Ion stacking and pulse extraction at ERIS

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The ERIS (electron-beam-driven RI separator for SCRIT)[1)] at the SCRIT electron scattering facility[2)] is an online isotope separator system for the electron scattering of unstable nuclei. Ion beams from the ERIS are transported to the FRAC (fringing-RF-field-activated ion beam compressor).[3)] The FRAC realizes the continuous injection followed by trapping, and after the appropriate accumulation time, pulsed beams from the FRAC are injected to the SCRIT system. During the accumulation inside the FRAC, some of the trapped ions escape through the entrance because the entrance potential is lower than the beam energy. In order to reduce the ratio of escaped ions to injected ions, it is necessary to shorten the opening period of the entrance and inject same number of ions as in the continuous injection. Ion stacking and pulse extraction[4)] are proposed, and we report the results obtained at the ERIS in this paper.

Figure 1 shows a schematic drawing of the new ionization chamber of the ERIS. The new ionization chamber consists of a cathode, an ionization chamber (anode), and entrance and exit grids. The entrance and exit grids are connected to the ionization chamber through an insulator. The schematic potential structure of these electrodes is also shown in Fig. 1. The ion stacking and extraction are controlled by switching the voltage of the exit grid. Neutral atoms continuously enter the ionization chamber, passing through the cathode. They are ionized by electrons emitted from the surface of the cathode, which is kept at approximately 2000 °C. In the longitudinal direction, ions are trapped between the entrance and exit grids. The number of stacked ions inside the ionization chamber is determined by the ionization rate and ion-trapping lifetime.

The properties of the ion stacking and pulse extraction at the ERIS were studied using 6-keV ^{132}Xe ion beams. The voltages of the cathode, anode, and entrance grid were set to 0, 180, and 182 V, respectively. The exit-grid voltages at the stacking and extraction were 182 and 40 V, respectively. The typical pulse shape, measured at the entrance of the FRAC with a 1-ms stacking time and a 300-μs extraction period, is shown in Fig. 2(a). The pulse height is about five times larger than that of the continuous beam. Figure 2(b) shows the stacking ratio, which is the ratio of the total charge within a 300-μs pulse width to the total charge obtained by integrating the continuous beam over the stacking time and extraction period. This results shows that a pulsed beam with the same number of ions as those of the continuous injection is provided with a 1-ms stacking time and 300-μs pulse width. Using this scheme, the number of ions accumulated inside the FRAC is 2–3 times larger than when using continuous injection.[5)]

The decay time of the stacking ratio corresponds to the ion-trapping lifetime, which is estimated to be 4 ms. In order to extend the ion-trapping lifetime, a transverse potential like an RFQ potential is needed.

In addition, in Fig. 2(b), the stacking ratio exceeds one when the stacking time is shorter than 1 ms. This is believed to be because the extraction efficiency is different from that in the continuous extraction. One possible reason for this is that the potential distribution inside the ionization chamber is modified by the charge of the stacked ions.

In summary, we performed ion stacking and pulse extraction at the ERIS. The obtained accumulation efficiency at FRAC is still half of the target value[5)]. More detailed study and developments are in process.

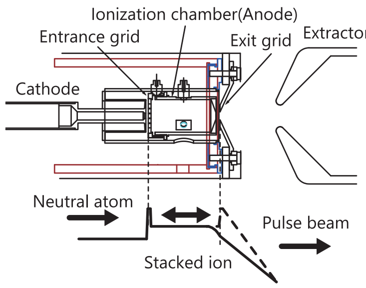

Fig. 1. Schematic drawing of the new ionization chamber of the ERIS. The schematic potential structure is also shown.

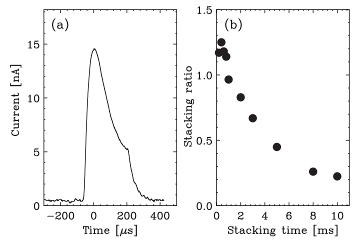

Fig. 2. (a) Pulse shape extracted from the ERIS after the stacking. (b) Stacking time dependence of the stacking ratio. Details are given in the main text.

References

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