High-density plasma production with ICRF heating in the anchor cells on GAMMA 10/PDX

S. Sumida, M. Ichimura, S. Jang, M. Hirata, R. Ikezoe et al.

Department of Nuclear Engineering, Kyoto University

High-density plasma production is one of the critical issues of tandem mirror devices and is required for extending operation regimes of a divertor simulation experiment which has been implemented on GAMMA 10/PDX. Ion Cyclotron Range of Frequency (ICRF) heating builds up plasmas in minimum-B anchor cells which keep the Magneto-Hydro-Dynamics (MHD) stability. Two Nagoya Type-III (Type-III) antennas in the central cell and two Double Arc Type (DAT) antennas in both anchor cells are used for effective heating of the anchor-cell plasmas. The line density in the east anchor cell increases more than tenfold typical one at the maximum \(4.0 \times 10^{14} \text{ cm}^{-2}\) by appropriate control of the phase difference between a Type-III antenna and a DAT antenna on east side with additional gas injections. Simultaneously controlling both east and west phase differences for effective heating of the both anchor-cells plasmas, we have succeeded in producing high-density plasmas in the both anchor cells. The line density in the anchor cell on a lower-density side has reached \(1.4 \times 10^{14} \text{ cm}^{-2}\). As the results, we have obtained the higher-density plasmas \(4.4 \times 10^{12} \text{ cm}^{-3}\) than typical one \(2.0 \times 10^{12} \text{ cm}^{-3}\) in the central cell. We have believed that one of possible mechanisms of the high-density plasma production in the central cell is a formation of positive potentials in the both anchor cells [1].

Figure 1 shows the potentials in the central cell \(\phi_c\) and in the anchor cells on the lower-density side \(\phi_A\) and axial confinement potentials \(\phi_e = \phi_A - \phi_C\) as a function of the anchor ICRF heating power with the DAT antenna in the anchor cell on the lower-density side. The \(\phi_C\) is measured with a gold neutral beam probe. We have assumed the potential measured with ion energy analyzers at the end regions indicates the anchor potential \(\phi_A\) since the most of ions toward the end regions overcome the potential in the anchor cell.

The \(\phi_e\) becomes larger as the anchor ICRF power increases, and is estimated to be larger than axial potential differences from the Boltzmann relation. It is considered that one of possible mechanisms of the difference between the \(\phi_e\) and the Boltzmann potential differences is electron pumping due to \(\vec{E}_z\) of the ICRF waves [2]. We will analysis \(\vec{E}_z\) profiles by using TASK/WF as a full wave code.

Fig. 1. \(\phi_A\), \(\phi_C\) and \(\phi_e\) as a function of the anchor ICRF heating power with a DAT antenna.

Acknowledgments

This work was partly supported by the bidirectional collaborative research program of the National Institute for Fusion Science, Japan (NIFS15KUGM100 and NIFS14KUGM086).