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150 kHz 帯大電力バースト型誘導性結合窒素プラズマの特性

Characteristics of 150 kHz Band High Power Burst Inductively Coupled Nitrogen Plasma

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Introduction

Inductively coupled plasma (ICP) has been widely used for plasma processing of materials such as deposition of film and etching because of its advantage [1]. A new ICP system using burst wave has been developed [2]. In this system, the frequency is set to 100-200 kHz, which is not necessary for the impedance matching circuit required in conventional ICP systems, and the high power can be delivered to the plasma. Therefore, high density plasma can be obtain in this system. In addition, the burst width and duty ratio can be freely set to optimize the process condition.

In this study, Electron temperature and plasma density in the high power pulsed ICP were estimated by numerical calculations based on calculated using global model. The results were compared those obtained by of double-probe measurement.

Experimental Setup

Figure 1 shows a schematic of the experimental apparatus. The vacuum chamber consisted of a cylindrical glass tube. The plasma source consisted of a solenoid coil (50 turns, length 70 mm, 83μH) wound on a glass tube. A capacitor (12 nF) was connected to the coil in parallel and was used to make a resonance circuit. The 400 μs wide high voltage burst pulses with frequency 157 kHz were generated using power supply (PS-1, PEKURIS KJ14-4873) and applied the solenoid coil to generate ICP. The repetition rate of the burst pulse is 25 Hz. nitrogen gases were supplied though mass flow controllers (SEC-400MK3 and SEC-E40MK3, HORIBA) into the chamber. Pressure inside the chamber is 2 Pa. Input power is in range of 6.4-8.5 kW. The electron temperature and ion density are measured using a double probe. The probe has two cylindrical stainless steel electrodes with a diameter of 0.4 mm and exposed length of 3 mm. The distance between the electrodes is 8.5 mm. The potential of the probe is varied from −40 to 40 V using a variable resistor and dc power supply. The probe current is measured by the current transformer (Pearson, Current monitor model 110A), where the tip of the probe is placed 45 mm from the solenoid coil center. The global model analysis is obtained by calculating the particle balance equation and the energy balance equation.

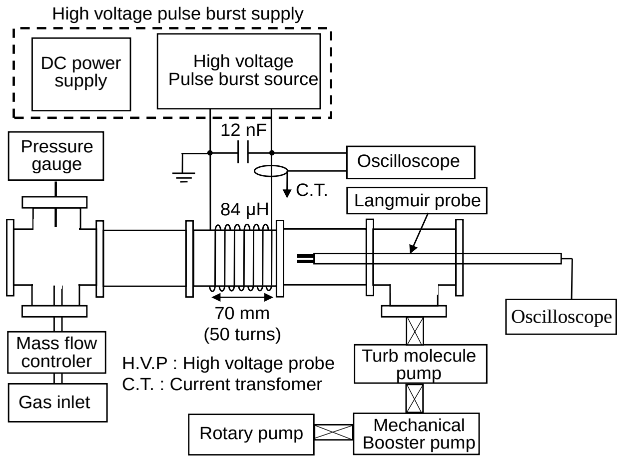

Fig. 1. Schematic of the experimental apparatus.

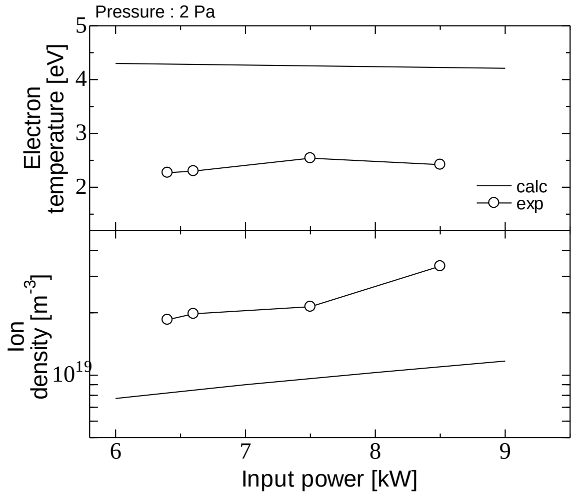

Fig. 2 Input power dependence of (a) electron temperature and (b) ion density.

Results

Fig. 2 shows the input power dependence of (a) electron temperature and (b) plasma density. The ion density increased with increasing input power. The electron temperature was almost independent of the temperature and plasma density shows that the calculated and experimental values have similar tendency with respect to the input power. The electron temperature is obtained as 2-4 eV. The plasma density is on the order of 10^{18}-10^{19} m^{-3}.

References

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