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Development of Charge Stripping Plates for Tandem accelerators
金属表面を使ったタンデム加速のための荷電変換器開発

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A robust electron stripper for H^- to H^+ using a metal surface was developed for a compact tandem-type DD or DT neutron generator of next generation. The experimental results showed that the conversion efficiency, H^+ fraction in the reflected particles, improved by surface polish up to the maximum value of about 90%. Roughness parameters were measured for 2 samples of metal surface, polished and non-polished, using a 3D laser-scanning microscope. The surface measurement indicated that there was factor 4 improvement in the average roughness by polish.

1. Introduction

Compact and high intensity neutron generators are strongly demanded in various fields, such as application to in-situ calibration of neutron diagnostics in nuclear fusion [1], security systems, land mining, and structural evaluation of tankers or nuclear reactors. A tandem acceleration concept has been proposed for a DD or DT neutron generator [2-3]. In this approach, a D^- beam is accelerated up to several-hundreds keV toward a high voltage stage for electron stripping, and the D^+ beam produced is re-accelerated and injected to a D^- or T-target with almost doubled energy. This type of accelerator requires a compact, mechanically robust electron stripping system, which can endure high heat load.

As a new concept, a metal plate electron stripper was tested, using 60 – 150 keV H^- beam [4]. The roughness of the metal surface samples was measured by 3D Laser scanning microscope.

2. Measurement of the Conversion Efficiency

A layered stripping plate was proposed by Terai et al. [4] for a compact neutron source. In this system, a H^- beam is injected onto a metal surface with an oblique angle. In order to test this concept, an experiment was performed using a test stand which was developed for an alpha particle diagnostics method, Advanced Beam Source 103 (ABS103) [5-6]. The details of the experimental setup were described in the reference 4.

The stripper was a pile of molybdenum plates of 0.4 mm in thickness, 31mm wide and 25 in length to the beam direction. A set of 25 parallel plates separated by 0.2 mm in gap was tilted to the beam direction so that the beam incident angle to the plates was 89 degrees. The reflected H^+ ions were detected by the movable faraday cup. One of strippers was fabricated with a molybdenum plate commercially available (non-polished). The other stripper was fabricated with highly polished molybdenum (polished).

The beam from the stripper plate was firstly charge-separated by an electric field separator, and the beam profile was measured by a movable faraday cup.

The conversion efficiency from H^- to H^+ was evaluated by comparing the measured H^+ beam current profile with the theoretical prediction of outgoing beam profile calculated using the TRIM code [7], where charge exchange probability was not taken into account. The calculated H^+ beam profile normalized showed the good agreement with the measured result. The H^+ beam current integrated over the beam profile are shown in Fig. 1, as a function of beam energy. The experimental results of two cases, with the non-polished stripper (triangles) and with the polished (circles) indicated that the reflected H^+ current depends on the surface condition. The H^+ fraction in the reflected particles, that is the ratio of the H^+ beam current integrated over the beam profile to the results of TRIM calculation (squares), depends on the incident beam energy and the surface condition, with the maximum value of about 90% with the polished surface.

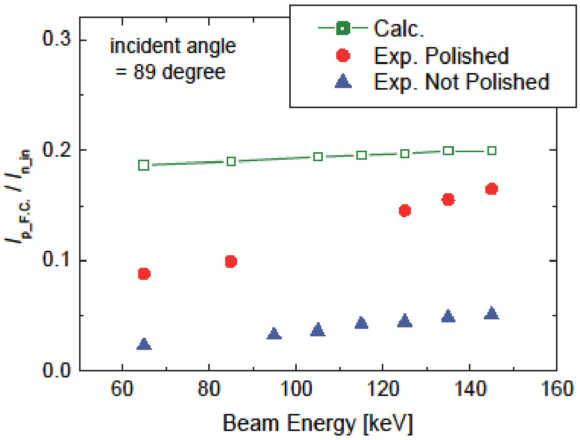

Fig. 1 The H^+ beam current integrated over the beam profile divided by the initial H^- beam current, with the non-polished stripper (triangles) and with the polished stripper (circles). The squares indicate the results of TRIM calculation.

3. Measurement of the Surface Roughness

The roughness parameters, the maximum (Rp) and minimum (Rv) height in a sample unit area, the average roughness (Ra), skewness (Rsk), and Kurtosis (Rku) were measured for 2 samples of stripper molybdenum surface using a 3D laser-scanning microscope (KEYENCE VK-970). The results are shown in Table 1. There was factor 4 difference in average roughness between the 2 samples.

4. Conclusion

As a robust electron stripper for H^- to H^+, a metal surface stripper was proposed for a compact tandem-type DD or DT neutron generator of next generation.

High conversion efficiency, up to 90% was obtained with a polished molybdenum surface. Roughness parameters of the surface were measured using a 3D laser-scanning microscope. The surface measurement indicated that a factor 4 improvement in average roughness results in factor 4 improvement in the conversion efficiency.

Acknowledgments

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Table I. Measured Roughness

	Peak value Rp[μm]	Valley Rv[μm]	Average Ra[μm]	Skewness Rsk	Kurtosis Rku
Not Polished	0.209	0.207	0.053	-0.147	3.56
Polished	0.024	0.037	0.012	-0.336	2.06