Current status of RI beam production at electron-beam-driven RI separator for SCRIT (ERIS)

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The electron-beam-driven RI (Radioactive Isotope) separator for SCRIT (ERIS) at the SCRIT electron scattering facility[1)] consists of a RI generator and an ISOL-type RI separator employed to produce low-energy RI beams used for the electron scattering of unstable nuclei. In ERIS, the photofission of uranium driven by an electron beam is used for RI production. Details of ERIS were reported in Ref. 2. During the present year, uranium-carbide target was prepared, and the RI production has been started. In this paper, we report the first result of the RI production at ERIS.

For the RI production, we prepared uranium-caribide disks. Uranium carbide was obtained by the carbothermal reduction of uranium oxide in presence of carbon around 1800 °C. First, uranyl nitrate was mixed with 20μm graphite grains, after which uranyl nitrate was oxidized to UO_3 under air flow by heating to 500 °C. Next, UO_3 powders with graphite were manually ground, and they were formed into a disk without a binder at 180-MPa compression. The obtaind disk was 20 mm in a diameter and around 2 mm in a thickness. It was heated to 1000 °C in a vaccum for outgassing, and the reduction reaction $UO_3 \rightarrow UO_2$ proceeded. The finished disk consisted of about 0.7-g grahpite and 1.9-g UO_2 powders. Mass concentration of uranium in the disk was estimated as 1.9 g/cm^3. In total, 20 disks were prepared. The sum of the thicknesses of 20 disks was almost 50 mm, and the total amount of uranium was about 30 g. Finally, all uranium-oxide disks were converted into uranium carbide at around 1800°C by using the heating system in ERIS.

The prepared uranium-carbide disks were irradiated with electron beams accelerated to 150 MeV by RTM [1)]. The electrom beam power was nearly 10 W. Tantalum disks with a thickness of 5 mm and a diameter of 20 mm were inserted in front of the production target to increase the production of γ rays. The target temperature was around 2000 °C. Produced RIs were accelerated to 20 kV and mass-separated by the analyzing magnet. They were transported to the particle identification system for ERIS (PIE) located at the exit of ERIS. PIE consists of a rotating Al disk and a Ge detector, and it measures γ rays corresponding to the decay of the RIs stopped inside the rotating disk.

Figure 1 shows the rate of Sn and Xe isotopes at PIE. These rate are estimated from the observed γ-ray yield using the efficiency of the Ge detector and the half-life of each isotope. By comparing with the expected production rate inside the target, the overall efficiency can be estimated. Here, the overall efficiency includes the efficiency of release from the target, ionization in the ion source, and efficiecy of transport from ion source to PIE. For example, the measured rate for ^{137}Xe is 1.1×10^5 atoms/s and the expected production rate is about 1.6×10^8 atoms/s. The overall efficiency for ^{137}Xe is estimated to be 0.07%. In this experiment, the overall efficiency of stable xenon with a calibrated gas flow was measured to be 1%. Since the stable xenon was introduced into the ionization chamber through a gas inlet, the measured overall efficiency of stable xenon includes only ionization and transport efficiencies. The release efficiency of ^{137}Xe is estimated as 7% from these results. In the case of ^{132}Sn, the measured and expected production rates are 6.0×10^3 and 2.6×10^7 atoms/s, respectively. The release efficiency of ^{132}Sn is evaluated as 2.3% using the same ionization and transport efficiencies as those of Xe. This assumption is supported by the results obtained at ALTO[3)]. The release efficiency of Sn at ERIS is lower than that of Xe. One of the reasons is the inadequate conditions of the adsorption process at ERIS, such as temperature.

Further studies concerning the target fabrication and the optimization of the target and ion source conditions are in progress to increase the release efficiency.

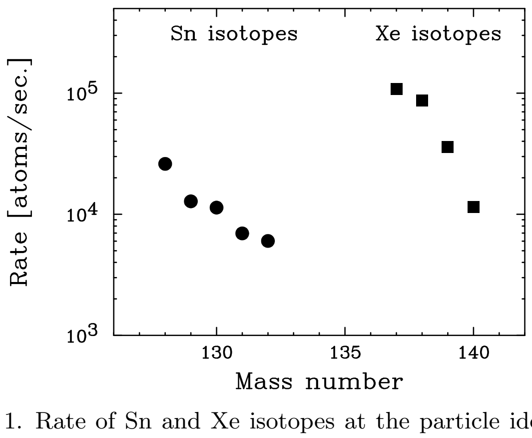

Fig. 1. Rate of Sn and Xe isotopes at the particle identification system of ERIS. The electron beam power was almost 10 W during the measurement. These rates are estimated on the basis of the observed γ-ray yield.

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References
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