§10. Development of Lost Ion Probe for MHD Activity Measurements

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Measurement of escaping energetic ions is important for the study of fundamental confinement properties of energetic ions in LHD, and for the study of various types of collective phenomenon driven energetic particles. In addition damage caused by energetic particle bombardment on the first wall is one of the concerns in a nuclear fusion reactor. The diagnostics by a scintillator probe is known as a possible tool for lost ion measurement.

Because a scintillator probe is exposed to high heat load, especially on a helical device where a probe from an available port accesses to the lost ion region across a diverter leg. In our previous work, it was turned out that Ce:YAG ceramic scintillator fabricated at Osaka University showed the degradation of luminescence intensity under high temperature is tolerably low up to 500^{o} C. The scintillation decay time was sufficiently short (about 65 nsec) to study the effect of MHD instabilities.

In the present collaboration research, the effect of the hard ion beam irradiation was studied at the Dynamitron Accelerator Facility (FNL), Tohoku University. Fig. 1 showed the experimental setup for the measurement. The Ce:YAG ceramic scintillator was bombarded by an 3.0 MeV He+ beam, collimated by a 6 mm in diameter diaphragm. The luminescence spectra were measured by a Hamamatsu PMA-11 spectrometer, and the data were stored continuously in a PC. The luminescence intensity changed as the accumulated ion flux was increased (Fig.2). Arrows in the graph indicate the time of the beam irradiation was stopped, either by a Faraday cup insertion, or by stop of the accelerator operation. Recovery effect was clearly observed. Diamonds indicate the results of 2007, and circles those of 2008, where the beam intensity was 3 times higher and the ceramic sample was different. The degradation of luminescence and the recovery effect show different behavior, but both data can be fitted by a sum of two degradation terms and one recovery term, and one permanent damage. The strength of each term differs depending on the sample.

These samples are analyzed by using X-ray Photoelectron Spectroscopy (XPS). The sample of high recovery term showed the charge-state change of Ce^{3+}, while that of low recovery term showed appearance of impurity spots and the loss of Ce^{3+}.

1) Hirouchi, T., Nishiura, M., Nagasaka, T., Ido, T., Sasao, M., Fujioka, K., Isobe, M., and Mutoh, T., J. Nuclear Materials 386-388(2009)1049.

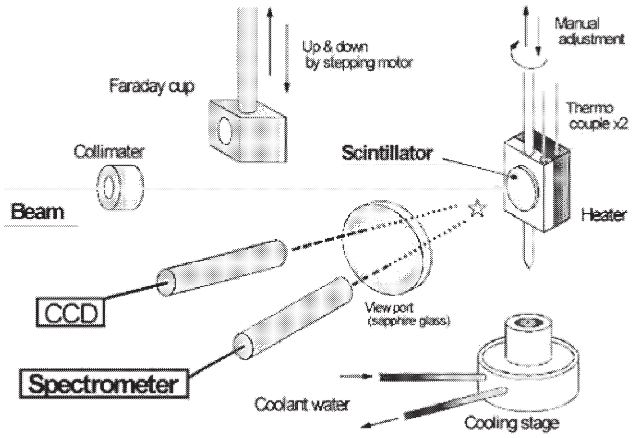

Fig. 1 The Experimental arrangement for ion bomberdment test of Ce:YAG scintillator at the Dynamitron Accelerator Facility (FNL), Tohoku University.

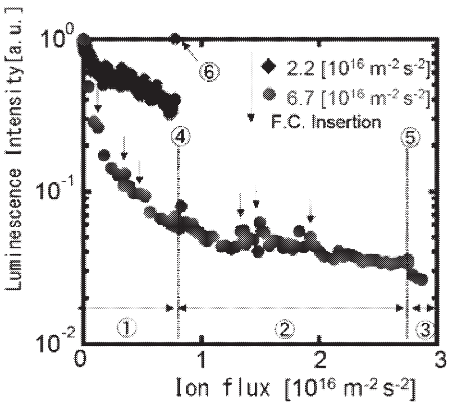

Fig. 2. Endurance test of Ce:YAG ceramic scintillator by ion beam irradiation. Irradiation duration; ① 13860sec. ② 28800sec. ③ 1902sec. Annealing duration with room temperature; ④48540sec. Annealing duration with 300ºC; ⑤ 46140sec.

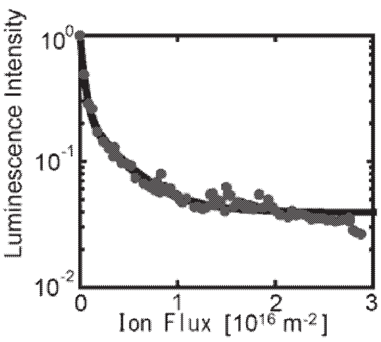

Fig. 3. Degradation of luminescence intensity can be fitted into a curve (solid line). The fitting curve is a sum of two degradation terms and one recovery term, and one permanent damage. The strength of each term differs depending on the sample.