Measurement of beam-spot temperature on production target at BigRIPS

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The primary beam intensity until U beams at the RIBF is increasing yearly towards the final goal of 1 puA with 350 MeV/nucleon. The target needs to withstand the beam intensity. We report on the measurement of the beam-spot temperature on the production target for the BigRIPS for the primary ^{48}Ca, ^{78}Kr, and ^{238}U beams.

For the BigRIPS, two types of targets are used. One is a ladder-shaped target with water cooling, which is a fixed target for a low-beam-power experiment (a few kilowatts of energy loss) and the other is a water-cooled rotating disk target for a high-beam-power experiment. Details of the target system are described in ref. 1). We have measured the temperature of the surface of the target using an infrared thermos-viewer at a distance of 14 m from the target.

Figure 1 shows the beam-spot temperature on the fixed- and rotating-Be target as a function of the primary beam intensity at the exit of the SRC of ^{48}Ca, ^{78}Kr and ^{238}U beams with a beam-spot size approximately 1.5 mm in diameter. The maximum intensities of the ^{48}Ca, ^{78}Kr, and ^{238}U beams in these measurements are 480 pnA, 270 pnA, and 38 pnA, respectively. The calculated beam-spot temperature for the fixed targets is described in ref. 2). We can observe the image of the temperature distribution for the rotating Be target for the first time. Figure 2 shows the temperature image of the 15-mm-thick Be target at 100 rpm bombarded by 48Ca with 420 pnA as an example. A significant change of the beam-spot temperature due to the difference in rotational speeds, 100 rpm and 300 rpm, was not observed.

By Comparing the observed temperatures for the fixed- and rotating-Be target of the same thickness for ^{48}Ca and ^{78}Kr, it can be seen that the latter has a 5-8 times gain in the primary beam intensities. The results indicate that we have a sufficient margin for the lighter primary beams below Kr with an intensity of 1 puA.

We also measured the beam-spot temperature only on a fixed target for ^{238}U with 38 pnA, as shown in Fig. 1. In the case of the 3-mm-thick Be target, its maximum temperature is 333 degrees, which is sufficiently lower than the melting point of Be. However, the center of the target had a melted mark and small cracks with spike shapes on the downstream side after the experiment, as shown in Fig. 3. Although the reason for this is currently under investigation, we have assumed that the fixed target reaches the critical limit in this intensity. We are planning to introduce the rotating target in ^{238}U next time. Even if the rotating target has an eightfold gain as compared to the fixed one, as is the case for Kr beams, it is difficult for the target to withstand the goal intensity, i.e., 1 puA for ^{238}U beams. We will have to improve the target system based on various measurement data including the beam-spot temperature and its model calculations.

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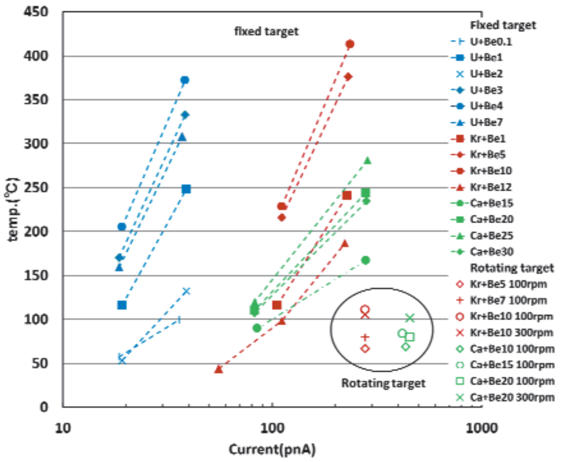

Fig.1 Beam-spot temperature on a Be target as a function of the primary beam intensity of ^{48}Ca, ^{78}Kr, and ^{238}U beams.

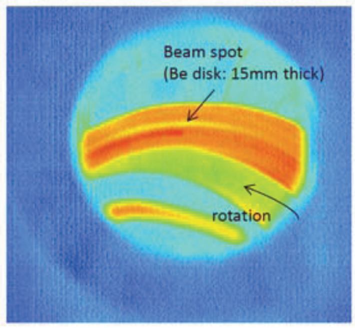

Fig.2 Observed temperature image in the 15-mm-thick rotating Be target with 100 rpm bombarded by ^{48}Ca with 420 pnA.

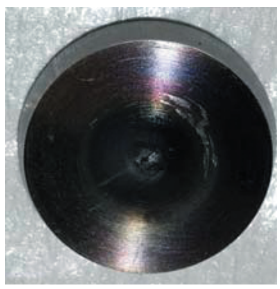

Fig.3 The downstream side of the 3-mm-thick Be target bombarded by a ^{238}U beam with 38 pnA after the experiment.

References

1) A. Yoshida et al.: Nucl. Instrum. Meth. Phys. Res. A 655, 10 (2011) and their references.
2) Z. Korkulu et al.: In this report.