§16. Applicability Study of Radiophotoluminescence (RPL) Glass Dosimeter to Fusion Neutronics Experiments

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Detailed neutronics designs of liquid cooled blanket systems have been conducted by using neutron and gamma-ray transport calculation codes and nuclear data library. To evaluate accuracies in the neutronics calculations and designs, DT neutron irradiation experiments on the mock-up assembly simulating the blanket structures and accurate measurements of neutron transport, tritium production etc. in the assembly are required. The purpose of the present study is to examine the applicability of radiophotoluminescence (RPL) glass detector, which has been developed for personal dosimeters, to accurate neutron measurements in fusion neutronics experiments.

While commonly-used Al-Na RPL glass (P: 32, O:51, Al:6, Na:11, Ag:0.1 wt%) can keep information of a radiation dose up to 200 ^{o}C, a new Ca-Na RPL glass (P:32, O:49, Ca: 16, Na: 3, Ag: 0.1 wt%) examined in the present study can keep the information up to 300 ^{o}C. Especially in the present study, powders of LiOH with natural Li (^{6}Li: 7.5 %, ^{7}Li: 92.5%), ^{6}Li enriched lithium (^{6}Li:93 %) and ^{7}Li enriched lithium (^{7}Li:99 %) have been added in a synthesize process of the Ca-Na RPL glass for measurement of thermal neutrons. The size of the fabricated glass detectors is 18 x 7 x 1.7 mm^3. The concentrations of lithium were 0.9 – 1.3 at%.

Responses of the lithium contained Ca-Na RPL detectors have been examined in a thermal neutron field constructed by using an ^{241}Am-Be neutron source and graphite blocks (Fig. 1). Between the neutron source and the examined RPL glass detectors, a brass rod of 2.6cmϕ x 30 cm was placed. The neutron fluence was 1x10^9 n/cm^2 for each detector.

Figure 2 shows the RPL intensities of the Ca-Na RPL glass detectors after the irradiation. The RPL intensities have been evaluated by luminescence intensities in the range of >600 nm under excitation with a 330-380 nm UV light. The RPL intensities of the detectors without lithium and containing ^{7}Li enriched lithium were contributed from interactions of neutrons and gamma-rays with the glass materials of other than ^{6}Li. In the detectors containing natural lithium and ^{6}Li enriched lithium, contribution from the ^{6}Li(n,α)T reaction, which has a significantly large cross section for thermal neutrons, enhanced the magnitude of the response. Therefore, by subtracting the response of the detector containing ^{7}Li enriched lithium from those of detectors containing natural lithium and ^{6}Li enriched lithium, the responses corresponding to the ^{6}Li(n,α)T reaction can be obtained. A ratio of the RPL intensities corresponding to the ^{6}Li(n,α)T reaction agreed well with a ratio of ^{6}Li atoms contained in the detectors. This indicates that the lithium contained RPL glass detectors can be used for a measurement of thermal neutrons. This response also corresponds to a direct measurement of tritium production from ^{6}Li.

Responses of the present RPL glass detectors in a neutron environment of Li cooled and Flibe cooled blanket systems are planned to be investigated by neutron transport calculations. The influence of nuclear reactions of fast neutrons on the detector response is the most important issue. The composition of the glass detectors could be modified based on the results of the investigation in the future study.

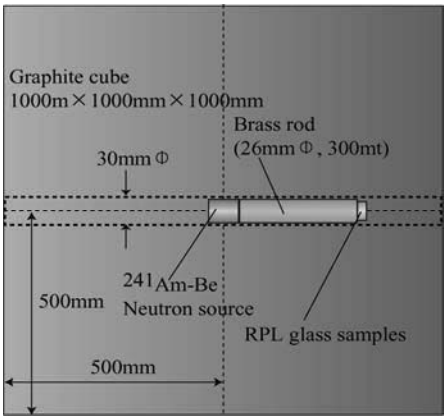

Fig. 1 Schematic drawing of response examination of Ca-Na RPL glass detectors in thermal neutron field.

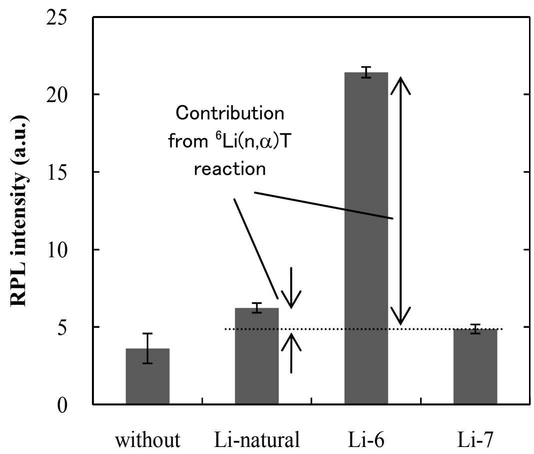

Fig. 2 Radiophotoluminescence (RPL) intensities obtained by RPL glass detectors without lithium and containing lithium.