Pressure measurement of plasma window with large diameter

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The plasma window (PW),[1] which separates a vacuum from an atmosphere by an arc plasma filling the discharge channel, is a novel beam window technology. It has several applications in an accelerator system such as a gas charge stripper[2,3] for a heavy ion accelerator or a beam window for an accelerator-driven subcritical reactor (ADS).[4] In addition, a target system using PW has been proposed in the ImPACT Fujita program[5] for the transmutation of long-lived fission products (LLFP) into a stable or short-lived nuclei. However, the small diameter of PW is a crucial problem for these applications. The first PW invented by Hershcovitch,[1] with an aperture of 2.36 mm, aimed at electron beam welding in an atmosphere. However, the beam spot size in our intended case is several tens of millimeters or more. Therefore, to implement the PW in the accelerator system, its diameter needs to be enlarged. Furthermore, an investigation of the relation between confinement pressure and diameter is also important to predict the performance of PW for various purposes. Therefore, we have developed a PW with large diameter in reference to a PW designed by Namba *et al.*[6] In a previous study,[7] we reported the performance of a PW with a diameter of 10 mm. After that, we systematically measured the pressure by varying the diameter from 6 to 20 mm. In this study, the preliminary results of pressure measurement have been reported.

The experimental setup is shown in Fig. 1. Argon gas was introduced from the upstream of the PW. It was then exhausted by two mechanical booster pumps (Edwards, EH 500, the exhaust speed of each pump was approximately 100 L/s). Three DC power supplies (TDK Lambda, ESS-400-37-2-D) were connected in parallel between the cathode and anode, and an arc current of 100 A was supplied. The discharge voltage was monitored by a data logger (KEYENCE, NR-600). The gas flow rate was maintained at 20 L/min by the mass flow controller (MKS Instruments, 1579 A) and both upstream and downstream pressures, P_1 and P_2, were measured.

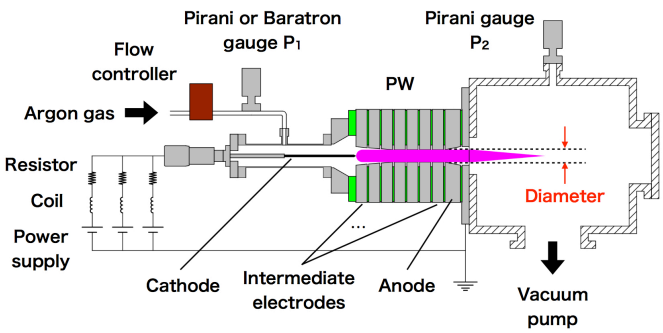

Fig. 1. Experimental setup.

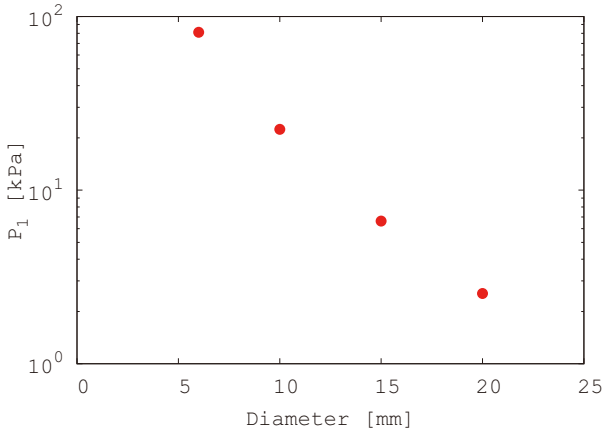

Fig. 2. Dependence of P_1 on the diameter of PW.

Figure 2 shows the upstream pressure P_1 on each diameter, which decreased with an increase in the diameter of PW. P_2 was maintained at approximately 200 Pa in each condition. These results will be compared with those of an existing theoretical model ($P_1 \propto 1/r^2$) based on viscous laminar flow.[8,9] We will determine a prediction model that can describe the confinement pressure in the PW with a large diameter.

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References

1) A. Hershcovitch, J. Appl. Phys. **78**, 5283 (1995).
2) H. Okuno *et al.*, Phys. Rev. Accel. Beams **14**, 033503 (2011).
3) H. Kuboki *et al.*, J. Radioanal. Nucl. Chem. **299**, 1029 (2014).
4) S. Ben-Liang *et al.*, Chin. Phys. C **38**, 018201 (2014).
5) Impulsing Paradigm Change through Disruptive Technologies Program ImPACT, `http://www.jst.go.jp/impact/en/index.html`, accessed: January 21, 2019.
6) S. Namba *et al.*, Rev. Sci. Instrum. **87**, 083503 (2016).
7) N. Ikoma *et al.*, RIKEN Accel. Prog. Rep. **51**, 144 (2018).
8) W. A. J. Vijvers *et al.*, Phys. Plasmas **15**, 093507 (2008).
9) S. Huang *et al.*, Phys. Plasmas **21**, 123511 (2014).

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