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Characterization of a linear helicon plasma device in convergent magnetic fields

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Helicon plasma sources [1], which utilize radio-frequency (rf) waves propagating in magnetized plasmas, can efficiently produce high-density plasmas above $n_e \sim 10^{19}$ m^{-3} for an rf power of a few kW. A typical helicon plasma reactor has a simple structure composed of just two distinct regions: a plasma source and a diffusion chamber. Due to the potential performance as a high-density plasma source, the helicon sources have attracted much interest in various practical applications such as an electric propulsion device called a helicon thruster [2, 3].

Researches on the helicon plasmas have been actively conducted over the last few decades. One of the most interesting issues is "the density limit" of the helicon discharges, as it is remarkably hard to produce high-density plasmas with a density greater than 10^{20}m^{-3}. The density limit has been considered to result from a neutral depletion phenomenon leading to a lack of fuel gas densities in the plasma core [4, 5]. Sustaining an extremely dense plasma of $\sim 10^{20}$ m^{-3} is an indeed challenging issue, which contributes to performance improvement of the helicon thruster because the thrust can be given by the electron pressure term and the electron diamagnetic effect [2].

In the previous studies, two helical antennas were employed to increase the deposited power and a maximum plasma density of 8×10^{19} m^{-3} has been obtained [5]. In this study, the effect of a magnetic field on helicon plasma densities is focused on and experimentally investigated.

The experiments are performed in the Heliex device shown in Figure 1(a) [ADD Ref. submitted]. The device mainly consists of a source tube, an about 1-m-long cylindrical vacuum chamber, and seven solenoid coils around the source tube and the chamber. Each solenoid has an independent DC power supply; hence the magnetic field configuration and strength can be controlled by adjustments of the solenoid currents. To avoid high heat load on the solenoids by large continuous currents, pulsed currents are applied to the solenoids. Figure 1(b) shows a circuit diagram of the pulsed solenoid current [6]. After capacitor is charged by a DC power supply, an IGBT gate signal is input and the IGBT is turned on; then the pulsed current flows to the solenoid. In this work, the capacitance is chosen as 37.6 mF and the peak value of the current applied to the solenoid is 60 A for the charging voltage of 300 V, giving the magnetic field strength of about 0.2 T. The densities are measured by a Langmuir Probe (LP) inserted from the downstream vacuum port as shown in Fig.1(a).

The results show the plasma densities nearly saturate for the high rf power due to the neutral depletion when increasing the rf power, while the maximum density can be increased by applying the strong magnetic field. The detailed results will be shown in the presentation.

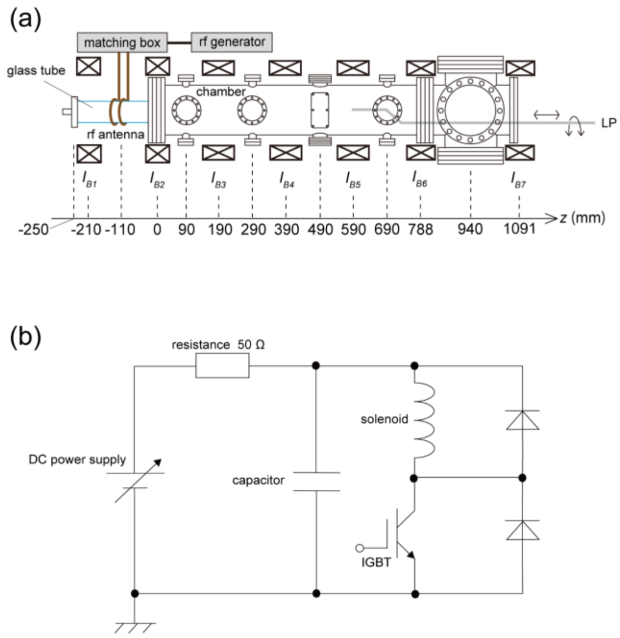

Figure 1. Schematic diagram of (a) the linear plasma device, (b) the switching circuit of the solenoid current [6].

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