7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Evaluation of Electrode Potential and Heat Load of a Cascade Arc Discharge for Realization of High Density Hydrogen Plasma Discharge

R. Miyauchi, N. Ezumi, T. Seto, T. Okamoto, K. Takanashi, S. Takahashi, K. Kouno, H. Kawahara, S. Togo, Y. Nakashima, M. Sakamoto
Plasma Research Center, University of Tsukuba, Tsukuba, Japan
miyauchi_reina@prc.tsukuba.ac.jp

A DEMO reactor design is underway in Japan as the next step after ITER. The design of the crucial divertor for realizing the DEMO is intended to be carried out using simulation codes. However, it is anticipated that the DEMO divertor will experience a higher heat load and more complex physical phenomena compared to ITER, necessitating an improvement in the accuracy of the simulation code. Simulation experiments using linear devices have contributed to enhancing the accuracy of the simulation code. Nevertheless, the current linear device cannot conduct DEMO-class divertor simulation experiments. We are currently constructing a new linear-type device called the "Pilot GAMMA PDX-SC (Pilot Device)", aiming to generate steady-state, high-density plasma equivalent to a DEMO reactor divertor. The Pilot device has two superconducting coils, generating a steady magnetic field of up to 1.5T. The Pilot device uses a plasma source that employs a hot cathode arc discharge to generate steady-state high-density hydrogen plasmas.

The plasma source consists of a LaB_6 cathode with 150 mm in diameter, a copper anode, and five intermediate floating electrodes. These electrodes designed along the magnetic field lines generated by superconducting coils contribute to the large diameter plasma. Using a large-diameter cathode matched to the magnetic field lines enhances the thermal electron emission performance of the cathode. It contributes to the generation of high-density plasma. So far, the first plasma was generated in October 2022 (Figure 1). In this case, argon and hydrogen plasmas were successfully generated with densities of $1.5 \times 10^{19} \mathrm{m}^{-3}$ and $0.8 \times 10^{19} \mathrm{m}^{-3}$ at the magnetic throat, respectively. However, the hydrogen plasma generated by hot cathode arc hydrogen discharge was unstable and difficult to achieve higher density. Understanding the discharge characteristics is important for achieving steady-state high-density hydrogen plasmas. To evaluate the potential structure and heat loss inside the plasma source related to the optimization of hydrogen discharge, the potential of each discharge electrode and the heat load on each electrode and component were measured. As shown in Figure 2, the electrode potentials were measured as the floating potentials of the intermediate electrodes and the cathode vessel. Each electrode and component heat load were evaluated by the calorimetry method based on the flow rate of the cooling water and its temperature change. This presentation will explain the evaluation results of electrode potential and heat load to the electrode and component during discharge, comparing the relationship with discharge characteristics.

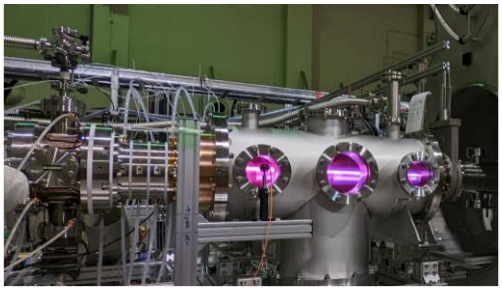

Figure 1 The first plasma in Pilot GAMMA PDX-SC (Hydrogen plasma)

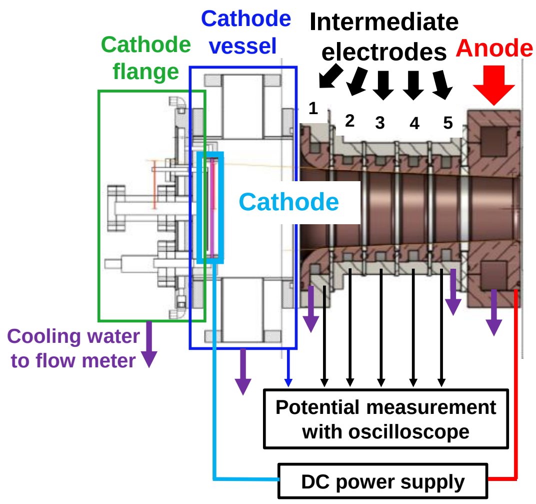

Figure 2 Cross-sectional view of the hot cathode DC arc plasma source

This work was partly supported by NIFS Collaboration Research program (NIFS20KUGM148, and NIFS23KUGM174)