5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Concept of SUb-atmospheric Radio-frequency Engine (SURE) for Near-Space Environment

Xiaogang Yuan[1,2], Lei Chang[1,2*], Xinyue Hu[3], Xin Yang[1], Haishan Zhou[1,2] and Guangnan Luo[1,2]
[1] Institute of Plasma Physics, HFIPS, Chinese Academy of Sciences
[2] Graduate Island of Sciences, University of Science and Technology of China
[3] School of Aeronautics and Astronautics, Sichuan University
e-mail (speaker): lei.chang@ipp.ac.cn

Near space, with typical altitude from 20 km (Armstrong line) to 100 km (Karman line) and pressure in the range of 32~5332 Pa, lies in the region between conventional aviation and aerospace. It has been attracting great attention recently for civil and military explorations due to certain advantages, such as persistent intelligence, surveillance, reconnaissance, long endurance, beyond line of sight communication, and low-cost access to space-like performance. Propulsion system plays the most critical role for high-altitude aircraft and low-altitude satellite in this space, in terms of long-duration flight and gesture control. However, conventional aeronautic propulsion schemes, including turbine and propeller, cannot work efficiently because of low-density atmosphere, and present astronautic propulsion schemes, such as electric thrusters, neither are suitable due to high power consumption for ionization and excessive aerodynamic drag.

In this work, we propose a novel concept of RF plasma thruster (named SURE for SUb-atmospheric Radio-frequency Engine) that can ionize the filling air efficiently for the entire pressure range of 32~5332 Pa in near space. There is no plasma-facing electrode, yielding long life and high efficiency, and does not require an external magnetic field so that can be structurally compact and light. Moreover, it is an air-breathing system that does not need to bring propellant as traditional electric thrusters do in aerospace and, thus, can further extend the lifespan. In principle, SURE can work permanently using the efficient and unlimited solar energy in near space. Hence, this concept is a very promising candidate for near-space propulsion. Please note that this is the first phase of SURE, namely, a concept proposal, and will be followed by the second phase of prototype test.

Fig. 1 shows the typical discharges driven by single (one-leg) and dual (two-leg) antennas. The filling pressure is 200 Pa, and the input power is around 800 W. We can see that the discharge for dual antennas is much brighter than that for single antenna, implying higher plasma density; in fact, the measured plasma density is nearly two-order higher: (left) 3.99×10^{16} m^{-3} for 890 W (2.94 eV) and (right) 1.33×10^{18} m^{-3} for 800 W (2.48 eV). Moreover, the discharge has an axial preference regarding the middle of dual antennas (from discharge images), which labels the acceleration feature of the second leg. This axial preference will be further quantified by adding a Langmuir probe from the other end of the tube in our following experiment. The influences of the number of coils and background pressure on discharge are shown in Fig. 2.

References

[1]. X. Yuan, et al., IEEE Trans. Plasma Science 48(12): 4326-4330, 2020.

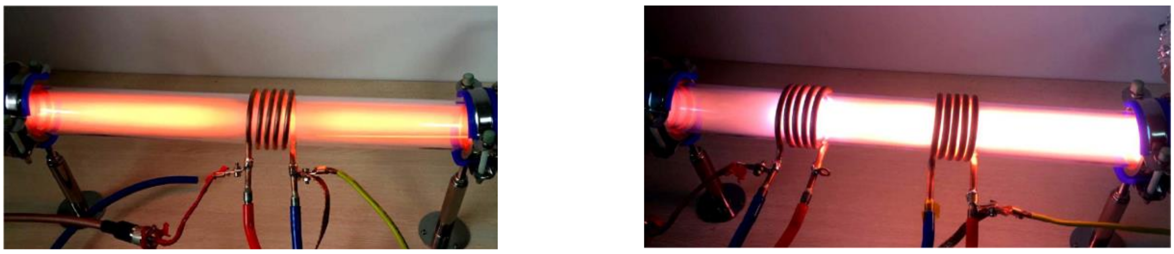

Fig. 1 Typical discharges driven by single (one-leg) and dual (two-leg) antennas.

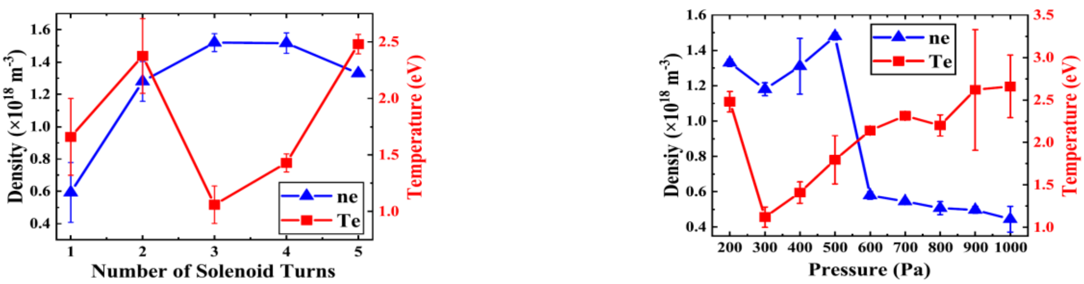

Fig. 2 Influences of the number of coils and background pressure on discharge.