Performance of a resonant Schottky pick-up for the Rare-RI Ring project

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Construction of a new storage ring called "Rare-RI Ring" was started in 2012[1,2] at RIBF. This project aims at precise isochronous mass measurements for extremely neutron-rich exotic nuclei in the r-process nucleosynthesis. To precisely tune the ion-optical condition to be isochronous, the resonant Schottky noise pick-up technique will be employed. We performed an off-line test of the resonant Schottky pick-up.

Figure 1 shows the resonant Schottky pick-up that will be installed in the Rare-RI Ring. It consists of a pillbox-type resonant cavity electrically isolated from the beam pipe by a ceramic tube. A schematic view of the pick-up is shown in Fig. 2(a): a chamber shown in blue is the beam pipe and the shaded cylinder surrounding the beam pipe is the cavity equipped with two ports (yellow). The ports are movable plunger pistons that can adjust the resonance frequency ($f_{\rm res}$) of the eigenmode. Fig. 2(b) shows the cross-sectional view of the cavity, and the detailed structure of the gap can be seen at the center. The cavity itself is filled with air and has the shape of a pillbox with an outer diameter of 750 mm and length of 200 mm. The inner diameter is 320 mm. The lower flanges (see Fig. 1) are prepared for feedthroughs to take out signals from a loop coil that magnetically couples to the cavity field induced by the beam.

Using a network analyzer, we measured the basic quantities characterizing the resonant cavity: the resonance frequency, the shunt impedance $R_{\rm sh}$, and the unloaded Q factor Q_0. To measure $R_{\rm sh}$, the perturbation method was adopted. From the measurements, $f_{\rm res} = 171.54(\pm 0.44)$ MHz, $R_{\rm sh} = 169$ kΩ, and $Q_0 = 1884$ were obtained.

For tuning the isochronous field settings, the proposed pick-up is required to have an excellent single-ion sensitivity. By using the results of the off-line test, the output signal power corresponding to a single ion with charge q at resonance[3] is estimated to be $P = q^2 \times 2.8 \times 10^{-21}$ W , and the power of thermal noise $P_{\rm noise}$ is 7.1×10^{-19} W. For $q \geq 16$, the signal power exceeds the noise floor, and the signal from the beam can be detected by the present Schottky pick-up. Therefore, the performance is sufficient for precise tuning of isochronus field settings of the Rare-RI Ring.

The resonant Schottky pick-up will be soon installed into the Rare-RI Ring. Detailed results of the off-line test and online beam performance test will be reported in forthcoming publications.

Fig. 1. The resonant Schottky pick-up that will be installed in the Rare-RI Ring. The resonant cavity surrounds the beam pipe with a ceramic gap. The lower flanges for feedthroughs are the output coupler loop, and the upper feedthroughs are the movable plunger pistons, using which the resonance frequency of the eigenmode can be adjusted.

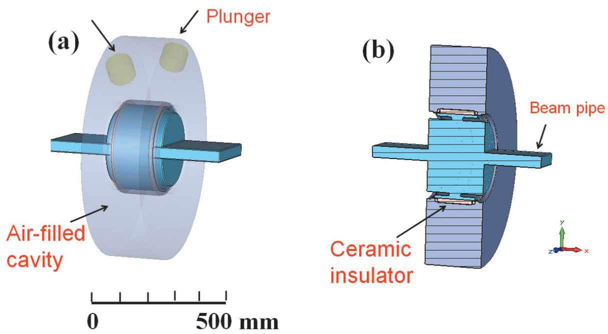

Fig. 2. Schematic view of a resonant cavity for the Rare-RI Ring. (a) The pillbox-type cavity shown translucently surrounds the beam pipe separated by a ceramic tube. (b) A cross-sectional view of the cavity showing the detailed structure of the gap.

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