Improvements in the working environment for target handling at ERIS

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The electron-beam-driven radioactive isotope separator for SCRIT (ERIS)[1] at the SCRIT electron scattering facility[2] is an online isotope-separator system used to produce low-energy radioactive isotope (RI) beams using the photofission of uranium. In this year, we transported a ^{137}Cs beam to the SCRIT system installed inside the electron storage ring[3] and performed the RI trap. Under these circumstances, ERIS has become a full-scale operation, around 4-month RI beam operation in a year. Therefore, it is important to maintain the working environment of target handling. In this paper, we introduce the working environment of the RI production target, as one of the recent developments of ERIS.

Uranium carbide is used as a RI production target using the fission reaction of uranium. It is more suitable for RI production target than uranium oxide because its vapor pressure and density are lower and higher than those of uranium oxide, respectively. Further, damages to materials of the ion source can be reduced using a small amount of oxygen.

The recent study shows that the porous structure with the nano material is important for fast diffusion inside the target and high-extraction efficiency of RI.[4] However, this porous structure causes high susceptibility to oxidation. Figure 1 shows the oxidation reaction of uranium carbide in the air. The uranium carbide disks shown in Fig. 1 are made with graphene. Oxidation started 1 min after the removal from the vacuum container, and it ended after almost 10 min. The temperature of uranium carbide disks reaches around 800°C, as shown in Fig. 1. After oxidation, these disks cannot hold their shape and turn into powder. The uranium oxide powder is planned to be cemented solid after sufficient cooling.

A glove box was installed in the draft chamber at the working area to handle uranium carbide targets safely. Figure 2(a) shows the setup with the glove box. Since this glove box has the capacity of vacuum gas replacement, the oxygen concentration becomes less than 0.001% vacuum gas replacement with nitrogen gas (less than 2% per one replacement is performed three times). In this situation, target handling can be performed without worrying about oxidation. One such example is shown in Fig. 2(b).

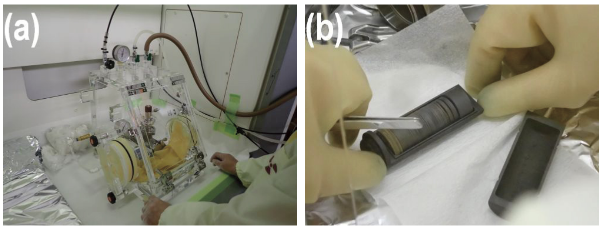

Fig. 2. (a) Photograph of the setup with the glove box inside the draft chamber. (b) Photograph of handling the uranium carbide disks inside the glove box.

The present size of the glove box is smaller than the target chamber, and therefore, we need to work in the air to install the target in the target chamber. A graphite-target container with keyway, as shown in Fig. 3, is used to reduce the installation time, and the target insertion practice is performed beforehand. It took almost 5 sec to remove the graphite-target container with the uranium target disks from the container filled with nitrogen gas, insert it into the target holder inside the target chamber, and start the vacuum pump. This short time was sufficient, as evidenced by the small amount of gas released during heating.

In the near future, the safety treatment of the production target will become an important issue because of the high radiation (a few mSv/h), which is two orders of magnitude higher than the present value (~10 μSv/h), and active operation. Therefore, we plan to introduce a large glove box adapted to the target chamber and establish a remote handling system.

Fig. 1. Photograph of the oxidation reaction of uranium carbide disks in the graphite container. Diameter and thickness of a disk are 18 mm and 0.8 mm, respectively. The amount of uranium in a disk is about 0.7 g.

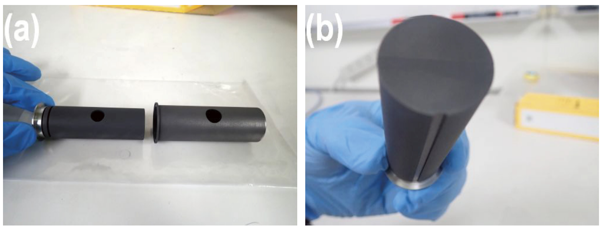

Fig. 3. (a) Photograph of the graphite-target container with keyway (left) and the target holder (right). (b) Photograph of keyway of the graphite-target container.

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References
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