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Dependence of neutron generation rate on the ring electrode shape by the small-sized IECF
小型 IECF におけるリング電極形状に対する中性子発生率の依存性

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Neutron beam is expected in wide range of applications in the fields of medical, industrial, nuclear energy. In this research, a new type of a small-sized neutron source is developed. The inertial electrostatic confinement fusion is the one of the new concept of neutron sources. Characteristics of this neutron source are as follows. (i) Required device is small. (ii) Portability is high. (iii) Neutron energy is monochromatic. (iv) Controllability is high. (v) Durability of the device is high. (vi) Cost is low. To product the neutron by a nuclear reaction, the ring-shaped electrode is used for the convergence of the nucleus in this research. The maximum neutron production rate is approximately 10^4 n/s, and it will be possible to increase by the optimization of the shape and the size of the ring electrode.

1. Introduction

1.1 *Background*

Neutron is one of the particles in atomic nucleus similar to a proton. The neutron has many physical characteristics. Transmittance of neutron in a matter is high because the neutron has no net electrical charge. Consequently, the neutron interacts mainly with atomic nuclei and it is sensitive to a light element. For this reason, the neutron source is expected in many engineering applications. For example, nondestructive inspection by using a neutron beam is detection system of the light element. The neutron radiography will become an effective method and it is more sensitive than X-rays. The capture gamma ray and backscattering peculiar to the neutron are used a mine detection. Nuclear reaction of boron and the neutron is applied to a cancer treatment (BNCT).

1.2 *Neutron source*

The generation of a neutron beam needs a nuclear reaction. The nuclear reaction can classify in three methods as follows, a fission reaction, a nuclear spallation and a nuclear fusion. The fission reaction produces a neutron by a nuclear reactor. Nuclear spallation produces a neutron by a destroying the nucleus in the large accelerator. Nuclear fusion produces a neutron by nucleus collision in the accelerator. The main stream of neutron source is currently the fission reaction because nuclear reactor can emit many neutrons. However, the neutron source by using a fission reaction dose not spread because fission device is large and cost is high. It is important for spread of neutron application to develop a small sized neutron source with low cost, high portability and high controllability.

1-3. *Inertia electrostatic confinement fusion*

The inertia electrostatic confinement fusion (IECF) is one of the neutron sources by using a nuclear fusion reaction. The IECF can satisfy condition of a small size, high portability and low cost and so on. In this research, a ring-shaped electrode is used for the convergence of the nucleus. In previous experiment, the generation of the neutron was confirmed under the condition of applied voltage of -12kV and more. The maximum neutron production rate is approximately 10^4 n/s. The purpose of this study is to optimization of the shape and the size of the ring electrode by neutron production rate by the ring.

2. Experimental device

2.1 *Small sized cylindrical IECF*

The basic ideas of IECF device is the concept of Fusor[1]. Principle of nuclear fusion of IECF is very simple. The system mainly consists of the cathode and anode. The anode connect to the earth and the cathode is applied a negative high voltage. The glow discharge forms between the electrodes. The generated the ions are accelerated by the high voltage and the accelerated ions are converged in spherical cathode center. Accelerated the ions collide each other and the fusion reaction occurs. The gas used in the experiment is deuterium.

The characteristics of IECF system are greatly different from other neutron sources. The advantage of the IECF is that it can easily control the generation rate of the neutron. The fusion reaction is dependent on the applied voltage and discharge current. The device of IECF can design in a simple structure. In general IECF device, the geometrical arrangement of the electrodes is spherical. The schematic drawing of the spherical IECF is shown in Fig.1. The electric potential distribution of a spherical IECF is the spherical symmetry. Therefore the ions accelerate toward the center of the cathode. Structurally, the cathode is located in the plasma. As a result, the cooling of the cathode becomes serious problem.

In our research, the electrode arrangement is almost cylindrical. Figure 2 shows the schematic drawing of the cylindrical IECF. In the cylindrical IECF, ion beams forms through the center of the ring cathode. The ions beam does not collide with the cathode directly. Consequently, loss of the ions is reduced and there is no necessity of the cooling of the cathode .

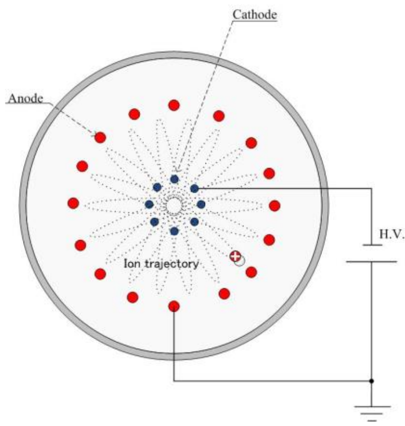

Fig.1. Schematic drawing of the general IECF [2]

2.2 *Experiment device and setup*

In this research, a ring-shaped electrode is used for the convergence of the nucleus. Diameter of the ring cathode is ϕ 20 and ϕ 26 mm respectively. The width of ring electrode is 20 mm. In addition, the two anodes are located at the both sides of the ring cathode and the glow discharge forms between

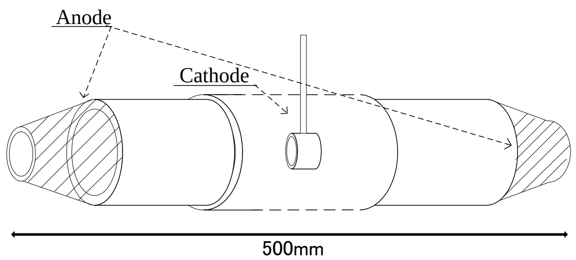

Fig.2. Schematic drawing of the cylindrical IECF

anode and cathode. High cathode voltage accelerates the deuterium ions and the fusion reaction will occurs at the center of the ring cathode hole. Maximum cathode voltage is -30kV and the Maximum cathode current is 10 mA.

3. Experimental result and conclusions

The purpose of this study is to optimization of the shape and the size of the ring electrode by neutron production rate by the ring. Figure 3 shows the neutron production rate at the applied voltage of -18kV. The neutron production rate increases with increasing the cathode current. The maximum neutron production rate is approximately 10^4 n/s. It will be possible to increase the number of neutrons by stabilizing the discharge at high voltage and high current region. In the poster, experimental setup, results and conclusive summary are presented.

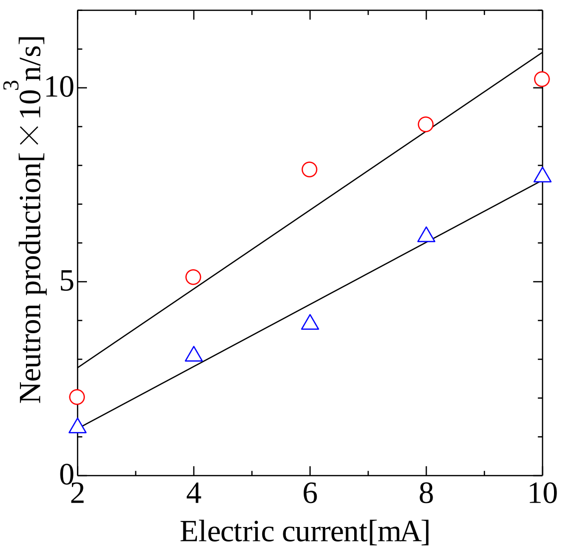

Fig.3. Dependence of current on neutron production rate.
○:the inside and outside diameters are 20mm and 36mm,
△:the inside and outside diameters are 26mm and 36mm,

References

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