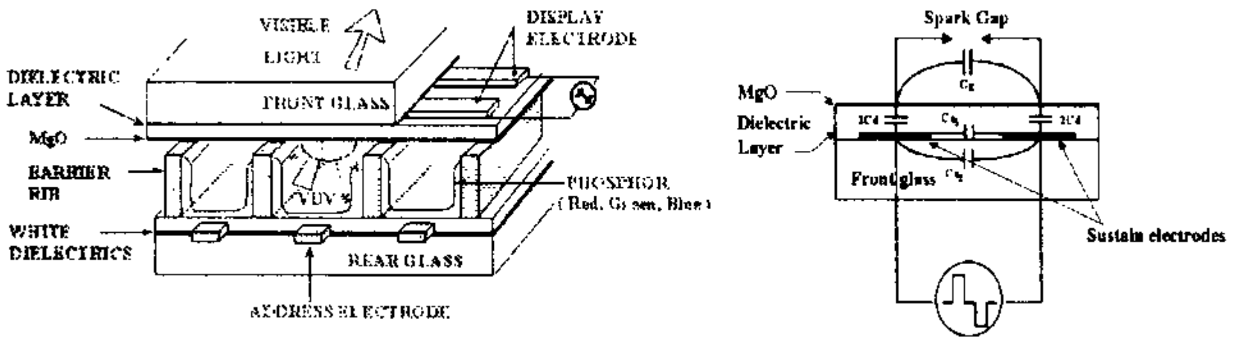


Fig.1 A schematic diagram and a equivalent circuit of ac-PDP

Experimental

Fig. 2 shows a schematic diagram of experimental apparatuses. The experimental apparatuses consist of three parts, that is, circuits of generating pulses, signal controller, vacuum apparatuses.

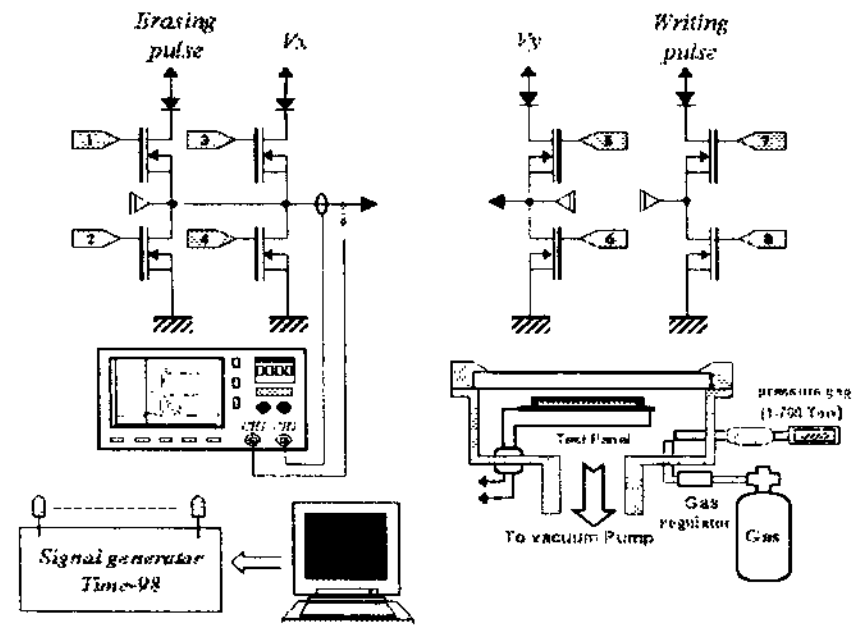


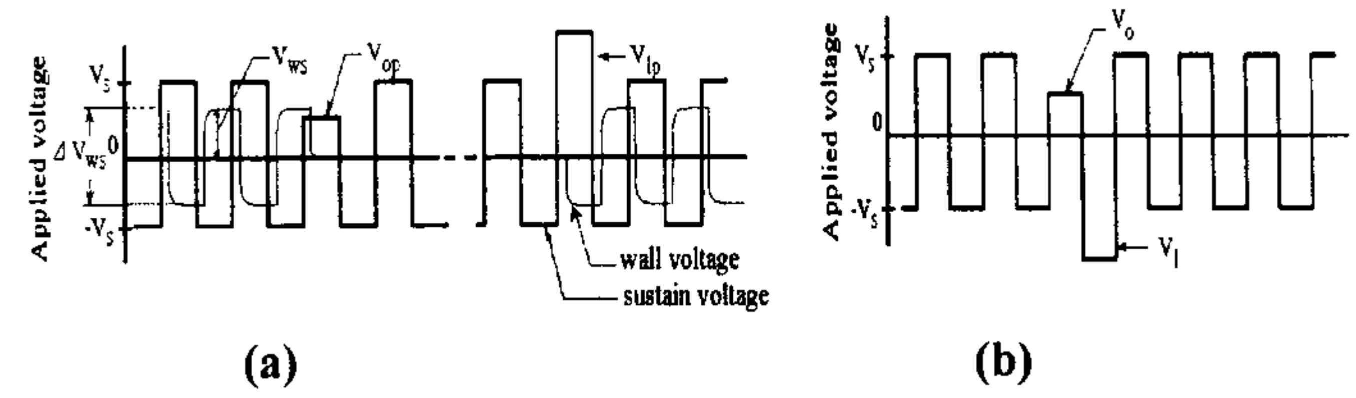
Fig.2 a schematic diagram of experimental apparatuses

The circuits of generating pulses consists of the sustain pulse circuits and erasing/writing pulse circuits. The signal controller generates the control signals to change frequency and pulse width. The vacuum chamber is a cylindrical type with 12cm diameter and 17cm height, to change gas species and gas pressure. This vacuum chamber is exhausted up to "10^{-6} Torr in order not to be affected by residual gas. And then gases are filled to a given pressure.

The specification of 3-inch test panel is as follows. ITO width is 320μm, ITO electrode gap is 60μm, barrier rip height is 150μm. In this experiment, 104cells are tested.

Measurement of a voltage transfer curve involves two steps.

The first step, we establish a steady state operating condition and then determine its coordinates on the VTC. To determine a steady state operating point, we measure a perfect erasing voltage Vop and the perfect writing voltage Vlp.



(a) **(b)**

Fig.3 Applied voltage waveform to determine

Fig. 3 (a) shows the applied voltage waveform to determine the steady state operating point. The perfect erasing voltage Vop perfectly erases wall voltage Vws made by sustained pulse Vs and is indicated by the absence of micro-discharge activity over some reasonably large number of subsequent sustain cycles. As an aid to unambiguous identification of the perfect erase pulse amplitude, it is useful to use a sustain amplitude as close as practical to the maximum for which erasure is possible.[1]

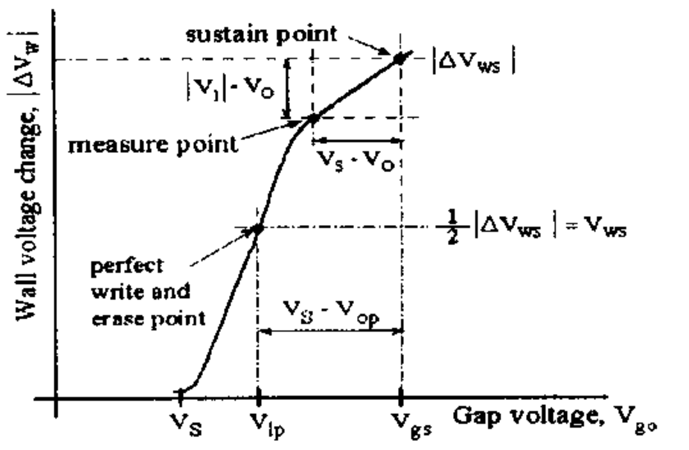


Fig. 4 Measuring the coordinates of the sustain point and plotting the curve relative to the measured sustain point

A perfect writing pulse Vlp is then decided, which is identified by ON state under the condition of Vs pulses. The perfect erasing pulse and the perfect writing pulse each transfer the same amount of voltage, since the former reduces the wall voltage from Vws to zero and the latter from zero to -Vws.

Consequently, $V_{ws} + V_{op} = V_{lp}$ (1)

$$|\Delta V_{ws}| = 2V_{ws} = 2(V_{lp} - V_{op}) \quad (2)$$

At steady state operating condition the applied voltage in micro-discharge space is the sum of the external voltage and wall voltage formed by the previous discharge.

$$V_{gs} = V_s + V_{ws} \quad (3)$$

Equation (2) and (3) define the coordinates of the sustain point on the VTC. Fig. 4 shows the relationships between perfect write/erase point and Vlp(or Vop).

The second step, as shown in Fig. 3 (b), any point on the curve is determined by applying an erase pulse during the first half cycle, followed immediately by a write pulse in the half cycle. The gap voltage Vgo is determined by the amplitude of the erase pulse Vo. Therefore, equation (4) is obtained.

$$V_{go} = V_o + V_{ws} \qquad (4)$$

The corresponding value of $\triangle V_w$ is determined by the amplitude of the write pulse Vl needed to restore precisely the voltage transferred by the erase pulse Vo. The write pulse Vl is identified by the equality of the quantity of discharge charges at steady state micro-discharge to that of the next pulse of Vl. The write and erase pulses transfer the same magnitude of voltage.[1]

$$V_o + V_{ws} = -(V_l + \triangle V_w + V_{ws}) \qquad (5)$$

Since the polarity inverses between successive half cycles, $\triangle V_w$ is taken with the sign appropriate to the erase operation. And solving for $\triangle V_w$

$$\bullet \triangle V_w \bullet = \bullet \triangle V_{ws} \bullet - (\bullet \triangle V_l \bullet - V_o) \qquad (6)$$

Equation (4) and (6) define the VTC relative to the coordinates of the sustain point.

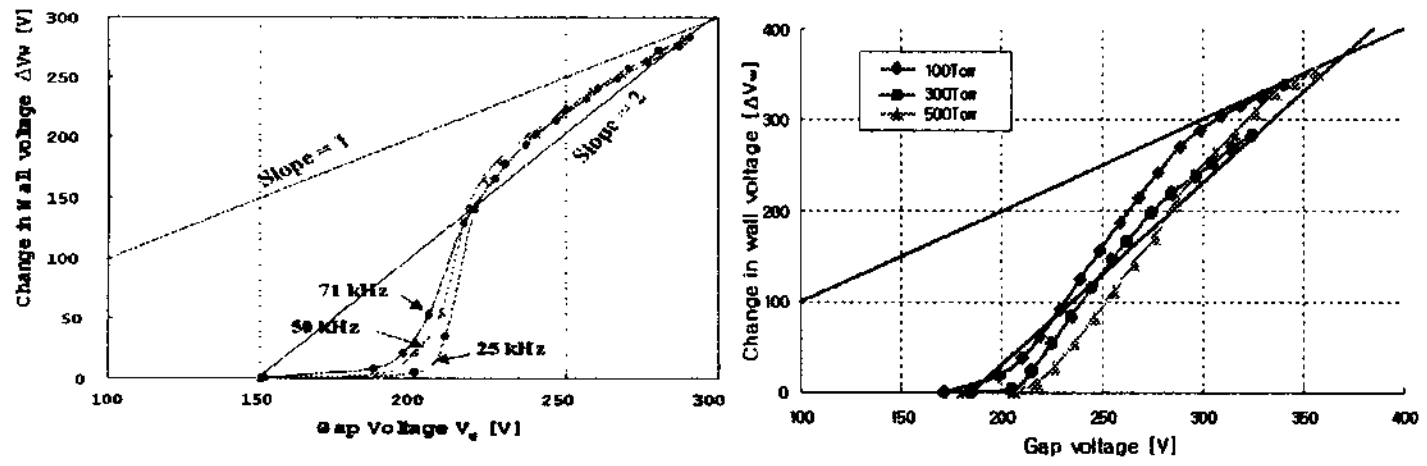
The capacitance of the dielectric on sustain electrode varies significantly dependent on the micro-discharge strength. The micro-discharge strength varies also for different points along the VTC. Therefore, the equivalent wall capacitance Cd can be determined by taking the ratio of the charge and voltage transfer at each point.

First, we measured the quantity of charge Q, which can be obtained by integrating a discharge current, and determined $\triangle V_w$ on VTC under the same gap voltage. The equivalent wall capacitance Cd can be obtained by

$$C_d = Q / \triangle V_w \qquad (7)$$

Results and discussion

Fig.5 (a)shows the effects of sustain frequency with He+Ne(30%)+Xe(4%) at 400Torr. As the frequency decreases, the minimum sustain voltage and the firing voltage increase. This reason may be the priming effect to a micro-discharge space.[2] The voltage margins are almost same regardless of the sustain frequency.



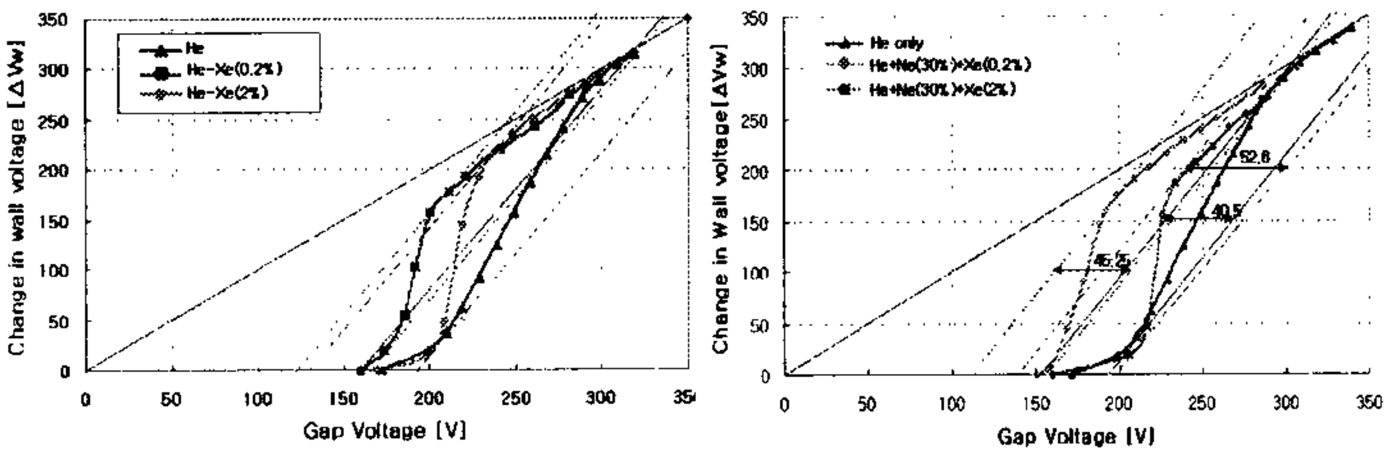
(a) (b)

Fig. 5 The effects of frequency and working pressure on VTC

Fig.5 (b)shows the effects of the working pressure with He gas, sustain frequency 50kHz. The voltage margins are respectively 38V at 100Torr, 40.5V at 300Torr, and 52V at 500Torr.

As the working pressure increases, the voltage margin is increased. However, the lowest value of the firing voltage 192V is obtained at 300Torr, which is near to Paschen minimum.

Fig. 6 shows VTCs as a parameter of gas species with sustain frequency 50kHz and working pressure 300Torr. Fig. 6(a) shows voltage transfer characteristics for He and He+Xe. The firing voltage of He+Xe(0.2%) is lower than that of He+Xe(2%). The reason may be that penning ionization of He+Xe(0.2%) is much stronger than that of He+Xe(2%). Fig. 6(b) shows VTCs for 3mixture gas. Compared with He+Ne(30%)+Xe (2%), the voltage margin of He+Ne(30%) +Xe(0.2%) from the VTC is 45.25V, i.e., about 7V less than the voltage margin of He+Ne(30%)+Xe(2%).



(a) (b)

Fig. 6 voltage transfer curves as a parameter of gas species

Fig. 7 shows effective wall capacitance as a parameter of sustain frequency with He+Ne(30%)+Xe(4%), working pressure 400Torr. As a frequency decreases, the variation rate of effective wall capacitance increases in the lower regions of gap voltage Vg. This is attributed to the priming condition at a micro-discharge and the dependence of the lateral spread of the micro-discharge upon its strength. As Gap voltage increases, the effective wall capacitance Cd is gradually saturated. In spite of frequency, the saturated Cd is almost same.

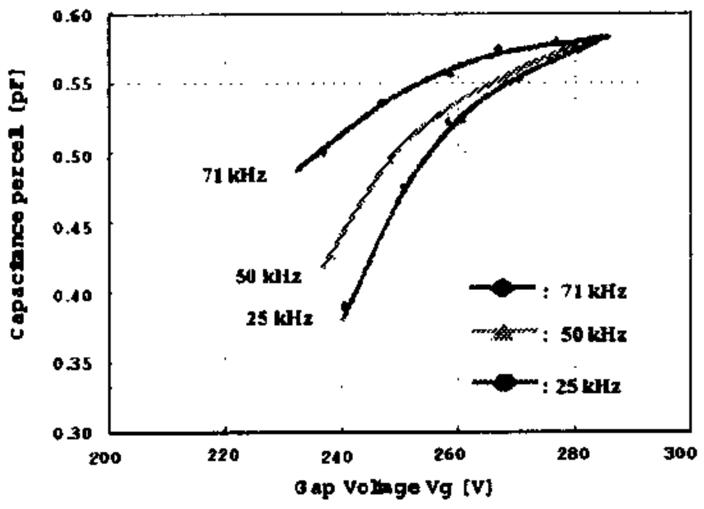


Fig. 7 The variation of effective wall capacitance as a parameter of sustain frequency

Conclusions

In this paper, we discussed the effects of gas species, pressure and frequency of applied voltage on VTC in the micro-discharge characteristics.

As the frequency decreases, the minimum sustain voltage and the firing voltage increase. However, the voltage margin are almost same, regardless of the sustain frequency. As the working pressure increases, the voltage margin is increased. The lowest value of the firing voltage 192V is obtained at 300Torr, which is near to Paschen minimum. The He gas shows a gradual decrease in wall voltage, while the mixture gases (He+Xe, He+Ne+Xe) have a very sharp response, which is desirable for a sharp transition from the firing voltage and the minimum sustain voltage, to the gap voltage. The effective wall capacitance varies significantly dependent on the lateral spread of the micro-discharge upon micro-discharge strength. In upper regions, the respective capacitance is almost the same regardless of the frequency.

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