Effect on the Electrode Characteristics by the Metal Ring Encircling the Electrode

Yoshio Watanabe, Tomohiro Yamaguchi

Department of Electronics and Informatics Frontier, Kanagawa University, Yokohama 221-8686, Japan
watalab@kanagawa-u.ac.jp

Hg-dispenser method is employed in a fluorescent lamp manufacturing. The electrode characteristics are measured by two methods. The results show that Ni-ring surrounding an electrode affects the anode fall characteristics of that electrode. Moreover, cathode fall characteristics are also affected by Ni-ring. It is indicated that cathode fall voltage increases by Ni-ring, then high frequency oscillation is produced at twin portion of the cathode fall voltage waveform of the electrode encircled by Ni-ring.
.

1. Introduction

Mercury is filled in a fluorescent lamp as a discharge medium. To control a quantity of filling mercury, following method has been developed [1], [2]. The compound containing mercury is painted on a Nickel-made ring, and Ni-ring is mounted near one of the electrodes in the discharge tube as shown in Fig.1. After lamp making, the mercury is released into the discharge space by heating Ni-ring. As the electrode is encircled by the metal ring, the electrode fall characteristics must be affected by Ni-ring. In this paper, the influence by Ni-ring on the electrode fall voltage characteristics is investigated.

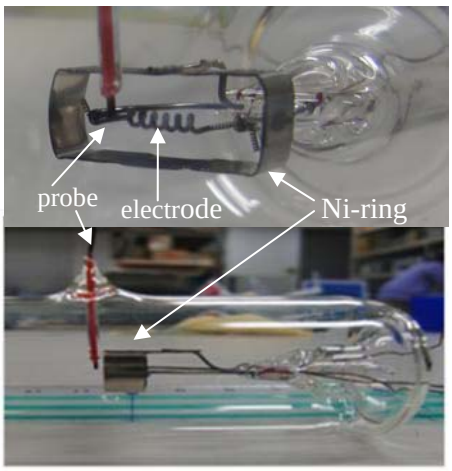


Fig.1 View of the experimental lamp

2. Experimental setup

The view of the lamp employed in the experiment is shown in Fig.1. The lamp specification is basically the same as an ordinary 40W fluorescent lamp (FL40S). The tube diameter is 32 mm and filled with Ar-Hg mixture gas. Electrodes are made of an oxide coated tungsten coil. The arrangement of the Ni-ring, a probe for measurement and the electrode is illustrated in Fig.2. The ambient temperature of the lamp in the experiment is 25 ºC.

The discharge current waveform is sinusoidal wave of 50 Hz. The electrode fall voltage is measured by two methods; the voltage waveform obtained by a probe and the discharge voltage obtained by the lamp of which discharge distance is about 10 mm.

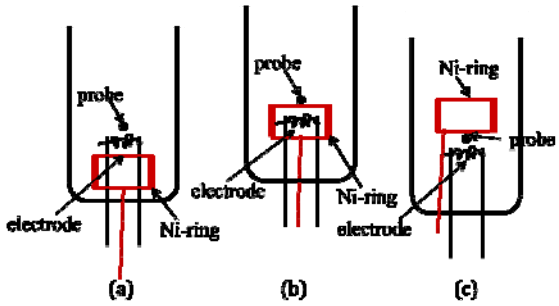
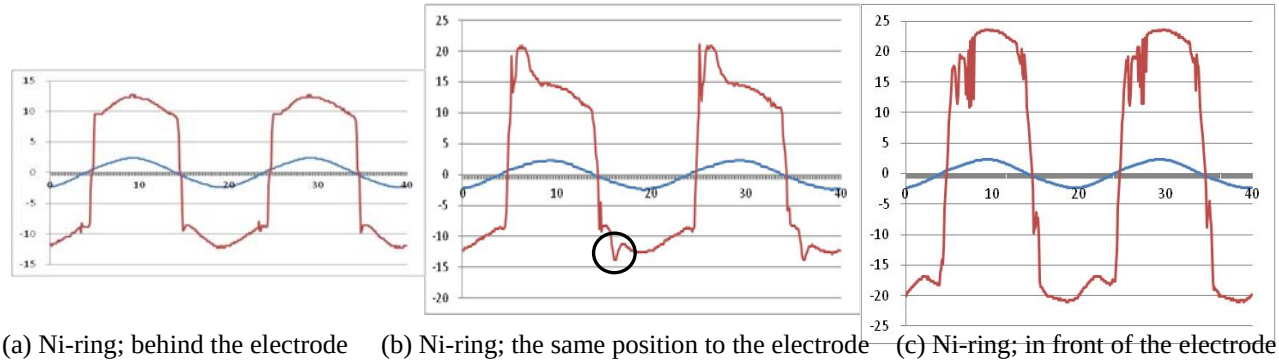


Fig.2 Arrangement of Ni-ring, probe and electrode

3. Experimental results

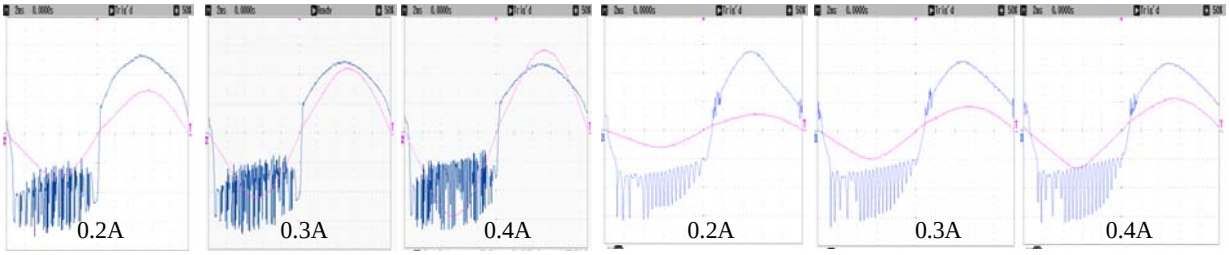
The discharge voltage waveform taken by the lamp with short discharge distance is shown in Fig.3.


(a) Ni-ring; behind the electrode (b) Ni-ring; the same position to the electrode (c) Ni-ring; in front of the electrode
Fig.3 Discharge voltage and discharge current waveforms taken by the lamp with short discharge distance at 50Hz.

The electrode surrounded by Ni-ring acts as an anode during upper side of voltage waveform, and acts as a cathode during lower side of voltage waveform. The discharge voltage is almost equal to the electrode fall voltage in the case of short discharge distance. Moreover, anode fall voltage is not produced when the electrode is immersed in a negative-glow due to the short discharge distance [3].

Fig.3(a) is taken by the lamp shown in Fig.2(a) in which Ni-ring is located behind the electrode. Anode fall voltage is not produced, and voltage waveform is the same between the upper side and the lower side. Thus Ni-ring does not affect the voltage characteristics of cathode fall and anode fall when Ni-ring is located behind the electrode. Fig.3(b) is taken by the lamp shown in Fig.2(b) in which Ni-ring is located at the same position to the electrode. The voltage waveform when the electrode surrounded by Ni-ring acts as a cathode is nearly the same as the one shown in Fig.3(a), but a small voltage-spike encircled by a circle in Fig.3(b) appears at rising phase of the cathode cycle. At the same time, anode fall voltage is produced in the anode cycle. Therefore Ni-ring surrounding the electrode affects the cathode fall characteristics and the anode fall characteristics both. Fig.3(c) is taken by the lamp shown in Fig.2(c) in which Ni-ring is located in front of the electrode. In this case, anode fall voltage accompanying with anode oscillation is produced through both cycle of the electrode operation.

Using the tube in which Ni-ring is located at the same position to the electrode and discharge distance is 100mm, the electrode fall voltage waveform is measured by the probe and shown in Fig.4. The electrode surrounded by Ni-ring acts as a cathode during upper side of voltage waveform, and acts as an anode during lower side of voltage waveform. Fig.4(a) is obtained when Ni-ring potential is free, while Fig.4(b) is obtained when Ni-ring is connected to the electrode potential. The cathode-cycle voltage waveform shown in Fig.4(a) is basically the same as the one in Fig.3(a). On the other hand, the cathode-cycle voltage waveform shown in Fig.4(b) is slightly different from the one shown in Fig.4(a). Namely, high frequency oscillation appears at two portions of cathode-cycle voltage.



(a) Ni-ring potential is free (b) Ni-ring is connected to the electrode potential.

Fig.4 Probe voltage waveform by the lamp in which Ni-ring is located at the same level to the electrode

4. Discussion

When an electrode is encircled by Ni-ring, anode fall characteristics are affected by Ni-ring. Anode fall voltage is easily produced at the electrode by encircling Ni-ring. This means that ions in front of the anode are easily removed by Ni-ring. The results shown in Fig.3(b) and Fig.4(b) indicate that Ni-ring also affects the cathode fall characteristics even though the effect is not so distinct. The existence of twin high frequency oscillation on the cathode-cycle voltage of the electrode encircled by Ni-ring indicates that electron emission from the electrode excesses at that phase [3]. This means that cathode fall voltage increases. The cathode fall voltage is enhanced when Ni-ring is biased to minus potential.

5. References

[1] Oomen M.; “Mercury Reduction in the Fluorescent Lamps”, IL03, Proc. of 8th Int. Symp. Sci. & Tech. of Light Sources, pp.24-32, Greifswald, Germany (1998)

[2] Matsuo K., Atagi T. and Ikai Y.; “Mercury Consumption Reduction in Fluorescent Lamps”, A07, Proc. of 8th Int. Symp. Sci. & Tech. of Light Sources, pp.144-145, Greifswald, Germany (1998)

[3] Watanabe Y. and Murayama S.: “Cathode Fall Characteristics under High-frequency Operation”, Jpn. J. Appl. Phys., 32-8 Part1, pp.3593-3600 (1993)

[4] Waymouth J. F.; “Electric Discharge Lamps”, The M.I.T. Press, Cambridge, 1978, pp.93-94.