Measurement of pulsed xenon discharge fluorescent lamp with auxiliary external electrode by laser induced fluorescence

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1. Introduction

Mercury fluorescent lamp: (most-used in general lighting, currently)
- High luminance and efficacy
- Harmful to environment and human body

Xenon fluorescent lamp:
- Getting constant radiation without influence of surrounding temperature
- Low luminance and efficacy
- To get high luminance — Necessity of expanding positive column when increasing current

By our previous research

Using an external electrode — Achievement of large luminous flux and high efficiency [1]

To turn this lamp to practical use

It is important to know detailed characteristics of the lamp plasma

Measurement of pulsed xenon discharge plasma using LIF spectroscopy

Measuring spatial distribution of metastable atom density of xenon in the case with and without an external electrode

2. Experimental

Laser-induced fluorescence (LIF) spectroscopy

Measurement of this fluorescence induced by laser

Fluorescence

Laser

Excited atom density

Xenon Grotrian energy level diagram

Measurement of atom density at this level

excitation: 490.1 nm laser beam

measurement: 764.2 nm LIF

5p(1P3/2) → 6s(3/2) L

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Fig. 1: Principle of LIF spectroscopy

Xe(II) Grotrian (in Air)

Fig. 2: Xe Grotrian energy level diagram

Experimental setup

Measurement of LIF signal

Oscilloscope

Measurement

Dispersion (746.2 nm)

Collecting LIF

Focus laser beam on center of the lamp (see Fig. 5 left)

Adjusting laser power (0.3 mJ)

Lamp: One cathode — Two anodes

- Filled gas: xenon
- Pressure: 10.7 kPa
- External electrode (Aluminum tape 2.5 mm width)
- Internal electrode

"V" shape formed by two rounded platinum cathode: 2mm x 10 mm, anode: 4mm x 10 mm

Adjusting delay time to synchronize

Oscillation of 450 (1) nm laser beam

Detection of part of laser beam reflected from Al Mirror

Trigger signal of the oscilloscope (= laser signal)

Fig. 3: Circuit for pulsed discharge

Fig. 4: Experimental setup

Fig. 5: Discharge lamp

3. Result and discussion

Waveforms of current, voltage and laser signal

Laser incident timing: near current peak

WITH an external electrode

Peak current value: 8.9 mA

Without an external electrode

Peak current value: 6.4 mA

Fig. 7: Waveforms of current, voltage and laser signal (WITH an external electrode)

Fig. 8: Waveforms of current, voltage and laser signal (WITHOUT external electrode)

Spatial distribution of metastable atom density

LIF signal intensity

WITH an external electrode

Without an external electrode

Spread of distribution

WITH an external electrode

Without an external electrode

By installing an external electrode, metastable atom density is higher over a discharge lamp

Distribution state of metastable atoms by an external electrode

Becomes wide and symmetry

Fig. 9: Spatial distribution of metastable atom density

4. Conclusion

Installing an external electrode

Metastable atom 5p(1P3/2)6s(3/2) L density: Increase over a discharge lamp

Attribution of large luminous flux reported in reference [1] to this results

Reference