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放電型核融合中性子源による模擬ブランケットへの中性子照射とトリチウム生成率計測

Measurement of tritium production rate in a blanket mock-up using a discharge type fusion neutron source

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Introduction

Tritium breeding ratio (TBR) is required to be greater than 1.05 for the continuous operation of a deuterium–tritium fusion reactor. Together with computational design studies, an experimental measurement of tritium production rate (TPR) is needed to guarantee tritium fuel self-sufficiency. However, opportunities for neutron irradiation experiments have been limited by low availability of fusion neutron irradiation facilities (e.g. shutdown of Fusion Neutron Source at JAEA in the mid-2010s). Here we propose a neutronics study using a discharge-type compact fusion neutron source. Tritium production rate in a blanket mock-up was experimentally measured using a single-crystal diamond detector (SDD) with a thin ^{6}LiF film.

Methods

Fusion neutrons were generated by a discharge-type cylindrical fusion device [1]. Blanket mock-ups composed of a polyethylene moderator, a graphite reflector, and a lithium carbonate (Li_2CO_3) tritium breeder with a natural abundance of Li were irradiated by DD fusion neutrons (Fig. 1). The SDD was supplied from Cividec instrumentation GmbH, and the single-crystal diamond was fabricated by chemical vapor deposition [2]. The thickness of the LiF film and 6Li isotope ratio were 1.9 μm and 95.62%, respectively. The SDD covered by a lead-shield was positioned at five positions.

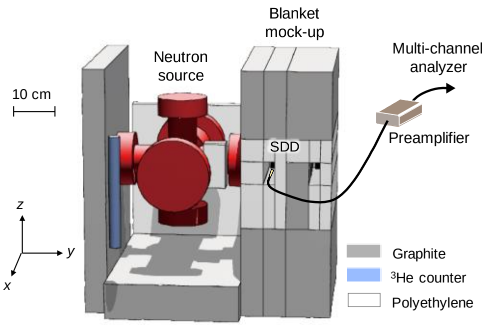

Fig. 1 Experimental assembly for neutron irradiations

Results and Discussion

Fusion neutrons with the energy of 2.45 MeV were generated under the optimized discharge conditions (9 mA and 60 kV) in hours of operation period, which yielded total neutron generation greater than 10^{9}. Fig. 2 shows the energy spectra of the SDD compared with the energy depositions calculated by the PHITS code. The triton peaks from 2.4 to 2.69 MeV were integrated and then converted into ^{6}Li(n,t) reaction rates using calibration factor obtained by using an unsealed ^{241}Am α emitter. At positions with sufficient thermal neutron fluxes, the TPRs in the blanket mock-ups were measured with the experimental errors of 8.4–8.5%. The computational to experimental (C/E) values were 0.96–1.29 with the FENDL-3.1 nuclear data library.

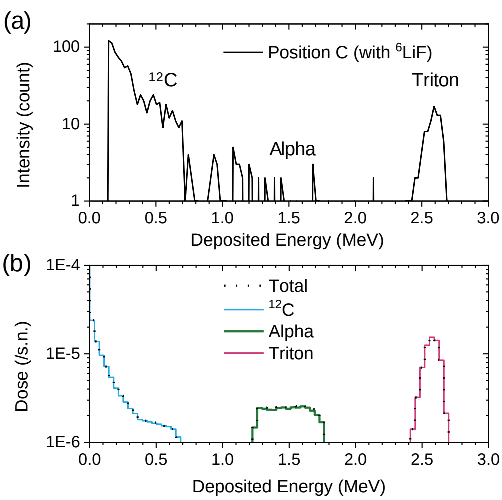

Fig. 2 Energy spectra by the SDD detector at position C (a) and calculated energy depositions (b).

References

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