DEVELOPMENT OF NEUTRON GENERATING TARGET FOR COMPACT NEUTRON SOURCES USING LOW ENERGY PROTON BEAMS

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ABSTRACT

Neutron is a useful probe for basic science, material analysis and non-destructive testing for industries. Compact neutron sources are recently attracting attention since they are useful in expanding application areas of neutron beams. In order to construct compact accelerator-driven neutron source, low energy Be(p,n) reaction is one suitable nuclear reaction to generate neutrons. However, low energy proton beams usually cause serious problem of hydrogen embrittlement in target called "blistering". This is because proton is injected into Be target in a thin layer just below the surface because of Bragg peak effect. The depth of this layer is about 400micrometer when proton beam energy is 7MeV.

The authors have proposed a new target design that can prevent the problem of blistering without losing the neutron generation efficiency (Fig.1). The neutron yield in Be(p,n) reaction drops steeply at 2MeV. So, when the thickness of beryllium is equal to the thickness with which proton beam loses energy down to 2MeV, most of proton beam penetrate beryllium layer and absorbed by the substrate. If substrate is made of metal having high hydrogen diffusion constant, hydrogen will be diffused away to prevent blistering. Vanadium, niobium, tantalum have relatively high hydrogen diffusion constant. Among them, vanadium has highest hydrogen diffusion constant and, besides, activation product caused by neutron capture has very short half-life, which is suitable for safe maintenance work of compact neutron sources. Hydrogen diffusion was computationally simulated using Monte-Carlo method and finite element analysis. Based on those analysis, a new concept target with 300um beryllium with vanadium substrate was manufactured and tested at RIKEN compact Accelerator-driven Neutron Source (RANS)(Fig.2) for about 1 year. After, 1 year operation, the target was inspected by microscope and no blistering was observed (Fig.3). In addition, activation level of the target is measured using gamma-ray detector.

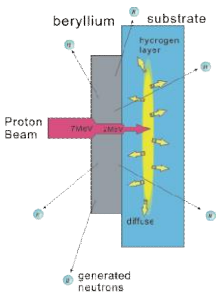

Fig. 1 Schematic view of the target

Fig.2 RIKEN compact Accelerator-driven neutron source (RANS)

Fig.3 Manufactured target before use and after 1 year