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小型プラズマ源を用いた高域の高周波数印加による高密度プラズマ生成

Generation of High-Density Plasma by Applying Upper Region of Radio Frequency Using Small Plasma Source

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In recent years, a long-term space mission with a planetary probe has been carried out. It is important to extend an operation lifetime and make a larger thrust with a good efficiency in electric propulsion systems for further long-distance exploration. However, the lifetime of conventional electric thrusters is limited by a damage of electrodes contacting directly with a plasma. To solve this problem, we have proposed electrodeless plasma propulsion systems [1].

In addition, a miniaturization of the electrodeless thruster is also important to keep the total weight lighter, because the increasing of the payload brings a higher cost. Needless to say, this plasma thruster is promising in not only the electrical propulsion but also industrial application fields. However, characterization of a magnetized radio frequency (RF) plasma in a small diameter tube is not enough. In our previous the result [2], an electron density n_e is higher at RF frequency of 70 MHz than 7 MHz keeping RF power P_{RF} = 400 W. However, this investigation has been executed under a high Ar gas pressure (~ 1.6 Pa).

Therefore, we need to measure n_e by using the small electrodeless plasma source under the lower gas pressure (< 1 Pa) and the upper frequency (140 MHz) than conventional ones. In addition, we must take note of Electron Cyclotron Resonance (ECR) condition, which has been usually investigated at a frequency of 2.45 GHz [3].

In this paper, we have investigated the characteristics of small diameter magnetized plasma, using Small Helicon Device (SHD), as shown in Fig. 1 [4]. Here, a quartz tube, 20 mm in inner diameter, is connected to a vacuum chamber. A base pressure of the chamber is < 10^{-4} Pa. A single loop RF antenna, made of copper plate with 20 mm wide, is wound around the quartz tube. The magnetic field satisfying the resonance condition for the ECR of 50 G can be applied near the antenna region by a small electromagnetic coil. To measure n_e and light emission intensity, we have used a Langmuir probe and a wide-range spectrometer, Ocean Optics HR2000+, respectively, located on the same axial position on the RF antenna.

Figure 2 shows n_e under the antenna region vs. RF power P_{rf}. From this, n_e shows the highest value at a frequency of 140 MHz keeping P_{RF} = 100 W at a low gas pressure of 0.2 Pa. Detailed results will be shown in the presentation.

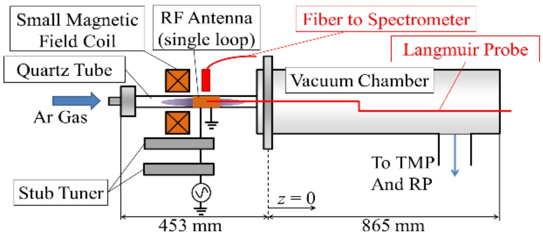

Fig. 1 Small Helicon Device (SHD).

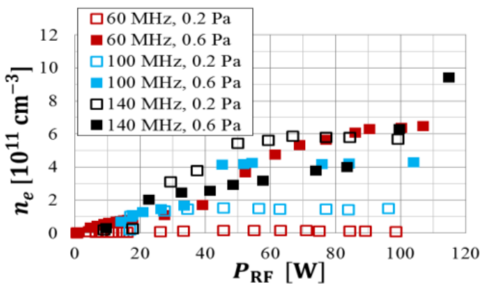

Fig. 2 Electron density n_e vs input RF Power P_{rf}.

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[4] D. Kuwahara *et al.*, *Rev. Sci. Instrum.*, **84** (2013) 103502.