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Development of Noble DC Plasma Source for Divertor Simulation Study
ダイバータ模擬研究のための高性能直流プラズマ源の開発

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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 ~10^{19} 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.

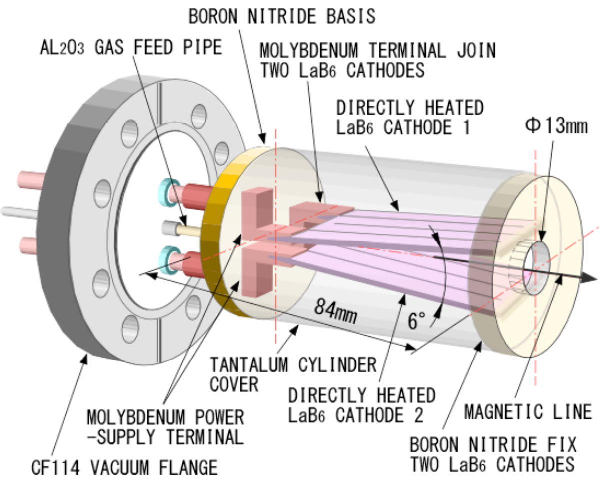

Fig. 1. Plasma source assembly for the device PS-DIBA.

The connection method is different from usual way. The LaB6 cathode tapered with V configuration is fixed by being pushed to a molybdenum terminal with a V-shaped groove. This method was used to reduce the thermal stress of the connection of thermally fragile LaB6. Gas is supplied from the hole of the boron nitride basis center behind the laB6 cathodes. The generated plasma is focused and come out from a orifice in 13 diameters of a boron nitride circular disc. And the LaB6 cathodes are covered with a tantalum cylinder. This cover improves the heat-retaining property and can efficiently supply the gas for discharge. As a result, flat temperature distribution of the LaB6 cathode surface was realized, as shown in Fig.2.

Temperature distribution of the LaB6 cathode surface is shown in Fig. 2. The temperature of the connection of the LaB6 cathode (triangle mark in Fig. 2) is a little lower.

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 1.1×10^{19} m^{-3} and electron temperature of 4.0 eV.

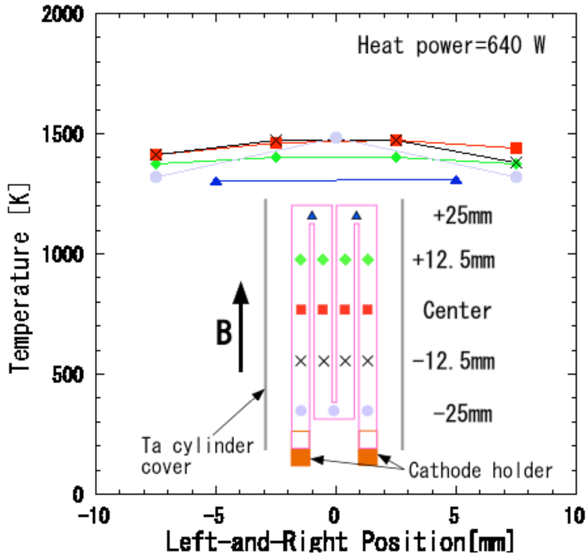

Fig. 2. Temperature distribution of LaB6 cathode surface.

2.2 *DC Plasma Source for the Device NAGDIS-T*

Another plasma source was developed to improve the heating efficiency and produce higher-density plasma for the device NAGDIS-T. The plasma source assembly is shown in Fig. 3. Two directly heated LaB6 cathodes are angled 7 degrees (toward the direction of the generated plasma, left side in Fig. 3) and connected in series. Gas is supplied from the hole of a boron nitride basis right-and-left center and further into the cell.

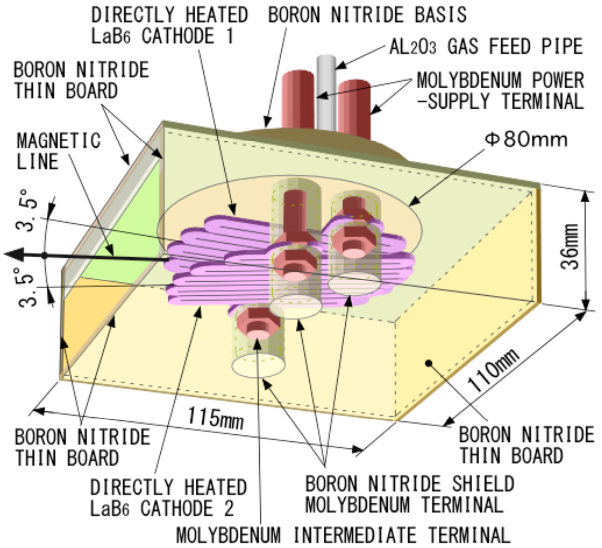

Fig. 3. Plasma source assembly for the device NAGDIS-T.

The LaB6 cathodes are also covered with five boron nitride thin boards except the side of the generated plasma. Therefore flat temperature distribution of the LaB6 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 3.8×10^{18} m^{-3} and electron temperature of about 0.1 eV.

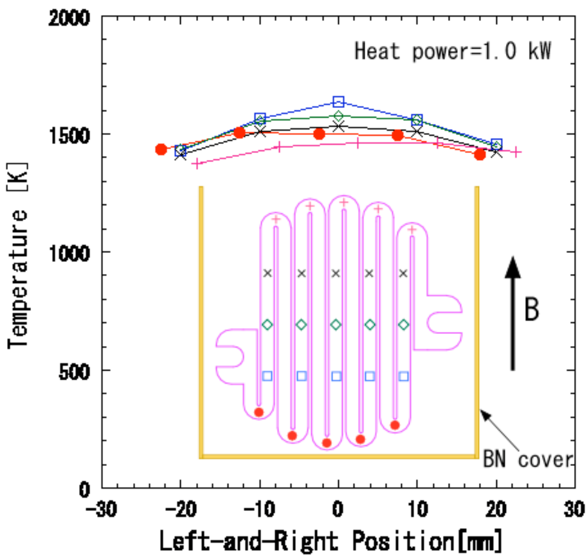

Fig. 4. Temperature distribution of LaB6 cathode surface.

3. Summary

The structure of two DC plasma sources and temperature distribution of the LaB6 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

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