AN IRRADIATION SYSTEM FOR CARBON STRIPPER FOILS WITH 750 keV H$^-$ BEAMS

A. Takagi[1], I. Sugai[1], Y. Irie[2] , Y. Takeda[1], K. Ikegami[1], Z. Igarashi[1], C. Kubota[1], Y. Arakida[1]
N. Saito[3], S, Dairaku[3]. K. Senzaki[3], A. Satoh[3]
[1]KEK Tsukuba 305-0801, [2]JAEA Tokai 315-195, [3]Kyoto Univ. Kyoto 606-8502, Japan.

Abstract

Carbon stripper foils will be installed in the J-PARC 3 GeV Rapid Cycling Synchrotron. They should have a tolerance to the high temperature at around 1800K. We have developed a new irradiation system with negative hydrogen beams at the KEK 750keV Cockcroft-Walton type high voltage accelerator in order to simulate the energy depositions onto the foil. It is found that, by adjusting the peak intensity and the pulse length of the hydrogen beams appropriately, the energy deposition becomes equivalent to that exerted by the incoming H$^-$ and the circulating beams at the injection process of the RCS. The new irradiation system and some preliminary results on the carbon foil are presented.

INTRODUCTION

The Japan-Proton Accelerator Research Complexes (J-PARC) requires thick carbon stripper foils (250-500 μg/cm^2) to strip electrons from the H$^-$ beam supplied by the linac before injection into the RCS (Rapid Cycling Synchrotron)[1]. The 200 MeV H$^-$ beam from the linac has a pulse length of 0.5 ms with a repetition rate of 25 Hz and an average beam current of 335 μA. For this high-energy and high-intensity beam, conventional carbon stripper foils will break in a very short time and even a diamond foil will be ruptured at around 1800 ºK by the MW class accelerator. Thus, thick carbon stripper foils with high durability at 180 0ºK produced by energy deposition in the foil are indispensable for this accelerator.

For this purpose, we have been developing carbon stripper foils of 350 μg/cm^2 by means of both the controlled DC and AC/DC arc-discharge method. Recently, we have successfully developed hybrid type thick boron doped carbon stripper foils, which showed a drastic improvement not only with respect to the lifetime, but also with respect to thickness reduction and shrinkage at high temperature during long beam irradiation[2].,[3]

By this purpose, we have been developed an irradiation system for the life time test at the high temperature above 1800 ºK.with 750 keV negative hydrogen beams(H$^-$) of dc and pulsed operation.

HIGH VOLTAGE ACCELERATOR

There are two set of 750keV H$^-$ pre-injector in the KEK 12 GeV proton synchrotron. After shutdown of 12 GeV-PS, an irradiation system in the 750 keV low energy beam line of the second pre-injector.

The 750keV pre-injector consists of a high voltage generator, a high voltage terminal and an accelerating column.

The parameters of the 750 keV Cockcroft-Walton accelerator are shown in table 1 and the circuit diagram of of the 750keV Cockcroft-Walton high voltage generator.is shown in figure 1. Figure 2 shows the total layout of the low energy beam line for the 750keV pre-injector at 12GeV-PS.

The high voltage generator is one of the Cockcroft-Walton type which can generate dc voltage of 800 kV(max.). The nominal maximum output voltage of the high voltage generator is –800 kV, but the actual maximum voltage of the accelerating column is –720 kV.

Table 1: Parameter of the 750keV Preinjector

C-W out put voltage (nominal)	-800 kV
C-W output current (nominal)	5mA
HVT voltage(Acc. voltage)	-720kV
Beam current (dc mode)	1mA/dc
Beam current (pulsed mode) (20Hz, 200μsec)	30mA/peak
Type of Ion source	Muti-cusp Surface H$^-$

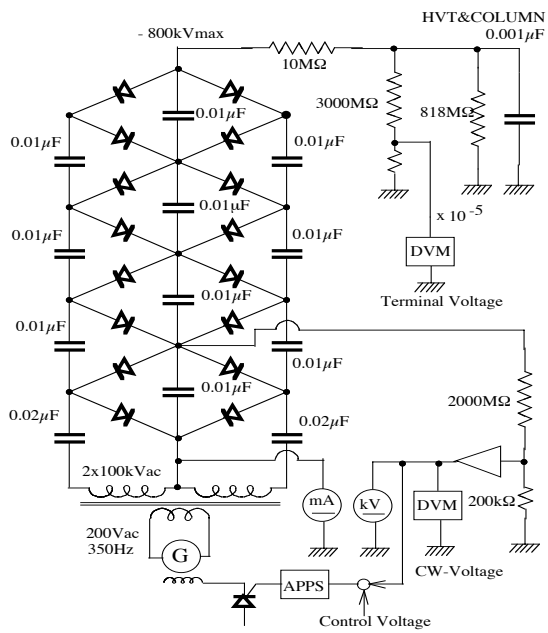


Figure 1: Circuit diagram of the 750keV Cockcroft-Walton high voltage generator..

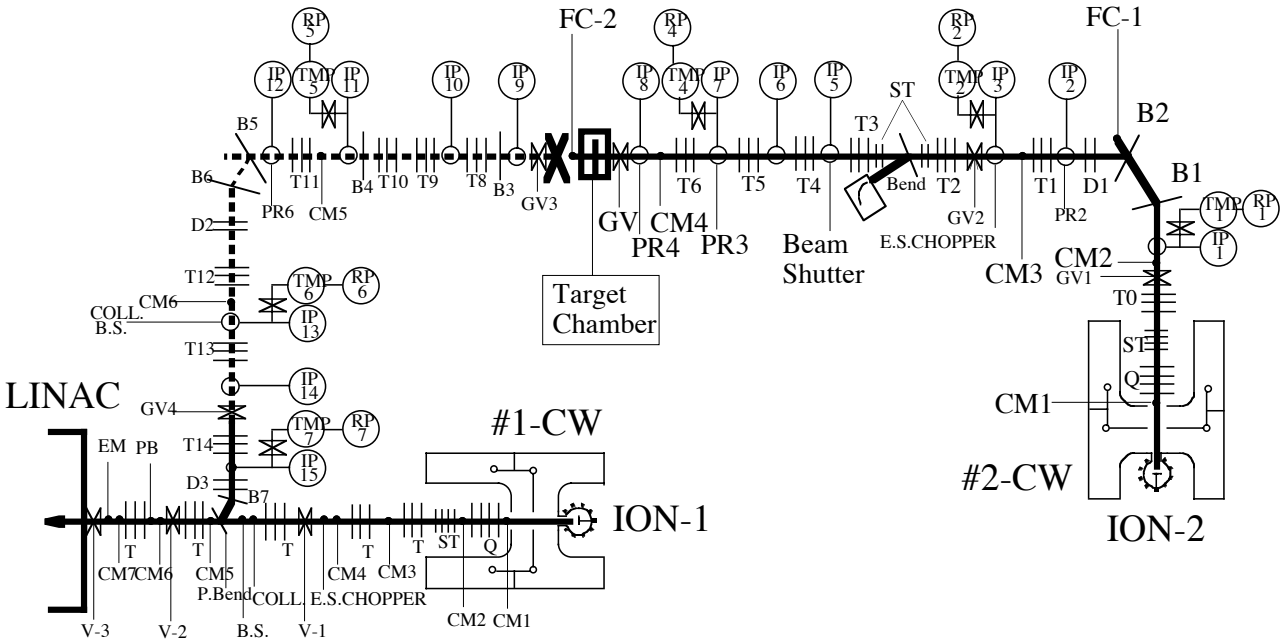


Figure 2: Layout of the low energy beam line for the 750keV pre-injector at 12GeV-

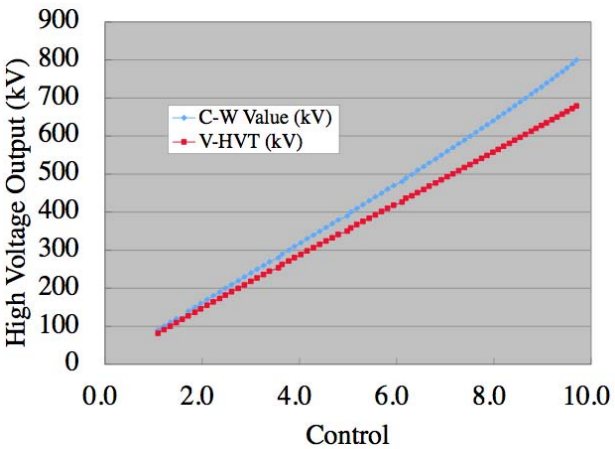


Figure3: The terminal voltage of ion source v. s. the nominal C-W output voltage.

These voltage difference between the nominal vale of C-W and the measured value of Hugh voltage terminal are cause by the feedback circuit of high voltage generator.

Figure1 shows the circuit diagram of the 750keV Cockcroft-Walton high voltage generator. In this circuit, the feedback signal of high voltage output is collected from 1/4 part of the voltage multiplier. By this reason, the total voltage of high voltage generator is not well controlled as shown in figure 3.

A high intensity multi-cusp negative hydrogen ion source is installed in the acceleting column of the KEK 750 keV pre-injector . This ion source is base on the surface-production mechanism. The converter electrode is inserted in the central part of plasma chamber of ion source. High current of negative hydrogen ions are produced on the surface of the converter electrode which is coated with some metal vapor from the cesium and and extracted from the anode hole of ion source.

TARGET CHAMBER AND TARGET FOLDER ARRAY

Figure 4 shows a target chamber which is placed in the 750 keV low energy beam line. A movable target folder array is installed in this target chamber, and four target folders are mountable on the target array.

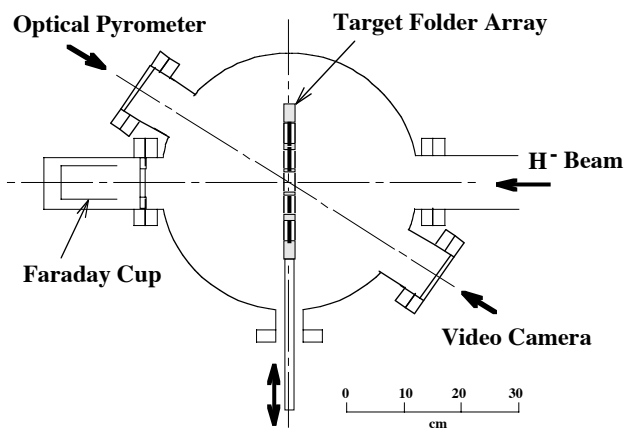
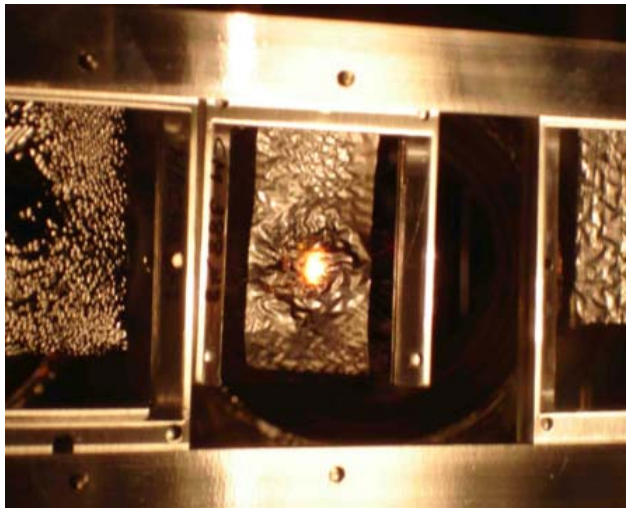


Figure 4::Layout of the target chamber with multiple target folders.



Figyre 5: An example of beam spot on the carbon foil.

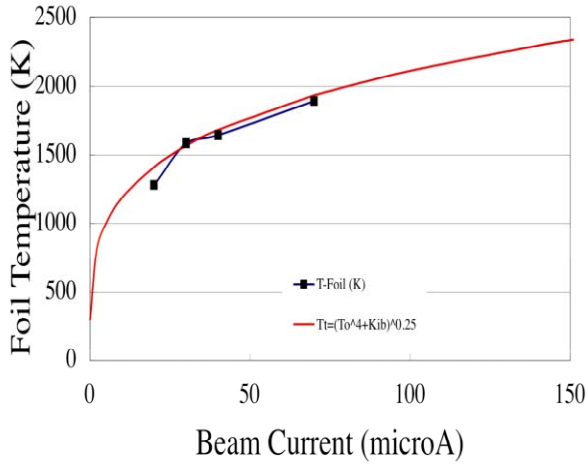


Figure 6: Foil temperatyre v. s, dc beam current

DC H^- BEAM TEST

The preliminary tests of H^- beam irradiation for several carbon foils were performed. Figure 5 shows an example of photograph of beam spot on a carbon foil.

The temperature of beam spot on the carbon foil was measured by the optical pyrometer and plotted as shown in Figure 6. The maximum temperature reached up to 2000 ºK with beam sopt of 2~3 mm dai.

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