Analysis of vacuum and residual gas in the chamber to generate 10 ns proton beam pulse

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1. Introduction

Nuclear data, which represents the interaction between neutron and material, is source technology for nuclear power to improve various industrial fields such as nuclear reactor, basic science, medical, and space industry and hence, the demand to secure more nuclear data has been increasing. Due to such a demand, proton linear accelerator (linac) has attracted attention as one of the techniques to secure nuclear data through generating high velocity neutron, which is formed when proton pulse beam crashes some target.

Now, we are planning to develop the technique for 10 ns proton beam pulse to produce more accurate neutron energy and it can provide the foundation for generation of nuclear data. Its system is designed as two major parts; one is deflector part in order to altering DC beam, which is extracted from ion source, into short pulse beam and the other is beam bunching system to compensate reducing beam current [1].

In this paper, we have examined the vacuum and residual gases in the fabricated deflector chamber as basic research for generation of 10 ns beam pulse to achieve efficient pumping system and examine the effect of residual gases. In the accelerator, the high vacuum system is important factor related to beam losses and radiation background.

2. Experiments

2.1. Deflector chamber and Vacuum system

The deflector chamber, made of stainless steel, included two deflecting Al electrodes of 140 × 140 mm^2 connected to high voltage feed-through with ceramic insulator and its size was around 600 × 300 × 300 mm^3. Its pumping system was designed with a turbo molecular pump (TMP) with 45,000 rpm, Osaka Vacuum, and a scroll pump with 300 l/min, ANEST IWATA Cor., which was connected to TMP but not chamber directly. The variation of pressure was observed by using LABVIEW system in real time.

2.2. Set up Residual Gas Analyzer (RGA)

After reaching high vacuum above 1 x 10^{-5} Torr, residual gas in deflector chamber was analyzed by using RGA, PFEIFFER Vacuum, which is called quadrupole mass spectrometer [2]. QUADSTAR 422 was used as execution program but not LABVIEW.

The RGA test was performed according to variation of pressure as shown in Table 1.

Table I. Experimental condition for RGA

Time (min)	Pressure (Torr)
25	1×10^{-5}
40	5×10^{-6}
150	1×10^{-6}
300	5×10^{-7}
1700	1×10^{-7}
3 days later	5×10^{-8}
4 days later	3×10^{-8}

3. Results and Discussion

3.1. Vacuum

Fig.1 (a) and (b) shows time verse pressure and fitting variation of pressure in 400 min, respectively. 4 days later, pressure reached around 3 × 10^{-8} Torr and its outgassing rate was around 1 × 10^{-9} Torr·L/sec·cm^2. At Fig.1 (b), fitting line (red line) indicated $P \sim At^n$ and here, n is around -0.7. It indicated that the pressure of fabricated chamber was similar to ideal pressure when considering n = -1 at that [3].

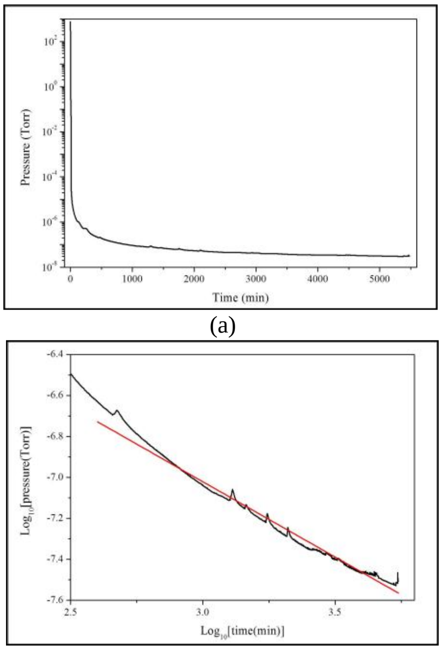
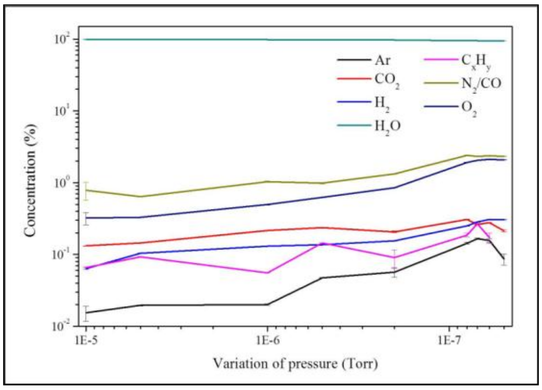


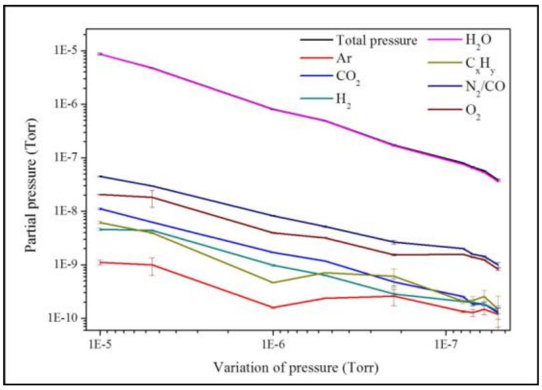
Fig. 1. Pressure variation for 4 days: (a) pressure verse time, and (b) fitting for variation of pressure in 400 min.

3.2. RGA test

As the result of RGA test, the residual gases were identified as Ar, CO_2, H_2, H_2O, C_xH_x, N_2/CO, and O_2. Most of residual gas was H_2O which took up over 94 % of concentration percent in pressure ranges we observed and that of H_2O reduced from 98 to 94 % when pressure varied from 1×10^{-5} to 3×10^{-8} Torr [3]. Fig. 2 (a) showed that the lower total pressure, the higher concentration percent of N_2/CO and O_2. It meant that total amount of gases reduced as total pressure reduced and H_2O might be pumped better in high vacuum than other gases due to more quantity than others and hence, partial pressure reduced in accordance with such tendency of concentration variation as represented in Fig. 2 (b). It was expected that N_2/CO and O_2 influenced beam loss or variation of total pressure in ultra-high vacuum, assuming to continue such variation tendency for partial pressure and concentration.



(a)



(b)

Fig. 2. RGA results for each total pressure: (a) variation of concentration percent verse variation of total pressure, and (b) variation of partial pressure verse variation of total pressure.

4. Summary

The basic researches for vacuum of deflector chamber were performed to examine efficient gas pumping and beam loss by residual gas. The pressure for chamber could reached around 3×10^{-8} Torr when scroll pump and turbo pump were applied and at this moment outgassing rate was 1×10^{-9} Torr·L/sec·cm^2. At RGA test, H_2O took up most of concentration percent and its partial pressure hardly distinguish total pressure. When total pressure varied from 1×10^{-5} to 3×10^{-8} Torr, concentration percent of H_2O reduced from 98 to 94 % and when total pressure was getting lower, the gap between partial pressures of N_2/CO, O_2 and H_2O was narrower even though it was tiny variation.

Acknowledgements

This work was supported by Ministry of Science, ICT & Future Planning.

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