§28. Performance Improvement of a D-D Fusion Neutron Source as a Calibrator for Neutron Detectors

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An inertial electrostatic confinement fusion (IECF) device consists of a spherical vacuum chamber as an anode at ground potential and a highly transparent central cathode grid at a negative potential $-V_c$ (see Fig. 1). Ions produced by a glow discharge between them are, on one hand, accelerated towards the center and the spherical focusing of these ions results in an appreciable steady-state D-D neutron yield of 10^7 - 10^8 sec^{-1}. On the other hand, the electrons produced inherently at the same time gain the full energy corresponding to the bias $-V_c$ and hit the chamber, leading to a copious amount of undesirable X-ray emission. Furthermore, the power consumption for the electron beams (see the clear spokes in the discharge photo in Fig. 1) is known to exceed 90 % of the total input power, which greatly limits the efficiency and accordingly the neutron yield of the IECF with an applicable power.

In this study, we have proposed a new IECF-based scheme to cope with this problem, by use of an additional gridded anode set concentrically between the cathode and the chamber as shown schematically in Fig. 2. Experimental results in this double-grid configuration have shown that the escaping electrons mostly pass through the gridded anode and reach the chamber with a reduced energy, i.e. the chamber serves as a depressed collector, and as a consequence the X-ray emission is found to reduce greatly as expected. Meanwhile, the electrons hitting the chamber produce secondary electrons, which are found to induce ionizations between the chamber and the anode, resulting in a considerable current through the anode power supply (see Table I). The anode current due to the secondary electron emission should be minimized in order to maximize the neutron yield per input power.

For this purpose we then installed an additional mesh at a negative potential of ~100 V in the vicinity of the chamber wall as shown schematically in Fig. 2. The geometrical transparency of the mesh is ~70 %. As the result, the anode current was seen reduced by half (see Table I). Figure 3 shows the neutron yield as functions of the cathode and anode potentials. The neutron yield is seen determined by the voltage between the cathode and the anode as expected.

In summary, in the present double-grid system, the X-ray emission per neutron yield is reduced by an order of magnitude successfully, while the neutron yield per input power remains that in the single-grid system, i.e. the anode current remains the same as the cathode current in Table I, though the addition of the mesh is found to be effective. We thus plant to install a mesh with a higher transparency (e.g. 90 %) in order to reduce the input power further.

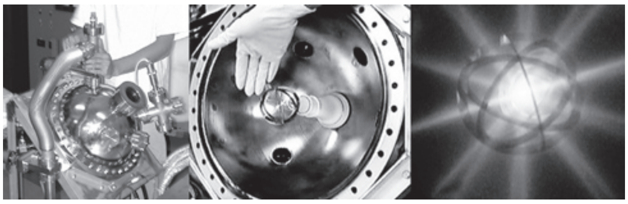

Fig. 1. A conventional single-grid IECF device and a discharge photo

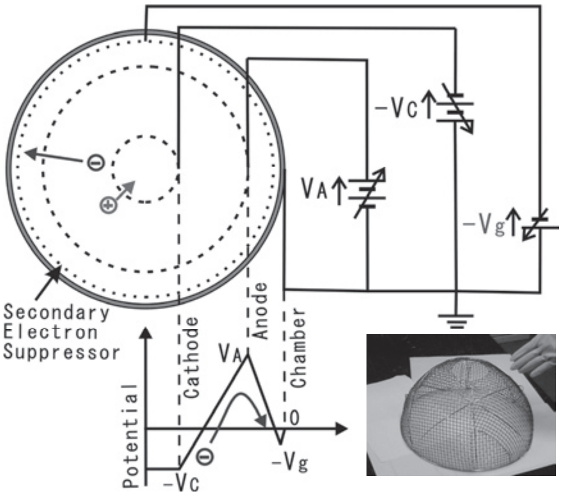

Fig. 2. Schematic cross-section of the double-grid IECF device, with an additional mesh set in the vicinity of the chamber wall for suppression of the secondary electron emission.

Table I. Comparison of currents through the power supplies with and without the secondary electron suppressor mesh.

	V_C [kV]	I_C [mA]	V_A [kV]	I_A [mA]
w/o mesh	15	2.3	23	4.4
with mesh	15	2.4	25	**2.4**

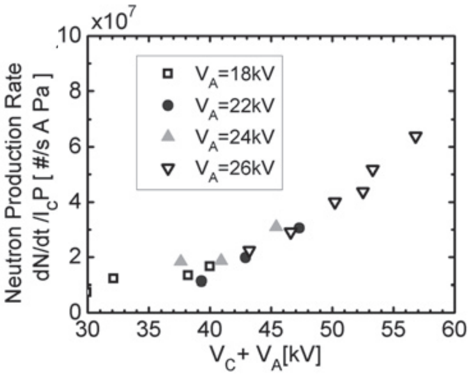

Fig. 3. Normalized neutron production rate as a function of voltage between the cathode and the anode (V_C+V_A in Fig. 2) for various anode potential V_A.