無電極磁気ノズルヘリコンプラズマスラスター

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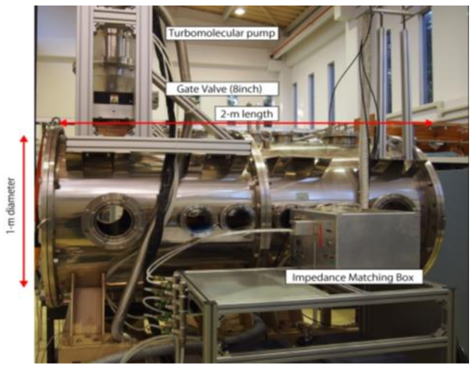
Over the past few decades, various electric propulsion devices such as ion gridded thruster, hall effect thruster, and magnetoplasmadynamic thruster have been developed and some of them have been successfully used in space. A new concept of an electrodeless plasma thruster called helicon thruster is recently investigated experimentally and theoretically, which consists of only an insulator source cavity and an expanding magnetic field (magnetic nozzle). The initial basic laboratory experiments have shown a spontaneous formation of a current-free double layer or ambipolar electric field; then the source ions are subsequently accelerated by the electric field [1]. The electrostatically accelerated ions are observed to be detached from the expanding magnetic field lines and collimated ion beams are detected at 10-20 cm downstream of the thruster exit [2]. Theoretical work suggests that the spontaneously formed electric field does not impart a momentum to the plasmas [3]; hence the thrust value itself does not correlate with the electric field formation, which has been experimentally confirmed by using a permanent magnet helicon double layer thruster, and an inductively-coupled plasma (ICP) thruster [4]. In the ICP thruster, the effect of the source cavity size on the imparted thrust has been investigated and well explained by an electron pressure term estimated from a global model. Theoretical and experimental studies on the magnetic nozzle have shown the additional component of the thrust, arising from the presence of the magnetic nozzle [5,6]. The performance improvement is also demonstrated by inhibiting a cross-field diffusion and the resultant significant contribution of the magnetic nozzle term [7].

Based on the above-mentioned and other previous works, improvement of the thruster performance of the helicon plasma thruster is progressed, where the key issue to improve the performance might be the source cavity size (source efficiency) and the plasma expansion in the magnetic nozzle. Experiments are performed within a 1-m-diameter and 2-m-long vacuum chamber (Mega-HPT), which is evacuated by 3000L/s turbomolecular pump. The thruster head is attached to a pendulum thrust balance installed inside the chamber. The two different diameter (24-mm and 80-mm inner diameter) source cavities are used and the imparted thrust is assessed for the rf power of ~1kW and argon propellant. The higher thrust value of ~20mN is obtained for the larger source cavity and a highest magnetic field strength (~1kGauss), while the thrust imparted for the smaller diameter cavity is only several mN. Hence it is demonstrated that the source cavity size significantly affects the thruster performance. Furthermore, the rf power is increased up to ~6 kW in the present experiment; then the highest thrust value of 60 mN can be obtained. As the thrust efficiency is still 10-15 %, further development will be required. In the presentation, the results will be presented and would like to discuss on “how we can improve the performance” with your plasma physics insights.



Photograph of the Mega-HPT vacuum chamber

I would like to thanks to wonderful master course students (K. Oguni, T. Sasaki, Y. Igarashi, Y. Itoh, K. Suzuki, T. Suzuki, K. Miyamoto, D. Dato, and A. Chiba) working with me in Iwate University (2007-2013) and Tohoku University (2013-).

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