# Three-dimensional Fluid Simulation for the Variation of Electrode Geometry in ITO-less PDP Cells

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## Abstract

*Several ITO-less PDP cell structures are presented to improve luminous efficacy. The ITO-less PDP have been applied recently at actual panel manufacture. The influence of ITO-less PDP cell structure on the discharge characteristics has been investigated by using three-dimensional fluid simulation. The variations of electrode geometry parameters such as gap distance, cross bar length, and hump length are investigated for the optimization of cell design.*

## 1. Introduction

Recently, a price competition becomes important elements in plasma display panel (PDP). There are several efforts to reduce the production cost by new driving methods [1] and new manufacture technologies [2]. In AC-PDP, luminance and luminous efficacy are important issues and high luminous efficacy structures are reported [3,4], but significant modification of cell structure increase production cost. Therefore, ITO-less PDP cell is the simple method to reduce the manufacture cost. But low luminance and luminous efficacy must be improved. Therefore, it is important to know the effects of the variation on the electrode geometry in ITO-less PDP cells in order to optimize the PDP cell structure.

In this study, the effects of the variation of electrode geometry were investigated in ITO-less PDP cells by using a 3- dimensional fluid code [5-7], and ray trace calculation for ultra violet (UV) calculation [8]. The discharge characteristics are analyzed such as density of excited species, electric field intensity inside the cell, and the time history of particles in the simulation. Experimental results are compared with simulation result for the variation of gap distance.

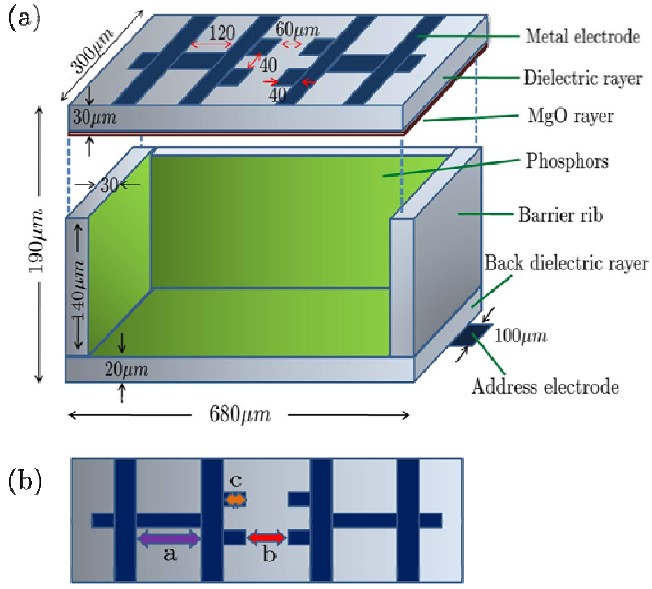


**Fig. 1(a) Simulation structure and (b) variation parameters, a: cross bar, b: gap distance, c: hump length**

## 2. Results

Fig. 1(a) shows the schematic diagram of the simulated ITO-less PDP cell and Fig. 1(b) shows that variation parameters of a ITO-less structure are the cross bar length, gap distance, and the hump length. Reference values are a cross bar length of 120 μm, a gap distance of 60 μm, and a hump length of 40 μm. Simulation conditions are as follows. The

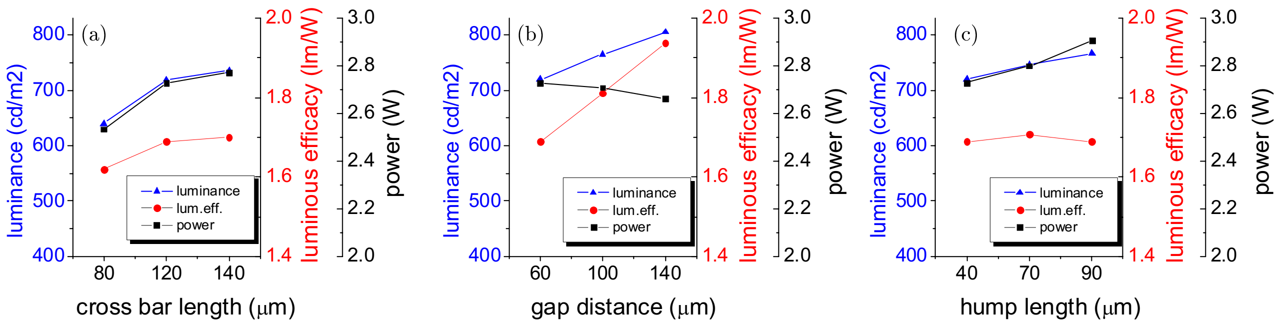


**Fig. 2 Simulation results of luminance, luminous efficacy and power for variations of (a) cross bar, (b) gap distance, and (c) hump length.**

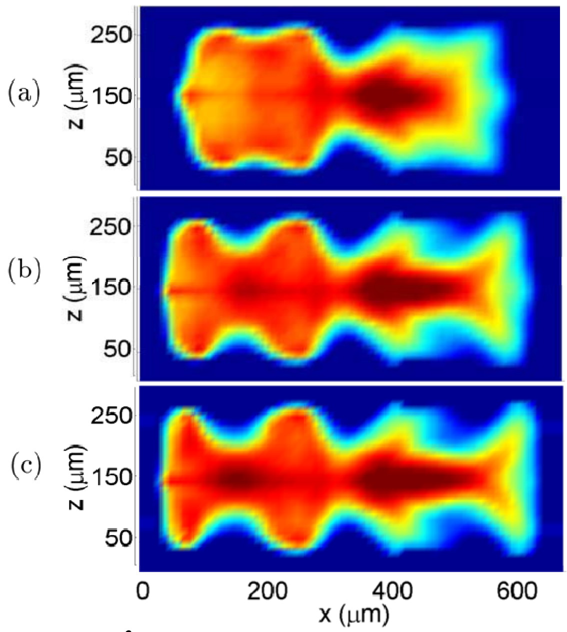


**Fig. 3 Xe*($^3P_1$) density profiles at discharge peak (t=40.3e-5 μs) for cross bar length (a) 80 μm, (b) 120 μm, (c) 140 μm.**

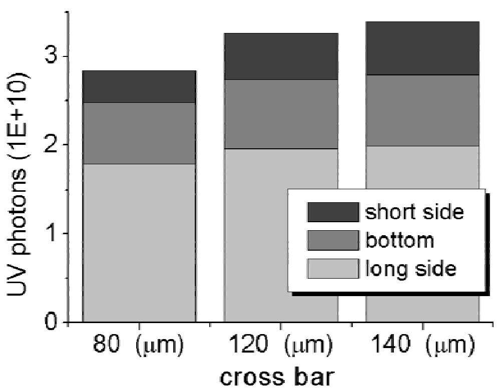


**Fig. 4 The number of UV photons reaching each phosphor surface.**

working gas is a Ne + Xe 8% mixture with a total pressure 400 Torr. The applied sustain voltage is 260 V with a frequency of 100 kHz and a duty ratio is 0.3.

Fig. 2 shows that luminance, luminous efficacy, and power for the variation of structures. In fig. 2 (a) cross bar length is related to luminance increase. As the cross bar length increases, the open window for visible light is extended and power dissipation is grown. Fig. 2(b) presents the same tendency as well known results for the variation of gap distance [9,10]. As the gap distance becomes longer, luminance and luminous efficacy increase considerably. Fig. 2 (c) shows luminance increases when hump length increases, but luminous efficacy decrease when hump length increase from 70 μm to 90 μm.

Fig. 3 shows Xe*($^3P_1$) distribution at discharge peak (t=40.3 μs). The Xe*($^3P_1$) density is distributed along the electrode pattern. Thus, the long cross bar length make good use of discharge space and shows high luminance.

Fig. 4 shows that the number of UV photons on phosphor surface. Total UV photons grows by 19% when cross bar length is 140 μm compared with cross bar length is 80 μm. The distribution ratio of UVs to reach the lateral short side (640μm by 140μm surface) increases when cross bar increases from 80 μm to 140 μm.

Fig. 5, show experimental power, luminance and luminous efficacy for gap distance 60 μm and 140 μm as a function of sustain voltages. These results present the same as simulation results in Fig. 2(b). As the gap distance becomes longer, luminance and luminous efficacy increase considerably, but sustain voltage also increase.

Fig. 6 shows the time evolution of electric field intensity under a front surface 15 μm. The electric field intensity is lower when the electrode gap distance increase from 60 μm to 140 μm, because discharge path is extended. In this reason generated excited species grows rather than ionized particles.

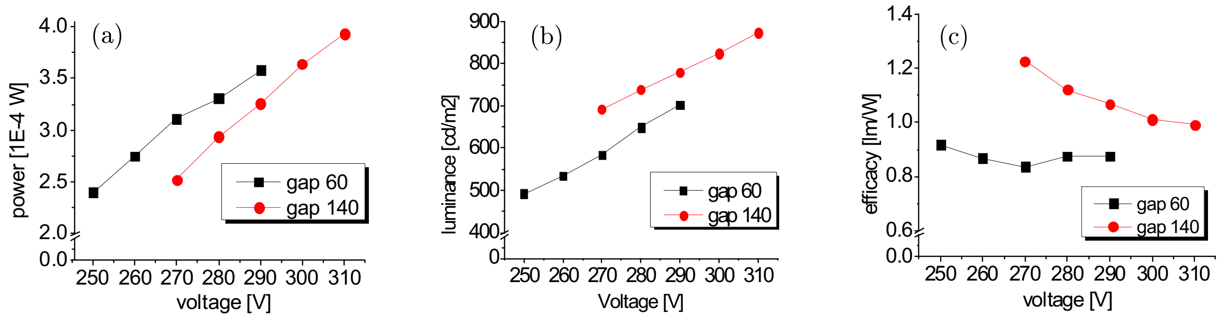


**Fig. 5 Experiment results of (a) power, (b) luminance, and (c) luminous efficacy with respect to sustain voltage.**

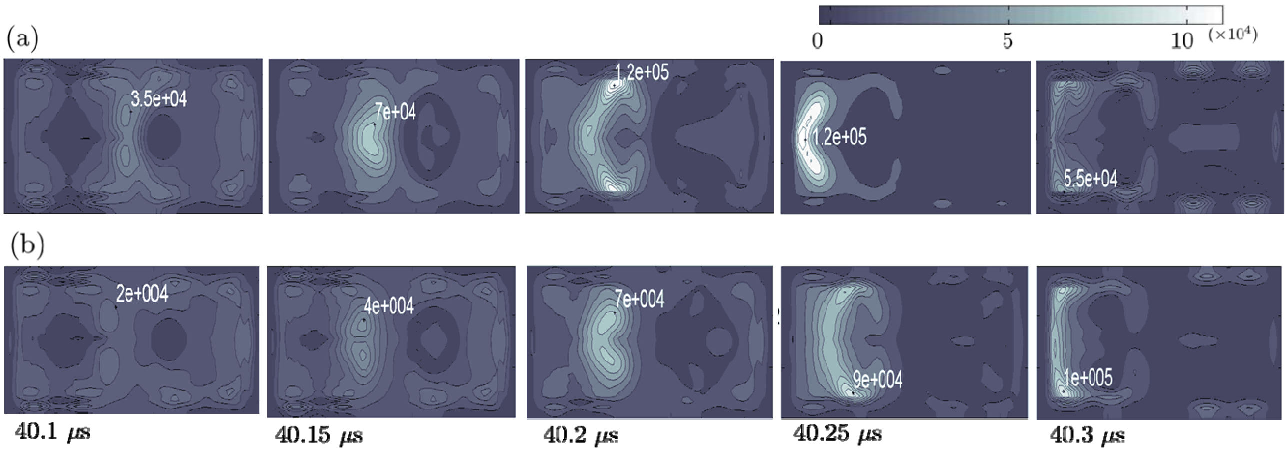


**Fig. 6 Time evolution of electric field intensity with respect to ITO-less structure with a (a) gap 60 μm (b) gap 140 μm.**

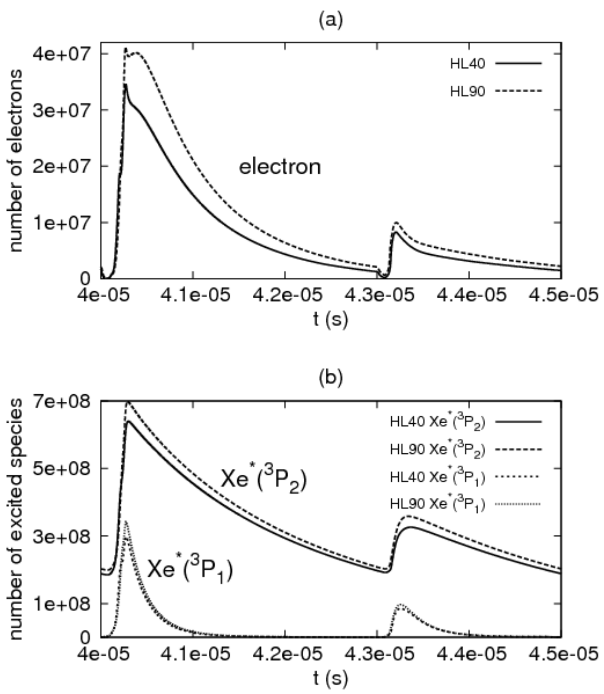


**Fig. 7 Time variation of (a) electorn and (b) excited species for hump length with a 40 μm and 90 μm.**

Another characteristic is the time to reach the peak value of electric field delayed when electrode gap distance increases.

Fig. 7(a) and 7(b) show that number of electrons and excited species ($Xe^*(^3P_1)$ & $Xe^*(^3P_2)$) respectively. The number of electrons grows by 10 % when hump length increases form 40 μm to 90 μm. But the number of excited species grows by 5%. As shown in Fig. 2(c), the luminance increases slightly but power loss also increases.

## 4. Acknowledgements

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## 4. Conclusion

In this study, discharge characteristics were investigated for electrode geometry variation in ITO-less PDP cell using a three-dimensional fluid simulation. In the simulation results, the luminance improved when cross bar length, gap distance, and hump length increase. However, the power dissipation also decreases as to increment of gap distance. In the case of long gap distance, electric field intensity is lower and the open window area is increased. Therefore, gap distance is the most important parameter on luminous efficacy.

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