Operation of the Pelletron tandem accelerator

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Ion beams with an energy range of MeV are available from the tandem accelerator (Pelletron 5SDH-2, 1.7 MV max.) in the Nishina R&D Building, which is managed by the Detector Team of RNC. This accelerator is also registered as joint-use equipment in Wako campus for material analysis. As shown in the configuration of the accelerator and beam lines (Fig. 1), two ion sources are available. One is the RF charge-exchange ion source, called Alphatross, for experiments using He ion beams. The other is the Source of Negative Ions by Cesium Sputtering (SNICS), which can generate almost all other ions. Thus far, ion species of H, He, Li, B, C, N, O, Si, Ti, Ni, Cu, and Au have been accelerated at 0.5–1.7 MV.

There are four beam lines named BL-E/W*nn* (*nn* denotes the bending angle). In 2020, BL-E15 was restarted for a user group in the field of material science to perform the analysis of Rutherford backscattering (RBS) spectrometry. In the west side, BL-W15 (multipurpose line) was used for a micrometer-sized ion beam based on glass capillary optics with an end window. This was for horizontal microbeam irradiation experiments. The irradiation port was developed to have a simple connection to the BL-W15 line. It took a few hours to mount the microbeam port, including the vacuum pumping. At the end of 2020, BL-W30 was under construction for new microbeam irradiation studies of the biological samples in air or solution.

From January 1 to December 31, 2020, the total machine time (MT) including a machine study was only

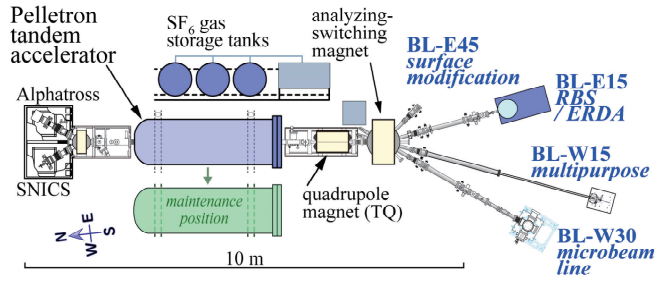

Fig. 1. Pelletron tandem accelerator and beam lines in the Nishina R&D Building.

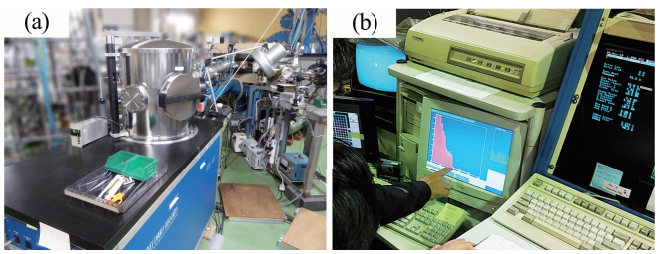

Fig. 2. (a) Apparatus for the RBS spectrometry connected to the Pelletron accelerator. (b) Online analysis.

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Table 1. Beam conditions and experiments conducted in the tandem accelerator.

Ion	Energy [MeV]	Beam current [pnA]	Experiment	Operation time [days]
$^{1}H^{+}$	2.0–3.0	1–120	Irradiation	8
$^{4}He^{2+}$	2.28	0.25–5	RBS	4

Table 2. Approved conditions at the RIKEN Pelletron.

Ion	Maximum Energy	Ion	Maximum Energy
H	3.5 MeV	B	10.2 MeV
He	5.1 MeV	C	12 MeV
Li/Be	6.8 MeV	other	0.6 MeV/nucleon

12 days, where the condition test of the ion sources is not included. In addition to the total MT, development activities were suppressed in 2020.

The ion species accelerated in this year were the light ions H^{+} and He^{2+} with energies ranging from 2.0 to 3.0 MeV, as summarized in Table 1. The RBS experiments always used the energy of 2.28 MeV, following convention. Points 1–6 below list the studies that used the beam lines, along with the number of days of MT. All the studies, including those with zero days of MT, were routine experiments before 2020.

(1) Microbeam performance study with H ions using glass capillaries at BL-W15 and W30[1,2] (7 days)
(2) Microbeam (He ion) irradiation for single cells at BL-W30[3] (0 days)
(3) RBS/ERDA experiments using carbon ions (4 days)
(4) Educational experiment of proton capture by carbon/boron nucleus for Nishina School (0 days)
(5) Development of charged-particle/gamma-ray detector to be used for RIBF experiments (0 days)
(6) Other development using protons (1 day)

The maximum energies of accelerated ions are summarized in Table 2. Since 2019, the regulation of the maximum energy of carbon ions was changed from 7.2 MeV to 11.9 MeV, where $^{12}C^{6+}$ is accelerated with the full voltage of 1.7 MV.

A commercial RBS apparatus (Charles Evans and Associates Model RBS-400) is shown in Fig. 2(a). A goniometer to rotate the sample is fixed inside the chamber, which is in a vacuum level of the order of 10^{-7} Torr. The He^{2+} beam intensity was less than 10 nA. Improvements in the vacuum level and beam intensity are in progress.

References

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