# Discharge Characteristics of Low Xe and High Xe Content in He-Ne-Xe Gas Mixture in PDP

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## Abstract

*The discharge characteristics of He-Ne-Xe gas mixture with the variation of Xe content are investigated through the numerical simulation. VUV efficacy in the gas condition of low Xe content increases due to more excitation and the case of high Xe content shows the improvement of VUV efficacy with the increase of He content but decreased VUV efficacy after tthe He mixing ratio of He and Ne is 0.5 due to frequent ionization.*

## 1. Introduction

The Plasma Display Panel (PDP) needs to improve the luminous efficacy in order to compete with other display devices, OLED, LCD, and so on. To achieve the improvement of the luminous efficacy, there are attempts to use various discharge gases. Above all, it is reported that the increase of the Xe content causes the luminous efficacy to increase [1-2]. Ternary gas mixture, He-Ne-Xe as well as Ne-Xe gas mixture is used to increase the luminous efficacy [3-5]. Thus the high Xe content and He-Ne-Xe gas mixture are adopted together so that the high luminous efficacy is expected. For low- and high-Xe content, the effect of adding He content to Ne-Xe gas mixture is investigated through the numerical simulation [6] in this paper.

## 2. Experimental

The cell structure of a 50" XGA AC PDP cell used in the numerical simulation has the cell pitch of 810 ㎛ and the barrier rib height of 140 ㎛, The dielectric layer in the front panel has 30 ㎛- thickness on the sustain electrodes and 20 ㎛-dielectric layer and 10 ㎛ - phosphor layer in rear panel cover the address electrode. The width of sustain electrode is 260 ㎛ and the sustain electrode gap is 60 ㎛. The sustain voltage used in this paper is the medium of the minimum and maximum sustain voltages. Two Xe content ratios [5%] and [20%] are used to investigate the effect of adding He gas to Ne-Xe mixture. The secondary electron emission coefficient of He, Ne, Xe ion used in this paper are referred to [7].

## 3. Results and discussion

As the ion mobility increases, the collisional sheath width increases and the electric field at the cathode sheath is weakened [1]. As He content is added in Ne-Xe gas mixture, Xe ion's mobility is increased, which can be expected from the by Blanc's law [5]. As Xe content increases, the incremental rate of Xe ion's mobility with the increment of mixing He content ratio becomes lower. The ion mobility in the discharge space can be regarded as Xe ion mobility because Xe ions are dominant.

Figure 1 shows VUV efficacy and VUV output in 20% Xe content as well as 5% Xe content. In 5% Xe content, VUV efficacy is increased with the increment of mixing He content ratio (He/(He+Ne)). In 20% Xe content, VUV efficacy is increased, but is decreased above The He mixing ratio of 0.7. VUV output in 5% Xe content ratio is increased as The He mixing ratio increases, but is decreased after The He mixing ratio of 0.5, while VUV output in 20% Xe content ratio is increased and is constant above The He mixing ratio of 0.5. Two partial efficacies which are proportional to VUV efficacy [2] are used to explain the above VUV efficacy behavior. As shown in Fig. 2, in low Xe content, both the electron heating efficacy $\rho_1$ and the Xe excitation efficacy $\rho_2$ are increased with the increment of He content and in high Xe content, as He content increases, $\rho_2$ decreases, but $\rho_1$ increases before He content ratio of 0.7 and decreases after that ratio.

In order to analyze the tendency of two partial efficacies, the potential profiles in the discharge space is required. Fig. 3(a) shows the potential profiles in

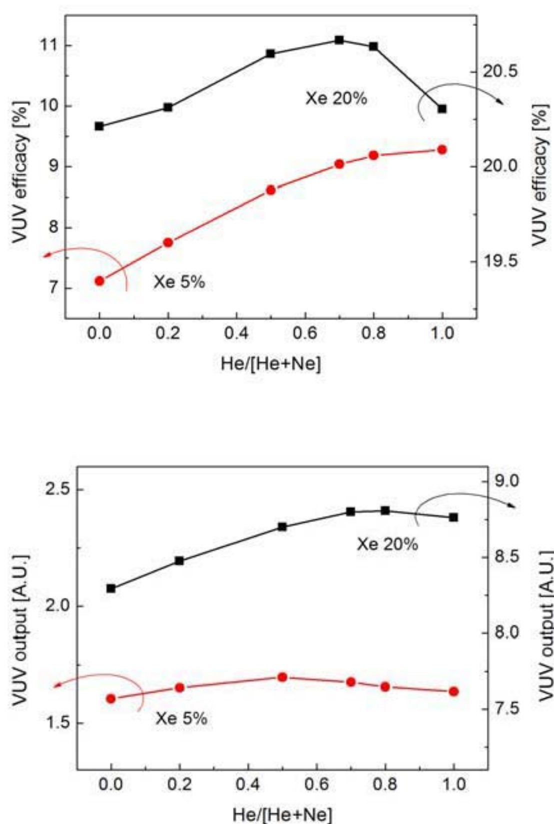



**Fig. 1 VUV efficacy and VUV output of low and high Xe content in He-Ne-Xe with the increase of mixing ratio of He and Ne.**

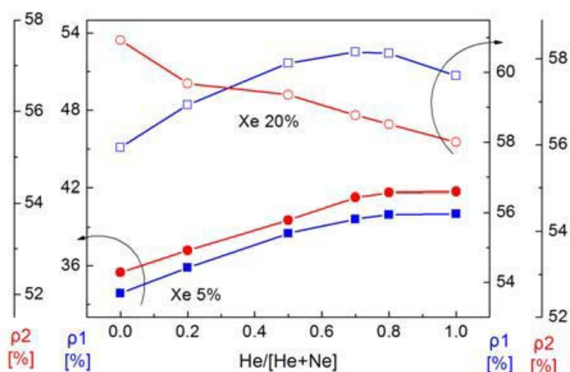
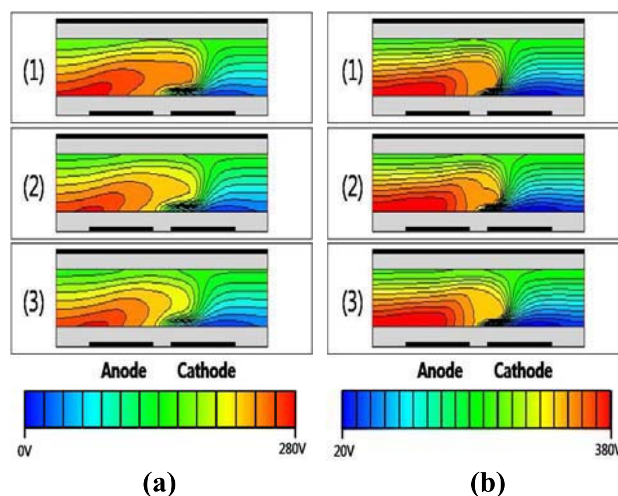



**Fig. 2 Electron heating efficacy $\rho_1$ and Xe-excited species generation by electron $\rho_2$ in low [5%] and high [20%] Xe content with the increase of The He mixing ratio. Blue line is $\rho_1$ and red line is $\rho_2$. Full symbol is 5% Xe content and empty symbol is 20% Xe content.**

5% Xe content ratio at the time of the current peak. As the He mixing ratio increases, the potential of the cathode sheath is reduced and the formation of the plasma is more concentrated at the electrode gap instead of above the cathode. The potential contours become sparse at the cathode and dense at the electrode gap, which means the place where electrons are supplied with the power moves from the cathode sheath to the electrode gap. As shown in Fig. 4, in 5% Xe content ratio, the power delivered to electrons is diminished by the decrease of the electric field of the cathode sheath so that the excitation of Xe occurs frequently instead of the ionization and the power delivered to ions is also diminished with the increment of The He mixing ratio. The incremental rate of the power delivered to Xe-excited species is larger than electrons so that ρ2 increases with the increment of The He mixing ratio, and ρ1 also increases because the decreased rate of the power of ions is larger than that of electrons.




**(a) (b)**

**Fig. 3 Potential profiles at the peak of the current in discharge space.**
**(a) low Xe content [5%] (b) high Xe content [20%]. The He mixing ratio = (1) 0, (2) 0.5, (3) 1**

In 20% Xe content ratio, the electric field at the cathode sheath is also weakened with the increase of The He mixing ratio, but the decreased amount of the electric field is much less than that of 5% Xe content ratio as shown in Fig.3(b). Although the electric field at the cathode sheath is decreased, the power delivered to electrons with the increment of the He mixing ratio is increased due to the increase of the effective γ.

As shown in Fig.5, the effective γ in 20% Xe content

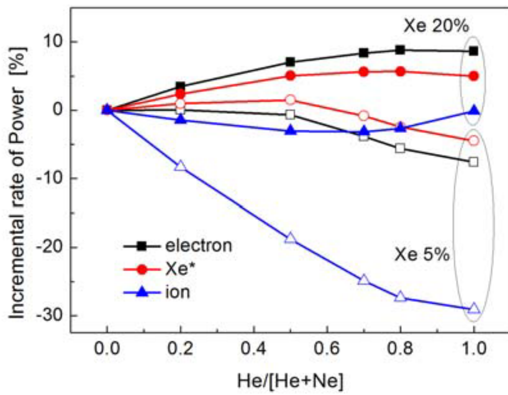



**Fig. 4 Incremental rate of power for electron, ion, excited-Xe compared to Ne-Xe gas mixture in low [5%] and high [20%] Xe content with the increase of The He mixing ratio. Full symbol is 5% Xe content and empty symbol is 20% Xe content.**

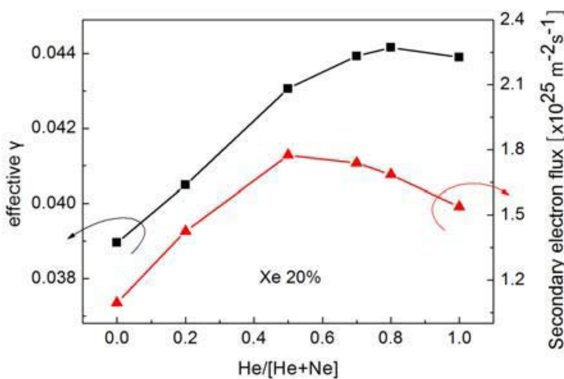



**Fig. 5 Effective γ and secondary electron flux in 20% Xe content.**

ratio which represents the secondary electron emission coefficient to consider the contribution of various ion species (the sum of emitted secondary electron flux by each ion species/the sum of each ion species flux) is increased with the increase of He content ratio. The increase of effective γ means that for the same amount of ion flux, more secondary electrons are emitted with the increase of The He mixing ratio, that is, electron heating efficacy is increased. The increase of the power delivered to electrons contributes to ionize inert gases so that ρ2 decreases with the increment of He content ratio. As shown in Fig. 4, the power delivered to electrons is consumed to ionize the gases because of the increase of the emitted secondary electron flux and the high ionized amount of Xe gas instead of Ne gas. The power delivered to ions decreases slightly, but increases after The He mixing ratio is more than Ne. Thus ρ1 increases and decreases above The He mixing ratio of 0.7.

## 4. Summary

In low Xe content, the addition of He gas is beneficial to increase VUV efficacy because the electron energy is consumed by excitation rather than ionization of Xe. However, in high Xe content, VUV efficacy increases only under He content ratio of 0.5 due to the high secondary electron emission coefficient of He ion and above He content ratio of 0.7, VUV efficacy decreases because of frequently occurred ionization of Xe. The analysis shown in this paper might help to suggest the gas conditions for increasing the luminous efficacy of AC PDP.

## 5. References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