Effect of Barrier Rib Height Variation on the Luminous Characteristics of AC PDP

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Abstract

We studied the effect of barrier rib height variation using ray-optics code incorporated with three-dimensional plasma simulation to analyze the effects of cell geometry for varying pressure conditions. The optimal barrier rib height decreased as the Xe partial pressure increased which resulted in due to the formation of local, strong sheath under high Xe partial pressure condition.

1. Introduction

Recently, PDP(Plasma Display Panel)s with high Xe content (>10%) and high total pressure (>400torr) have attracted considerable attention, because high luminous efficiency could be obtained for high sustain voltages in the high Xe partial pressure gas condition[1].

The main focus of this work is based on the analysis of the differences in the discharge characteristics according to the barrier rib height changes between two different gas conditions (i.e., high Xe content, high total pressure and low Xe content, low total pressure gas condition).

We will analyze the effect of barrier rib height variation on the luminance and luminous efficiency using ray-optics code incorporated to three-dimensional discharge code to get the optimal heights when the Xe content and total gas pressure are increased.

2. Results

In the numerical simulation, we assumed the local field approximation (LFA) model, and fourteen reaction level models were used for Ne and Xe, i.e., Ne(ground), Ne^*, Ne^{**}, Ne^+, Ne_2^*, Ne_2^+, Xe(ground), $Xe^*(^1s_5)$, $Xe^*(^1s_4)$, Xe^{**}, Xe^+, $Xe_2^*(1_u,0_u^-,v\approx0)$, $Xe_2^*(0_u^+,v>>0)$, Xe_2^+[2].

Fig. 1 shows the schematic diagram of ac PDP cell used in our computational simulation. The cell size of a sub-pixel is 1080×360μm, and the barrier rib height including the phosphor changes from 100μm to 180μm. The address electrode of rear plate is covered with a 10μm dielectric layer, and the sustain electrodes of front plate is covered with a 30μm dielectric layer.

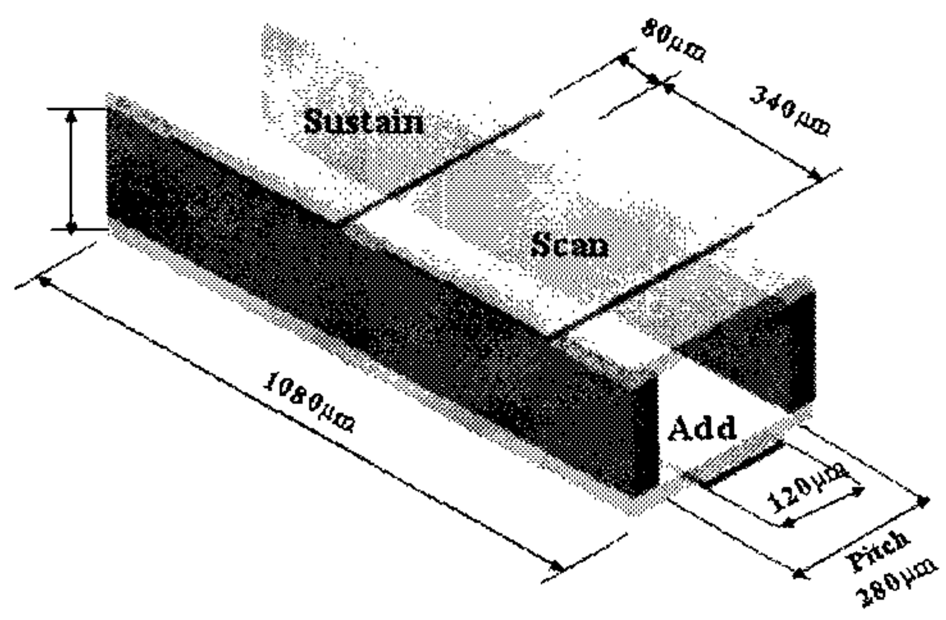
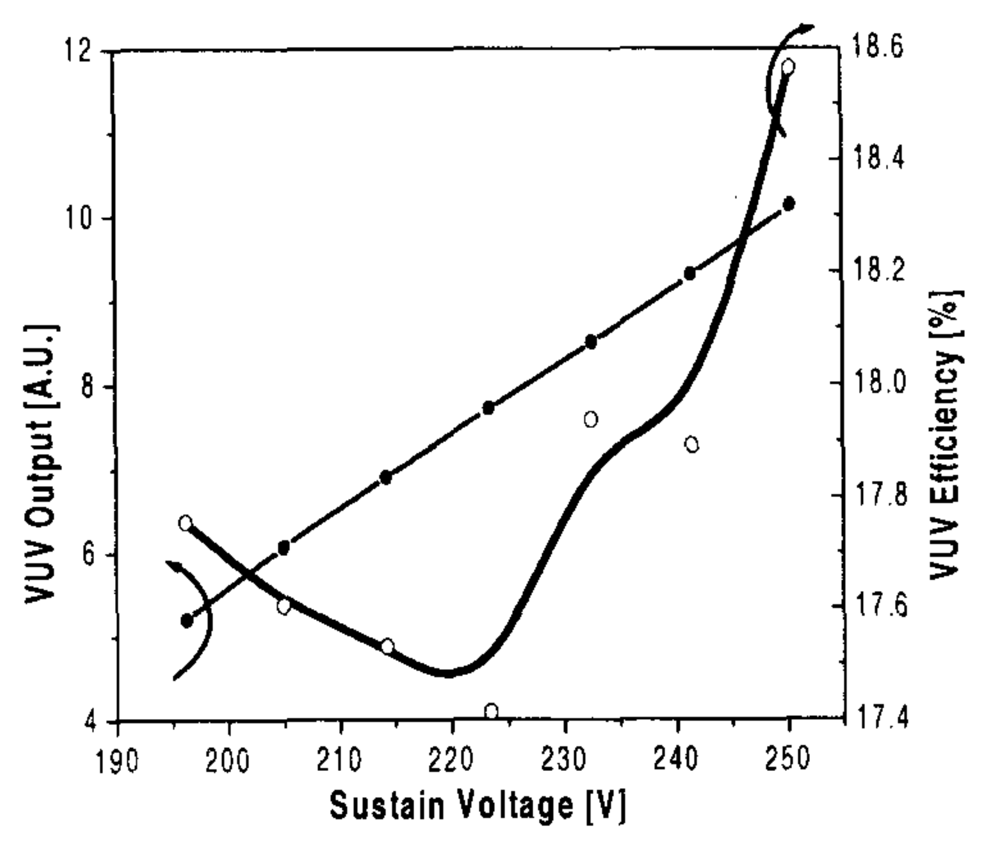
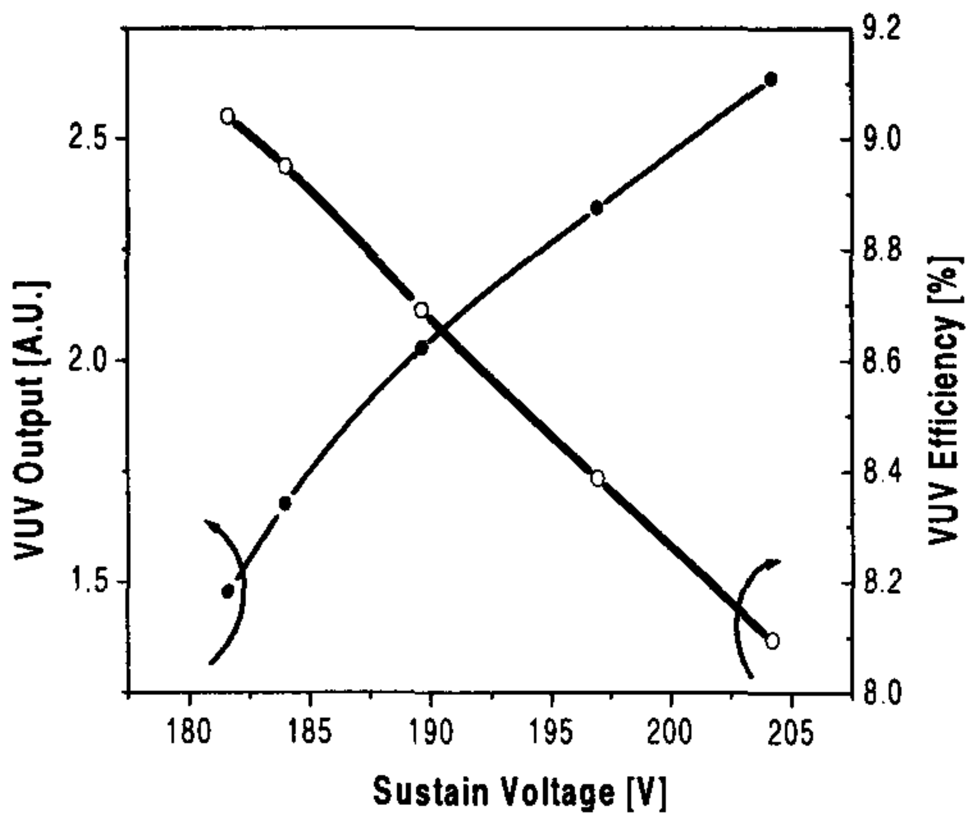


Fig. 1 Schematics of ac PDP cell

Fig. 2 shows the simulation results of VUV output and VUV generation efficiency change with sustain voltage with low Xe pressure (Ne-Xe5%, 300torr) and high Xe pressure (Ne-Xe10%, 400torr) condition. In the high Xe pressure condition of Fig. 2(a), the VUV generation efficiency increases as the sustain voltage increases when the sustain voltage is larger than 220 V.



(a)

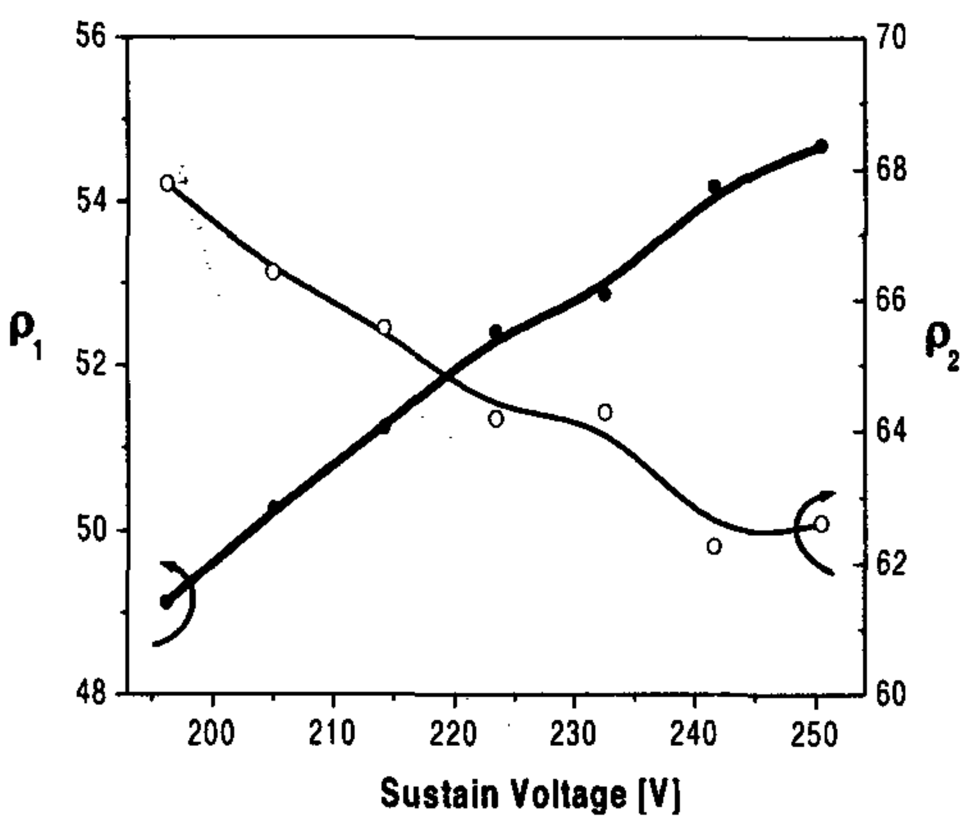


(b)

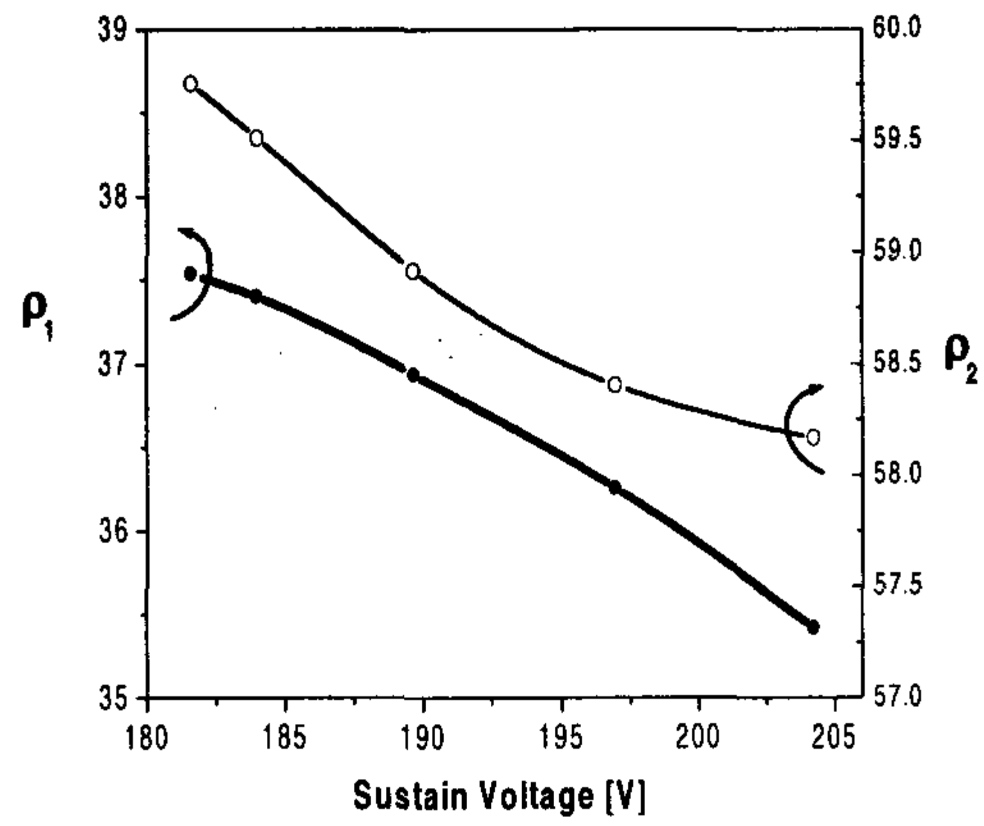
Fig. 2 VUV output and generation efficiency vs. sustain voltage (a)high pressure condition and (b)low pressure condition

The VUV generation efficiency is proportional to the generation efficiency of Xe excited species which is composed of two partial efficiencies, one (ρ_1) the electron heating efficiency, and the other (ρ_2) the excitation efficiency by electrons. The dependences of the two partial efficiencies on the sustain voltage are shown in Fig. 3 for the low and high Xe pressure gas conditions.

Due to the local and strong sheath formation under high Xe pressure condition, though the excitation efficiency by electrons decreases as the sustain voltage increases, the increase in electron heating efficiency with high sustain voltage compensates it and the overall efficiency increases [3].



(a)

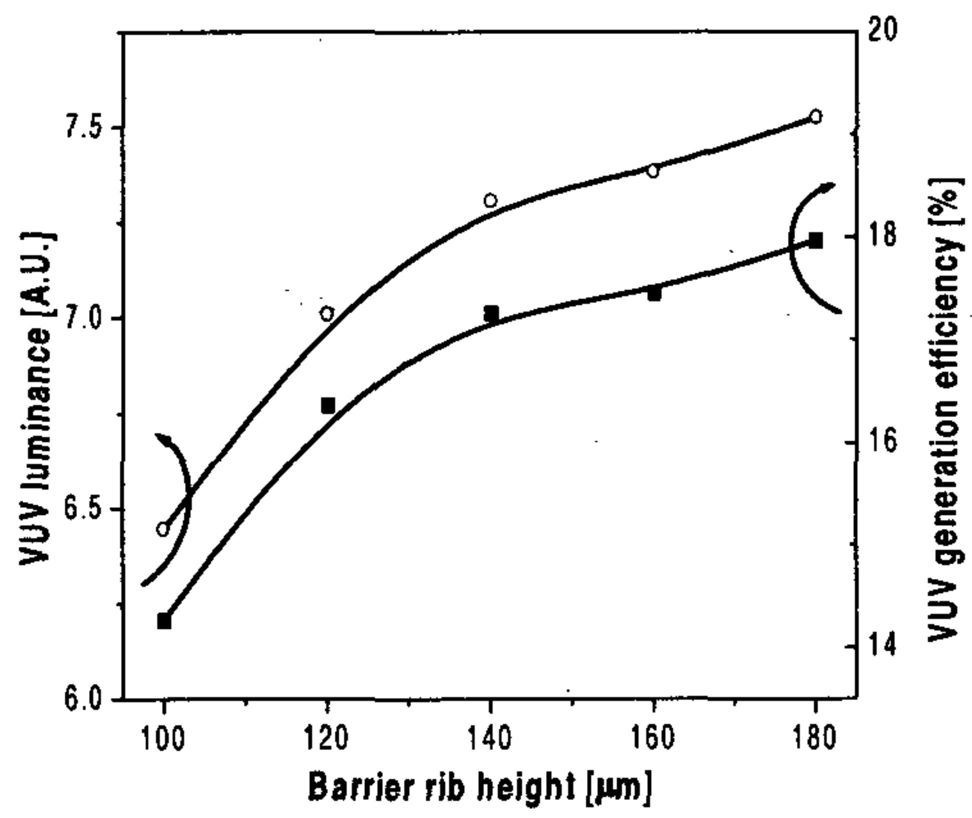


(b)

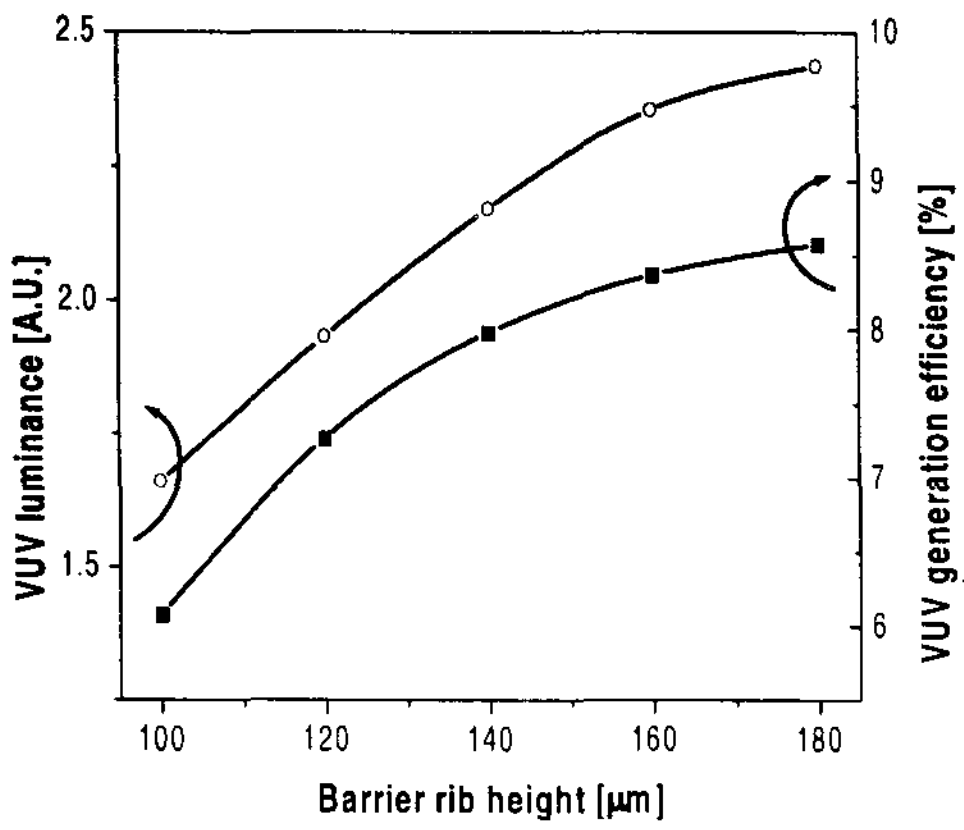
Fig. 3 Two partial efficiencies (a)high pressure and (b)low pressure condition

To compare the discharge characteristics under two gas conditions, we elaborated the geometrical parameter changes. Because the variation of barrier rib height directly affects the discharge volume, it has a large influence on the luminous efficiency.

Fig. 4 shows VUV luminance and efficiency as the barrier rib height varies from 100 to 180 μ m. Both of the VUV luminance and efficiency increase as the barrier rib height increases. However, the experimental results generally tells the existence of an optimal rib height for the maximum luminous efficiency for a given cell pitch and gas condition.



(a)



(b)

Fig. 4 VUV luminance and efficiency vs. barrier rib height (a)high pressure and (b)low pressure

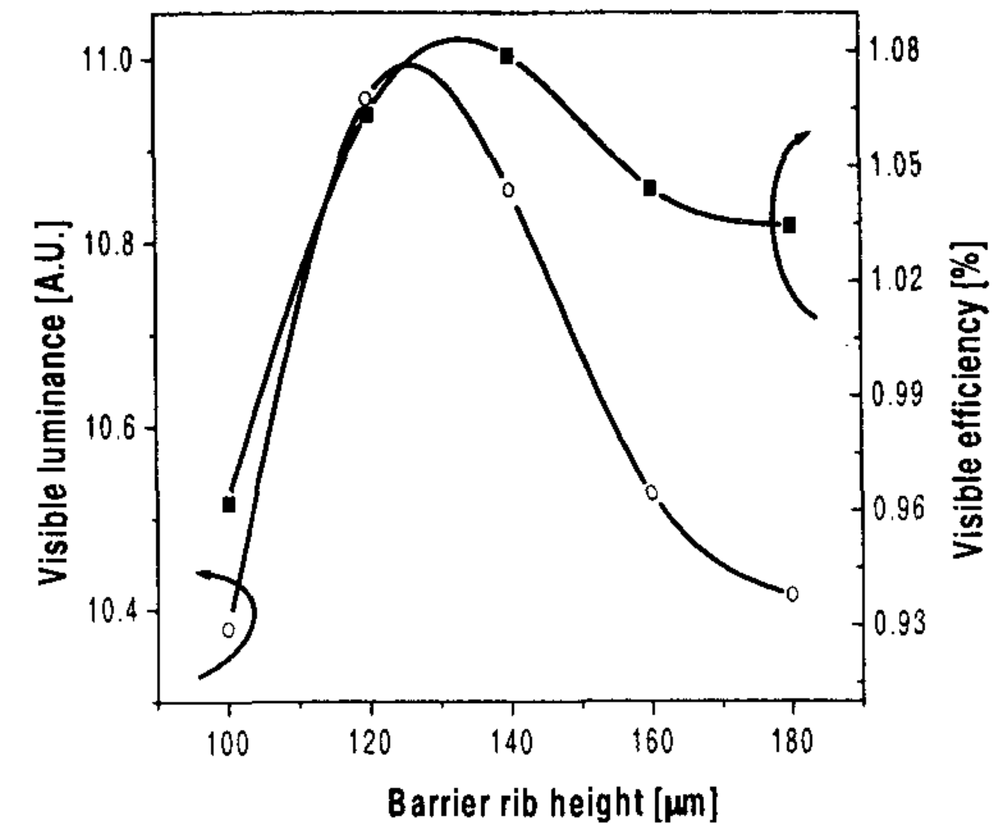
Therefore, we calculated the luminance and efficiency of visible light using ray-optics code [4]. After the spatial radiation distributions of VUV (147nm, 150nm, 173nm) were obtained from three-dimensional discharge code, they were fed into the ray-optics code to obtain the visible light emission through the front plate.

Fig. 5 shows the change of luminance and efficiency of the visible light as the barrier rib height changes. Under low Xe pressure gas condition, for the height of over 150 μm, the luminance saturates, the efficiency reaches its maximum value at the barrier rib height of the about 160 μm.

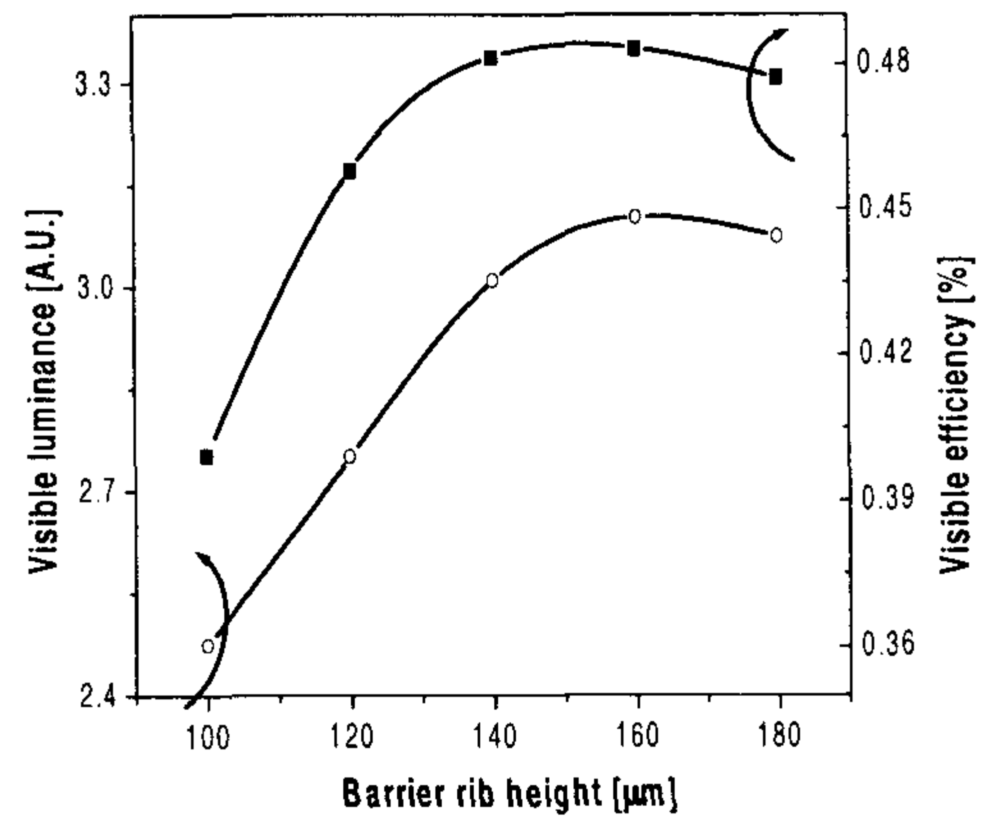
In Fig. 5(a), high Xe pressure condition shows some different results that the luminance has its maximum value in the vicinity of 120 μm in height, and the efficiency shows its maximum value at around 140 μm. In other words, visible luminance and its efficiency calculation by ray-optics code shows the existence of optimal rib height for given cell pitch and gas condition.

We think these results can be explained by the shadow effect. Higher rib height can provide bigger discharge plasma volume and thus increase VUV radiation, but the part of the visible light from the phosphor can be obstructed if the rib height is too excessive.

The smaller value of optimal height with high Xe pressure compared with that of low Xe pressure may be due to the constriction of discharge volume as the Xe partial pressure and total gas pressure increase.



(a)



(b)

Fig. 5 Visible light luminance and efficiency vs. barrier rib height (a)high pressure (b)low pressure

3. Conclusion

In order to study the dependence of luminous characteristic on barrier rib height variation, we used ray-optics code incorporated with three-dimensional discharge simulation code. In general, VUV photons are being generated more as the barrier rib height increases even for coplanar discharge, so the VUV luminance and generation efficiency also increases.

However, if the barrier rib height becomes too high, the visible photons through the front plate are obstructed due to the shadow effect.

Also, the lower optimal barrier rib height exists in high Xe pressure condition due to the formation of local, strong sheath in comparison with the low Xe partial pressure condition.

4. References

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