Discharge Characteristics of a Flat Plasma Backlight with Long Electrode Gap

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Abstract

The discharge characteristics of a flat plasma backlight with long electrode gap are investigated. The effect of operating voltage and repetition rate on brightness and luminance efficiency is investigated. A new high efficacy mode is found at low frequencies around 15-40 KHz; a lumen efficacy of 15.3 lm/W is achieved at a luminance of 2400 cd/m^2. In the high brightness mode, present at high voltage, we find a maximum luminance of 5900 cd/m^2 at 30KHz.

1. Introduction

The flat plasma backlight is very promising for use as a scanning backlight for TFT-LCD displays, to eliminate moving image blur. Also it has a uniform luminance, a rapid response time, and is mercury free [1,2]. The main challenge for the plasma backlight is to be able the flat backlight at high xenon levels, and increase the luminance and the efficiency [3].

To improve the efficiency of the discharge, the electrode gap length was increased, so that a longer discharge is obtained; the structure is shown in figure 1. The effect of operating voltage and frequency on brightness and lumen efficacy is investigated.l

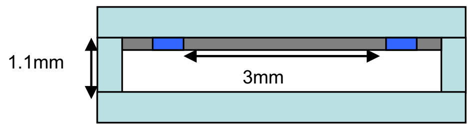


Figure 1 Structure of backlight with large electrode gap

2. Experiments and Results

The backlight panel that was investigated has a surface discharge with a discharge electrode gap of 3mm, while the height of the discharge space is 1.1mm. A gas mixture of Ne+20%Xe is used and the total gas pressure is 500 Torr. The white phosphor consists of a mixture of red, green and blue phosphors; for the green phosphor pure YBT is used, which is known to be less saturating than the standard Willemite (ZnSiO4:Mn)

The brightness is measured at the different working voltages, after initial backlight panel firing. The luminance efficiency for the panel is calculated as the differential value near the operating point, so that the value is independent from circuit losses. The plot of luminance and efficacy versus externally applied operating voltage is shown in figure 2 for driving frequencies of 15kHz, 30kHz and 60kHz respectively. The images of the IR discharge intensity at 15 kHz for several values of the operating voltage are shown in figure 3.

3. Discussion

From figure 2, we see that the luminance increases gradually with the operating voltage. This curve is almost independent from the sustain frequency. From basic principles one would expect the luminance to increase proportional to the number of sustain pulses, but this is clearly not the case. In fact it is more or less independent from the sustain frequency, suggesting that some kind of saturation mechanism is present in the flat plasma lamp (either plasma and/or phosphor).

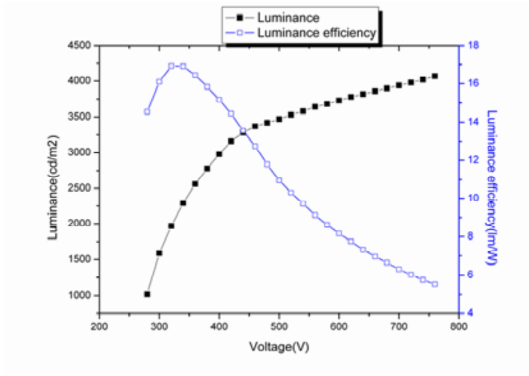
The curves of luminance versus voltage (figure 2) show two different sections, most clearly seen at 60 kHz. Around 350 Volt there is a trend change (inflection point). These efficacy plots versus voltage suggest a mode jump or saturation. Above this operating point, when increasing the voltage, the efficacy values decrease from 10lm/W to about 2 lm/W, for instance in the case of 60 KHz.

At or just below the inflection point however the highest values for the efficacy are found, with a maximum at voltages around 300 Volt. At 15 KHz an efficacy is achieved of 15.3 lm/W at a luminance of 2400 cd/m2, while using a sustain voltage of only 340Volt. The maximum luminance on the other hand occurs in the high voltage mode, and has a value of 5900cd/m^2 at f=30KHz, for a sustain voltage of V=780V.

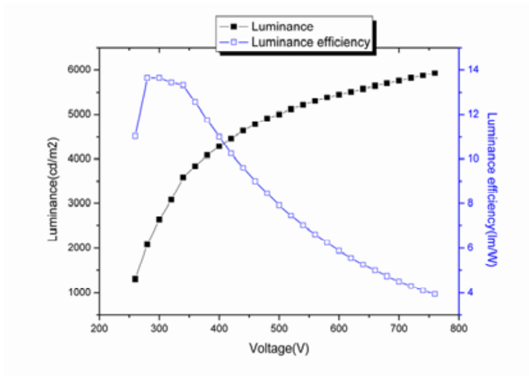
Looking at the 823+ 828nm NIR waveforms (figure 3) it is clear that in the high efficacy mode at 380Volt, the discharge intensity starts only after the usual initial delay (discharge formation time T_f) of about 2 us. After achieving its maximum value, the NIR light then slowly decays in about 5 us from its maximum value, typical for xenon excitation and decay.

At higher voltages however (figure 3b and 3c) a fast light pulse is additionally present, occurring prior to the broadband IR-emission. The origin of this peak will be investigated by using an ICCD camera.

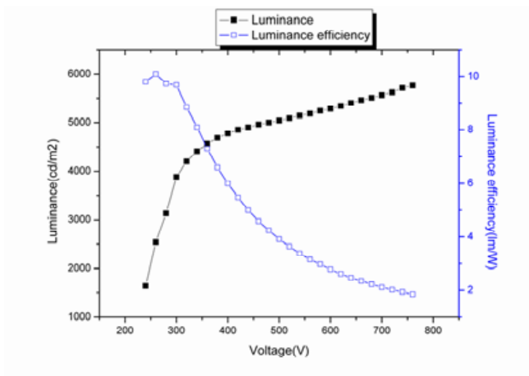
Finally figure 4 shows the trend of the maximum values for the luminance and luminous efficiency as a function of frequency.



(a) f=15KHz

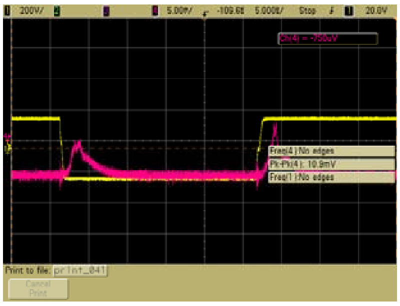


(b) f=30KHz

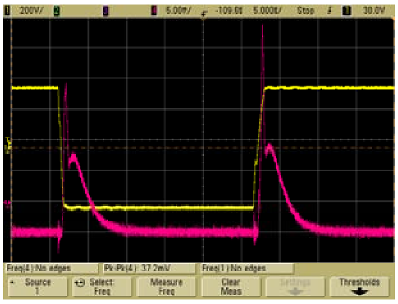


(c) f=60KHz

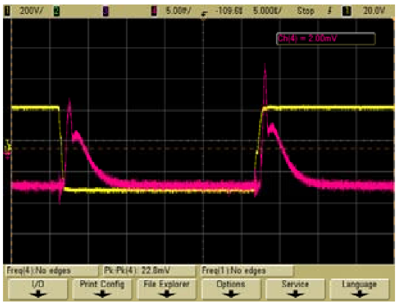
Figure 2 Luminance and luminous efficiency vs operating voltages under different frequency



(a) 380 V

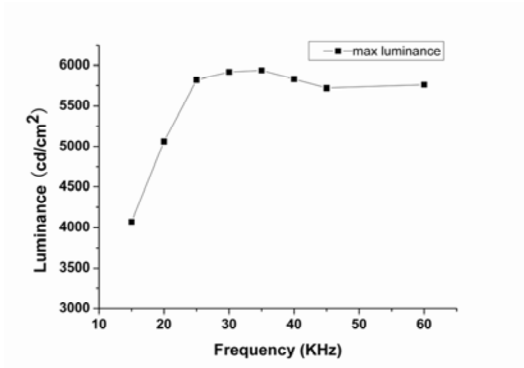


(b) 540 V

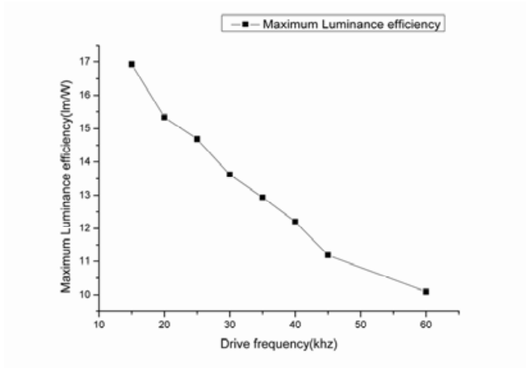


(c) 760V

Figure 3 Image of IR discharge uder 380V, 540V, 760V, under 15KHz, time scale is 5us/grid



(a) luminance



(b) luminous efficiency

Figure 4 Trend of maximum luminance and luminous efficiency with frequency

4. Conclusions

The conclusion for the 3 mm gap flat plasma lamp is that the highest differential efficacies is obtained at a relatively low frequency (15kHz), and low voltage (340 Volt) with a luminance of 2400 cd/m2, increasing to 4100 cd/m2 at high voltage (780Volt).

Doubling the frequency does not double the luminance. A maximum value of 5900 cd/m2 is obtained at 30 KHz, while at 60 KHz the luminance appears to be fully saturated, with luminance values similar to those of 30 KHz.

Probably at the higher frequencies both plasma and phosphor saturation are strongly affecting the performance of the flat plasma lamp. By further analyzing the long-gap flat backlight and removing these obstacles, we expect significant improvements in the near future.

5. Acknowledgment

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6. Reference

1. L. Hitzschke, F. Vollkommer, K. D. BauerL. et.al"A 32-in. Integrated Hg-free Lamp that Eliminates Problems of Backlights with Multiple Lamps" SID 04 Digest, p.1322
2. Seyno Sluyterman, Dynamic-Scanning Backlighting Makes LCD TV Come Alive, Information Display,vol.21,No.10,pp.28-31,2005
3. Byung-Gwo Cho, Bo-Sung kim,Heung-Silk Tae, A New Driving Waveform for Improving luminous Efficiency in ACPDP with Large Sustain Gap under High Xe Content, SID 05 Digest, p.1138