Study of plasma window for larger aperture

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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). They are made of 99.9999 % oxygen-free copper (OFC) because of its high thermal conductivity. Each part has internal channels for water cooling.

Table 1. Number of cathodes and pressure reduction factor.

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<tr>
<th>Current × Cathode</th>
<th>Pressure Reduction Factor</th>
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<tr>
<td>12 A × 3</td>
<td>133</td>
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<tr>
<td>36 A × 1</td>
<td>122</td>
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Fig. 2. Dependence of voltage and pressure reduction factor on the number of cooling plates.

Second, we measured the pressure reduction factor in the condition of 12 A × three cathodes and 36 A × 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 × 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.

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References

Fig. 3. Spectrum of He plasma.

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