§17. Study on Erosion, Transport and Redeposition of Wall Materials in GAMMA-10 and its Contribution to Divertor Development

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GAMMA-10 end plasmas have several advantages in making plasma materials interaction experiments comparing linear plasma devices such as high ion energy with Maxwell distribution and presence of a high magnetic field. Under these conditions, plasma ions impinging plasma facing materials (PFMs) have oblique incident angles and energy distribution, which significantly affect erosion of PFMs. In addition, after ionization of sputtered atoms their motion strongly affected by the strong magnetic field. Due to these features, GAMMA-10 provides unique experimental environment to simulate plasma materials interaction.

In this study, chemical sputtering of graphite and local transport phenomena of carbon atoms together with high Z atoms are investigated. Especially, chemical erosion of graphite is well known to be affected by ion energy distribution. For example, small amount of high energy ions significantly enhance chemical sputtering erosion by low energy ion bombardment. In this case, high energy ions make damage on graphite, with which high flux low energy ions combine to form C-H chemical bonds, leading to volatile hydrocarbon compound. But so far there are no systematic investigation on this energy distribution effects.

Concerning GAMMA-10 end plasmas, ion energy distribution is well approximated by bi-Maxwellian. These effective ion temperatures can be controlled by heating power of plasmas. Therefore, this is desirable for investigation of ion energy effects on graphite erosion. We installed graphite and Mo samples at the E-divertor test section with a sample surface tilted 45 deg from magnetic lines of force. Schematic drawing of experimental setup is shown in Fig. 1. Erosion flux of carbon and Mo will be measured by a framing camera with an appropriate spectral line filter. This setup allows us to study not only erosion characteristics but also short range migration of sputtered atoms including ionization in plasmas, transport along magnetic field lines driven by plasma flow and deposition on samples.

In Osaka university, we also plan to make a complementary experiment with a HiFIT ion beam device, which is equipped with two ion beam sources. They can be operated separately. Therefore, graphite samples will be irradiated with difference ion beam (difference ion species and energies). By these experiments, we investigate graphite chemical sputtering by impinging ions with energy distribution. This result will make it possible to correctly evaluate sputtering erosion of graphite under fusion reactor edge plasma conditions.

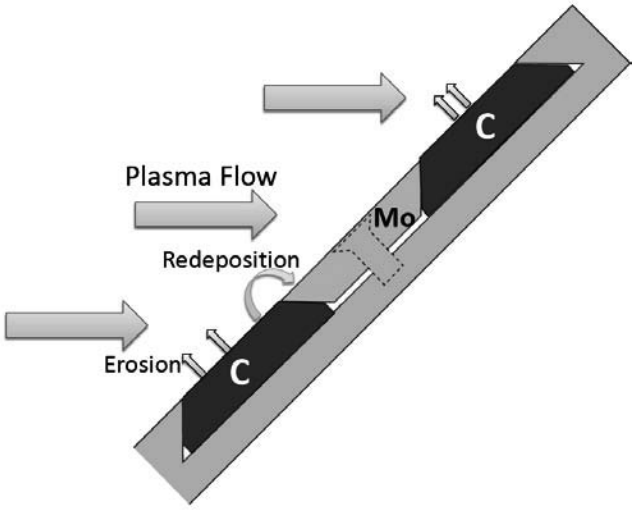

Fig. 1. Setup for erosion and redeposition experiments in GAMMA-10 end plasmas.

It is well recognized that PWI research is one of the key issues for the success of ITER and DEMO. In order to increase Japanese contribution in this field, combined scientific meeting on PWI study was organized with the other regular meetings, Plasma Research Center symposium (Tsukuba University), and Fusion Plasma and Engineering clusters meetings. In this combined meeting, discussions on important issues on divertor R&D and effective collaboration between experimental studies and simulation studies were performed. In terms of PWI simulations, Dr. Hoshino presented a recent simulation result on detached divertor plasma. Prof Ohya presented erosion, transport, and redeposition of wall materials, and Prof. Tanaka presented a simulation result of dust dynamics. Since these subjects in general can be studied in GAMMA-10, it is important to plan possible experimental arrangement in future. The role of a divertor simulator on PWI studies was summarized by Prof. Ohno.

In addition, presentations and discussions on collaboration research between 6 major facilities in universities (Plasma Research Center in University of Tsukuba, Advance Fusion Research Center in Kyushu University, Institute of Advanced Energy in Kyoto University, Hydrogen Isotope Research Center in University of Toyama, Institute of Material Research in Tohoku University, and National Institute for Fusion Science) were made. There were a lot of fruitful discussions and valuable comments, which will surely promote collaboration research in Japan in the field of PWI.