Development of Portable Interrogation System for Special Nuclear Materials (III)

(3) The status and Achievements of the Ultra-Compact Neutron Generator based on IEC for SNM Interrogation System

*Mahmoud Bakr[1], Kai Masuda[1] and Masaya Yoshida[2]

[1]Institute of Advanced Energy, Kyoto Univ., [2]Graduate School of Energy Science, Kyoto University

The second prototype of the ultra-compact neutron generator based on inertial electrostatic confinement fusion with a titanium anode of 17 cm in diameter was fabricated and tested. A neutron yield more than 7×10^7 n/s from DD fusion reactions was achieved by applying 6.3 kW. The modification which has been made on the first prototype and test performance comparisons between the two prototypes will be presented in this paper.

Keywords: Special nuclear materials, inertial electrostatic confinement fusion, neutron generator

1. Introduction: We are developing the first of its kind, portable, and lightweight active interrogation system for special nuclear materials (SNMs) [1]. The inertial electrostatic confinement (IEC) fusion device [2] is utilized as a neutron source in this system. The 1st and 2nd prototypes have been fabricated and tested. Specifications, operational conditions, and achievements of the 1st and 2nd prototypes are presented in Table 1 in comparison with IEC fabricated 11 years ago by our group, and the R&D goals.

Table 1. Parameters of 1st & 2nd prototypes compared with existing transportable IEC together with R&D goals.

	IEC-LM 2007 Achieved	1st prototype IEC17	2nd prototype IEC17	R&D target
Diameter [cm]	36	22	22	<25
Length [cm]	130	60	70	<70
Weight [kg]	>40(SUS)	42 (SUS)	35(TI)	<30
Anode dia. [cm]	25	17	17	-
Cathode dia. [cm] (Molybdenum)	8	6	6	-
Vacuum withstand voltage [kV]	100/100	110/120	120/120	120
Discharge voltage [kV]	80	70	70	<120
Discharge power [kW]	8	10.5	6.3	<24
DD NPR [10^7 n/sec]	1	2.8	7.5	>5

2. Results: In the 2nd prototype of the IEC17, Ti has been used as anode material instead of SUS in the 1st version for two reasons; to decrease the total weight of the device and to increase the neutron production rate (NPR). Preliminary measurements of NPR have been carried out at a different applied voltage with a maximum power of 6.3 kW, and the results are shown in Fig. 1. It can be seen in figure 1 that ~7.5×10^7 n/s was achieved at 70 kV applied voltage and 90 mA grid current, which is found to be seven times higher than that produced by the 1st prototype at the same applied power (~20% of the power supply capacity). The improvement in the NPR can be explained by the fusion reaction taking place on the anode surface between the energetic neutrals, which are generated from the frequent charge exchange collisions between energetic ions and background neutral molecules, and the embedded ions on the Ti surface.

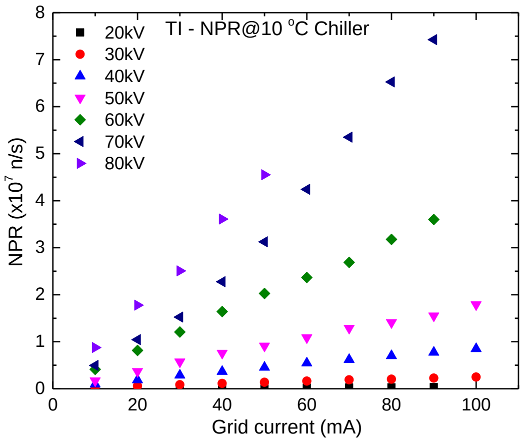

Fig. 1. The NPR from the 2nd portable IEC chamber

3. Conclusions: Using Ti as an anode material in the 2nd prototype of the IEC neutron generator introduces a significant enhancement on the NPR compared to SUS anode in the 1st prototype at the same applied power. This tendency due to the fusion reaction occurred in the anode surface between the energetic neutrals with the background neutral molecules and embedded ions on the Ti surface. The achieved NPR from the 2nd prototype was 7.5×10^7 n/s by applying only ~20% of the power supply capacity. This NPR exceeds the R&D goal for the neutron generator to be used in the SNM interrogation system.

References

[1] M. Bakr et al., to be published in the CAARI 2018 proceeding.

[2] R.L. Hirsch, J. Appl. Phys. 38, 4522 (1967).