§ 26. Performance Improvement of a Spherically Converging Ion Beam Colliding Fusion Neutron Source by Use of External Ion Sources

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An inertial electrostatic confinement fusion (IECF, see Fig. 1) neutron source is a device injecting ions and electrons towards the spherical center through a transparent hollow cathode, trapping both species in the electrostatic self-field and making fusion reactions in the dense core. An IECF device can be promising for a portable neutron source. At present, D-D fusion neutrons of about ten millions/sec are successfully produced continuously at our research group, and at several institutions, as we ll.

To enhance the neutron yield by an IECF source, it is essential to produce sufficient ions, particularly, in the vicinity of the vacuum chamber to provide full energy under the relatively low pressure to prevent accelerating ions from unnecessary charge-exchange (neutralization) with background gases. Furthermore, it is very encouraging that numerical studies so far have predicted nonlinear dependence of neutron yield on discharge current under low gas pressure condition through formation of electrical double well potential within the central hollow cathode.

The objectives of this study are to improve the IECF neutron source performance by use of magnetron discharge mechanism as an extremely compact and simple ion source, and also to extend the accessible pressure range in order to verify the aforementioned numerical prediction of nonlinear regime.

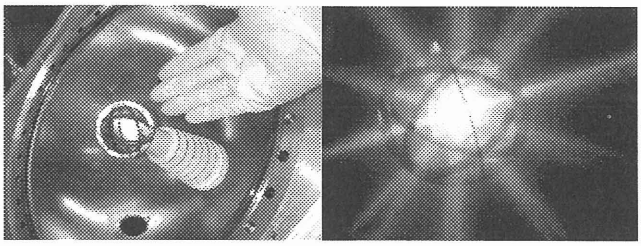

Fig. 1. The hollow cathode at the center of the spherical vacuum chamber as the anode, and an IECF plasma within the hollow cathode

As schematically shown in Fig. 2, magnetron discharge mechanism of the coaxial configuration set up in the nozzle (IFC70, inner diameter of 35 mm) surrounded by a Nd-Fe cylindrical permanent magnet was adopted. Two kinds of different inner cylindrical stainless steel anode were tested, i.e., outer diameter of 6 mm, and 25 mm with 30 mm length.

It is found that the magnetron discharge can be achieved even for 0.1 mTorr with an applied inner anode voltage of around 1 kV, and sufficient ions can be supplied toward the IEC cathode. As a consequence, the IECF device can run with a reduced gas pressure of 2 mTorr for a hollow cathode voltage of 50 kV and current of 10 mA, which is found much lower than the limited pressure of around 6 mTorr for the pure glow discharge based device with the same applied voltage and current (Fig. 3).

By controlling the voltage applied to the inner anode of the magnetron-type ions source, the gas pressure was varied for a constant hollow cathode voltage and current of 40 kV and 10 mA, respectively. In Fig. 4, it is clearly seen that the neutron yield normalized by the gas pressure tends to increase drastically with decrease of gas pressure. This would result from both longer lifetime of the ions due to less charge-exchange processes, and larger fraction of high-energy ions due to localized birthplace in the vicinity of the outer anode (vacuum chamber).

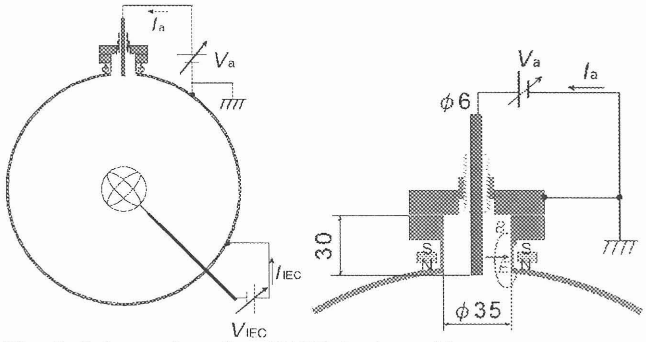

Fig. 2. Schematics of an IECF device with a magnetron-type ion source.

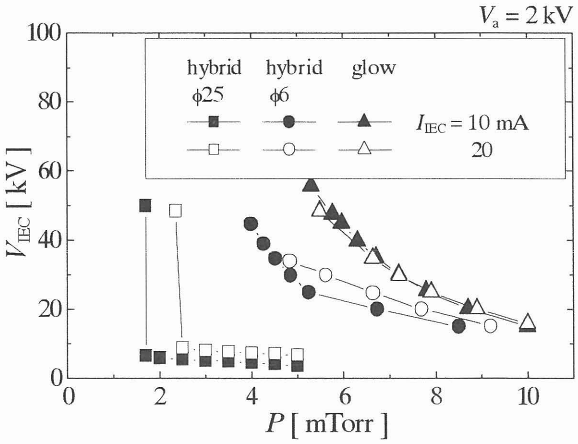

Fig. 3. Glow-magnetron hybrid discharge charachteristics.

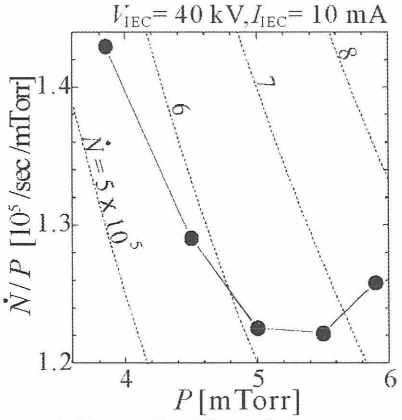

Fig. 4. Neutron yield as a function of gas pressure.