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Generation and measurement methods for neutral gas beam using supersonic gas puffing

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A radio-frequency (RF) plasma thruster has been proposed as a long-life and high-thrust thruster, e.g., [1,2]. Here, a helicon plasma, which is well known as an efficient high-density plasma generation method, is a type of RF plasma with a magnetic field. It has a potentially long lifetime, since an RF excitation antenna, wrapped around the outer side of the insulation tube, does not directly contact the plasma.

Here, new gas feeding methods have been newly proposed to increase the thrust performance of the RF plasma. Figure 1 shows concepts of conventional and proposed type RF plasma thrusters. In conventional methods, the propellant neutral gas is supplied via the upstream of a discharge tube, causing uniform neutral distribution. On the other hand, the proposed methods aim to supply the gas into the central generation region of the plasma. The main objective of this method is to mitigate the depletion of neutral particles in the high-density plasma core. The depletion phenomenon may limit the maximum central electron density [3,4]. Therefore, since the plasma thrust is proportional to the electron density, to increase the higher density is crucial in getting better plasma performance.

The proposed method, a supersonic gas puffing (SSGP) method, uses a concentrated narrow gas beam generated by the Laval nozzle and a high-pressure gas [5]. This method can supply the neutral particle in a center region where the neutral depletion occurs. This method was originally developed as a fuel gas supply method for a magnetically confined fusion plasma field. However, if the amount of gas and the beam profile can be controlled more widely, it is expected to be applied to many areas of plasma science and industry. In order to utilize this method, it is important to evaluate as well as generate the gas beam. Since there is no commercially available vacuum gauge which can measure low pressure (~ Pa) and high spatial resolution (~ mm), we have developed several measurement methods such as a compact Pirani gauge [2], a schlieren method and shadowgraph method. The latter two methods are optical imaging measurements using a high-speed camera with high spatio-temporal resolution. Figure 2 shows preliminary results of the schlieren method. In low background pressure case (b), concentrated gas plume was observed.

In the presentation, detail of the SSGP method and its measurement methods will be shown.

References

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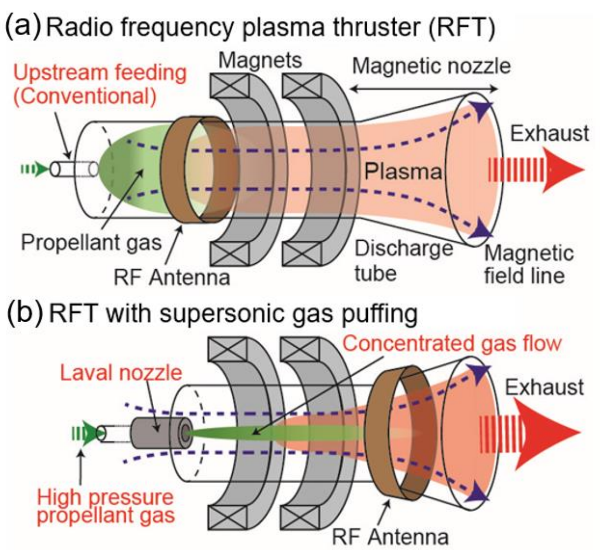

Fig. 1 Concepts of radio frequency plasma thruster. (a) typical gas feeding, (b)supersonic gas puffing method.

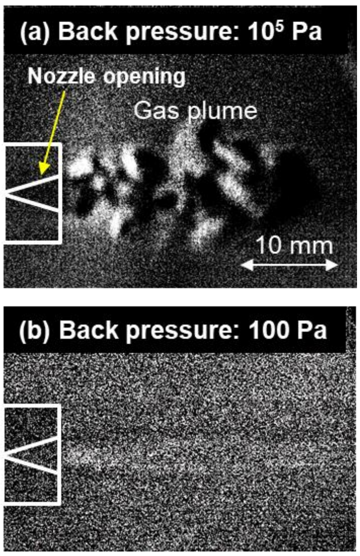

Fig. 2 Images of Schlieren method. Feeding pressure: 6 MPa, nozzle throat: 0.1 mm. Exposure time: 0.1 ms.