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Luminance Enhancement of Xenon Fluorescent Lamps by Burst Pulse Drive
バーストパルス駆動によるキセノン蛍光ランプの輝度向上

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In the environmental point of view, non-toxic and environmentally friendly products are demanded. For fluorescent lamps, mercury-free ones are developed and xenon is used as a substitute for mercury. However, their total flux and the efficacy is not enough for general lighting. The authors tried a novel driving voltage waveform to solve this problem. By using a burst pulse drive, i.e. by applying a successive sub-pulse (triangle waveform) after the main pulse (rectangular waveform), the maximum luminance was enhanced, because of suppression of power injection concentration during the main pulse application. However, the lamp efficacy decreased on the contrary, because of depletion of the metastable atoms by step-wise ionization.

1. Introduction

In the environmental point of view, non-toxic and environmentally friendly products are demanded. Fluorescent lamps contain mercury as phosphor exciting UV (ultraviolet) radiator. Xenon plasmas radiate fairly strong VUV (vacuum ultraviolet) emissions and they are the most promising candidate of substitution for mercury. Although xenon fluorescent lamps are used for special purpose, such as for image scanners and photocopies, the lamps for general lighting with enough total flux and the efficacy have not been realized yet.

Since xenon atom has high excitation level (8.3 eV for resonance level), xenon fluorescent lamps are driven by pulsed voltage and strong VUV emissions from non-equilibrium plasma are utilized. However, excess ionization of xenon atoms by high voltage pulse can result in low efficiency. The authors tried suppressing the excess ionization and tried exciting xenon atoms to the resonant and metastable levels with high efficiency by burst pulse drive; the idea is to ionize xenon atoms and initiate the plasma by first main high voltage pulse, and then to excite xenon atoms by successive low voltage sub-pulse. This paper discusses experimental results of luminance enhancement of xenon fluorescent lamps by burst pulse drive.

2. Experimental Procedure

The cold cathode xenon fluorescent lamp made for the experiment had following specification. The xenon filling pressure was 6.7 kPa. The distance between the electrodes was 50 mm, the inside and outside diameter were 26 and 30 mm respectively. Tri-band phosphor for plasma display panel was coated on the inside of the lamp. In this study, a triangle waveform was used for the sub-pulse, as shown in Fig. 1. The pulse repetition frequency and the pulse width of the first main pulse were set at 17 kHz and 5 μs respectively. The luminance of the lamp surface was measured at the center of the lamp with a luminance meter (Topcon, SR-3). The amplitude and the duration of the sub-pulse were optimized by monitoring the lamp luminance.

3. Results and Discussion

Figure 2 shows the luminance vs. the power consumption when (a) the amplitude and (b) the duration of the sub-pulse were changed. The input power was set within the range in which a stable diffuse positive column was obtained; this means that if the input power was over the range shown in Fig. 2 for each condition, the positive column

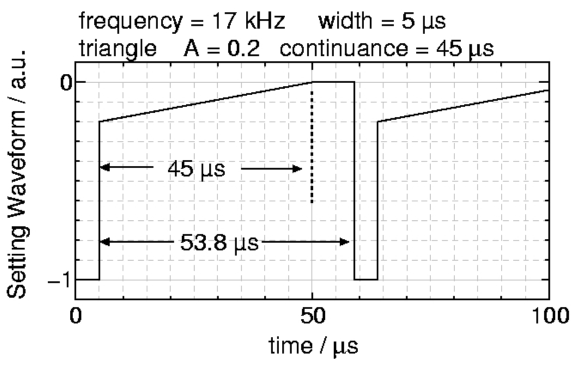

Fig. 1. An example of the schematic of the burst pulse.

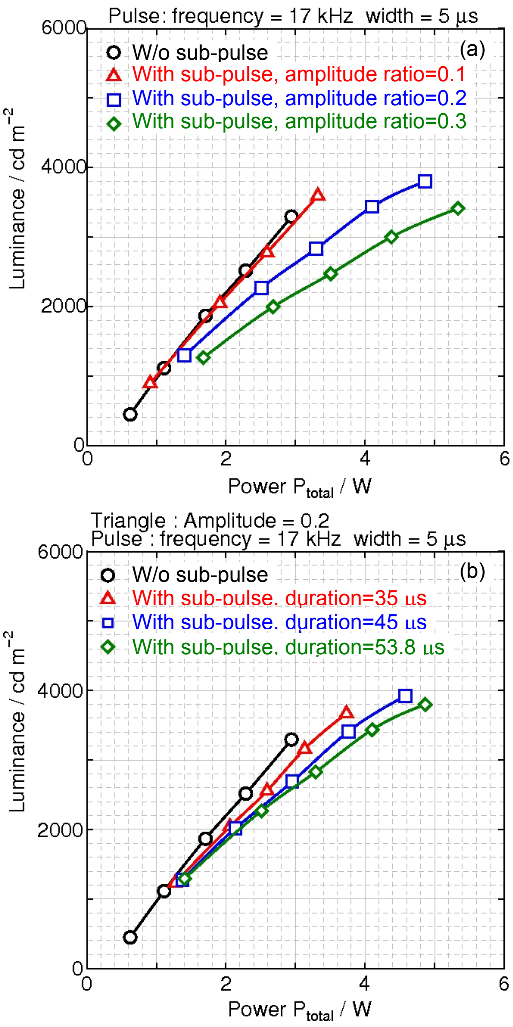

Fig. 2. The luminance vs. the power consumption when (a) the amplitude and (b) the duration of the sub-pulse were changed.

constricted and the discharge turned to the filamentary mode. It is found that the maximum input power under which the stable diffuse discharge was obtained increased by applying the sub-pulse and by increasing its amplitude and duration. As a result, maximum luminance increased with the amplitude ratio of sub- to main pulse of 0.2 and the duration of the sub-pulse of 45 µs. When the sub-pulse was applied, the power injection occurred during both main and sub-pulse. On the other hand, when the only main pulse was applied, power injection concentrated for the short time range during the main pulse application; this resulted in the positive column constriction at the lower threshold value of the input power. On the contrary, however, the lamp efficacy dropped with sub-pulse application, which was against the hypothesis described in Sec. 1. Figure 3 shows an example of (a) the applied voltage and (b) the lamp current. It is found that the lamp current during the sub-pulse application is not small. It means the ionization rate during the sub-pulse application is not small in spite of low voltage amplitude. This can be resulted from the step-wise ionization, which requires lower electron energy than direct ionization. Thus, sub-pulse application resulted in depletion of the metastable atoms and efficacy drop. Optimization of waveform etc. is necessary as a future task.

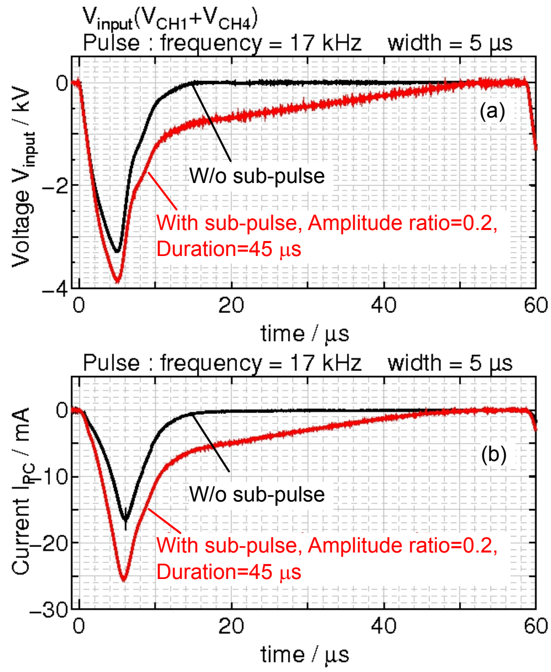

Fig. 3. An example of (a) the applied voltage and (b) the lamp current.

4. Conclusion

A novel driving voltage waveform for mercury-free xenon fluorescent lamps is introduced. By using a burst pulse drive, i.e. by applying a successive sub-pulse after the main pulse, the maximum luminance was enhanced, because of suppression of power injection concentration during the main pulse application. However, the lamp efficacy decreased on the contrary, because of depletion of the metastable atoms by step-wise ionization.

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