First α-γ spectroscopic study using a Si-Ge detector array installed at the focal plane of GARIS

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A basic study on α-γ spectroscopy was performed using a Si-Ge detector array installed at a focal plane of a gas-filled recoil ion separator GARIS.

The GARIS has been applied for studying production and decay properties of superheavy element (SHE) nuclides produced via Pb/Bi-based fusion reactions (cold fusion); in particular, these studies focused on the search for 113^{th} element on the basis of ^{209}Bi(^{70}Zn,n)^{278}113 reaction from 2003 to 2012[1–3]. In the most of these experiments, the number of identified atoms was limited because of the low production cross section of the SHE nuclides. The nuclide identification method was based on the genetic relation between mother and daughter. It involved measuring the α-decay and spontaneous fission SF. Therefore, a detailed decay scheme including γ-decay could not be obtained. In 2013, we newly installed a Si-Ge detector array, as shown in Fig. 1, at the focal plane of GARIS for studying the production and decay properties of reaction products for ^{248}Cm+^{48}Ca[4]. The Si-Ge array is useful as a probe for detecting prompt γ-ray coinciding with SF[5]. Before the experiment, we calibrated the Si-Ge array by using a ^{207}Pb(^{48}Ca,2n)^{253}No reaction.

Projectiles of ^{48}Ca with a charge state of 11^+ were extracted from the 18-GHz ECR ion source and accelerated up to 218.5 MeV using the RILAC. The intensity of a typical beam incident on a target was 5.2×10^{12} s^{-1} (0.86 pμA). The metallic ^{207}Pb target was prepared by vacuum evaporation on a 60 μg/cm^2 carbon foil. Target thickness was 371 μg/cm^2 for ^{207}Pb (enrichment of 99.59%). Sixteen frames of the sector targets were mounted on a ϕ30 cm rotating wheel, which was rotated at 3300 rpm. The reaction products were separated in-flight from projectiles and other by-products by GARIS, and they were guided into the focal plane detection system after they passed through the time-of-flight detector. The separator was filled with helium gas at a pressure of 73 Pa. The magnetic rigidity $B\rho$ was set to 2.064 T·m for ^{253}No. Gamma rays emitted in prompt coincidence with α-particles registered by a conventional position-sensitive Si detector (PSD box)[1–3] were measured using a planar-type Ge detector for counting low-energy photons (CANBERRA BE6530; active volume: ϕ91.5 mm$\times$31.6 mm^t). The distance between PSD and Ge detector was c.a. 6 mm (3 mm between PSD and 1 mm^t Al window + 2 mm between Al window and Ge detector). The peak efficiency for 122-keV photons was 22.8% at the middle position of the PSD. Figure 2 (a) shows a two-dimensional energy plot of α- and γ-rays observed in prompt coincidence. The energy spectrum of γ-rays observed in prompt coincidence with α-decays is given in Fig. 2 (b). These data were obtained under low-background condition, despite the high beam intensity of 0.86 pμA. Observed α- and γ-transitions due to ^{253}No agree well with previously reported values[6].

The Si-Ge array will be applicable to study α-γ(X) spectroscopy of SHE nuclides.

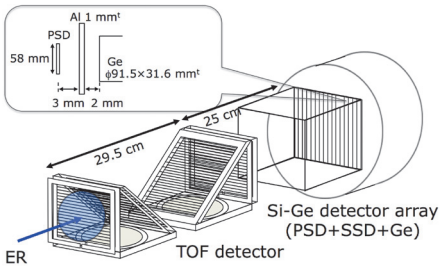

Fig. 1. New focal plane detector including Si-Ge array.

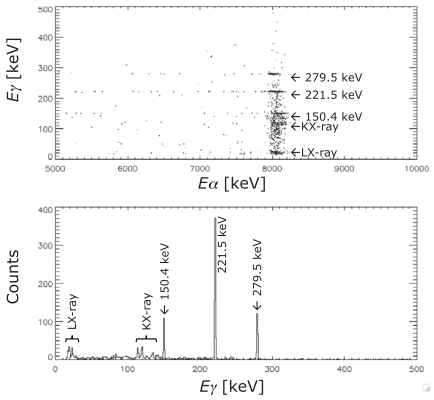

Fig. 2. (a) Two-dimensional plot of α-γ coincidence. (b) Projection of the events onto the γ-energy axis.

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