Property of high-pressure Ar plasma induced by femtosecond laser

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A femtosecond laser is focused at high-pressure Ar gas up to 100atm. An electron density and an electron temperature of are respectively measured at the focal spot. Dense plasma with an electron density of the order of 10^{25} - 10^{26} m^{-3} at focal spot is obtained. The initial electron is produced by multiphoton ionization because the laser intensity at the focal spot reaches 10^{13}W/cm^2. The electron density is calculated by cascade ionization and two-electron three-body recombination. The calculated results under 10atm are lower than the experimental results, because this theoretical calculation does not include effect of multiphoton ionization.

1. Introduction

When a nanosecond excimer laser was focused at high-pressure Ar gas up to 150atm, property of laser-induced plasma had been investigated. The laser intensity at the focal spot reached 10^{11} W/cm^2. An electron density at focal spot reached order of 10^{26} - 10^{27} m^{-3}[1], and an electron temperature reaches 10eV[2].

When high-pressure Ar gas up to 100atm is irradiated by femtosecond laser, electron density and electron temperature of laser induced plasma at the focal spot are respectively measured.

2. Experimental arrangement

The experiment arrangement of electron density measurement is shown in Fig. 1. The titan sapphire femtosecond laser is operated with a single shot operation. A pulse half width is 100fs, a wavelength is 780nm and a laser energy reaches 100mJ. The laser power is controlled by the ND filter. Electron density is measured by Mach-Zender interferometer. The Ar-ion laser is used as a probe laser source. The peak time of interferometric signal is measured. It is difficult to find out a turning point of interferometric signal at which the electron density reaches a maximum. Therefore, the peak electron density is estimated by extrapolating the observed electron density up to the time at which laser pulse is terminated.

3. Experimental results and discussion

Dense plasma with an electron density of the order of 10^{25} - 10^{26} m^{-3} at focal spot is obtained. The theoretical calculation of electron density and experimental results are shown in Fig. 2. The initial electron is produced by multiphoton ionization because the laser intensity at the focal spot reaches 10^{13}W/cm^2. The electron density is calculated by cascade ionization and two-electron three-body recombination. The calculated results under 10atm are lower than the experimental results, because this theoretical calculation does not include effect of multiphoton ionization. We are planning to report the electron temperature at the focal spot in the conference.

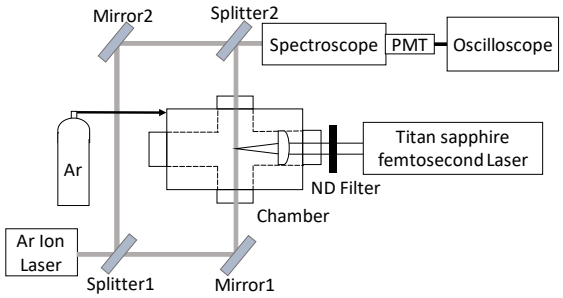

Fig.1 Experimental arrangement

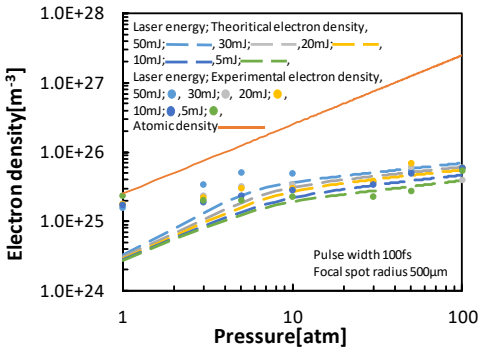

Fig.2 Electron density

4. References

[1] N.Tsuda, Y.Uchida, J.Yamada, Jpn. J. Appl. Phys., Vol. 36, Part 1, No.7B, (1997), pp.4690-4694.

[2] N.Tsuda, J.Yamada, Jpn. J. Appl. Phys., Vol. 38, No.6A, (1999), pp.3712-3715.