Realization of High Luminous Efficacy PDP with Low Voltage Driving

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Abstract

The use of high Xe content gas is a powerful method for improving the discharge efficacy in PDP, but the accompanying high driving voltage prevents it from being used aggressively. In this paper, we tried to find a method to lower the driving voltage under high Xe gas condition with a new protecting layer. The effective secondary electron emission caused by Xe ions can result in the low voltage driving in panels with high Xe content gas and more importantly high luminous efficacy which were confirmed with the computer simulation and panel experiment.

1. Introduction

Recently, the improvement of luminous efficacy is one of the most important topics in PDP (Plasma Display Panel). Many studies in relation to the high efficacy have been reported by several research groups with high Xe content discharge gas [1]–[3]. The mechanism for the high luminous efficacy with high Xe content, high gas pressure was understood to be due to the improved electron heating efficiency [4].

But the high discharge efficacy with high Xe content gas generally accompanies the increase of driving voltage and discharge delay which prevent it from being used in the commercial PDPs aggressively.

The protecting layer on the dielectric layer helps to lower the discharge voltage through the secondary electron emission by ion mechanism [5]. MgO has been used widely as the dielectric protecting layer in PDP for a long time but seems to have limited application as the Xe content increases.

Recently, new materials which can show higher secondary electron emission than that of MgO have been investigated [7]. Especially, alkaline earth metal oxides such as BaO, CaO and SrO attract attention again, which had been studied in the initial PDP researches. In this paper, we looked into the effects of having non-zero secondary electron emission by Xe ions on the driving voltage and luminous efficacy in PDP with the computer simulation and panel experiment.

2. Secondary electron emission theory

The improvement of luminance efficacy can be achieved by using high Xe content discharge gas, but in the case of high Xe contents, the increase of the driving voltage is usually accompanied. High secondary electron emission related to γ (ion-induced secondary electron emission coefficient) process lowers the sustain voltage [6] and increases the luminous efficacy, because electrons from cathode gain powers through the high electric field of the cathode sheath [4]. Especially, the high secondary electron emission for Xe^+ is needed because Xe^+ are the most abundant ions in PDP discharge [8].

Mechanisms of the secondary electron emission are distinguished by how to escape the protective layer for electrons, which are the potential and the kinetic emission [5]. As shown in Fig. 1, the potential emission occurs through the Auger process involving two electrons and one ion, but does not occur for Xe^+ in MgO case due to the high bandgap energy plus electron affinity. The kinetic ejection occurs when ions impact the surface with sufficient kinetic energies which are generally much higher values than the most ions have in PDP. In the case of high Xe content, the increase of electron energy loss through collisions by Xe atoms and recombination loss with the increase of Xe content results in the increase of the driving voltage.

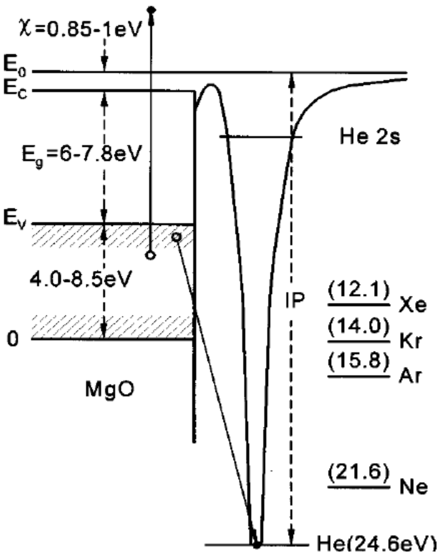


Fig. 1. Energy diagram in case of potential emission of a secondary electron through Auger emission for He ion [5]. Energy requirement of potential emission is IP≥2(χ+Eg), IP is the ionization potential, χ the electron affinity, Eg the band gap energy.

As shown in Fig. 2, the secondary electron emission coefficient for Xe^+ is much lower than those of other ions due to its relative low ionization potential.

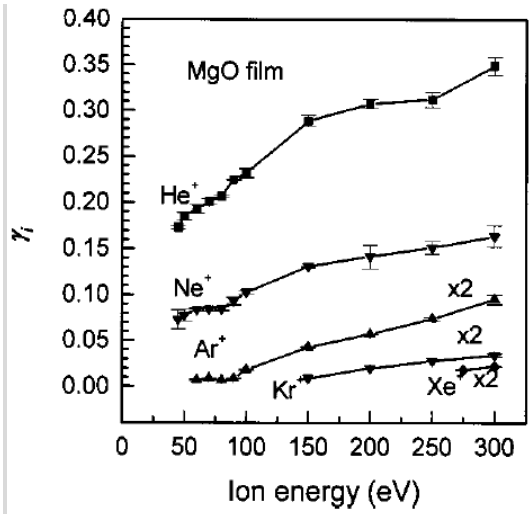
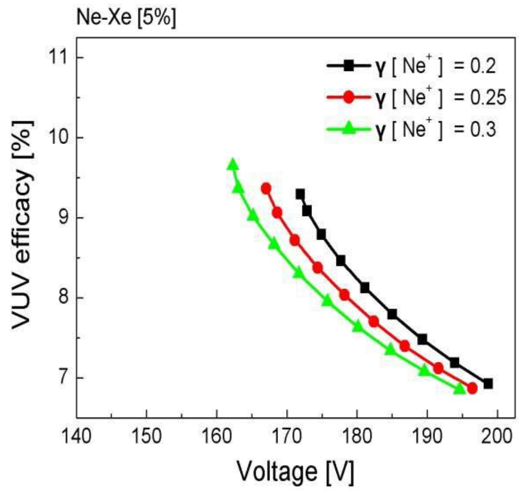


Fig. 2. Secondary electron emission coefficient for various ions at MgO surface [5]

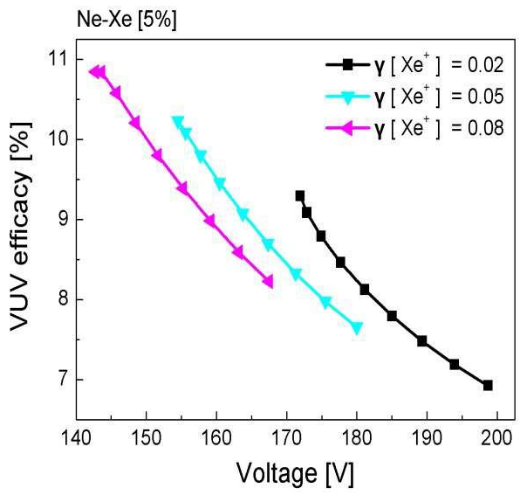
In order to increase the secondary electron emission for Xe^+, the potential emission as well as the kinetic ejection should be allowed for Xe^+ which would require the protection layer to have low band gap energy [7].

3. Results and discussion

Using the numerical simulation, we investigated the VUV efficacy dependence on the sustain voltage change with varying gamma value for Ne and Xe ions as shown in Fig. 3. The details of the computer code had been reported previously [9]. When the secondary electron emission coefficient, gamma, for Ne^+ varies from 0.2 to 0.3 at the fixed Xe^+'s gamma 0.02 in Fig. 3(a), the VUV efficacy lines shift slightly toward the low voltage. Consequently, the absolute values of efficacy and voltage do not change much with the variation of Ne^+ gamma value.



(a)



(b)

Fig. 3. VUV efficacy changes according to the gamma value changes for Ne and Xe ions

In Fig 3(b), when the gamma value of Xe^+ varies from 0.02 to 0.08 at the fixed Ne^+'s gamma 0.2, the sustain voltage decreases and the decremental rate of voltage are comparatively big. Compared to the result of Ne^+ gamma variation, even though the variation of Xe^+ gamma were smaller, the magnitudes of the VUV efficacy and sustain voltage variation were remarkable.

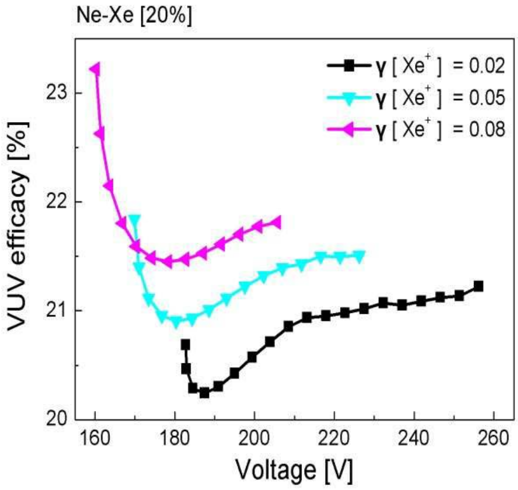


Fig. 4. VUV efficacy changes according to the gamma value changes for Xe ions under high Xe gas condition (Ne-Xe[20%])

Much more improvement of the discharge characteristics can be observed when the Xe content increase to 20% as shown in Fig. 4.

When the gamma value of Xe^+ becomes 0.08, the sustain voltage region in the gas condition of Ne-Xe [20%] corresponds with that of Ne-Xe [5%]. Simultaneously VUV efficacy particularly goes up with the decrease of sustain voltage in the low voltage region. As the Xe^+ gamma increases, that incremental slope of VUV efficacy rises rapidly. From those simulation results, it can be said that the high Xe content gas can be used in PDP to achieve the high luminous efficacy if the cathode material can have non-negligible secondary electron emission by Xe^+.

The high secondary electron emission by Xe ions is very effective in not only lowering the driving voltage but also increasing the discharge efficacy. Additionally, this effect is more distinct under higher Xe content. Consequently, when a new protecting layer made of some materials which can generate secondary electron emission by Xe ion is adopted in PDP, it could be possible to achieve the high luminous efficacy with very low voltage region.

Among the various alkaline earth metal oxides, SrO has a lower bandgap energy than that of MgO, so that it can be a powerful candidate material for the protecting layer having non-vanishing Xe^+ gamma [7]. In this study, two test panels having SrO and MgO as the cathode materials were compared in the view of the discharge voltage, luminance and luminous efficacy. The test panels have 50-inch XGA resolution and green phosphor and Ne-Xe [10%] gas were used. And continuous sustain pulses driven by 50 kHz were applied to the panels for the experiments.

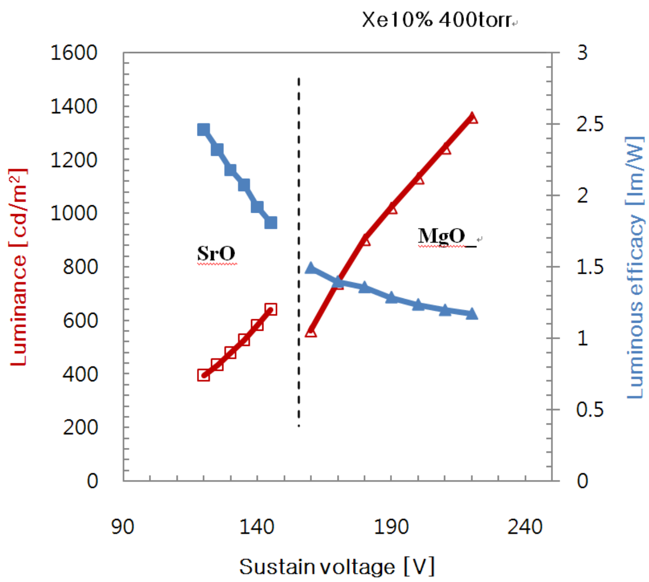


Fig. 5. Comparison of discharge characteristics between the test panels with SrO and MgO protecting layers

As expected, the result of SrO shows very low driving voltage region, so that the operation voltage region of SrO and MgO cases are separated completely. Compared to that of MgO, the case of SrO shows higher luminous efficacy values in the whole driving voltage region. In the low voltage area which was brought by SrO layer, the luminous efficacy increases rapidly as the sustain voltage goes down. The incremental slope in the efficacy line for SrO is almost the twice as large as that of MgO's efficacy line. These results correspond with the previous simulation data well.

4. Summary

For the achievement of the low voltage driving under high Xe gas condition, it can be a solution to increase Xe^+ gamma value by adopting a new protecting layer besides MgO which has limited Xe^+ gamma. In this study, we obtained the discharge characteristic variation according to the gamma values variation for Xe ions by computer simulation. Additionally, SrO material was applied as the protecting layer in the real PDP panel, and the discharge characteristics of test panels with SrO and MgO layers were compared. From the results of computer simulation and panel experiment, it was confirmed that the improvement of Xe^+ gamma characteristics can result in the low voltage driving and high luminous efficacy.

5. References

[1] G. Oversluizen, S. de Zwart, S. van Heuden, and T. Dekker, *IDW'00*, Dec. 2000, pp. 631–634.

[2] G. Oversluizen, S. de Zwart, T. Dekker, and M. F. Gillies, SID'02, May 2002, pp. 848–851.

[3] G. Oversluizen, M. Klein, S. de Zwart, S. van Heusden, and T. Dekker, *J. Appl. Phys.*, vol. 91, no. 4, pp. 2403–2408, 2002.

[4] W. J. Chung, B. J. Shin, T. J. Kim, H. S. Bae, J. H. Seo, and K.-W. Whang, IEEE Trans. Plasma Sci., vol. 31, no. 5, pp. 1038-1043, Oct. 2003

[5] K. S. Moon, J. Lee, and K.-W. Whang, J. Appl. Phys., vol. 86, pp.4049-4051, Oct. 1999

[6] Yuri P. Raizer, Gas discharge physics, Springer-Verlarg, 1991

[7] Y. Motoyama, Y. Murakami, M. Seki, T. Kurauchi, and N.Kikuchi, IEEE Trans. Electron devices., vol. 54, no. 6, pp. 1308-1314, Jun. 2007

[8] H.S Jeong, B.J Shin, and K.-W Whang,"Two-dimensional multifluid Modeling of the He-Xe Discharge in an AC Plasma Display Panel," IEEE transactions on Plasma sci., Vol.27, no. 1, pp.171~181, Feb. 1999

[9] J.H.Seo, W.J.Chung, C.K.Yoon, J.K.Kim, and K.-W.Whang, "Two-dimensional modeling of a surface type alternating current plasma display panel cell: Discharge dynamics and address voltage effects," IEEE Trans. Plasma Sci., vol. 29, no. 5, pp. 824–831, Oct. 2001