Analysis of the luminous efficacy improvement in Full HD ac Plasma Display Panel

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Abstract

We analyzed the effect of cell resolution on the luminous efficacy through three-dimensional numerical simulation to understand the inherent discharge mechanism change in the plasma display panel. As the resolution increases from VGA to Full HD, the luminous efficacy decreases. With higher Xe content, VUV generation efficacy of Full HD becomes much lower than those of VGA or XGA cells, due to the increased plasma loss and lower electron heating. However a long electrode gap 140μm in Full HD cell with Ne-Xe [20%] results in the high luminous efficacy comparable to that of the XGA cell with 60μm gap. When comparing the effects of Xe content variation on the luminous efficacy of two different subpixel types, i. e., SDE (Segmented electrode in Delta color arrayed, Enclosed subpixel) [1] and conventional stripe barrier type in the XGA and Full HD cells, the luminous efficacy of SDE structure shows higher improvement in Full HD resolution compared with that of conventional type XGA cell, whose cause is identified as the reduced plasma loss.

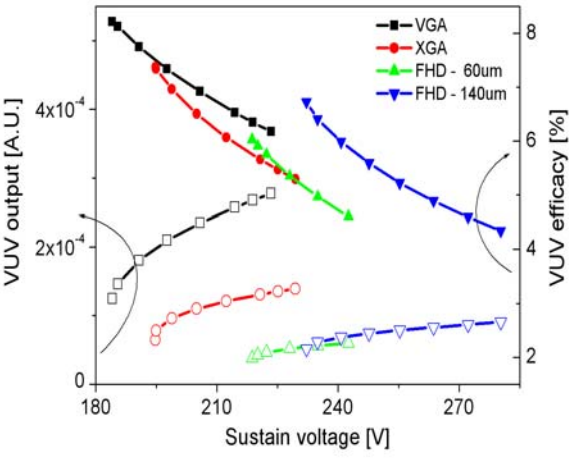
1. Introduction

Recently, PDP (Plasma Display Panel) with the gas condition of high Xe content (>10%) and with the cell geometry of long sustain electrode gap have attracted considerable attention, because they show the high luminous efficacy [2-5]. The demand for the high resolution display increases as the high definition digital TV broadcasting begins. But the decrease of the pixel size in PDP results in the undesirable decrease of luminous efficacy and increase of driving voltage [6]. In this paper, the computer simulation which is an useful tool to analyze the discharge mechanism is applied to the investigation of the luminous efficacy improvement characteristics in Full HD PDP cell.

2. Results and discussion

We investigated the effect of cell resolution change on the luminous efficacy. VGA cell specification is with 42 inch PDP, and XGA and Full HD are with 50 inch PDP, where the sustain electrode gap is fixed in 60μm. But in the case of Full HD, the electrode gap varies from 60 to 140μm. The Xe content increases from 5% to 20%.

Fig. 1 shows VUV output and VUV generation efficacy dependent on the sustain voltage with various resolutions and Xe contents. When comparing the efficacies of three cells, VGA, XGA, and Full HD, with the same electrode gap of 60μm, the overall low luminous efficacy is obtained in the high resolution cell. Because the small discharge volume and electrode area result in reduced plasma generation, the VUV output and efficacy decrease.



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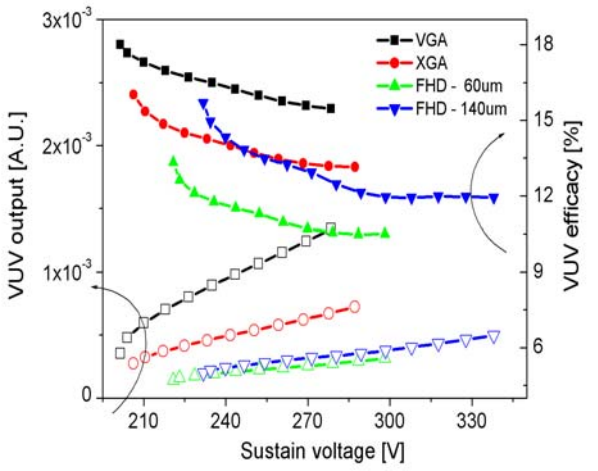


(b)

Fig. 1. VUV output and VUV generation efficacy dependence on the sustain voltage with varying resolution (a) Ne-Xe [5%] (b) Ne-Xe [20%]

In the high Xe content of Fig. 1 (b), the efficacy of Full HD becomes much lower than those of VGA and XGA cells. Fig. 2 shows the incremental ratio of the wasted energy carried away by the lost plasma to the enclosing walls. Because of the nearness between the center of electrode where the plasma density is highest and the side surfaces of vertical barrier ribs in the Full HD cell, the plasma loss is bigger and the electron heating efficacy is lower in the cell with high Xe content gas, which results in the low luminous efficacy.

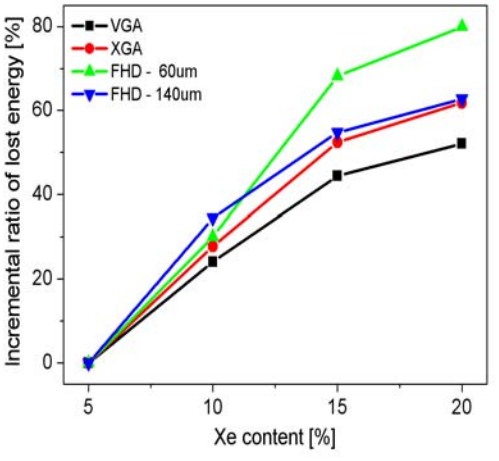
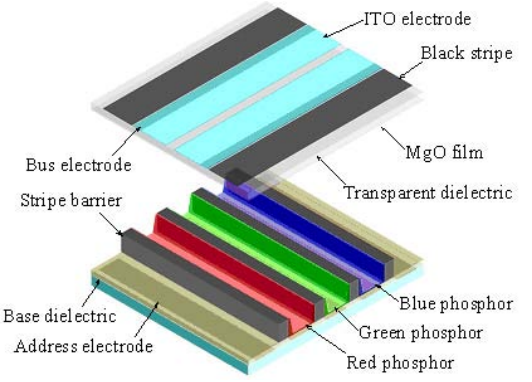


Fig. 2 Incremental ratio of lost particle energy dependence on Xe content with varying resolution

In Fig. 1 (b), a long electrode gap 140μm in Full HD cell with high Xe content results in the improved luminous efficacy comparable to that of the XGA, which is due to higher electron heating by strong cathode sheath field [5].

To improve the luminous efficacy in the Full HD PDP, the effects of Xe content variation in two different subpixel types, i. e., SDE (Segmented electrode in Delta color arrayed, Eenclosed subpixel) and conventional stripe barrier type in the XGA and Full HD resolutions were investigated, whose schematics of two different subpixel arrangement are shown in Fig. 3.



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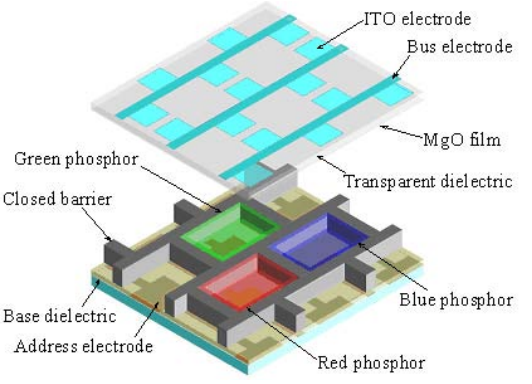


(b)

Fig. 3. Schematics of subpixel arrangement (a) Conventional structure with stripe barrier ribs (b) SDE structure

In Fig. 4, using the ray-optics code in conjunction with the three-dimensional plasma simulation, the increment of luminous efficacy improvement in SDE type is clearly shown in the Full HD resolution with bigger efficacy incremental ratio of 57% between the two subpixel types, which results in the high luminous efficacy than that of conventional type XGA cell, 36%.

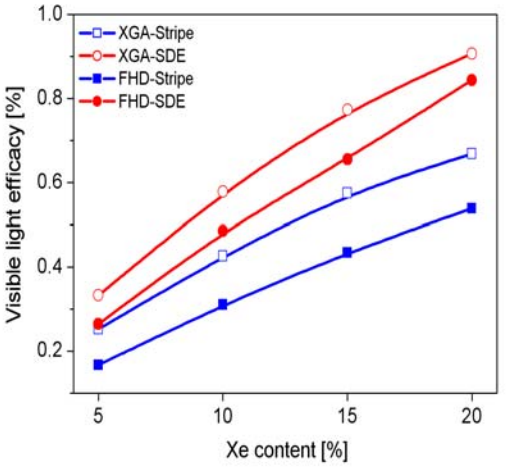


Fig. 4. Visible light efficacy dependence on Xe content with varying resolution and subpixel type

Fig. 5 shows the incremental ratio of the lost particle energy to the total enclosing walls which consist of vertical, horizontal barrier ribs, and top and bottom surfaces, with Xe content variation. Both of XGA and Full HD resolutions, SDE type shows smaller increment of lost plasma energy with increasing Xe content, which results in higher increment of luminous efficacy. In Xe content of 20%, the SDE type in Full HD shows bigger plasma loss decremental ratio of 17% between two subpixel types in comparison with that of XGA, 14%. And thus the SDE structure in Full HD resolution shows bigger luminous efficacy improvement as shown in Fig. 4.

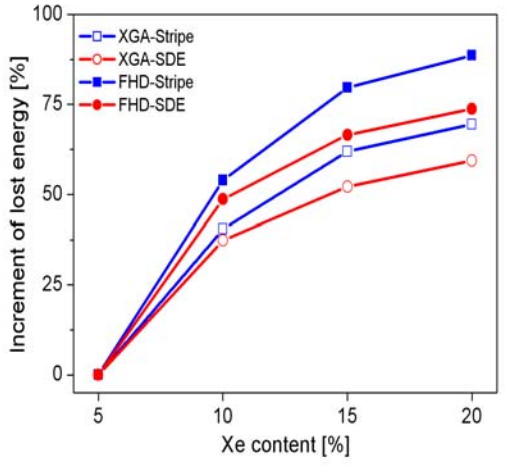
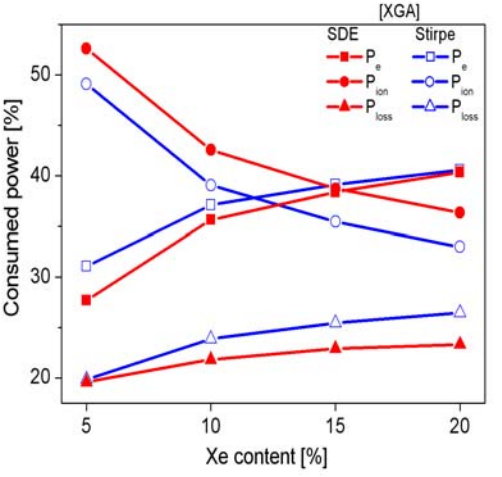


Fig. 5. Incremental ratio of lost particle energy dependence on Xe content with varying resolution and subpixel type

Fig. 6 shows the percentage of consumed power for electron, ion heating and lost particles for two structures with Xe content variation. The process of ion heating in a cathode sheath is the main energy loss route in a discharge. The loss percentage to the total electrical energy input in SDE type of XGA shows about 4% smaller value than that of convention structure. In Full HD cell of Fig. 6 (b), SDE shows bigger decrease of 7%. As a result, the SDE type in Full HD resolution shows the increased improvement in the VUV and visible light luminous efficiency due to smaller increment of plasma loss to the enclosing surfaces as the Xe content increases.



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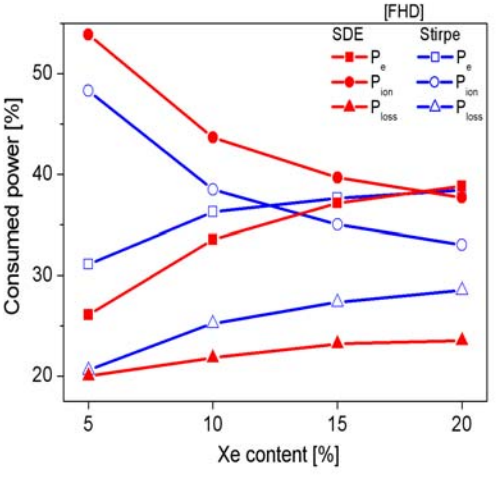

(b)

Fig. 6. Consumed power in Stripe and SDE structures as a function of the Xe content (a) XGA (b) Full HD

3. Summary

Until now, the detailed analysis of the discharge mechanism of the luminous efficacy change with cell resolution and Xe content variation has not been reported. The numerical analysis shown in this paper might suggest directions to go in the design of cell structures for the Full HD PDP to realize the high luminous efficacy.

The increase of Xe content to improve the luminous efficacy resulted in a much bigger decremental ratio of luminous efficacy and higher driving voltage as the cell resolution increases. The increase of the sustain electrode gap in the co-planar type discharge cell is another effective way of realizing high luminous efficacy. The SDE type in Full HD shows the improvement of luminous efficiency due to the reduced plasma loss with high Xe content.

4. References

1. Hyun Sook Bae, Joong Kyun Kim, Tae Jun Kim, Dong Cheol Jeong, Ki-Woong Whang, IEEE *Trans. Plasma Sci.*, 34[3], pp.954-960 (2006)
2. G. Oversluizen, S de Zwart, S. van Heuden, and T. Dekker, in *Proc. 7th Int. Display Workshop*, pp.631-634 (2000)
3. Woo Joon Chung, Bhum Jae Shin, Tae Jun Kim, Hyun Sook Bae, Jeong Hyun Seo, and Ki-Woong Whang, IEEE *Trans. Plasma Sci.*, 31[5], pp.1038-1043 (2003)
4. Kyung Cheol Choi, Nam Hoon Shin, Kyo Sung Lee, Bhum Jae Shin, and Seong-Eui Lee, *IEEE Trans. Plasma Sci.*, 34[2], pp.385-389 (2006.)
5. Hyun Sook Bae and Ki-Woong Whang, IEEE *Trans. Plasma Sci.*, 35[2], pp.467-472 (2007)
6. G. Oversluizen and T. Dekker, SID’06, pp.1110-1113 (2006)