Effect of Secondary Electron Emission of Phosphor on the Plasma Display Panel Discharge

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Abstract

We studied the effect of secondary electron emission from the back plate of AC-PDP, on the ramp waveform driving of the system, using two-dimensional PDP cell discharge simulator. It is found that the secondary electron emission from back plate plays a significant role in getting a stable weak discharge during the ramping up of X-Y electrode voltage. This is because grounded address electrode acts as a cathode during the setup of surface charge, and the secondary electron emission from phosphor in the back plate must be large enough to accumulate surface charges on the dielectric layers without strong plasma discharge. We have concluded that the secondary electron emission coefficient(γ) of phosphor, besides MgO, must be known to understand the characteristics of the PDP system. A few suggestions for improvement of the system is also made and tested.

1. Introduction

Typical Planner electrode type AC PDP panel has an MgO layer on the front plate, which has two purposes. One is to protect dielectric layer from ion bombardment, and the other is to reduce discharge voltage by increasing secondary electron emission. These secondary electrons are emitted from the surface of MgO layer when one of the X and the Y electrodes act as a cathode. During the ramping up of driving voltage, however, the address electrode is always grounded and acts as a cathode too, and if there is no secondary electron emission from phosphor of the back plate, weak plasma discharge between X-A or Y-A electrode are very hard to occur, and the weak discharge by ramping up of the scan voltage could be unstable.

MgO is known to have a very high secondary electron emission coefficient (γ) for Neon ion, which ranges from about 0.3 to 0.5 [2]. Second electron emission coefficient (γ) of phosphor in PDP is not well known, but expected to be about 1/3 of γ_{MgO} or less for Neon ion[Moon, private communication]. Though this value is much smaller than MgO, it cannot be ignored, as is demonstrated in the following.

2. Simulation Model

To investigate the effect of γ value of phosphor on the PDP discharge, we have performed a set of computer simulation. Our program is based on the two-dimensional fluid model of plasma. For simplicity, the momentum equation is simplified using drift-diffusion approximation, which is valid for highly-collisional plasma like PDP.

$$\frac{\partial n}{\partial t} + \nabla \cdot \varphi = S$$

$$\varphi = \pm n\mu E - \nabla(nD)$$

The source term of continuity equation is calculated using local field approximation, which is also acceptable as it was already validated previously [1].

$$S = v_{collision}\left(E/p\right)\prod n$$

The Poisson equation is solved for electron, ion and surface charges, and we have used successive over-relaxation method and semi-implicit scheme to achieve numerical stability and minimal computing time.

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$$\nabla \cdot (\varepsilon E) = -(n_i - n_e)$$

3. Result and Discussion

3.1 Effect of $\gamma_{phosphor}$

Figure 1 and 2 shows the Y-reset interval of PDP driving stage when $\gamma_{phosphor}$ is ignored. These graphs represent the motivation of our study. The γ of MgO is set to 0.5

In Figure 1, we have used a typical driving voltage for the AC PDP discharge simulation. During the ramping up of Y electrode voltage, however, the system grows exponentially and strong discharges occur, while most of the real PDP systems make weak discharges in the interval.

The situation changes dramatically when we give $\gamma_{phosphor}$= 0.1, as shown in figure 3 and 4. The electron density remains under 10^{10} cm^{-1} and stable, and the surface charge profile in figure 4 shows that there was a weak discharge during the ramp up.

From the results, we can deduce that in our system, the weak discharge is mostly due to the weak breakdown between Y and A electrode, and the breakdown voltage between Y and A can be lower than between Y and X, if we take $\gamma_{phosphor}$ into account.

Figure 5 shows the potential and electron density profile of the system at the breakdown when $\gamma_{phosphor}$ = 0. In our numerical experiment, the breakdown voltage was determined so sharply that we couldn't find the condition to generate weak discharge while $\gamma_{phosphor}$ = 0. Note that electron density profile confirms that the discharge occurred between X and Y.

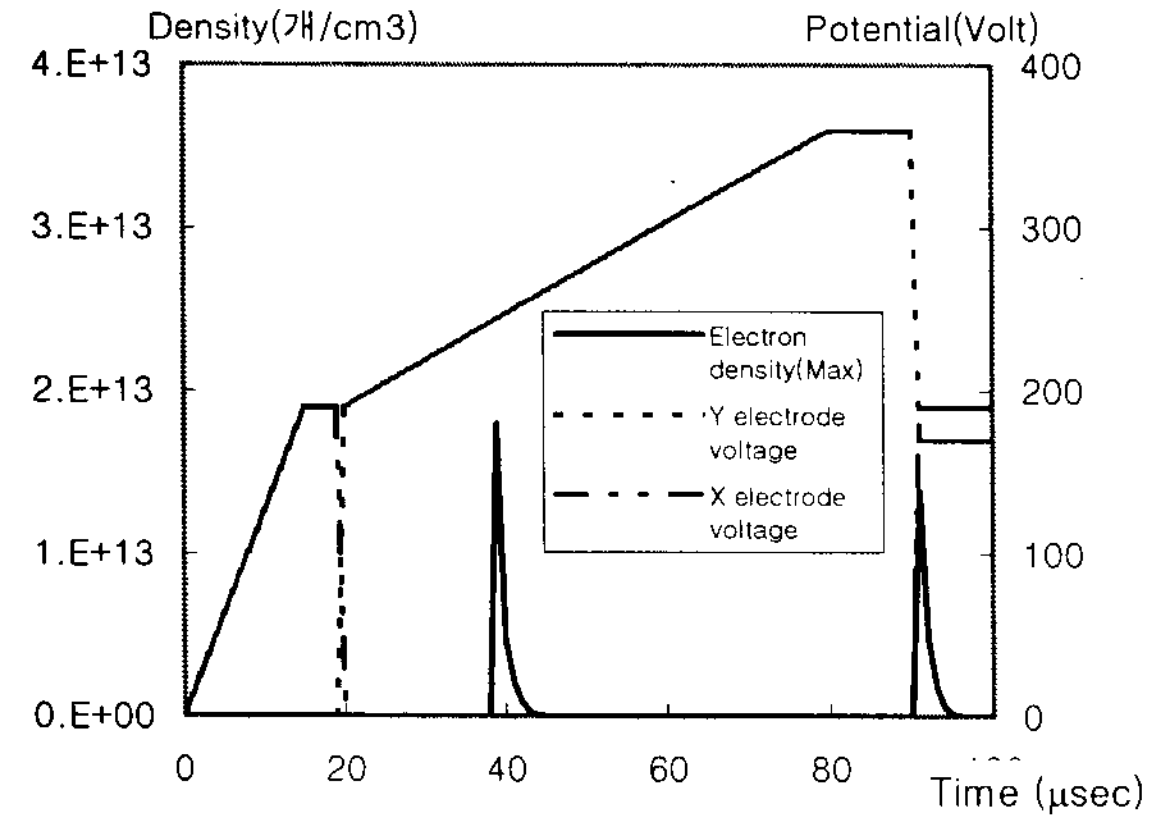


Figure 1 Y-reset interval: weak discharge failed when $\gamma_{phosphor}$ = 0.

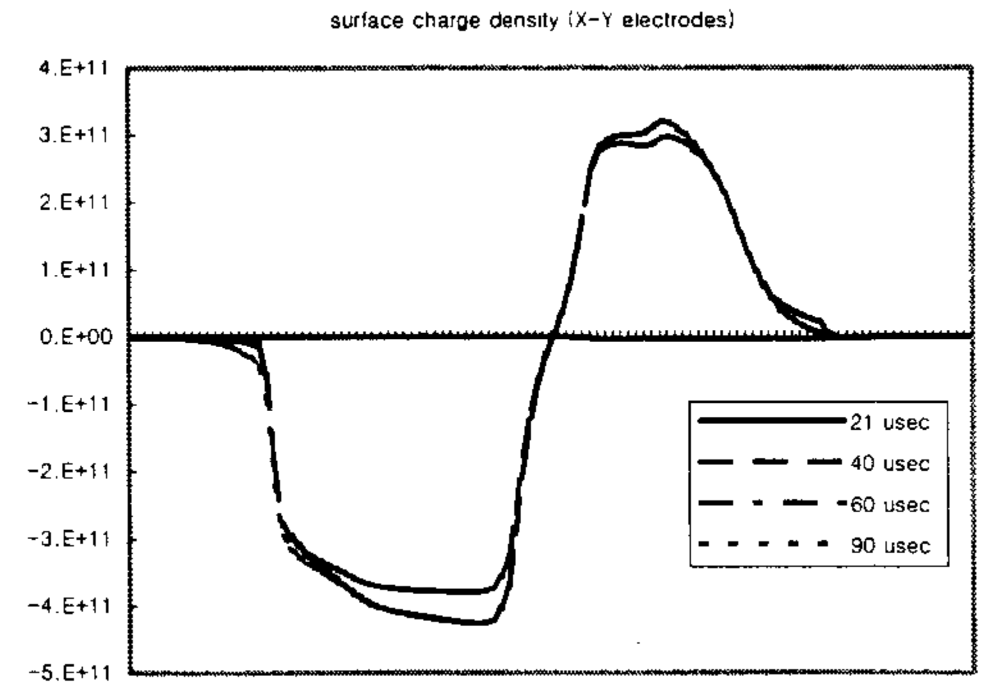


Figure 2 The surface charge profile shows that there was a strong discharge near at 40μsec.

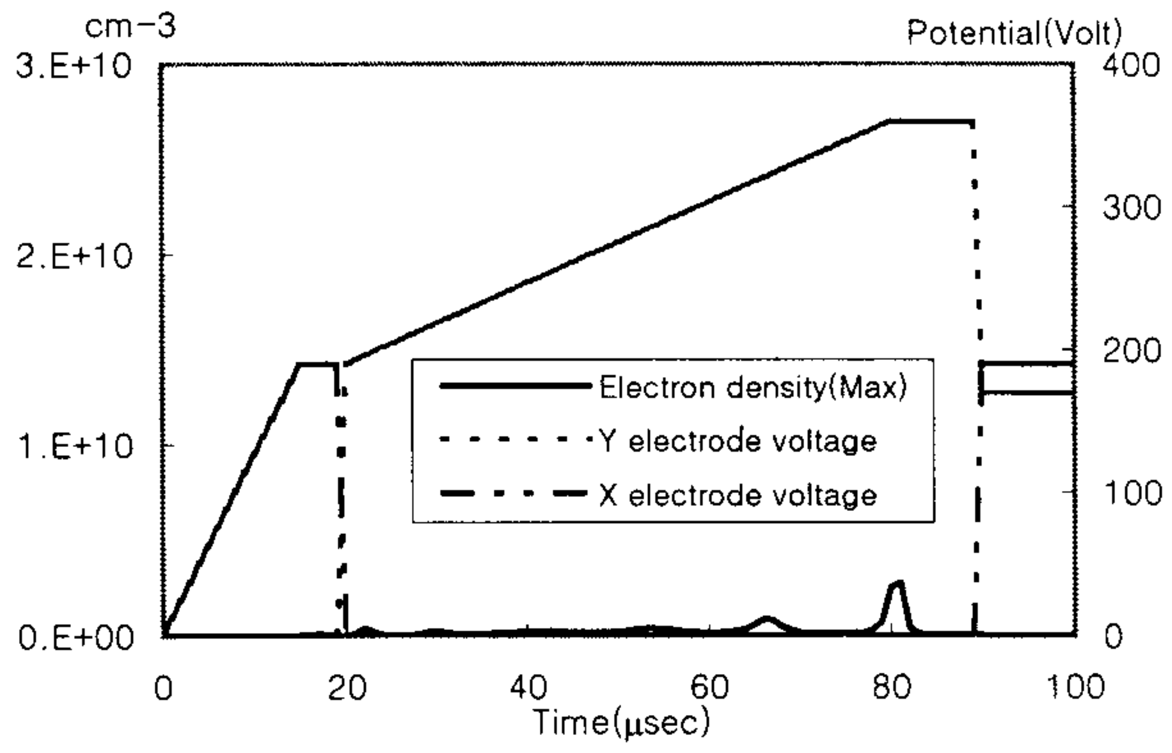


Figure 3 The reset interval: weak discharge succeeded when $\gamma_{phosphor}$ = 0.1

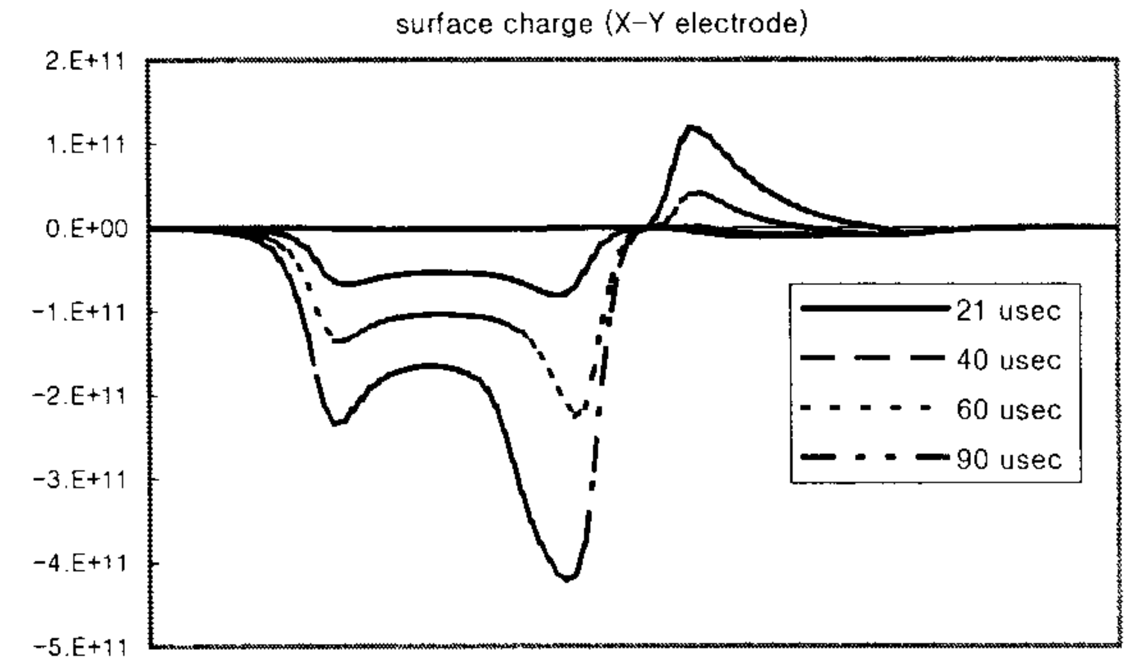
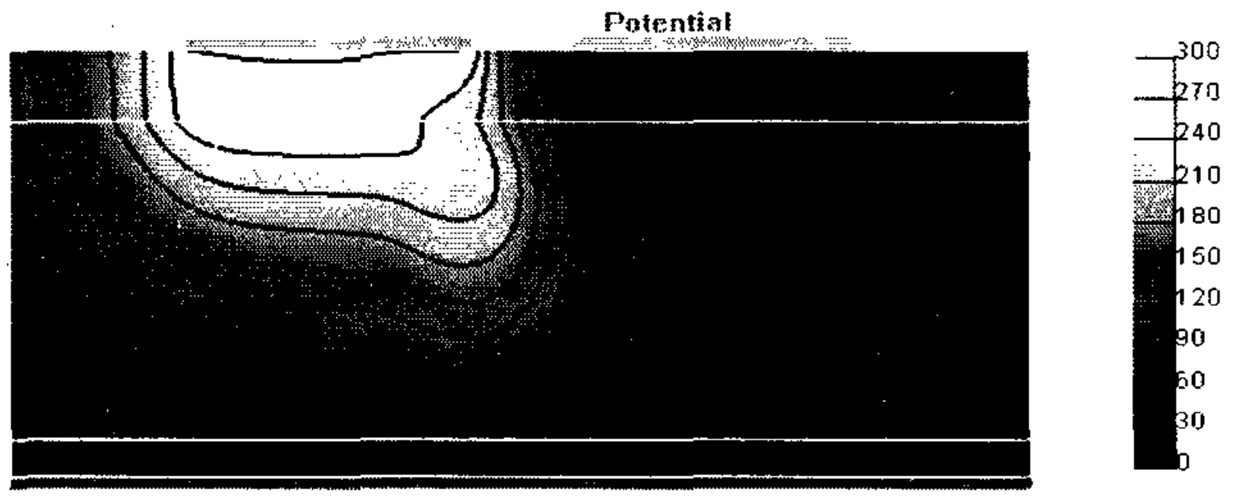
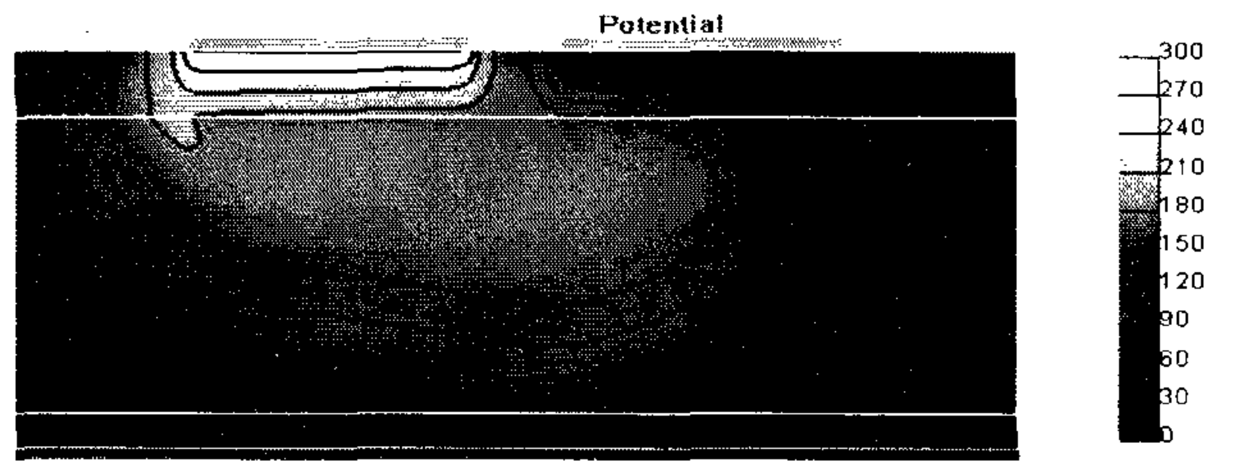


Figure 4 The surface charge profile during the ramping up of Y voltage when $\gamma_{phosphor}$ = 0.1

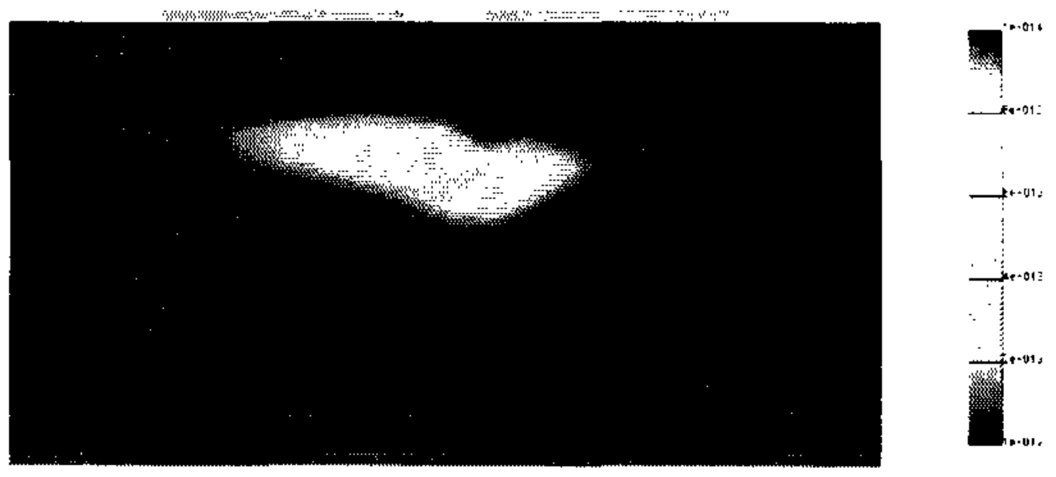
Figure 6 shows the two dimensional profile of the potential, electron and ion densities during the weak discharge when $\gamma_{phosphor}$ is 0.1. Ion density profile in this figure shows an interaction between Y and address electrode.



(a) Potential profile when $\gamma_{phosphor}$ =0 and just before the breakdown



(b) Potential profile after the breakdown. 0.25 μs passed from (a)



(c) Eectron density profile shows that the discharge occurred between X and Y electrodes.

Figure 5 potential and electron density profile of the PDP cell when $\gamma_{phosphor} = 0$

$\gamma_{phosphor}$	1.33 V/μs		2.67 V/μs		5.33 V/μs	
	γ_{MgO}:0.3	0.5	0.3	0.5	0.3	0.5
0.0	X	X	X	X	X	X
0.1	O	O	O	O	O	O

Table 1 Weak discharge test for different Y voltage slope, $\gamma_{phosphor}$ and γ_{MgO}

Table 1 indicates strong dependency of weak discharge on the $\gamma_{phosphor}$. We started Y electrode voltage from 190 volt, and increased to 350 volt. 3 different slopes of the ramp voltage profiles were tested. In our simulation, the success of weak discharge entirely depends on whether there is finite $\gamma_{phosphor}$ value or not.

In figure 7, the weak discharge profile for different $\gamma_{phosphor}$ value is demonstrated. For the $\gamma_{phosphor}$ value of 0.01 and 0.02, the system fails to generate weak discharge and the electron density has peaked to the order of 10^{13} cm^{-3}. The density remains below 10^{11} cm^{-3} when $\gamma_{phosphor}$ is 0.05 or larger. Though the exact value of minimum $\gamma_{phosphor}$ required to generate weak discharge will be different for different PDP geometry or other different conditions, it is strongly suggested in these numerical experiments that $\gamma_{phosphor}$ takes a crucial role in generating weak discharge, during the ramping up of Y-voltage in the reset stage of PDP discharge.

Figure 6 Two dimensional profile of the system during the weak discharge when $\gamma_{phosphor}$=0.1

3.2 New weak discharge driver.

The secondary electron emission characteristics of phosphor is not well known, and it will not be easy to control the characteristics, while maximizing the photo emission efficiency of the material for the desired light spectrum.

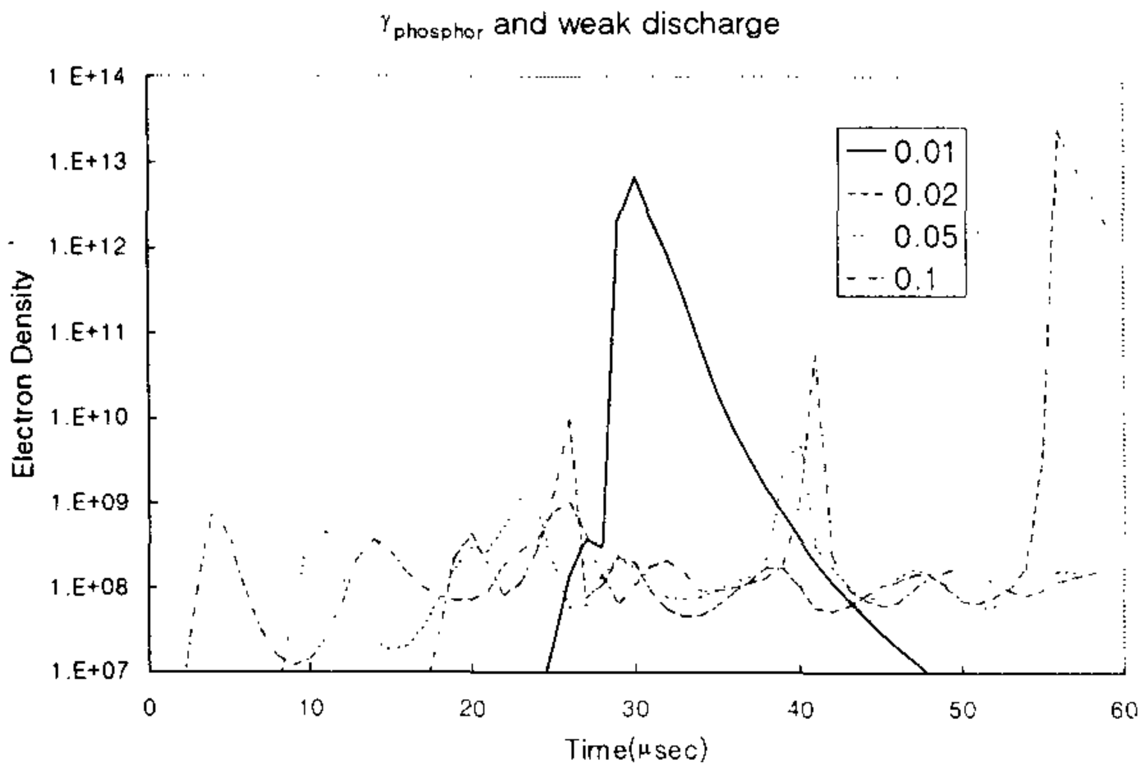
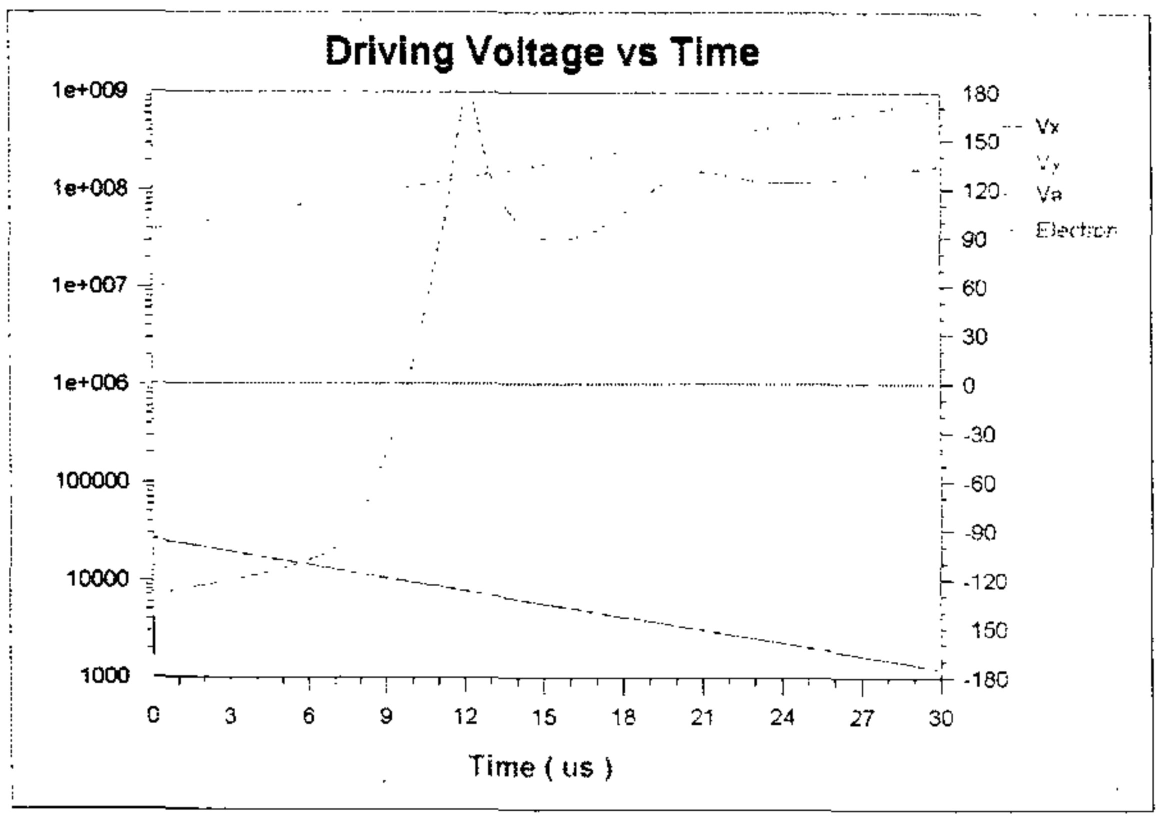
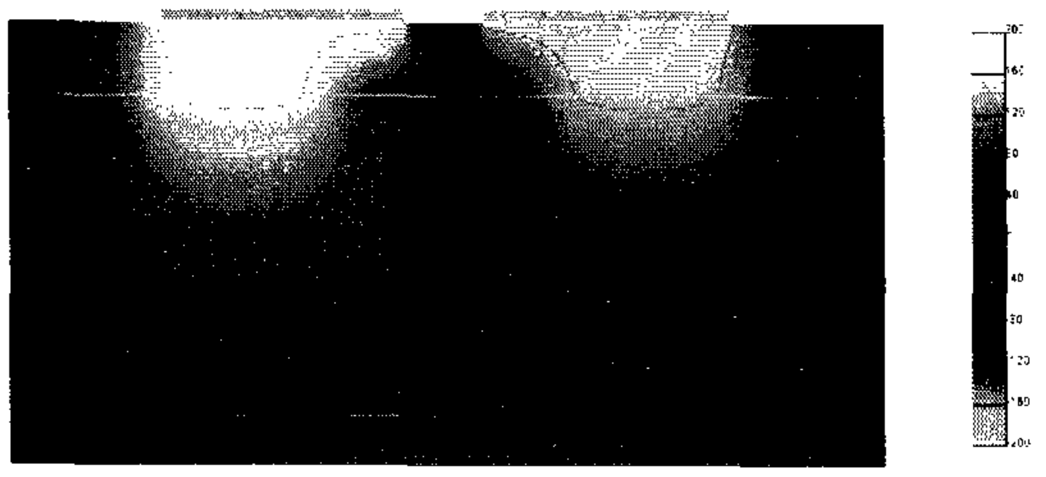


Figure 7 $\gamma_{phosphor}$ vs. weak discharge profile.



(a) Driving voltage and electron density



(b) Electric potential profile at near 30μsec

Figure 8 New driving method to generate stable weak discharge

Figure 8 shows an example of driving method to generate stable weak discharge, independent of the value of $\gamma_{phosphor}$.

In this driver, the Y electrode voltage is increased from 95 volt to 175 volt, while X electrode voltage is decreased from –95 volt to –175 volt. The potential difference between X and Y is the same as in the previous driving profile, but the potential of the address electrode is now centered between the values of two scanning electrodes.

The result in figure 8 was generated on the condition that $\gamma_{phosphor}$ is 0. It is checked that the result is irrelevant of the value of $\gamma_{phosphor}$. Figure 8 (b) shows that the potential is distorted due to the surface charge. The surface charge is localized between the two electrodes. Even if the surface charge cannot neutralize the high potential at the outside from the center of two electrodes, electric field strength doesn't exceed the breakdown because the distance between the two potential peaks is largest. The amount of surface charge at the address electrode side is small because 1) the electric field near the address electric field is now halved; 2) the major secondary electron emission source is now MgO, not phosphor.

4. Conclusion

From the simulation study of PDP weak discharge, we have concluded that the secondary electron emission coefficient of phosphor has a crucial role in generating weak discharge during the ramping up of scanning electrode. We have provided a number of simulation results regarding the relation between $\gamma_{phosphor}$ and the weak discharge, and suggested a new driving method to generate a stable weak discharge, independent of the characteristics of phosphor.

7. References

[1] C. Punset, J.-P. Boeuf, and L. C. Pitchford, J. Appl. Phys. **83** 1884 (1998).

[2] *For example*, Y. Kim *et al*, Mat. Res. Soc. Symp. Proc. **621** Q5.6.1 (2000)