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Design and Fabrication of Titanium Target for Portable Neutron Generator

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1. Introduction

A portable sealed tube neutron generator that has a low neutron flux in the order of 10^6 - 10^8 n/s is useful on industrial fields such as landmine detection, material research, non-destructive instruction, and so on. For the neutron generator to produce a neutron flux of the above order, a target that produces fast neutrons in the generator plays an important role, and the target is used and applied to develop the generator due to its simplicity and inexpensive. Making suitable targets for neutron production, especially mono-energy neutrons, has always been of interest. These targets have been used for neutron production reaction studies, calibration of detectors, and neutron therapy. Different studies have been carried out on deuterium and tritium for making solid targets to produce mono-energy neutron from D-D and D-T reactions. A lot of investigations have been carried out on solid target properties such as lifetime, thermal stability, neutron yield, and energy. Vaporized zirconium and titanium layers on a high thermal conductivity substrate (Cu, Mo, Ag) have been used as deuterium and tritium absorbing metals. The density of titanium is smaller than zirconium and the range of charged particles in the titanium targets is more than that in zirconium targets. Thus, titanium targets have more neutron yield than zirconium targets in a low energy beam and titanium is usually used to make a target. Choosing an optimum thickness of the target is an important point to access the suitable lifetime and maximum neutron yield [1-3].

2. Methods and Results

2.1 Simulation

100 – 150 keV energy of a deuterium or tritium beam is required to produce a neutron flux on the order of 10^8 n/s through D-D (neutron energy 2.5 MeV) or D-T (14 MeV) nuclear reaction. A simulation code, called SRIM-2013, was used to determine the thickness of the titanium target. The simulation parameters are below:

- Ion species : deuterium and tritium
- Beam energy : 150 keV
- Number of particle : 10000
- Target species : titanium

Figure 1 shows a trace of deuterium and tritium beams in the titanium target. The maximum moving distances of the deuterium and tritium beams are 1.25 and 1.54 μm. The target should be much thicker than 1.54 μm to trap injected particles into the target. Thus, the thickness of the titanium target, which is chosen to capture all particles, is 2 μm.

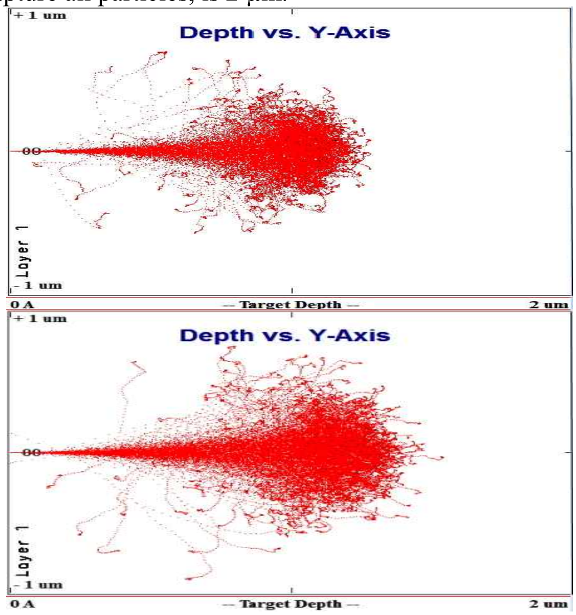

Fig. 1. Particle trace of deuterium(Top) and tritium(Bottom) beams with 150 keV in titanium target

2.2 Design and Fabrication

Copper has been used as a substrate, because of its high thermal conductivity. The dimensions of copper are 36 and 1 mm in diameter and thickness, respectively. Its diameter is the same as that of the target holder diameter in most neutron generators. Two titanium targets were fabricated. The titanium has been deposited on a copper substrate by an evaporation method, and the evaporation velocity is 0.1 nm/s in a vacuum. The thickness and diameter of the layer is 2 μm and 30 mm. A titanium pellet with 99.995% purity is used and heated in a crucible and evaporated on the copper. When the thickness of the titanium is 2 μm through a thickness monitoring system, an evaporation instrument is stopped by the automatic system. Figure 2 shows the target fabricated by evaporation for neutron production.

2.3 Thickness

The thickness and roughness of the target was measured using a profiler. Figure 3 shows the thickness and roughness of the target layer. The thickness was confirmed by measuring the height between the titanium and the copper. The thickness of the two targets was measured as 2.108 and 2.190 µm. The target is suitable to capture injected deuterium and tritium particles.

Table I: Thickness of titanium target measured using a profiler method

Thickness [µm]	Target no.
2.108	1
2.190	2

Fig. 2. 2µm titanium target fabricated by evaporation instrument for fast neutron production

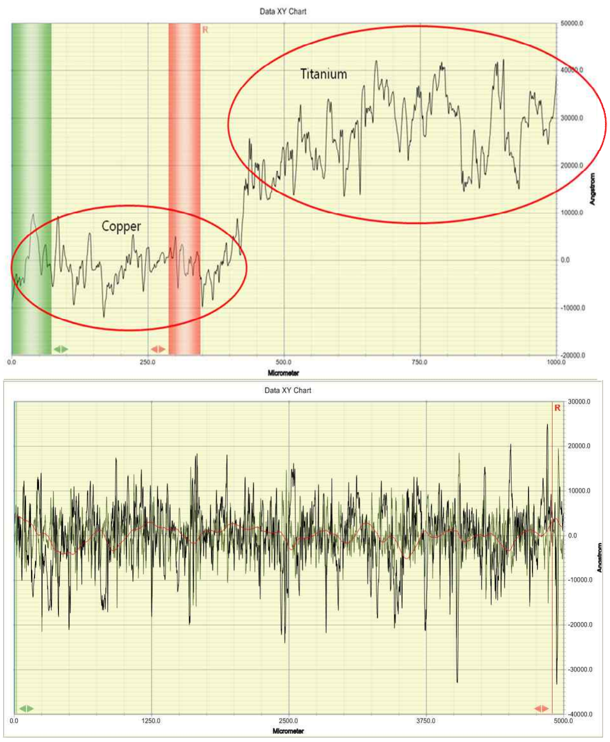

Fig. 3. Thickness of titanium layer measured by using a profiler

3. Conclusions

A fast neutron with mono-energy is generated by a D-D or D-T nuclear reaction. The titanium target was designed and simulated to determine the suitable thickness of the target. As a result of the simulation, the target was fabricated to generate fast neutrons by the reaction. The thickness of the target was measured using a profiler. The thickness of the two targets is 2.108 and 2.190 µm. The target will be applied to produce neutrons in a neutron generator.

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