§30. Development of Lost Particle Detector for High Temperature and High Heat Flux Environments

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In burning plasma experiments in ITER, the loss of 3.5 MeV alpha particles produced by DT reaction causes a degradation of self-heating power input. In addition, localized loss of alpha particles onto the first wall will give rise to serious problems. It is, therefore, important to understand alpha particle loss mechanism and to avoid these problems. Scintillator lost ion probe (SLIP) is one of possible tools for lost alpha particle measurement in ITER. A scintillator is mounted in the head of SLIP system. Lost fast ions enter the SLIP detector through an aperture, and hit the scintillator, which produces the luminescence. The information on the ion energy and pitch angles can be obtained from bright spots on the scintillator. For the SLIP diagnostics, it is important to develop and characterize scintillation materials during and after hard irradiations of ions, gamma ray, and neutrons under the environment of first wall of ITER, where the SLIP will be mounted.

The hard irradiation environment was simulated experimentally to study the effect of ion beams and neutron irradiation on the luminescence of the polycrystalline ceramic of Ce: YAG as a scintillator in the ITER operation range. The scintillator was irradiated with ion beams of up to 300 nA at room temperature. The ion beam was limited to 6 mm in diameter using a diaphragm on the beam line. The luminescence spectra during 3.0 MeV H^+ and He^+ irradiations was measured by a spectrometer (Hamamatsu, PMA-11) at the dynamitron accelerator facility of Fast Neutron Laboratory (FNL) in Tohoku University. Figure 1 shows the dependence of the luminescence intensity on the incident particle flux. The luminescence intensity corresponds to the value integrated over the wavelength from 450 to 800 nm. In both ion species, the luminescence intensity increased linearly, when the ion flux goes up to 6.7×10^{16} $m^{-2}\cdot s^{-1}$, which simulated the environment of ITER for lost alpha diagnostics.

The polycrystalline Ce: YAG samples were irradiated with neutron and gamma ray at the Japan Research Reactor 3 (JRR-3) in Japan Atomic Energy Agency. The fast neutron flux was set to 1.6×10^{16} $m^{-2}\cdot s^{-1}$ for 12 hours and 1.7×10^{16} m^{-2} for 48 hours, respectively at the sample temperatures of about 200 °C. The samples were annealed at 200, 300, and 800 ºC for an hour after irradiations to observe the recovery of the luminescence intensity with anneal, because it was reported that the annealing was effective to the recovery of irradiation damage.

Figure 2 shows the decay time of photoluminescence for polycrystalline Ce:YAG scintillator excited by a pulse Nd-YAG laser. From the curve fit using $I/I_0=\exp(-t/\tau)$, the decay time is 65 ns. This decay time is found to be sufficient to detect the plasma instabilities.

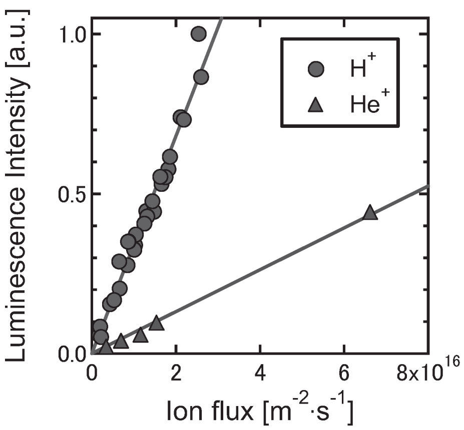

Fig. 1. Luminescence intensity of 1 mol% Ce: YAG by irradiating H^+ and He^+ beams with the energy of 3.0 MeV.

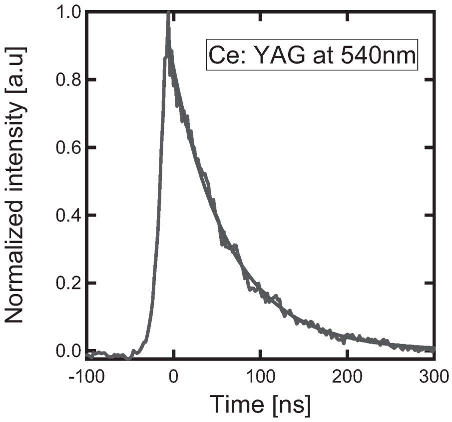

Fig. 2. Time evolution of luminous intensity using a pulse laser for excitation light at room temperature.

1) T. Hirouchi, M. Nishiura, T. Nagasaka, T. Ido, D. Funaki, T. Kobuchi, A. Okamoto, S. Kitajima, M. Sasao, K. Fujioka, M. Isobe, and T. Mutoh, J. Nucl. Materials in print.