The optical analysis of discharge lamp by Laser

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Abstract : In this paper, we introduced a LIF measurement method and summarized the theoretical side. When an altered wavelength of laser and electric power, lamp applied electric power, we measured the relative density of the metastable state in mercury after observing a laser induced fluorescence signal of 404.8nm and 546.2nm, and confirmed the horizontal distribution of plasma density in the discharge lamp.

The results confirmed the resonance phenomenon regarding the energy level of atoms along a wavelength change, and also confirmed that the largest fluorescent signal in 436nm, and that the density of atoms in 546.2nm ($6^3S_1 \rightarrow 6^3P_2$) were larger than 404.8nm ($6^3S_1 \rightarrow 6^3P_1$). According to the increase of lamp applied electric power, plasma density increased, too. When increased with laser electric power, the LIF signal reached a saturation state in more than 2.6mJ. When partial plasma density distribution along a horizontal axis was measured using the laser induced fluorescence method, the density decreased by recombination away from the center.

Key Words : LIF, Laser Induced Fluorescence, Plasma density

1. Introduction

This paper introduces a LIF method, and examines the theoretical aspects of this method. In addition, a device for this LIF method was configured to measure the relative density of mercury under a metastable state by varying the wavelength of the laser, applied power to the lamp. The spatial distribution of the plasma was also investigated by varying the distance from the central axis of the lamp.

2. Experiments

A LIF (Laser Induced Fluorescence) method excites incident energy beams, which has a wavelength equal to the transition energy (E=hv) of an atom or molecule, and then observes the radiation of fluorescence when the atom or molecule returns to a lower state of energy.

The LIF experiment consists of a laser preparation process, plasma generation process, and measurement process. The laser used in this experiment consisted of a Nd:YAG laser (LQ 829) and OPO (Optical Parametric Oscillator, OPO 483), in which the Nd:YAG laser plays a role as a pump, and has a very narrowed linear width, which is required for the LIF experiment.

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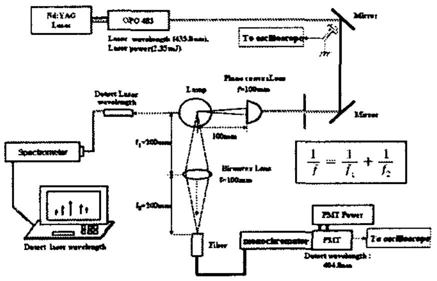

Fig. 1 Configuration of the experiment using a LIF method

The output energy beam can be controlled, and the final output can also be obtained by increasing the output energy beam, even though there is a certain amount of loss due to a few number of reflections.

3. Results

In order to verify the resonance of the energy level based on the wavelength of 436nm, the laser induced fluorescence signal in Fig. 1. was investigated by varying the applied wavelength of laser from 435.8nm to 436.2nm with an interval of 0.1nm.

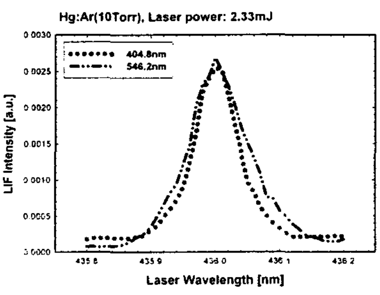

Fig. 2 LIF signals for the applied laser wavelength

the relative density of atoms or molecules, which corresponded to the wavelength of 404.8nm ($6^3S_1 \rightarrow 6^3P_1$) and 546.2nm ($6^3S_1 \rightarrow 6^3P_2$), was measured by varying the applied voltage to the lamp based on the wavelength of 436nm because the largest fluorescence signal was measured at 436nm. As a result, the laser induced fluorescence signal linearly increased according to the increase in the applied voltage to the lamp as illustrated in Fig. 2. Thus, the number of excited atoms or molecules relatively increased according to the increase in the applied power to the lamp. The density of plasma also increased.

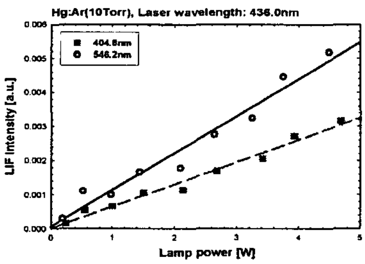

Fig. 3 LIF signals for the applied lamp power

Fig. 4 presents the results of the saturation test on the plasma according to the applied power of the laser. The laser induced fluorescence signal was measured at the wavelength of 404.8nm ($6^3S_1 \rightarrow 6^3P_1$) and 546.2nm ($6^3S_1 \rightarrow 6^3P_2$) by increasing the power of the laser at 436nm as presented in Fig. 3.

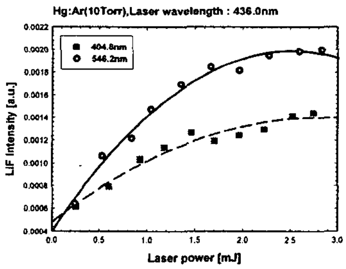

Fig. 4 Measurement of the LIF signal for the applied laser power

In order to examine the partial distribution of the density of plasma for the horizontal axis using a LIF method, the laser induced fluorescence signal was measured by moving the applied laser to the lamp from the center to the left and right at an interval of 1mm using the wavelength of 436nm of the applied laser. As a result, it is evident that the laser induced fluorescence signal decreased according to the increase in the distance from the center position.

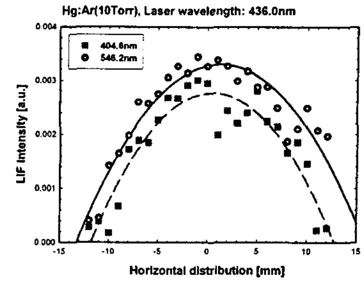

Fig. 5 Distribution of the plasma density at the horizontal axis of the discharge lamp

4. Conclusions

In order to investigate the resonance for the energy level of an atom or molecule based on the wavelength of 436nm, the results present the largest fluorescence signal at 436nm for the applied wavelength from 435.8nm to 436.2nm with an interval of 0.1nm. and the density of plasma increased when the relative density of atoms or molecules, which corresponded to 404.8nm ($6^3S_1 \rightarrow 6^3P_1$) and 546.2nm ($6^3S_1 \rightarrow 6^3P_2$), based on the wavelength of 436nm increased according to the increase in the applied power to the lamp. also, The laser induced fluorescence signal presents a constant value due to the saturation of the applied power exceeded by 2.6mJ for the wavelength of 404.8nm ($6^3S_1 \rightarrow 6^3P_1$) and 546.2nm ($6^3S_1 \rightarrow 6^3P_2$) while the power of the wavelength for the 436nm laser increased. and The partial distribution of the density of plasma for the horizontal axis using a LIF method decreased in the density of ions and neutral objects due to the reunion according to the increase in the distance from the center point.

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