§36. Study on Tritium Behavior in Liquid Blanket System of Laser Inertial Fusion Reactor

Fukada, S. (Kyushu Univ.),
Norimatsu, T. (Osaka Univ.)

Li-Pb eutectic alloy is one of the most promising liquid wall materials for inertial fusion reactors. Recent development on FIREX (Fast Ignition Realization Experiment) showed a higher possibility to realize an inertial fusion reactor earlier. Based on a conceptual design of the Koyo-fast ignition Laser fusion reactor, in the present research, we discuss some issues to be developed from a viewpoint of tritium recovery and safety to operate a fusion reactor. In addition, we carried out experiment of hydrogen isotope transfer through $Li_{0.17}Pb_{0.83}$ eutectic alloy for a liquid wall material.

In the conceptual design of KOYO having 800 MW fusion power, the tritium generation rate is estimated as 1.5 MCi/day. The tritium concentration in $Li_{0.17}Pb_{0.83}$ is lowered down to 1 ppm for inventory limit, and the rate of the overall tritium leak through heat-transfer tube walls is limited down to 10 Ci/day for safety reason. These necessary conditions demand the tritium recovery ratio of higher than 99.999%. Therefore, a tritium extraction tower having a higher recovery rate and tube walls showing a lower tritium permeation rate should be developed in the whole Li-Pb loop. A counter-current dual-tube extraction column where Li-Pb flows downward and He bubbles flow upward is designed in the present study. Concentration profiles through the tower and tritium extraction rates are calculated and discussed. Tritium permeation rates through ferrite steel as a heat-transfer tube candidate are calculated.

Hydrogen solubility, diffusivity and permeability of the $Li_{0.17}Pb_{0.83}$ eutectic alloy that has the lowest melting temperature are determined from transient-state and steady-state permeation rates experimentally. Since there were some discrepancies in the previous data of solubility and diffusivity of Li-Pb that were determined by a constant-volume method, there were some errors in evaluation of the tritium inventory and leak to the environment. Therefore, the dependence of hydrogen solubility and diffusivity in Li-Pb on pressure and temperature are determined by the present permeation method in details. The results are shown in Figs. 1-3. It is found that hydrogen is dissolved in Li-Pb as a form of dissociated atom and the activity of Li in the Li-Pb eutectic alloy is decreased heavily. Chemical activities of hydrogen and Li in the eutectic alloy are estimated based on the above results.

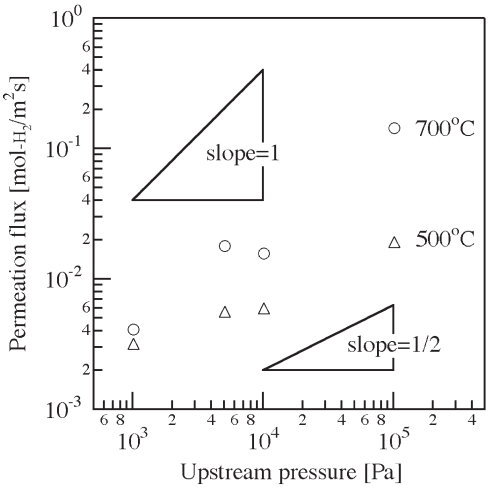

Fig. 1 Dependence of permeation flux on H_2 pressure

Our references presented in 2006
[1] S. Fukada, *et al*, "Verification to recover tritium in neutron-irradiated Li by Y plate", Proc. 24th SOFT, Warsaw, Poland (2006), Fusion Engineering and Design, in printing
[2] S. Fukada, "Recovery of tritium from liquid blanket materials", Proceedings of A mini-workshop on ITER Related Tritium Technology in China, August 10-11 (2006) 51-57.
[3] M. Kinoshita, S. Fukada, *et al.*, "Experimental study of tritium recovery from liquid lithium by yttrium", Fusion Engineering and Design, 81 (2006) 567-571.

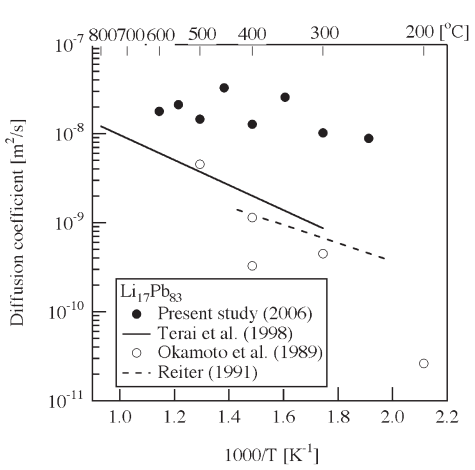

Fig. 2 Hydrogen diffusivity in $Li_{0.17}Pb_{0.83}$

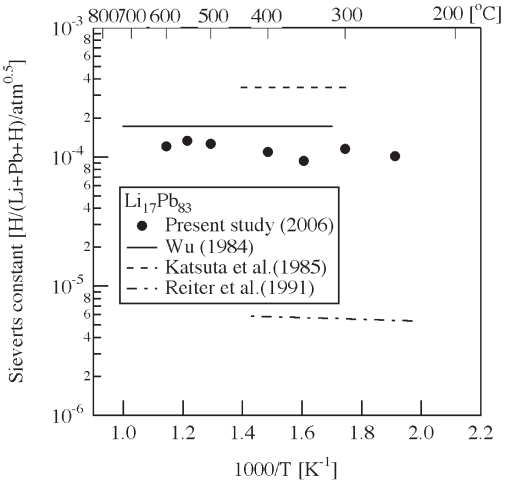

Fig. 3 Hydrogen solubility in $Li_{0.17}Pb_{0.83}$