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Experimental Identification of Azimuthal Induced Current and Ion Acceleration in an Inductive RF Plasma Thruster

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Electrodeless plasma thrusters (EPTs) are of interest in the electric propulsion community. EPTs can dim inish the erosion of the electrodes which is one of t he most difficult problem for the conventional plasm a thrusters, e.g. Hall effect thrusters and ion thruster s, to prevent, which leads longer lifetime of the pro pulsion system than that of the existing one. The ba sic electrodeless plasma thrusters have a cylindrical source tube made of glass and accelerate plasmas al ong axial direction toward the open source exit[1].

A variety of combinations of the plasma production and acceleration mechanisms have been proposed[2–5]. Some of the electrodeless thrusters utilize the electr omagnetic acceleration. The features of the accelerati on are the inductive production of azimuthal current loop/sheet j_θ via an external coil and the plasma a cceleration by axial Lorentz force $f_z = j_\theta B_r$. Pulsed inductive thrusters (PITs)[6] produces Townsend-like di scharge plasmas and accelerate them electromagnetic ally. Faraday Acceleration with Radio-frequency Assi sted Discharge (FARAD)[7] employed rf discharge as pre-ionization to lower the necessary high voltage fo r PITs to ionize propellant gas.

In order to suppress the plasma loss to the wall of the FARAD, Radio-frequency Inductive Accelerator with Low-aspect-ratio Plasma (RIPAL)[8] employs rf d ischarge for plasma production and acceleration in th e same region. In addition to that, it accelerates plas ma utilizing low-frequency (O(10-100 kHz)) divergin g magnetic field instead of pulsed diverging magneti c field aiming the improvement of propellant utilizat ion efficiency. Thrust measurements with a target-typ e thrust stand showed the thrust-to-power ratio of th e RIPAL of ~1.5 mN/kW. It is considered the physi cal insight of the electromagnetic acceleration proces s and resultant momentum transportation give the ke y to develop the RIPAL and the other electromagnet ic electrodeless plasma thrusters. However, the plasm a acceleration mechanisms on the RIPAL have not b een understood enough yet.

In the present study, the spatiotemporal distributions of azimuthal induced electric current j_θ and radial magnetic field B_r were obtained by B-dot probe (B P) measurements. The distributions of the azimuthal currents correspond to the azimuthal electric field, in dicating the current formation is mainly derived by t he electric field. With the induced current measurem ents, the plasma acceleration process was investigate d by the measurements of the spatiotemporal distribu tions of ion saturation currents of a rf-compensated Langmuir probe (LP). It was found that the relations hip between the azimuthal current formation and res ultant plasma acceleration. Moreover, it clearly show ed the applied static magnetic field have a great infl uence on the mechanisms of plasma acceleration.

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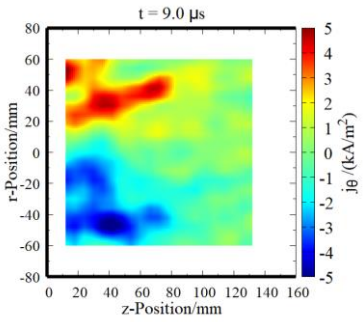

Figure 1. Azimuthal induced current distribution measured by the BP.

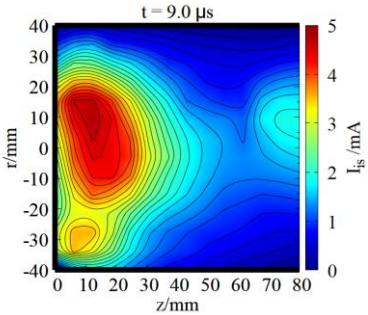

Figure 2. . Measured ion saturation current of the LP.