Verification test of ^{107}Pd transmutation†

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In a previous study, we reported the construction of an implantation beam line for ^{107}Pd transmutation.[1] After that, ^{107}Pd was implanted into a carbon foil and irradiated by a deuteron beam. In this study, a verification test for the ^{107}Pd transmutation is reported.

^{107}Pd ions were implanted into a carbon foil as $^{107}PdO^-$ with an energy of 20 keV. This foil is a multilayer graphene sheet with a thickness of 360 μg/cm^2 developed by KANEKA.[2] The amount of implanted ^{107}Pd was analyzed by inductively coupled plasma mass spectrometry (ICP-MS) to be approximately 270 ng in a carbon foil. The ^{107}Pd-implanted sample was irradiated by deuteron at 12 MeV/nucleon with a current of 1–2 particle μA. The cumulative irradiation current was 1.09 C, which corresponds the irradiation with a beam current of 1 particle μA for 12.6 days.

After cooliing, γ-ray measurements were conducted. The γ-ray spectrum of the irradiated sample is shown in Fig. 1. γ-ray emitting from radionuclides of ^{7}Be, ^{105}Ag, and ^{106m}Ag were detected. ^{7}Be is produced from carbon, while ^{105}Ag and ^{106m}Ag are generated from the transmutation of ^{107}Pd. The activities of ^{105}Ag and ^{106m}Ag were calculated from the γ-ray spectrum of 345 keV and 450 keV, respectively. The activity was determined using the total net count of γ-ray peaks. The radioactivity was decay-corrected from the day when the deuteron irradiation finished. Considering the γ-ray abundance of 0.41 at 345 keV and 0.28 at 450 keV, the activity was calculated to be 8.38×10^2 Bq and 4.98×10^4 Bq, which correspond with 0.8 pg of ^{105}Ag and 9.0 pg of ^{106m}Ag, respectively.[3]

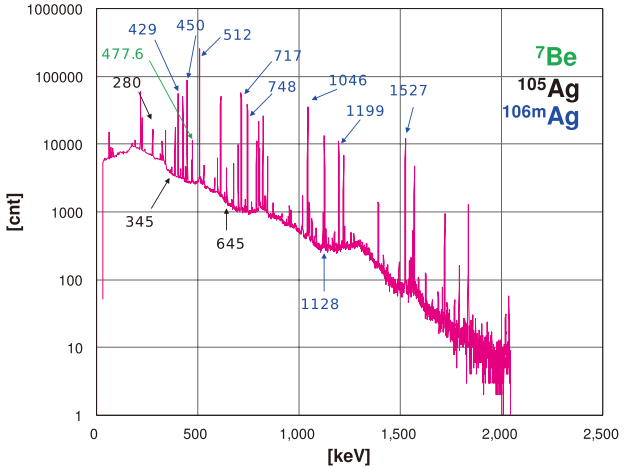

Fig. 1. γ-ray spectrum of irradiated sample.

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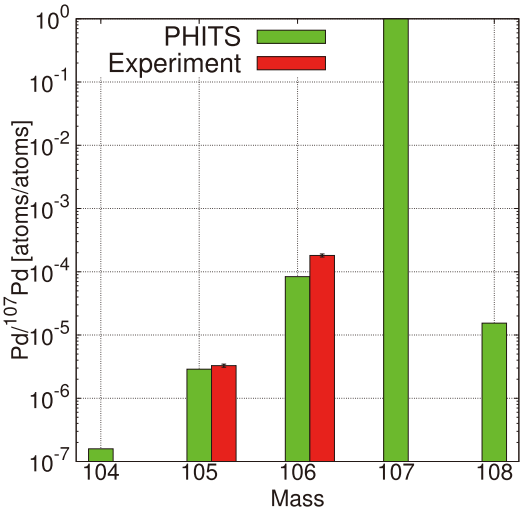

Fig. 2. Isotopic ratio of Pd/^{107}Pd of irradiated sample.

The production yield of nuclides per deuteron was calculated using the Particle and Heavy Ion Transport code System (PHITS) to estimate the amount of ^{105}Pd and ^{106}Pd generated by the experiment.[4] Assuming that all ^{105}Ag and ^{106m}Ag detected by the γ-ray measurements will be converted into ^{105}Pd and ^{106}Pd, respectively, they amount to 92% for ^{105}Pd and 25% for ^{106}Pd generated from the ^{107}Pd transmutation. Therefore, the total amount of ^{105}Pd and ^{106}Pd was estimated to be 0.9 pg for ^{105}Pd and 40 pg for ^{106}Pd. Considering that the amount of implanted ^{107}Pd was estimated to be 270 ng, the isotopic ratios were calculated to be 3.29×10^{-6} for ^{105}Pd/^{107}Pd and 1.49×10^{-4} for ^{106}Pd/^{107}Pd.

The isotopic ratio normalized by the number of ^{107}Pd nuclei (Pd/^{107}Pd) was also evaluated by a simulation using PHITS. Considering the production yield of each nuclide, the change in the isotopic ratios were estimated to be 2.90×10^{-6} for ^{105}Pd/^{107}Pd and 8.43×10^{-5} for ^{106}Pd/^{107}Pd for deuteron irradiation performed with a beam current of 1 particle μA for 12.6 d. This estimation is consistent with the experimental results, thereby preliminarily verifying the ^{107}Pd transmutation (Fig. 2).

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References

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