Development of Noble DC Plasma Source for Divertor Simulation Study

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Divertor simulation study is important to understand plasma wall interaction and edge plasma physics. For that purpose, development of DC plasma source of high density and steady state plasma is an important issue. Lately, we developed a compact and noble DC plasma source that used directly heated LaB₆ cathode. One of the plasma sources can be attached to a CF114 vacuum flange and can generate a plasma with the electron density of ~10¹⁹ m⁻³. For the other one, the heating efficiency was improved and a high-density plasma was produced. The detailed structure and the characteristic of the generated plasma are reported.

1. Introduction
LaB₆ is remarkable thermionic electron emission material for cathodes to generate plasmas. LaB₆ has a property of efficient thermionic electron emission and lower work function than any refractory metals. And LaB₆ has an advantage that the necessary power can be reduced, because the operating temperature is lower than the other cathode materials [1].

We have been using LaB₆ as the cathode material for DC plasma sources [2]. Especially, the input power of directly heated cathode is lower than indirectly heated cathode, and the size of the directly heated cathode can be more compact. In this study, we report the detailed structures of two different cathodes plasma sources that we lately developed and the characteristic of the generated plasmas.

2. Structure and Heating Efficiency of the DC Plasma Source
The DC plasma sources that we will show consist of two directly heated LaB₆ cathodes. The cross section is 2mm×4mm. These cathodes are placed almost parallel, so that they can be heated due to each other’s radiation heat more efficiently. Plasma is generated toward the side of the LaB₆ cathodes.

2.1 DC Plasma Source for the Device PS-DIBA
The plasma source was newly developed for the device PS-DIBA. The plasma source assembly is shown in Fig. 1.

The plasma source is very compact and can be attached to a CF114 vacuum flange. Two directly heated LaB₆ cathodes are angled to 6 degrees (toward the direction of the generated plasma) and connected in series.
A H$_2$ plasma that was generated with a toroidal magnetic field intensity of 20 mT, gas pressure of 2.0 Pa and discharge power of 2.0 kW had the electron density of $1.1 \times 10^{19}$ m$^{-3}$ and electron temperature of 4.0 eV.

The LaB$_6$ cathodes are also covered with five boron nitride thin boards except the side of the generated plasma. Therefore flat temperature distribution of the LaB$_6$ cathode surface was realized, as shown in Fig.4.

The cross-section shape of the generated plasma is sheet. A deuterium detached plasma that was generated with the magnetic field intensity (Bt: 13 mT, Bv: 0.9 mT), gas pressure of 1.2~1.5 Pa and discharge power of 6.0 kW had the electron density of $3.8 \times 10^{18}$ m$^{-3}$ and electron temperature of about 0.1 eV.

3. Summary

The structure of two DC plasma sources and temperature distribution of the LaB$_6$ cathode surface were reported in detail. It was shown that high-density hydrogen and deuterium plasmas on the order of $10^{18}$~$10^{19}$ m$^{-3}$ were produced by using the compact plasma sources.

References