§4. Surface Analysis of Carbon Samples Exposed to GAMMA 10 Plasmas by the Use of the Monte Carlo Simulation

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Control of hydrogen recycling is one of the most important issues for improvement of plasma performance such as density control and energy confinement. The first wall of plasma device is exposed to charge exchange fast neutral emitted form hot-ion plasma, and desorbed hydrogen from the wall induces hydrogen recycling. The aim of this research is control of hydrogen recycling by using carbon sheet pump (CSP) [1, 2] in actual devices. The pumping effect of CSP has already been confirmed with GAMMA10 hot-ion plasmas [3 - 5].

The purpose of surface analysis of carbon materials is to improve performance of CSP and to examine application to actual devices from a microscopic point of view. As shown in fig. 1, we additionally installed the surface station to the CSP test module. Exposure conditions can be arbitrary set because samples can be replaced without opening the GAMMA10 vacuum chamber to air. Moreover, not only CSP but also other candidates for plasma facing material can be exposed to actual plasma by the use of the surface station. Used samples were annealed at a steady temperature of 800 °C for 10 minutes before exposure. These samples were exposed to fast neutrals from hot-ion plasma in GAMMA 10. The samples were analyzed by the use of several MeV He ion beam extracted from Van de Graaff accelerator in Nagoya University.

Samples were analyzed by means of elastic recoil detection (ERD) and Rutherford backscattering spectroscopy (RBS) techniques. Isotropic carbon material doped with boron (GB-010, Toyo-Tanso Co., Ltd) was exposed to the GAMMA 10 plasmas as a candidate for improved CSP. In the exposed sample we confirmed hydrogen atoms caused by charge exchange fast neutrals. As a result of analyzing RBS spectrum of the exposed sample, a small quantity of oxygen was detected. However, this is not serious problem because the analysis was carried out after ventilation and the ratio of oxygen to carbon was less than 1 %. Although impurities generated from CSP cause no trouble to plasma at the present time, the boron doped CSP is proposed as an improvement plan of CSP. It is expected that the boron doped CSP reduces oxygen impurity in plasma and has superior resistance to chemical erosion.

Unlike a mono-energetic ion beam, plasma has an energy distribution. Accordingly, numerical simulations in which carbon material was exposed to ion flux that had Maxwell distribution were carried out by means of Monte Carlo simulation code TRVMC95 [6, 7] in order to analyze the results of ERD in detail. The experimental result agrees with numerical calculation at the ion temperature of 2 keV qualitatively as shown in fig. 3. The ion temperature of 2 keV also agrees with a typical ion temperature of GAMMA10 plasmas (0.5 ~ 5 keV). It is thought that projectiles come to rest and are trapped by carbon near each projected range. In order to evaluate quantitatively, we must take account of hydrogen transport in samples and two components of the ion temperature.

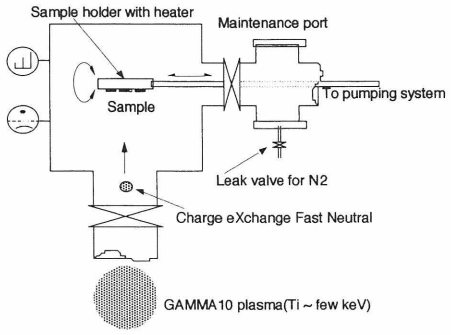

Fig. 1. Schematic of the surface station.

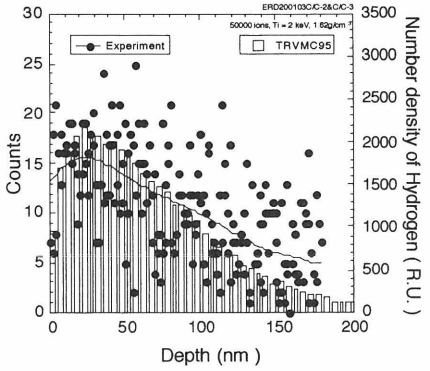

Fig. 2. Comparison between Hydrogen depth profile measured by ERD and that calculated by means of Monte Carlo simulation TRVMC95.

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