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Generation of a high-density Ar plasma for plasma window applications

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The cascade arc discharge (i.e., wall-stabilized arc plasma) that generates an atmospheric high-density plasma channel was proposed by Maecker [1]. In order to realize a novel vacuum-atmosphere interface that does not require a large pumping system, a cascade arc discharge source called the *plasma window* has been developed by Hershcovich *et al.* [2]. They utilized the cascade arc apparatus similar to those of the Eindhoven group, by which Ar plasma with a temperature of ~1 eV and a density of ~10^{17} cm^{-3} was generated. However, further improvement of the apparatus is essential for practical application. In this study we have fabricated a high-density stationary plasma source, which is called the TPD plasma (Test Plasma by Direct current discharge) device originally developed at the National Institute for Fusion Science (NIFS).

Figure 1 shows a photograph of the cascade arc apparatus. The CeW cathode is a needle shaped rod that is 3.2 mm in diameter, and the Mo anode has an opening

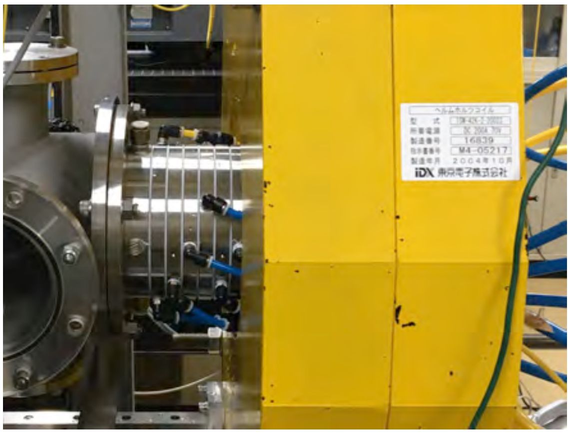

Figure 2. Schematic of the cascade arc discharge apparatus developed.

of 3 mm in diameter. The openings of eight intermediate electrodes have also 3-mm channel diameter, which makes the potential gradient between the anode and cathode smooth. Argon gas is fed into the discharge section at a constant flow rate up to 2.0 L/min. A power supply provides a discharge current of up to 60 A. The TPD plasma apparatus consists of two sections: a discharge region and a plasma expansion section. Absolute pressures in the discharge and expansion sections are measured to examine the performance as the plasma window. For characterization of the plasma parameters, visible UV emission spectroscopy is carried out by using used Jobin Yvon HR1000 with *f*=1 m and 2400 grooves/mm [3].

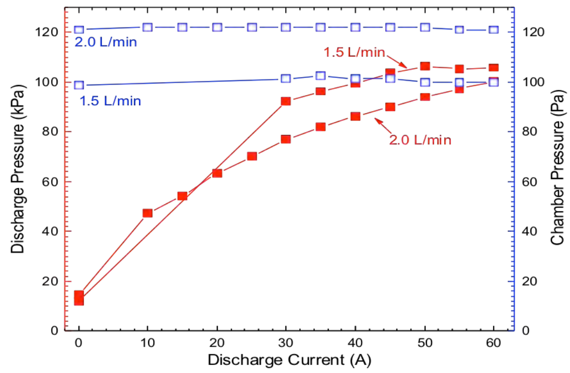

Figure 1. Dependence of the gas pressure of the discharge and the expansion sections on the discharge current.

Figure 2 shows the dependence of the gas pressure of the discharge and the expansion sections on the discharge current for two gas flow rates of 1.5 and 2.0 L/min. At 60 A discharge, the gas pressures in the discharge section for both flow rates reach 100 kPa, while the pressures in the expansion section are kept around 100 Pa. Therefore, the pressure ratio of the discharge and the expansion sections is ~1000. On the other hand, in high-density plasmas the spectral line shape is significantly broadened due to the Stark effect. The TPD discharge can readily generate high-density plasmas, so that the density is determined by measuring the Ar I line spectrum (430 nm) [4]. From the broadening width, the density at the anode was determined to be ~10^{16} cm^{-3}. Spectral analysis of Ar I emission also yields the plasma temperature. The Boltzmann plot method showed that the electron temperature was of ~1 eV at 50 A at the anode exit.

References

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