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 efficacy [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

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Excited atom density

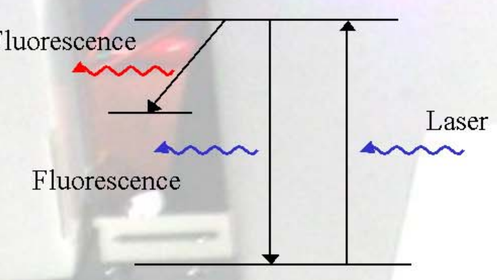

Fig. 1: Principle of LIF spectroscopy

Xenon Grotrian energy level diagram

Measurement of atom density at this level

$5p^5(^2p_{3/2})6s[3/2]_2 \rightarrow 5p^5(^2p_{1/2})6p[1/2]_1 \rightarrow 5p^5(^2p_{1/2})6s[1/2]_0$

Excitation: 450.1 nm laser beam

Measurement: 764.2 nm LIF

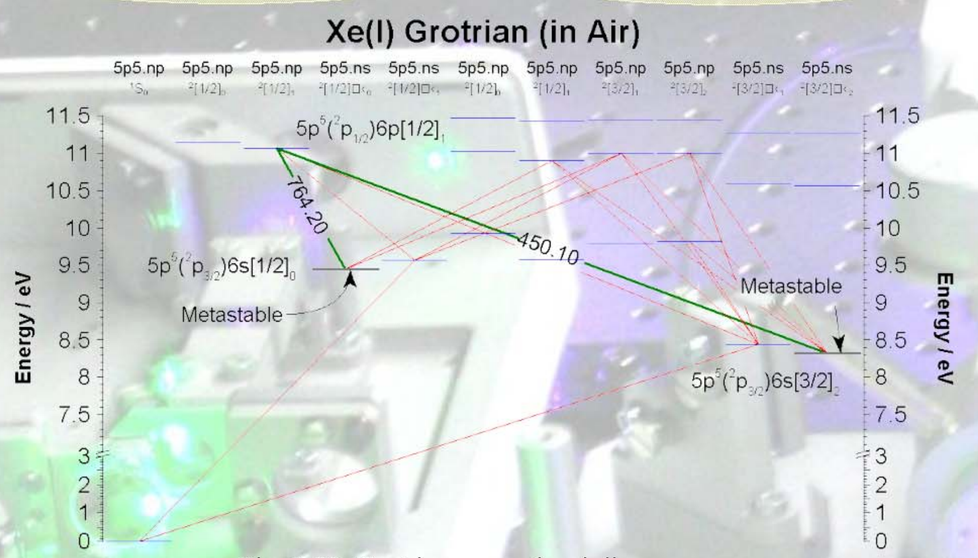

Fig. 2: Xe Grotrian energy level diagram.

Conditions for discharge

- Pulsed discharge
  - Pulse repetition rate: 25 kHz
  - Pulse width: 2 μs
- Set peak current as near the value shown in reference (1) as possible
  - ↳ { ・Highest luminance under this condition
    ・peak current value
    with an external electrode 9.2 mA
    without external electrode 6.8 mA

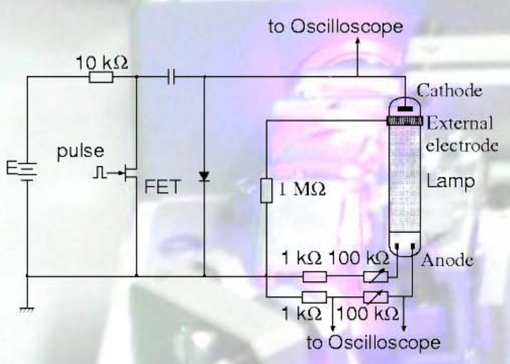

Fig. 3: Circuit for pulsed discharge

Experimental setup

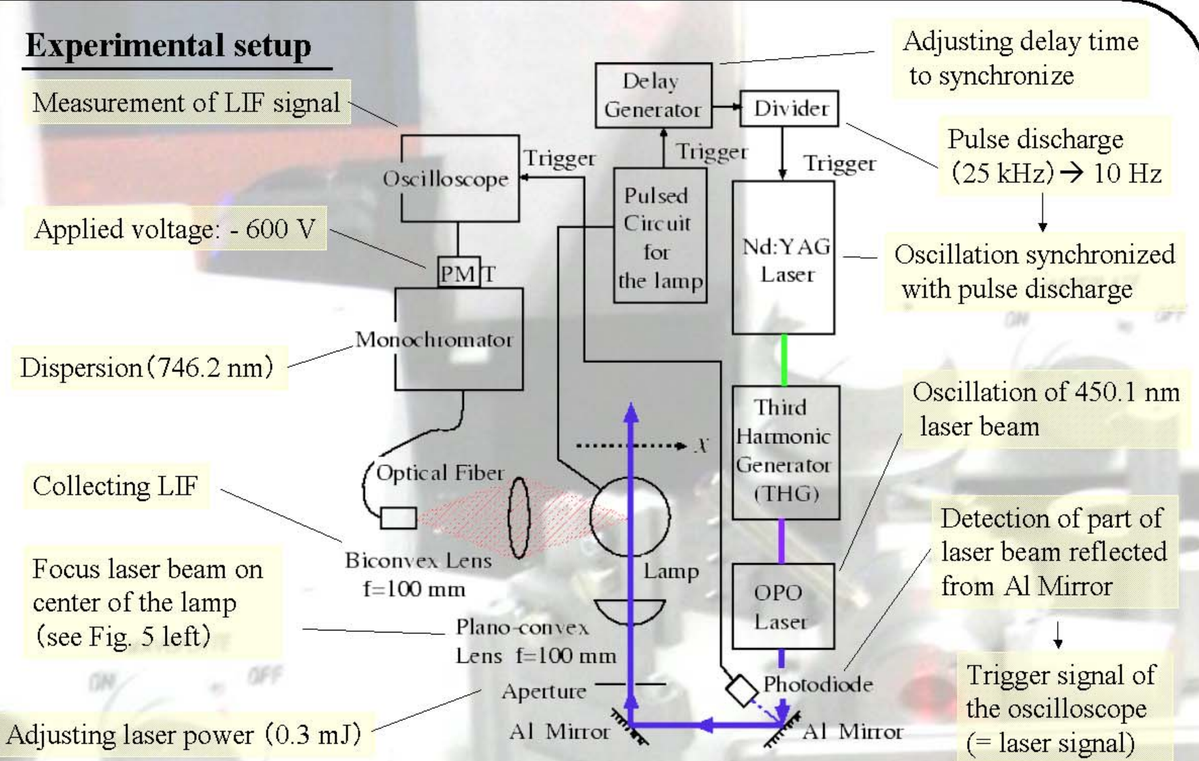

Fig. 4: Experimental setup

Lamp : one cathode – two anodes

- Filled gas: xenon
- Pressure: 10.7 kPa
- Internal electrode ('V' shape formed by two nickel plates) cathode: 12mm × 10 mm, anode: 4mm × 10 mm
- External electrode Aluminum tape (2.5 mm width)

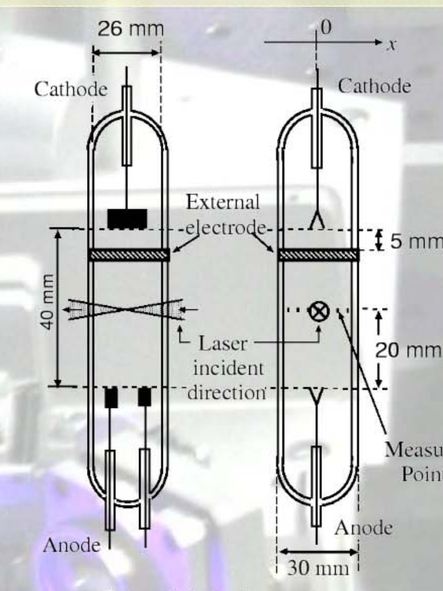

Fig. 5: Discharge lamp

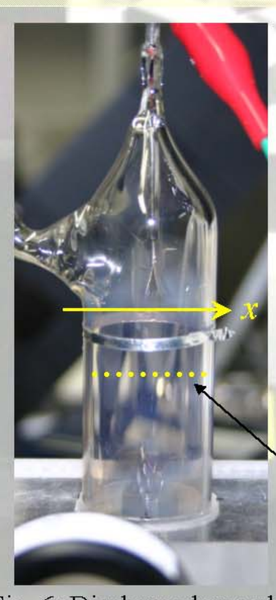

Fig. 6: Discharge lamp photo

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

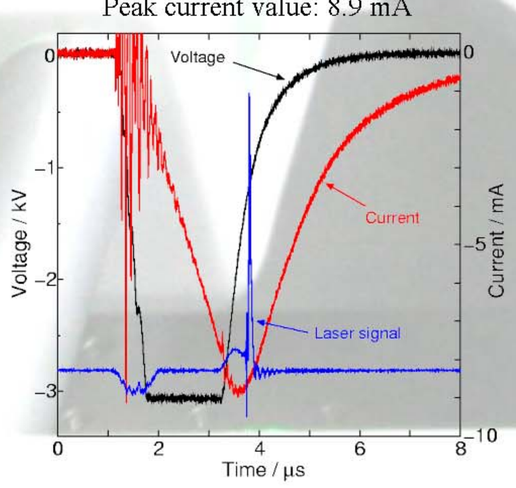

Fig. 7: Waveforms of current, voltage and laser signal (WITH an external electrode)

WITHOUT external electrode
Peak current value: 6.4 mA

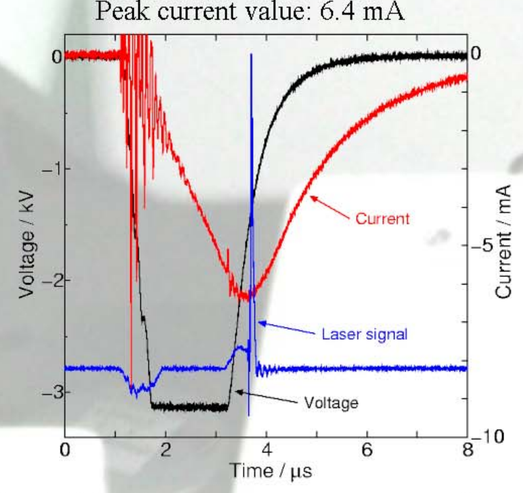

Fig. 8: Waveforms of current, voltage and laser signal (WITHOUT external electrode)

Spatial distribution of metastable atom density

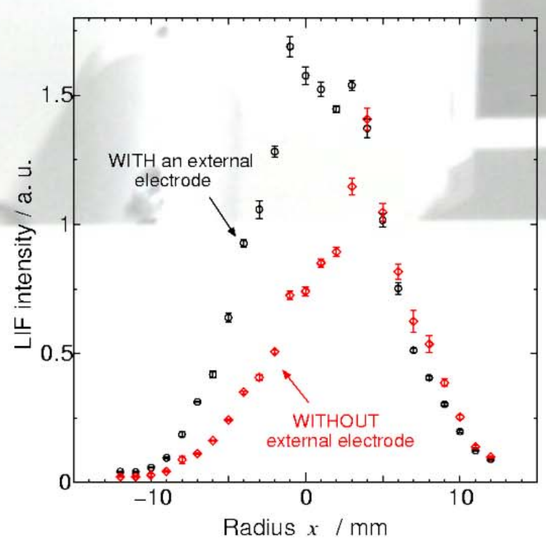

Fig. 9: Spatial distribution of metastable atom density

LIF signal intensity

WITH an external electrode > WITHOUT external electrode

Spread of distribution

WITH an external electrode > WITHOUT 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

4. Conclusion

Installing an external electrode

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Metastable atom $5p^5(^2p_{3/2})6s[3/2]_2$ density: Increase over a discharge lamp

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

Reference

[1] K. Toryuu, T. Murakami, M. Okamoto, H. Kurokawa, H. Motomura, M. Jinno: Improvement of Luminance and Efficacy of a Multi-Pairs Electrodes Rare Gas Lamp by Using External Electrode, The papers of Joint Technical Meeting on Electrical Discharges, Dielectrics and Electrical Insulation and High Voltage Engineering, IEE Japan, pp.39-44 (2005)