Light Source Using Electroderess Discharge

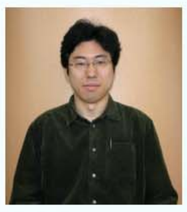
R. Miki, Y. Narukawa, H. Motomura, M. Jinno

Department of Electrical and Engineering, Ehime University

(E-mail: *mjin@mayu.ee.ehime-u.ac.jp*)


R.Miki


Y.Narukawa


H.Motomura


M.Jinno

Introduction

Now, the lighting is indispensable to our life. Fluorescent lamps are most widely used among them.

mercury → Hazardous to environment → Mercury free

electrode → Limits life of lamp → electrodeless

↓

Electrodeless and mercury free light source

For this purpose, a mercury-free electrodeless discharge lamp operated by inductively coupled plasma (ICP) was developed in this study. The influence of change of power supply frequency on luminance and luminous flux is studied

Principle of Inductively Coupled Plasma (ICP)

High frequency current flows through a coil

↓

High frequency magnetic field is generated inside the lamp

↓ law of electromagnetic induction

Electric field is generated

↓

The electric field accelerates electrons and ionization occurs

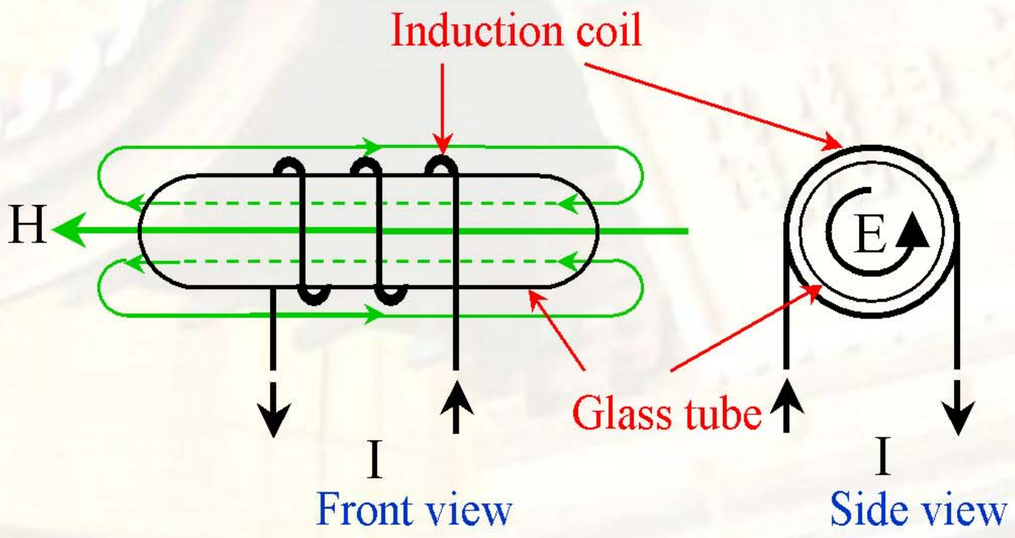


Fig 1 : Principle of Inductively Coupled Plasma

Experimental set up

Lamp

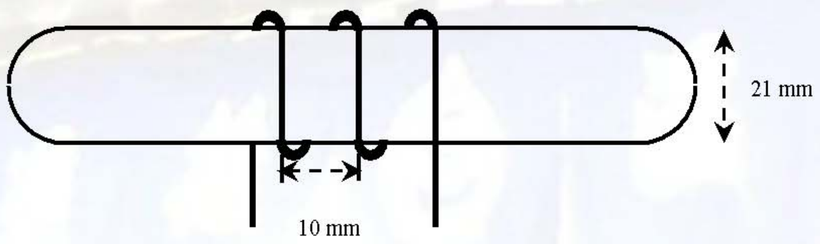


Fig 2 : Schematic illustration of the lamp used in study

Gas : Xe (39.9 Pa)	Coil made of copper wire (ϕ 1.6 mm)
Inside diameter : 21 mm	Coil turn : 3 turn
Lamp length : 250 mm	Coil length : 40 mm
No phosphors	Coil pitch : 10 mm

Lighting circuit

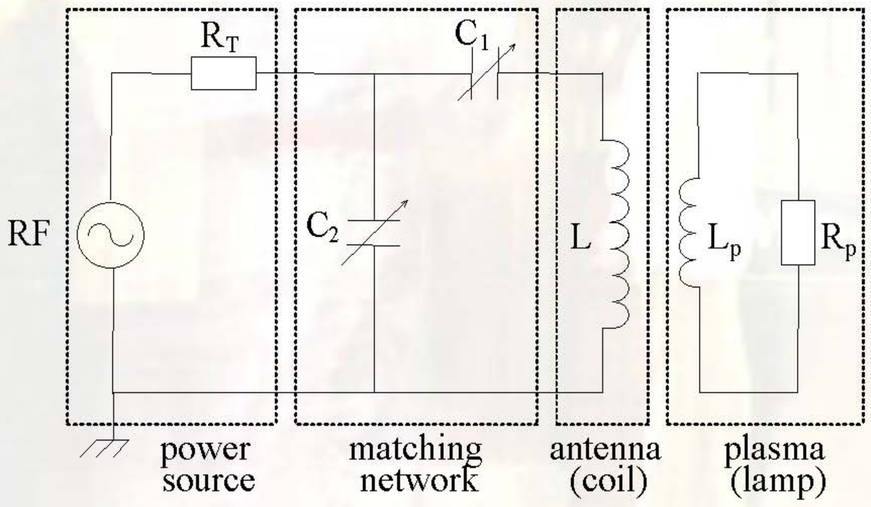


Fig 3 : Lighting circuit

L_C , R_C : **inductance and resistance of coil**

L_p , R_p : **inductance and resistance of plasma**

C_1 , C_2 : **variable capacitor**

(suppression of the power reflection occurring at high frequency)

Results and discussion

Relation between the frequency and luminance measured at center of the lamp in each input power is shown in Fig. 4, and relation between the frequency and luminous flux in each electric power is shown in Fig. 5.

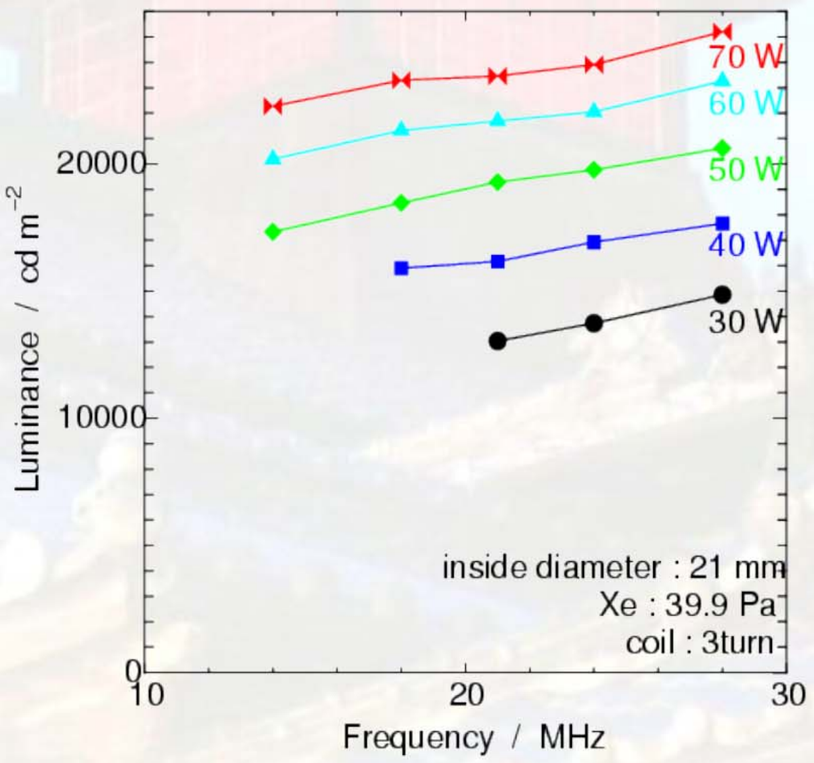


Fig 4 : Relation between the frequency and luminance in each electric power

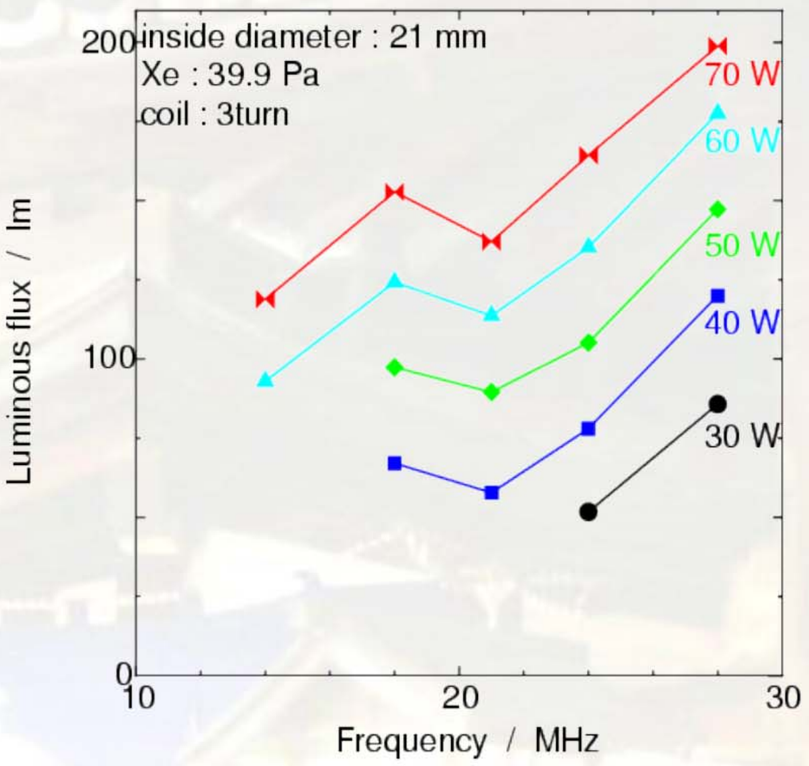


Fig 5 : Relation between the frequency and luminous flux in each electric power

- When power supply frequency was increased, luminance and luminous flux increased
- The minimum power that can maintain the discharge in ICP mode decreased by about 30W

Frequency is increased

Time derivative of the magnetic field becomes large

↓

Electron energy distribution shifts towards higher energy and number of electrons that have more energy than ionization level increases

↓

Number of pair of electrons and ions increases and recombination emission intensity becomes high

↓

Luminance and luminous flux increased

Skin depth becomes thinner

↓ $R_P = l_P / (\sigma S)$

(l_P : length of plasma current flows)

R_p increases

↓ $U_P = R_P I_P$

(R_p : resistance of plasma)

Power consumption by the plasma U_P increases

↓

The minimum input power that can maintain the discharge in ICP mode decreases

Conclusion

By increasing power supply frequency, total luminous flux and luminance became higher and the minimum input power which can maintain the discharge in ICP mode became small.