§ 3. Electrical Insulating Property of Ceramic Coating Materials under 14 MeV Neutron Irradiation

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In the development of the V/Li blanket system for advanced fusion reactors, reduction of MHD pressure drop in Li coolant flow is one of important issues to be solved. The pressure drop is induced by electrical currents flowing between Li coolant and metal cooling ducts, and causes severe load to coolant pumps. Therefore, fabrication of insulating coating on a structural material has been studied in the fusion engineering research center. So far, nonconventional ceramic materials such as Y_2O_3, Er_2O_3 and $CaZrO_3$ have been selected and characterized as candidates from the aspect of viability in highly corrosive liquid Li coolant. However, almost no data have been obtained as to electrical properties under radiation environment. In the present study, degradation of insulating properties of some candidate ceramic materials were examined under 14 MeV neutron irradiations.

Specimens prepared for neutron irradiations were an Y_2O_3 plate of 5.0 x 5.0 x 1.0 mm^3, an Er_2O_3 disc of 7.5 mmϕ x 1.0 mm and a $CaZrO_3$ disc of 15 mmϕ x 3.5 mm made by hot-press sintering method. The electrical conductivities of the specimens measured before irradiations were 3.3 x 10^{-13}, <5.0 x 10^{-14} and 8.8 x 10^{-13} S/m, respectively. 14 MeV neutron irradiations were performed at FNS (Fusion Neutronics Source) facility of Japan Atomic Energy Research Institute. Fig. 1 shows a schematic drawing of experimental arrangement and a measurement system. Platinum electrodes were made on both sides of each specimen by vapor deposition. Bias voltages up to 1 kV were applied to one of the electrodes. The opposite electrode was connected to the electrometer (Keithley 6517A) with a copper lead wire. Changes in leakage currents flowing through the specimens were measured under neutron irradiations as the effect of radiation induced conductivity (RIC). The maximum neutron fluxes were 7.0 x 10^8 n/cm^2/s for the Y_2O_3 and Er_2O_3 specimens and 8.0 x 10^9 n/cm^2/s for the $CaZrO_3$ specimen.

Fig. 2 shows an example of changes in a leakage current under neutron irradiation. The leakage current was changed rapidly according to the neutron flux. The radiation induced currents were almost proportional to the neutron flux and the bias voltage. Also the ohmic characteristics were observed in I-V measurements under irradiations. The results indicate that the electrical insulating properties were degraded by drift of electrical charges induced in the specimens. The radiation induced conductivities extrapolated or interpolated to the neutron flux of 1.0 x 10^9 n/cm^2/s were 1.5 x 10^{-10}, 4.2 x 10^{-11} and 3.7 x 10^{-11} S/m for the Y_2O_3, Er_2O_3 and $CaZrO_3$ specimens, respectively. These values were one or two orders higher than previous results for well examined high quality Al_2O_3. It is considered that examination of the effects of impurities and other material characteristics on radiation induced currents is important for the development of coating materials. Similar irradiation experiments are in progress for thin coating specimens of few micrometers in thickness.

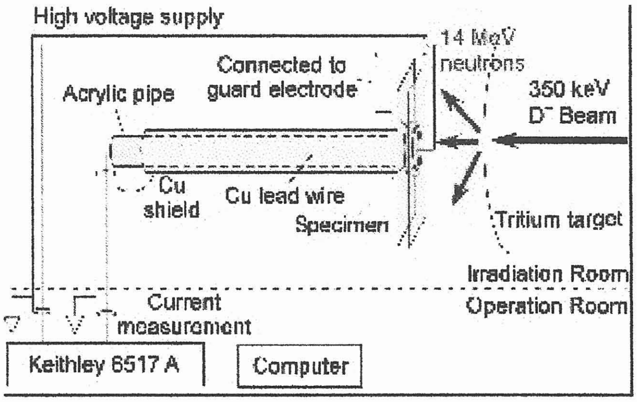

Fig. 1. Schematic drawing of experimental arrangement and measurement system.

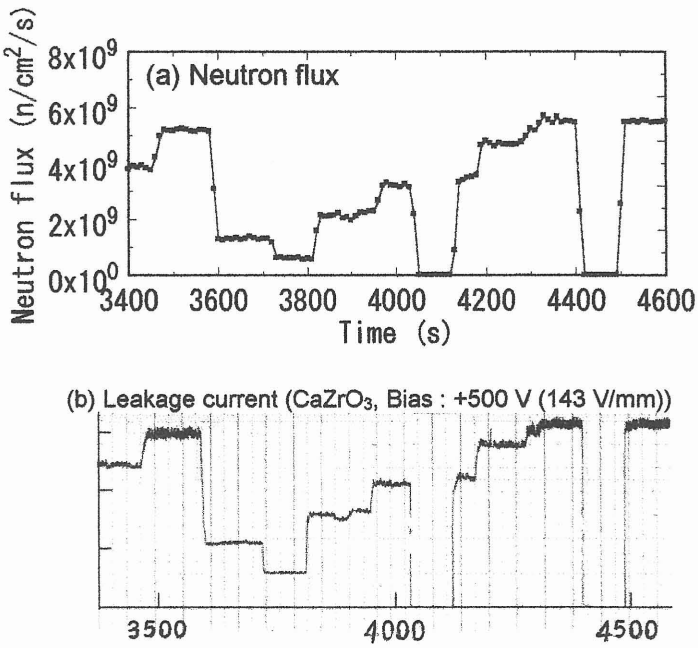

Fig. 2. Example of changes in leakage current under neutron irradiation.