新電子cyclotron共振イオンソース

著者

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電子cyclotron共振イオンソースの開発についての報告です。
II. 2. New Electron Cyclotron Resonance Ion Source for Heavy-ions

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Heavy ions delivered for the 930 cyclotron have been produced using a 14.5 GHz electron cyclotron resonance ion source (ECRIS) made of all-permanent-magnet\(^1\). This ion source can produce multi-charged ions of gaseous elements up to argon. Typical beam intensities extracted from the 14.5 GHz ECRIS are 10 e\(\mu\)A for \(^{16}\text{O}^{5+}\) and 1.5 e\(\mu\)A for \(^{40}\text{Ar}^{9+}\). Recently, improvements in beam intensity and energy are requested from users. To meet the needs, we have newly installed a 10 GHz ECRIS, which was operated at RIKEN accelerator research facility\(^2\-4\).

The 10 GHz ECRIS has eight solenoid coils for producing axial magnetic field. The currents for the coils can independently be varied to optimize an axial field profile. A plasma chamber is 100 mm in diameter and 520 mm in length. A microwave of 10 GHz is axially introduced into the plasma chamber, which works as a multimode cavity. The maximum microwave power is 1 kW. The extraction voltage is varied around 10 kV according to the injection condition to the 930 cyclotron. Gas mixing can be performed to obtain higher beam intensity for highly charged ions.

The first beam for a user experiment using the 10 GHz ECRIS was \(^{16}\text{O}^{5+}\) at June, 2010. In Fig. 1, a charge state distribution of \(^{16}\text{O}\) obtained at the experiment is shown with the solid line. For comparison, a typical beam current of \(^{16}\text{O}\) from the 14.5 GHz ECRIS is also plotted with the dashed line. In these measurements, parameters for the ECRISs were optimized to maximize the beam current of \(^{16}\text{O}^{5+}\). The beam current of 200 e\(\mu\)A is achieved for \(^{16}\text{O}^{5+}\) using the 10 GHz ECRIS. The achieved beam current is more than 10 times higher than the current of \(^{16}\text{O}^{5+}\) from the 14.5 GHz ECRIS.

The beam energy accelerated by a cyclotron is proportional to the square of the charge state of ions. The beam energy can thus be increased by increasing the charge state.
of ions. As can be seen from Fig. 1, the $^{16}\text{O}^{7+}$ beam from the 10 GHz ECRIS is obtained with a current of 10 eµA, which is comparable to the current of $^{16}\text{O}^{5+}$ from the 14.5 GHz ECRIS. Hence, the beam energy for $^{16}\text{O}$ can be increased by using the $^{16}\text{O}^{7+}$ beam from the 10 GHz ECRIS, without a decrease in beam current.

The 10 GHz ECRIS has been used for 10 experiments with beams of $^{16}\text{O}^{5+}$, $^{18}\text{O}^{4+}$, $^{18}\text{O}^{5+}$ and $^{12}\text{C}^{4+}$ in FY2010. For further enhancement of beam intensity, beam energy and variety of ions from the 930 cyclotron, we have some improvement plans including an optimization of gas mixing and introduction of so-called an accel-decel extraction system and of a metallic sample insertion system.

References


Figure 1. Charge state distributions of $^{16}\text{O}$. 