Letter

A New-type of Xenon-Neon Barrier Discharge Fluorescent Lamps : Double Helical External Electrodes Lamp (DHEL)

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ABSTRACT

Recently as interests in environmental issues increase, demands for mercury-free fluorescent lamps are increasing because mercury is harmful to human beings and creatures. As one of the solutions of this issue the authors have developed a new-type of mercury-free fluorescent lamps using double helical external electrodes. In this paper the fundamental characteristics of Xenon-Neon discharge in the Double Helical External Electrodes Lamps (DHEL) such as the luminance, power consumption and lamp current are investigated. When the pressure ratio of Xe : Ne was fixed at 7 : 3, total pressure at 1.33 kPa and external electrode pitch as 10 mm, luminance over 10000 cd / m² is achieved. In addition as a prototype 1 m length DHEL is prepared and demonstrated to show basically there is no limit in length of DHEL.

KEYWORDS: barrier discharge, mercury-free, fluorescent lamp, xenon, external electrode, DHEL.

1. Introduction

As interests in environmental issues has been increasing from the end of 80s, demands for abolition of poisonous substances in electric electronic product have been increasing as well. Mercury used for fluorescent lamp is not an exception because mercury is harmful to human beings and creatures. Therefore research and development of mercury-free fluorescent lamp using rare gas have been done by many researchers¹⁻⁶. The authors' group also have been developing mercury-free discharge lamps⁷⁻¹². The most effective gas in the rare gases used for a fluorescent lamp is xenon because of better conversion efficiency of VUV (Vacuum ultraviolet) to visible light by phosphors because of longest wavelength of VUV emission of rare-gases. Luminance and efficacy of xenon fluorescent lamps are still not enough high except for the one which is developed by the authors' group^{9,12}. The authors' xenon pulsed fluorescent lamp achieves 12000 cd/m² and 90 lm/W simultaneously, but the lamp voltage is too high to operate a lamp with enough length. This means the this authors' xenon fluorescent lamp is not suitable for LCD backlighting or scanner light sources.

Generally it is difficult to enhance the luminance because of positive column contraction issue at large current. One of the most effective way to restrain the positive column contraction is to use barrier discharge by external electrodes. As one of this type of lamps, DHEL (double helical external electrodes lamp) is developed by the authors.

2. DHEL

The structure of DHEL is shown in Figure.1. Two thin metal wires are alternatively and helically wound with constant intervals on the outside of the discharge tube of DHEL as external electrodes. By this structure, DHEL is given following advantages. The discharge gap is independent of the length of the lamp because the discharge occurs between vicinal winds of anode and cathode. Therefore, the discharge voltage can be suppressed low level even if the lamp is long. Next, the light shielding area by the thin metal wires is less than that by other type of external electrodes. The same of as the lamp with other type of external electrodes or because filling gases do not react with electrodes or sputter them, the lamp has long life and even reactive gas could be used if it has a good property. Also more than one DHELs can be operated in parallel with only one ballast because DHEL discharges coactively. So, as large size LCD backlights, low operation voltage and parallel operability with single ballast are most important and benefitable characteristics.

3. Experimental setup

Figures 1 and 2 show a schematic illustration and a photograph of the DHEL used in this study. As shown in Figure 1, the lamp is made of borosilicate glass and the inner diameter is 3.0 mm. The outer diameter is 4.0 mm

Figure 1 DHEL used in this study (side view)

Figure 2 Photograph of DHEL (280 mm long) used in this study and 1 yen coin with 20mm diameter for size comparison

Figure 3 Relation between the lamp current and the luminance of DHEL

and the length is 280 mm. The inner wall of the lamp is coated with white phosphor, which consists of three phosphors emitting blue (Nichia, NP-107), green (NP-220), and red (NP-360). A part of the phosphor layer is removed to make a line aperture, which allows light to radiate to its direction through this line aperture. This is typical aperture for scanner light. The mixture of xenon and neon is introduced into the lamp. The filling gas ratio of Xe : Ne

Figure 4 Relation between the lamp power and the luminance of DHEL

Figure 5 One meter long DHEL with a 170cm height human

is fixed at 7 : 3 and total gas pressure is 1.33 kPa. The electrodes are made of Ni wire with 0.1 mm diameter and are wound with 10 mm pitch. The waveform of the applied voltage is sinusoidal and the frequency is 30kHz. Luminance, input power, and current were measured under this condition. Measurement point of the luminance is on the aperture and the center of the lamp in length.

4. Result and discussion

Figure 3 shows the relation between the lamp current and the luminance and figure 4 shows the relation between the input power and the luminance. The luminance increases as the current or the input power increases. At 8.5 W the

luminance reaches to 10000 cd/m². In this DHEL, the contraction of the positive column is not observed. This is because the DHEL is operated in barrier discharge, and because discharge paths are dispersed to each gap between each vicinal winds of anode and cathode and discharge occurs in two directions that is along and across the lamp axis.

Since it is shown that this DHEL can be operated by sinusoidal voltage wave with high luminance of 10000 cd/m², in order to show the advantages of limit-less in length 1 m length of DHEL is prepared and operated. As shown in Figure 5, 1 m length of DHEL works well.

Through the experiment reported in this paper, the advantages of the DEHL are proved.

5. Conclusion

It is shown that the DHEL can be operated and the luminance of the DHEL achieves over 10000cd/m². As a future work, optimization of the condition such as electrodes pitch, gas pressure and so on are required.

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