The Korea Atomic Energy Research Institute Heavy Ion Irradiation Facility at KAERI: Present Status and Future Plans

Sung-Ryul Huh [a*], Dae-Sik Chang [a], Yong-Sub Cho [a], Churl-Kew Hwang [b], Seok-Kwan Lee [c], Jeong-Tae Jin [a], Byung-Hoon Oh [a], Suk-Kwon kim [a], Dong Won Lee [a]
[a]*Korea Atomic Energy Research Institute, 111 Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, South Korea*
[b]*Heo-Gyu, 110-505, 43 Gajeong-ro, Yuseong-gu, Daejeon, South Korea*
[c]*Joong-Ang Vacuum Co., Ltd., 13 Daejeon-ro 1395beon-gil, Daedeok-gu, Daejeon, South Korea*
[*]*Corresponding author: srhuh7@kaeri.re.kr*

1. Introduction

Based on linear accelerators (linacs) of the Tokai Radioactive Ion Accelerator Complex (TRIAC) given from the high energy accelerator research organization (KEK), Japan [1–4], a heavy ion beam irradiation facility has been successfully constructed at Korea Atomic Energy Research Institute (KAERI), Daejeon, Korea, for nuclear/fusion materials research and development. This facility, first called Daejeon Ion Accelerator Complex (DIAC) and later renamed Korea Atomic Energy Research Institute Heavy Ion Irradiation Facility (KAHIF), produces heavy ion beams with energies up to about 1 MeV/nucleon. In this article, status, plans, and test results are presented and discussed.

2. Description and Current Status of the KAHIF

The ion beamline of the KAHIF consists roughly of an electron cyclotron resonance (ECR) ion source, a split-coaxial radio-frequency quadrupole (SCRFQ) linac, a rebuncher (RB), an interdigital H-type (IH) linac, and a target chamber as shown in Fig. 1 (a) and (b).

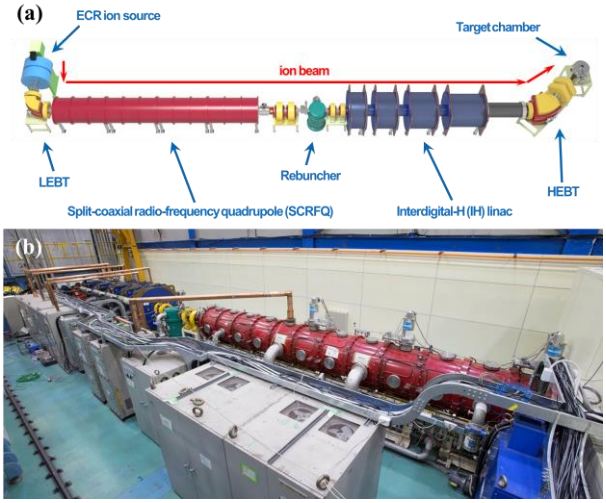

Fig. 1. (a) Schematic layout of the KAHIF, (b) picture of the KAHIF beamline.

The KAHIF is designed to provide stable non-radioactive beams. An 18 GHz ECR ion source together with low energy beam transport line (LEBT) can supply linacs with ions heavier than protons. The 25.96 MHz SCRFQ linac accelerates the heavy ions up to 178 keV/ nucleon. Then, the accelerated ions reach to the 51.92 MHz IH linac via a transport system composed of an RB and two sets of quadrupole doublet. Finally, the IH linac can reaccelerate the ions up to 1.09 MeV/ nucleon. The detailed specifications of the KAHIF linacs can be found in Table I [1].

Table I: Specifications of the KAHIF linacs

	SCRFQ	IH
Frequency	25.96 MHz	51.92 MHz
Charge-to-mass ratio	≥ 1/28	≥ 1/9
Input energy	2.07 keV/nucleon	178 keV/nucleon
Output energy	178 keV/nucleon	178–1090 keV/nucleon
Normalized emittance	0.6πmm·mrad	
Energy spread	1.03%	≤ 2.8%
Repetition rate	20–1000 Hz	
Total length	8.6 m	5.6 m

During the last four years, (1) assembly of the ECR ion source and linacs delivered in pieces from the KEK, (2) fabrication of a beam target chamber, (3) installation of the power supply, coolant circulation system, and vacuum pump system, (4) alignment of the beamline, (5) construction of radiation shielded walls and safety interlock system for the facility, (6) reorganization of the integrated control system, (7) acquisition of the radiation safety license, and (8) performance testing of the beamline components have been completed. Presently, beam tuning and commissioning of the KAHIF accelerators are in progress. The following section gives first results of the KAHIF beamline.

3. Results of the KAHIF Beamline Tests

To investigate the performance of the KAHIF beamline, helium (He) and argon (Ar) ion beam acceleration tests were carried out. He^{+} and Ar^{10+} ions were selected for the tests and separated from other

species by adjusting magnetic field intensity of the LEBT bending electromagnet as illustrated in Fig. 2.

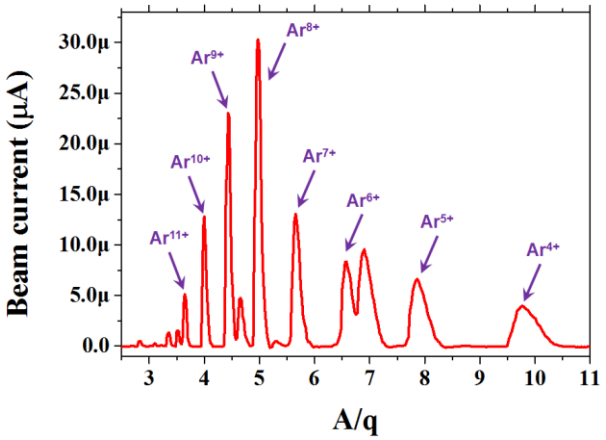

Fig. 2. The measured Ar ion beam currents as a function of mass-to-charge ratio (A/q) at the SCRFQ entrance.

Prior to the beam tuning, we checked whether the ion beam reached to the target chamber using lights emitted by a Chromox plate (see Fig. 3).

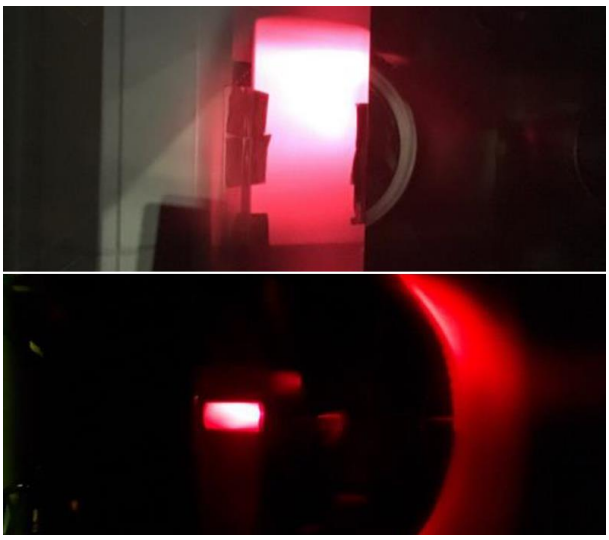

Fig. 3. The light emitted by the Chromox scintillating plate during ion beam irradiation.

Table II: Results of the ion beam acceleration tests

	He^+	Ar^{10+}
Beam energy	0.7–4.2 MeV	42.3 MeV
Peak beam current	7.8 eμA (@ 4.2 MeV)	0.8 eμA (@ 42.3 MeV)
Duty cycle	28.8%	
Repetition frequency	120 Hz	
Pulse width	2.4 ms	
Beam flux	4.9×10^{17} #/m^2·s	5.1×10^{15} #/m^2·s
Beam spot size	10 × 10 mm^2	

Table II above shows results of the He^+ and Ar^{10+} ion beam acceleration tests. The beam currents were measured with a Faraday cup in the target chamber, and the measured values of He^+ and Ar^{10+} beam currents were 7.8 and 0.8 eμA, respectively. Since the facility is still in need of optimization of beam dynamics, it is expected that the beam currents can be increased by the delicate beam tuning.

4. Future Plans

Heavy ion beams in the KAHIF now serve a vast range of scientific users in the fields of nuclear/fusion engineering. The facility can be used for simulating nuclear/fusion reactor environments. In the near future, a project to achieve higher utilization will be launched. The beam tuning for improving the beam quality and development of a new metal ion source for supplying metal ion beams to the users may be primary goals of the project.

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