High Xe-content PDP

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Abstract

High Xe-content PDP characteristics are discussed. A high efficacy, up to 5 lm/W for a 50% Xe in Ne gas mixture, is realized in 4-inch color PDP test panel designs with low cost stripe-type barrier rib structures, that are powder blasted in soda lime glass. Furthermore, for a high Xe-content a high luminance can be obtained with a relatively small electrode area. Therefore the inter cell gap and the driving margin can be increased in a stripe-type barrier rib structure. Finally, for a high Xe-content the panel lifetime increases, due to increasing luminance and firing voltage stability.

Clearly, these findings may direct the design development for next generation PDPs towards a high Xe-content

1. Introduction

The power consumption, the lifetime and the panel cost are the major issues for the next PDP generation [1]. The present-day PDP white light efficacy, typically about 1.5 lm/W, is rather low in comparison with a CRT (5 lm/W). Especially for large panel sizes low power consumption, i.e. a high panel efficacy is important. A large increase of both the efficacy and the luminance can be obtained in high Xe-content PDP [2,3]. However, this is accompanied by an increase of the firing voltage that may affect the driving margin and the lifetime.

In this paper the panel efficacy, luminance, driving margin and lifetime of high Xe-content PDP test panels with a low cost stripe-type barrier structure are evaluated.

2. Experimental details

The design of the default 4-inch test panels with 256 columns and 48 rows, which resembles the one used in mainstream commercial products, has been described previously [4]. Several types of test panels are used. The Xe-content in Xe,Ne-mixtures is varied from 3.5% to 30% in default color panels. The 50% Xe panel data discussed here refer to a slightly modified design, tuned for large margin and low operational voltages. In 20% Xe test panels, designed for a cross talk investigation, the inter cell gap is varied from 300 μm to 500 μm. The panel luminance and efficacy is measured at 148 kHz in ADS-addressed condition [5]. The lifetime is investigated by accelerated aging for continuous sustain at 100 kHz. In these tests a less efficient design without a TiO_2-layer underneath the phosphor is applied. Further, in the aging set-up, the common electrode is grounded and the scan electrode is switched. This asymmetric driving results in an asymmetric load on the electrodes. Presumably, the degradation increases more than linearly for increasing load, which implies that for realistic symmetric drive conditions the depreciation would be less. For these reasons the absolute depreciation is only indicative for real panel behavior. However, in first order a comparison of the depreciation for several Xe-concentrations and drive voltages remains valid. An acceleration factor of 50 is taken assuming an effective sustain time of 20% and 10% video load in TV images.

3. Results and discussion

3.1 High efficacy high Xe PDP

The increase of the efficacy for increasing Xe-concentration, or gas pressure, is well known [6], and recently published data show that the Xe-content is the dominant factor in the discharge efficiency, where about a factor 3 in efficiency can be gained [2,3].

Figure 1 shows the sustain voltage dependence of the efficacy for color test panels with several Xe-contents. Indeed, a large increase of the efficacy, up to 5 lm/W for 50% Xe, is found. The white luminance is about 5000 cd/m^2 for a sustain voltage of 260V.

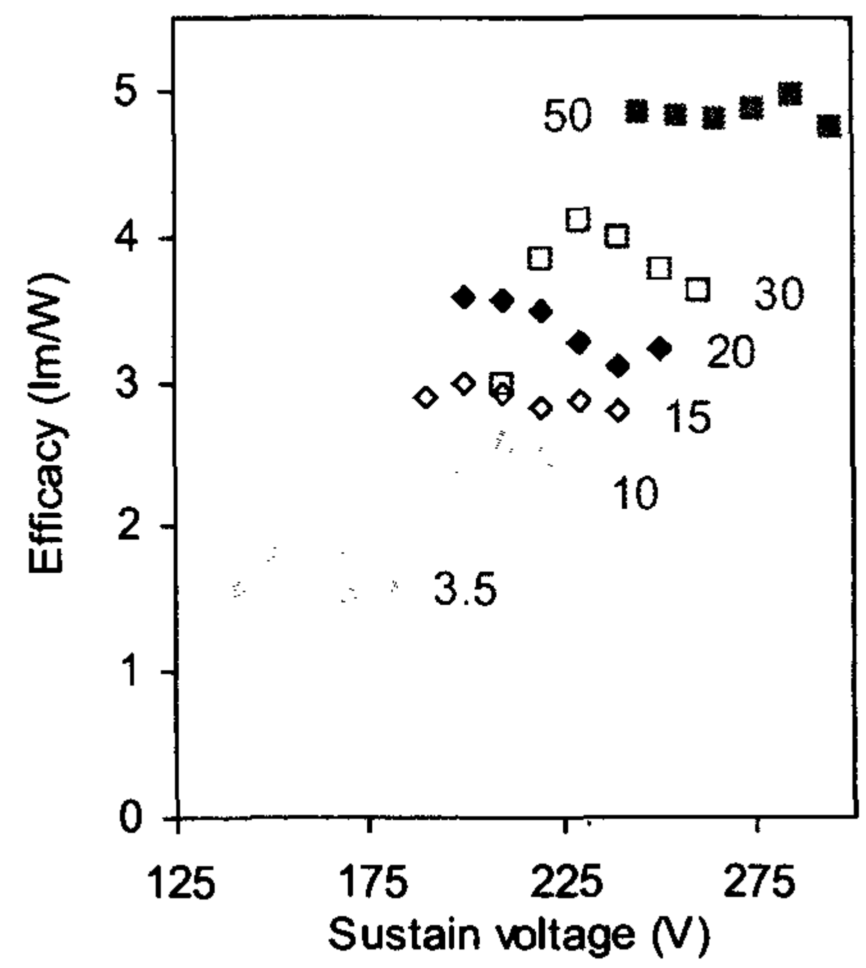

FIG.1 Efficacy as a function of sustain voltage for several Xe concentrations in color test panels, measured in addressed condition; the numbers indicate the Xe-content in a Ne,Xe-mixture.

The sustain voltage increase for increasing Xe-content is due to a low coefficient for ion induced secondary electron emission [6,7], but a detailed understanding of the dependence of the efficacy on the sustain voltage is not yet available.
Figure 2 shows the concurrent increase of efficacy and luminance with increasing Xe-content; see figure 4 below for the selected sustain voltages.

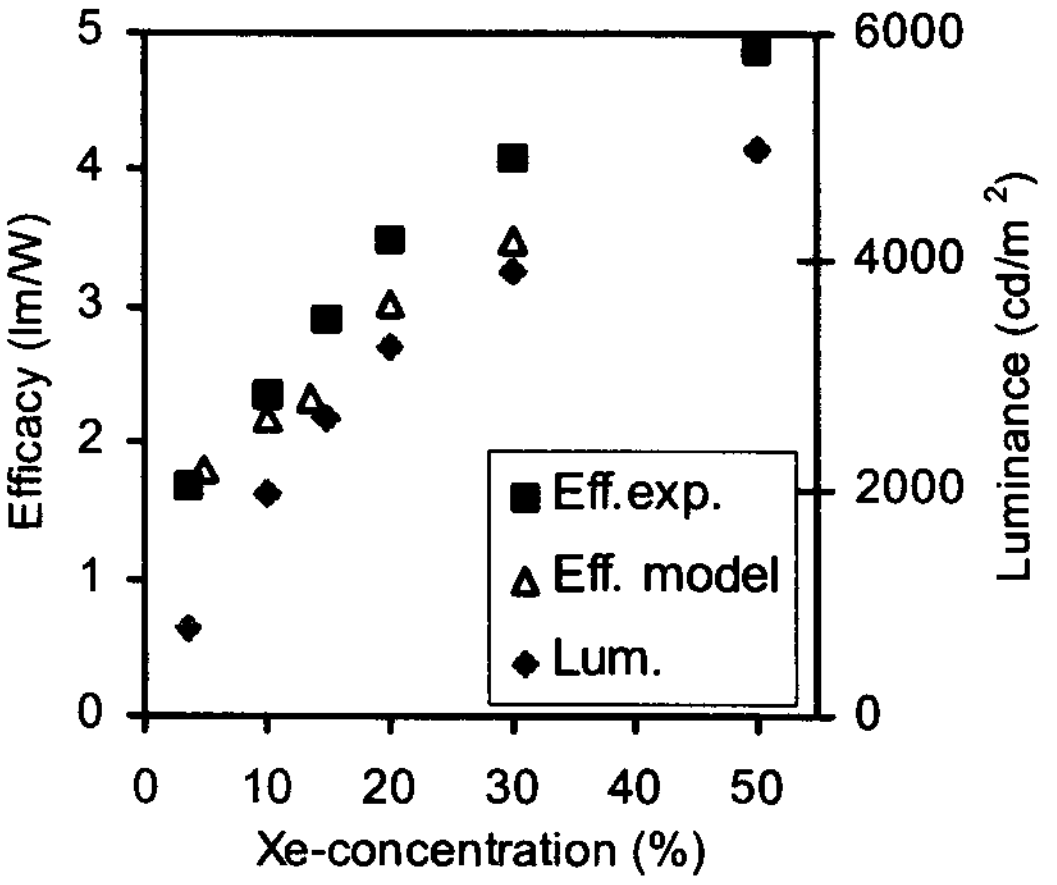

FIG.2 Dependence of the efficacy and the luminance on the Xe-content.

The luminance increase is much larger than the efficacy increase because the power input also increases for the higher driving voltages at high Xe-content. Also plotted is the efficacy increase calculated with a 2D numerical fluid model, described previously [8], and normalized with respect to the lowest value. The discharge efficiency is the product of the electron heating efficiency and the conversion efficiency of electronic energy into VUV-photons. For convenience the latter, which includes ionization and Ne losses, is named Xe-excitation efficiency. The experimental trend is well reproduced by the model even though the drive conditions, set at 270 V and 50 kHz in all cases, are slightly different from the experimental conditions. Figure 3 shows the dependence of the calculated overall discharge efficiency, the Xe-excitation efficiency, and the e-heating efficiency on the Xe-content. Roughly, both underlying factors contribute about equally to the efficiency increase, although the e-heating efficiency increase appears mainly above a Xe-content of 15%. The increase of the Xe-excitation efficiency is due to a decrease of the electron temperature, and the increase of the e-heating efficiency is attributed to lower ion heating losses in the cathode sheath [8].

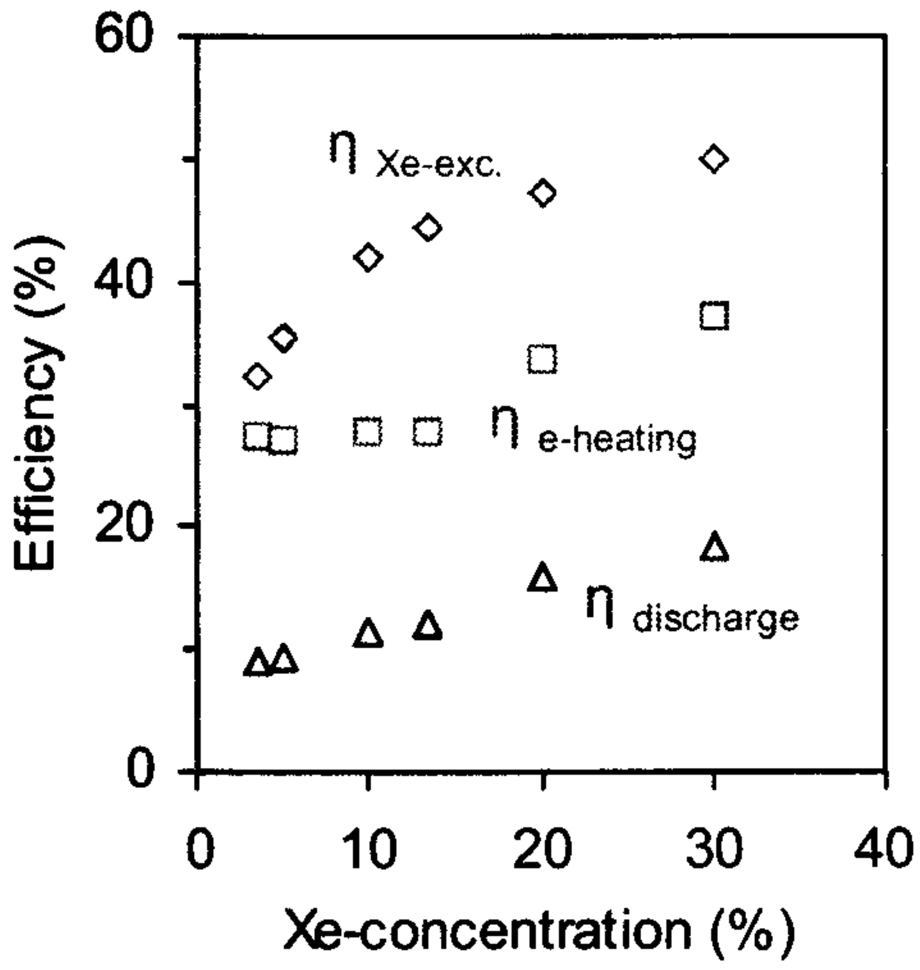

FIG.3 Calculated dependency of the discharge efficiency, the e-heating efficiency, and the Xe-excitation efficiency on the Xe-content.

3.2 Influence of the Xe-content on driving voltage and margin.

The firing voltage increases for increasing Xe-content [2,6,7]. Therefore the increase of the sustain voltages in addressed condition shown in figure 4 is anticipated. Fortunately, the margin also increases. The margin for 50% Xe is larger than 50V, but a value could not be determined because of driver limitations. These findings are in line with data reported for continuous sustain [5,9].

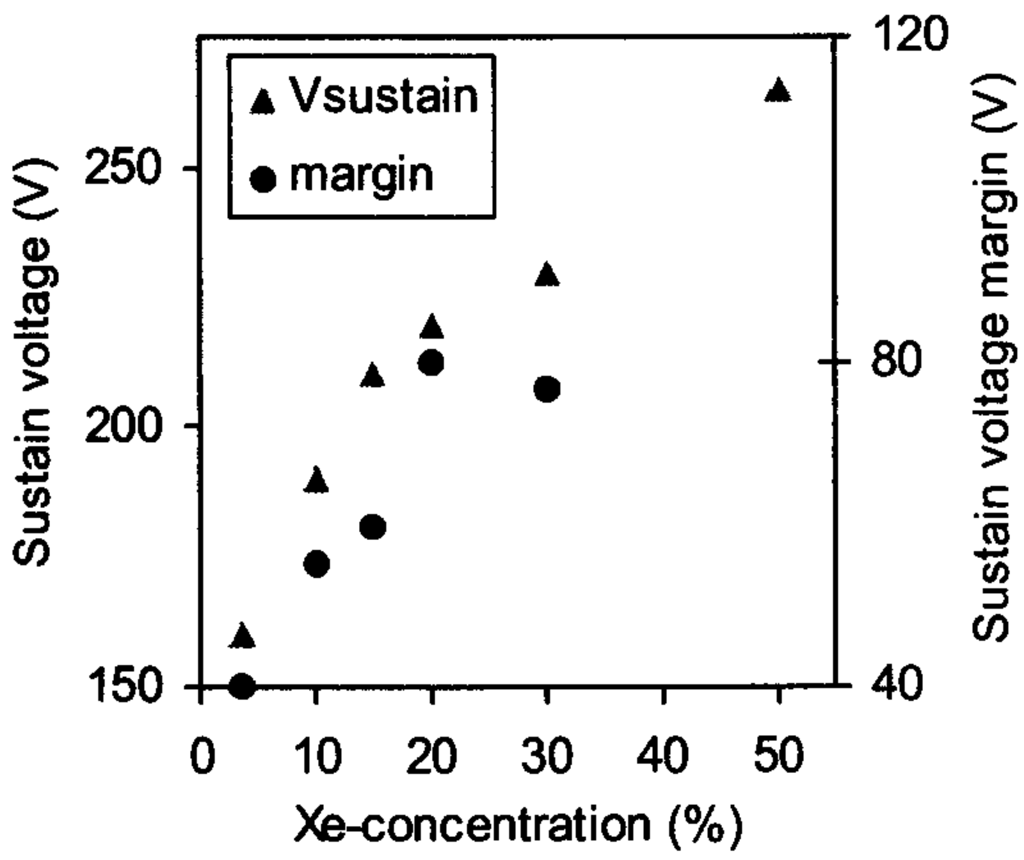

FIG.4 Dependence of the sustain voltage and margin on the Xe-content.

The increasing sustain voltage causes increasing cross talk and decreases the data pulse margin [5]. Fortunately, the high brightness of high Xe-content PDP allows a decrease of the electrode area, and an increase of the inter cell gap. Therefore the data pulse margin is assessed in 1.08 mm pitch designs, where the electrode area and inter cell gap vary complementary. Figure 5 shows the dependence of the data voltage margin on the sustain voltage for several inter cell gap values. The margin is seen to decrease for increasing sustain voltage. However, an increase of the inter cell gap causes a strong decrease of the cross talk and for an inter cell spacing of 500 μm a sufficient margin is obtained also at high sustain voltage.

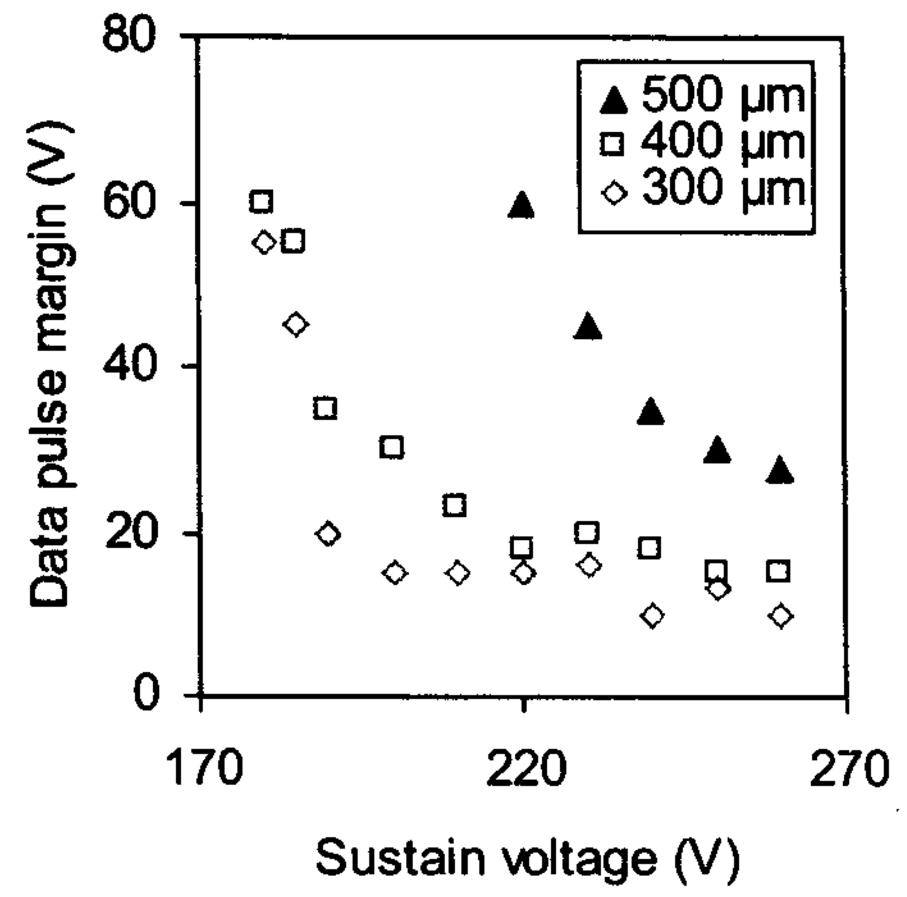

FIG.5 Dependence of the data pulse margin on the sustain voltage for several inter cell gap values; the Xe-content is 20%.

In figure 6 the address windows of a default low Xe-content panel and a 50% Xe panel are compared. For the 50% Xe panel the inter cell gap was set at 500 μm.

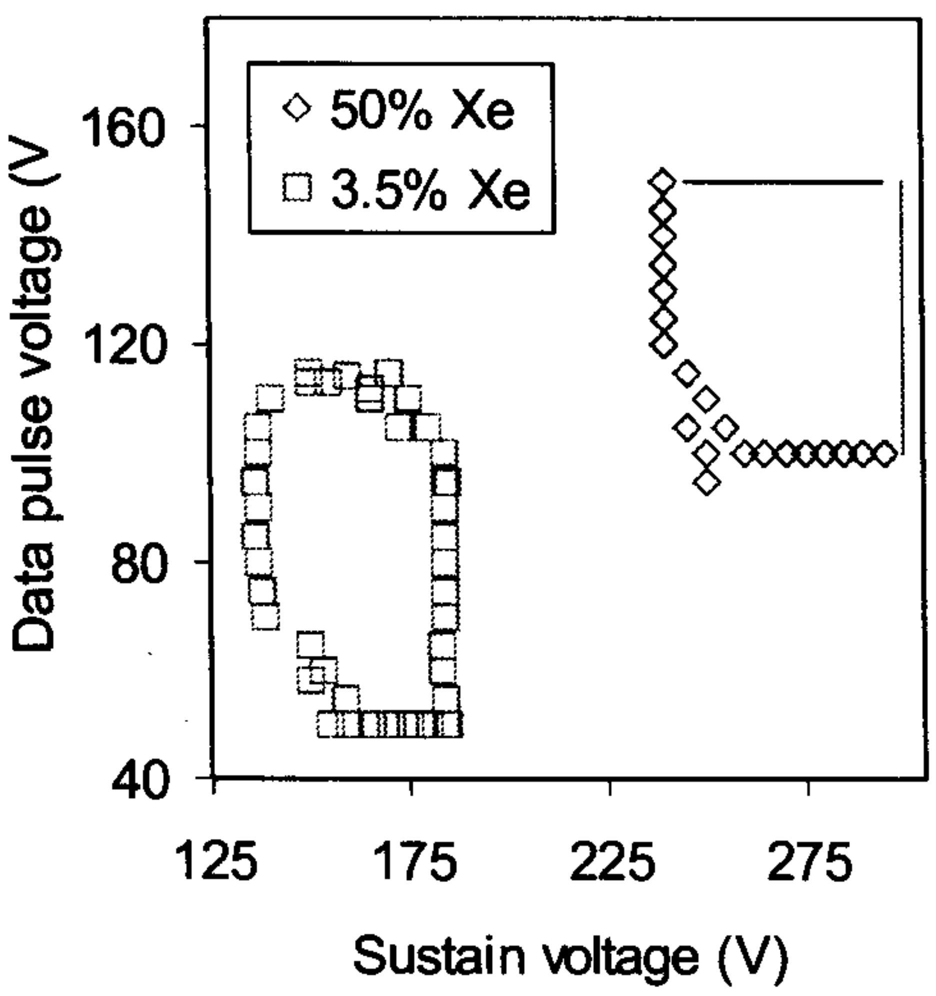

FIG.6 Comparison of address window for a default and a high Xe-content PDP.

At high Xe-content the drive voltages increase significantly because of the increased firing voltage, and the high voltage limits of the window could not be measured because of the driver limitation indicated by the drawn lines (fig. 6). Yet, it can be concluded that a large margin is also obtained for the high Xe-content case. It is further noted, that the drive voltage increase can be counteracted by adapting the cell design, the sustain frequency and the addressing method [2,11,12].

3.3 Influence of the Xe-content on lifetime

The sustain voltage and the gas composition are important factors for the ion bombardment intensity, and the MgO sputter rate is a main factor for panel depreciation [1]. The luminance decreases and the driving voltages increase with operation time. Several factors contribute: 1) sputter damage of the MgO decreases the value of the coefficient for ion induced secondary electron emission, causing a decrease of the discharge efficiency and an increase of the firing voltage 2) re-deposition of the sputtered MgO, which absorbs VUV, on the phosphors decreases their conversion efficiency 3) blackening of the front plate decreasing the light-out efficiency. On the one hand the increased driving voltages for high Xe-content increase the acceleration field and therefore sputter ion energy, but on the other hand the heavier Xe gas atoms moderate more effectively decreasing the sputter ion energy. Modeling studies agree that the high-energy tail of the Xe ion flux distribution is less populated at higher Xe-content [13]. However, the calculation is very sensitive for the used scattering cross section values and the net result is hard to predict.

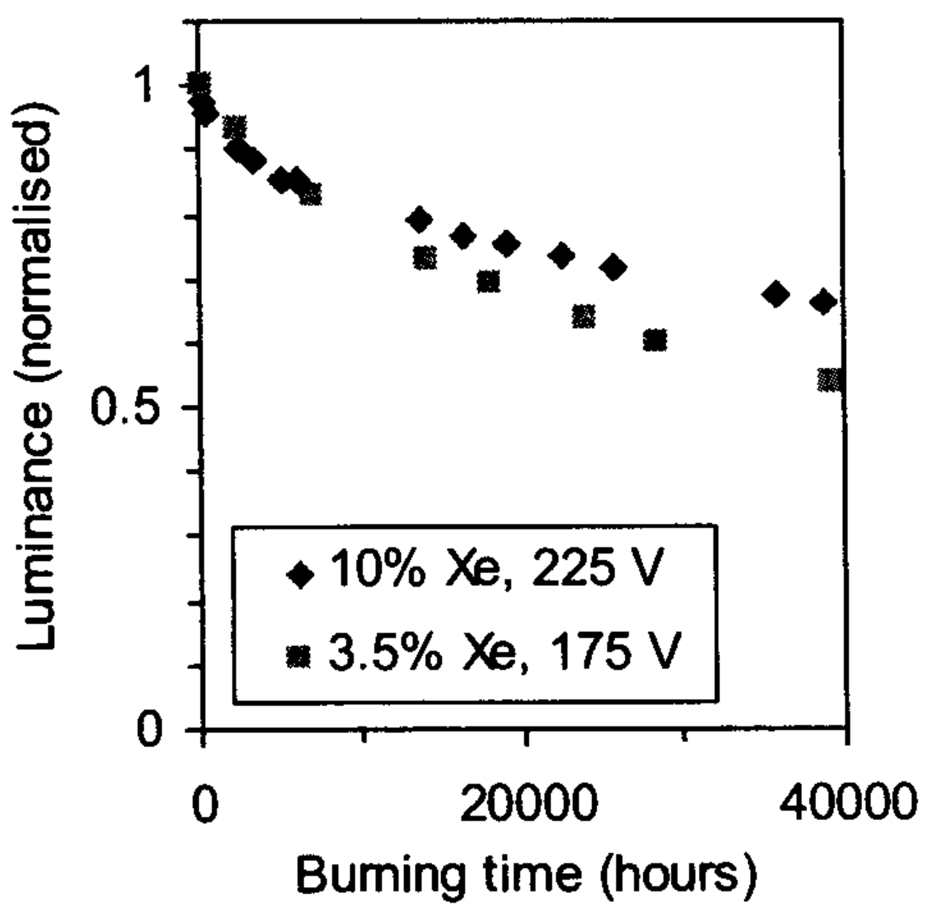

FIG.7 Comparison of the luminance depreciation for a default and a high Xe-content panel.

In figure 7 the luminance depreciation for a default panel operated at 175 V and a 10% Xe panel operated at 225 V is compared in an accelerated aging test. The initial luminance of the 10% Xe panel is 2.3 times the initial luminance of the default panel. Thus for the 10% Xe panel less sustain time would be required to obtain the luminance level of the default condition and the acceleration factor is enhanced accordingly (x 2.3). The 10% Xe panel becomes warmer during aging than the default panel. The results are not corrected for this difference in aging temperature, as the scaling factor is unknown. It is seen that the high Xe-content panel outperforms the default panel, even though it is driven at a rather high sustain voltage. Apparently the decrease of the high-energy tail population of the Xe ion flux is very effective. For the improved high Xe-content designs discussed in section 3.1 a much more efficient 30% Xe panel could be operated at 225 V; see figure 1 and 4. In that case the lifetime improvement would be much larger. It is further noted that the increase of the lifetime with Xe-content is also reported in other experimental studies [14,15].

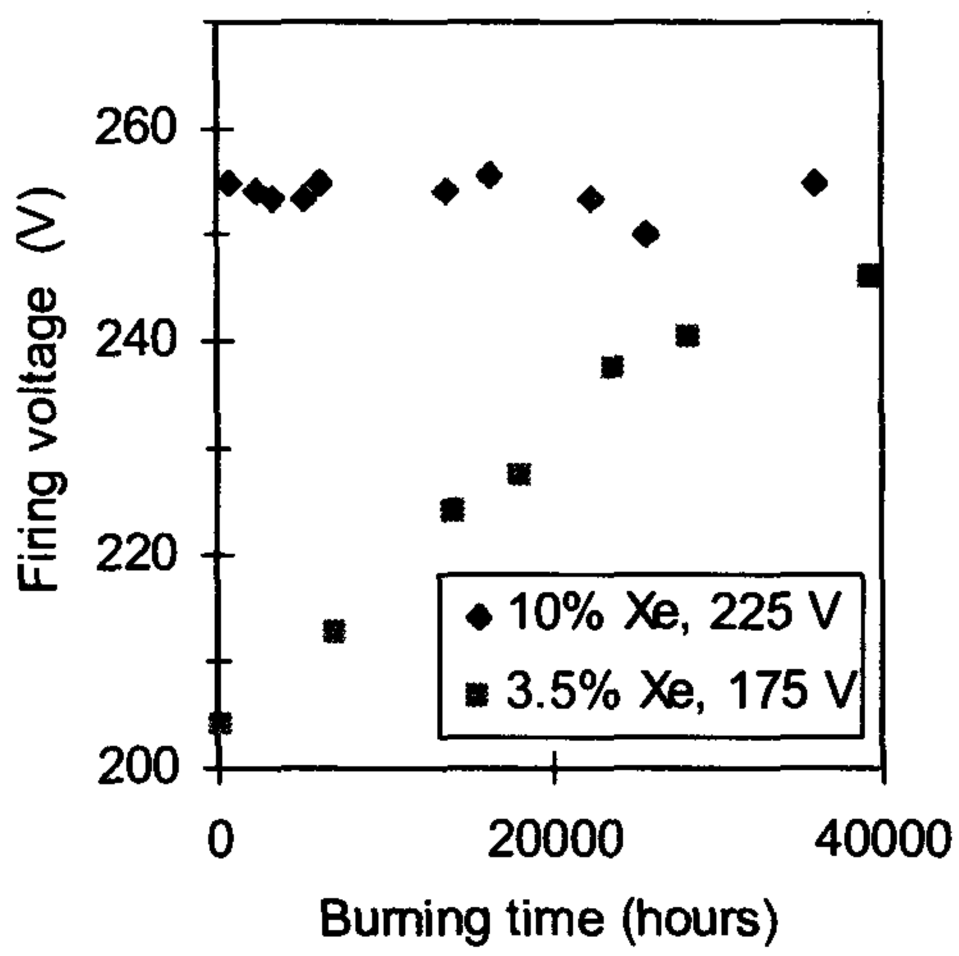

FIG.8 Comparison of the firing voltage increase for accelerated aging of a default and a high Xe-content panel.

In figure 8 the change of the firing voltages in the accelerated aging experiment is compared for the default and the 10% Xe panel. The firing voltage for the default panel increases markedly, while that of the 10% Xe panel is almost constant. A similar result is found for the minimum sustain voltage (not shown). The increased stability of these voltages is attributed to: 1) a lower sputtering rate and 2) a lower sensitivity for the MgO surface condition at higher Xe-content. It is further noted that a comparison of figures 7 and 8 shows that there is no straightforward correspondence between discharge voltage increase and luminance decrease. This indicates a relatively small contribution of the discharge efficiency decrease.

In summary, a high Xe-content increases the lifetime in terms of less luminance depreciation, and an increased drive voltage margin and stability.

4. Conclusion

An improved PDP efficacy, increased lifetime and decreased cost are required to enhance market penetration. The present investigation shows that for a high Xe-content gas mixture a marked increase of efficacy, luminance, drive margin and lifetime is achieved, at a moderate increase of the operation voltages. The results are obtained with a conventional stripe-type barrier cell configuration blasted in low cost soda lime glass. A stripe-type barrier structure is attractive because it is less alignment sensitive compared with the cell-type structures otherwise used to increase efficacy. Larger drive voltage and alignment margins imply higher yield. Also, less critical alignment allows the use of low cost soda lime glass.

It is therefore concluded that a high Xe-content is an attractive route to go for the next PDP generation. Yet, further investigations on larger panels are needed for a final evaluation.

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