

Study of plasma window for larger aperture

N. Ikoma,^{*1,*2} T. Kikuchi,^{*2} H. Kuboki,^{*3} H. Hasebe,^{*1} H. Imao,^{*1} T. Nagatomo,^{*1} H. Okuno,^{*1}
and O. Kamigaito^{*1}

Many applications in accelerator-based science are expected of the plasma window (PW) that can work as the interface between the vacuum and the high pressure region. It can be used for the efficient confinement of helium or hydrogen gas in beam line for electron stripping¹⁾ or used as beam windows in high-power target system. The Small aperture, however, is one of the key issues for the PW that needs to be overcome. The first PW invented by Ady Hershcovitch in 1995²⁾ had an aperture of 2.3 mm. We started its development with the help of Ady Hershcovitch.³⁾ Now, its aperture has been enlarged up to 6 mm in diameter. For further enlargement, we studied the dependence of PW performance in the condition of different lengths of the PW.

PW consists of three cathodes with thoriated tungsten tip, cathode housing, five insulated cooling plates, and an anode plate (Fig. 1). They are made of 99.9999 % oxygen-free copper (OFC) because of its high thermal conductivity. Each part has internal channels for water cooling.

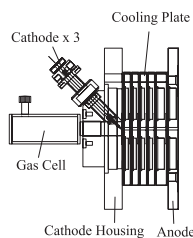


Fig. 1. Schematic of Plasma Window.

First, we measured the pressure reduction factor i.e., the ratio of vacuum chamber pressure to gas cell pressure, and applied voltage with different numbers of the cooling plates from one to seven (Fig. 2). In this experiment, we used He gas. The current and flow rate were 36 A/cathode and 17.1 slm, respectively. 12 cooling plates and 140 V are required to obtain the factor 100 by extrapolation. We will evaluate the contribution of the plasma length to the pressure reduction factor from the difference between the measured pressure reduction factors with and without plasma.

Second, we measured the pressure reduction factor in the condition of 12 A \times three cathodes and 36 A \times one cathode (Table 1). This experiment was carried out using Ar gas because we could not ignite PW by He under a small current such as 12 A. Its flow rate was 9.9

slm. We obtained the higher pressure reduction factor than He gas. In addition, The condition of 12 A \times three cathodes has a higher pressure reduction factor because plasma fills in the cooling plates uniformly. In addition, we can reduce the load per one cathode to increase the number of cathodes.

Plasma spectroscopy on the plasma in PW under various conditions is on-going (Fig. 3). We will obtain their physical quantities such as temperature and density of free electron in the plasma to discuss the optimum condition for an aperture larger than 1cm.

This project is supported by the IMPACT Fujita program.

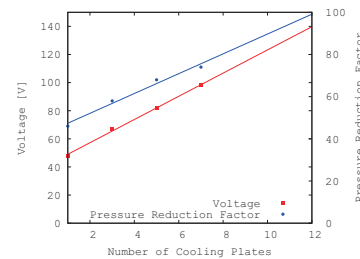


Fig. 2. Dependence of voltage and pressure reduction factor on the number of cooling plates.

Table 1. Number of cathodes and pressure reduction factor.

Current \times Cathode	Pressure Reduction Factor
12 A \times 3	133
36 A \times 1	122

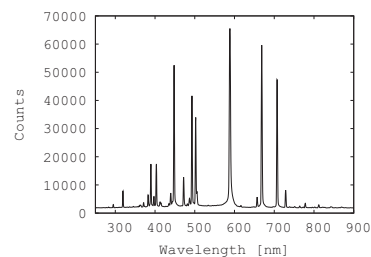


Fig. 3. Spectrum of He plasma.

References

- 1) H. Okuno et al., Phys. Rev. ST Accel. Beams **14** 033503 (2011).
- 2) A. Hershcovitch, J. Appl. Phys. **78**, 5283 (1995).
- 3) H. Kuboki et al., J. Radioanal. Nucl. Chem. **299**, 1029 (2014).

^{*1} RIKEN Nishina Center

^{*2} Department of Nuclear System Safety Engineering, Nagaoka University of Technology

^{*3} High Energy Accelerator Research Organization