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高密度ヘリコン源を用いた回転磁場法による無電極プラズマ加速
Electrodeless Acceleration by Rotating Magnetic Field Method Using High-Density Helicon Plasma Source

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An electric thruster is useful for a long-time mission such as a deep space exploration, because it has a high specific impulse. However, there is a problem of a short lifetime for the conventional electric thruster due to the direct contacts between a plasma and electrodes in a process of accelerating and/or generating a plasma. To overcome this problem, we have proposed a completely electrodeless electric propulsion system [1], using a high-density helicon plasma for a dense source, and employing a Rotating Magnetic Field (RMF) [2] method for plasma acceleration [1, 3].

RMF is generated by two opposing sets of coils, which have a phase difference of 90 degrees. If the angular frequency of RMF is in the range $\omega_{ci} < \omega < \omega_{ce}$, where ω_{ci} (ω_{ce}) is the ion (electron) cyclotron angular frequency, electrons rotate with RMF while the ions are unaffected, then j_θ is generated. Finally external radial magnetic field B_r and azimuthal current j_θ generate the Lorentz force F_z [1, 3]. Figure 1 shows a conceptual diagram of this scheme.

Figure 2 shows a setup of RMF coils on a Large Mirror Device [3] (LMD). A high-density plasma is generated by a radio frequency (rf) power P_{RF} of ≦ 3 kW with a frequency of 7 MHz in a tapered quartz tube. The RMF coils are located in a downstream region of an rf antenna, and a number of RMF coil turns is 5 with a size of 100 × 150 mm. Applied current of the coils I_{RMF} is ≦ 40 A_{pp} with a frequency of 5 MHz.

To investigate the influence of RMF on plasma performance, we have compared an ion velocity v_i and an electron density between the cases of w/ or w/o RMF in the downstream of RMF coils by a Mach probe. Here, RMF penetration into the plasma is important for the generation of j_θ [4], which needs a lower neutral pressure and the higher RMF. Figure 3 shows that v_i increased by increasing RMF coil current. Detailed results will be presented in this conference.

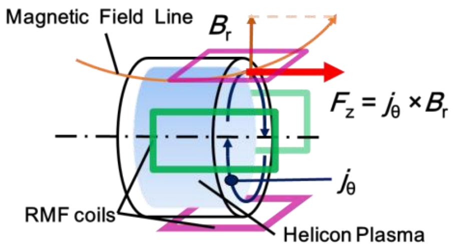

Fig. 1 Principle of RMF acceleration.

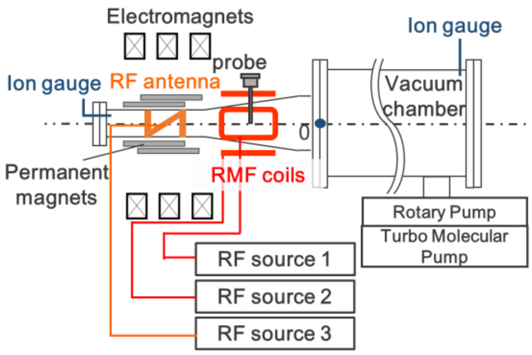

Fig. 2 LMD and RMF acceleration system.

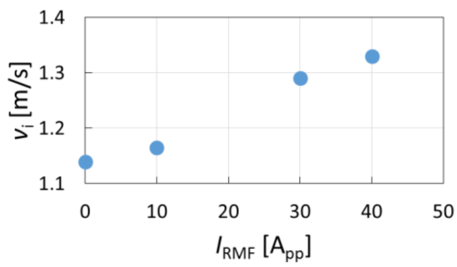

Fig. 3 v_i vs I_{RMF}.
[P_{RF} = 1 kW, radial (axial) position r (z) = 60 (-130) mm and Ar gas pressure = 0.098 Pa]

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[3] S. Otsuka *et al.*, Plasma Fusion Res. **10** (2015) 3401026.
[4] R. D. Milroy, Phys. Plasmas **6** (1999) 2771.