23Ap08

直線型 ECR プラズマ装置 NUMBER におけるプラズマの高密度化
Improvement of plasma density in linear ECR plasma device NUMBER

矢ヶ崎 誇楠，岡本 敦，藤田 隆明，杉本 みなみ，樋口 舜也，小池 宗生，馬 洋一
Konan YAGASAKI, Atsushi OKAMOTO, Takaaki FUJITA, Minami SUGIMOTO, Shunya HIGUCHI, *et al.*

名大院工
Nagoya Univ.

1. Introduction

It is considered that heat flux flowing into divertor target will exceed its tolerance in fusion reactors. Handling of heat flux into divertor target will be one of the significant issues for implementation of fusion power plants. To decrease heat flux, plasma detachment from divertor target is considered as one of the good solutions and is investigated in many linear plasma devices. It is realized that volumetric recombination, which becomes more active in high electron density n_e and low electron temperature T_e, is required for the detachment.

We have started experiment of plasma detachment in a linear plasma device NUMBER. Plasma in NUMBER is made by electron cyclotron resonance heating (ECRH) for simulating non-equilibrium and anisotropic plasma in divertor. However, plasma detachment has not been achieved yet in ECR devices while it has been done in many DC-arc discharge devices. It is considered that electron density in NUMBER is still low to realize detachment, and therefore improvement of plasma density is needed.

2. Setup

The schematic of ECR linear plasma device NUMBER is shown in Fig. 1. The vacuum vessel is about 2.5 meters long and 0.2 meters in diameter. It is composed of three regions: production region, test region (divertor-simulating region) and ion source chamber. Plasma is produced by ECR, with 2.45 GHz microwave, with the maximum power of 6 kW. Helium, hydrogen and argon are available for experiment. These gases are supplied in production region through a mass flow controller and exhausted by two pumps. We can control gas pressure and microwave power as parameter. There are two orifices, and there is an end plate at $z = 2.0$ m.

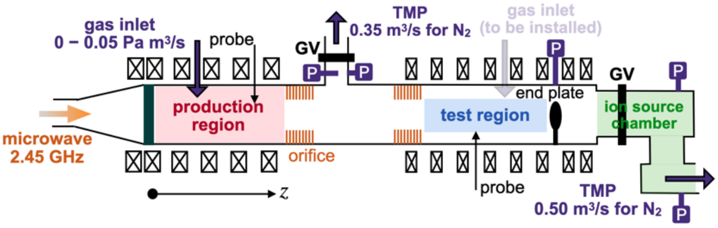

Fig.1 The schematic of NUMBER. Vacuum gauges are installed at the position indicated by [P].

3. Results

As controlling experimental parameters, we measured electron temperature and density in both production and test region. As shown in Fig. 2, when helium gas pressure $p = 0.40$ Pa and incident microwave power $P = 6$ kW, $n_e = 4.0 \times 10^{17}$ m^{-3} and $T_e = 3$ eV are achieved in test region. When the pressure is higher than this condition, electron density in test region decreases due to enhancement of radial diffusion. Though the condition of the microwave power and pressure are as good as achievable, electron density is much lower than other linear devices which have achieved plasma detachment, while electron temperature is low enough[1].

One of the keys to improve electron density is absorption efficiency of incident microwave. Now, efficiency is just 50 % and almost half of wave is reflected. Because microwave is linearly polarized, which is mixture of right- and left-handed circularly polarized wave fifty-fifty. Right-handed wave is the mode which is well absorbed by plasma. Hence, we made right-handed circularly polarized wave exciter to change incident mode of microwave and improve absorption efficiency. It is expected that electron density will increase.

Relatively high pressure is required to realize plasma detachment in test region, but it might badly affect production of plasma. Therefore, controlling pressure distribution is also essential to improve electron density and neutral density in test region. By installing two orifices in NUMBER, pressure in production region became more independent from that in test region as shown in Fig. 3, and the conductance between two regions is decreased almost 90%. Now additional puff at test region is planned, which will enhance volumetric recombination more, and improve electron density.

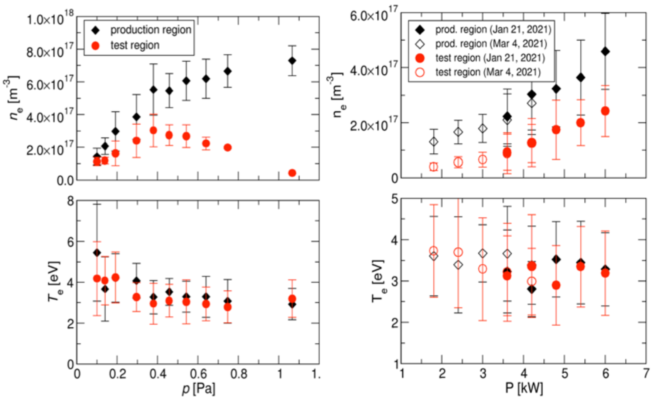

Fig.2 n_e and T_e as functions of helium gas pressure p (left) and incident microwave power P (right) in NUMBER.

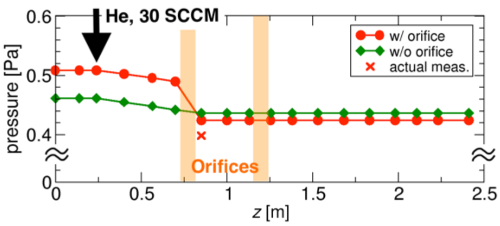

Fig.3 Pressure Distribution in NUMBER. X represents experimental measurement at [P] on $z = 0.85$ m in Fig. 1.

The work is supported by JSPS KAKENHI Grant Numbers JP19H01869, JP20H01883 and by Hibi Science Foundation.

[1] N. Ohno, Plasma Phys. Control. Fusion **59** (2017) 034007