주파수 변화에 따라 기체 방전관 색상 제어에 관한 연구

A Study on Color Control in Gas Discharge Tube with the Variation of Frequency

이 종 찬*, 박 대 희
(Jong-Chan Lee , Dae-Hee Park)

원 광 대 학 교 전 기 공 학 부
(Wonkwang University , School of Electrical Engineering)

Abstract

In this paper, the pulsed mode operated gas discharge tube is composed with mixed gas of Hg-Ne (10 Torr), in the tube of 15.0 mm outer diameter and has variable color from red to blue with changing frequency in high voltage. As increasing frequency in the gas discharge tube, the phenomena, that the electron temperature in the positive column increases and the radiation from atoms of higher upper state energy levels increases, exist. The color have the locus from red (0.4972, 0.3128) to blue (0.2736, 0.2619) in CIE chromacity diagram with increasing frequency. The method of changing frequency has been shown to be suitable for the luminous color control.

1. INTRODUCTION

The crisis of energy and the requirement of the better visual environment have been driving in great force to develop lamps with higher efficiency and better color performance[1]. The progress of new materials and process technology have also contributed to the development of new

The responses of the tube depend on the gas composition, on the kind of electrode and on the geometry of the arc and the discharge vessel. To keep constant one of the electrical quantities or a composition of them to stabilize the tube power, the arc position, or an other feature of importance is possible. The basic problem to do so is to find an information which is representative for the actual condition of the tube, and to translate it into an electrical signal which can be introduced by the electronic power supply. As a example, recently the fluorescent discharge lamps which discharge the mixed Hg-Ar gas in the A.C. or D.C., use the ultraviolet radiation with the Hg resonant wavelength of 253.7 nm[1]. The color of the tubes are controlled by the kind of phosphor and the spectroscopic properties of the ultraviolet radiations[5]. In this paper, the pulsed mode operated discharge tube is introduced, which is possible to modify the color and color rendering index independently by means of controlling the spectroscopic properties of the radiations in the discharge, just as the variable peak power and the variable repetition frequency of the pulse series[3

2. EXPERIMENTS

In the experiment, the discharge driving circuit, the gas discharge tube and the optical measuring instruments are respectively important parts as follows. The function of the discharge driving circuit switches D.C. with pulse as well as properly applies power. The gas discharge tube is as follows. The electrode is coated inside of the gas discharge tube, which is constructed by the inner diameter, the electrode and the electrode interval are 12.9, 10.0 and 128.0 mm respectively. In the discharge tube, Hg-Ne (10 Torr) are filled with mixed gas. The optical measuring instruments are following Fig. 1. The radiations of the gas discharge tube through the slit are derived to the monochrometer (Nikon P250). The photomultiplier (Hamamatsu C659) converts optical to electrical signal and then the radiations are amplified. To measure the distributions of the radiations, the amplified signals are averaged with Boxcar Averager (EG&G PAR 162) and amplified signals are output to the pen recorder. To obtain the radiations with time domain variable, the amplified signals are compared with applied signals on the digital oscilloscope (Tektronix 2430A) and are stored to the personal computer. And to plot the CIE chromaticity chart, which has a brief reference, luminance colormeter (BM-7, TOPCON) is used.

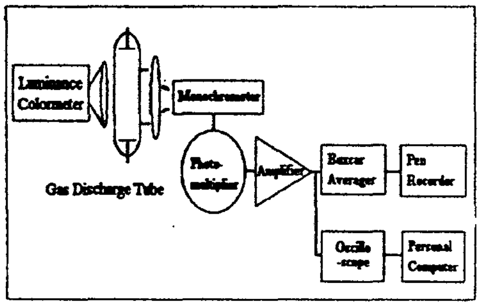


Fig. 1. The schematic of the optical measuring instruments

At first, to measure the radiations of the gas discharge tube, the controlling of the discharge driving signal is needed with observing the tube color by the change of the pulse width, which means the variation of the spectroscopic property in the radiations. The red to blue color of the tube is existed in the variation of frequency from 100 to 1000 Hz. The distributions of the radiations are plotted to the pen recorder through the Boxcar Averager at their tube color and then checked the peak energy with the wavelength. The each intensities are compared with the biased signals at the checked wavelength.

3. RESULTS

The radiations in the gas discharge tube have lights with the variable wavelengths. Hg and Ne gas make many related distributions, which means that their gas have a lot of excitations at distinct wavelength, but especially the wavelengths of 365.0 nm(Hg), 435.8 nm(Hg), 585.2 nm(Ne) and 640.0 nm(Ne) in visible region are chosen. As increasing the frequency in the gas discharge tube, the electron temperature in the positive column increases. Hg radiated intensities of 365.0 nm and 435.8 nm are increased with augmentative frequency but Ne radiated intensities of 585.2 nm and 640 nm are decreased with augmentative frequency in Fig. 2.

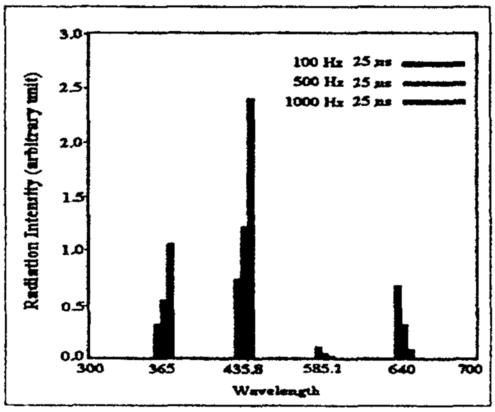
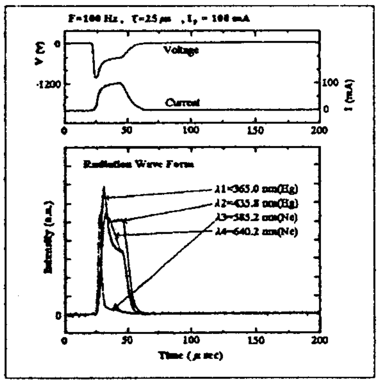
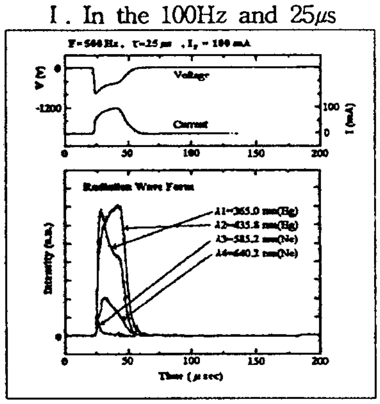


Fig. 2. The distribution of radiated intensity

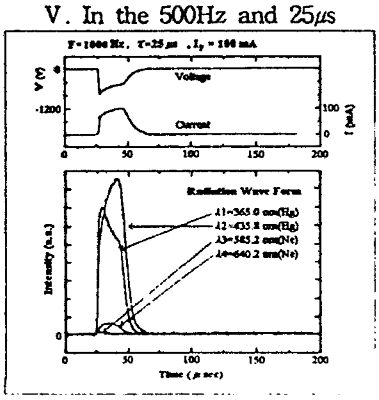
The intensity of radiations which are described as pulse width of 25 μs, are respectively obtained at 100 Hz, 500 Hz and 1000 Hz in the Fig. 3. The one of Hg radiation on 365.0 nm rapidly increases to the peak energy in first stage and exponentially decreases. At 435.8 nm, the Hg radiation are similar to current and have the most high intensities in the visible region, which is related with Fig. 2. Hg radiations at 365.0 nm and 435.8 nm are augmented with increasing of frequency. The Ne radiations of 585.2 nm at 100 Hz just have intensities at first stage but in high frequency have very small intensities. At 640.0 nm, the Ne radiation which have also small intensities above of the 500 Hz, increase and slowly dwindle to end of current.



I. In the 100Hz and 25μs



V. In the 500Hz and 25μs



VII. In the 1000Hz and 25μs

Fig. 3. Radiation wave forms in 25 μs, 50 μs, 75 μs and 100 μs with 100 Hz 500 Hz and 1000 Hz

When the frequency is changed from 100 to 1000 Hz and the pulse width is fixed at 25 μs, the luminous color changes from red which is restricted (0.4972, 0.3128) by CIE chromaticity coordinates to blue (0.2736, 0.2619) as shown in Fig. 4. The luminous colors of Hg and Ne are shown by the points Hg (0.217, 0.198) and Ne (0.705, 0.295) respectively. Increasing the frequency, the color of the gas discharge tube varies from the red which is close to that of Ne toward the blue of Hg. In the method of changing frequency, increasing the repetition frequency of pulses, the color varies from red to blue. Whenever Ne with high excitation levels is excited, Hg with low excitation levels is excited and emits radiation, because of the spread of the distribution of electron energy.

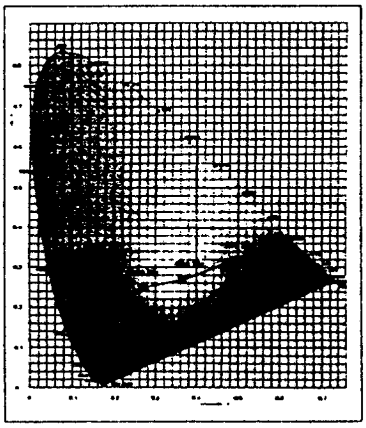


Fig. 4. CIE chromaticity diagram for luminous color in the Hg-Ne gas discharge tube

4. CONCLUSIONS

In the mixed gases of Hg-Ne (10 Torr) discharge tube, the color have the locus from red (0.4972, 0.3128) to blue (0.2736, 0.2619) in CIE chromacity diagram with increasing frequency. Especially, with changing of frequency, the electron temperature in the transient period is affected by the changes of the residual ion and metastable atom densities. In the gas discharge tube, the changing method of frequency has been shown to be suitable for the luminous color control.

REFERENCES

[1] 渡辺良男 他, " Ar-Hg放電における253.7nm光學光效率の直管依存性" 照明學會誌 Vol.11, No.11, pp. 762~677, 1995

[2] 加納忠男, "光源システムの技術動向と展望", 照明學會 調査報告書, pp. 147~155, 1993. 3.

[3] T. Hanada, "Lighting Industries In Japan", Symp. Proc. of The 7th Inte. Symp. Scie. & Tech. of Light Sour., Japan, pp. 17~25 ,1995

[4] K. Günther, "Electronic Optimization of HID Lamps ", ibid., p.93~100 ,1995

[5] M. Aono, et al., "Color Control of Fluorescent Lamps", ibid., p.81~82 ,1995

[6] G. Chodil, "Gas Discharge Displays for Flat -Panel", Proc. SID, Vol. 17, p.14~22, 1976

[7] L. F. Weber, "Plasma Displays", L. E. Tannas Jr., Ed., New York: Van Nostrand Reinhold, p.332~414 ,1985

Acknowledge

The authors wish to express their gratitude to Dr. Masaharu Aono for his contirbution to this paper.