Current Status and Progress of Developing a D-D Neutron Generator

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1. Introduction

The research to develop a D-D neutron generator was begun in 2001. A prototype device was built in 2004 [1-3], and partly modified in 2005 [4,5]. By using the modified prototype D-D neutron generator, neutron generation runs were performed, and the characteristics of D-D neutron generation was investigated [4-7]. The final goal of maximum neutron yield is 10^8 n/s, while a yield of 6.5×10^7 n/s has been achieved [7]. Here, the results of neutron generation runs performed by using the modified prototype device are summarized, and the feature of a new ion source [8] to be tested in weeks is briefly described.

2. Current Status

The results of neutron generation runs are plotted in figure 1 for varied beam energy. The neutron generation runs were performed within the beam energy range of 30 ~ 88 keV, and beam current was varied within the range of 0 ~ 4 mA. Three kinds of Ti target with thickness of 1 mm, 40 μm and 10 μm were used. Neutron yield increases drastically in pace with the beam energy, mainly due to the rising $D(d,n)^3He$ reaction cross section. And neutron yield increases proportionally to the beam current. The effect of target thickness is not significant but it affects neutron yield somewhat. The detailed effects of beam energy and target condition are being investigated. The maximum value of neutron yield is 6.5×10^7 n/s, when the beam current is 4 mA and the beam energy is 88 keV.

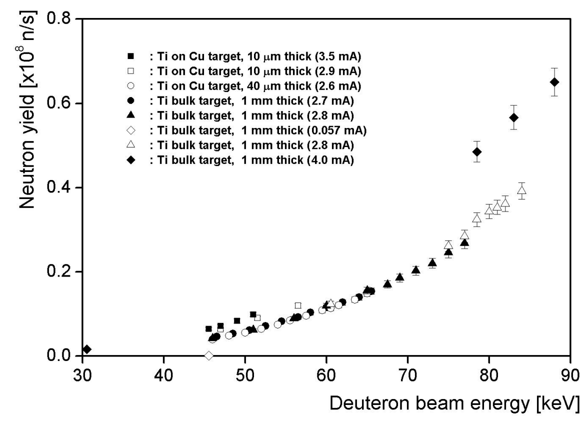

Figure 1. Results of neutron generation runs performed by using the modified prototype D-D neutron generator.

3. New Helicon Plasma Ion Source

A new helicon plasma ion source [8] has been designed and constructed to supply higher beam current to the target of D-D neutron generator. The cross-sectional view of the new helicon plasma ion source is shown in figure 2. The measured maximum plasma density is 2.0×10^{12} cm^{-3}, which is achieved with 1 kW RF power (13.56 MHz) at the magnetic field intensity of 500 G. In order to increase the extraction beam current, extraction position is drawn into denser plasma region. Three-electrode extraction system is used in order to block the back-streaming electrons. The maximum current of proton beam extracted from the ion source is 50 mA at the extraction bias of 34 kV, when the plasma source is turned on at 427 G magnetic field intensity with 1.9 kW RF power. Hence, it is expected to achieve at least 20 ~ 30 mA of extraction beam current from the ion source with long term stability, and a few tens mA of beam current can be supplied to the target of D-D neutron generator. The monatomic fraction of proton beam is more than 90% [8].

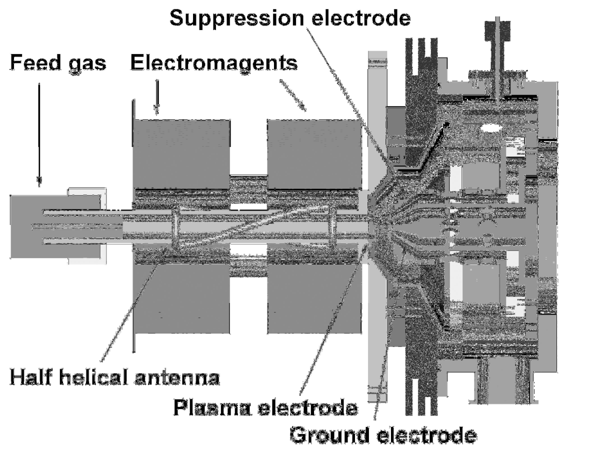

Figure 2. Cross-sectional view of the new helicon plasma ion source.

4. Conclusion

By using the modified prototype D-D neutron generator, the characteristics of D-D neutron generation was investigated, and the neutron yield of 6.5×10^7 n/s was achieved. Now, the D-D neutron generator is being reassembled with a new large current helicon plasma ion source [8] replacing the prototype one. Beam line components are modified to be fitted to the new configuration. Radiation protection shield is reinforced. It is expected that neutron yield be enhanced at least by several times in the new generator.

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REFERENCES

[1] I.J. Kim and H.D. Choi, Development of D-D Neutron Generator, 18th International Conference on the Application of Accelerators in Research and Industry, Oct. 2004, Fort Worth, USA.
[2] I.J. Kim, S.K. Kim, C.S. Park, N.S. Jung, H.D. Jung, J.Y. Park, Y.S. Hwang and H.D. Choi, Experiment of Neutron Generation by Using Prototype D-D Neutron Generator, Transactions of the Korean Nuclear Society Spring Meeting, May 2005, Jeju, Korea.
[3] I.J. Kim and H.D. Choi, Development of D-D Neutron Generator, Nuclear Instruments and Method B, Vol. 241, p. 917, 2005.
[4] I.J. Kim, S.K. Kim, C.S. Park, N.S. Jung, M.J. Park, H.D. Jung, J.Y. Park, Y.S. Hwang and H.D. Choi, Development of a D-D Neutron Generator and the Result of Neutron Generation Experiments, 6th International Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications, Jun. 2005, Hamilton, Canada.
[5] I.J. Kim, S.K. Kim, C.S. Park, N.S. Jung, H.D. Jung, J.Y. Park, Y.S. Hwang and H.D. Choi, Modification of Prototype D-D Neutron Generator, Transactions of the Korean Nuclear Society Autumn Meeting, Oct. 2005, Busan, Korea.
[6] I.J. Kim, S.K. Kim, C.S. Park, N.S. Jung, H.D. Jung, K.J. Chung, Y.S. Hwang and H.D. Choi, Study on Neutron Generation by Using Modified Prototype D-D Neutron Generator, Transactions of the Korean Nuclear Society Spring Meeting, May 2006, Chuncheon, Korea.
[7] I.J. Kim, S.K. Kim, C.S. Park, N.S. Jung, H.D. Jung, K.J. Chung, Y.S. Hwang and H.D. Choi, Development of a D-D Neutron Generator and Investigation on the Characteristics of Neutron Generation, 52nd Annual Radiobioassay & Radiochemical Measurements Conference, Oct. 2006, Chicago, USA.
[8] H.D. Jung, J.Y. Park, K.J. Chung, M.J. Park, I.J. Kim, H.D. Choi and Y.S. Hwang, Study on a High-Current Helicon Ion Source for Neutron Generator Application, 11th International Conference on Ion Sources, Sep. 2005, Caen, France.