Status and Plans for the Daejeon Ion Accelerator Complex at KAERI

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1. Introduction

The Daejeon ion accelerator complex (DIAC) is being built at the Korea atomic energy research institute (KAERI) in order to fulfill an increasing demand for heavy ion beam facilities for various applications including biological and nanomaterial research. Based on linacs of the Tokai radioactive ion accelerator complex (TRIAC) given from the high energy accelerator research organization (KEK), Japan, the dedicated accelerators in the DIAC are designed to produce stable heavy ion beams with energies up to 1 MeV/u and beam currents up to 300 μA. [1–4] In this article, status, plans, and some preliminary test results for the DIAC construction are presented and discussed.

2. Status of the DIAC Construction

2.1 Overview of the DIAC beam line

The stable heavy ion beam line of the DIAC consists of an electron cyclotron resonance (ECR) plasma ion source, a radio-frequency quadrupole (RFQ) linac and an interdigital H-type (IH) linac as shown in Fig. 1.

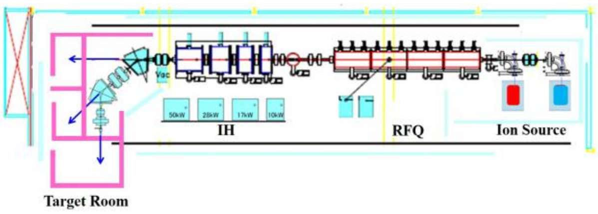

Fig. 1. Layout of the DIAC.

The multi-charged ions are produced and extracted in the ECR ion source. For the purpose of the DIAC, two ECR ion sources are considered. One is an 18 GHz ECR ion source given from the KEK. With a metal oven, it will be used for making metal ions. The other is a 14.5 GHz ECR ion source developed by the KAERI and will be employed for production of multi-charged carbon ions. The details of the KAERI ECR ion source are provided elsewhere. [5] After the extraction, they are soon entered to the 25.96 MHz RFQ linac as a post-accelerator. The RFQ linac accelerates them from 2 keV/u to 178 keV/u. Then, the accelerated ions reach to the 51.92 MHz IH linac via a transport system composed of a rebuncher and two sets of quadrupole doublet. In the IH linac, the ions are re-accelerated up to 1 MeV/u. Finally, they get to one of the targets with an energy of 1 MeV.

2.2 Status of the DIAC beam line

Up to now, (1) assembly of the ECR ion source and linacs delivered in pieces, (see Fig. 2.) (2) installation of power supply, coolant circulation system and vacuum pump system, (3) operation test of the ECR ion source, and have been completed.

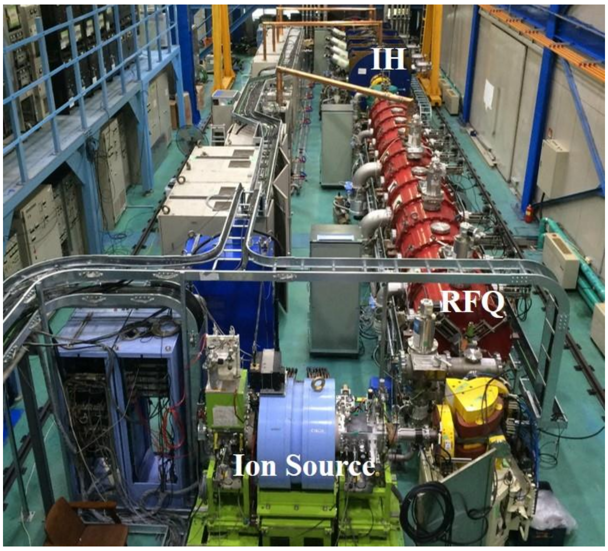

Fig. 2. The DIAC beam line.

Presently, operation test of IH and RFQ linacs are ongoing, and radiation shield for the DIAC facility and three target rooms are being designed. The following section gives preliminary results of the IH linac operation test, mainly regarding vacuum test and full-power test.

3. Preliminary Results of the IH Linac Operation Test

3.1 Vacuum Test in the IH tanks

To prevent generation of discharges during the full-power test for the IH linacs, high-vacuum condition should be required. Prior to the full-power test, pressure reduction in four tanks of the IH linac versus pumping time was measured using Pirani gauges (WP-02, Ulvac inc.) and metal ionization gauges (GI-M2, Ulvac inc.) for evaluation of the IH tank vacuum level. Rotary vane pumps, scroll pumps, and turbo molecular pumps were utilized for vacuum. Figure 3 shows characteristic pump-down curves of the IH tanks.

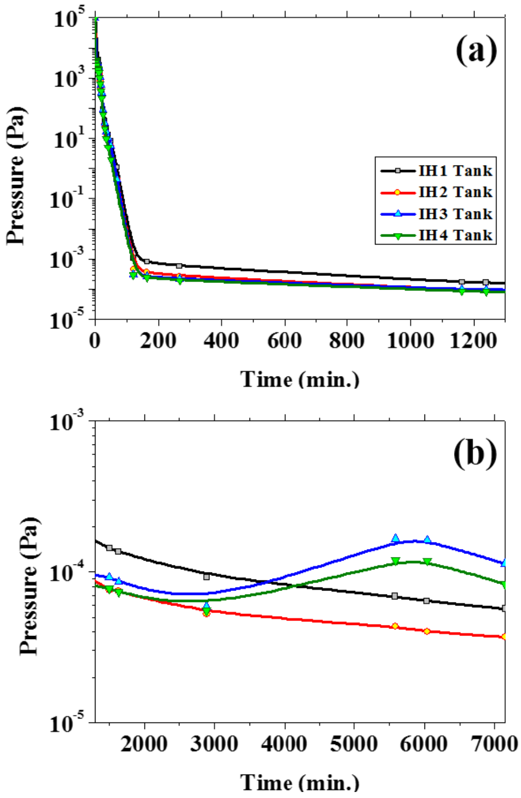

Fig. 3. Pump-down curves of the IH tanks for (a) 0 – 1300 min. and (b) 1300 – 7200 min.

In Fig. 3 (a), it appears that the characteristic curves over the pressure range from atmospheric pressure to $10^{-2\ \sim\ -3}$ Pa are nearly linear. For 0 – 100 min., evacuating the gas volume inside the tanks is the majority of the gas load. After 100 min., gases from surfaces are significant contributors to the gas load. In spite of the outgassing at surfaces as seen in Fig. 3 (b), it was confirmed that all ultimate pressures of the IH tanks were less than 1×10^{-4} Pa. This guarantees the discharge prevention during the full-power test.

3.2 Full-Power Test

Due to electron multipacting in the cavities, the full-power tests of high power IH2–4 (22, 30, and 50 kW) linacs were restricted. The full-power tests of the IH2–4 will be carried out after aging processes to clean the surfaces. We investigated the resonant frequency and the intensity of pick-up signal in the IH1 (12 kW) cavity as shown in Fig. 4. Since a change in RF power may cause temperature variation of the cavity structure, it seems that the resonant frequency depends on RF power as shown in Fig. 4. (a). It is clear that the resonant frequency decreases when RF power (or temperature) increases.

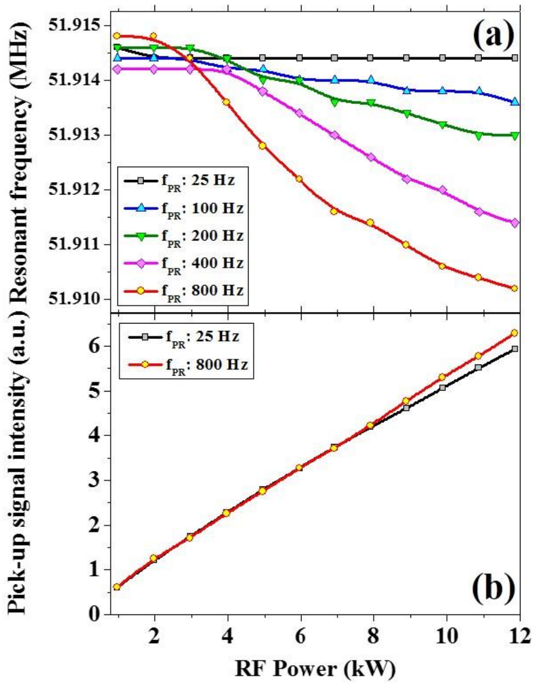

Fig. 4. Dependence of (a) resonant frequency of the IH1 (12 kW) cavity and (b) pick-up signal intensity on RF power. f_{PR} denotes pulse repetition frequency. Pulse width was 100 μs.

The reduction in the resonant frequency becomes significant at higher pulse repetition frequencies. This is due to the fact that a rise in the pulse repetition frequency leads to an increase in averaged RF power and then temperature. As illustrated in Fig. 4 (b), there is a closely linear increase in the cavity field intensity with increasing RF power. This indicates that the Q-value does not decrease over the entire IH1 RF power range (12 kW). More details on experimental data and analyses will be reported.

4. Future Plans

At present the full-power test of the IH2–4 linacs is limited by the multipacting. Based on the understanding of the multipacting characteristics, full-power test of all IH linacs will be finished soon. After that, full-power test of the RFQ linacs, the radiation shielding analysis, the beam tuning will be done until the end of this year.

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