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Title

Optimization of Wave-Plasma Interaction in RF Powered Propulsion Technology based on Ultra-Compact Helicon Reactor

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Abstract

The emergence of new space business models imposes a high level of competitiveness driven by reliability, performance, cost and flexibility for the electric propulsion systems. Relevant strategic applications such as Earth Observation under 250 km (VLEO), Space Exploration, Telecommunication, Human Spaceflight require innovative propulsion technologies able to generate a certain thrust level at high specific impulse during an extended operational time, while being compact, light and efficient. To overcome the drawbacks related to the most mature electric propulsion technology such as IEs or HETs, COMOTI and ESA in the framework of the GSTP De-Risk Program explored the potential of a disruptive RF Powered Propulsion Technology based on helicon discharges with the strategic goal to advance the development of a new cost-effective generation of Space Transportation System. Based on this, a family of ultra-compact Helicon Plasma Thrusters can be derived, enabling new space market such as large constellation in LEO-MEO and air-breathing satellites in VLEO.

The Helicon Plasma Thruster couples a radiofrequency magnetized cylindrical plasma source based on multipole magnetic confinement system and a magnetic nozzle acceleration stage. The current prototype is composed of a discharge chamber where plasma is generated, an m=+1 mode RF antenna and a magnetic nozzle. The RF power is transferred to the antenna through a RF Generator and a Matching Box that adapts the RF power to the plasma electromagnetic behavior. In the thruster`s first stage a cold and dense argon plasma is generated through a stochastic RF - electron interaction at a representative frequency of 13.56 MHz. To provide the required environment for both excitation of the propagating electromagnetic wave and for radial plasma confinement in the helicon reactor, it is involved a multipole magnetic confinement system based on a set of 8 plate-shape NdFeB permanent magnets displace in alternating rows of north and south pole along the confinement tube.

This scientific paper is devoted to study the coupled effect of the m=+1 half-wavelength Right Helical Antenna and Nagoya Type III and of the static magnetic field intensity on power absorption in the first stage of the HPT. In order to maximize the power deposited into the helicon reactor, several m=+1 RF antennas of different architectures and lengths have been tested in relevant laboratory conditions in both Continuous Wave Mode and Pulsed Wave Mode within $50 \div 500W$ power range. It is demonstrated that half-wavelength Right Helical Antenna produces non-axisymmetric RF energy coupling, which generates higher electron density than the Nagoya Type III antennas. Since the propulsive matrix is related to the wave-plasma coupling by the RF antenna, the actual combined numerical-experimental research improved the prediction/assessment of a high argon plasma density within the HPT. Alongside, this study summarizes

the various performance parameters of the propulsion system along a discussion of ongoing research and future roadmap.

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