Recent developments of RIKEN 28 GHz SC-ECRIS†

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In the past two years, we have attempted to improve the performance of RIKEN 28GHz SC-ECRIS for the production of an intense U ion beam. Last year, we produced ~200 eμA of U^{35+} at an injected radio frequency (RF) power of ~2.6 kW. For the RIKEN RIBF experiment, we produced ~110 eμA of U^{35+} ions with the sputtering method for longer than one month without interruption. In this case, we surely require a very stable beam to increase the transmission efficiency in the accelerators and avoid any damage to the components of the accelerator due to the high-power beam. Very recently, we tested the production of a highly charged Zn ion beam to meet the requirements of the RIBF project and to produce an intense beam with a very low consumption rate.

Figures 1(a) and (b) show the extraction current of the ion source and the beam intensity of U^{35+} ions, respectively. The extracted current is quite stable, and the average beam intensity of U^{35+} was ~102 eμA over a long period of time. Under this condition, a maximum beam intensity of ~49 pnA was successfully extracted from the superconducting ring cyclotron for the RIBF experiment conducted last autumn[1].

For long-term operation, it is important to minimize the material consumption rate. To obtain the consumption rate, we operated the ion source with the same sputtering voltage for approximately one month. In 2012, we produced an intense beam of U^{35+} with a sputtering voltage of approximately –5 kV. In this experiment, we observed that the consumption rate of the material is higher than that in the oven method[2]. To minimize the consumption rate while maintaining the beam intensity, we systematically studied the consumption rate for several sputtering voltages. At a sputtering voltage of –1 kV, the consumption rate was ~2.1 mg/h for the production of approximately 100 eμA of U^{35+} ions, which is significantly lower than the consumption rate at approximately –5 kV (~5 mg/h) .

For the production of Zn vapor, we used a low-temperature oven[3] of the same type as that used for the 18 GHz ECRIS at RIKEN. In the test experiment, we used He gas as a support gas and $_{nat}$ZnO as a sample. Fig. 2 shows the typical charge distribution of the highly charged Zn ions. The injected RF power was ~1.6 kW (28 GHz + 18 GHz). B_{inj}, B_{min}, B_{ext}, and B_r[4] were 3.1, 0.62, 1.78, and 1.94 T, respectively, and the typical gas pressure was 6.5–7.5×10^{-5} Pa. The average beam intensity was ~26 eμA of $^{64}Zn^{19+}$ ions, which is the required charge state of the Zn ions for RIBF experiments. The consumption rate of Zn was ~0.20 mg/h. If we assume the use of enriched ^{70}Zn, the beam intensity will be ~60 eμA, which is the required beam intensity. (the natural abundance of ^{64}Zn is about 48.6 %) Furthermore, the consumption rate for 28 GHz SC-ECRIS was almost same as that for 18 GHz ECRIS.

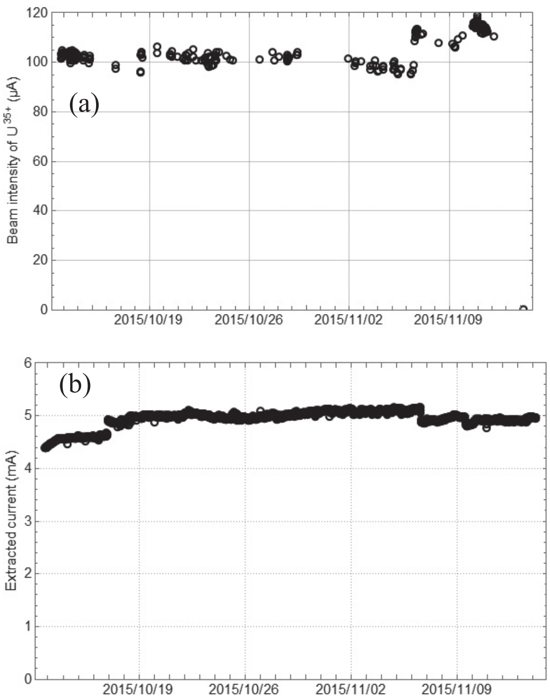

Fig. 1. (a) Beam intensity of U^{35+} ions and (b) the extracted current as a function of time.

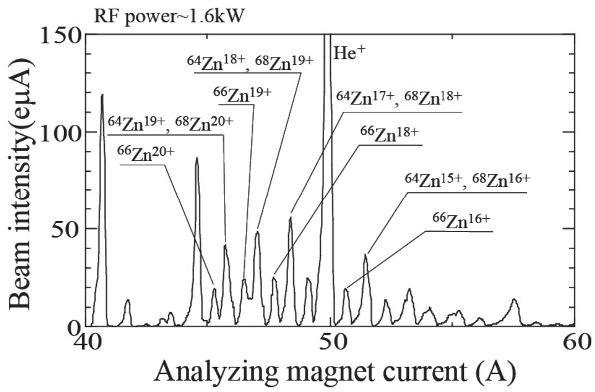

Fig. 2. Charge distribution of the highly charged Zn ion beam.

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References

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