Characteristics of plasma jet emitter

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Abstract

In order to investigate characteristics of plasma jet emitter, a proton source including the emitter is developed. The method to generate the pulsed plasma with reliability is suggested. The influences of the magnetic field, the pressure and the timing of the pulse power supplies on the discharge are studied.

1 Introduction

To diagnose the plasma for nuclear fusion, it is necessary for neutral beams to have small emittance. The neutral beams can be inserted into high magnetic field in Tokamak. Further, the technology to produce intense beams is demanded for the purpose. The beams with small divergent are also useful to develop a new type of ion source which needs good quality of beams in magnetic field[1]. These small divergent beams are required to have current densities of 0.1~1.0 A/cm² at a distance of several meters from the ion source and total current of up to 10 A.

For usual plasma ion sources, the beams are extracted by an electrical field from the plasma which is produced by a discharge. This type of extracting system makes a distortion on the plasma emission. The distortion influences the quality of the extracting beams, which is a big problem for the beam production. To solve the problem, and make intense and small divergent beams, plasma jet emitter is developed[2]. In this work, the plasma jet emitter is newly developed to investigate the mechanism of the beam formation. The characteristics of discharge and plasma expansion are discussed from experimental data.

2 The system of the ion beam formation

The schematic drawing of the ion beam formation in the plasma jet emitter is shown in Fig. 1. The beam formation has some original characteristics. For example, the plasma expansion is utilized without collision[2]. The plasma is expanded by a pressure difference between the plasma generation space and the plasma expansion space. The transverse ion temperature to the beam's axis is decreased rapidly by the plasma expansion because of the effect of plasma adiabatic cooling. As one of other characteristics, the plasma jet emitter has the four accele-decele multi-slit lens system. The multi-slit lens system consists of molybdenous wires which are fixed at intervals of 1.5 mm. To produce the beams with small divergence, the part which has the parallel velocities to the beam's axis is utilized by restriction in solid angle.

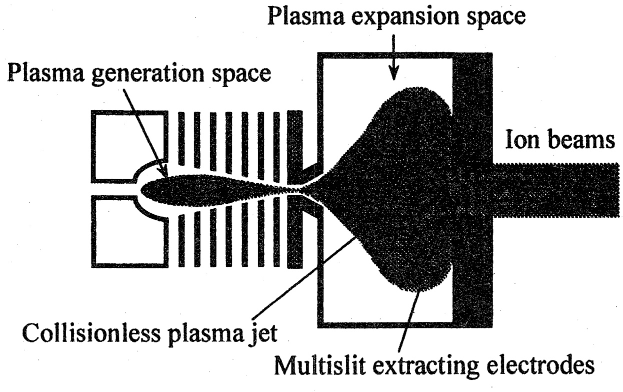

Fig. 1 The schematic drawing of the ion beam formation

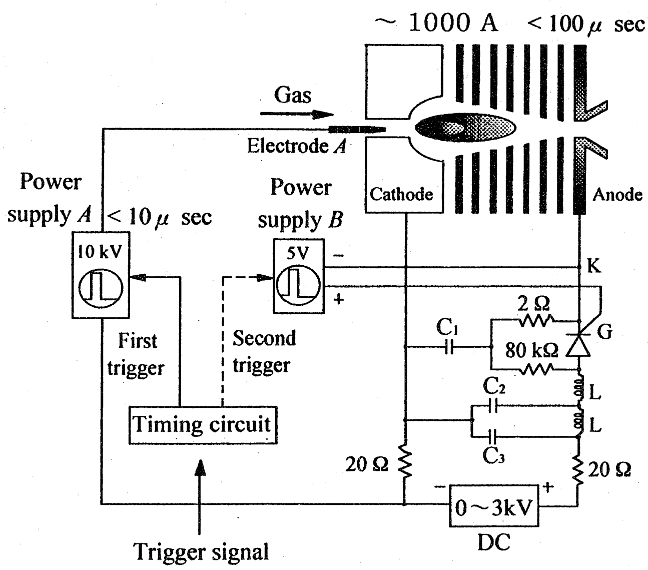

Fig. 2 The schematic drawing of the electrical circuit for the arc discharge

3 The experimental equipment for discharge and extraction

The schematic drawing of the electrical circuit for arc discharge in the plasma jet emitter is shown in Fig. 2. In the experiment, the discharge is ignited three times to decrease the plasma impedance, which generates the pulsed plasma of a few hundreds amperes with reliability. Time intervals for the three discharges can be controlled by using of two triggers which are made in the timing circuit. The first discharge is ignited between the electrode *A* and the cathode, when the first trigger arrives at the pulse power supply *A* in Fig. 2. Current of a few amperes flows between the cathode

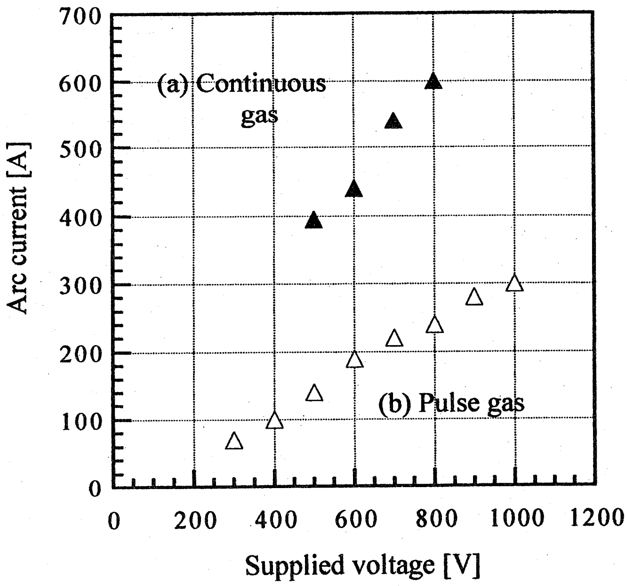

Fig. 3 The relations between the arc current and the supplied voltage

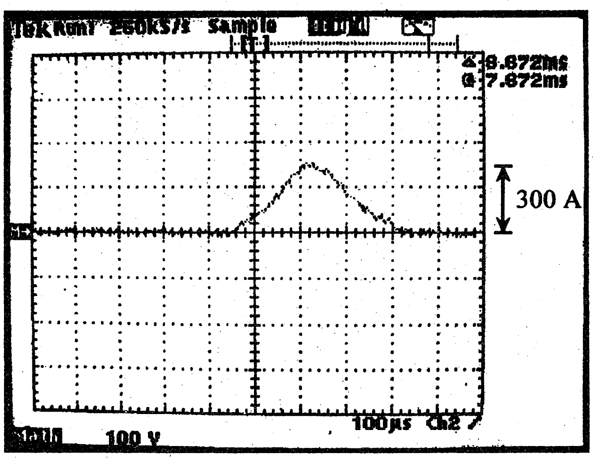

Fig. 4 The wave form of the arc current in the pulse mode

and the anode, when the second discharge is generated by the stored charges in the condenser C_1. The second discharge is necessary to ignite a big discharge (the third). The gate (G) of the thyristor, which drives the stored charge in the condenser C_2 and C_3 between the cathode and the anode, is opened for the third discharge, when the second trigger arrives at pulse power supply *B* in Fig. 2. Thus, the plasma of a few hundreds amperes is generated between the cathode and the anode.

For accele-decele lens system which makes proton beams from the plasma, two pulse power supplies of several 10 amperes and 5 kV are utilized.

4 The experimental results and the discussion

To investigate the characteristics of the discharge, the pulsed arc discharge is ignited in static gas pressure. This is called the continuous mode in this paper. In the case of continuous mode, the discharges are ignited in only the plasma generation space in Fig. 1 without flowing out from the space. In the case of the pulse mode, the plasma flows out from the plasma generation space to the plasma expansion space by the pressure difference between those spaces.

The relations between the arc current and the supplied voltage are shown in Fig. 3. The plot (a) indicates a data for the case of the continuous mode, and (b) indicates a data for the case of the pulse mode. In the pulse mode, the wave form of the arc current is shown in Fig. 4. As a value of the arc current, the peak of the wave form is measured. In the experiment, the discharge times of the pulse and the continuous modes are about 300 μs and 100 μs, respectively. In Fig. 3, the arc current of the pulse mode is lower than that of the continuous mode, which is caused by the following thing. The flowed out charges from the condensers are almost the same quantities in those modes, therefore, those arc currents depend on those discharge times.

Under the conditions of the constant supplied voltage and pressure, in the pulse and the continuous mode, the arc currents are influenced hardly by the change of the magnetic field. Similarly, under the conditions of the constant supplied voltage and magnetic field, those are influenced hardly by the change of the pressure.

5 conclusions

The method to ignite three discharges is useful to generate the pulsed plasma of a few hundreds amperes with reliability and periodically. In the pulse mode and the continuous mode, the supplied voltage has a great influence on the arc current. The magnetic field and the pressure have a little influence on it.

References

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[2] V. I. Davydenko, et al., "Reception of precise high-intensity ionic and atomic beams" ,Dokl. Akad. Nauk SSSR271 (1983) 1380.