

ヘリコンプラズマにおける中性粒子挙動  
**Neutral particle behavior in helicon plasma**

桑原大介<sup>1)</sup>, 篠原俊二郎<sup>1)</sup>, 島田智広<sup>1)</sup>, 谷田佑莉子<sup>1)</sup>, 宮澤順一<sup>2)</sup>  
 D. Kuwahara<sup>1)</sup>, S. Shinohara<sup>1)</sup>, T. Shimada<sup>1)</sup>, Y. Tanida<sup>1)</sup>, and J. Miyazawa<sup>2)</sup>

1) 農工大工, 2) 核融合研  
 1) TUAT, 2) NIFS

Most practical electric thrusters have a lifetime problem coming from a damage of electrodes directly contacting with a plasma. A helicon plasma thruster has been proposed as a long lifetime thruster, because it works without any contact electrodes. Therefore, it has a potential to become a main thruster for a deep space explorer, which requires high-thrust and high-specific impulse. Authors have been promoting the Helicon Electrodeless Advanced Thruster (HEAT) project [1] that uses the helicon plasma for generating a source dense plasma, and electromagnetic forces for accelerating the source plasma to gain the enough thrust and specific impulse.

In thruster studies, a neutral particle, e.g., H<sub>2</sub>, Ar, and Xe works as a fuel gas. In most cases, these gases are supplied to a discharge tube by the use of a simple nozzle, and a supplying pressure is low. Therefore, the neutral particle fills a discharge tube homogenous. However, there are two problems in this configuration. First, there is a limitation of an electron density increase, due to a neutral particle depression in the center axis of the high-density helicon plasma [2]. This limitation reduces the thrust performance directly. Second, the high-density plasma causes an erosion of discharge tube wall. For the future MW class thruster, such as a main thruster of a human mars explorer, this problem becomes serious because the particle and heat fluxes of the plasma will increase drastically. Here, in a field of magnetically confined fusion plasma science, there is an advanced neutral particle fueling method named a supersonic gas puffing (SSGP) [3]. This method uses a concentrated sharp gas beam by injecting a high pressure gas via the Laval nozzle, in order to achieve a deep penetration length in the fusion plasma compared to the conventional gas puffing.

To solve above-mentioned problems, we have proposed a supersonic gas puffing system for the high-density helicon plasma. By the use of the SSGP along the center axis of the helicon plasma, the depression of neutral particles in the central

region will improve. In addition, a number of neutral particles near the wall of the discharge tube will be clearly decreased, causing an electron density decrease, which suppresses the wall damage.

In this paper, we have carried out preliminary studies of the helicon plasma generation using SSGP. First, we have to estimate and compare behaviors of the neutral particle using the SSGP with those with the conventional gas puffing. We have developed a Schultz type ionization gauge which can measure a pressure even in the high pressure range (~100 Pa). Since the size of this gauge is quite small, three dimensional distribution of the neutral particle density can be measured by scanning of its position. Figure 2 indicates a nozzle which is developed in this study. The nozzle is installed in a vacuum chamber of Large Mirror Device, an inner diameter of 445 mm and an axial length of 1,700 mm. This chamber is evacuated by two turbomolecular pumps, and the background pressure of the chamber is  $\sim 5 \times 10^{-4}$  Pa. The injection of a neutral gas is controlled by an electromagnetic valve, and an opening time is set around 1 ~ 10 ms.

In the presentation, we will show characteristics of the neutral particle density distribution by the use of the SSGP. In addition, preliminary results of characteristics of the helicon plasma fueled by the SSGP will be presented.

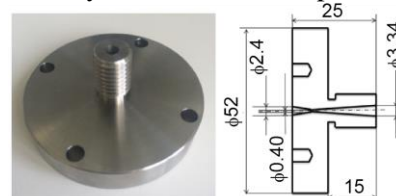


Figure 1 SSGP Nozzle.

- [1] S. Shinohara *et al.*, IEEE Trans. Plasma Sci. **42** (2014) 1245.
- [2] A. Fruchtman, Plasma Sources Sci. Technol. **17** (2008) 024016.
- [3] A. Murakami *et al.*, Plasma Fusion Res. **5** (2010) S1032.