§32. Applicability Study of Radiophotoluminescence (RPL) Glass Dosimeter to 14 MeV Neutron Irradiation Experiments

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Neutoronics design studies of liquid cooled blanket systems have been conducted at NIFS to achieve sufficient tritium fuel breeding and radiation shielding performances in helical type DEMO and commercial fusion reactors. Evaluation of calculation accuracies in the design studies and confirmation of the expected performances are considered essential to show the feasibility of the reactor designs and have to be performed by 14 MeV neutron irradiation experiments with blanket mock-up assemblies. In the present study, applicability of radiophotoluminescence (RPL) glass detector which has been developed for a 14 MeV neutron irradiation experiment with a Li/V-alloy assembly has been examined.

New Ca-Na RPL glass (P:32, O:49, Ca: 16, Na: 3, Ag: 0.1 wt%) examined in the present study can keep radiation dose information up to 300 °C. In the fiscal year of 2010, three types of the RPL glass detectors containing natural Li (^{6}Li: 7.5 %, ^{7}Li: 92.5 %), enriched ^{6}Li (^{6}Li: 93 %) and enriched ^{7}Li (^{7}Li: 99.9%) have been fabricated for measurements of tritium production from lithium under neutron environments. Reponses of the detectors have been examined under graphite-moderated neutron field.[1] In the fiscal year of 2011, applicability of the RPL glass detectors to benchmark experiments of fusion neutron transport has been examined by neutron transport calculations.

A DT neutron irradiation experiment with a Li/V-alloy assembly (Fig. 1) has been performed previously at the FNS facility of JAEA.[2] Responses of the Li-containing RPL glass detectors in the assembly have been simulated by neutron transport calculations. Neutron spectra in the assembly were calculated with the Monte Carlo neutron transport calculation code MCNP4C. Energy depositions on three types of the RPL glass detectors, i.e. detectors without lithium, with enriched ^{6}Li and with enriched ^{7}Li, were evaluated by multiplying the neutron spectra by kerma factors which were weighted by the material compositions of the detectors. Energy deposition from nuclear reactions and scatterings of ^{6}Li and ^{7}Li can be evaluated by subtracting the energy deposition in a detector without Li from that in a Li-containing detector. Major contributions of lithium to energy deposition are considered to be the ^{6}Li(n,α)T reaction and elastic scattering in the ^{6}Li containing detector and the ^{7}Li(n,nα)T reaction and elastic scattering in the ^{7}Li containing detector. Under neutron environments in mock-up assemblies where energy depositions by ^{6}Li(n,α)T and ^{7}Li(n,nα)T are considerably larger than those by elastic scatterings, these detectors could be used for direct evaluation of tritium production.

Fig. 2 shows the calculated energy depositions by lithium in the ^{6}Li containing and ^{7}Li containing detectors. In the Li/V-alloy assembly, the energy deposition to the ^{6}Li-containing detector is mostly from ^{6}Li(n,α)T reaction. The calculated distribution of the energy deposition shows enhancement of tritium production from ^{6}Li around a V-alloy layer in the assembly. The energy deposition to the ^{7}Li-containing detector is mostly from ^{7}Li(n,nα)T and elastic scattering. The energy deposition and RPL intensities shown in Fig. 2 are estimated with a condition of 3.7 hours irradiation with a neutron generation rate of 1.3 x 10^{11} n/s. The calculation results indicate that the Li-containing RPL glass detectors can be used for the direct evaluation of tritium production especially from the ^{6}Li(n,α)T reaction in the Li/V-alloy assembly. The estimated PRL intensities are sufficient for measurements of the energy depositions.

The RPL glass detectors[3] are expected to apply also to the future benchmark experiments simulating coolants of LiPb, Flibe, etc. and neutron shielding experiments.

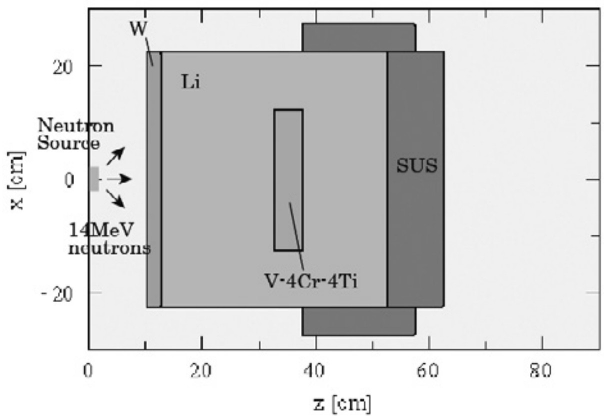

Fig. 1. Horizontal cross section Li/V-alloy assembly for DT neutron irradiation experiment.

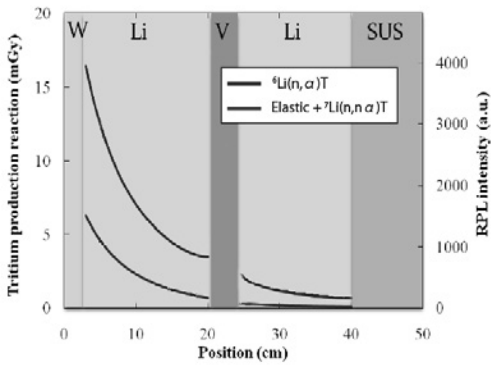

Fig. 2. Calculated energy depositions by neutron scattering and nuclear reactions of lithium contained in RPL glass detectors.

1) Iida, T., et al., annual report of national institute for fusion science, April 2010- March 2011, 243.
2) Tanaka, T., Fus. Sci. Technol, **60**(2011)681.
3) Nagai, S., master thesis, Graduate school of Engineering, Osaka University, Feb. 2011.